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Diallel crossing for assessment of yield and its components in sesame (*Sesamum indicum* L.)

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Abstract

The experiment was conducted at the AICRP, JNKVV, College of Agriculture Tikamgarh, Madhya Pradesh in kharif 2015-16. The crosses were attempted between parents in Diallel mating design (without reciprocal). The genetic variance of combining ability was separated into general (GCA) and specific (SCA) combining ability variance components. The results indicated significant differences among the parents for general combining ability (gca) and crosses for specific combining ability (sca) for all the characters studied except for capsule length (cm) in $F_{1's}$. While parent v/s crosses for all the characters had adequate genetic variability. However, the sca component of variance was predominant indicating the predominance of non additive gene effects for the traits studied. Among the parents ES-230 and SI-1147 were good general combiners for seed yield per plant (g) and its attributing traits. Estimates of gca effects in parents and $F_{2's}$ indicated that ES-230 and SI-775 were good general combiner for seed yield per plant (g) and its attributing traits. The estimates of specific combining ability revealed that the crosses ES-230 x NIC-8401, IS-1162 x NIC-8401, IS-1162 x MT-75, SI-1147 x SI-775, SI775 x DS-10 and SI-775 x MT-75 were the best specific combiner for seed yield per plant. The $F_{1's}$ hybrids showing high sca and parents having good gca will be included into sesame improvement breeding programme for further improvement of seed yield in sesame.

Keywords: Sesame, Till, Combining ability, Exotic genotypes, Gene effects, Additive, Dominance

Introduction

Sesame (*Sesamum indicum* L.) belongs to the Pedaliaceae family which contains over 30 species but with *Sesamum indicum* as the only cultivated species with chromosomal number (2n=26). It is normally called 'Till' in India and it is a traditional and important oilseed crop in India. Sesame seed is a rich source of oil (50%), protein (25%), and minerals; contains about 47% oleic acid and 39% linolenic acid (Brar and Ahuja, 1979) [3]. Although sesame is widely used as oriental food for its distinctive quality due to the presence of natural antioxidants such as Sesamin and sesamol. Sesame growing area is shrinking due to several reasons. Ironically, the demand for sesame seed is increasing year after year. Globally, it is cultivated in an area about 6.65 million ha with production of 4.10 million tons. In India, it occupies an area of 1.67 million ha with production of 0.68 million tons. The productivity of sesame is very low (405 kg/ha) in India compared to world average (617 kg/ha) (FAOSTAT 2014). This disparity in yields is caused by various constraints including lack of improved varieties.

Successful breeding programme depends on the variability available among the different genotypes and in-depth understanding of the underlying gene action and genetic architecture of traits related to yield. Selection of parents based on their performance *per se* alone may not always be a sound procedure, since phenotypically superior genotypes may yield inferior hybrids and/or poor recombinants in the subsequent segregating generations (Banerjee and Kole, 2009) [4]. It is very important to identify parents with high GCA value for the trait to be improved (Banerjee and Kole, 2009) [4]. Griffing (1956) [7] provides an efficient estimation of combining ability and the nature of gene action involved. General combining ability is largely due to additive genetic effects and additive x additive epistasis, while specific combining ability is largely a function of non-additive dominance and other types of epistasis.

Knowledge of the nature of the combining ability effects and their resulting variances has a paramount significance in deciding on the selection procedure for exploiting either heterosis or obtaining new recombinants of desirable types in sesame (Solanki and Gupta, 2003) [15]. Combining ability is helpful to identify the desirable to identify the desirable parents for producing better recombinants (Muhammad and Sedeck (2015) [10]. The ability of parents to combine will depend on complex interaction among genes, which cannot be predicted from yield performance and adaptability of the parents (Allard 1960) [2].

The objectives of the present study were to estimate general and specific combining ability that would help plant breeder to have directional breeding approach for sesame improvement.

Materials and Methods

Eight elite genotype of sesame (viz, ES-230, IS-1162,SI-1147,SI-775,NIC-8401,NIC-16220,DS-10 and MT-75) were selected on the basis of their diversity. The crosses were attempted between parents in Diallel mating design (without reciprocal). The parents, $F_{1'S}$ and $F_{2'S}$ alongwith one standard check were evaluated in RBD with three replications. The study was conducted at AICRP, JNKVV, College of Agriculture Tikamgarh, Madhya Pradesh. Each F_1 plot consisted of a 6 m long single row while F_2 and checks were planted in four rows plot of 6m length with row to row and plant to plant distance of 30 cm and 10 cm, respectively. Fifteen competitive plants in parents and $F_{1'S}$ and 25 plants in $F_{2'S}$ and check were selected randomly for recording observation on eight characters. The observation on days to 50% flowering and days to maturity were recorded on whole plot basis. The analysis of variance was analyzed as per the standard method described by Panse and Sukhatme (1985). The Combining ability analysis was done as per the Griffing (1956) [7] method II and Model I. The estimates of GCA effect for the parents and the SCA effects for the crosses were calculated according to Singh and Chaudhary (1985) [17].

The model followed was:

$$Y_{ij} = \mu + g_i + g_j + s_{ij} + \frac{1}{bc}\sum_k\sum_l \varepsilon_{ijkl} \quad i,j=1,\ldots p,$$

Where

Y_{ij} is the observation of cross (x_{ij}), μ is the population mean, g_i and g_j are the general combining ability effect for the i^{th} and j^{th} parents, S_{ij} is the specific combining ability effect of the cross between the i^{th} and j^{th} parents such that $S_{ij} = S_{ji}$ and ε_{ijkl} is the experimental error due to environmental effect associated with the $ijkl^{th}$.

The variance component was calculated using the formula: $\sigma^2_g=(MS_{gca}-MS_{error})/(p-2)$; $\sigma^2_s=(MS_{sca}-MS_{errror})/1$

where:

MS_{gca}= variance due to GCA; MS_{sca}= variance due to SCA; MS_{error}= Error variance

Gene action

Since the parents used in the crosses were considered fixed, coefficient of genetic determination were used to estimate total genetic variability, broad sense and narrow sense coefficient of genetic determination (CGD) by the formula below:

Baker's ratio (Baker, 1978) = $(2\ \sigma^2_{gca})/\ (2\ \sigma^2_{gca} + \sigma^2_{sca})$

$CGD_{BS}= (2\ \sigma^2_{gca} + \sigma^2_{sca})/\ (2\ \sigma^2_{gca} + \sigma^2_{sca} + \sigma^2_e$

$CGD_{NS}= (2\ \sigma^2_{gca})/\ (2\ \sigma^2_{gca} + \sigma^2_{sca} + \sigma^2_e)$

Results and Discussion

The analysis of variance showed highly significant difference among parents, $F_{1's}$ and $F_{2's}$ for all the characters except for capsule length (cm) in $F_{1's.}$ While parent v/s crosses for all the characters had adequate genetic variability. This indicated that both additive and non-additive gene action played a role in determining various characters in sesame. Thus, the importance of these two components of genetic variance cannot be underestimated for the improvement of sesame. This suggests that parents selected were quite variable and adequate amount of variability existed among the hybrids for most of the traits studied.

Analysis of variance for combining ability revealed that the variance due to gca and sca were highly significant for all the character studied except capsule length (cm) in $F_{1's.}$ This indicates presence of adequate amount of variation in parents and crosses. Also, both kinds of gene effects were important in controlling the inheritance of all the characters studied. The ratio of sca/gca was greater than one for all the characters thereby indicating the preponderance of non additive variance in expression of these traits. The preponderance of non additive variance for yield and yield contributing characters in sesame. Significant results of GCA suggest the role of additive genetic effects in the inheritance of these characters. Raja Ravindran and Amirtha Deva Raghinam (1996) [14] reported predominance of additive gene effects in traits like branches per plant, days to 50%flowering, 1000 seed weight and height to first capsule. Early flowering could be a desirable selection criterion if the reproductive period was long enough to increase productivity or if the shorter time to flowering resulted in a concomitant decrease in time to maturity without decreasing the yield to a significant level or if it helps escape the terminal drought.

The general combining ability estimates revealed that among the parents ES-230 and SI-1147 were good general combiners for seed yield per plant (g) and its attributing traits. Estimates of gca effects in parents and $F_{2's}$ indicated that ES-230 and SI-775 were good general combiner for seed yield per plant (g) and its attributing traits. Thirugnana *et al* (2006) [18] recorded higher SCA variance than GCA variance for number of branches, number of capsules, number of seeds per capsule, 1000 seed weight and seed yield under normal conditions compared to analysis under floods. They also reported that the magnitude of GCA variance was higher than that of SCA variance for days to 50 per cent flowering and plant height under normal conditions indicating the predominance of additive and additive x additive type of gene action. The SCA is considered to be the best criterion for selection of superior hybrids (Aladji-Abatchoua *et al* 2014) [1]. Whereas, parent SI-1162,SI-1147 and SI-775 exhibited good gca for number of capsules per plant in $F_{1's}$ and $F_{2's.}$ (Table 1-2). In view of the above, breeders may utilize the good general combiner in specific breeding programme for the improvement of seed yield per plant (g) and number of capsules per plant in sesame. ES-230 and SI-775 can be utilized extensively in the hybridization programme to accelerate the pace of genetic improvement of seed yield per plant in sesame. Goyal, S.N. and S. Kumar. 1988 in relation to general and specific combining ability in sesame. To synthesize a dynamic population with most of the favorable genes accumulated, its will be necessary to make use of these two parents, which are good general combiner for different traits. Apart from conventional breeding methods relying upon additive or additive x additive type of gene action, population improvement appears to be a good alternative.

The estimates of specific combining ability revealed that the crosses ES-230 x NIC-8401,IS-1162 x NIC-8401,IS-1162 x MT-75,SI-1147 x SI-775, SI775 x DS-10 and SI-775 x MT-75 were the best specific combiner for seed yield per plant. Specific combing ability effects of $F_{2's}$ revealed that eleven best $F_{2's}$ which exhibited highest magnitude of positive sca effects for seed yield per plant were ES-230 x NIC-8401, ES-230 x DS-10, IS-1162 x NIC-8401, IS-1162 x MT-75, SI-1147 x SI-775, SI147 x NIC-8401, SI-775 x NIC-16220, SI-775 x DS-10, SI775 x MT-75 NIC-16220 x DS-10 and DS-10 x MT-75. Seven $F_{2's}$ for number of primary branch per plant, sixteen for number of capsule, length for capsule length fifteen for number of grain per capsule and nine for days to 50% flowering showed significant sca effects. Praveenkumar *et al*. (2012) [13] revealed that additive gene action was predominant for plant height, number of secondary branches per plant, number of capsules per plant, 1000 seed weight and number of seeds per capsule. SCA showed significant effect for only capsules on branches and yield per plant thus indicating major action of non-additive gene action for these traits. Murty (1975) [11] reported that general combining ability variance was larger than specific combining ability variance for all the characters except of oil, indicating the predominance of additive gene action. Saravanan and Nadarajan (2003) [16] reported that the GCA variance was greater than the SCA variance for eight traits including days to 50% flowering, plant height and number of primary branches per plant incidence indicating preponderance of additive gene action for those traits while the SCA variance was greater than gca variance for number of capsules per plant, number of seeds per capsule, single plant yield indicating predominance of dominant gene action for these traits. Mothilal and Manoharan (2005) [9, 12] non-additive to be involved in the expression of characters viz. number of capsules on branches, 1000 seed weight and seed yield per plant. They observed overdominance for number of branches, number of seeds per capsule and seed yield per plant. Thirugnana *et al* (2006) [18] reported the magnitude of GCA variance was higher than that of SCA variance for days to 50 per cent flowering and plant height under normal conditions. Praveenkumar *et al*. (2012) [13] also recorded that the proportion of GCA variances was high compared to SCA. Aladji *et al*. (2014) [1], showed that the values of GCA/SCA ratios had SCA variance higher than GCA variance component except for number of seeds per capsule and days to maturity). They recorded that the SCA variance was more than GCA variance indicating the role of non-additive gene action for the inheritance of date to flowering, duration of maturation, plant height, number of branches, number of capsules per plant, capsule length.

It is therefore recommended that new materials should be used in future breeding programme for recombining the desirable traits in the elite genotypes for producing desirable transgressive segregants in advance generations. The crosses having high specific combining ability effects will be useful if the parents involved are also good general combiner especially in the offen cross pollinated crops.

Table 1: GCA and SCA effects for different characters in Parents and hybrids of sesame

Genotype	Plant height (cm)	Number of primary branches per plant	Number of capsules per plant	Capsule length (cm)	Number of grains per capsule	Days to 50% flowering	Days to maturity	Seed yield per plant
P1 (ES-230)	1.15**	-0.55**	-7.55**	0.04	-0.78*	1.70**	1.90**	0.89**
P2(IS-1162)	-2.18**	0.13*	5.58**	-0.06	-1.28**	0.50*	0.18	0.14
P3(SI-1147)	-0.30	0.33**	4.88**	0.07	0.12	-0.05	-1.43**	0.71**
P4(SI-775)	-2.35**	0.05	6.38**	0.09	-1.16**	0.98**	0.88**	0.14
P5 (NIC-8401)	1.05**	-0.18	-3.55**	-0.03	2.22**	0.00	1.85**	-0.41*
P6 (NIC-16220)	2.05**	-0.48**	-1.75**	0.02	0.94**	-0.90*	-2.03**	-0.26
P7(DS-10)	1.95**	0.375**	-1.70**	-0.06	0.02	-0.98*	0.45*	-0.14
P8(MT-75)	0.73**	0.33**	-2.28**	-0.08	-0.08	-1.25**	-1.8**	-1.06**
P1 x P2	-3.67**	0.90**	7.84**	0.31*	4.50**	-4.06**	-9.99**	-1.19**
P1 x P3	14.96**	0.20	0.79*	-0.31*	1.35**	0.24	0.86**	-2.41**
P1 x P4	5.7**6	-0.53**	-20.21**	-0.09	1.37**	0.71**	7.56**	-0.50*
P1 x P5	5.71**	-0.55**	-8.04**	0.04	0.75*	0.94**	-2.92**	18.55**
P1 x P6	-1.89**	0.75**	6.16**	0.49**	0.28	2.59**	5.71**	-0.48*
P1 x P7	-0.79	-0.10	2.86**	0.06	-3.30**	-0.34	7.23**	1.29**
P1 x P8	-7.57**	-0.30**	3.67**	-0.41**	-2.45**	-2.56**	-7.02**	-0.68**
P2 x P3	4.28**	0.77**	10.16**	0.29	-2.15**	2.94**	-3.92**	-1.43**
P2 x P4	0.08	0.05	3.91**	0.26	-10.63**	-1.84**	-6.22**	-0.04
P2 x P5	7.03**	-0.48**	-7.16**	-0.36	0.00	-0.86**	4.56**	5.33**
P2 x P6	-2.57**	-0.18	5.54**	0.34*	-2.48**	0.04	2.68**	-0.29
P2 x P7	-0.72	-0.03	11.74**	-0.09	1.20**	0.86**	2.71**	-5.59**
P2 x P8	2.26**	0.02	8.56**	-0.06	1.55**	4.14**	7.21**	3.05**
P3 x P4	6.21**	0.60**	-4.39**	0.14	-0.03	-1.04**	1.88**	1.44**
P3 x P5	6.16**	2.82**	13.79**	-0.24	-2.15**	-0.81**	2.91**	0.05
P3 x P6	2.94**	-1.13**	-6.76**	-0.04	2.13**	0.09	1.18**	-1.40**
P3 x P7	-5.09**	-0.73**	1.69**	0.29	-2.20**	1.41**	2.81**	-1.30**
P3 x P8	-8.87**	-0.68**	2.51**	0.06	0.65*	-2.81**	-6.19**	-0.63**
P4 x P5	-0.79***	0.10	12.29**	0.49**	2.38**	2.41**	3.11**	-6.12**
P4 x P6	-6.14**	0.65**	-3.51**	-0.31*	3.40**	0.81**	-1.52**	0.66*
P4 x P7	0.96*	-1.45**	-8.06**	-0.24	2.58**	-0.11	-3.24**	2.40**
P4 x P8	1.93**	-0.65**	-12.24**	-0.46*	-2.08**	3.16**	2.26**	2.30**
P5 x P6	-4.94**	-0.13*	-13.59**	-0.19	-1.23**	3.79**	1.51**	-1.92**
P5 x P7	-6.09**	-1.23**	-14.89**	-0.11	-2.55**	-2.39**	-2.48**	-5.16**
P5 x P8	1.13**	-0.68**	-11.31**	-0.34*	0.80**	-2.36**	0.03	-1.45**
P6 x P7	-2.44**	-0.43**	-1.44**	0.09	0.46*	-1.99**	-8.84**	0.74
P6 x P8	1.03**	0.62**	8.89	0.11	-0.68**	-1.71**	-5.09**	0.65
P7 x P8	11.38**	2.52**	15.09	0.19	1.50**	0.86**	-7.07**	0.61

*, ** significant at 5 and 1 percent respectively

Table 2: GCA and SCA effects for different characters in Parents and $F_{2,}$s of sesame

Genotype	Plant height (cm)	Number of primary branches per plant	Number of capsules per plant	Capsule length (cm)	Number of grains per capsule	Days to 50% flowering	Days to maturity	Seed yield per plant (g)
P1 (ES-230)	0.95**	-1.31**	-2.08**	3.25**	-0.06	0.45*	0.23	1.35**
P2(IS-1162)	-1.08**	1.13**	3.25**	-1.05**	-2.12**	0.43*	0.32	0.09
P3(SI-1147)	-1.36**	2.33**	4.26**	0.05	2.13**	-0.08	-1.89**	0.12
P4(SI-775)	-1.05**	1.09**	4.32**	0.15	-2.15**	0.45*	0.78**	0.89**
P5 (NIC-8401)	2.06**	-2.16**	-2.13**	-1.02**	1.02**	0.03	1.23**	-0.56**
P6 (NIC-16220)	3.05**	-6.08**	-1.65**	1.06**	0.62*	-0.65*	-2.13**	-1.36**
P7(DS-10)	2.05**	1.56**	-0.98**	-1.02**	0.08	-0.65*	0.36	-0.26
P8(MT-75)	1.73**	1..39**	-1.45**	-1.02**	-1.07**	-1.09**	-1.12**	-1.76**
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P1 x P2	-2.68**	7.98**	10.67**	3.09**	2.56**	-2.36**	-7.89**	-2.08**
P1 x P3	11.36**	8.27**	1.39**	-0.01	0.89*	0.36	2.36**	-1.08**
P1 x P4	6.36**	-7.56**	-13.01**	-0.05	3.27**	0.32	5.32**	-1.35**
P1 x P5	4.51**	-3.54**	-5.05**	0.05	1.05**	0.45*	-3.32**	12.23**
P1 x P6	-2.82**	1.05**	4.12**	0.0 9	1.25**	1.23**	3.65**	-1.23**
P1 x P7	-1.76**	-1.16**	5.89**	0.05	-2.32**	-1.32**	5.13**	0.89**
P1 x P8	-3.07**	-1.35**	4.07**	-0.05	-1.12**	-1.06**	-5.03**	-1.61**
P2 x P3	6.08**	0.45	15.17**	0.08	-1.01**	1.95**	-5.95**	-0.23
P2 x P4	2.09**	0.09	6.05**	0.25	-9.53**	-0.89*	-5.29**	-1.24**
P2 x P5	8.03**	-0.23	-4.26**	-1.46**	0.56*	-1.01**	6.42**	2.56**
P2 x P6	-4.32**	-0.10	6.52**	3.24**	-1.22**	0.08	1.65**	-1.30**
P2 x P7	-1.43**	-0.93**	15.08**	-0.89*	0.98*	0.12	4.76**	-8.23**
P2 x P8	1.06**	0.04	5.58**	-1.02**	2.54**	5.12*	3.56**	6.12**
P3 x P4	7.01**	0.66*	-5.33**	2.12**	-1.09**	-2.05**	5.45**	2.45**
P3 x P5	8.13**	2.50**	12.75**	-1.32**	-1.05**	-0.21	1.23**	1.08**
P3 x P6	3.04**	-1.08**	-4.06**	-2.02**	3.18**	0.48*	0.15	-2.44**
P3 x P7	-4.09**	-0.65*	4.69**	2.21**	-3.28**	1.56**	1.09**	-2.35**
P3 x P8	-7.07**	-0.45*	3.41**	1.08**	0.39	-1.23**	-1.08**	-2.23**
P4 x P5	-1.09**	0.09	14.08**	2.42**	4.39**	3.53**	2.01**	-2.08**
P4 x P6	-5.12**	0.42*	-2.58**	-2.32**	4.47**	0.31	-0.89**	2.35**
P4 x P7	2.35**	-1.36**	-7.07**	-1.04**	1.49**	-0.41*	-2.09**	1.45**
P4 x P8	2.12**	-0.23	-15.22**	-1.21**	-1.09**	2.45**	1.09**	1.09**
P5 x P6	-3.57**	-0.10	-10.29**	-1.13**	-3.12**	5.45**	8.06**	-2.32**
P5 x P7	-7.08**	-1.08**	-10.71**	-1.05**	-1.56**	-3.24**	-1.23**	-2.23**
P5 x P8	3.14**	-0.23	-9.12**	-2.34**	2.65**	-1.46**	2.08**	-3.08**
P6 x P7	-3.54**	-0.36*	-2.56**	2.01**	2.35**	-3.75**	-2.82**	3.23**
P6 x P8	5.03**	0.42*	5.89**	2.11**	-1.08**	-3.23**	-3.14**	2.56**
P7 x P8	13.21**	1.12**	13.04**	3.11**	0.89**	1.02**	-5.06**	-2.65**

*, ** significant at 5 and 1 percent respectively

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