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Heterosis and inbreeding depression in sesame (*Sesamum indicum* L.)

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Abstract : Hybridization was effected between twenty lines and four testers and the resultant eighty F_1 hybrids were selfed to obtain F_2 seeds. The F_1s and F_2s were evaluated along with their parents. Observations were recorded for six quantitative traits namely days to maturity, plant height, number of capsules, test weight, seed yield and oil content. Two hybrids namely Si.3214 x SVPR 1 and TMV 6 x SVPR 1 recorded significant heterosis over standard check Co 1. In general, crosses with significant heterosis expressed significant inbreeding depression in F_2. The F_2 progenies of cross Si.3214 x SVPR 1 showed high heterosis with non-significant inbreeding depression for seed yield. ***(Key words: Heterosis, Inbreeding depression, Sesame.)***

Crop improvement in sesame *(Sesamum indicum* L.*)*, so far has been mostly confined to selection or hybridization followed by selection and in this way only marginal improvement could be effected. Therefore, to have a quantum jump in yield, exploitation of hybrid vigour and heterosis breeding is gaining importance. In addition, for enhancing yield potential of hybrids it is necessary to reshuffle the genes by crossing and study the heterotic effects in F_1 and its maintenance in F_2 generation. Hence, attempts were made to study the heterosis and inbreeding depression in sesame. This study will have a direct bearing on the breeding methodology to be emplyed for rapid genetic improvement in sesame.

Materials and Methods

Hybridization was effectd between twenty lines *viz.* S.0613, Si. 102, Si.1577 Si.3232, S.0626, NL 4, IVTS 18-94, JLSC.50, TNAU 137, Si.1576, S.0651, TNAU 72, TNAU 65, TMV 6, TMV 4, Si.3214, Si.1071, Si.1671 and Si.9091 and four testers *viz.* Annamalai 1, TMV 3, Co 1 and SVPR 1 in line x tester model (Kempthorne, 1957). The resultant eighty F_1 hybrids along with their 24 parents were raised in a randomized block design with three replications during *rabi*-1995. A portion of the seeds of F_1 (Fresh crosses) were preserved for sowing in the next season (*kharif*-1996). Each entry was grown in single row of three metre long with a spacing of 30 x 30 cm. The F_1's were selfed to obtain F_2 seeds. Simultaneously, the parents were selfed to maintain their purity. The generated materials *viz.* F_1 and F_2 of eighty crosses were grown along with their parents in a randomized block design with three replications during *kharif* 1996. In each replication the parents and F_1's were raised in three rows (each 3-m long) and F_2's in ten rows by adopting 30 x 30 cm spacing. Observations were recorded on ten randomly selected healthy plants in parents and F_1 and 50 plants in F_2 in each replications for six quantitiative traits namely days to maturity, plant height, number of capsules per plant test weight, seed yield per plant and oil content. The cultivar Co 1 was used as standard check. The overal mean values for each character in each parent and hybrid were taken to estimate heterosis and inbreeding depression as given below.

i. Standard heterosis (d_{iii}) $= \dfrac{F_1\text{-}SC}{SC} \times 100$

where, F_1 = Mean of F_1 hybrids

SC = Mean of standard check Co1

The test of signficance of heterosis was ascertained as per the formula suggested by Snedecor (1983).

ii. Inbreeding depression $= \dfrac{F_1 - F_2}{F_1} \times 100$

Where, F_2 = Mean of F_2 progenies of the respective F_1s

The significance of inbreeding depression was tested by computing least significant differences (LSD).

Results and Discussion

The range of standard heterosis and crosses exhibiting significant heterosis in desirable direction is presented in Table 1. The potentiality of a hybrid might be judged by comparing the *per se* performance and heterotic vigour. In the present study, close association between *per se* performance of hybrids and heterosis expression was observed for all the traits, suggesting that the selection of crosses based on *per se* performance would be more realistic in sesame as reported by Kadu *et al.* (1992) and Subbalakshmi (1996).

Promising hybrids showing significant standard heterosis for six metric traits is given in Table 3. For seed yield the crosses Si.3214 x SVPR 1 and TMV 6 x SVPR 1 recorded the highest standard heterosis of 28.02 and 9.71 per cent, respectively (Table 2). The hybrid Si.3214 x SVPR 1 have also recorded significant heterosis for plant height, number of capsule, test weight, oil content and days to maturity. Thus, heterosis for seed yield in the cross Si.3214xSVPR 1 was due to simultaneous heterosis of yield attributing traits. It is in close agreement with the findings of Raj Gupta (1980).

In respect of oil content the extent of standard heterosis was very narrow and maximum of 9.29 per cent was observed in TVTS 18-94 x SVPR 1 which indicated that it could be very difficult to improve this trait and the increment was rather low. Balsane *et al.* (1994) observed similar trend for this economic trait.

Hybrid vigour is based primarily an allelic non-additive gene action while inbreeding depression is based on allelic additive gene action (Fasoulas, 1980). Based on this theory, it is essential to study the F_1 and F_2 generations to distinguish whether the observed heterosis is due to fixable genes and to see whether the vigour is maintained or not. The significant negative inbreeding value indicates the presence of inbreeding vigour whereas significant positive value indicates inbreeding depression.

The range of inbreeding depression in F_2 progenies of eighty crosses for six metric traits is given in Table 1. Majority of the corsses which showed significant heterosis in F_1 has also showed significant inbreeding depression in F_2 for the characters studied (Table 2). The F_2 progenies of the cross combination *viz.* Si.102 x Annamalai 1 and TNAU 65 x Annamalai for plant height, TMV 6 x SVPR 1 for number of capsules and seed yield, TNAU 137 x Annamalai 1 and S.0651xCo 1 for test weight, and Si.1071 x SVPR 1 for oil content recorded significant positive standard heterosis coupled with high inbreeding vigour for the respective traits. The increased depression might be due to non-allelic interaction of higher magnitude in the inheritance of these traits and fixation of unfavourable recessive genes in F_2. Similar observations were made by Chavan *et al.* (1982) Sodani and Bhatnagar (1990) and Anandakum[ar] (1995).

The extent of inbreeding depression for c[...] content was low (maximum 7.67 per cent) and it mig[ht] be due to the inherently limited variability availab[le] in the base population. The F_2 progenies of cross[es] JLSC 50 x Annamalai 1 and TNAU 137 x Annamal[ai] 1 exhibited high standard heterosis coupled with mo[re] inbreeding vigour (i.e. negative inbreeding depression) for number of capsules and test weight, respectively. Presence of such enhanced vigour for these traits could be attributed to epistatic gene action.

However, in some F_2 progenies of crosses *viz.* TMV 4 x TMV 3 for plant height, Si.3214 x SVPR 1 for number of capsules, test weight, seed yield and oil content, TNAU 65xCo1 for test weight, IVTS 18-94 x SVPR 1 for oil content there was significant standard heterosis in F_1 with no marked inbreeding depression in F_2. This suggests that there might be a high proportion of fixable genes in these crosses (Fasoulas, 1980 and Sharma and Chauhan, 1983) and inheritance is due to stable polygenic system.

Instances were also found in which significant negative heterosis over standard check Co 1 coupled with high inbreeding vigour was observed as in the cases of S.0626 NL4 x SVPR 1, TMV 6 x SVPR 1 and Si.1576 x SVPR 1 for days to maturity, suggesting the occurrence of transgressive segregation for this trait. Such segregates might be handled through pedigree breeding for the isolation of high yielding genotypes as viewed by Naidu and Sathyanarayana (1993) and Hedge et al. (1996). However, selection would be more effective only in later filial generation

Table 1. Range of standard heterosis (d_{iii}) and Inbreeding depression (I.D) and crosses exhibiting significant standard heterosis in desirable direction

Heterosis (d_{iii})			Inbreeding depression (I.D)			
Range	Hybrid showing minimum & maximum value	Crosses showing significant heterosis in desirable direction	Range	Hybrid showing minimum & maximum value	No. of F_2 showing significant I.D.in Negative side (I.vigour)	No. of F_2 showing significant I.D.in Positive side (I.D)
1. Days to maturity						
-24.55 to -2.49	S.026 NL4 x SVPR 1, TNAU 137xCo 1	JLSC 50 x Annamalai 1, TNAU 137xAnnamalai 1, IVTS 18-94 x TMV 3, JLSC 50 x MV 3, JLSC 50 x Co 1 and all crosses involving SVPR 1 as tester	-18.86 to 10.99	VRI 1 x SVPR 1 Si.1671 x TMV 3	20	11
2. Plant height (cm)						
-46.18 to 12.86	S.0651 x SVPR 1, Si.102 x Annamalai 1	TNAU 65 x Annamalai 1, TMV 3 and Si.3214 x SVPR 1	-23.37 to 36.04	IVTS 18 94 X Annamalai 1, TMV 6 x SVPR 1	9	31
3. No. of capsule per plant						
-52.30 to 12.86	JLSC 50 X SVPR 1, TMV 6 x SVPR 1	Si.3232x Annamalai 1, IVTS 18-94 X Annamalai 1, TNAU 72 x Annamalai 1, TMV 4 x Annamalai 1, Si. 1071 x Annamalai 1, Si.163 x TMV 3, TNAU 72 x TMV 3, TNAU 65 x TMV 3, TMV 6 x TMV 3, Si.1671 x TMV 3, S. 9091 x TMV 3, Si.1577 x SVPR 1, TMV 6 x SVPR 1, Si.3214 x SVPR and S.9091 x SVPR	-59.77 to 50.31	TNAU 65 x SVPR 1, S.0626 NL4 x Co 1	8	37
4. Test weight (g)						
-70.12 to 28.02	IVTS18-94 x Annamalai 1, TNAU 137 x Annamalai 1	TNAU 137 X Annamalai 1,S.0651 X Co 1 and Si.3214 x SVPR1	-18.22 to 21.04	JLSC 50 X Annamalai 1, TNAU 72 x TMV 3	18	12
5. Seed yield per plant (g)						
-70.12 to 28.02	IVTS18-94 x Annamalai 1, Si. 3214 x SVPR 1	TMV 6 x SVPR 1 and Si. 3214 x SVPR 1	-22.06 to 7.67	Si.1576 x Annamalai, 1 TMV 6 x TMV 3	11	26
6. Oil Content (%)						
-8.91 to 9.29	Si.1577 x TMV 3, IVTS 18-94 x SVPR 1	Si.102 x TMV 3, Si.163 x TMV 3, Si.1576 x TMV 3, IVTS 18-94 x TMV 3, Si. 1671 x TMV3, S. S. 9091 x TMV 3, Si.3232 x Co 1, Si. 163 x Co 1, TNAU 72 X Co 1, TMV 4 x Co 1, Si.1071 x Co 1, S.9091 x Co 1, Si.3232 x SVPR 1, S 0626 NL4 x SVPR 1, Si.3214 x SVPR 1, Si. 1071 x SVPR 1 and Si.1671 x SVPR 1	-22.06 to 7.67	Si. 1576 xAnnamalai, TMV 6 x TMV 3	11	17

Table 2. Extent of inbreeding depression for the top ranking hybrids with significant standard heterosis

Traits	Top ranking crosses	Standard heterosis (%)	Inbreeding depression (%)
1. Days to maturity	S. 0626 NL4 x SVPR 1	-24.55**	-18.86*
	TMV 6 x SVPR 1	-18.86**	-5.79**
	Si. 3214 x SVPR 1	-19.93**	-0.55
	Si. 1576 x SVPR 1	-19.99**	-6.80**
2. Plant height (cm)	Si. 102 x Annamalai 1	12.86**	20.80**
	TNAU 65 x Annamalai 1	5.50**	15.24**
	TMV 4 x TMV 3	4.98**	-7.79
3. No of capsule per plant	Si. 1071 x Annamalai 1	74.66**	45.36**
	Si. 3214 x SVPR 1	71.35**	-0.04
	JLSC 50 x Annamalai 1	67.45**	-43.32**
	S. 0626 NL4 x Co 1	50.68**	50.31**
	S. 9091 x TMV 3	43.29**	26.95**
4. Test weight (g)	TNAU 137 x Annamalai 1	9.35**	-10.33**
	S. 0651 x Co 1	8.39**	9.23**
	TNAU 65 x Co 1	8.06**	2.39
	SI. 3214 x SVPR 1	8.06**	0.67
5. Seed yield per plant (g)	Si. 3214 X SVPR 1	28.02**	8.43
	TMV 6 x SVPR 1	9.71**	16.64**
6. Oil content (%)	IVTS 18-94 x SVPR 1	9.29**	3.35
	Si 3214 X SVPR 1	8.19**	-0.01
	Si. 1017 x SVPR 1	7.30**	4.14**
	Si. 3232 x SVPR 1	7.03**	-0.46
	Si. 163 x Annamalai 1	6.64**	6.16**

*, ** Refers to significant at P=0.05 and 0.01 levels respectively.

Thus, the present study has showed a maximum of 28 per cent standard heterosis for seed yield in the hybrid Si.3214 x SVPR 1. This cross has also showed non-significant inbreeding depression in F_2 generation. However, it requires test verification across the seasons and environments for practical utility. To realize the heterotic potential of the hybrid, it can be initially recommended for high input conditions where nutrients and the water are not limiting. Further, exploitation of residual heterosis in F_2 generation would further motivate the farmers for taking up hybrid sesame on commercial scale.

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Fungitoxic properties of some essential oils from higher plants

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Abstract : Essential oils of *Callistemone lanceolatus, Citrus medica, Eclipta alba, Hyptsis suaveolens and Ocimum canum* showed fungitoxicity against *Rhizoctonia solani*, the incitant of damping-off disease. The essential oils of *C. media, E.alba* and *O. canum* completely inhibit the growth of the fungus within 24 hours. Other oils take more time. The essential oil of *C. lanceolatus* was capable of penetrating the soil upto 4 cm while it was 3 and 2 cm respectively for *C. medica* and *O.canum*. The essential oil of *C. lanceolatus* and *O.canum* could control damping-off disease of tomato (*Lycopersicon esculentum*) and chilli (*Capsicum annum*) upto 57.13, 71.44, 40.90 and 83.32 percent respectively. ***(Key words: Essentials oils, Higher plants, Fungitoxic properties.)***

Use of seed protectants, soil fumigants and cultural practices are some of the common methods for the control of damping-off diseases. Synthetic chemicals which are used for this purpose has now been cautioned due to their side effects (Arya, 1988 . Lingk, 1991). There is need for application of only selective chemicals which will not affect the non-target organisms that may even be beneficial to crops. Lately the increasing relience on plant products as alternative source for disease management is gaining importance. Essential oils of different plants has been explored by several workers for their antifungal activity (Singh *et al.* 1998, Caccioni *et al.* 1995).

Hence, essential oils from some higher plants were tried against *Rzhizoctonia solani* Kuhn, the incitant of damping-off of tomato and chilli. Formaldehyde, the routinely used chemical, was taken for comparison. Before conducting the actual *in-vivo* tests, some properties of these oils i.e., minimum inhibitory concentration, killing time and persistence of efficacy were studied. The data obtained were subjected to factorial design for statistical analysis.

Materials and Methods

Isolation of essential oils

Essential oils (volatile fungitoxic fractions) of some plants (*Callistemone lance olatus, Citrus medica, Eclipta alba, Hyptsis suaveolens* and *Ocimum canum*) were isolated by hydrodistillation