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Exploitation of Heterosis for Seed Yield and Quality Traits in Sesame (*Sesamum indicum* L.)

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ABSTRACT: An experiment was conducted to know the heterosis for seed yield and quality parameters in sesame. In this study Line × Tester analysis in sesame using twenty lines and two tester was carried out to assess the heterosis and combining ability for various quantitative traits *viz*., days to 50% flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, capsule length, 1000 seed weight, oil content and seed yield per plant. The ratio of General combining ability (GCA) to Specific combining ability (SCA) variance showed the preponderance of non-additive gene action in the expression of all the traits which can be improved by heterosis breeding method. The crosses MT-10-8-2, AT-207, RT-362 and JLS-301-24 were recorded the high, significant and positive standard heterosis for seed yield per plant and some of its component traits. Such crosses could be exploited for practical heterosis breeding programme in sesame. The hybrid combination Mangala Local × GT-1 and MT-10-8-2 × DS-5, which showed high SCA and standard heterosis (GT-1) for seed yield per plant. Hybrids along with the parents were screened for resistance against leaf spot (*Alternaria sesami*). Majority entries found resistance to *Alternaria* but None of the entries showed highly susceptible and immune reaction to *Alternaria*. The potential crosses which were identified would be tested over locations, for their yield superiority and released for commercial cultivation and also these crosses can be utilized for further breeding program to develop potential purelines.

Keywords: Sesame, Heterosis, Line × Tester, SCA, GCA.

INTRODUCTION

Sesame (*Sesamum indicum* L.) generally known as gingelly, beniseed, simsim, til or tal is the oldest indigenous oilseed crop, with longest history of cultivation in India. It is the sixth most important oilseed crops grown in India. Sesame is a diploid species with 2n=26 chromosomes. It is a self-pollinated crop belongs to the family Pedaliaceae and its center of origin is variously reported from southern Africa to central Asia. More than 36 species have been described under genus Sesamum. In addition to the cultivated sesame, two wild species, *S. prostratum* and *S. laciniatum*, are found in India. Sesame is described as the "Queen of oilseed crops" because of its high oil content which ranges from 38-54 per cent.

World Sesame production is around 4 million tonnes grown over 7 million hectares with a productivity of 535 kg/ha. Today India and China are the world's largest producers of Sesame. India has an area of 1.74 million hectares under sesame cultivation with production of 0.83 million tonnes, with productivity of 474 kg/ha. In India Madhya Pradesh Secure first place in area having 3.59 lakh ha but in production (2.13 lakh tonnes) and productivity west Bengal (952 kg/ha) secure first place. Karnataka secure eighth place in area (0.41 lakh ha) and production (0.22 lakh tonnes) (Anon., 2015).

However, the productivity of India (474.0 kg/ha) is very low as compared to world average productivity (500.0 kg/ha) and it is far below as compared to Egypt(1200 kg/ha) and China (897.7 kg/ha) (FAO. 2013). This indicates the scope for enhancing the potentiality of the crop for improvement in yields. The present sesame varieties under cultivation have limited yield potential, most of the varieties evolved and released for cultivation are selections from local or closely related populations under low levels of management, in addition they lack of resistance to biotic and abiotic stresses, all these major causes associated to low productivity of sesame genotypes grown in India. This indicates the need to enhance the productivity of this crop by developing high yielding cultivars, which depend on the availability of variability for yield and its component traits in the populations (Ashri, 1998).

Heterosis breeding has been a potential method of increasing yield in most of the cross as well as self fertilizing crops. Heterosis study provides information about probable gene action and helps in sorting out desirable genotypes (Chauhan *et al.*). Hybridization programme is a practical tool for improve the yield and other important trait and also creation of variability in sesame. In the absence of viable male sterility system in sesame, hybrids have to be developed exclusively by hand emasculation and pollination as done in other crops like chilli and cotton. In an often crosspollinated crop like sesame there is a good scope for exploitation of heterosis because out crossing (20-30 % cross pollination through honeybees) which indicates the potentiality of the crop for improvement in yields.

For breaking the present yield barrier and evolving varieties with high yield potential, it is desirable to combine the genes from genetically diverse parents. The success in identifying such parents mainly depends on the gene action that controls the trait under improvement, combining ability and genetic makeup. Abdelaziz *et al.,* (2010); Sedeck and Hasan (2015) indicated the importance of gene action for all traits. In this background a research work were carried out to study the effects of heterosis for yield and its yield components and the combining ability via line x tester analysis.

MATERIAL AND METHODS

The base material of present study comprised of twenty lines *viz.*,AT-201, RT-362, JLS-301-24, CUHY-57, AT-255, JLS-110-12, CUMS-17, SSD-19, AT-231, AT-207, SSD-9, SSD-11, MT-10-8-1, MT-10-8-2, Mangala Local, Chikka Mandya Local, Shivalli Local, Kodihalli Local, Kanakapura Local and Kirugavalu Local and two testers (GT-1 and DS-5). These twenty lines were crossed with two testes in line × tester mating fashion to derive 40 F_1 hybrids. The hybrids along with their parents were evaluated during *Rabi* 2016 in a randomized block design with two replications in Zonal Agriculture Research Station, V. C. Farm, Mandya. The hybrids and parents were raised in 3 meter length row. The spacing adopted was 30 × 10 cm. Recommended package of practices was done to raise the crop. Observations recorded on five randomly selected plants for various biometrical characters *viz.*, days to 50% flowering, days to maturity, plant height, number of branches, number of capsules per plant, capsule length, 1000 seed weight, oil content and seed yield per plant. The data recorded on different traits was analyzed statistically as per the method suggested by Kempthorn (1957). Disease screening was done based on per cent leaf area covered by leaf spot and blight symptoms as per the rating scale suggested by Mayee and Datar (1986).

RESULTS AND DISCUSSION

The analysis of variances for combining ability revealed that, highly significant differences for all the quantitative traits due to females × males interaction (Table 1). Hence the lines did not appear to behave consistently over different testers and *vice versa*. Same result is shown by Chauhan *et al.*, 2019, in this study he revealed that highly significant differences due to genotypes for all the traits. This suggests that parents and their hybrids under study possessed a sufficiently high amount of genetic variability. It revealed the presence of dominant gene action. The GCA effects of twenty two parents and SCA effects of forty crosses for various characters are detailed in Table 3 and 4 respectively.

For days to 50 % flowering, negative heterosis is desirable which indicates the earliness. Crosses AT-231 × DS-5 (-7.69), Kanakapura × DS-5 (-12.96) showing highly significant negative heterosis over MP, BP respectively (Table 2).

Table 1: Analysis of variance for combining ability for yield and yield contributing characters in sesame.

Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches	No. of capsule per plant	Capsule length (cm)	Seed yield (g)	Test weight (g)	Oil content (g)
Replication	1	0.010	0.020	2.812	0.021	0.085	0.019	0.028	0.010	0.010
Crosses	39	2.963**	22.122	185.762**	0.560**	660.625**	0.068**	11.501**	0.178**	7.417**
Line Effect	19	3.818**	24.724**	226.018**	0.552	1100.524**	0.084	9.975**	0.268**	13.922**
Tester Effect	1	0.450	11.250**	310.472**	0.946	441.800	0.295*	30.876**	0.200	0.002
Line x Tester Eff.	19	2.239**	20.092**	138.941**	0.546**	232.243**	0.040**	12.007**	0.087**	1.302**
Error	39	0.000	0.010	15.493	0.012	0.088	0.005	0.027	0.002	0.004
Total	79	1.463	10.921	99.389	0.282	326.176	0.036	5.691	0.089	3.664

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

Table 2: Top four hybrids based on *per se* performance and their heterosis value.

Sr. No.	Characters	Crosses	*Per se* erformance	Per cent heterosis		
				MP	BP	CC
1.	Days to 50% flowering	Kanakapura Local × GT-1	47.00	-5.05	-12.96	2.17
		JLS-301-24 × GT-1	47.00	-2.08	-4.08	2.17
		AT-231 × DS-5	48.00	-7.69	-11.11	4.35
		CUMS-17 × DS-5	48.00	-4.95	-11.11	4.35
2.	Days to maturity	JLS-301-24 × DS-5	98.00	-10.50	-14.78	1.03
		SSD-11 × GT-1	98.00	-6.22	-8.41	1.03
		JLS-301-24 × GT-1	99.00	-6.16	-7.48	2.06
		Mangala Local × GT-1	101.00	-4.72	-5.61	4.12
3.	Plant height (cm)	Kirugavalu Local × DS-5	118.0	41.06	37.37	43.29
		Kanakapura Local × DS-5	114.50	31.99	30.71	39.04
		Mangala Local × DS-5	113.40	28.57	25.30	37.70
		Mangala Local × GT-1	112.80	31.01	24.64	36.98
4.	First capsule bearing node	Chikkmandya Local × GT-1	4.00	34.45	33.33	3.90
		Kanakapura Local × DS-5	4.00	19.40	2.56	3.90
		Chikkmandya Local × DS-5	4.00	16.79	2.58	3.90
		Shivalli Local × GT-1	3.90	35.65	30.00	1.30
5.	No. of branches/plant	AT-231 × DS-5	5.70	33.33	2.70	14.00
		MT-10-8-2 × DS-5	5.35	25.15	-3.60	7.00
		JLS-301-24 × DS-5	5.05	7.45	-9.01	1.00
		AT-201 × DS-5	4.90	-5.31	-11.71	-2.00
6.	No. of capsule/plant	MT-10-8-2 × DS-5	120.15	36.88	25.09	21.36
		MT-10-8-2 × GT-1	117.05	32.15	19.87	18.23
		Kanakapura Local × DS-5	112.15	14.12	11.59	13.28
		CUHY-57 × GT-1	111.30	14.80	13.98	12.42
7.	Capsule length (cm)	CUMS-17 × GT-1	3.60	39.81	35.85	22.03
		CUMS-17 × DS-5	3.16	11.86	5.33	7.12
		Kirugavalu Local × GT-1	3.15	24.51	23.05	6.78
		SSD-19 × GT-1	3.14	17.38	10.18	6.44
8.	Test weight (g)	Mangala Local × GT-1	3.85	15.79	13.24	16.67
		Mangala Local × DS-5	3.80	19.69	16.92	15.15
		SSD-11 × DS-5	3.80	11.76	2.70	15.15
		AT-201 × GT-1	3.60	7.46	5.88	9.09
9.	Oil content (%)	MT-10-8-1 × GT-1	49.25	4.46	3.88	2.82
		Chikkmandya Local × GT-1	48.82	2.47	1.96	1.93
		AT-255 × DS-5	48.73	4.12	3.95	1.73
		Mangala Local × DS-5	48.60	6.67	3.68	1.47
10.	Seed yield/plant (g)	MT-10-8-2 × DS-5	14.20	58.22	11.11	19.83
		RT-362 × DS-5	13.25	9.28	4.33	11.81
		Chikkmandya Local × GT-1	11.55	18.46	6.10	2.53
		AT-207 × DS-5	11.50	1.32	9.45	2.95

MP- Mid-parent, BP-Better parent, CC-Comercial check

Also, similar results were reported by Sundari and Kamala (2012), Vavdiya *et al*., (2013); Sedeck and Hassan (2015). Among the parents Kirugavalu Local, RT-362 and JLS-301-24 were found to be good general combiners for this trait (Table 3). Negative and significant SCA effects were observed in MT-10-8-1 × GT-1 hybrids. Karande *et al.,* 2018 mention that heterosis may be positive or negative, depending on the magnitude of the hybrid means. For exploitation of hybrid vigour, high degree of heterosis for seed yield and its components is a prerequisite. The negative heterosis is important for characters like earliness. The SCA variance was greater than GCA variance indicating non-additive gene action for the inheritance of this trait. Hence exploitation of heterosis will be preferred for such trait to obtain early flowering hybrids. These results are in conformity with the results obtained by Vidhyavathi *et al*., (2005).

Table 3: General combining ability effects for different character in sesame.

Lines	**Days to 50 % flowering**	**Days to maturity**	**Plant height (cm)**	**First capsule bearing node**	**No. of branches per plant**	**No. of capsule per plant**	**Capsule length (cm)**	**Test weight (g)**	**Oil content (%)**	**Seed yield (g)**
AT-201	-0.175	-1.875	-11.218**	0.036	0.444**	-22.190**	-0.240**	0.222**	0.747	0.231
RT-362	-1.175**	-1.375	-8.693**	0.111	-0.106	-21.365**	0.025	-0.002	1.277**	2.456**
JLS-301-24	-1.175**	-6.875**	0.333	0.286**	0.119*	-17.765**	-0.050	-0.478**	-0.120	1.881**
CUHY-57	-0.175	0.125	-14.018**	-0.039	0.319**	12.810	0.105**	-0.128	1.057	-1.219**
AT-255	0.825**	-0.375	-1.717	0.036	0.019	2.235	-0.055	-0.128	1.540**	-0.144
JLS-110-12	1.325**	1.125	-1.018	0.036	0.044	10.685**	0.090*	-0.178	-4.998**	-0.269
CUMS-17	-0.175	0.625	-4.268*	-0.239**	0.019	9.860**	0.475**	-0.228	-1.515**	-1.594**
SSD-19	0.325**	3.125**	-5.718**	-0.339**	-0.356**	-7.065	0.050	-0.403	-3.790	-1.694**
AT-231	-0.175	0.625	-2.768	-0.314**	0.844**	-8.115	-0.030	0.098	-1.458**	0.581
AT-207	-0.175	0.625	3.182	-0.139	-0.081	-10.840	0.070	-0.028	0.907	2.656**
SSD-9	-0.675**	3.125**	3.782	0.036	0.219**	-18.790**	-0.150**	0.047	-1.183*	-0.794**
SSD-11	-0.175	-4.875**	-3.018	-0.714**	0.019	6.085	-0.030	0.472**	1.195**	-0.844**
MT-10-8-1	-0.175	2.125	2.483	-0.139	-0.056	13.210**	0.070	0.023	2.340**	-1.444**
MT-10-8-2	0.325**	-0.875	6.783**	-0.064	0.594**	37.685**	-0.055	0.098	1.190	2.781**
Mangala Local	-0.675**	-0.875	16.333**	-0.714**	-0.156**	0.560	-0.180**	0.598**	0.942	1.031**
Chikka mandya Local	-0.175	1.125	1.283	1.011**	-0.581**	1.210	0.020	0.148	1.955**	1.456**
Shivalli Local	0.825**	3.125**	1.458	0.611**	-0.756**	-18.415**	-0.005	0.123	0.280	-1.894**
Kodihalli Local	2.825**	-0.375	-4.817*	0.011	-0.231**	-10.990	-0.105**	-0.278**	-0.988	-2.019**
Kanakapura Local	-1.675**	1.125	10.883**	0.511**	-0.081	25.810**	-0.055	0.047	0.610	0.006
Kirugavalu Local	0.325**	0.625	10.733**	0.011	-0.231**	15.385**	0.045	-0.027	0.015	-1.169**
SE (g_i)	0.020	0.210	1.889	0.085	0.054	0.164	0.035	0.019	0.027	0.079
CD (g_i)@ 5 %	0.216	0.412	3.820	0.173	0.109	0.331	0.071	0.039	0.055	0.161
CD (g_i)@ 1 %	0.452	0.231	5.114	0.232	0.146	0.443	0.095	0.052	0.074	0.215
Testers										
GT-1	-0.075	-0.375	1.970**	0.026	-0.109**	2.350	0.061	-0.050	0.005	-0.621
DS-5	0.075	0.375	-1.970**	-0.026	0.109**	-2.350	-0.061	0.050	-0.005	0.621
SE (g_i)	0.214	0.433	0.597	0.027	0.017	0.052	0.012	0.006	0.008	0.025
CD (g_i)@ 5 %	0.001	0.072	1.208	0.054	0.034	0.105	0.022	0.012	0.017	0.051
CD (g_i)@ 1 %	0.504	0.044	1.617	0.073	0.046	0.141	0.030	0.016	0.023	0.068

*Significant at 1 % level, ** Significant at 5 % level

Early maturity is very desirable character especially in rainfed crop like sesame. For this also negative heterosis is desirable and hybrids with early maturity are more desirable as they produce more yields per day and fit well in different cropping systems. For days to maturity, JLS-301-24 × DS-5 recorded significant negative heterosis over MP and BP respectively (Table 4). Similar reports indicating significant negative heterosis was also reported by Mathapathi (2003), Singh *et al*. (2007); Jatothu *et al*, (2013). The parents JLS-301-24 and SSD-11, were good general combiners for this trait. the hybrid SSD-9 × DS-5 recorded the highest negative significant SCA and SCA variance was more than GCA variance suggesting that days to maturity was largely under the control of non-additive gene action obtained by Vidhyavathi *et al*., (2005); Yamanura *et al*., (2009).

Plant height is an important growth parameter from productivity point of view the hybrid Kirugavalu Local × DS-5 recorded highly significant and positive heterosis over MP, BP, CC. SSD-19 × DS-5 hybrid exhibited significant negative heterosis over better parent indicating dwarfness of the hybrids. Similar work was also reported by Sumathi and Muralidharan (2008), Sundari and Kamala (2010); Jatothu *et al.,* (2013). Among parents Mangala Local recorded high significant GCA effect for plant height. In the contrary, negative heterosis was found in the parent CUHY-57. Hence these parents could be used in hybridization programmes and were found to be good general combiners for increasing and decreasing plant height. The highest significant positive SCA effect was observed in Kirugavalu Local. The ratio of GCA/SCA was less than one and proportion of SCA variance was higher than GCA variance. This implied the predominance of non-additive gene action for the inheritance of plant height. Vidhyvathi *et al*., (2005); Yamanura *et al*., (2009) also observed the predominance of SCA variance.

For number of branches per plant AT-231 × DS-5 hybrid recorded highly significant positive heterosis over MP and CC (Table 4). The hybrid CUHY × GT-1 showed highest positive heterosis over BP. Similar results was given by Prajapati *et al*., (2010), Sundari and kamala (2012) andSedeck and Hassan (2015). The highly significant positive GCA effects were recorded in AT-231, MT-108-2. The hybrids JLS-301-24 × DS-5, CUHY-57×GT-, were shown highly significant positive SCA effect. The SCA variance was more than GCA variance indicating the role of non-additive gene action for the inheritance of number of branches per plant. Hence it is suggested that this character can be possibly enhanced through exploitation of heterosis. Similar work was also reported by Sundari and Kamala (2012); Jatothu *et al*., (2013); Kumar *et al*., (2015). In the present study SCA variance was greater than GCA variance. This reveals that both additive and non-additive gene action is important for the inheritance of this trait. For this trait, JLS-110-12, CUMS-17, MT-10-8-1, MT-10-8-2, Kanakapura Local and Kirugavalu Local, were found to be good general combiners. The highest SCA effect was noticed in CUHY-57 × GT-1 involving the parents having high x high GCA combinations, was also reported by Yamanura *et al*., (2009); Sedeck and Hassan (2015).

Table 4: Specific combining ability effects for different character in sesame.

Sr. No.	Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsule per plant	Capsule length (cm)	Test weight (g)	Oil content (%)	Seed yield per plant (g)
1.	AT-201×GT-1	0.075	-0.125	-6.020 *	-0.191*	-7.025	0.114*	0.200**	-0.008	0.546
2.	AT-201×DS-5	-0.075	0.125	6.020*	0.191	7.025	-0.114*	-0.200	0.008	-0.546
3.	RT-362×GT-1	0.075	-0.625	2.105	-0.391**	-5.850	-0.061	0.075	-0.883	-2.229
4.	RT-362×DS-5	-0.075	0.625	-2.105	0.391**	5.850	0.061	-0.075	0.883**	2.229**
5.	JLS-301-24×GT-1	-0.925	0.875	-5.270	-0.666**	-5.300	-0.036	-0.250	0.780	1.546
6.	JLS-301-24×DS-5	0.925	-0.875	5.270	0.666**	5.300	0.036	0.250**	-0.780**	-1.546**
7.	CUHY-57×GT-1	0.075	-0.125	0.980	0.484**	15.225**	-0.051	-0.150**	-0.138	1.946
8.	CUHY-57×DS-5	-0.075	0.125	-0.980	-0.484**	-15.225**	0.051	0.150	0.138	-1.946**
9.	AT-255×GT-1	0.075	1.375	6.380 *	0.434**	-7.500	-0.021	-0.150**	-0.760**	-2.829
10.	AT-255×DS-5	-0.075	-1.375**	-6.380 *	-0.434**	7.500	0.021	0.150	0.760	2.829**
11.	JLS-110-12×GT-1	-0.425	0.875	2.580	0.059	9.150**	0.004	-0.200	0.087	-1.254**
12.	JLS-110-12×DS-5	0.425	-0.875	-2.580	-0.059	-9.150	-0.004	0.200**	-0.087	1.254
13.	CUMS-17×GT-1	1.075**	2.375**	-1.370	0.584**	3.257	0.159**	0.150	-0.155	0.471
14.	CUMS-17 × DS-5	-1.075	-2.375	1.370	-0.584**	-3.257	-0.159**	-0.150**	0.155	-0.471
15.	SSD-19 ×GT-1	0.575	-2.125	10.380 **	0.159	0.000	0.124*	0.075	0.760	0.071
16.	SSD-19 ×DS-5	-0.575	2.125**	-10.380**	-0.159	0.000	-0.124*	-0.075	-0.760**	-0.071
17.	AT-231 ×GT-1	1.075**	1.375	0.230	-0.591**	-2.850	0.014	0.025	-0.903	-0.604
18.	AT-231 ×DS-5	-1.075	-1.375**	-0.230	0.591**	2.850	-0.014	-0.025	0.903**	0.604
19.	AT-207 ×GT-1	-0.925	3.375**	9.680 **	0.084	5.475	-0.086	-0.050	0.497	-0.279
20.	AT-207 ×DS-5	0.925	-3.375	-9.680**	-0.084	-5.475	0.086	0.050	-0.497*	0.279
21.	SSD-9× GT-1	-0.425	1.875	-0.720	0.384**	9.675	-0.066	-0.125**	-0.108	0.421
22.	SSD-9 × DS-5	0.425	-1.875**	0.720	-0.384**	-9.675**	-0.066	0.125	0.108	-0.421
23.	SSD-11 ×GT-1	-0.925	-2.125	7.780 **	0.184	2.750	0.014	-0.050	-0.015	1.721
24.	SSD-11 ×DS-5	0.925	2.125**	-7.780**	-0.184*	-2.750	-0.014	0.050	0.015	-1.721**
25.	MT-10-8-1 ×GT-1	0.075	-1.125**	2.680	0.159	5.625	0.014	0.200**	0.470	0.821
26.	MT-10-8-1 ×DS-5	-0.075	1.125	-2.680	-0.159	-5.625	-0.014	-0.200	-0.470	-0.821
27.	MT-10-8-2 ×GT-1	-1.425**	-2.125	-3.320	-0.491**	-	-	-	-	-
28.	MT-10-8-2 ×DS-5	1.425**	2.125**	3.320	0.491**	-	-	-	-	-
29.	Mangala Local × GT-1	-0.425	-3.125	-2.270	0.259**	-	-	-	-	-
30.	Mangala Local × DS-5	0.425	3.125**	2.270	-0.259**	-12.425	0.286**	-0.075	1.233**	-3.046
31.	Chikkmandya Local × GT-1	1.075**	4.875**	-2.620	-0.466**	-8.525**	0.014	0.025	0.430	2.771**
32.	Chikkmandya Local × DS-5	-1.075	-4.875	2.620	0.466**	8.525	-0.014	-0.025	-0.430	-2.771
33.	Shivalli Local × GT-1	1.075**	0.875	2.805	-0.191*	-10.550**	0.089	0.200**	0.450	-0.179
34.	Shivalli Local×DS-5	-1.075	-0.875	-2.805	0.191	10.550	-0.089	-0.200	-0.450	0.179
35.	Kodihalli Local×GT-1	0.075	-1.625**	-2.720	-0.066	-4.875	-0.061	-0.100**	0.492	0.096
36.	Kodihalli Local×DS-5	-0.075	1.625	2.720	0.066	4.875	0.061	0.100	-0.492*	-0.096
37.	Kanakapura Local×GT-1	0.575	-4.125	-8.820**	0.084	-7.775	-0.061	0.225**	-0.210	-2.379
38.	Kanakapura Local×DS-5	-0.575	4.125**	8.820**	-0.084	7.775	0.061	-0.225	0.210	2.379**
39.	Kirugavalu Local×GT-1	-0.425	-0.625	-12.470**	0.184	0.550	0.139**	-0.150**	0.180	-0.854
40.	Kirugavalu Local×DS-5	0.425	0.625	12.470**	-0.184*	-0.550	-0.139	0.150	-0.180	0.854
	SE (S_{ij})	0.082	0.458	2.670	0.076	0.232	0.049	0.027	0.038	0.112
	CD (S_{ij})@ 5 %	0.055	0.123	5.402	0.155	0.469	0.100	0.054	0.078	0.227
	CD (S_{ij})@ 1 %	0.107	0.099	7.232	0.207	0.627	0.134	0.074	0.104	0.304

*Significant at 5 % level, ** Significant at 1 % level.

Capsule length is also important economic trait associated with seed yield in sesame. It directly influences the number of seeds per capsule. For this trait, CUMS17 × GT-1 hybrid recorded highest positively significant heterosis over MP, BP, CC respectively. Which corroborated with the findings of Jatothu *et al*., (2013); Kumar *et al*., (2015). The parents CUMS-17, CUHY-57 and JLS-110-12 were found to be good general combiners. The highest SCA effect was noticed in JLS-301-24 × DS-5.

In sesame, 1000 seed weight is serves as an indicator to the end product i.e., seed yield. The low seed yield in sesame hybrids are attributed mainly to the 1000 seed weight (Jatothu *et al*., 2013). The GCA effects of parents indicated that were good general combiners and highest GCA effect reported by the parent SSD-11. High SCA effects were recorded in JLS301-24 × DS-5 followed by AT-201 × GT-1 and JLS-110-12 × DS-5. The SCA variance was more than GCA variance which indicates the 1000 seed weight was predominantly governed by the non-additive gene action in the present material under study. In contrast, Vidhyvathi *et al.,* (2005), Yamanura *et al*., (2009), reported that 1000 seed weight controlled by additive genes. The hybrids namely AT-207 × DS-5, Mangala Local × DS-5 and Chikka Mandya Local × GT-1 recorded the maximum significant heterosis over MP, BP, CC respectively. Chikka Mandya Local × GT-1 exhibited high test weight and hence it is recommended for breeding bold seeded type. Sundari and Kamala (2012); Kumar *et al.,* (2015) also reported high heterosis for 1000-seed weight in sesame.

For oil content most of the hybrids expressed positive heterosis. The hybrid combination MT-10-8-1 × GT-1 exhibited highest positive heterosis followed by Chikka Mandya Local × GT-1 and AT-255x DS-5 Similar reports were reported Jatothu *et al.*, (2013) and Vavdiya *et al*., (2013) Low heterotic effect for this trait could be due to lack of sufficient diversity in the material studied. Among parents, MT-10-8-1 and Chikka Mandya Local were found to be good general combiners. The hybrid combination Mangala Local × DS-5 exhibited the highest positive SCA effects followed by AT-231 × DS-5 and RT-362 × DS-5.

SCA variance was found to be more predominant than GCA variance indicating that oil content is largely governed by non-additive gene action. Hence, it is possible to improve the oil content through heterosis breeding. Similar results indicating non-additive gene action were reported by Mathapathi (2003); Yamanura *et al*., (2009); Kumar *et al.*, (2012).

Seed yield is one of the most important objectives of any of the plant breeding programme. The diverse high yielding hybrid MT-10-8-2 × DS-5 recorded significant maximum positive heterosis over check. The increased seed yield is definitely because of increase in one or more than one yield component. Sundari and Kamala (2012); Jatothu *et al*., (2013) reported that high heterosis was due to genetic divergence in the parents and dominant nature of gene action. The GCA effect of parents suggested that MT-10-8-2, AT-207, RT-362 and JLS-301-24 are the best general combiners and the highest SCA effects were resulted in the hybrid Mangala Local × GT-1 followed by MT-10-8-2 × DS-5.The SCA variance was more than GCA variance indicating the role of non-additive gene action for the inheritance of this trait. Hence, it is suggested that yield can be possibly enhanced through exploitation of heterosis. The present findings were in conformity with those of Vidhyavathi *et al*., (2005); Yamanura *et al*., (2009).

The present investigation resulted in to identification of higher heterotic combinations with higher magnitude of heterosis over commercial check for more than one desirable traits *viz*., Kirugavalu Local × DS-5 for plant height, AT-231 × DS-5 for number of branches per plant, MT-10-8-2 × DS-5 for number of capsules, CUMS-17 × GT-1for capsule length, Chikka Mandya Local x GT-1for 1000 seed weight, MT-10-8-1 × GT-1for oil content and MT-10-8-2 × DS-5 for seed yield per plant. The hybrid MT-10-8-2 × DS-5 had higher heterotic combinations with higher magnitude of heterosis over commercial check for number of capsules and seed yield per plant.

Majority of sesame entries were showing resistance (thirty-one) and moderately resistance (twenty-four) reaction to *Alternaria* disease, while few entries recorded moderately susceptible (six) and susceptible reaction (one) (Table 5). The present findings were in conformity with those of Pavithra *et al.,* (2015); Ginoya and Gohel (2015).

Table 5: Screening of sesame entries for Alternaria leaf spot disease under natural field condition.

Scale	Per cent severity on leaf	Resistant category	No. of entries	Entry name
0		I	-	-
1	< 10	R	31	JLS-301-24×DS-5, CUHY-57×GT-1, CUHY - 57×DS-5, AT-255×GT-1, AT-255×DS-5, JLS-110-12×GT-1, JLS-110-12×DS-5, CUMS-17×GT-1, CUMS-17×DS-5, SSD-11×GT-1, SSD-11×DS-5, MT-10-8-1×GT-1, MT-10-8-1×DS-5, MT-10-8-2×GT-1, MT-10-8-2×DS-5, Chikk Mandya Local×DS-5, Shivalli Local×GT-1, Shivalli Local×DS-5, Kodihalli Local×GT-1, Kodihalli Local×DS-5, Kanakapura Local×GT-1, Kanakapura Local×DS-5, Kirugavalu Local×GT-1, Kirugavalu Local×DS-5, AT-201, JLS-301-24, CUHY-57, JLS-110-12, MT-10-8-2, GT-1, DS-5
3	11-25	MR	24	RT-362×GT-1, RT-362×DS-5, JLS-301-24×GT-1, SSD-19×GT-1, AT-231×GT-1, AT-231×DS-5, AT-207×GT-1, AT-207×DS-5, SSD-9×GT-1, SSD-9×DS-5, Mangala Local×GT-1, Mangala Local×DS-5, Chikk Mandya Local×GT-1, RT-362, AT-255, CUMS-17, SSD-11, MT-10-8-1, Mangala Local, Chikk Mandya Local, Shivalli Local, Kodihalli Local, Kanakapura Local, Kirugavalu Local
5	26-50	MS	6	AT-201×GT-1, AT-201×DS-5, SSD-19×DS-5, SSD-19, AT-231, AT-207
7	57-75	S	1	SSD-9
9	>75	HS	0	-

I-Immune, R-Resistance, MR-Moderately Resistance, MS-Moderately susceptible,
S-Susceptible, HS-Highly susceptible.

CONCLUSION

The studies on combining ability indicated predominance of dominance variance than additive variance for all the characters. This suggested that usefulness of heterosis breeding or any breeding plan which makes use of specific combining ability effects more effectively for improvement in these traits. Further research is needed to potential crosses which were identified (MT-10-8-2 × DS-5, RT-362 × DS-5 and Chikka Mandya Local × GT-1) would be tested over locations, for their yield superiority and released for commercial cultivation and also these crosses can be utilized for further breeding program to develop potential purelines.

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