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Research Paper

Inter-relationship of mean performance, heterosis, combining ability and genetic divergence in sesame (*Sesamum indicum* L.)

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Abstract

Sesame has good potential for exploitation of heterosis. The present investigation was undertaken to find inter-relationship among mean performance, heterosis, combining ability of cross combinations and *inter se* genetic divergence of parents using 12x12 diallel matting in sesame based on morpho-economic traits including seed yield and oil content. Mean performance of all component traits and seed yield/plant exhibited invariably significant positive correlation with both relative heterosis (Hr) and heterobeltiosis (Hb) except number of primary branches/plant, capsule breadth and seeds/capsule. Similarly, mean performance was also shown to have significant positive correlation with specific combining ability (SCA) for all characters under study except capsule breadth. In contrast, mean value of all traits except days to maturity, plant height, capsule breadth and 500-seed weight had no *inter se* consistent significant relationship with genetic divergence.

Keywords: Inter-relationship, Mean performance, Heterosis, Combining ability, Genetic divergence, *Sesamum indicum* L.

Introduction

Sesame (*Sesamum indicum* L, Family: Pedaliaceae) is the oldest oilseed crop and considered as the queen of high quality vegetable oils for human consumption as it contains high levels unsaturated fatty acids and antioxidants e.g., sesamol, sesamin, sesamolin and sesaminol[1]. Besides, sesame oil is rich in carbohydrate, protein, calcium and phosphorus and used as a source of biodiesel with superior environmental performance[2]. Its unique semi-drying property makes it suitable for use in paint formulation[3]. In addition, sesame seed is traditionally used for direct consumption as well as for confectioneries, cookies, cake and margarine and in bread making. It is also useful in the manufacture of soaps, cosmetics, perfumes, insecticides and pharmaceuticals products.

India shares largest area (35%) under sesame and ranked second largest producer of sesamum seeds (13.1%), but suffers a serious setback in terms of productivity (368kg/ha) as compared to world average (489kg/ha). This is due to large scale cultivation of low yielding varieties in marginal lands. High levels of morphological genetic diversity do exist in sesame[4] but this has not been fully harnessed for genetic improvement of the existing cultivars. Development of high yielding cultivars requires a thorough knowledge on the selection of cross combinations for follow up effective selection strategy. But, information in this aspect is limited and often contradictory in sesame. Thus, the present investigation was undertaken to assess nature of inter-relationship among mean performance, heterosis, specific combining ability of crosses and *inter se* genetic divergence of parents using diallel matting design in sesame.

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[5]. Emasculation and pollination were carried out in late afternoon using fevicol method[6] for all possible combinations of parental genotypes in a diallel mating design (Parents + crosses without reciprocals). 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. The data were analysed to derive estimates of heterosis, combining ability and genetic divergence as per the standard statistical methods of Tumer [7], Griffing [8] and SAS (Statistical Analysis System, SAS Institute, Inc. Cary. NC, USA, 2010, version 9.3) programme respectively. Inter-relationship between mean performance, heterosis (relative heterosis and heterobeltiosis), specific combining ability of crosses and *inter se* genetic divergence of parents was estimated in terms of simple correlation coefficients as per Panse and Sukhateme[9].

Results and Discussion

For choice of parents to be utilized in hybridization programme of any crop, it is believed that genetically divergent parental combinations produce hybrids of high heterotic response, though it may not be the sole factor. Besides, a few parents over a series of cross combinations may produce better F_1s, while certain combinations do relatively better or worse than would be expected on the basis of average performance of lines involved. The former relates to selection of parents with high general combining ability (GCA) and the later reveals appropriate cross combination with heterotic performance due to high specific combining ability (SCA). In the present study, an attempt was undertaken to find relationship if any between mean performance, heterosis (Hr and Hb), SCA and genetic divergence (Table 1).

Mean performance of all component traits and seed yield/plant exhibited invariably significant positive correlation with both relative heterosis (Hr) and heterobeltiosis (Hb) except number of primary branches/plant, capsule breadth and seeds/capsule. Thus, mean performance may be considered important criterion for direct selection of hybrids for higher grain yield. Capsule breadth exhibited negative relationship between mean performance and heterosis (both Hb and Hr) indicating the fact that capsule breadth of all cross combinations never excelled over better parent; and in general, equal to or less than the mid parental value. In the present investigation, mean performance was also shown to have significant positive correlation with specific combining ability (SCA) for all characters under study except capsule breadth. In contrast, mean value of all traits except days to maturity, plant height, capsule breadth and 500-seed weight had no *inter se* consistent significant relationship with genetic divergence. For instance, the cross combination B67 x Pratap exhibiting highest Euclidian genetic distance (40.39) revealed non-significant mean performance for all agro-economic traits. Similarly, genetic divergence had no significant positive relationship with SCA for all traits; and also no relation with either Hr as well as Hb in case of all traits except 500-seed weight at 5% level of significance. Das *et al*. [10] revealed rare significant relationship between heterosis with genetic divergence based on morpho-economic traits, seed storage protein and SSR (simple sequence repeats) primer based molecular finger printing in sesame. However, Drinic *et al.*[11] and Xangsayasane *et al.* [12] revealed close positive relation between molecular genetic divergence and heterosis in maize and rice respectively.

In recent years, production and cultivation of sesame hybrids by means of cytoplasmic and genetic male sterility system on commercial scale is being attempted. The success relies with attempting a large number of crosses and identifying a suitable heterotic cross combination. The relationship of the estimates of heterosis and mean performance may help in selection of heterotic crosses.

Table 1: Correlation among mean performance, Heterosis, SCA and Euclidian genetic divergence

Corre-lation	Days to initial flowering	Days to cessation of flowering	Period of flo-wering	Days to maturity	Plant height	Height to first cap-sule	No. of pry. braches	No. of capsules/plant	Capsule length	Capsule breadth	Seeds /cap-sule	500-seed weight	Oil content	Seed yield /plant
r(M, Hb)	0.523**	0.435**	0.781**	0.307*	0.667**	0.656**	-0.040	0.803**	0.359**	-0.342**	0.156	0.896**	0.856**	0.821**
r(M, Hr)	0.355**	0.630**	0.740**	0.336**	0.822**	0.758**	0.086	0.812**	0.484**	-0.187	0.121	0.906**	0.717**	0.896**
r(M, CA)	0.510**	0.660**	0.804**	0.458**	0.723**	0.700**	0.570**	0.805**	0.563**	0.023	0.288*	0.748**	0.750**	0.793**
r(M, GD)	0.196	0.304*	0.235	0.368**	0.356**	0.087	-0.148	0.191	0.229	0.396**	0.018	0.343**	0.216	0.237
r(Hb, Hr)	0.741**	0.795**	0.941**	0.754**	0.918**	0.944**	0.696**	0.953**	0.918**	0.965**	0.900**	0.965**	0.873**	0.923**
r(Hb, ca)	0.768**	0.634**	0.829**	0.661**	0.806**	0.769**	0.260*	0.796**	0.685**	0.558**	0.750**	0.823**	0.825**	0.749**
r(Hb, D)	0.468**	-0.221	0.030	-0.404**	-0.167	-0.497**	0.151	0.174	-0.153	-0.509**	-0.390**	0.295*	0.194	0.192
r(Hr, sca)	0.833**	0.871**	0.868**	0.845**	0.881**	0.850**	0.632**	0.811**	0.821**	0.659**	0.866**	0.847**	0.902**	0.824**
r(Hr, GD)	-0.271*	-0.174	0.007	-0.115	0.120	-0.298*	0.183	0.235	0.0002	-0.448**	-0.331**	0.287*	0.186	0.226
r(SCA,GD)	-0.213	-0.146	0.008	-0.089	0.074	-0.132	-0.009	0.175	0.123	-0.089	-0.162	0.072	0.075	0.174

Table 2: Identification of desirable crosses based on mean performance, heterosis and combining ability for seed yield/plant and *inter se* parental genetic distance

Parameter	Over all range	Range of sig. +ve values	Freq. of elite crosses	Desirable F_1s
Mean performance	2.64 to 7.82	4.94-7.82	29	CST 785x E8(7.82), T13xE8(6.95), **Pratapx RT 103(6.67),** Phule Til 1x E8(6.38)
Relative heterosis	-2.7 to 156.3	6.80-156.3	63	T13 x E8(156.3), **Pratap x RT 103(138.4),** CST 785x E8(127.0), BS 5-18-6x T13(125.5), BS 5-18-6 xT13(125.5)
Heterobeltosis	-15.8 to 224.6	7.70-224.6	60	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)
SCA	-0.80 to 1.93	0.79-1.93	12	**PratapxRT103(1.93),** CST 785 x E8(1.79), BS5-18-6xPhuleTil-1(1.56),T13x E8(1.47)
Genetic distance between parents	9.7507-40.3983	10.8770-40.3983	65	PratapxB67(40.398), **PratapxRT 103(40.159)**, PratapxBS 5-18-6(38.648), PratapxT13 (36.58), PratapxTMV 5 (36.00)

As expected, both the heterosis estimates (Hb and Hr) had significant *inter se* positive association for all agro-economic traits including seed yield indicating the fact that either Hb or Hr may be considered for selection of crosses for heterotic behaviour. In terms of breeding implication, the heterotic crosses are invariably expected to generate wide array of genetic variability in F_2 generation and more particularly, these pave the way for selection of desirable transgressive segregants. In the present investigation, mean performance for seed yield though had high significant positive correlation with heterosis, but mean seed yield of crosses had no significant positive association (r= 0.237ns) with genetic divergence in the present set of materials. Arunachalam[13] observed higher degree of favourable heterosis in crosses with moderate (rather than extreme) values of D^2 between the parents. However, Dikshit and Swain[14] found no relationship between F_2 segregation potential for yield and parental diversity as measured by D^2. Further, in the present investigation, it is interesting to note that Hb as well as Hr had strong significant relationship with SCA for all characters including seed yield indicating the fact that crosses with higher SCA invariably have high heterotic performance. Thus, F_1 crosses selected based on heterotic value could be aminable for genetic improvement of agro-economic traits e.g., days to initial flowering, period of flowering, plant height, height to first capsule, number of capsules/plant., capsule length, oil content and seed yield/plant having higher proportion of non-additive gene action [5].

Early elimination of poor crosses helps in efficient utilization of resources and allows handling of reasonably large segregating populations for a few promising crosses with a view to recover desirable recombination for quantitative characters. Therefore, an attempt was undertaken to identify promising crosses considering mean performance, heterosis (Hr and Hb), and combining ability (SCA) for seed yield and number of capsules/plant. The most top ranking crosses e.g., CST 785 x E8, T13x E8 and Pratap x RT103 in terms of seed yield performance; were also shown to be equally important for relative heterosis(Hr), heterobeltiosis(Hb) as well as specific combining ability(SCA) (Table 2). Phule Til-1, E8, CST 785 and Pratap were the favourably good general combiner for productivity (seed yield/plant)[5]. It is interesting to note that each of the above three best heterotic cross combinations included at least one parent with good general combining ability for productivity. These crosses can be advanced to isolate superior recombinants without altering their known heterotic pattern. Moreover, it was revealed that most of the crosses which recorded high SCA effects involved at least one parent with desirable GCA effect for that trait [15]. This allows to short list the number of crosses to be forwarded to F_2 and follow-up generations. Nass (1979) [16] reported that crosses identified as high yielding in F_1 had significantly higher mean yield in F_4 than those of low yielding in F_1 crosses in spring wheat. Curnow[17] made a comparative evaluation of F_1 yield performance and combining ability; and he argued that F_1 performance *per se* could be used as better criterion for selection of crosses when SCA variance was more than twice of GCA variance. The promising crosses identified in the present investigation, also revealed higher estimates of mean performance, heterosis (hr and Hb) and specific combining ability(SCA) for number of capsules/plant[5]. Besides, BS 5-18-6 x Phule Til 1 can be selected based on the above criteria owing to its moderately higher estimates for mean performance along with Hr, Hb and SCA. None of the above crosses revealed significantly higher oil content [5]. However, a cross combination RT103x T13 had shown significantly higher oil content along with moderately high seed yield and significantly higher estimates of relative heterosis and heterobeltiosis [5]. All the above crosses may be selected for further carry over to F_2 generation for expected recovery of transgressive segregants through gene shuffling.

Conclusion

Breeders attempt a number of crosses among a set of selected parents using a suitable mating design with a view to assemble desirable traits to constitute promising breeding lines. However, only a few crosses would be valuable and need to be carried to F_2 to save time, space and cost of experimentation. Mean performance of almost all component traits and seed yield/plant exhibited significant positive correlation with heterosis (Hr and Hb) and specific combining ability (SCA). Thus, F_1s with significantly high mean performance for seed yield and important morpho-economic component traits may be selected to carry over to F_2 generation for recovery of transgressive segregants through gene shuffling.

References

1. Nupur M., Bhat K.V. and Srivastava P.S., Variation in fatty acid composition in Indian germplasm of sesame, Journal of the American Oil Chemists' Society, 87 (11), 1263-1269 **(2010)**

2. Ahmed M., Khan M.A., Zafar M. and Sultana S., Environment-friendly renewable energy from sesame biodiesel, Energy Sources Part A– Recovery Utilisation and Environmental Effects, 32(2), 187-197 **(2010)**

3. Bedigian D., Evolution of sesame (Revisited): Domestication, diversity and prospects, Genetic Resources and Crop E, 50, 779-787 **(2003)**

4. Arriel N.H.C, Mauro A.O.D., Arriel E.F., Trevisoli S.H.U., Costa M.M., Bárbaro I.M. and Muniz F.R.S., Genetic divergence in sesame based on morphological and agronomic traits, Crop Breed. and Applied Biotechnol., 7, 253-261, **(2007)**

5. Mishra D.R., Parental genetic diversity, heterosis and genetic analysis for quantitative traits in sesame (*Sesamum indicum* L.). Ph.D. Thesis submitted to the Utkal University, Vani Vihar, Bhubaneswar, India, 50-55 **(2016)**

6. Das P.K., A simple modified technique for selfing and hybridization in (*Sesamum indicum* L.). Andhra Agriculture Journal, 37, 104-106 **(1990)**

7. Tumer J.H., A study of heterosis in upland cotton, combining ability and inbreeding effects, Agronomy Journal, 45, 487-490 **(1953)**

8. Griffing B., The concept of general and specific combining ability in selection to diallel crossing system, Aus. J Biol Sci., 9, 463-93 **(1956)**

9. Panse V.G. and Sukhatme P.V., Statistical methods for agricultural workers Fourth enlarged edition, ICAR, New Delhi, 97-103 **(1985)**

10. Das A., Pandey S. and Dasgupta T., Association of heterosis with combining ability and genetic divergence in sesame (*Sesamum indicum* L.), Int. J. Sci. and Tech. Res., 2(12), 307-314 **(2013)**

11. Drinic M.S., Trifunovic S., Drinic G´. and Konstantinov K., Genetic divergence and Its correlation to heterosis in maize as revealed by SSR-Based Markers, Maydica, 47, 1-8 **(2002)**

12. Xangsayasane P., Fangming X., Jose E.H. and Teresita H.B., Hybrid Rice Heterosis and Genetic Diversity of IRRI And Lao Rice, Field Crops Research, 117(1), 18-23 **(2010)**

13. Arunachalam, V., Concepts of breeding derived from experiments in pea- nut (*Arachis hypogea* L.). J. Oil seeds Res., 10, 70-80 **(1993)**

14. Dikshit U.N. and Swain D., Genetic analysis of F2 and transgressive segregants for yield in sesame. J. Oilseeds Res.,18:170-172 **(2001)**

15. Raghunaiah E., Ganga Kishan A. and Ansari N.A., Combining ability and heterosis for yield and yield components in sesame (*Sesamum indicum* L.), Journal of Research ANGRAU, 36 (2&3), 9-16 **(2008)**

16. Nass H.G., Selecting superior spring wheat crosses in early generations, Euphytica, 28, 161-167 **(1979)**

17. Curnow R.N., Selecting crosses using information from a diallel cross, Biometrics, 36, 71-76 **(1980)**