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Combining Ability Studies for Earliness and Determinate Trait in Genetically Diverse Lines of Ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi]

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A B S T R A C T

Six genotypes as lines and two genotypes as testers of ricebean were studies in line x tester analysis. The study revealed that the gene action involved in controlling characters namely, days to flowering, days to maturity, plant height, branches per plant, pods per plant, clusters per plant, pods per cluster, seeds per pod and yield per plant was non-additive gene action while two traits namely, 100-seed weight and pod length was under the control of additive gene action. Genotype RBHP-38 and RBHP-43 were found to be good general combiner for earliness and for determinate habit RBHP-38 and RBHP-108 were found to be top ranking general combiners. None of the testers found good general combiner for all the characters. The cross RBHP-36 x PRR-2007-2 recorded significant negative sca effects for days to flowering, days to maturity and plant height indicating earliness and determinate habit. The crosses RBHP-36 x RBHP-900 and RBHP-61 x PRR-2007-2 recorded positive significant positive sca effects for branches per plant, pods per plant, clusters per plant, pods per cluster and yield per plant. These crosses could be further exploited to obtain transgressive segregants in the breeding programme.

Introduction

Ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] is one of such underutilized warm season annual vine legume with diploid chromosome number (2n=2x=22) which belong to subgenus *Ceratotropus* in the genus *Vigna*. It is a vital source of protein, especially for the poor who often cannot afford animal products. These crops also contain high amounts of macro and micronutrients (Ca, P, K, Fe and Zn), vitamins (niacin, Vitamin A, Ascorbic Acid, Inositol), fibre and carbohydrate for balanced nutrition. Its wild progenitor is *V. umbellata var. Gracilis* with which it is cross fertile (Tomooka *et al.*, 1991). Study of heterosis in ricebean is important for the plant breeder to find out the superior crosses.

However, success depends primarily upon identification of best parental lines which may produce desirable gene combinations. The knowledge of gene action and combining ability helps in the selection of suitable parents for hybridization and F_1's for identification of transgressive segregants for further exploitation in breeding programmes.

The present study was therefore, carried out to know the type of gene action and combining ability for earliness and determinate traits.

Materials and Methods

The experimental material consists of 12 F_1's of ricebean involving six high yielding but indeterminate genotypes; RBHP-36, RBHP-38, RBHP-43, RBHP-61, RBHP-107 and RBHP-108 and two early and determinate genotypes as testers; PRR-2007-2 and RBHP-900. These 20 genotypes (12 F_1's and 8 parents) were sown in *kharif* 2016 in randomized block design with three replications and each genotype was sown in 1 m long single row spaced 30 cm apart. Within rows seeds were sown at 10 cm distance. Observations were recorded on five randomly selected plants from each F_1 and parents on twelve quantitative traits *viz.*, days to 50% flowering, days to 75% maturity, plant height (cm), branches per plant, pods per plant, clusters per plant, pods per cluster, seeds per pod, 100-seed weight(g), pod length (cm) and yield per plant (g). The statistical analysis was done as per procedure given by Kempthrone (1957) for heterosis and combining ability analysis.

Results and Discussion

The analysis of variance for general (gca) and specific (sca) combining ability for various traits are presented in Table 1.The variance due to lines was significant for all the traits whereas variance due to tester was significant for all traits except branches per plant. The variance due to lines x testers was highly significant for all the traits. The significant differences among different genotypes of urdbean and their F_1 hybrids for grain yield and other component traits in different sets of material were also reported by Purohit *et al.*, (2016), Kujur and Lavanya (2011) and Gill (2014).

The relative estimates of variance due to sca were higher than variance due to gca. The preponderance of additive type of gene action was registered by 100-seed weight and pod length. Maximum values of σ^2gca were negative indicated no role of this component of variance in the inheritance while the positive value of σ^2sca indicated the importance of non-additive gene action. The predominance of non-additive gene action brought out that this component could be exploited in hybrid development. Purohit *et al.*, (2016) recorded the predominance of non-additive gene action for all the characters under study in urdbean. Bainade *et al.*, (2014) also observed negative values for σ^2gca or additive variance for days to 50% flowering, days to maturity, number of primary branches per plant and number of seeds/pod in green gram. However, Singh *et al.*, (2003) reported the importance of both additive and non-additive components for plant height and grain yield per plant in urdbean.

The estimates of GCA of parents are given in Table 2. The parents with significant gca effects are considered as good general combiners for deriving desirable transgressive segregants in self-pollinated crops. However for certain traits like days to maturity and flowering and plant height negative gca effects are desirable. In the present study significant negative GCA effects were observed for RBHP-38 and RBHP-43 for days to flowering and days to maturity. In case of days to flowering, genotype RBHP-43 was observed to be the best general combiner as it showed the highest significant negative GCA effect. In case of days to maturity, genotype RBHP-38 was the best general combiner as it showed the highest negative GCA effects. The female RBHP-43 was also observed a good general combiner for maturity indicated superiority of these parents in transmitting desirable gene for earliness and maturity to their descendants. For plant height, highest negative GCA effects were observed for RBHP-38 followed by RBHP-108. Among the testers, RBHP-900 showed negative but non-significant GCA effect for days to flowering. PRR-2007-2 showed significant negative GCA effect for days to maturity and found to be best combiner. For plant height, highest negative GCA effect was observed for RBHP-900. For all the three traits *viz.*, days to flowering, maturity and plant height RBHP-38 and was found to be the best general combiner.

In case of branches per plant which is an important yield contributing trait, the best combiner was RBHP-107 and other female parents having positive GCA effect was RBHP-43. Number of pods per plant has a direct bearing on the total productivity of rice bean. Keeping this in view, three lines were identified as best general combiner, *viz.*, RBHP-108 followed by RBHP-36 and RBHP-43. For cluster per plant, best general combiner was RBHP-108. For pods per cluster best general combiner was RBHP-61. For seeds per pod best general combiner line was RBHP-107 followed by RBHP-36. In case of 100-seed weight, the best combiner was RBHP-38 and for pod length three lines, *viz.*, RBHP-107 and RBHP-36 were adjudged as the best general combiners on the basis of their significant positive GCA effects. For seed yield per plant, there was only one line which showed significant positive general combining ability effects, *viz.*, RBHP-61. Other female parents, which had positive, though, non-significant GCA effects were RBHP-43 followed by RBHP-36 and were the average general combiner. PRR-2007-2 showed significant positive GCA effect for three traits, *viz.*, pods per plant, clusters per plant and 100-seed weight. RBHP-900 showed significant positive GCA effect for two traits, *viz.*, pods per cluster and pod length. The similar type of results also reported by Patel *et al.*, (2010), Yadav and Lavanya (2011), Sujata and Kajjidoni (2013), Bainade *et al.*, (2014) and Vaidya *et al.*, (2015)

Table.1 Analysis of variance for combining ability for various characters

Source of variation		Lines	Testers	Lines x Testers	Error	σ^2gca	σ^2sca	σ^2gca/ σ^2sca
Traits	df	5	1	5	22			
Days to flowering		31.400*	9.000*	58.933*	2.053	-0.6514	18.96	-0.0343
Days to maturity		389.333*	386.777*	473.977*	4.340	-1.7723	156.54	-0.0113
Plant height		1201.109 *	525.173*	1447.93*	37.630	-7.4892	470.1	-0.0159
Branches per plant		0.265*	0.027	0.750*	0.023	-0.0109	0.24	-0.0454
Pods per plant		108.568*	156.333*	191.243*	1.297	-1.5565	63.3	-0.0245
Clusters per plant		6.241*	251.328*	61.899*	0.188	-0.3086	20.57	-0.0150
Pods per cluster		0.199*	1.006*	1.813*	0.042	-0.0308	0.59	-0.5220
Seeds per pod		1.917*	1.604*	2.041*	0.220	-0.0037	0.60	-0.0061
100-seed weight		1.549*	4.389*	1.352*	0.062	0.0140	0.43	3.91
Pod length		4.650*	5.994*	2.143*	0.292	0.0569	0.61	2.33
Yield per plant		7.511*	7.493*	24.698*	1.890	-0.3581	7.60	-0.0471

Table.2 Estimates of general combining ability (gca) effects of the parents for various characters

Lines	Days to flowering	Days to Maturity	Plant height	Branches per plant	Pods per plant	Clusters per plant	Pods per cluster	Seeds per pod	100-seed weight	Pod length	Yield per plant
RBHP-36	0.17	3.00*	-0.96	-0.21*	1.85*	0.16	0.11	0.56*	-0.02	0.74*	0.86
RBHP-38	-1.50 *	-8.33*	-20.00*	-0.24*	-7.02*	-1.57*	-0.16	0.06	1.00*	-0.93*	-0.72
RBHP-43	-2.50 *	-6.00*	15.55*	0.16 *	1.48*	-0.54*	0.00	-0.16	-0.07	-1.16*	0.76
RBHP-61	0.17	-1.33	10.90*	-0.11	-1.81*	0.15	0.30*	-0.09	-0.34*	0.39	1.24 *
RBHP-107	-0.50	14.33*	7.84*	0.26*	-0.18	0.26	-0.10	0.58*	-0.36*	0.99*	0.53
RBHP-108	4.17 *	-1.67	-13.33*	0.13	5.68*	1.53*	-0.16	-0.96*	-0.21	-0.03	-1.61*
SE(gi) ±	0.58	0.85	2.50	0.06	0.46	0.17	0.08	0.19	0.10	0.22	0.56
SE(gi-gj) ±	0.82	1.20	3.54	0.08	0.65	0.25	0.11	0.27	0.14	0.31	0.79
Testers											
PRR-2007-2	0.50	-3.28*	3.82*	0.03	2.08*	2.64*	-0.17*	-0.21	0.35*	-0.41*	0.46
RBHP-900	-0.50	3.28*	-3.82*	-0.03	-2.08*	-2.64*	0.17*	0.21	-0.35*	0.41*	-0.46
SE(gi) ±	0.33	0.49	1.44	0.03	0.26	0.10	0.04	0.11	0.05	0.12	0.32
SE(gi-gk) ±	0.47	0.69	2.04	0.05	0.37	0.14	0.06	0.15	0.08	0.18	0.45

*P≤0.05

Table.3 Estimates of SCA effects of different cross combinations for various characters

Crosses	Days to flowering	Days to Maturity	Plant height	Branches per plant	Pods per plant	Clusters per plant	Pods per cluster	Seeds per pod	100-seed weight	Pod length	Yield per plant
RBHP-36 X PRR-2007-2	-4.33*	-12.72*	-20.54*	-0.56*	-9.75*	-5.74*	-0.30 *	0.31	0.25	-0.02	-3.80*
RBHP-36 X RBHP-900	4.33*	12.72*	20.54*	0.56*	9.75*	5.74*	0.30 *	-0.31	-0.25	0.02	3.80*
RBHP-38 X PRR-2007-2	-1.33	-1.06	1.18	0.41*	-0.96	0.99*	0.10	-0.46	0.31 *	-0.21	0.88
RBHP-38 X RBHP-900	1.33	1.06	-1.18	-0.41*	0.96	-0.99*	-0.10	0.46	-0.31 *	0.21	-0.88
RBHP-43 X PRR-2007-2	0.00	6.28*	4.78	-0.06	3.88*	1.02*	0.10	0.53	-0.13	0.83 *	0.87
RBHP-43 X RBHP-900	0.00	-6.28*	-4.78	0.06	-3.88*	-1.02*	-0.10	-0.53	0.13	-0.83 *	-0.87
RBHP-61 X PRR-2007-2	0.33	5.94*	6.74	0.34*	4.18*	3.41*	0.83*	-0.37	-0.39 *	0.36	2.15 *
RBHP-61 X RBHP-900	-0.33	-5.94*	-6.74	-0.34*	-4.18*	-3.41*	-0.83*	0.37	0.39 *	-0.36	-2.15 *
RBHP-107X PRR-2007-2	0.00	-8.06*	22.42*	0.04	5.02*	1.72*	0.10	0.69 *	0.61*	-0.00	-0.09
RBHP-107 X RBHP-900	0.00	8.06*	-22.42*	-0.04	-5.02*	-1.72*	-0.10	-0.69 *	-0.61*	0.00	0.09
RBHP-108 X PRR-2007-2	5.33*	9.61*	-14.58*	-0.16	-2.37*	-1.41*	-0.83*	-0.71 *	-0.65*	-0.96*	-0.01
RBHP-108 X RBHP-900	-5.33**	-9.61*	14.58*	0.16	2.37*	1.41*	0.83*	0.71 *	0.65*	0.96*	0.01
SE (Sij)±	0.82	1.20	3.54	0.08	0.65	0.25	0.11	0.27	0.14	0.31	0.79
SE (Sij-Skl)±	1.16	1.70	5.00	0.12	0.93	0.35	0.16	0.38	0.20	0.44	1.12

*P≤0.05

Table.4 List of good general combiners for different traits

Traits	Lines	Testers
Days to flowering	RBHP-43 and RBHP-38	None
Days to Maturity	RBHP-43 and RBHP-38	PRR-2007-2
Plant height	RBHP-38 and RBHP-108	RBHP-900
Branches per plant	RBHP-107 and RBHP-43	None
Pods per plant	RBHP-108, RBHP-36 and RBHP-43	PRR-2007-2
Clusters per plant	RBHP-108	PRR-2007-2
Pods per cluster	RBHP-61	RBHP-900
Seeds per pod	RBHP-107 and RBHP-36	None
100-seed weight	RBHP-38	PRR-2007-2
Pod length	RBHP-107 and RBHP-36	RBHP-900
Yield per plant	RBHP-61	None

Table.5 List of cross combinations showing good specific combining ability (SCA) effects for different traits

Traits	Cross combination
Days to flowering	RBHP-108 x RBHP-900 and RBHP-36 x PRR-2007-2
Days to Maturity	RBHP-36 x PRR-2007-2
Plant height	RBHP-107 x RBHP-900, RBHP-36 x PRR-2007-2 and RBHP-108 xPRR-2007-2
Branches per plant	RBHP-36 x RBHP-900, RBHP-38 x PRR-2007-2 and RBHP-61 xPRR-2007-2
Pods per plant	RBHP-36 x RBHP-900, RBHP-61 x PRR-2007-2, RBHP-43 x PRR-2007-2 and RBHP-108 x RBHP-900
Clusters per plant	RBHP-36 x RBHP-900, RBHP-108 x RBHP-900, RBHP-107 xPRR-2007-2, RBHP-61 x PRR-2007-2, RBHP-43 x PRR-2007-2 and RBHP-38 x PRR-2007-2
Pods per cluster	RBHP-108 x RBHP-900, RBHP-61 x PRR-2007-2 and RBHP-36 x RBHP-900
Seeds per pod	RBHP-108 x RBHP-900 and RBHP-107 x PRR-2007-2
100-seed weight	RBHP-108 x RBHP-900, RBHP-107 x PRR-2007-2, RBHP-61 x RBHP-900 and RBHP-38 v PRR-2007-2
Pod length	RBHP-43 x PRR-2007-2 and RBHP-108 xRBHP-900
Yield per plant	RBHP-36 x RBHP-900 and RBHP-61 x PRR-2007-2

In present investigation, the good general combiners with respect to different traits indicated that no single parent was proved to be a good general combiner for all the traits. Line ‘RBHP-43’ was found to be a good general combiner for days to flowering, days to maturity, branches per plant and pods per plant. Likewise line RBHP-38 was found to be good general combiner for most of the traits, *viz.*, days to flowering, days to maturity, plant height and 100-seed weight. Line RBHP-107 was found to be good general combiner for number of branches, seeds per pod and pod length while the line RBHP-108 was found to be good general combiner for pods per plant, number of clusters and plant height. RBHP-61 was found to be good general combiner for pods per cluster and yield per plant. RBHP-36 was found to be good general combiner for pods per plant, seeds per pod and pod length.

Tester PRR-2007-2 was found to be good general combiner for days to maturity, pods per plant, number of clusters and 100-seed weight and RBHP-900 was found to be good general combiner for plant height, pods per cluster and pod length. On the basis of the performance of parents with respect to GCA effects for different traits, it can be concluded that line RBHP-43, RBHP-38 was found to be good general combiner for four traits followed by RBHP-108, RBHP-107 and RBHP-36 for three traits followed by RBHP-61 for two traits. The high GCA effects are associated with additive and additive x additive interaction effects (Griffing, 1956) hence, these good general combiners can be used in the varietal improvement programme.

The SCA effect is an important criterion for the evaluation of hybrids. Among the various gene interactions contributing towards SCA, the additive x additive type of gene interaction is fixable in later generations in self-pollinated crops. Thus, the ultimate aim of a breeder is to generate desirable transgressive segregants to develop potential homozygous lines through hybridization. The cross combinations with significant desirable SCA effects along with GCA effects of the parents for various traits are listed in Table 3. The cross RBHP-36 x PRR-2007-2 recorded significant negative SCA effects for days to flowering, days to maturity and plant height indicated the best specific combiner for earliness and determinate trait. The crosses RBHP-36 x RBHP-900 and RBHP-61 x PRR-2007-2 recorded positive significant positive SCA effects for branches per plant, pods per plant, clusters per plant, pods per cluster and yield per plant. The crosses RBHP-108 x RBHP-900 and RBHP-40 x PRR-2007-2 recorded positive significant positive SCA effects for pods per plant, clusters per plant and pod length. RBHP-107 x PRR-2007-2 and RBHP-38 x PRR-2007-2 recorded significant positive SCA effects for clusters per plant and 100-seed weight. The results were in accordance with Patil *et al.,* (2011), Sujata and Kajjidoni (2013), Patil *et al.,* (2014) and Vaidya *et al.,* (2015).

It was observed that the desirable cross combination included high x high, medium x high, high x low, medium x medium and low x low type of general combiner (Gill *et al.,* 2014).The high x medium or vice-versa combination could be due to additive and additive x additive type of gene action which is fixable in nature. The desirable performance of cross combination like low x medium, medium x medium general combiners may be ascribed to complimentary gene effects. The present study described the importance of both additive and non-additive components of inheritance in ricebean. Since the main aim was to identify best parents for incorporating earliness and determinate habit, hence parents RBHP-38, RBHP-43, RBHP-400 and PRR-2007-2 were found best general combiners for the trait of interest while the cross RBHP-36 x PRR-2007-2 recorded significant negative SCA effects for days to flowering, days to maturity and plant height indicated the best specific combiner for earliness and determinate trait.

Authors' Contributions

Both the authors have equal contribution in the research work mentioned in the paper and the paper is written by both of them.

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