Journal of Biological Sciences 3 (11): 1026-1031, 2003
ISSN 1727-3048

Genotype-Environment Interaction and Stability Analysis in Soybean

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Abstract: Genotype × environment interactions through different stability parameters and performance of the traits of genotypes were studied. The traits were; days to maturity, number of branch/plant, 100 seed weight and seed yield/plant in ten soybean genotypes across five environments represented by sowing dates. Significant difference were observed for genotypes, environments and genotype-environment interaction. Stability analysis after Eberhart and Russell's model suggested that the genotypes used in this study were all, more or less responsive to environmental changes. Most of the genotypes perform better in Env. 3 (5th January date of sowing). Based on phenotypic indices (Pi), regression (S^2di) genotype colombus was found stable for days to maturity. Shohag, BS-60, G-2120 and Cobb were identified as stable for number of branch/plant, whereas; the genotype BS-60 was found stable for 100 seed weight. The genotype BS-60 and Cobb were considered as most stable genotypes for seed yield/plant. In general the genotype BS-60 was found stable for most of the characters studied.

Key words: Soybean, genotype-environment interaction and stability

Introduction

Soybean (***Glycine max*** (L) Merrill) is a leguminous crop and has a tremendous value in agriculture as a good source of high quality plant protein and vegetable oils in one hand and nitrogen fixing ability on the other. Yield is a complex character which is dependent on a number of agronomic characters and is highly influenced by many genetic factors as well as many environmental fluctuations (Joarder ***et al.***, 1978). Genotypes which can adjust its phenotypic state in response to environmental fluctuations in such a way that it gives maximum stable economic return can be termed as well "buffered" or stable (Allard and Bardshaw, 1964). In a plant breeding programme, potential genotypes are usually evaluated in different environments before selecting desirable ones. For stabilizing yield it is necessary to identify the stable genotypes suitable for wide range of environments. To identify such genotypes, G-E interaction are of major concern for a breeder, because such interaction confound the selection of superior cultivars by altering their relative productiveness in different environments (Eagles and Frey, 1977). Varietal stability in yield with respect to wide range of environments (different sowing dates) is one of the most desired property of a genotypes to fit the crop under available cropping pattern. So, wider adaptability and stability are prime consideration in formulating efficient breeding programme. Stability analysis is a good technique for measuring the adaptability of different crop varieties to varying environments (Morales ***et al.***, 1991). The present study was undertaken:

- to estimate the G-E interactions through stability parameters and performance of some traits of ten soybean genotypes across environments and
- to identify the suitable genotypes for future breeding programme

Materials and Methods

The experiment was conducted at the Experimental Farm, Department of Genetics and Plant Breeding, Bangladesh Agricultural University (BAU), Mymensing, Bangladesh. Ten soybean genotypes including two varieties namely Shohag (Pb-1) and BS-4 (G-2120) were used in the study. Five cultural environments as represented by sowing dates at an interval of 15 days, were Env. 1 (5th December/01), Env.2) 20th December/01), Env.3 (5th January/02), Env. 4 (20th January/02) and Env.5 (5th February/02). The experiment was laid out in a randomized complete block design with three replications in each environment/sowing date. The unit plot size in a replication measured 3 m in length and 1.8 m in width accomoding 6 rows of 360 plants per genotypes keeping row to distance 25 cm and plant to plant distance 5 cm. Fertilizer were applied @ 120:60:30 kg ha^{-1} of TSP, MP and Gypsum. TSP, MP and Gypsum were applied as basal dose during the final land preparation. As soybean is leguminous plant and has the unique ability of fixing atmospheric nitrogen through rhizobial symbiosis at root zones; so, for the source of nitrogen ***Rhizobium*** inoculum was used @ 25 g kg^{-1} seed. Normal cultural practices were followed as and when necessary. Data on various characters were recorded, but only four characters (days to maturity, number of branch/plant, 100 seed weight (g) and seed yield/plant (g) are considered and presented in this paper. The genotype-environment interaction and stability were done following the method suggested by Eberhart and Russell (1966), also quoted by Singh and Chaudhary (1985), Dabholkar (1992) and others.

Results and Discussion

The results of the combined analysis of variance after Eberhart and Russell's model are presented in Table 1. The mean squares for genotypes and environments for all the traits under study were highly significant ($p<0.01$), 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 all the characters, indicating that all the traits were highly influenced by the change in environments leading to extension of analysis for estimating stability parameters. The linear portion of G-E interaction were highly significant ($p< 0.01$) for all the characters. Thus the prediction of the genotypes in the environments appeared to be feasible for all the characters under study. The variance due to pooled deviation (non-linear) considerably in respect to their stability in cultural environments. Singh ***et al.*** (1995) also found significant linear and non-linear components interaction in soybean.

The mean performance of the individual genotype along with their stability parameters (Pi, bi and S^2di) for maturity are presented in Table 2. From the environmental mean it was observed

Table 1: Combined analysis of variance (MS) for four characters in a genotype-environment interaction study in soybean after Eberhart Russell's model

Sources of variation	d.f.	Days to maturity	Number of branch per plant	100 seed weight (g)	Seed yield per plant (g)
Genotypes	9	145.617**	1.386**	55.183**	5.459**
Environments	4	1567.969**	1.353**	40.216**	47.183**
Genotype × Environment	36	9.786*	0.174*	1.274*	1.824*
Env. + Gen. X Env.	40	165.604	0.292	5.168	6.36
Env. (linear)	1	6271.876**	5.413**	160.864**	188.733*
Gen. X Env. (linear)	9	21.965**	0.377**	2.839**	4.012**
Pooled deviation	30	5.514**	0.096**	0.677**	0.985**
pooled error	100	0.487	0.057	0.307	0.229

Table 2: Average days to maturity, response and stability parameters of ten genotypes of soybean evaluated under five environments (showing dates) using Eberhart and Russell's model

Varieties/ genotypes	Environments Env-1	Env-2	Env-3	Env-4	Env-5	Mean	Phenotypic index (PI)	Regression coefficient (bi)	Deviation from regression(S^2dl)
BS-23	123.00	126.67	122.33	114.67	103.33	118.00	-5.41	0.70	12.79**
BS-16	146.33	142.67	135.33	125.67	117.00	133.40	9.99	0.97	-0.12
Cobb	141.00	129.33	124.67	120.67	107.33	124.60	1.19	0.95	14.17**
BS-15	145.33	145.67	133.33	120.00	108.33	130.93	7.53	1.30	6.34**
Colombus	137.33	132.67	125.67	115.33	106.00	123.40	-0.01	1.02	-0.04
BS-60	134.00	128.33	120.67	115.00	106.00	120.80	-2.61	0.87	1.81**
BS-3	130.67	129.33	125.00	116.33	104.67	121.20	-2.21	0.85	3.50**
Shohag	130.33	124.33	113.67	108.67	100.33	115.47	-7.94	0.94	6.40**
G-2120	138.33	134.67	125.33	115.00	103.33	123.33	-0.07	1.15**	-0.36
Gaurab	140.33	135.00	125.33	111.67	102.33	122.93	-0.48	1.26*	2.22*
Environmental mean	136.67	132.87	125.33	116.30	105.87	123.41 $\bar{\bar{x}}$			
Environmental index	13.260	9.460	1.927	-7.104	-17.540				

*P<0.05, **P<0.001

that Env.5 was the most favorable environment. Analysis of the stability parameters of the individual genotype indicated that two genotype showed individual linear response and seven others showed non-linear response. However, one of the genotype (Gaurab) showed combined bi and S^2di sensitivity which suggests that both linear and non-linear component were responsible for significant genotype × environment interaction. Genotype shohag, BS-23, BS-3, BS-60, G-2120, Cobb Guarab and Colombus had the negative phenotypic indices therefore; they are desirable genotypes for this character. Genotype G-2120 showed bi value higher than the unity with non significant S^2di values, indicating its suitability only for favorable environmental condition. BS-23, BS-3, Cobb, BS-15, BS-60, Shohag and Gaurab showed significant S^2di values, thus prediction of their performance over environment would not be authentic. Considering all the three estimates of stability parameters, it appeared that genotype Colombus which had very low negative phenotypic indices with the regression co-efficient around unity and non significant S^2di value was the most stable genotypes among the genotypes studied.

Table 3: Average number of branch/plants, response and stability parameters of ten genotypes of soybean evaluated under five environments (showing dates) using Eberhart and Russell's model

Varieties/ genotypes	Environments Env-1	Env-2	Env-3	Env-4	Env-5	Mean	Phenotypic index (PI)	Regression coefficient (bi)	Deviation from regression(S^2dl)
BS-23	3.30	3.27	4.00	4.30	3.36	3.64	-0.09	0.76	0.14*
BS-16	4.77	5.20	4.23	4.33	4.67	4.64	0.91	-0.29	0.12*
Cobb	3.50	4.00	3.93	3.52	2.79	3.55	-0.18	1.16	0.01
BS-15	3.97	4.37	4.29	4.50	4.70	4.36	0.63	-0.16	0.04
Colombus	3.07	4.64	4.73	3.90	2.67	3.80	0.07	2.40*	0.04
BS-60	3.43	3.13	4.00	3.63	2.85	3.41	-0.32	0.94	0.05
BS-3	3.20	3.40	3.97	3.72	3.07	3.47	-0.26	0.93	-0.03
Shohag	2.63	2.80	3.53	2.50	2.13	2.72	-1.01	1.17	0.05
G-2120	3.77	4.10	4.00	4.37	3.17	3.88	0.15	1.03	0.03
Gaurab	3.30	4.18	4.72	4.10	2.80	3.82	0.09	2.07*	-0.05
Environmental mean	3.49	3.91	4.14	3.89	3.22	3.73 $\bar{\bar{x}}$			
Environmental index	-0.24	0.18	0.41	0.16	(-0.51)				

Table 4: Average 100 seed weight (g), response and stability parameters of ten genotypes of soybean evaluated under five environments (showing dates) using Eberhart and Russell's model

Varieties/ genotypes	Environments Env-1	Env-2	Env-3	Env-4	Env-5	Mean	Phenotypic index (PI)	Regression coefficient (bi)	Deviation from regression(S^2dl)
BS-23	13.37	16.92	15.53	14.38	12.08	14.45	2.54	0.74	1.50**
BS-16	14.77	15.01	11.69	10.41	8.71	12.12	0.21	1.31	0.60*
Cobb	17.03	16.76	14.78	12.11	8.91	13.92	2.01	1.66	0.52*
BS-15	17.54	18.28	14.47	13.30	12.25	15.17	3.26	1.23	0.83**
Colombus	6.80	8.00	7.89	6.76	5.81	7.05	-4.86	0.38*	0.01**
BS-60	15.68	18.02	14.65	14.85	12.93	15.23	3.32	0.84	0.46
BS-3	14.08	15.05	13.76	11.09	7.88	12.37	0.46	1.43	0.05
Shohag	15.44	16.18	14.89	12.34	10.37	13.84	1.94	1.20	-0.14
G-2120	8.17	8.55	8.52	6.11	5.79	7.43	-4.48	0.62	0.08
Gaurab	7.59	9.19	7.86	7.00	5.83	7.49	-4.42	0.59*	-0.14
Environmental mean	13.05	14.20	12.40	10.83	9.05	11.91 $\bar{\bar{x}}$			
Environmental index	1.142	2.289	0.496	-1.072	-2.854				

*P<0.05, **P<0.001

The stability parameters along with the average number of branches in different genotypes and environment are presented in Table 3. From the environmental mean it was observed that Env. 3 was the favourable environment and Env. 5 was the most unfavourable one.

Analysis of stability parameters of individual genotypes indicated that none of the genotypes showed combine bi and S^2di sensitivity suggesting either linear or non linear component alone or their cumulative effects were responsible for significant genotype-environment interaction.

Table 5: Average seed yield per plant (g), response and stability parameters of ten genotypes of soybean evaluated under five environments (showing dates) using Eberhart and Russell's model

Varieties/ genotypes	Environments Env-1	Env-2	Env-3	Env-4	Env-5	Mean	Phenotypic index (PI)	Regression coefficient (bi)	Deviation from regression (S^2dl)
BS-23	10.40	9.67	13.67	9.83	4.57	9.63	2.00	1.42	1.36**
BS-16	9.93	8.90	8.53	4.73	4.67	7.35	-0.27	0.95	2.33**
Cobb	9.50	8.30	9.93	6.17	3.43	7.47	-0.16	1.22	0.10
BS-15	7.83	5.13	5.83	4.87	4.33	5.60	-2.02	0.38	1.35**
Colombus	8.50	10.33	10.67	6.17	3.00	7.73	0.11	1.43	0.53*
BS-60	8.40	7.70	10.00	7.87	4.97	7.79	0.16	0.79	0.26
BS-3	8.33	9.03	9.60	8.90	6.50	8.47	0.85	0.49*	0.18
Shohag	5.97	8.43	8.60	6.67	4.67	6.87	-0.76	0.64	0.93**
G-2120	10.00	9.63	12.57	5.50	2.53	8.05	0.42	1.82**	0.24
Gaurab	7.07	8.33	9.83	6.90	4.33	7.29	-0.33	0.89	0.31
Environmental mean	8.59	8.55	9.92	6.76	4.30	7.62 $\bar{\bar{x}}$			
Environmental index	0.969	0.922	2.299	-0.865	(-3.325)				

*P<0.05, **P<0.001

Genotype BS-16, BS-15, G-2120, Gaurab and Colombus had the positive phenotypic indices; therefore, they were desirable for this character. Gaurad and colombus had the higher bi value (2.07 and 2.40 respectively) with non-significant S^2di indicating their suitability for growing in better environmental conditions. Genotype BS-15 had the lowest bi values (-0.16) with non-significant S^2di values that indicated the genotype was suited only for poor environmental condition. BS-16 and BS-3 had significant S^2di values, so the performance of these genotypes under different environmental condition is unpredictable. Taking all the three stability parameters genotype Shohag, BS-3, BS-60, G-2120, Cobb are considered as stable and desirable genotype for no. of branches per plant in soybean.

The average 100 seed weight of individual genotype over five environments with their regression co-efficient and deviation from regression are presented in Table 4. From the environmental mean it was observed that most of the genotypes produced maximum 100 seed weight when sown in Env.2. The highest 100 seed weight (15.23 g) was produced by the genotype BS-60 and the lowest (7.05 g) by the genotype Gaurab. The phenotypic indices of Shohag BS-3, BS-15, BS-16, BS-23, BS-60 and Cobb were positive. Therefore, they are desirable genotype for this character. Analysis of the stability parameters of the individual genotypes indicates that the genotype BS-16 showed combined bi and S^2di sensitivity suggesting both linear and non-linear components were responsible for genotype environment interaction. Shohag, BS-16, Cobb, BS-15 and BS-3 showed higher bi values (1.43, 1.66, 1.73 and 1.20 respectively) indicating their suitability only for highly favourable environments.

The genotype BS-15, BS-16, BS-23 and G-2120 showed significant S^2di values which indicate that they were more affected by the environmental fluctuations i.e. performance of these genotypes over environments were unpredictable. Considering all the three parameters (Pi, bi and S^2di) the genotype BS-60 was found most stable among all the genotypes having bi value near to unity with non-significant S^2di values.

The average yield performance of the individual genotype along with Pi, bi and S^2di are presented in Table 5. From the environmental mean it was observed that Env.3 had the highest mean yield (9.92 g plant^{-1}) and lowest in Env.5 (4.30 g plant^{-1}). This indicated that Env.3 was the most favourable one and the majority of the genotypes had the capacity to exploit that environment to confer the highest yield. Over all the environments genotype BS-23 gave the highest yield (9.63 g plant^{-1}) and lowest in BS-15 (5.60 g). Five genotypes showed negative Pi while the same for others were positive. However it was highest (Pi=2.0) in BS-23 while the lowest in BS-15 (Pi=-2.02). Analysis of the stability parameters of the individual genotypes indicated that none of the genotypes showed combined bi and S^2di sensitivity suggesting either linear or non-linear component alone or their cumulative effects were responsible for significant genotype-environment interactions. Genotype G-2120 had the higher bi values which was significantly different from unity with non significant S^2di values; so this genotype was highly responsive to environmental fluctuation and suitable for highly favourable environment. All the other genotypes had the bi values which were not significantly different from unity. The genotypes Shohag, BS-15, BS-16, BS-23 and Colombus showed significant S^2di values, indicating that their performance were unpredictable. Based on three stability parameters into consideration, it was observed that BS-60 and Cobb having bi≈1 and $S^2di \approx 0$ were most stable and desirable genotypes among all the genotypes.

The study suggested that the genotype Coloumbus may be selected for stability in days to maturity. On the other hand, the genotype BS-60 may be selected for number of branch/plant, 100 seed weight as well as seed yield/plant. These materials can be used in soybean breeding program as a source of genes for stability.

References

Allard, R.W. and A.D. Bradshaw, 1964. Implication of Genotype-environment interactions in applied plant breeding. Crop Sci., 4: 503-508.

Dabholkar, A.R., 1992. Elements of Biometrical Genetics. Concept Publishing Company. New Delhi, India, pp: 338-359.

Eagles, H.A. and K.J. Frey, 1977. Repeatability of the stability variance parameter in oats. Crop Sci., 17: 253-256.

Eberhart, S.A. and W.A. Russell, 1966. Stability parameters for comparing vanities. Crop Sci., 6: 36-40.

Joarder, O.I., S.K. Ghose and M. Salehuzzaman, 1978. Genotype environment interaction shown by yield and some of its components of ***Brassica campestris*** (L.). Z. Pflanzenziichtg, 81: 284-257.

Morales, A.C., A.A. Paragas, V.R. Carangal, 1991. Phenotypic stability for grain yield in mungbean (***Vigna radiata*** (L), Wilczek). FLCG Newsletter, 16: 12-15.

Singh, M., G. Singh, D.T. Dhutia and R.P. Awasthi, 1995. Stability analysis in soybean (***Glycine max***) in Sikkim. Indian J. Agric. Sci., 65: 757-759.

Singh, R.K. and B.D. Chaudhary, 1985. Biometrical Methods in Quantitative Genetic Analysis (rev. Ed.). Kalyani Publishers, New Delhi, India, pp: 252-269.