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Research Article

Combining ability and gene action studies for seed yield and its components in sesame (*Sesamum indicum* L.)

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Abstract

A line x tester analysis using 12 lines and three testers was carried out to study the combining ability and gene action in sesame for seed yield and 14 quantitative traits. Analysis of variance for combining ability revealed significant differences among the mean squares due to lines, testers and lines x testers for all the characters except oil content, which indicated the existence of genetic diversity among the parents and hybrids. General and specific combining ability variances showed the involvement of both type of gene actions in the inheritance of these characters. Among the lines, IC-81564, NIC-75, Borda-1 and among testers, G.Til-10 were good general combiners for seed yield per plant and some of its contributing traits. The cross combination, IC-81564 x G.Til-10 showed significant and positive *sca* effect for seed yield per plant and involved good x good combining parents. It was followed by AT-238 x G.Til-10, NIC-75 x G.Til-4, TNAU-12 x G.Til-4, Keriya-2 x G.Til-3 and Keriya-2 x G.Til-10 which involved either good x good, good x poor or poor x poor combining parents. These crosses have been identified as best hybrids for improving seed yield per plant and could be evaluated under different environment to confirm their superiority.

Key words

Sesame, combining ability, gene action, line x tester analysis

Introduction

Sesame (*Sesamum indicum* L.) is one of the most ancient and important oilseed crop grown next to groundnut and mustard in India. The oilseed crops play important role in agriculture and industrial economy of our country. It is called as the 'queen' of oilseeds in view of its oil and protein which are of very high quality. In India, sesame is cultivated on an area of 19.01 lakh ha with production of 8.10 lakh tonnes and productivity 426 kg/ha (Anonymous 2011). However, the productivity is low in India as compared to other countries which need to be improved. In the absence of a viable male sterility system in sesame, hybrids have to be developed exclusively by hand emasculation and pollination as done in other crops like cotton. Commercial exploitation of heterosis is feasible only if the means of producing hybrid seeds economically viable. It is possible in sesame because indeterminate plant with epipetalous nature of the flower facilitating easy emasculation, low seed rate, high seed multiplication ratio, natural out crossing, frequent visit by a large number of insects including honey bees and higher number of seeds set in a single pollination. In an often cross-pollinated crop like sesame there is a good scope for exploitation of heterosis because out crossing reached up to 68% which indicates the potentiality of the crop for improvement in yields.

Further, an understanding of the combining ability and gene action is a pre-requisite for any successful plant breeding programme. Testing the parents for their combining ability is very important because many times, the high yielding parents may not combine well to give good hybrids. Line x tester analysis helps in testing a large number of genotypes to assess the gene action and combining ability. The present experiment was, therefore planned to study combining ability and gene action in sesame.

Material and methods

The present study on sesame was conducted at Department of Genetics and Plant Breeding, Junagadh Agricultural University, Junagadh, Gujarat. Twelve diverse lines *viz.,* IC-205314, IC-43063, IC-81564, IC-204983, AT-164, AT-238, AT-115, Borda-1, Patan-64, TNAU-12, Keriya-2, NIC-75 and three testers *viz.,* G.Til-3, G.Til-4 and G.Til-10. The selected 12 lines and three testers were crossed in a line x tester design during summer 2012 to produce 36 hybrids. The resulting 36 hybrids along with 15 parents were evaluated during kharif-2012 in a Randomized Block Design with three replications. Each plot was constructed with a row length of 3m and adopted a spacing of 45 x 15cm. All need based agronomic practices were followed during the crop growth period to raise a good crop. Observations were recorded on randomly selected five plants in each entry for 15 quantitative traits *viz.*, days to 50 % flowering, days to maturity, plant height (cm), height to first capsule (cm), number of branches per plant, number of internodes per plant, length of capsule (cm), width of capsule (cm), number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule, 1000-seed weight (g), oil content (%), protein content (%) and seed yield per plant (g) for each replication. The mean values were used for the analysis of variance for experimental design. The data were statistically analyzed for combining ability in accordance with Kempthorne (1957).

Results and discussion

Analysis of variance for combining ability (Table 1) showed significant differences among mean squares due to lines, testers and line x tester for all the characters except oil content and indicated the existence of genetic diversity among the parents. However, mean squares due to testers were larger than those due to lines for all the characters except days to 50 % flowering, length of capsules, 1000-seed weight, oil content and protein content indicating more diversity among the testers for these characters recorded. Estimates of genetic component of variance revealed that the variances due to lines (σ^2l) were higher than the variances due to testers (σ^2t) for all the characters except height to first capsule, number of branches per plant, number of capsules per plant, number of capsules per leaf axil and seed yield per plant indicating the greater role of lines towards total additive genetic variance (σ^2gca). Estimates of σ^2gca and σ^2sca revealed that the magnitude of *gca* variance were higher than those due to *sca* variance for days to 50 % flowering, days to maturity, plant height, height to first capsule, number of branches per plant, number of capsules per plant, oil content and seed yield per plant. The σ^2gca:σ^2sca ratio was also more than unity suggesting involvement of additive gene action in the inheritance these characters. For number of internodes per plant, length of capsule, width of capsule, number of capsules per leaf axil, number of seeds per capsule, 1000-seed weight and protein content, the sca variance was higher than gca variance which indicated greater role of non-additive gene action in the control of these characters. This was also confirmed by ratio of σ^2gca:σ^2sca which is less than unity for these characters. The findings of the present investigation for seed yield per plant and its attributing traits are in close conformity with the findings of Sakhare *et al.* (2000), Mothilal and Manoharan (2004), Mishra *et al*. (2009) and Parameshwarappa and Salimath (2010).

An overall appraisal of gca effects (Table 2) indicated that none of the parents was good general combiner for all the characters studied. However, among lines, IC-81564 gave desirable gca effect simultaneously for nine characters *viz.*, days to 50 % flowering, days to maturity, plant height, number of branches per plant, length of capsule, width of capsule, 1000-seed weight, protein content and seed yield per plant followed by NIC-75 for six characters *viz*., plant height, number of branches per plant, number of internodes per plant, length of capsule, number of capsules per plant and seed yield per plant, Borda-1 for five characters *viz*., plant height, number of internodes per plant, length of capsule, number of capsules per plant and seed yield per plant. Among testers, G.Til-3 showed desirable gca effect for as many as seven characters *viz.*, days to 50 % flowering, days to maturity, height to first capsule, length of capsule, width of capsule, number of seeds per capsule and 1000-seed weight followed by G.Til-10 which gave desirable gca for six traits *viz.*, plant height, number of branches per plant, number of internodes per plant, number of capsules per plant, protein content and seed yield per plant. The parents which are good general combiners simultaneously for more number of characters are considered as the potential parents and should be preferred in breeding programme in order to combine more number of characters by involving fewer numbers of parents in a crossing programme.

The study also indicated that the parents showing good general combining ability had high *per se* performance for almost all the traits studied. This suggested that while selecting parents for hybridization programme in sesame, *per se* performance of the parents may be given due consideration. High general combining ability effects mostly contribute either additive gene effects or additive x additive interaction effect or both and represent fixable portion of genetic variation. Accordingly, IC-81564, NIC-75, Borda-1, AT-238 and G.Til-10 offered the best possibilities of exploitation for the development of improved purelines with enhanced yielding ability. Further, the lines showing good general combining ability for particular components may be utilized in component breeding programme for improving specific trait of interest.

The best specific combination was observed in cross IC-81564 x G.Til-10 for seed yield per plant and involved good x good combining parents (Table 3). The top yielding cross combinations *viz.*, AT-238 x G.Til-10, NIC-75 x G.Til-4, TNAU-12 x G.Til-4, Keriya-2 x G.Til-3 and Keriya-2 x G.Til-10 showed high, significant and positive sca effects for seed yield per plant and involved either good x good, good x poor or poor x poor combining parents. These cross combinations also depicted significant and positive sca effects for various yield contributing traits.

The good general combiners when crossed may not always produce the best hybrid. Marked negative effects in crosses between good x good were noteworthy, which could be attributed due to the lack of complementation between favourable alleles of the parents involved. Marked positive sca effects in crosses between good x poor and poor x poor could be ascribed for better complementation between favourable alleles of parents involved. These findings are in agreement with the earlier findings of Sakhare *et al*. (2000), Arulmozhi *et al*. (2001), Kar *et al*. (2002), Mothilal *et al*. (2003) and Mothilal and Manoharan (2004).

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Table 1. Analysis of variance for combining ability and variance components for different characters in sesame

Source	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Number of branches per plant	Number of internodes per plant	Length of capsule (cm)
Replications	2	2.704	1.333	131.545**	13.467	0.038	5.290	0.002
Lines	11	99.201**++	93.960**++	1283.175**++	448.357**++	5.397**++	89.840**+	0.301**+
Testers	2	63.065**++	308.778**++	4618.340**++	2514.055**++	28.623**++	302.512**++	0.103**
Lines x Testers	22	11.004**	10.556**	187.968**	99.275**	1.274**	39.428**	0.121**
Error	70	3.485	3.952	24.921	8.192	0.055	1.996	0.005
Variance components								
$\sigma^2 l$		10.635	10.001	139.806	48.907	0.594	9.760	0.033
$\sigma^2 t$		1.655	8.467	127.595	69.607	0.794	8.348	0.003
$\sigma^2 lt$		2.506	2.201	54.349	30.361	0.407	12.477	0.039
$\sigma^2 gca$		3.451	8.774	130.037	65.467	0.754	8.630	0.009
$\sigma^2 sca$		2.506	2.201	54.349	30.361	0.407	12.477	0.039
$\sigma^2 gca / \sigma^2 sca$		1.377	3.986	2.392	2.156	1.852	0.691	0.230

Table 1. Contd..

Source	d.f.	Width of capsule (cm)	Number of capsules per plant	Number of capsules per leaf axil	Number of seeds per capsule	1000-seed weight (g)	Oil content (%)	Protein content (%)	Seed yield per plant (g)
Replications	2	0.0003	9.939	0.001	0.472	0.006	1.060	0.325	0.758
Lines	11	0.0175**	1630.863**++	0.523**	50.397**	0.857**++	17.876**++	22.435**	105.741**++
Testers	2	0.0183**	14938.920**++	3.380**++	79.613*	0.505**	13.285+	10.561**	441.553**++
Lines x Testers	22	0.0092**	255.380**	0.439**	70.722**	0.255**	2.634	14.619**	14.661**
Error	70	0.0005	12.145	0.005	17.327	0.005	4.540	0.935	1.984
Variance components									
$\sigma^2 l$		0.0019	179.858	0.057	3.674	0.095	1.482	2.389	11.529
$\sigma^2 t$		0.0005	414.633	0.094	1.730	0.014	0.243	0.267	12.210
$\sigma^2 lt$		0.0029	81.078	0.144	17.798	0.083	-0.635	4.561	4.226
$\sigma^2 gca$		0.0008	367.678	0.086	2.119	0.030	0.491	0.692	12.074
$\sigma^2 sca$		0.0029	81.078	0.144	17.798	0.083	-0.635	4.561	4.226
$\sigma^2 gca / \sigma^2 sca$		0.2759	4.534	0.597	0.119	0.361	-0.773	0.151	2.857

*, ** Significant at 5 and 1 per cent levels, respectively

+,++ Significant at 5 and 1 per cent levels, respectively against lines x testers interaction

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Table 2. General combining ability effects for different traits in sesame

Sr. No.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Number of branches per plant	Number of internodes per plant	Length of capsule (cm)
Lines								
1	IC-205314	6.157**	6.444**	5.909**	1.959*	0.391**	2.891**	-0.214**
2	IC-43063	-1.843**	1.043	5.909**	2.559**	0.035	0.602	-0.076**
3	IC-81564	-1.731**	-2.778**	4.698**	-1.041	0.280**	0.335	0.284**
4	IC-204983	-2.065**	1.778**	-8.046**	-5.885**	0.191*	-2.709**	-0.166**
5	AT-164	-3.843**	-4.667**	-15.802**	-9.641**	-0.698**	-3.443**	-0.267**
6	AT-238	-1.731**	-1.111	-8.980**	-4.530**	-0.431**	-3.154**	0.203**
7	AT-115	-0.065	1.667*	0.620	-1.241	0.080	-1.643**	0.112**
8	Borda-1	1.935**	3.444**	8.531**	10.937**	0.146	3.602**	0.053*
9	Patan-64	6.046**	1.556*	-11.580**	-5.907**	-1.343**	-3.087**	-0.046*
10	TNAU-12	-3.731**	-2.333**	-1.624	1.604	0.169*	2.624**	0.108**
11	Keriya-2	0.046	-4.111**	-7.791**	-3.552**	-0.654**	-1.998**	-0.030
12	NIC-75	0.824	0.111	28.554**	14.737**	1.835**	5.980**	0.256**
	SE(g_i)	**0.622**	**0.663**	**1.664**	**0.954**	**0.078**	**0.471**	**0.023**
	SE(g_i-g_j)	**0.880**	**0.937**	**2.353**	**1.349**	**0.110**	**0.666**	**0.033**
Testers								
1	G.Til-3	-1.509**	-0.722*	-3.549**	-3.496**	-0.776**	-1.243**	0.057**
2	G.Til-4	0.963**	-2.500**	-9.127**	-6.041**	-0.198**	-2.070**	-0.008
3	G.Til-10	0.546	3.222**	12.676**	9.537**	0.974**	3.313**	-0.049**
	SE(g_i)	**0.311**	**0.331**	**0.832**	**0.477**	**0.039**	**0.236**	**0.012**
	SE(g_i-g_j)	**0.440**	**0.469**	**1.177**	**0.675**	**0.055**	**0.333**	**0.016**

*, ** Significant at 5% and 1% levels, respectively

Contd…

Table 2. Continue…

Sr. No.	Parents	Width of capsule (cm)	Number of capsules per plant	Number of capsules per leaf axil	Number of seeds per capsule	1000-seed weight (g)	Oil content (%)	Protein content (%)	Seed yield per plant (g)
Lines									
1	IC-205314	-0.033**	10.335**	-0.202**	1.785	-0.554**	-0.895	-0.694*	0.801
2	IC-43063	-0.007	8.557**	-0.224**	0.074	-0.124**	-0.849	-0.391	1.818**
3	IC-81564	0.055**	-4.865**	-0.180**	1.019	0.552**	1.076	1.653**	1.977**
4	IC-204983	-0.041**	-13.265**	-0.224**	-1.004	0.221**	-0.495	2.084**	-1.091*
5	AT-164	-0.075**	-5.820**	0.087**	-3.970**	0.017	0.352	2.364**	-3.229**
6	AT-238	0.023**	-4.220**	0.354**	2.785*	0.111**	1.197	-1.555**	-1.305**
7	AT-115	0.012	-11.865**	0.354**	-1.570	0.168**	1.201	-0.309	-3.990**
8	Borda-1	0.010	11.046**	-0.091**	0.207	-0.021	0.229	-1.091**	4.117**
9	Patan-64	0.038**	-13.709**	0.354**	-2.970*	0.182**	-0.002	0.565	-4.121**
10	TNAU-12	-0.047**	-1.509	-0.224**	4.130**	-0.516**	-3.738**	-3.093**	-0.820
11	Keriya-2	0.074**	-7.198**	0.109**	-1.715	0.107**	1.122	0.696*	-1.577**
12	NIC-75	-0.008	32.513**	-0.113**	1.230	-0.140**	0.801	-0.229	7.420**
	SE(g_i)	**0.007**	**1.162**	**0.024**	**1.387**	**0.023**	**0.710**	**0.322**	**0.469**
	SE(g_i-g_j)	**0.010**	**1.643**	**0.034**	**1.962**	**0.032**	**1.004**	**0.456**	**0.664**
Testers									
1	G.Til-3	0.025**	-12.704**	-0.185**	1.699*	0.128**	0.334	-0.479**	-2.025**
2	G.Til-4	-0.020**	-10.793**	0.354**	-1.065	-0.022*	0.367	-0.108	-2.019**
3	G.Til-10	-0.005	23.496**	-0.169**	-0.634	-0.106**	-0.701*	0.588**	4.044**
	SE(g_i)	**0.004**	**0.581**	**0.012**	**0.694**	**0.011**	**0.355**	**0.161**	**0.468**
	SE(g_i-g_j)	**0.005**	**0.821**	**0.017**	**0.981**	**0.016**	**0.502**	**0.228**	**0.332**

*, ** Significant at 5% and 1% levels, respectively

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Table 3. Sca effects for various characters of best selected crosses on the basis of seed yield per plant

Characters	Hybrids									
	IC-81564 x G.Til-10	**AT-238 x G.Til-10**	**NIC-75 x G.Til-4**	**TNAU-12 x G.Til-4**	**Keriya-2 x G.Til-3**	**Keriya-2 x G.Til-10**	**Borda-1 x G.Til-4**	**Borda-1 x G.Til-3**	**IC-43063 x G.Til-4**	**AT-115 x G.Til-3**
Days to 50% flowering	-2.77*	2.90**	-2.41*	0.15	-0.82	0.45	0.48	-3.82**	0.59	0.95
Days to maturity	1.67	2.67*	-0.17	-0.39	-1.06	1.00	1.83	3.28**	-0.39	-0.50
Plant height(cm)	7.51**	3.99	7.59**	0.97	9.53**	-15.66**	2.42	-7.05*	-4.69	-5.25
Height to first capsule (cm)	6.88**	1.71	5.68**	-1.38	4.56**	-5.34**	5.48**	-3.01	-5.94**	-7.61**
Number of branches per plant	-0.60**	-0.15	-0.51**	0.09	0.29*	0.07	-0.22	-0.36**	0.15	0.09
Number of internodes per plant	1.15	0.71	2.36**	2.85**	0.64	2.02*	3.47**	-0.40	2.00*	-4.71**
Length of capsule (cm)	-0.13**	0.12**	0.02	0.26**	-0.01	0.01	-0.03	-0.15**	-0.25**	0.08*
Width of capsule (cm)	-0.07**	0.02	0.02	0.04**	0.09**	-0.13**	-0.06**	-0.01	0.02	-0.05**
Number of capsules per plant	16.77**	1.73	6.21**	2.50	3.84	-2.10	-5.12*	9.01**	3.90	0.90
Number of capsules per leaf axil	0.12**	-0.41**	-0.40**	-0.35**	-0.01	-0.16**	-0.09	-0.19**	-0.35**	-0.39**
Number of seeds per capsule	1.84	-1.25	3.43	2.80	3.11	2.41	-0.65	-5.13**	-6.95**	-2.53
1000-seed weight (g)	-0.01	0.14**	0.19**	0.25**	0.43**	0.08*	-0.23**	0.13**	0.45**	0.13**
Oil content (%)	-0.60	-0.20	-0.63	-0.92	-0.83	-0.53	-0.61	-1.17	0.24	-0.71
Protein content (%)	-2.21**	-0.15	1.58**	-1.30*	0.32	-0.94	3.13**	2.66**	1.31*	0.69
Seed yield per plant (g)	3.90**	3.81**	2.44**	2.23**	1.66*	1.62*	1.51	0.30	1.00	0.96

*, ** Significant at 5% and 1% levels, respectively