Legume Res., **37** (6) : 568-574, 2014
doi:10.5958/0976-0571.2014.00678.X

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com / www.legumeresearch.in

EVALUATION OF GENOTYPIC VARIATION AND SUITABILITY OF RICE BEAN GENOTYPES FOR MID-ALTITUDES OF MEGHALAYA, INDIA

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Received: 23-05-2012 Accepted: 06-05-2013

ABSTRACT

In the North Eastern Hill Region of India, the shifting or jhum cultivation is practiced in 16.79 lac ha area and rice bean is an essential part of jhum. Increasing the productivity of jhum is one of the important management options to uplift the economies of farmers. Identification / development of early maturing, high yielding rice bean genotypes that may give stable yields, is the most important breeding objective in this region. Fifty two rice bean genotypes were evaluated in *kharif* seasons for three consecutive years to select suitable genotypes for cultivation in this region and identify suitable parents for hybridization programmes. Wide range of variability was observed for the characters studied. Grain yield was found to be positively correlated with all the characters except days to maturity. Two lines, IC 187911 and RCRB 1-3 with high grain yield/plant, average stability and predictable performance over three years, were identified as suitable for cultivation in the region. An analysis of the percentage contribution to genetic diversity revealed that 100-seed weight and pod yield/plant were the major contributing characters towards genetic diversity. Based on the diversity in clusters and their mean performances for various characters, probable parents were identified for developing high yielding and early maturing genotypes.

Key words: D^2 statistic, Genotypic variation, Jhum cultivation, Rice bean, Stability.

INTRODUCTION

Rice bean [*Vigna umbellata* (Thunb) Ohwi & Ohashi = *Phaseolus calcaratus* Roxb.] is a native of South and South East Asia. It is a multipurpose grain legume crop mainly cultivated for food, fodder and green manure specifically by the resource poor farmers in the marginal areas of South Asia and South East Asia. It is mainly cultivated in the tropical and sub tropical climatic region of south and south East Asia such as Nepal, India, Bangladesh, Thailand, Vietnam and China (Gautam 2007). In India, as a cultigen, its distribution is mainly confined to the tribal regions of north eastern hills and hilly tracts of Western and Eastern Ghats. In the North Eastern region of India (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura), rice bean, an underutilized crop, is mostly cultivated in the non irrigated and marginal land which, otherwise, remains uncultivated. High suitability of rice bean for intercropping with maize also shows its potential to increase food production. Similarly, being a grain legume, it is also effective in Nitrogen fixation in the soil and, thus, improves soil quality that plays a positive role in increasing the production of subsequent crops. In addition, it is also a valuable fodder crop. In this sense, cultivation of rice bean is considered to be important in contributing towards food and nutritional security and utilize uncultivated marginal land (Gautam 2007). In the North Eastern region of India, rice bean is an important component of the 1.7 million ha area of shifting cultivation (Sarma *et al.* 1995) for upliftment of the socio economic condition of farmers. Rice bean exhibits photosensitivity in terms of flowering and reproduction. Depending upon genotypes it starts blooming in September and October as the day length is reduced and pods mature in November-December. Accordingly, this

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crop is sown in June- July (*kharif*) and harvested in November – December. Most of the local land races, available with farmers, are highly photosensitive. This crop is essentially grown as rainfed. Highly photosensitive genotypes bloom very late and face terminal drought at the time of pod formation. Development of high yielding and early maturing rice bean genotypes is the prime breeding objective in this region. Further, the crop is grown in jhum areas with little inputs and climatic conditions vary from year to year. Genotypes having wider adaptability to varying climatic conditions are desirable. Fifty two (52) genotypes of rice bean, collected from various parts of north eastern hill region, NBPGR and other sources were evaluated for variability, correlation, path and stability analyses for ten morphological quantitative traits to select suitable genotypes for this region. The objective was also to take up hybridization programme to identify suitable genotypes in the segregating population. For this, D^2 analysis was carried out to identify suitable parents for crossing. Results of variability, correlation, path, stability and genetic divergence analyses are reported for ten morphological traits.

MATERIALS AND METHODS

Fifty two genotypes of rice bean were evaluated during *kharif* (rainy season) in three consecutive years (2008, 2009 and 2010) at the experimental farm of Plant Breeding Division, ICAR Research Complex for NEH Region, Barapani, Meghalaya, in RBD with two replications, at a spacing of 50 cm X 10 cm and row length of 4 m in a 5-row plot with three checks *viz.*, RBS-16, RBS-53 and RCRB 1-2. The recommended agronomic practices and plant protection measures were followed to ensure normal crop growth. Observations were recorded for days to flowering, plant height, days to maturity, number of branches/plant, stem thickness, pod length, number of seeds/pod, 100-seed weight, pod yield/plant and grain yield/plant on ten randomly selected plants in each replication. Mean values were used for analysis of variance (Panse and Sukhatme 1978), phenotypic and genotypic variances and covariances (Burton and Devane 1953), heritability (Hanson *et al.* 1956), genetic advance (Johnson *et al.* 1955), genotypic and phenotypic correlation coefficient and path coefficient (Dewey and Lu 1959). Stability analysis was carried out following Eberhart and Russel (1966). The data were subjected to analysis of genetic divergence through D^2 statistic (Mahalanobis 1936) to measure genetic divergence as suggested by Rao (1952). Tocher's method was used to form clusters.

RESULTS AND DISCUSSION

Genetic variability, heritability and genetic advance: Analysis of variance (table not shown) revealed that genotypic differences were significant for all the characters studied. The range of variation was maximum in plant height (Table 1). Pod length was the most conservative trait as it had the least range of 1.7 cm (8.3-10.0 cm) followed by number of seeds/pod which had a range of 2.0 (6.2-8.2) only. High phenotypic and genotypic coefficients of variation were observed for pod weight/plant and 100-seed weight (Table 1). In all the traits, the phenotypic coefficients of variation were slightly higher than the corresponding genotypic coefficients of variation. The 100-seed weight and pod weight/plant, not only exhibited high GCV and PCV, but also had high heritability and genetic advance values. Grain yield/plant exhibited high heritability and moderate genetic advance. Days to flowering and days to maturity exhibited high heritability values

TABLE 1: Estimation of GCV, PCV, heritability and genetic advance in rice bean

Characters	Mean	Range	GCV(%)	PCV(%)	Heritability (%)	Genetic advance (% of mean)
Days to flower	74	55.67-80.83	8.20	10.51	60.34	13.06
Days to maturity	141	112.5-157.3	4.20	6.09	48.25	6.06
Plant height (cm)	145.14	90.8-219.7	15.80	32.46	23.79	15.90
Branches/plant	4.86	3.8-6.3	8.60	22.73	14.32	6.71
Stem thickness (mm)	5.76	3.9-6.3	9.80	19.21	26.20	10.36
Pod Length (cm)	9.16	8.3-10.0	3.40	8.61	15.98	2.84
Seeds/pod	7.00	6.2-8.2	2.90	14.19	4.24	1.24
100-seed Wt (g)	20.38	2.3-39.6	33.90	44.54	58.03	53.25
Pod wt/plant (g)	28.09	3.3-54.8	33.90	45.04	56.91	52.81
Yield/Plant (g)	8.30	5.1-13.4	18.70	19.31	93.33	37.12

but low genetic gain. High heritability and moderate to low genetic advance suggested for high proportion of genetic component of variation with respect to total variation (high heritability) but the existence of low magnitude of total variability for these traits (low genetic advance). Less range in days to flower and days to maturity may be explained by the highly photosensitive nature of this crop. Rice bean is a short day crop (Sarma *et al.* 1995, Chaudhury and Prasad 1972, Chandel *et al.* 1988, Lokesh *et al.* 2003) and irrespective of the sowing time it flowers when day length starts to reduce in September. Because of the photosensitive nature, most of the genotypes flower and later mature in a short span of time and this result in low variation for these traits. However, significant genotypic differences for these traits and high heritability estimates suggest that selection for early maturing types is possible in this collection. High phenotypic and genotypic coefficients of variation (%) for 100- seed weight have also been reported by Borah *et al.* (2002). They have also reported the high heritability but low genetic advance values for grain yield/plant as in this case.

Character association and path coefficient analysis: Genotypic and phenotypic correlation coefficients were worked out among ten traits in 52 genotypes (Table 2) and these indicated association between almost all the traits studied, which might have occurred due to the pleiotropic action of genes, linkage or more likely both.

Grain yield was found to be significantly and positively correlated with all the traits except days to maturity. Rice bean is a long duration crop and one of the breeding objectives is to reduce the maturity duration in this crop. No correlation between days to maturity and yield/plant suggested that selection for early maturity will not hamper yield. Significant positive association of grain yield with plant height, pod length, number of seeds/pod and 100-seed weight has also been reported earlier (Borah *et al.* 2002, Islam *et al.* 2002). Most of the associations among other characters were significantly positive except between *100-seed* weight and number of seeds/pod, which was negative. Days to flower and days to maturity were positively correlated with all the traits except seeds/pod. In the present investigation the path coefficient

TABLE 2: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among the ten characters of rice bean

Characters	Days to Flower	Days to Maturity	Plant Height	Branches/ Plant	Stem Thickness	Pod Length	Seed/ pod	*100-seed* Wt	Pod wt/ plant	Yield/Plant
Days to flower	**1.000**	0.346	0.701	0.368	0.713	0.781	0.044	0.691	0.536	0.538
Days to maturity	0.148 **	**1.000**	0.383	0.407	0.430	0.427	0.177	0.381	0.180	0.166
Plant Height	0.196 ***	0.267 ***	**1.000**	0.755	0.824	0.944	0.939	0.542	0.519	0.524
Branches/plant	0.129 *	0.056	0.166 **	**1.000**	0.415	0.518	0.053	0.486	0.348	0.328
Stem thickness	0.228 ***	0.210***	0.477 ***	0.345***	**1.000**	0.995	0.915	0.567	0.596	0.585
Pod Length	0.247 ***	0.155 **	0.211 ***	0.097	0.174**	**1.000**	0.460	0.802	0.753	0.742
Seeds/pod	0.003	0.024	0.114 *	0.049	0.064	0.550 ***	**1.000**	-0.149	0.619	0.621
100-seed Wt	0.526 ***	0.251 ***	0.248***	0.161 **	0.278 ***	0.309 ***	-0.061	**1.000**	0.326	0.323
Pod wt/plant	0.245 ***	0.090	0.192***	0.173 **	0.240***	0.283 ***	0.225 ***	0.231 ***	**1.000**	0.998
Yield/Plant	0.250***	0.068	0.181**	0.162**	0.236***	0.286***	0.222***	0.233***	0.988***	**1.000**

*, ** and *** - Significant at 5%, 1% and 0.1% level

analysis was worked out to estimate the direct and indirect contribution of various traits towards grain yield/plant (Table 3). Further compartmentalization of correlation coefficients into direct and indirect effects discerned the true nature of association between two traits. Maximum positive direct effect on yield was exhibited by pod weight/plant followed by pod length and plant height. Path coefficient analysis identified the pod weight/plant as the most important character as it, not only, had the maximum direct effect but all other characters also exhibited their maximum positive indirect effects through this trait. Plant height and pod length also exhibited positive indirect effects. Similar path coefficient results for plant height, pod length and number of pods/plant have also been reported earlier (Islam *et al.* 2002). Negative direct effect on grain yield was exhibited by days to flower, branches/plant, stem thickness, seeds/pod and 100-seed weight and it was maximum for stem thickness. High negative direct effect of stem thickness and branches/plant was compensated by very high indirect effect of these traits through pod yield/plant.

Stability parameters of genotypes: The variances due to environment and G x E interactions were significant for days to maturity, plant height, branches/plant, stem thickness, pod yield/plant and grain yield/plant (Table 4). Significant variance due to environment indicated that the environment played a major role in causing variation. Significant mean squares due to G x E interaction indicated that the genotypes interacted considerably with environmental conditions that existed over different years. The environment (linear) and environmental interaction [G x E (linear)] components were highly significant for all of these 6 traits. Significant pooled deviation (non-linear) was observed for grain yield/plant and pod yield/plant. Significant pooled deviation suggested that the performance of different varieties fluctuated considerably in respect to their stability for these characters. Thus, while for pod yield/plant and grain yield/plant, both predictable (linear) and unpredictable (non linear) components contributed significantly, for other characters only linear components were important.

Stability parameters were worked out for three important traits, namely, days to maturity,

TABLE 3: Estimates of direct and indirect effects at genotypic level rice bean

Characters	Days to Flower	Days to Maturity	Plant Height	Branches/ Plant	Stem Thickness	Pod Length	Seed/ pod	*100-seed* Wt	Pod wt/ plant
Days to flower	**-0.0173**	-0.006	-0.0122	-0.0064	-0.0124	-0.0135	-0.0008	-0.012	-0.0093
Days to maturity	0.0057	**0.0164**	0.0063	0.0067	0.0071	0.007	0.0029	0.0062	0.0029
Plant Height	0.0932	0.0508	**0.1329**	0.1003	0.1095	0.1255	0.1248	0.072	0.0691
Branches/plant	-0.0379	-0.0419	-0.0777	**-0.103**	-0.0427	-0.0534	-0.0055	-0.0501	-0.0359
Stem thickness	-0.141	-0.0851	-0.163	-0.0821	**-0.1979**	-0.1969	-0.181	-0.1121	-0.1179
Pod Length	0.1607	0.0879	0.1944	0.1067	0.2048	**0.2059**	0.0947	0.165	0.1551
Seeds/pod	-0.0013	-0.0052	-0.0274	-0.0016	-0.0267	-0.0134	**-0.0292**	0.0044	-0.0181
100-seed weight	-0.0481	-0.0265	-0.0377	-0.0338	-0.0394	-0.0557	0.0104	**-0.0695**	-0.0227
pod wt/plant	0.5238	0.176	0.508	0.3407	0.5828	0.7369	0.6051	0.3192	**0.978**
*rg with Yield/plant	0.538	0.166	0.524	0.328	0.585	0.742	0.621	0.323	0.998

Residual effect = 0.070; *rg = Genotypic coefficient of correlation with yield/plant
Diagonal bold values indicate direct effects

TABLE 4: Pooled analysis of variance (mean sum of squares) in rice bean over three environments

Source	Df	Days to Maturity	Plant Height	Branches / Plant	Stem Thickness	Grain Yield/ Plant	Pod Yield/Plant
Genotype (G)	51	126.08***	2429.08***	1.04***	1.41***	160.73***	309.83***
Year (E)	2	720.17***	78042.81***	122.74***	143.07***	87.15*	204.10**
G x E	102	25.30***	974.14***	0.70***	0.48***	30.99*	60.75*
Env + (G x E)	104	38.66***	2456.23***	3.05***	3.22***	32.07*	63.51*
Env. (linear)	1	1440.34***	156085.62***	245.48***	286.14***	174.31**	408.20**
G x E (linear)	51	39.17***	1823.27***	1.27***	0.84***	43.50**	84.04**
Pooled Deviation	52	11.21	122.62	0.13	0.12	18.13***	36.74***
Pooled Error	156	15.00	759.80	0.40	0.43	8.15	16.27

*, ** and *** - Significant at 5%, 1% and 0.1% level

TABLE 5: Estimates of stability parameters in rice bean over three environments

Genotype	Days to Maturity			Grain yield/plant			Pod yield/plant		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
RBS 16	152.7	-0.47	-17.2	25.25	-4.53	45.71*	34.01	-4.25	86.33*
RBS 53	140.5	0.66	6.2	22.76	-5.06	-3.17	30.41	-3.93	-13.77
RCRB 1-2	137.2	0.73	-11.0	19.07	-2.10	-3.76	25.48	-1.77	-13.11
RBS 35	135.7	1.66	60.8 *	25.47	-2.08	24.41*	35.39	-1.95	43.54
EC 12562	142.5	0.53	-4.5	14.57	-2.07*	-8.11	20.05	-1.44	-14.79
EC 18155	138.3	-0.21	-13.3	22.45	6.13	55.11 **	30.21	5.44	78.83*
RCRB 1-3	136.3	0.66	10.4	33.25	-2.90	11.03	45.81	-1.84	3.71
EC114077	157.3	1.56	-4.1	30.53	1.78	26.24 *	43.54	4.06	73.09 *
EC 37221	149.2	3.89	-5.8	26.27	-0.15	-7.79	37.23	-1.08	-3.61
RCRB 1-5	149.0	3.29*	-17.6	20.79	4.79	8.93	28.40	4.46	16.13
EC 18181	140.5	1.67	-8.2	22.06	4.32	-2.08	30.57	4.34	-6.88
RBS 24	112.5	2.00	21.0	26.46	0.63	14.79	35.51	0.47	4.14
IC 20769	140.0	1.88*	-18.3	19.38	1.38	-4.12	26.40	0.58	-2.77
IC 156691	151.3	3.18	54.9 *	20.35	4.98	-2.49	27.50	4.74	-6.60
IC 19097	150.3	3.57	5.2	20.51	-0.41*	-8.17	28.08	-0.91	-15.95
IC 16742	149.0	2.84	16.8	21.58	2.33	2.16	30.00	1.70	15.13
IC 97882	144.5	1.96	-9.7	22.47	-3.19	18.04	31.85	-1.91	54.42 *
IC 2696	138.0	0.60	-14.8	18.72	2.46	5.29	25.73	1.77	-6.90
RBL 1	139.5	2.09	-15.4	39.57	9.40	159.35***	54.82	7.44	506.50***
RBS 15	140.0	0.40	-12.2	27.71	3.73	12.00	38.12	4.24	30.67
IC 15668	145.8	2.22	-12.1	24.07	3.24	0.33	32.30	2.36	-9.42
EC 18155	138.0	-0.06	-14.9	13.90	-0.89	0.19	18.96	-0.59	-4.30
IC 187911	143.3	0.28	-7.8	33.43	2.42	-2.35	46.05	3.01	7.58
RBS 2	147.0	2.22	-9.9	21.62	1.66	-5.15	30.37	0.98	-11.50
RBS 110	146.2	2.35	-17.6	26.95	3.19	0.39	35.93	2.41	-4.74
IC 176563	147.8	2.16	12.7	23.99	2.70	16.89	33.83	4.02	13.43
RBL 39	145.5	2.49	-15.5	22.44	2.89	-7.75	32.03	2.30	-15.24
IC 15510	138.5	0.20	-17.9	22.17	-6.94	104.65 ***	31.23	-6.47	137.30 **
EC 958	149.2	2.97	-3.3	23.40	3.30*	-8.15	32.70	3.23	-16.03
IC 3074	138.3	0.54	-18.1	25.35	4.94	-0.34	35.51	3.38	2.17
IC 19350	138.8	0.13	-18.1	20.09	-0.87	-2.79	27.97	-1.01	-13.15
PRR 9402	136.8	0.53	-9.9	25.92	-1.97	-3.64	36.11	-0.60	-7.23
PRR 8901	136.8	0.07	-17.2	18.47	-1.71	-4.92	25.40	-1.96	-9.08
PRR 9401	137.8	0.53	-15.5	10.65	8.49	21.48	14.71	7.61	27.67
PRR 8801	136.7	0.80	-13.9	21.63	2.64	-0.74	30.61	3.73	3.60
CxM-12-P2	139.0	-0.47	-17.9	25.52	1.46	-6.95	35.01	1.12	-12.92
RBL 6	137.5	0.134*	-18.3	25.34	0.93	4.23	34.52	0.67	-8.68
Naini	137.5	-0.07	-17.9	15.66	7.03	20.86	22.21	6.62	51.54 *
PRR 2	141.2	1.27	-16	10.76	-1.18	-8.05	14.73	-1.08*	-16.38
MNPL 2	137.8	0.14	-14.2	7.85	-0.71	-5.21	10.53	-0.73	-12.22
MNPL 3	140.3	0.53	-15.5	5.56	0.77	-7.15	7.57	0.86	-15.03
MNPL 1	139.3	1.00	-5.8	12.44	-2.03*	-8.02	16.98	-1.93*	-16.13
LRB 188	143.0	0.00*	-18.3	11.89	3.63	0.25	16.71	3.25	-7.58
PRR 9302	136.5	-0.13*	-18.3	14.62	7.88	31.14 *	20.90	8.10	62.94 *
PRR 9301	137.8	0.06*	-18.3	9.63	0.82	-7.92	12.77	0.58	-14.63
RCRB 1-6	143.5	0.62	26.5	20.98	-5.31	39.68*	28.37	-4.73	94.15 *
RCRB 6-10	138.8	-0.13	-7.6	19.12	2.75	48.99**	26.37	2.53	94.01 *
BRS 1	138.8	0.41	-14.2	4.83	1.55	-2.93	6.54	1.28	-7.28
PRR 1	138.0	0.07	-17.9	2.34	-0.28*	-8.16	3.26	-0.27*	-16.37
RBL 52	138.5	-0.55	-5.1	17.73	-3.68*	-8.05	24.22	-2.97	-13.14
BD 139-1	138.8	-0.41	-15.7	19.85	-3.00	-7.81	26.75	-2.45*	-16.03
EC 2074	137.5	-0.40*	-18.3	22.27	-1.14*	-8.17	30.25	-1.40*	-16.31

grain yield/plant and pod yield/plant. The genotypes RCRB 1-5 and IC 20769 were below average, RBL 6, LRB 188, PRR 9302, PRR 9301, EC 2074 were above average and all other genotypes were average in stability of maturity (Table 5). Two genotypes exhibited significant non-linear component indicating that these genotypes are very sensitive and unpredictable to environmental changes. With respect to stability in maturity RBS 24 was the most desirable genotype as this genotype took least number of days to mature and had non significant bi and S^2di values. For grain yield/plant six genotype were above average, one below average and others were average in stability. RBL 1 was the highest grain and pod yielding genotype, average in stability but significant S^2di forbids its recommendation to jhum areas which are full of unpredictable environments. Non significant bi and S^2di and high mean values for grain yield /plant and pod yield/plant were exhibited by IC 187911 and RCRB 1-3. RCRB 1-3 had second lowest number of days to maturity and IC 187911 was of moderate maturity duration. IC 187911 exhibited non significant S^2di and bi for all other traits and RCRB 1-3 exhibited above average stability for branches/plant, average stability for all other characters and non significant S^2di for all characters. Considering these results, RCRB 1-3 and IC 187911 may be recommended for cultivation in this region. From maturity point of view the earliest maturing genotype RBS 24 with relatively high grain yield and non significant S^2di may also be recommended for cultivation. Stability analysis model for identification of suitable rice bean genotypes has been practiced by various workers (Singh *et al.* 1998, Thaware *et al.* 1998).

Genetic divergence analysis: All of the fifty two genotypes could be grouped into five clusters (Table 6). Maximum number of genotypes (37) was retained by cluster I followed by cluster II (12) and all other three clusters had one genotype each. Among clusters I and II, with more than one genotype, the diversity was more in cluster II. Maximum genetic distance was observed between clusters II and V followed by II and IV, and II and III (Table 7). Maximum grain yield/plant (25.25 g) was exhibited by cluster IV which contained only one genotype (RBS 16) followed by cluster I (22.51g). Cluster IV and I retained late maturing, tall genotypes which had thick stem, long pods and high pod yield/plant. Cluster III with PRR 9302 alone exhibited least number of days to maturity (136.5) followed by cluster II (136.69 days). In this crop one of our main breeding objectives is to develop genotypes with early maturity and high yield. For this purpose genotype PRR 9302 (earliest maturing, cluster III) and those in cluster II would be crossed with RBS 16 (highest yielding, cluster IV) or one of the genotypes of cluster I (second highest yielder) to unleash a wide array of variability for these two traits. The maximum contribution towards the total divergence was from 100-seed weight followed by number of branches per plant and pod weight/plant.

TABLE 6: Distribution of fifty two rice bean genotypes into different clusters on the basis of D^2 statistics

Clusters	No. of genotypes	Genotypes
I	37	*RBS 53, RCRB 1-2, RBS 35, EC 12562, EC 18155, RCRB 1-3, EC 114077, EC 37221, RCRB 1-5, EC 18181, IC 20769, IC 156691, IC 19097, IC 16742, IC 97882, IC 2696, RBL 1, RBS 15, IC 15668, EC 18155, IC 187911, RBS 2, RBS 110, IC 176563, RBL 39, IC 15510, EC 958, IC 3074, IC 19350, PRR 8901, PRR 8801, MNPL 2, RCRB 1-6, RCRB 6-10, RBL 52, EC 2074, BD 139-1*
II	12	RBS 24, 9402, PRR 9401, CxM-12-P2, RBL 6, Naini, PRR 2, MNPL 3, LRB 188, PRR 9301, BRS 1, PRR 1
III	1	PRR 9302
IV	1	RBS 16
V	1	MNPL 1

TABLE 7: Inter- and intra-cluster distances ($\sqrt{D^2}$) in ten clusters of rice bean

Clusters	I	II	III	IV	V
I	1.57	3.23	2.64	3.2	4.83
II		1.8	4.86	5.66	7.21
III			0	1.7	2.53
IV				0	2.47
V					0

REFERENCES

Borah, H.K., Debchoudhury, P.K., Sheikh, I.A. and Barman, B. (2002). Genetic parameters correlations and path analysis among yield and yield characters in rice bean (*Vigna umbellata* (Thunb.) Ohwi and Ohasi). *Madras Agric. J.* **88**: 629-632.

Burton, G.W. and Devane, E.H. (1953). Estimating heritability in tall fescue (*Festuca arundanacea*) from replicated clonal material. *Agron. J.* **45**: 478-481.

Chandel, K.P.S, Arora, R.K. and Pant, K.C. (1988). Rice bean – A potential grain legume. *NBPGR Sci. Monogr.* No. **12**. NBPGR, New Delhi, pp 1-60.

Chaudhury, A.P. and Prasad, B. (1972). Flowering behaviour and yield of rice bean (*Phaseolus calcaratus* Roxb.) in relation to date of sowing. *Indian J. Agri. Sci.* **42**: 627-630.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested grass seed production. *Agron. J.* **51:** 515-518.

Eberhardt, S.A. and Russel, W.A. (1966). Stability parameters for comparing varieties. *Crop Sci.* **6**: 34-46.

Gautam, R. (2007). Food security through ricebean research in India and Nepal (FOSRIN) *Report 1*. Distribution of ricebean in India and Nepal

Hanson, C.H., Robinson, H.F. and Comstock, C.E. (1956). Biometrical studies of yield in segregating populations of Korean laslpedegza. *Agron. J.* **48**: 268-272.

Islam, A., Duara, P.K., Barua, P.K. (2002). Genetic variability in a set of rice bean genotypes assessed over sowing dates. *J. Agri. Sci. Soc. N. E. India*, **15**: 61-66.

Johnson, H.W., Robinson, H.F. and Comstcock, R.E. (1955). Estimates of genetic and environmental variability in soybean. *Agron. J.* **47**:314-318.

Lokesh, Verma, P. K., Gupta, S.N. and Behl, R.K. (2003). Path coefficient analysis for various morphological and quality parameters in rice bean [*Vigna umbellate* (Thunb.) Ohwi and Ohashi]. *Natnl. J. Pl. Improv.* **5**: 116-119.

Mahalanobis, P.C. (1936). On the generalized distance in statistics. *Proc. Natl. Acad. Sci., India* **2**: 49-55

Panse, V.G. and Sukhatme, P.V. (1978). Statistical Methods for Agricultural Workers, ICAR, New Delhi.

Rao, C.R. (1952). Advanced Statistical Methods in Biometrical Research, John Wiley and Sons, New York.

Sarma, B.K., Singh, M., Gupta, H.S., Singh, G. and Srivastava, L.S. (1995). Studies in rice bean germplasm. *Research Bulletin #* **34**. ICAR Research Complex for North East Hill Region, Barapani (Umiam), India pp70.

Singh, G., Chaudhar, B.S. and Singh, S.P. (1998). Stability analysis of some agro-morphological characters in ricebean. *Ann. Agr. Res.* **19**: 411-414.

Thaware, B.L., Birari, S.P., Dhonukshe, B.L. and Jamadagni, B.M. (1998). Stability analysis for grain yield in rice bean. *Indian J. Agric. Res.* **32**: 17-20