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Combining Ability Studies through Diallele Analysis for Yield and its Component Traits in Sesame (*Sesamum indicum L.*)

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***Abstract* — Diallel analysis, involving eight parents without reciprocals was carried out in F_2 generation of sesame for twelve important yield components. The analysis of variance indicated that though additive and non additive gene effects are important for these characters, there was specific role of additive gene control for plant height and number of capsules on main stem, for the remaining characters the non additive gene control was recorded. The GCA effects indicated that the parent Co-1 was good general combiner for seed yield per plant, plant height, number of capsules per plant, number of capsules on main stem and number of capsules on primary branches, ACV2 for early flowering and DT 9-10-2-25 for number of secondary and primary branches. Among the 28 hybrids studied the crosses Co-1 x AVT26, Co-1 x DT 9-10-2-25, TNAU 20 x AVT 26, Co-1 x TMV6 and TNAU 20 x TMV26 were the potential as they had high significant SCA effects with desirable per se mean for 3 to 4 yield components characters. Desirable transgressive segregants are expected from these crosses.**

***Keywords* — Combining Ability, Diallel Analysis, F_2 Generation and Sesame.**

I. Introduction

Globally, sesame is cultivated in an area about 6.65 million ha with a 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) [1]. Sesame belongs to the Pedaliaceae family with *Sesamum indicum* as the cultivated species with chromosomal number (2n = 26). In India it is normally called as 'Till' and it is an important traditional oilseed crop and the seed is a rich source of oil (50%), protein (25%), and minerals; it contains about 47% oleic acid and 39% linolenic acid [2]. 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 [3]. It is very important to identify parents with high GCA value for the trait to be improved [3]. The combining ability analysis developed by [4] is one of the powerful biometrical techniques which aid the breeder in making right choice of the parents and in the identification of superior cross combinations which would be used for developing high yielding hybrids and or varieties. 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. Therefore, the present investigation involving 28 F_2 populations of sesame resulting from diallel cross of eight parents was undertaken.

II. Material and Methods

Eight Sesame genotypes viz., Co-1, TNAU 20, CIANNO, TMV6, VRI-1, ACV2, DT 9-10-2-25 and AVT26 were crossed in a diallel mating design without reciprocals. Twenty eight F_2 progenies along with eight parents were sown in a randomized block design with three replications at S.V. Agricultural College Farm, Tirupati during *Rabi.* Each genotype was sown in two plot of 6.0m length. A spacing of 40 and 15 cm followed between and within the rows, respectively. All the recommended package of practices were followed. Observations were recorded on randomly selected thirty plants in each treatment in each replication. Mean values were used for combining ability analysis as suggested by [4] Model-I and Method-II. The observation on days to 50% flowering and days to maturity were recorded on whole plot basis. The estimates of GCA effect for the parents and the SCA effects for the crosses were calculated according to [5]. The model followed was: $Y_{ij} = \mu + g_i + g_j + s_{ij} + bc \sum 1\, k \sum 1\, \varepsilon_{ijkl}$ i, j = 1,…p,

Where Yij is the observation of cross (xij), μ is the population mean, gi and gj are the general combining ability effect for the ith and j th parents, Sij is the specific combining ability effect of the cross between the ith and jth parents such that Sij = Sji and εijkl is the experimental error due to environmental effect associated with the ijklth. The variance component was calculated using the formula: $\sigma 2\ g = (MSgca-MSerror)/(p-2)$; $\sigma 2\ s = (MSsca-MSerrror)/1$ where: MSgca = variance due to GCA; MSsca = variance due to SCA; MSerror = 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 = 2 σ2 gca)/ (2 σ2 gca + σ2 sca)
CGDBS = (2 σ2 gca + σ2 sca)/(2 σ2 gca + σ2 sca + σ2 e
CGDNS = (2 σ2 gca)/ (2 σ2 gca + σ2 sca + σ2 e).

III. Results and Discussion

The analysis of variance revealed highly significant differences among the treatments for all the quantitative characters studied except for capsule length, indicating Considerable variation in the material. 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_2's. The mean sum of squares due to GCA and SCA were significant for all the characters except for capsule length. The magnitude of the mean squares due to GCA was more than that of SCA for all characters except for plant height and number of capsules on secondary branches. The GCA to SCA variance ratio indicates there is an additive gene control for remaining all other characters (Table 1).

The GCA effects and per se performance of the parents are presented in (Table 2). The results indicated that the parent Co-1 was the best general combiner for the characters plant height, number of capsules on main stem and number of capsules on primary branches, number of capsules per plant, number of seeds per capsule and seed yield per plant. For the characters number of primary branches, number of secondary branches and 1000-seed weight, the parent DT 9-10-2-25 was the best general combiner. Further the per se performance of this parent was also high for these characters. For the character days to 50% flowering the parent ACV2 was found to be best general combiner. Based on per se performance also it was the best parent for early flowering. 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.

For the character days to maturity the parent CIANNO, for capsule length TNAU 20 and for harvest index VRI-1 were found to be best general combiners. Involvement of these parents in hybridization programme for evolving desirable genotype is suggested. In general, it was observed that the high values of GCA effect were associated with high per se performance of the parents for the following characters plant height, number of primary branches, number of secondary branches, number of capsules on primary branches, number of capsules on Secondary branches, number of capsules per plant and harvest index. Therefore high per se mean will be the best criteria of identifying good general combiners. [6] 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 [7].

Among the SCA effects of 28 F_2 progenies, the five promising crosses showing high SCA effect along with their high per se are presented in (Table 3). The cross combination Co-1x AVT 26 has shown good SCA effects along with the highest per se performance in F_2 generation for number of capsules on main stem, number of primary branches, number of secondary branches, number of capsules on primary branches, number of capsules on Secondary branches, number of capsules per plant, seed yield per plant. This result was in harmony with studies of [8-12]. Further, the parents of this cross had good general combining ability for the above said characters. Hence, these characters in this cross combination Co-1xAVT26 are governed by additive gene action. So simple selection is effective in improving these characters in the subsequent generations.

The cross Co-1x DT 9-10-2-25 (H x H) had shown highest SCA effects and high per se mean for plant height. This result was in consonance with studies of [13-15]. The cross TNAUxTMV6 (LxL) involving low combiners had shown highest SCA effects and per se performance for characters 1000-seed weight and number of branches indicating the presence of non additive gene action. These results were in agreement with the reports of [16-17].

[18] 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. [19] 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. [20] 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. [21] 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 over dominance for number of branches, number of seeds per capsule and seed yield per plant. [6] 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. [18] Also recorded that the proportion of GCA variances was high compared to SCA. [7] 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.

The evaluation of parents and hybrids in F_2 generation indicated that there was a close association between per se performance and GCA effects of parents and SCA effects and per se performance of hybrids for most of the characters. Based on the results we can conclude that the parents Co-1, DT 9-10-2-25, TNAU 20 were identified as best general combiners and the crosses Co-1 x AVT 26, Co-1 x DT 9-10-2-25, TNAU x TMV6 were identified as best crosses based on high per se performance and SCA effects compared to the crosses. These crosses can be advanced to further generations by simple selection to realize desirable segregants.

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Table 1. Analysis of variance for combining ability in a 8x8 diallel of sesame

S. No	**Character**	**Mean sum of squares**					
		GCA(df = 7)	**SCA(df = 7)**	**Error(df = 70)**			
1	Days to 50% flowering	6.516**	1.727**	0.582	0.050	0.478	0.106
2	Days to maturity	57.920**	20.89**	0.440	0.038	0.362	0.105
3	Plant height(cm)	230.28**	344.22**	7.216	0.631	0.593	1.064
4	Number of primary branches per plant	2.014**	0.361**	0.052	0.0045	0.043	0.106
5	Number of secondary branches per plant	2.390**	0.955**	0.082	0.007	0.067	0.106
6	Number of capsules on main stem	44.711**	30.137**	2.508	0.219	0.207	1.057
7	Number of capsules on primary branches	243.840**	214.05**	12.17	1.064	10.000	0.106
8	Number of branches on secondary branches	12.350**	20.180**	2.710	0.237	2.231	0.106
9	Number of capsules per plant	529.330**	459.610**	33.330	2.916	27.400	0.106
10	Capsule length(cm)	0.056	0.039	0.004	0.001	0.004	0.100
11	Number of seeds per capsule	53.670**	30.450**	1.627	0.142	1.133	0.125
12	1000-seed weight	0.249**	0.138**	0.000	0.000	0.000	0.100
13	Seed yield per plant(g)	40.010**	31.150**	0.323	0.028	0.266	0.010
14	Harvest index (%)	116.860**	99.910**	3.610	0.316	2.969	0.106

Significant at P = 0.01 level

Table 2. Estimates of general combining ability effects and per se performance of parents in sesame

S No	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches	Number of secondary branches	Number of capsules on main stem	Number of capsules on primary branches	Number of branches on secondary branches	Number of capsules per plant	Capsule length (cm)	Number of seeds per capsule	1000-seed weight (g)	Seed yield per plant(g)	Harvest index (%)
1	Co-1	1.57** (36.33)	4.34** (106.00)	11.10** (110.86)	0.26** (2.29)	-0.18** (2.29)	2.35** (21.80)	8.32** (56.77)	0.36 (6.98)	11.95** (88.88)	-0.02** (2.73)	4.46** (73.40)	0.12** (3.61)	4.13** (21.50)	-1.18** (56.33)
2	TNAU20	-0.27** (31.00)	0.11** (105.00)	0.53 (100.10)	0.13** (4.91)	-0.04** (3.12)	1.12** (26.09)	1.71** (48.20)	-0.33 (5.98)	1.18 (72.54)	0.09** (2.83)	-0.59** (66.93)	-0.10** (3.15)	-0.36** (13.83)	-2.85** (45.33)
3	CIANNO	-0.67** (33.00)	-3.98** (96.33)	-3.65** (96.68)	-0.92** (2.93)	-0.92** (2.93)	-0.36** (2.60)	-2.11** (23.13)	-5.55** (43.05)	-1.01** (12.49)	-8.44** (78.66)	-0.12** (2.18)	2.53** (88.53)	-0.236** (22.71)	-4.92** (56.00)
4	TMV6	-0.33** (31.00)	-1.39** (95.00)	-0.71 (96.25)	-0.05** (3.76)	-0.29** (2.21)	1.33** (25.75)	0.07 (48.85)	0.28 (10.70)	1.30 (85.31)	-0.05** (2.21)	-1.67** (69.94)	-0.06** (3.22)	-0.55** (18.38)	-0.78** (72.00)
5	VRI-1	-0.53** (35.00)	-0.46** (106.00)	-2.68** (106.07)	0.23** (5.80)	0.02** (2.51)	0.28 (29.42)	-3.12** (48.12)	-0.33 (9.48)	-2.92 (87.01)	-0.05** (2.47)	-2.08** (65.07)	-0.10** (3.42)	-0.92** (21.40)	5.15** (80.00)
6	ACV2	-1.03** (30.00)	-1.16** (100.38)	-2.37** (96.47)	-0.35** (4.05)	-0.38** (2.64)	0.06 (27.59)	-3.54** (36.51)	-1.68** (8.57)	-2.71 (72.65)	0.06** (2.91)	-1.45** (66.10)	0.01** (3.93)	-0.49** (19.30)	-0.35 (64.00)
7	DT 9-10-2-25	0.33** (34.00)	1.38** (108.00)	0.97 (59.24)	0.52** (5.78)	1.13** (8.70)	-4.13** (3.62)	-3.50** (20.50)	1.96** (20.31)	-8.47** (44.43)	0.08** (2.98)	0.11 (62.31)	0.20** (3.95)	-1.09** (10.84)	4.55** (60.00)
8	AVT26	-0.13* (34.33)	1.08 (107.33)	-3.71** (65.64)	0.18 (4.85)	0.09 (2.49)	1.09** (21.00)	5.76** (6.91)	0.75** (35.41)	8.12** (63.35)	0.01** (2.83)	-1.31** (69.52)	0.18** (4.24)	1.64** (20.51)	0.38 (59.67)
	SE±(gi)	0.051	0.03	0.63	0.00	0.01	0.22	1.26	0.23	2.91	0.00	0.14	0.00	0.01	0.32
	SE±(gi-gj)	0.11	0.09	1.44	0.01	0.01	0.50	2.43	0.54	6.60	0.09	0.32	0.0	0.06	0.72

- And ** indicate significant at 5 and 1 percent level, respectively.
- Figures in paranthesis indicate mean performance.

Table 3. Estimates of specific combining ability effects and per se performance of promising crosses in F_2 population

S No	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches	Number of secondary branches	Number of capsules on main stem	Number of capsules on primary branches	Number of branches on secondary branches	Number of capsules per plant	Capsule length (cm)	Number of seeds per capsule	1000-seed weight (g)	Seed yield per plant (g)	Harvest index (%)
1	Co-1 x AVT26	1.23* (35.00)	- 0.74* (103.67)	33.35** (146.36)	- 0.42** (4.95)	0.53** (3.76)	15.88** (43.55)	38.03** (102.19	12.97** (26.26)	65.71** (173.00)	0.11** (2.92)	-3.39** (66.93)	0.51** (4.25)	14.67** (39.86)	15.49** (78.67)
2	Co-1 x DT 9-10-2-25	0.10 (34.33)	1.96** (106.67)	43.73** (160.99)	0.48** (6.19)	-0.88** (3.40)	5.96** (28.42)	9.33 (64.22)	2.29 (16.80)	19.75 (109.45)	0.01* (2.89)	7.83** (79.59)	0.35** (4.11)	9.28** (31.75)	15.99** (83.33)
3	Co-1 x TMV6	-1.57** (32.00)	-2.27** (99.67)	1.64** (117.22)	0.11** (3.25)	1.28** (4.13)	-0.99 (26.92)	7.34 (65.68)	6.45** (19.28)	12.41 (111.88)	0.07** (2.82)	-2.09 (67.86)	-0.08** (3.42)	3.24** (26.24)	-12.35** (49.67)
4	TNAU x CIANNO	1.27** (32.67)	4.13** (99.33)	9.51** (111.56)	0.62** (4.76)	0.66** (3.59)	5.61** (28.85)	18.21 (64.44)	6.79** (17.65)	31.98 (110.94)	0.01** (2.89)	0.09 (69.21)	0.06** (3.15)	8.03** (24.73)	-2.88 (53.33)
5	TNAU x TMV6	1.27** (33.00)	0.63 (98.33)	2.128* (107.13)	1.14** (6.15)	0.34** (3.33)	0.98	-3.13	1.78	1.46	0.06**	-0.53	1.12**	7.69**	12.99**
	SE_Iig	0.47	0.36	0.59	0.04	0.67	2.06	10.00	2.23	27.40	0.00	1.33	0.00	0.26	2.96

- And ** indicate significant at 5 and 1 percent level, respectively.
- Figures in paranthesis indicate mean performance.