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Research article

Identification of heterotic crosses for sesame breeding using diallel matting design

Swapan K. Tripathy*, D.R. Mishra, S. Panda, N. Senapati, Pramod K. Nayak, G. B. Dash, Sasmita Dash, Kartik C. Pradhan, A.P. Dash, D. Mishra, S. K. Mohanty, P. M. Mohapatra and D. Lenka

Department of Agricultural Biotechnology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, India

*****Corresponding Author:swapankumartripathy@gmail.com [Accepted:23June 2016]

Abstract: Heterosis over better parent (Hb) was estimated in a set of diallel crosses comprising 12 diverse sesame varieties, for fourteen morpho-economic traits *viz.* days to initial flowering, days to cessation of flowering, duration of flowering, days to maturity, height to first capsule, plant height, number of primary branches/plant, number of capsules/plant, capsule length, capsule breadth, number of seeds/capsule, 500-seed weight, oil content and seed yield/plant. Sixty out of 66 hybrids revealed significant positive heterosis for seed yield. T13 x E8 was considered as the best heterotic cross combination which had yield advantage of 93% over the best high yielding parent CST 785. Besides, Pratap x RT 103 exhibiting second highest Hb value for number of capsules/plant, resulted significantly higher seed yield with second highest positive heterosis. Similarly, CST 785 x E8 with first highest and second highest significant positive Hb value for capsule number and number of primary branches, had also shown to be equivalent to third highest position in terms of significant heterobeltiosis for seed yield/plant. Pratap x T13 and Pratap x Madhabi harbour *per se* oil content more than 58% which resulted maximum heterobeltiosis for the trait among the crosses.
Keywords: Mean performance - Morpho-economic traits - *Sesamum indicum* L.

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INTRODUCTION

Sesame (*Sesamum indium* L, Family: Pedaliaceae) is the oldest oilseed crop. India is the second largest producer of sesame in the world and the crop is considered as the queen of high quality vegetable oils owing to high levels unsaturated fatty acids and antioxidants *e.g.*sesamol, sesamin, sesamolin and sesaminol (Nupur*et al.* 2010). Sesame harbour comparatively high oil content (55% of dry seed) among the oilseed crops, but, it suffers a serious setback in terms of productivity (368 kg ha^{-1}) as compared to world average (489 kg ha^{-1}). This is due to large scale cultivation of low yielding varieties in marginal lands. High levels of morphological genetic diversity do exist in sesame (Arriel*et al.* 2007) but this has not been fully harnessed for genetic improvement of the existing cultivars through heterosis breeding. Heterosis for seed yield is due to simultaneous manifestation of allelic and inter-allelic interactions of innumerable number of genes controlling important morpho-economic component traits under certain environmental conditions. Hybrid vigour of even a small magnitude for individual components may have an additive or synergistic effect on the end product (Sasikumar&Sardana 1990). Thus, extent of heterotic response of F_1 hybrids largely depends on the breeding value and genetic diversity of the parents involved in the crosses (Young &Virmani 1990). Heterosis over better parent (heterobeltiosis: Hb) is relatively more important than relative heterosis for commercial exploitation of hybrids. Heterobeltiosis for seed yield and yield components in sesame has been reported by many workers (Saravannan&Nadarajan 2002, Prajapati*et al.* 2010, Padmasundari& Kamala 2012). Besides, heterotic crosses may be aminable for selection of high yielding transgressivesegregants in F_2 and follow up selfing generations.

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Therefore, in the present investigation, an attempt has been taken to identify most desirable heterotic combination(s) in sesame following half diallel mating design.

MATERIALS AND METHODS

Twelve popular parental genotypes of sesame collected from different states of India were tested along with all possible cross combinations in RBD with three replications to raise F_1 generation. Emasculation and pollination were carried out in late afternoon using Fevicol method (Das 1990) for all possible combinations of parental genotypes in a diallel mating design. Each parental genotype and cross was grown in five rows of 3.5m length with a spacing of 30 x 10 cm. Observations on days to initial flowering, days to cessation of flowering, duration of flowering, days to maturity, height to first capsule (cm), plant height (cm), number of primary branches/plant, number of capsule/plant, capsule length (cm), capsule breadth (cm), number of seeds/capsule, 500-seed weight (gm), oil content (%) and seed yield/plant (gm) were recorded. Mean values per replication for all traits were subjected to analysis of variance as per Panse&Sukhatme (1985).

Heterosis of 66 cross combinations in sesame was estimated over better parent for 14 morpho-economic traits including oil content and seed yield as per cent increase of the F_1 from higher or lower parent means (Tumer 1953). The statistical significance of heterosis estimate was tested by 't' test (Wynne *et al*. 1970). The test was performed on the difference of the F_1 mean and the higher or lower parent mean for heterobeltiosis (Hb) before expressing them in percentage.

RESULTS AND DISCUSSION

Heterosis is a common feature in most of the crop plants. It represents superiority over better parent when F_1 exceeded the higher parent or over lower parent if F_1 fell below the lower parent. A positive estimate of heterobeltiosis would truly reflect "hybrid vigour" for important favourable yield related traits and seed yield *per se* which are meant for improvement in positive direction. However, some of the traits related with flowering and maturity; and also plant height are favoured in negative direction where a negative estimate that referred as negative heterobeltiosis would be appropriate.

In the present investigation, a high level of heterosis in the desired direction was observed in several hybrids for seed yield and yield components including oil content (Table 1). Estimates of Hb for days to initial flowering (DIF), days to cessation of flowering (DCF) and days to maturity (DM) ranged from -17.62 to 14.29%, -14.05 to 13.13% and -10.44 to 5.12% respectively. A few crosses *e.g.*12, 6 and 4 crosses had shown significant positive Hb values while, a large number of crosses *i.e.* 39, 27 and 31 crosses exhibited significant negative Hb estimates for the above flowering and maturity traits. This indicates that there is ample scope for recovery of transgressivesegregants in F_2 and onwards towards negative direction for the said traits.Pratap x BS 5-18-6 had shown very high significant negative heterobeltiosis(-12.70) for both days to initial flowering and days to cessation of flowering.

Hb values for period of flowering ranged from -34.29 to 12.90% (Table 1). Seven crosses exhibited significant positive Heterobeltiosis for the trait with maximum value being observed in case of CST 785 x T 13(14.77%). These crosses may pave the way for wider scope for capsule formation and seed development. In contrast, as high as 42 crosses revealed significant negative Hb indicating tendency of large number of crosses for early and synchronous flowering.

In the present investigation, 14 crosses showed positive heterosis for plant height. Heterosis for plant height has been also reported by Dixit (1976) and Mishra *et al*. (1994). Singh *et al*. (2007), Raghunaiah*et al*. (2008) and Krishnaiah*et al.* (2003) observed maximum positive heterosis of 8.67% and 20.23% and 35.7% for plant height. But, hybrids with shorter plant type can withstand lodging. Two cross combinations *e.g.* BS 5-18-6 x Phuletil 1(-10.10%) and BS 5-18-6 x TMV 5(-9.52%) have been identified to have significant negative heterobeltiosis for plant height (Table 1). On the other hand, moderately tall plants that bore capsules from lower height can bring about more number of capsules/plant. As many as 27 cross combinations revealed significant negative heterobeltiosis for height to first capsule. Three elite cross combinations that exhibited lower most Hb values for the trait are RT 103 x Phule Til 1(-35.7%), BS 5-18-6 x Phule Til 1(-33.5%), Pratap x RT 103 (-32.6%) which would have better scope in sesame breeding.

Number of primary branches, number of capsules/plant, capsule length, number of seeds/capsule and 500-seed weight are the important determinants for seed yield in sesame. A tremendously higher number of crosses (40, 50, 41, 23 and 35) revealed significant positive heterobeltiosisfor above characters which ranged

Table 1. Heterobeltiosis (Hb%) of possible crosses involving twelve parents of sesame following half-diallel mating design.

Character	**Range of Hb values (and mean performance)**	**Freq. of elite crosses**	**Most desirable F_1s with high heterobeltiosis**
Days to initial flowering[b]	-17.62 to 14.29 (33.5-46.0)	12(39)	TC 25x Madhabi(14.29), PratapxPhuletil 1(13.11), RT 103x Madhabi(11.22)[a]
			TC 25 x Pratap(-17.62), Pratap x BS 5-18-6 (-12.70), CST 785 x Pratap (-11.89)
Days to cessation of flowering[b]	-14.05 to 13.13 (58.67-73.0)	6(27)	RT 103x Phuletil 1(13.13), TMV5x Madhabi(9.62), RT 103x T 13(8.94)
			TC 25x E 8 (-14.05), Pratap x BS 5-18-6(-13.02), BS 5-18-6x TMV 5 (-11.50)
Period of flowering	-34.29 to 12.90 (23.0-35.0)	7(42)	Pratap x TMV 5(12.90), CST 785x T 13(12.22), B67xVinayaka(8.33),
Days to maturity[b]	-10.44 to 5.14 (71.0-85.0)	4(31)	TC 25x RT 103(5.14), BS 5-18-6xMadhabi (4.59), TC 25x Madhabi(3.21)
			TC 25x TMV 5 (-10.44), TC 25 x E 8 (-9.22), BS 5-18-6 x TMV 5 (-8.63)
Plant height[b]	-10.10 to 31.86 (91.67-130.4cm)	14(2)	T 13x Madhabi(31.86), Pratap x TMV 5(19.50), Madhabix E 8(19.14)
			BS 5-18-6 x Phuletil 1 (-10.10), BS 5-18-6 x TMV 5 (-9.52)
Height to first capsule[b]	-35.7 to 24.99 (44.18-74.6 cm)	6(27)	T 13x Madhabi (24.99), B67xVinayaka(24.02), T 13x Madhabi(18.90),
			RT 103 x Phule Til 1 (-35.7), BS 5-18-6 x Phule Til 1 (-33.5), Pratap x RT 103 (-32.6)
No of primary branches	-38.68 to 116.67 (1.08-3.27)	40(0)	Pratap x T13(116.67), CST 785 x E 8(108.51), BS 5-18-6 x Phuletil 1(101.39)
No of capsules per plant	-15.6 to 102.56 (15.57-39.57)	50(0)	CST 785x E 8 (102.56), Pratap x RT103 (96.06), T 13 x E 8 (81.75)
Capsule length	-13.69 to18.84 (2.34-3.01cm.)	41(0)	CST 785 x Phuletil 1 (18.84), RT 103 x Phuletil 1 (15.35), RT 103x T 13 (13.84),
Capsule breadth	-26.81 to 1.61 (0.73-0.89cm.)	5(0)	TC 25 x Madhabi (1.61), Vinayaka X Madhabi (1.03), RT 103 x T 13 (0.83)
No of seeds per capsule	-25.25 to 22.31 (57.73-92.37)	23(0)	T 13 x E 8 (22.31), T 13 x Phuletil 1 (20.08), B67 x Madhabi (14.36)
500 -Seed weight	-13.37 to 12.84 (1.15-1.62gm)	35(0)	TC 25 x CST 785 (12.84), CST 785 x TMV 5 (11.88), TMV5 x E 8 (11.73)
Oil content	-13.57 to 11.59 (45.53-58.4%)	11(0)	PratapxT13(11.59%), Pratap x Madhabi(11.54%)
Seed yield per plant	-15.8 to 131.5 (2.64-7.82gm)	60(0)	T13 x E8 (224.6), Pratap x RT 103 (131.5), BS 5-18-6 x T13 (119.1), T13 x Madhabi(118.5), CST 785 x E8 (116.7),Pratap x T13(85.9%), Pratap x Madhabi(68.1%)

Note: a-Figures within the parenthesis indicates significant Hb value (%) of promising crosses at $P_{0.05}$ or $P_{0.01}$
b- Consideration for significant Hb values (%) in negative direction is marked bold.

from -38.68 to -116.67%,-15.6 to -102.56%, -13.69 to -18.84%, -25.25 to -22.31% and -13.37 to -12.84% respectively (Table 1). The top ranking crosses with high positive Hb value have been sorted out in respect of each of these important yield contributing traits. CST 785 x E8 with first highest (102.56%) and second highest

(108.51%) significant positive Hb value for capsule number and number of primary branches; had also shown to be equivalent to third highest position in terms of significant heterobeltiosis for seed yield/plant (116.7%). Similarly, Pratap x RT 103 exhibiting second highest Hb value for number of capsules/plant; had resulted tremendously higher seed yield with second highest estimated increase over better parent (131.5%).Prajapati*et al*. (2006) identified a sesame hybrid TMV-3 x C1013 which manifested highest significant positive heterosis for number of branches per plant (163.2%) and number of capsules per plant (26.0%) in a set of 10x10 diallel crosses. Similarly, Krishnaiah*et al*. (2003) observed significant positive heterosis ranging from 4.4 to 80.2% for capsules on main stem in 9 out of 28 crosses of a 8 x 8 half diallel design.

It is worth to note that only five crosses *e.g.* TC 25 x Madhabi (1.61%), Vinayaka X Madhabi (1.03%), RT 103 x T 13(0.83%), RT 103 x TMV 5(0.53%) and TC 25 x CST 785 (0.36%) exceeded over the better parent (Table 1)for capsule breadth and these crosses may result increase in 500-seed weight due to bold seeds. For instance, the cross combination TC 25 x CST 785 that had shown positive significant heterobeltiosis for capsule breadth; also was shown to have maximum increase (12.84%) in 500-seed weight over the better parent (CST 785). In contrast, Krishnaiah*et al*. (2003) observed lower estimates of maximum positive heterosis (4.6% and 5.92%) for 1000-seed weight in sesame while, Saravannan&Nadarajan (2002) identified significant positive heterosis as high as 35.3% in 4 out of 28 crosses in a 8 x 8 diallel mating design for the trait.

Sesame being an oilseed crop, identification of heterotic crosses for oil content and seed yield *per se* is of special concern. In the present investigation, RT 103, TC 25, TMV 5 and CST 785 exhibited high oil content in seed (≥54.0%) among the parents while, CST785 x Pratap, CST 785 x Madhabi, CST 785 x Phule Til 1, Pratap x T13 and Pratap x Madhabi and RT 103 x T13 resulted high *per se* oil content (≥ 58%) (data not shown). Hb values for oil content ranged from -13.57 to 11.59% (Table 1) as also reported by Prajapati*et al*. (2006). However, Navadiya*et al.* (1995) observed lower estimates of heterobeltiosis for oil content. In the present study, only eleven crosses revealed significant increase in oil content over better parent among whichPratap x T13 (11.59%) and Pratap x Madhabi (11.54%) had shown maximum positive Hb value (≥11.0%).

Heterosis breeding is one of the potential techniques to improve yields in sesame. All crosses except only six crosses exhibited significant positive increase over the respective better parent for seed yield in different cross combinations. Among these, T13 x E8 (6.95gm/plant, 224.6%) followed by Pratap x RT 103 (131.5%), BS 5-18-6 x T13 (119.1%), T13 x Madhabi (118.5%), and CST 785 x E8 (116.7%) may be sorted out as best five heterotic crosses for seed yield. To exploit commercially viable heterosis the new crosses are compared with released varieties or desirable parent, so that the crosses with high heterotic potential could be identified. In this context, T13 x E8 (224.6%) had shown yield advantage of 93% over the best high yielding parent CST 785(3.6 gm/plant). The increased seed yield in the above crosses can be attributed to increase in one or more than one yield component. Further, this envisaged that there is enough scope for increase in seed yield in selected crosses through selection of transgressivesegregants in F_2 and follow up selfing generations. It is worth to note that the above mentioned crosses (T13 x Madhabi, Pratap x T13 and Pratap x Madhabi) that exhibited around 6% increase in oil content over their better parent; had also shown significant increase in seed yield (over better parent) to the extent of 118.5%, 85.9% and 68.1% respectively. Thus, these crosses may pave the way for isolation of valuable pedigree lines in advance selfing generations for higher seed yield and more oil content. Singh (2002) studied heterosis for 7 characters in 21 crosses among 7 varieties and they recorded significant positive heterosis as high as 96.3% for number of capsules per plant and 120.7% for seed yield. Similarly, Saravannan&Nadarajan (2002) observed maximum positive heterosis of 87.85% and 140.1% for seed yield in a set of 5 x 5 and 8 x 8 diallel crosses in sesame respectively. Prajapati*et al.* (2010) identified a cross ABT23 x ABT26 showing highest heterosis for seed yield per plant in 45 F_1s of sesame resulting from 10 x 10 diallel. Besides, Padmasundari& Kamala (2012) identified a cross X-79-1 X EC 351887 in a 5 x 5 half diallel mating design which showed promising performance with heterosis and highly significant genetic gain in F_2 and F_3 for seed yield and yield components.

In the present investigation, 66 possible crosses are grouped into 15 high x high, 36 high x low and 15 low x low crosses on the basis of yield performance of the parental varieties among which 9, 15 and 4 crosses recorded significantly higher seed yield respectively (data not shown) Thus, it seems that high x low cross combinations can result significantly high yielding hybrids with high frequency. In this context, Busch *et al.* (1974) reported that the high x high crosses produced the highest frequency of superior F_6 lines, but the high x low crosses produced lines, though in low frequency, that was higher yielding than the best lines from high x high crosses. While the low x low crosses did not produce any high yielding line.In contrast, in the present study, the hybrids resulting from low yielding parents, involving RT 103 with Pratap and T13, exhibited substantial increase in yield with highly positive and significant heterobeltiosis. Such a situation could be attributed to high inter-allelic interaction canceling the individual unfavourable effects of each other.Knysh&Norik (1978), however, had shown that heterosis occurred most frequently when both the parents had high general combining ability *i.e.* in high x high GCA crosses, and more rarely in high x moderate crosses. But, the F_1 hybrids of high x low and moderate x low GCA crosses were inferior to the better parent in yield performance.

REFERENCES

Arriel NHC, Mauro AOD, Arriel EF, Trevisoli SHU, Costa MM, Bárbaro IM & Muniz FRS (2007) Genetic divergence in sesame based on morphological and agronomic traits. *Crop Breeding & Applied Biotechnology* 7: 253–261.

Busch RH, Janke JC &Frolberg RC (1974) Evaluation of crosses among high and low yielding parents of spring wheat (*Triticumaestivum* L.) and bulk prediction of the performance.*Crop Science* 14: 47–50.

Das PK (1990) A simple modified technique for selfing and hybridization in (*Sesamum indicum* L.).*Andhra Agriculture Journal*37: 104–106.

Dixit RK (1978) Combining ability in sesame. *Indian Journal of Agricultural Science* 48(6): 362–364.

Knysh AI &Norik IM (1978) Selection of inter varietal hybrids of winter wheat in F_2 and later generations on the basis of heterosis in the F_1. *SelskkhzyaistvennayaBiologiya* 13: 140–142.

Krishnaiah G, Reddy KR &Sekhar MR (2003) Heterosis and combining ability in sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research* 20: 229–233.

Mishra AK, Yadav LN, Tomar RKS & Raghu IS (1994) Heterosis and combining ability in genetical diverse line in sesame. *Sesame and Saflower Newsletter* 9: 21–29.

Navadiya LJ, Godhani PR &Fougat RS (1995)Heterosis studies in sesame (*Sesamum indicum* L.). *Gujarat Agriculture University Research Journal* 20(2): 73–77.

Nupur M, Bhat KV & Srivastava PS (2010) Variation in fatty acid composition in Indian germplasm of sesame. *Journal of the American Oil Chemists' Society* 87 (11): 1263–1269.

Padmasundari M & Kamala T (2012) Heterosis in *Sesamum indicum* L. *Asian Journal of Agricultural Sciences* 4(4): 287–290.

Panse VG &Sukhatme PV (1985) *Statistical methods for agricultural workers.Fourth Edition*. pp. 48–117.

Prajapati KP, Patel KM, Patel CJ &Thakker DA (2006) Heterosis breeding in sesame (*Sesamum indicum* L.).*Journal of Oilseeds Research* 23(2): 292–294.

Prajapati N, Patel NCG, Bhatt AB, Prajapati KP & Patel KM (2010) Heterosis in Sesame (*Sesamum indicum* L.). *International Journal of Agricultural Sciences* 6(1): 91–93.

Raghunaiah E, Ganga KishanA& Ansari NA (2008) Combining ability and heterosis for yield and yield components in sesame (*Sesamum indicum* L.). *Journal of Research ANGRAU* 36 (2&3): 9–16.

Saravanan S &Nadarajan N (2002) Studies on heterosis in sesame (*Sesamum indicum* L.).*Indian Journal of Genetics* 62: 271–272.

Sasikumar B & S Sardana (1990) Heterosis for yield and yield components in sesame.*Indian Journal of Genetics* 50(1): 87–88.

Singh PK (2002) Heterosis and inbreeding depression in sesame (*Sesamum indicum* L.).*Indian Journal of Genetics* 62: 169–170.

Singh AK, Lal JP, Kumar H &Agrawal RK (2007) Heterosis in relation to combining ability for yield and its components in sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research* 24(1): 51–55.

Tumer JH (1953) A study of heterosis in upland cotton, combining ability and inbreeding effects. *AgronomyJournal* 45: 487–490.

Wynne JC, Emery & PW Rice (1970) Combining ability estimates in *Arachis hypogea* 1. II. Field performance of F_1 hybrids. *Crop Science* 10(6): 713–714.

Young J &Virmani SS (199) Heterosis of rice over environments.*Euphytica*51: 87–98.