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HETEROSIS AND COMBINING ABILITY FOR GRAIN YIELD AND ITS COMPONENTS IN RICE BEAN (*VIGNA UMBELLATA* (THUNB) OHWI AND OHASHI)

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ABSTRACT

Twenty-four F_1s obtained from the line × tester mating system involving 8 lines and 3 testers, along with 11 parental lines were assessed for heterosis in the intervarietal crosses, components of genotypic variance for grain yield and its components in rice bean. The estimates of heterosis in rice bean suggested the possibilities for commercial utilization of F_1 hybirds for higher grain yield, if utilizable from of male sterility and fertility restorer systems are available. Of the genotypes studied, RBM - 31, among the lines, and C × $M_{12}P_3$, among the testers, were found to be the best general combiners for grain yield. The best specific combiners for grain yield per plant with the highest better parent heterosis and standard heterosis were RBM - 11 × C × $M_{12}P_3$ and RBM - 31 × C × M12P3 respectively. Estimates of components of genotypic variance indicated the importance of additive gene action for grain yield per plant. The present result, therefore, suggested the possibilities of grain yield improvment through the simple selection procedures in the segregating generations.

INTRODUCTION

Rice bean (*Vigna umbellata* (Thunb) Ohwi and Ohashi) an underutilized grain legume crop with high potential value in terms of grain yield and quality is still in a semi wild condition (Sarma et al, 1991; Sharma and Hore, 1994). Its cultivation is mainly confined to the tribal areas of Eastern and North - Eastern India (Arora et al., 1980). Till recent years, the rice bean improvement through breeding was mostly confined to the evaluation of varietal differences and selection from the llocal variability. If rice bean is to be popularised as a grain legume crop, devellopment of high yielding dwarf cultivars with desirable crop duration for density planting is considered very essential. Since the grain yield is a complex trait, which is controlled by many component characters and is also influenced by various environmental factors, estimates of heterosis, combining ability and components of genotypic variance for yield and its components are considered to be a pre - requisite so as to identify the parents which can nick well in hybridization programme and to suggest an appropriate breeding method according to the gene action. Information, at present, on these parameters are very limited in rice bean (Das and Dana,1978). Therefore, the present investigation was undertaken to estimate the extent of heterosis, the combining ability effects and the components of genotypic variance in the intervarietal crosses of rice bean.

MATERIALS AND METHODS

Twenty four F1s obtained from the line × tester mating system involving 8 lines, viz., RBM - 5, RBM - 8, RBM - 11, RBM - 19, RBM - 20, RBM - 22, RBM - 26 and RBM - 31 and 3 testers, viz. RBM - 1, RBM - 13 and C × M12 p3 along with 11 perental lines were used as the experimental materials in the present investigation. The experiment was laid out in randomized block design with four replications. Each plot size was of 3 × 4 sq.m. The seeds were dibbled on the 8th june, 1996 in raised plots at a spacing of 1 m row to row and 0.5 m plant to plant with a single seed per hill. A basal dose fertilizer @ 20:40:30 NPK kg/ha was applied and incorporated thoroughly into the soil. Weed control and plant protection measures were taken up as and when required.

Data on 12 important agronomic characters namely plant height at maturity (cm), days to first flowering, days to 80% maturity, pods/plant, seeds/pod, pod length (cm), 100 seed weight, seed breadth (mm), seed langth (mm), grain yield/plant (g), biological yield/plant (g) and harvest index were recorded from 5 randomly selected and tagged plants/plot. Heterosis was estimated as per cent increase or decrease of F1s over mid - parent (MP), better parent (BP) and standard variety (SV). The rice bean cultivar C × M12P3 was taken as the standard variety in the present study. General combining ability (gca) effect, specific combining ability (sca) effect and components of genotypic variance were estimated following line × tester analysis as outlined by Kempthorne (1957) and as worked out by Singh and Choudhary (1977)

RESULTS AND DISCUSSION

Heterosis

Based on the relative performance of F_1 s, the ranges of heterosis over MP, BP and SV for each character are presented in Table 1. The best cross for each category of heterosis for different characters is also presented (Table 2). Highly significant BP and SV heterosis in a number of crosses for different agronomic characters suggested the possibilities of operating over dominance mechanism of heterosis in these crosses of rice bean. Positive heterosis as high as 59.56% over the SV and 46.76% over the BP from the crosses RBM - 31 × C × $M_{12}P_3$ and RBM - 11×C×$M_{12}P_3$ recpectively suggested the possibilities of utilizing F_1hybirds of rice bean in commercial scale, if utilizable source of male sterility and fertility restorer systems are availablle. The highly significant negative heterosis over MP (- 38.26), BP (- 36.08) and SV (- 37.9) for plant height at maturity obtained from the cross RBM - 5 × C× $M_{12}P_3$ further suggested the possibilities of obtaining desirable plant height in the F_1 hybirds of rice bean for density planting. No desirable heterosis, in respect of days to first flowering and days to 80% maturity, was observed from any of the crosses. It might be due to the photo - insensitive nature of the rice bean genotypes used in the present study.

Combining ability effects and components of genotypic variance

Significance of variance ratio of treatments, parents and crosses for the characters under study suggested adequacy of continuing line × tester analysis (Table 3). Significance of variance ratio for the interaction of line × tester indicated that the lines did not behave consistently over different testers and *vice versa*. Non significant variance ratio due to lines for the characters —plant height at maturity, days to first flowering, days to 80% maturity, pods/plant and seeds/pod suggested that the lines were not significantly different from one another for these characters and further suggested the inadequacy of estimating gca effect of the lines for the above characters. Significance of variance ratio due to testers for grain yield/plant alone indicated that estimation of gca effect was adequate only for the character. Estimation of components of genotypic variance was, therefore , adequate only for the character grain yield in the present study.

RBM-31, among the lines, was recorded with the highest gca effect for five characters, viz. pod length, seed breath, 100 grain weight, grain yield/plant and biological yield. The highest gca effect, among the testers, was estimated from $C{\times}M_{12}P_3$. The crosses with the highest sca effect for all the 12 characters in rice bean are presented in Table 5. The crosses RBM-5$\times C{\times}M_{12}P_3$, RBM-19$\times C{\times}M_{12}P_3$ and RBM-11$\times C{\times}M_{12}P_3$ with the highest sca effect for the characters plant height at maturity, pods per plant and harvest index respectively also exhibited the highest value of standard heterosis for the respective character. Similarly, the crosses RBM-22×RBM-1 and RBM-11$\times C{\times}M_{12}P_3$ with the highest sca effect for 100 grain weight and grain yield/plant respectively exihibited the highest BP heterosis for the respective character.

Independence of the highest sca effect from the highest estimate of either standard heterosis or BP heterosis was observed for the characters days to first flowering, days to 80% maturity, pod length, seeds/pod, seed length, seed breadth and biological yield. Mather and Jinks (1971) were of the opinion that linkage might lead to an overstimation of interaction effects As a result, linkage always downgrades the significance of interaction as a cause of heterosis. Arunachanam (1977) also argued that the presence of dominance effect and dominance interaction were not necessary to realize heterosis for the traits governed by polygenes. Falconer (1961) explained that initial differences in gene frequency in parental lines caused heterosis in F_1s and absence of heterosis need not mean that individual loci show no dominance. Heterosis will be the greatest when one allele is in homozygous state in one parent and the other allele in the other parent. Therefore, independence of heterotic effect from the sca effect may be due to the number of genes governing the trait, their linkage relationship, gene frequency in the parental lines, etc. Unpredictable environmental effects also largely contributed to the manifestation of heterosis.

The estimates of gca and sca variances for grain yield/plant were 112.04 and 85.35 respectively. The higher estimate of gca variance that that of the sca variance suggested the importance of additive gene action for grain yield/plant in rice bean genotypes under study. Importance of additive gene action for grain yield/plant, in the present investigation, was further supported by the ratio of gca and sca variances which was more than unity. It is, therefore, suggested that the yield improvement in rice bean genotypes used could by made by adopting simple selection procedures in the segregating generations. The present finding is in agreement with the earlier report made by Das and Dana (1985) in rece bean.

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Table 1. Range of heterosis in rice bean

Characters	Relative heterosis (%)	Better parent heterosis (%)	Standard heterosis (%)
Plant height and maturity	-38.26 to 31.18	36.08 to 88.19	37.39 to 20.62
Days to first flowering	3.37 to 33.34	5.97 to 56.94	35.44 to 43.97
Days to 80 per cent maturity	-3.57 to 27.15	0.75 to 44.54	25.49 to 32.96
Pods per plant	-50.35 to 79.12	-58.60 to 59.63	-13.64 to 88.19
Pod length	-25.02 to 31.74	-29.40 to 29.67	-29.92 to 20.61
Seeds per pod	-46.40 to 76.34	-52.02 to 56.91	-49.28 to 14.29
100 grain weight	-21.95 to 6.63	29.55 to 46.76	-33.85 to 59.56
Grain yield per plant	-40.81 to 56.01	-48.92 to 32.05	-52.34 to 32.01
Biological yield	-21.02 to 88.19	-24.92 to 40.48	-26.19 to 63.62
Harvest index	-32.34 to 28.97	-33.10 to 18.92	-33.38 to 18.69

Table 2. Best heterotic crosses for 12 agronomic characters in rice bean

Characters	Relative heterosis	Better parent heterosis	Standard heterosis
Plant height at maturity	RBM5×C×$M_{12}P_3$ (–38.26**)	RBm5×C×$M_{12}P_3$ (–36.08**)	RBM5×C×$M_{12}P_3$ (–37.39**)
Days to first flowering	RBM11×RBM13 (3.37)^{NS}	RBM8×RBM13 (5.97*)	RBM8×C×$M_{12}P_3$ (35.44**)
Days to 80 per cent maturity	RBM11×RBM13 (–3.57*)	RBM5×C×M12P3 (0.75)^{NS}	RBM26×RBM1 (25.49**)
Pods per plant	RBM8×C×$M_{12}P_3$ (79.12**)	RBM8×C×$M_{12}P_3$ (59.63**)	RBM19×C×$M_{12}P_3$ (88.19**)
Pod length	RBM5×RBM1 (31.74**)	RBM31×RBM1 (29.67*8)	(20.61**)
Seeds per pod	RBM26×RBM13 (76.34**)	RBM26×RBM13 (56.91**)	NS
Seed breadth	RBM22×RBM1 (39.14**)	RBM22×RBM1 (28.37**)	NS
100 grain weight	RBM22×RBM1 (56.01**)	RBM22×RBM1 (32.05**)	RBM31×RBM13 (32.01**)
Grain yield per plant	RBM5×RBM1 (65.63**)	RBM11×C×$M_{12}P_3$ (46.76**)	RBM31×C×$M_{12}P_3$ (59.56**)
Biological yield	RBM22×RBM1 (88.19**)	RBM22×RBM13 (40.48**)	RBM31×C×M12P3 63.62**)
Harvest index	RBM5×C×$M_{12}P_3$ (28.97**)	RBM5×RBM13 (18.92**)	RBM11×C×$M_{12}P_3$ (18.69**)

*, ** Significant at 5% and 1% levels of probability. "NS" = Not significant

Table 3. Analyasis of variance for line × tester including parents

Sources	df	Mean sum of squares: Plant height	Days to first flowering	Days to 80% maturity of pods	Pods/ plant	Pod length	Seeds/ pod	Seed length	Seed breadth	100 grain weight	Grain yield/	Bilogical yield	Harvest index
Repli	NS	NS	NS	NS	**	**	NS	NS	NS	NS	**	NS	**
cations 1.67	3	73.87	6.45	9.28	1663.84	0.43	1.48	0.00	0.00	0.01	78.54	26.38	26.38
Treat- **		**	**	**	**	**	**	**	**	**	**	**	**
ments	34	2143.78	363.22	426.01	31159.85	2.64	5.58	0.03	0.01	21.84	6820.34	33833.77	13.02
Parents		**	**	**	**	**	**	**	**	**	**	**	**
	10	3107.80	834.19	1010.69	56127.01	2.70	8.76.	0.05	0.02	26.87	6300.34	41453.43	13.25
Crosses **	**	**	**	**	**	**	**	**	**	**	**	**	**
	23	1690.98	46.28	61.87	21371.89	2.71	4.20	0.02	0.01	20.59	6843.50	29442.33	13.20
Parents	**	**	**	**	**	NS	**	**	**	NS	**	**	**
vs. crosses	1	2917.85	2943.10	2955.10	6611.30	0.24	5.52	0.02	0.01	0.36	11487.64	58640.20	6.59
Lines	NS	NS	NS	NS	*	NS	*	*	**	**	**	**	**
	7	2227.68	76.21	85.73	10717.58	5.92	3.82	0.04	0.03	56.92	21208.58	91516.04	30.34
Testers	NS	NS	NS	NS	NS	NS	NS	NS	N	*	NS	NS	
	2	4003.97	21.85	11.49	45578.74	0.10	2.33	0.02	0.00	0.33	1987.19	572.98	13.30
Line ×		**	**	**	**	**	**	**	**	**	**	**	**
Tester	14	1092.21	34.81	57.13	23240.93	1.48	4.65	0.01	0.01	5.32	354.71	2529.67	4.61
Error	102	96.43	4.17	6.69	662.00	0.07	0.19	0.00	0.00	0.12	13.27	21.01	0.22

*, ** Significant at 5% and 1% levels of probability, respectively. NS = Not significant

Table 4. Estimates of general combining ability effects of parents in rice bean

Lines	Pod length	100 grain weight	Yield per plant	Biological yield	Harvest index
RBM 5	0.70**	0.12	16.71**	–3.01**	1.89**
RBM 8	–0.23**	0.83**	–31.56**	–58.38**	–1.09**
RBM 11	0.07	1.05**	33.19**	38.17**	1.75**
RBM 19	–1.05**	–3.15**	–36.32**	–75.35**	–1.02**
RBM 20	–0.38*	–3.09**	–39.47**	–104.28**	–0.14
RBM 22	–0.59**	–0.23*	–17.29**	32.62**	–2.53**
RBM 26	0.45**	1.26**	–7.47**	–5.44**	–0.34**
RBM 31	1.04**	3.21**	82.22**	175.68**	1.49**
Testers					
RBM 1	-	-	–8.14**	-	-
RBM 13	-	-	0.56	-	-
C×$M_{12}P_3$	-	-	7.58**	-	-

*, ** Significant at 5% and 1% levels of probability, respectively. Non asterisks are non significant.

RBM = Rice Bean Manipur.

Table 5. Crosses with the best specific combining ability effects in rice bean.

Character	Crosses with sca effects
Plant height at maturity	RBM5×$M_{12}P_3$ (–26.03**)
Days to first flowering	RBM31×C×$M_{12}P_3$ (–2.78**)
Days to 80 per cent maturity	RBM22×RBM1 (–5.62**)
Pods per plant	RBM19×C×$M_{12}P_3$ (143.56**)
Pod length	RBM8×C×$M_{12}P_3$ (0.90**)
Seeds per pod	RBM8×C$M_{12}P_3$ (1.80**)
Seed length	RBM11×C×$M_{12}P_3$ (0.10**)
Seed breadth	RBM20×C×$M_{12}P_3$ (0.07**)
100 grain weight	RBM22×RBM1 (1.68**)
Grain yield per plant	RBM11×C×$M_{12}P_3$ (23.10**)
Biological yield	RBM5×RBM (145.11**)
Harvest index	RBM11×C×$M_{12}P_3$ (1.11**)

*, ** Significant at 5% and 1% levels of probability.