Studies on heterosis in sesame (Sesamum indicum L.)

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Abstract

The experiment was laid out in randomized block design with three replications at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar. The present investigation on sesame comprised of a 6 x 6 diallel set their 30 crosses. The observations were recorded on days to flowering and days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, capsule length (cm), seed yield per plant (g), 1000 seed weight (g), harvest index (%) and oil content (%) on randomly selected five competitive individual plants. The data were subjected to estimation of heterosis. Analysis of variance revealed significant differences among the genotypes, hybrids and parents for all the traits except 1000 seed weight for parent studied. Several crosses exhibited significantly desirable heterobeltiosis and economic heterosis for seed yield per plant and other characters. On the basis heterosis it may be concluded that VRI 2 × GOWRI, TMV 6 × TMV 7 and GOWRI × VRI 2 can be rated as best hybrids and the hybrids TMV 6 × VRI 2 and TMV 5 × CO 1 can be rated as better hybrids based on the magnitude of heterosis.

Keywords: sesame, diallel, heterosis

Introduction

Sesame is an important source of high quality edible oil. The seeds contains 50-60 per cent oil. Sesame oil contains vitamin E and several important antioxidant constituents such as sesamol, sesamin and sesamolin, which are believed to promote the integrity of body tissues in the presence of oxidizing compounds. Sesame oil compounds have also multiple physiological functions, such as estrogenic activity, providing anti-inflammatory functions, decreasing blood lipids and arachidonic acid levels. In addition, sesame possesses some agricultural advantagessuch as the ability to grow well under tropical and subtropical climates with soil moisture without rainfall or irrigation, and grow as mixed stands with diverse crops. It is grown in tropical to the temperate zones from about 40°N latitude to 40°S latitude. However, it thrives best on well-drained soil with a moderate fertility and a pH between 5.5 and 7.0 (Aladji *et al.*, 2014).

Moreover similar to other crops, in sesame, the yield is a complex character and the lower productivity could be attributed to the interplay of different yield related, growth and morphological characters. In spite of rapid increase in the area under the crop, the productivity has declined over the years. The major constraints identified for lower productivity may be due to instability of yield, lack of wider adaptability, lack of availability of quality seeds and also due to genetic make up of the crop, indeterminate growth, abscission of floral parts, poor seed setting and cultivation under rainfed conditions.

Sesame is generally considered to be a self pollinated crop in spite of varying degree of cross pollination reported in this crop. Improvement of this crop so far has been mostly confined single plant selection. Heterosis plays a predominant role in accelerating the agricultural production and heterosis breeding opens up tremendous potential among the crops for quantitative improvement. A considerable amount of heterosis has been reported in this crop (Dixit, 1978; Yermanos and Kotecha, 1978). To explain heterosis, knowledge onchoosing appropriate parents of good genetic potential is very essential.

Materials and methods

The present investigation on the was conducted at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2013 – 2015.The six genotypes viz., TMV 5, TMV 6, CO 1, VRI 2, TMV 7 and GOWRI were crossed in a diallel mating design (including both direct and reciprocal crosses). The results 30 hybrids along with six selfed parents formed an effective complete diallel set for the present study. Thirty hybrids along with their six selfed parents were sown on June – July, 2014 in a Randomized Block Design, replicated thrice. Each combination was sown in a single row of plot size of 3 m length. Recommended agronomic practices and need based plant protection measures were judiciously followed. The observations were recorded on Days to 50 per cent flowering, Plant height at maturity, Number of branches per plant, Number of capsules per plant, Number of seeds per capsule, 1000 seed weight and Seed yield per plant. The heterosis for individual crosses was calculated using the following formula.

Relative heterosis

Increase the mean F_1 performance over the mean performance of the mid parent.

$$\text{Relative heterosis} = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

$$\text{Where} = \overline{MP} = \frac{P_1 + P_2}{2}$$

Heterobeltiosis

Increase of mean F_1 performance over that of the mean performance of better parent

$$\text{Heterosis} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

Standard heterosis

Increase of mean F_1 performance over that of the mean performance of standard parent

$$\text{Standard heterosis} = \frac{\overline{F_1} - \overline{SV}}{\overline{SV}} \times 100$$

Standard variety = CO 1

Test of significance

The significance of heterosis was tested using the formula as suggested by Wynne *et al.* (1970).

$$\text{'t' over } (d_i) = \frac{\overline{F_1} - \overline{MP}}{(3\sigma^2 e / 2r)^{1/2}}$$

$$\text{'t' over } (d_{ii}) = \frac{\overline{F_1} - \overline{BP}}{(2\sigma^2 e / r)^{1/2}}$$

$$\text{'t' over } (d_{iii}) = \frac{\overline{F_1} - \overline{SV}}{(2\sigma^2 e / r)^{1/2}}$$

Where,

'$\sigma^2 e$' = Error mean square obtained from ANOVA.

r = Number of replications

Results and Discussion

Analysis of variance was performed to test the difference among parents and hybrids for all the seven characters studied and are presented in Table 1. The 'f' values were highly significant for all the seven characters studied except for 1000 seed weight. . This indicated that sufficient amount of genetic variability was present in the experimental material for all the characters under study.

One of the important criterion for evaluating the hybrids is the expression of the phenomenon of hybrid vigour. Generally the hybrid vigour could be expressed in the cross whose parents are geographically and genetically diverse. A good hybrid should manifest high amount of heterosis for commercial exploitation. Relative heterosis is of limited importance because it is only the deviation of F_1 from mid parental value (Grakh and Chaudhary, 1985). Heterobeltiosis is a measure of hybrid vigour over the better parent. Swaminathan *et al.* (1972) and Bobby and Nadarajan (1994) stressed the need for computing standard heterosis for commercial exploitation of hybrid vigour. Hence, for the evaluation of hybrids, standard heterosis is to be given more importance rather than the other two.

For Days to 50 per cent flowering maximum, negative and significant relative heterosiswas recorded by GOWRI × CO 1 (-11.11 per cent) followed by GOWRI × TMV 5 (-10.66 per cent) and VRI 2 × TMV 6 (-9.20 per cent). Maximum positive and significant relative heterosis was recorded by GOWRI × VRI 2 (13.66 per cent) followed by CO 1 × VRI 2 (12.51 per cent) and CO 1 × TMV 6 (10.74 per cent) for plant height at maturity. The hybrid TMV 5 × TMV 7 (25.00 per cent) showed maximum significant positive relative heterosis followed by VRI 2 × TMV 5 (22.81 per cent) and TMV 6 × TMV 7 (20.69 per cent) for the character number of branches per plant. For number of capsules per plant the hybrid CO 1 × TMV 7 (16.36 per cent) showed maximumpositive significant relative heterosis followed by GOWRI × VRI 2(16.21 per cent) and CO 1 × TMV 5 (13.76 per cent). The number of seeds per capsule showed positive and significant relative heterosis and it was maximum in CO 1 × TMV 5 (36.72 per cent) followedby TMV 7 × TMV 6 and GOWRI × VRI 2 showed same value (25.93 per cent). The trait 1000 seed weight recorded maximum positive significant relative heterosis in CO 1 × TMV 5 (36.22 per cent) followed by VRI 2 × TMV 5 (34.36 per cent) and TMV 7 × TMV 5 (32.64 per cent). Relative heterosis was maximum positive and significant in the hybrid VRI 2 × TMV 5 (5.93 per cent) followed by GOWRI × CO 1 (5.11 per cent) for the trait seed yield per plant (Table 2).

Regarding heterobeltiosis, the trait days to 50 percent flowering maximum negative and significant heterobeltiosis was observedin GOWRI × CO 1 (-14.29 per cent) followed by GOWRI × TMV 5 (–11.73 per cent) and VRI 2 × TMV 6 (–11.38 per cent).Heterobeltiosis was maximum positive and significant inTMV 6 × CO 1 (10.65 per cent) followed byCO 1 × TMV 6 (6.57 per cent) andCO 1 × GOWRI (5.38 per cent) for the trait plant height at maturity.For number of branches per plant the hybrid TMV 5 × TMV 7 and TMV 6 × TMV 7 (16.67 per cent) showed maximum significant positive heterobeltiosis followed by

GOWRI × TMV 5 (14.29 per cent). The trait number of capsules per plant exhibited the hybrids GOWRI × VRI 2 (14.79 per cent) showed maximum positive significant heterobeltiosis followed by CO 1 × TMV 5 (11.71 per cent) and TMV 6 × TMV 7 (11.56 per cent). The number of seeds per capsule exhibited positive and significant heterobeltiosis and it was maximum in CO 1 × TMV 5 (31.58 per cent) followed by TMV 7 × TMV 6 (24.39 per cent) and GOWRI × VRI 2 (21.43 per cent). maximum positive significant heterobeltiosis was observed in VRI 2 × TMV 6 (27.59 per cent) followed by TMV 7 × TMV 5 (27.24 per cent) and CO 1 × TMV 5 (23.84 per cent) for the trait 1000 seed weight. For seed yield per plant Heterobeltiosis was maximum positive and significant in the hybrid CO 1 × TMV 5 (4.12 per cent) followed by VRI 2 × TMV 5 (2.88 per cent) (Table 2).

The hybrid VRI 2 × GOWRI possessed significant positive value for plant height at maturity, number of branches per plant and number of seeds per capsule. Maximum positive and significant standard heterosis was observed by the hybrid TMV 6 × TMV 7 for seed yield per plant. TMV 6 × VRI 2 was recorded positive significant heterosis for 1000 seed weight. GOWRI × VRI 2 recorded maximum negative and significant days to 50 per cent flowering. These hybrids have been identified as best hybrids from the productivity point of view further these high yielding hybrids may be tried under different environments to test their stability over locations and to confirm their superiority. These findings are in consonance with Thiyagu (2007), Jawahar *et al.* (2013), Vavdiya *et al.* (2013) and Parimala *et al.* (2013). The characters that contributed to vegetative growth such as plant height and number of branches per plant, maximum positive standard heterosis was observed in the hybrid TMV 6 × CO 1 which was in concurrence with the findings of Tripathi and Mishra (2005), Parimala *et al.* (2013) and Jawahar *et al.* (2013). Maximum standard heterosis for yield parameters were reported by Tripathi and Mishra (2005), Thiyagu *et al.* (2007), Mishra *et al.* (2008), Jawahar *et al.* (2013), Jadhav and Mohrir (2013), Vavdiya *et al.* (2013),Musibau *et al.* (2014) and Choudhari *et al.* (2014).

Grafius (1959) suggested that there could not be any one gene system for yield *per se* and that the yield was an end product of multiplicative interaction between yield components. Hence, from the foregoing discussion it may be concluded that VRI 2 × GOWRI, TMV 6 × TMV 7 and GOWRI × VRI 2 can be rated as best hybrids and the hybrids TMV 6 × VRI 2 and TMV 5 × CO 1 can be rated as better hybrids based on the magnitude of heterosis.

Table 1. ANOVA for yield and yield attributing characters in sesame

Source	df	MSS						
		Days to 50 per cent flowering (days)	Plant height at maturity (cm)	Number of branches per plant	Number of capsule per plant	Number of seeds per capsule	1000 seed weight (g)	Seed yield per plant (g)
Replication	2	0.95661	0.1944	0.4446	4.5278	1.1970	0.0038	0.0776
Genotype	35	18.4920 **	221.0277**	7.7143 **	155.2571**	151.6073 **	0.8234	2.4016**
Error	70	0.5441	0.5577	0.5397	5.1753	7.5035	0.0208	0.1307

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 2. Estimation of Relative heterosis, Heterobeltiosis and Standard heterosis for seed yield and yield contributing characters in sesame

S. No.	Hybrids	Heterosis	Days to 50 per cent flowering (per cent)		Plant height at maturity (per cent)		Number of branches per plant (per cent)		Number of capsules per plant (per cent)	
			Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal
1.	TMV 5 X TMV 6	RH	-6.38 **	-1.52 **	-6.08 **	0.77 **	7.41	-14.81	9.34	-4.33
		HB	-7.78 **	-2.99 **	-7.61 **	-1.56 **	3.57	-17.86	6.67	-6.67
		SH	-8.33 **	-3.57 **	-14.57 **	-8.98 **	-14.71 **	-32.35 **	8.11	-5.41
2.	TMV 5 X CO 1	RH	-5.45 **	-3.03 **	-9.11 **	-7.15 **	0.04	20.00	11.93 **	13.76 **
		HB	-7.14 **	-4.76 **	-13.90 **	1.68 **	-11.76	5.88	9.91 **	11.71 **
		SH	-7.14 **	-4.76 **	-13.90 **	1.68 **	-11.76	5.88*	9.91 **	11.71 **
3.	TMV 5 X VRI 2	RH	-0.93 *	-4.05 *	6.43	-8.35	12.82 **	22.81 **	-1.94	4.37
		HB	-1.85 **	-4.94 **	2.25 **	-9.66 **	3.23	12.90	-5.61	0.47
		SH	-5.36 **	-8.33 **	-8.54 **	-19.20 **	-5.88	12.90	-9.01 **	-3.15 **
4.	TMV 5 X TMV 7	RH	-0.61	0.61	-5.75	10.32	25.00 **	17.86 **	7.87 **	11.57 **
		HB	-2.38	-1.19	-13.44 **	-2.73 **	16.67 **	10.00 *	6.88 **	10.55 **
		SH	-2.38	-1.19	-7.47 *	3.99 **	2.94*	-2.94*	4.95**	8.56 **
5.	TMV 5 X GOWRI	RH	1.26 **	-10.06 **	-8.79 **	4.22 **	-27.87	31.15	-6.95	8.87
		HB	0.62 **	-11.73 **	-15.63 **	-0.57 **	-37.14 *	14.29 *	-9.35	6.07
		SH	-4.17 **	-14.88 **	-11.22 **	5.83 **	-35.29	17.65	-12.61 **	2.25 **
6.	TMV 6 X CO 1	RH	-6.27 **	-8.06 **	-7.15 **	10.74 **	9.68	-16.13	9.17	-4.25
		HB	-6.55 **	-8.33 **	10.65 **	6.57 **	0.05	-23.53 **	8.44	-4.89
		SH	-6.55 **	-8.33 **	-10.65 **	6.57 **	0.08	-23.53 *	9.91	-3.60
7.	TMV 6 X VRI 2	RH	-4.29 **	-9.20 **	7.05	-8.35	-8.47	11.86	0.71	4.37
		HB	-6.59 **	-11.38 **	1.23 **	-13.33 **	-12.90	6.45	-5.33	0.47
		SH	-7.14 **	-11.90 **	-6.40 **	-19.87 **	-20.59 *	-2.94 *	-4.05	-3.15 **

8.	TMV 6 X TMV 7	RH	-4.48 **	-4.48 **	-10.91 **	4.22 **	20.69 **	13.79 **	13.32 **	11.51 **
		HB	-4.76 **	-4.76 **	-16.92 **	-2.82 **	16.67 **	10.00 *	11.56 **	9.78 **
		SH	-4.76 **	-4.76 **	-11.19 **	3.89**	2.94*	-2.94*	13.06 **	11.26 **
9.	TMV 6 X GOWRI	RH	4.64	-0.93	-8.25	7.03	-26.98 **	-7.94 **	11.68	-13.55
		HB	1.20	-4.19	-13.82 **	0.54 **	-34.29 **	-17.14 **	6.22 **	-17.78 **
		SH	0.60	-4.76	-9.31 **	5.80 **	-32.35 **	-14.71 **	7.66 *	-16.67 *
10.	CO 1 X VRI 2	RH	-0.92	1.53	12.51 **	-6.74 **	-26.15 **	-20.00 **	-1.43 **	-18.10 **
		HB	-3.57 *	-1.19 *	2.61 **	-14.94 **	-29.41 **	-23.53 **	-6.76 **	-22.52 **
		SH	-3.57 *	-1.19 *	2.61**	-14.94 **	-29.41 **	-23.53 **	7.66 *	-16.67 *
11.	CO 1 X TMV 7	RH	-4.76	4.76	-0.78	-0.42	12.50	-18.75	16.36 *	-8.18 *
		HB	-4.76	4.76	-3.98 **	-3.64 **	5.88	-23.53 **	15.32	-9.01
		SH	-4.76	4.76	2.65 **	3.02 **	5.88**	-23.53	-6.76 **	-22.52 **
12.	CO 1 X GOWRI	RH	6.79 *	-11.11 *	-2.97 **	-3.26 **	-7.25 **	-24.64 **	-4.94	7.29
		HB	2.98 **	-14.29 **	-5.38 **	-5.67 **	-8.57 **	-25.71 **	-9.01	2.70
		SH	2.98 **	-14.29 **	-0.44	-0.74	5.88 **	-23.53 **	15.32	-9.01
13.	VRI 2 X TMV 7	RH	-0.31	1.53	-9.89	12.09	-21.31 **	-21.31 **	-12.02 **	-0.96 **
		HB	-2.98	-1.19	-20.21 **	-0.75 **	-22.58 **	-22.58 **	-16.06 **	-5.50 **
		SH	-2.98	-1.19	-14.71 **	6.10 **	-29.41 **	-29.41 **	-9.01	2.70
14.	VRI 2 X GOWRI	RH	-2.86 **	-7.30 **	-7.66 **	13.66 **	3.03	15.15	8.73 **	16.21 **
		HB	-3.77 **	-8.18 **	-17.67 **	1.34 **	-2.86	8.57	7.39 **	14.78 **
		SH	-8.93 **	-13.10 **	-13.37 **	6.63**	4.00*	11.76	-17.57 **	-7.21 **
15.	TMV 7 X GOWRI	RH	0.62	-2.47	-5.78 **	-3.35 **	7.69	-13.85	14.96	-12.59
		HB	-2.98 **	-5.95 **	-6.52**	-4.11**	0.09	-20.00	11.01	-15.60
		SH	-2.98 **	-5.95 **	-0.07 **	2.51 **	2.94*	-17.65	9.01	-17.12 *

* - Significant at 5% level RH- Relative heterosis HB – Heterobeltiosis SH- Standard heterosis
** - Significant at 1% level

CO 1 - Standard variety

Table 2. Contd…

S. No.	Hybrids	Heterosis	Number of seeds per capsule (per cent)		1000 seed weight (per cent)		Seed yield per plant (per cent)	
			Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal
1.	TMV 5 X TMV 6	RH	15.45 **	20.33 **	16.60	-12.02	2.22	-5.56
		HB	15.45 **	20.33 **	12.69	-14.97	-0.72**	-8.27**
		SH	6.77 *	11.28 *	-1.16 **	-25.42 **	3.37	-4.49
2.	TMV 5 X CO 1	RH	9.38 **	36.72 **	10.46 **	36.22 **	3.21**	5.10**
		HB	5.26 **	31.58 **	0.42 **	23.84 **	2.25**	4.12**
		SH	5.26 **	31.58 **	0.42 **	23.84 **	2.28*	4.12*
3.	TMV 5 X VRI 2	RH	-8.33	11.67	-16.29 **	34.36 *	-8.89	5.93**
		HB	-10.57	8.94	-19.69	28.89	-11.51**	2.88**
		SH	-17.29	0.75	-28.47	14.81	-7.87	7.12
4.	TMV 5 X TMV 7	RH	10.29 **	20.16 **	17.52 **	32.64 **	-1.11**	-4.80**
		HB	8.94 **	18.70 **	12.74 **	27.24 **	-4.29**	-7.86**
		SH	0.75	9.77	0.42	13.34	0.37	-3.37
5.	TMV 5 X GOWRI	RH	-18.88	27.71	-22.48	16.47	0.18	-1.60
		HB	-19.84	26.19	-27.12 *	9.49 *	-3.20**	-4.98**
		SH	-24.06	19.55	-32.25 **	1.79 **	1.87	0.00
6.	TMV 6 X CO 1	RH	-18.75 **	-14.06 **	20.54 *	-4.76 *	0.92**	-9.72**
		HB	-21.80 **	-17.29 **	13.13	-10.61	-1.08**	-11.51**
		SH	-21.80 **	-17.29 **	13.13	-10.61	3.0	-7.87
7.	TMV 6 X VRI 2	RH	-21.67	18.33	28.58 **	18.12 **	-19.78**	-4.32**
		HB	-23.58	15.45	27.59 **	17.22 **	-19.78**	-4.32**
		SH	-29.32	6.77 **	13.66 *	4.41 *	-16.48**	-0.37**
8.	TMV 6 X TMV 7	RH	19.34 **	25.93 **	-17.17	29.17	0.36	1.43

		HB	17.89 **	24.39 *	-17.81	28.18	0.06	1.07
		SH	9.02 **	15.04 **	-26.79	14.18	10.99**	5.99**
9.	TMV 6 X GOWRI	RH	14.86 **	10.04 **	-24.88 **	-13.26 **	-6.26**	1.97**
		HB	13.49 *	8.73 *	-27.01 **	-15.71 **	-6.76*	1.42*
		SH	7.52	3.01	-32.14 **	-21.64 **	6.74	6.74
10.	CO 1 X VRI 2	RH	-12.00 **	-23.20 **	-23.00 **	4.44 **	1.28*	3.85**
		HB	-17.29 **	-27.82 **	-27.21 **	-1.26 **	-0.72*	1.80
		SH	-17.29 **	-27.82 **	-27.21 **	-1.26 **	5.99**	5.99**
11.	CO 1 X TMV 7	RH	13.04	-19.37	14.33	-20.00	-1.65	-1.65
		HB	7.52	-23.31	8.09 *	-24.37 *	-3.93**	-9.93**
		SH	7.52	-23.31	8.09 *	-24.37 *	0.75	0.75
12.	CO 1 X GOWRI	RH	-21.24 **	-15.83 **	-28.91 **	3.43 **	0.73**	5.11**
		HB	-23.31 **	-18.05 **	-31.41 **	-0.21 **	-1.78	2.49
		SH	-23.31 **	-18.05 **	-31.41 **	-0.21 **	7.87**	7.87**
13.	VRI 2 X TMV 7	RH	-20.68 **	-17.30 **	-10.85 **	-18.28 **	-3.58**	5.73**
		HB	-21.67 **	-18.33 **	-10.85 **	-18.28 **	-3.93**	-6.07**
		SH	-29.32 **	-26.32 **	-20.59 **	-27.21 **	-1.50	-1.50
14.	VRI 2 X GOWRI	RH	16.87 **	25.93 **	-15.06	12.87	-9.48**	-0.18**
		HB	12.70 **	21.43 **	-16.84	10.51	-9.96**	-0.71**
		SH	6.77 *	15.04 **	-22.69 **	2.73 **	4.49	4.49
15.	TMV 7 X GOWRI	RH	6.50	-18.70	25.45	-12.87	-0.18*	-0.18
		HB	3.97	-20.63	22.82	-14.69	-0.36	-0.36
		SH	-1.50 **	-24.81 **	14.18	-20.69	4.87**	4.87**

* - Significant at 5% level RH- Relative heterosis HB – Heterobeltiosis SH- Standard heterosis
** - Significant at 1% level

CO 1 - Standard variety

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