HETEROSIS AND INBREEDING DEPRESSION FOR YIELD IN SOYBEAN [*GLYCINE MAX* (L.) MERRILL]

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ABSTARCT

Soybean is one of the most important oilseed crops of India. Breeding in soybean like other self-pollinated crops, is usually based on the pedigree, mass selection, single seed descent and early generation testing methods of pure line development. There also exists the possibility of hybrid varieties. The extent of heterosis will have direct effect on breeding methodology in the varietal improvement programmes. In soybean, male sterile genes and variability for increased out crossing may be potentially utilized for developing soybean hybrids. Although most of the studies have indicated 13-23 per cent heterosis for grain yield and more information on the heterotic pattern of soybean is needed before the feasibility of this approach can be evaluated. Keeping above in view, the present investigation was undertaken in soybean in rainfed condition to understand the heterosis and inbreeding depression for grain yield in 3 generations i.e., F_1, F_2 and F_3 of soybean. Based on the heterotic study, best economic crosses were identified for seed yield as PK 564 x PK 472, JS 71-05 x PK 472, JS 79-81 x NRC 12, JS 71-05 x MACS 58 and JS 79-81 x MACS 58 could be adjudged as the best heterotic crosses for seed yield.

Key Words: *Heterosis, Self pollination, Inbreeding Depression, Soybean (Glysine max L)*

INTRODUCTION

Soybean [Glycine max (L.) Merrill] regarded as "Wonder Crop", is the richest, cheapest and easiest source of best quality proteins and fats. The manifestation of heterosis and its judicious exploitation in soybean is one of the major challenges for plant breeders to mitigate the food requirements especially under semi-arid conditions. Heterosis is the manifestation of non-additive gene effects. Being non-fixable such genetic variation remains mostly unutilized under conventional pedigree method of breeding in self-pollinated crops including soybean. However, where suitable methods of crossing exist heterosis has been commercially exploited in the development of hybrids irrespective of the pollination mechanism **(Mayo, 1980)**. In soybean, **Nelson and Bernard (1984)** produced experimental quantities of hybrid seeds using genetic male sterility but at high cost to use of insects for pollination and low hybrid seed setting in male sterile female lines.

Discovery of new source of male sterility **Jin *et al.* (1997)** and increased out-crossing rates in soybean **(Culbertson and Hymowitz, 1990)** might help to improve the efficiency of producing hybrid seed. The first important step for the commercial exploitation of heterosis is to know its magnitude and extent. The magnitude of heterosis provides a basis for genetic diversity and guide for the choice of desirable parents for developing superior F_1 hybrids so as to exploit hybrid vigour and/or for building gene pools to be employed in breeding programme. The scope of exploiting heterosis in soybean also depends on the presence of adequate level of heterosis in the genetic material and under diverse environments. The present study was, therefore, conducted to assess the heterotic expression and its magnitude in soybean under subtropical rainfed conditions.

MATERIALS AND METHOD

Experimental materials consisted of F_1, F_2, and F_3 generations of 45 soybean crosses derived from 15 diverse lines crossed to 3 testers **(Kempthorne, 1957)**. The parents were selected on the basis of diverse pedigree, growth habit, geographical origin and adaptation. The experimental material including parents, F_{1S}, F_{2S} and F_{3S} were planted in randomized block design with 3 replications under rainfed conditions at the Instructional Farm, Rajasthan College of Agriculture, Udaipur. One row of 3 m of parents and F_{1S} while 3 rows each of F_2 and F_3 generations were planted. Seeds were dibbled at the spacing of 45 cm x 10 cm row to row and plant to plant. Bulk seed of 10 randomly selected competitive plants of parents and F_{1S}, where as 20 plants in F_2 and F_3 generations in each replication was used for analysis of seed yield per plant. Different types of heterosis viz., heterosis over mid parent **(Matinzinger, 1968)**, heterobeltiosis over better parent **(Fonseca and Patterson, 1968)** and economic heterosis over standard check JS-335, the high yielding variety recommended for the central zone covering southern Rajasthan. Inbreeding depression was estimated as per cent decrease in F_2 over F_1 (IDF_2) and in F_3 over F_2 generation (IDF_3).

RESULTS AND DISCUSSION

Analysis of variance was carried out for testers, lines and their crosses in 3 generations and revealed highly significant differences for all the lines, testers and crosses indicating sufficient variation in the material for grain yield per plant. The study for mean and range revealed that among parents there was great variability in the lines than testers for grain yield per plant. Among generations, F_{1s} showed superiority than their parents, F_2 and F3 generation as F_{1s} exhibited higher mean values and wide range of variation for grain yield per plant. It was reflected that the hybrids superior in F_1 involved both or at least one parent of

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high per se performance. Almost these hybrids showed consistent performance in their subsequent generations for grain yield. However, a considerable decrease from F_1 to F_2 and F_2 to F_3 generations for almost all the characters was noticed. Among the parents, PK 564, JS 71-05, PK 472, PK 416 and Pusa 24 appeared to be the most productive for seed yield. While among the

Table 1. Estimation of heterosis (MP), heterobeltiosis (BP), economic heterosis (SC) and inbreeding depression for seed yield per plant in soybean

Crosses	Seed yield per plant				
	MP	BP	SC	IDF2	IDF3
Bragg x PK 472	10.65	-	-	12.18	-0.18
JS 79-81 x PK 472	-3.63	-	-	14.75	1.54
RAUS 97-1 x PK 472	12.02	1.85	-	9.14	2.50
Pusa 24 x PK 472	4.52	3.40	0.80	12.24	0.11
PK 416 x PK 472	4.20	3.92	1.86	14.43	-1.78
PK 564 x PK 472	33.87**	23.53*	42.43**	21.37**	-0.27
JS 71-05 x PK 472	39.43**	34.63**	40.97**	22.16**	3.15
Pusa 20 x PK 472	9.47	0.72	-	17.01	-2.95
MACS 57 x PK 472	2.32	-	-	10.52	1.75
Monetta x PK 472	3.72	-	-	14.46	1.17
JS 80-21 x PK 472	19.42*	11.37	8.58	10.62	1.60
Pusa 40 x PK 472	3.69	-	-	15.01	2.13
PK 471 x PK 472	8.90	-	-	13.59	8.17
Pusa 16 x PK 472	16.43	10.29	7.52	15.49	1.38
NRC 2 x PK 472	11.27	-	-	10.66*	3.42
Bragg x MACS 58	24.71**	23.99	-	16.66*	0.99
JS 79-81 x MACS 58	36.00**	24.46*	15.85	10.69*	6.83
RAUS 97-1x MACS 58	29.89*	27.84*	2.01	8.46	3.38
Pusa 24 x MACS 58	23.79**	12.04	6.87	11.07	5.49
PK 416 x MACS 58	38.01**	23.42	20.96*	10.24*	9.33
PK 564 x MACS 58	20.57**	0.70	16.10	11.58*	4.84
JS 71-05 x MACS 58	32.82**	15.42	20.86*	10.54**	7.47
Pusa 20 x MACS 58	15.11	11.86	-	12.48	2.25
MACS 57 x MACS 58	15.99*	7.34	-	12.86	1.71
Monetta x MACS 58	21.25**	15.26*	-	14.87	2.72
JS 80-21 x MACS 58	23.98**	18.79	0.20	10.91	2.58
Pusa 40 x MACS 58	13.37	12.04	-	20.25	0.57
PK 471 x MACS 58	17.37*	16.42	-	12.04	-26.05
Pusa 16 x MACS 58	34.82**	27.14	10.88	13.39	5.27
NRC 2 x MACS 58	16.16	11.23	-	14.59	5.26
Bragg x NRC 12	13.72	11.93	-	17.54	0.63
JS 79-81 x NRC 12	42.07**	28.83**	19.91*	14.22**	6.09
RAUS 97-1 x NRC 12	29.76*	26.46*	0.90	12.97	2.06
Pusa 24 x NRC 12	29.95**	16.56	11.18	13.53	5.58
PK 416 x NRC 12	24.76*	10.57	8.38	9.67	8.97
PK 564 x NRC 12	35.99**	12.66	29.89*	9.85	3.85
JS 71-05 x NRC 12	39.97**	20.59	26.28*	17.04*	4.02
Pusa 20 x NRC 12	17.52	13.08	-	11.21	1.34
MACS 57 x NRC 12	24.12*	13.80	3.36	8.73	4.57
Monetta x NRC 12	19.50	12.51	-	10.81	1.81
JS 80-21 x NRC 12	23.81*	17.48	-	8.70	-4.77
Pusa 40 x NRC 12	19.95	17.36	-	10.48	4.10
PK 471 x NRC 12	11.10	10.88	-	9.70	2.64
Pusa 16 x NRC 12	30.44**	21.85	6.27	13.64	1.53
NRC 2 x NRC 12	13.97	10.20	-	10.46	-1.01
Range	-3.63-42.07	0.70-34.63	0.20-42.43	8.46-22.16	-26.05-9.33

*,** significant at 5% and 1% levels, respectively.

hybrids, PK 564 x PK 472, JS 71-05 x PK 472, PK 564 x NRC 12, JS 71-05 x MACS 58, PK 416 x MACS 58 and JS 71-05 x NRC 12 were superior and consistent performer for grain yield as they involved both or at least one of the parents with high per se performance. This indicated the importance of elite genotypes involving as a parent in the crossing programme.

For seed yield per plant, heterosis, heterobeltiosis, economic heterosis and inbreeding depression in F_2 were in the range of -3.63 to 42.07 per cent (24 crosses positive), 0.70 to 34.63 per cent (7 crosses positive), 0.20 to 42.43 per cent (7 crosses positive) and 8.46 to 22.16 per cent (10 crosses positive), respectively thereby indicating involvement of non-additive gene effects *(Table. 1)*. Crosses JS 79-81 x NRC 12, JS 71-05 x PK 472 and PK 564 x PK 472 appeared most potent hybrids for seed yield as these expressed all 3 combinations of heterosis **(Ponnosamy and Harer, 1999)** as well as inbreeding depression in F_2 **(Bastawisy *et al.*, 1997)**. The per se performance of these crosses was also high, therefore could be gainfully exploited for seed yield improvement. In addition to above, JS 71-05 x NRC 12, PK 416 x MACS 58, PK 564 x NRC 12 and JS 71-05 x MACS 58 showed significant mid parent and economic heterosis **(Cober and Voldeng, 2000)**. While, the crosses JS 79-81 x MACS 58, Pusa 16 x MACS 58 and Pusa 16 x NRC 12 expressed mid as well as better parent heterosis hence could be considered superior. Most of these crosses involved geographically diverse parents with higher per se performance for seed yield as also reported by **Ponnosamy and Harer (1999)** in soybean.

Based on the heterotic study, best economic crosses were identified for seed yield as PK 564 x PK 472, JS 71-05 x PK 472, JS 79-81 x NRC 12, JS 71-05 x MACS 58 and JS 79-81 x MACS 58 could be adjudged as the best heterotic crosses for seed yield. These crosses also involved geographically diverse parents supporting the findings of **Shang *et al.* (1992)**. Over and above these crosses also involved at least one parent with high per se performance revealing parental combination capable of producing the high level of transgressive segregants. Evidently, manifestation of heterosis for seed yield may be due to non-additive gene effects in the parents. Further, these crosses also showed high inbreeding depression in F_2 and F_3 generation for grain yield per plant thereby again highlighting the importance of non-additive gene effects. Further, high heterosis for seed yield was observed in some crosses, which might be due to dominance or epistasis. Although heterosis breeding makes maximal use of the non-additive genetic effects appears to be difficult for improving soybean **(Poehlman, 1987)** in view of the unavailability of mass pollination systems needed for hybrids seed production. Accordingly, the feasible alternative is to consider simultaneous exploitation of both additive and non-additive generation by adopting recurrent selection producers. Under similar situation **Harer and Deshmukh (1991)** recommended biparental mating in soybean followed by recurrent selection. Recurrent selection schemes have been used in soybean for increasing or improving seed yield **(Koinange *et al.*, 1981)**. Since crossing is tedious in soybean, genetic male sterility and single seed or single pod descent method could be employed to facilitate recurrent selection schemes **(Wilcox, 1998)**.

CONCLUSION

Inspite of fact that soybean exhibited good extent of heterobeltiosis and heterosis with preponderance of non-additive gene action in the inheritance of grain yield, the commercial exploitation of heterosis at commercial scale is difficult, therefore, alternate breeding options such as RS schemes should be adopted for yield improvement in soybean.

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