Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 3 (2): 239-242, 2004
ISSN 1682-3974

Stability Analysis for Pod and Seed Production in Dry Bean (*Phaseolus vulgaris* L.)

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Abstract: Genotype-environment interaction was studied for number of pods and seeds plant^{-1} in nine genotypes of dry bean under four cultural environments during rabi season of 2001-2002. There were significant variations due to genotypes (G), environments (E) and G×E interaction for both the characters, which were also highly correlated between themselves (r=0.920**). On the basis of stability parameters (Pi, bi, S^2di) genotype PB-S8 was found to be most desirable and stable.

Key words: G×E interaction, stability, dry bean, *Phaseolus vulgaris* L.

INTRODUCTION

Dry bean (*Phaseolus vulgaris* L.), also called french bean, common bean, rajmah bean, kidney bean etc., is one of the most important legume crops in the world. In Bangladesh, it is sporadically cultivated in some areas of Sylhet, Chittagong, Cox's Bazar and Chittagong Hill Tracts; but in recent times some non-govt. organizations (NGO's) have ventured on commercial production of dry bean and already started exporting little quantity of the produce (both green pod and dry seeds) to some European countries[1]. A study of genotype-environment interaction is of much value in the selection of better genotypes. In dealing with instability and uncertainity of yield and in developing improved varieties for wide cultivation, genotype-environment interaction is of major consideration to the plant breeders[2]. Ram and Dhar[3] conducted stability analysis in french bean genotypes under different fertilizer induced environments. Pan *et al.*[4] studied G×E interaction in dry bean considering pod characters. Islam and Newaz[5] studied G×E interaction for seed per pod including other yield components. The present research work was undertaken with a view to studying genotype-environment interaction and to identify stable and high yielding genotypes with greater pod and seed production under changing cultural environments.

MATERIALS AND METHODS

The field experiment for the study was carried out in a randomized complete block design with three replications at the Genetics and Plant Breeding Field laboratory, Bangladesh Agricultural University, Mymensingh during rabi season of 2001-2002. Some of the genotypes used in the study were received from CIAT (Centro International de Agricultura Tropical), Columbia, through the Govt. sponsored Crop Diversification Program (CDP) while the others were locally collected and developed. The cultural environments were created by the application of different rates of chemical fertilizers (NPKSZn) and a common dose of cowdung manure (Table 1). The unit block (replication) measured 3 m in length and 6 m in width, block to block distance was 60 cm, row to row distance 30 cm and plant to plant distance maintained at 10 cm. Standard agronomic practices were followed. The crop was harvested individually for each genotype when over 90% of the plants with mature pods withered and turned brown. Data recorded on number of pods per plant and number of seeds per plant were subjected to statistical analysis as required for the study following standard practice[6, 7]. Eberhart and Russell's[2] model was employed for genotype-environment interaction and stability analysis. The analysis was also extended to Francis and Kannenberg[8] genotype grouping technique.

RESULTS AND DISCUSSION

The results of the combined analysis of variance after Eberhart and Russell's[2] model are presented in Table 2. The mean squares due to genotypes and environments for number of pods per plant and number of seeds per plant were found significant, suggesting the existence of considerable variation among genotypes, as well as environments. The genotype-environment interaction when tested against pooled error was found significant for both the characters, indicating that they were highly

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Table 1: Four cultural environments as differentiated by application of chemical fertilizer and manure package used in the study

Environments	Package of fertilizer and manure
Env.-1	Cowdung = 10000 kg ha^{-1}; Urea = 80 kg ha^{-1}; TSP = 100 kg ha^{-1}; MP = 40 kg ha^{-1}; Gypsum = 100 kg ha^{-1}; $ZnSO_4$ = 10 kg ha^{-1}.
Env.-2	Cowdung = 10000 kg ha^{-1}; Urea = 120 kg ha^{-1}; TSP = 150 kg ha^{-1}; MP = 60 kg ha^{-1}; Gypsum = 120 kg ha^{-1}; $ZnSO_4$ = 15 kg ha^{-1}.
Env.-3	Cowdung = 10000 kg ha^{-1}; Urea = 160 kg ha^{-1}; TSP = 200 kg ha^{-1}; MP = 80 kg ha^{-1}; Gypsum = 140 kg ha^{-1}; $ZnSO_4$ = 20 kg ha^{-1}.
Env.-4	Cowdung = 10000 kg ha^{-1}.

Table 2: The analysis of variance for number of pods and seeds plant^{-1} after Eberhart and Russell's model in a Genotype-Environment interaction study in dry bean

Item	df	Number of pods per plant	Number of seeds per plant
Genotype (G)	8	7.60*	168.95**
Environments (E)	3	14.33**	100.98**
Genotype x Environment	24	1.70*	40.86**
Env. + Gen. x Env.	27	3.10	47.54
Environment (linear)	1	42.99**	302.95*
Gen. x Env. (linear)	8	0.67	19.50
Pooled deviation	18	1.97**	45.82**
Pooled error	72	0.89	14.96

* $P<0.05$, ** $P<0.01$

influenced by the changes in environments. The variance due to pooled deviation was found significant for both the characters suggesting that the performance of different varieties fluctuated significantly from their respective linear path of response to environments. Harer *et al.*[9] also found significant genotype, environment and G×E interaction in rajmah bean for number of pods per plant. Genotype-environment interactions (linear) for both the traits were found non-significant but pooled deviation mean square was significant indicating that in the performance of the genotypes were unpredictable.

The mean performance of the individual genotype along with their stability parameters (Pi, bi and S^2di) for number of pods per plant are presented in Table 3. It was observed that the genotypes grown in Env. 2 produced on an average the highest number (11.50) of pods per plants followed by (11.35) Env. 3. Thus Env. 2 (10.93) was the most favourable one for this trait and the majority of the genotypes had the capacity to exploit this environment to produce highest number of pods per plant. The genotype means over the four environments ranged from 6.32 to 9.62 and PB-125 gave the highest number of pods per plant (9.62), whilst the genotype PB-124 gave the lowest number of pods per plant (6.32).

The stability parameters of the individual genotypes (Table 3) indicated that none of the genotypes showed linear response. Thus, non-linear components were only responsible for significant genotype-environment interaction. On an average of environments the genotype PB-125 had the highest phenotypic index (P_1= 1.96) with highest number of pods per plant (9.62). As to other genotypes, PB-S8 and PB-S9 also had comparable high positive phenotype indices and number of pods, so these genotypes were also desirable for this character. Genotype PB-S9 had significant S^2di value, suggesting that the performance of this genotype over environment could not be predicted.

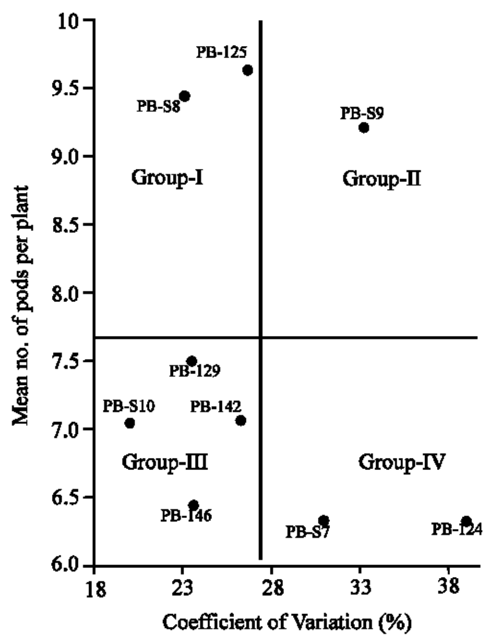

Fig. 1: Genotype grouping after Francis and Kannenberg using mean and CV for number of pods per plant of nine genotypes of dry bean in four environment

According to Francis and Kannenberg's[8] genotype grouping technique, the most stable and potential genotypes for number of pods per plant were those, which are placed in group 1 (Fig. 1) they registered higher number of pods per plant with consistent performance over environments. Upon grouping technique, genotypes PB-S8 and PB-125 could be considered stable and desirable for number of pods per plant, this result thus resembled Eberhart and Russell's[2] stability model.

The stability parameters along with the means of seeds per plant of different genotypes in different environments are presented in Table 4. Genotype means

Table 3: Average number of pods per plant, coefficient of variation (CV%), response and stability parameters of nine genotypes of dry bean evaluated under four environments using Eberhart and Russell's model

Genotypes	Environments Env-1	Env-2	Env-3	Env-4	Mean	CV%	Phenotypic index (Pi)	Regression coefficient (Bi)	Deviation from regression (S^2di)
PB-124	9.77	6.00	5.01	4.50	6.32	39.07	1.34	0.65	6.64**
PB-125	10.67	10.93	10.25	6.62	9.62	26.73	1.96	1.56	-0.53
PB- 129	7.33	8.42	9.04	5.17	7.49	23.54	-0.17	1.25	-0.25
PB-142	7.00	9.08	6.31	5.83	7.06	26.30	-0.6	0.84	0.51
PB –146	6.90	8.21	5.51	5.13	6.44	23.64	-1.22	0.82	0.48
PB-S7	5.59	7.86	7.87	3.98	6.33	31.00	-1.33	1.37	0.06
PB-S8	8.69	11.50	9.73	7.80	9.43	23.12	1.77	1.08	0.12
PB-S9	7.55	10.44	11.35	7.47	9.20	33.28	1.54	1.09	2.26*
PB-S10	7.50	6.21	8.38	6.07	7.04	20.04	-0.62	0.35	0.67
Env. mean	7.89	8.74	8.16	5.84	7.66 $\bar{x}$.	27.41 CV%.			
Env index	0.232	1.081	0.504	-1.817					

* P<0.05, ** P<0.01

Table 4: Average number of seeds per plant, coefficient of variation (CV%), response and stability parameters of nine genotypes of drybean evaluated under four environments using Eberhart and Russell's model

Genotypes	Environments Env-1	Env-2	Env-3	Env-4	Mean	CV%	Phenotypic index (Pi)	Regression coefficient (Bi)	Deviation from regression (S^2di)
PB-124	33.73	16.48	6.61	16.77	18.40	62.16	-8.23	1.02	158.56**
PB-125	39.87	47.73	39.81	26.16	38.39	23.89	11.76	2.56	-4.17
PB- 129	32.13	26.67	27.50	20.80	26.78	27.05	0.15	1.11	-2.26
PB-142	25.23	31.17	13.10	21.07	22.64	33.73	-3.99	1.18	48.90*
PB –146	21.80	19.17	16.07	19.57	19.15	20.82	-7.48	0.12	-5.91
PB-S7	21.70	27.41	30.77	15.84	23.93	35.18	-2.700	1.23	25.16
PB-S8	31.08	37.89	30.77	25.98	31.43	29.44	4.800	1.30	-6.26
PB-S9	26.74	36.49	38.52	28.48	32.06	32.84	5.430	0.41	47.07*
PB-S10	26.71	23.14	34.18	23.54	26.89	21.45	0.26	0.06	25.13
Env. mean	28.56	29.57	26.39	22.02	26.63 $\bar{x}$.	31.84 CV%			
Env. index	1.926	2.942	-0.26	-4.608					

* P<0.05, ** P<0.01

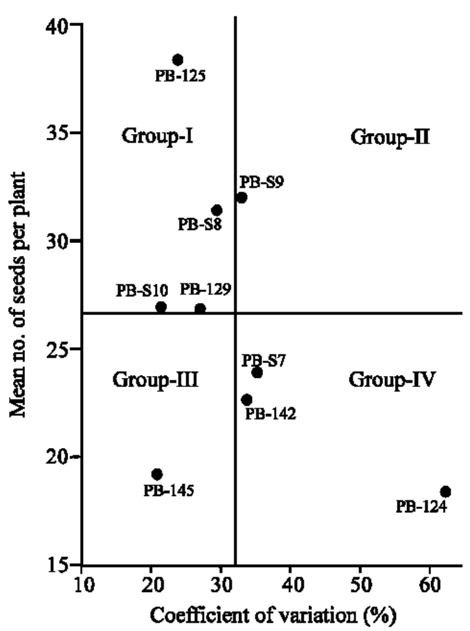

Fig. 2: Genotype grouping after Francis and Kannenberg using mean and CV for number of seeds per plant of nine genotypes of dry bean in four environments

for number of seeds per plant varied from 18.40 to 38.39 and environmental mean from 22.02 to 29.57. Five genotypes viz. PB-125, PB-129, PB-S8, PB-S9 and PB-S10 had positive phenotypic index values and were desirable for this trait.

The results showed that all the genotypes except PB-124, PB-142 and PB-S9 showed non-significant S^2di values which suggest that these genotypes were relatively stable under environmental fluctuations. All the genotypes showed positive bi values. Taking all the parameters into consideration, it was evident that genotypes PB-125, PB-129, PB-S8 and PB-S10, having bi≅1 and S^2di≅0, were less sensitive and desirable for this trait.

According to Francis and Kannenberg's[8] genotype grouping technique (Fig. 2) genotypes PB-S10, PB-129, PB-125 and PB-S8 were placed in group-1, which recorded high number of seeds per plant with less cv% so they might be considered stable and desirable for this trait; similar results were also obtained in Eberhart and Russell's[2] stability model.

An estimation of correlation coefficient between these two close components of yield showed they were highly positively correlated, r=0.920 (P< 0.01). Based on the results on both number of pods and number of seeds per plant genotype PB-S8 could be considered the best and most desirable.

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