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Genotype x Environment Interaction in Soybean (*Glycine max* L.)

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Abstract: The soybean genotype were evaluated under different environment (Sowing dates) to determine the genotype × environment interaction vis-a-vis stability over a wide range of environment. The genotype, environment and genotype × environment interactions differed significantly for all studied characters. Considering the yield and yield contributing characters and using three stability parameters viz., phenotypic index greater than zero, regression co-efficient around unity ($b \approx 1.0$) and least deviation from regression (non-significant S^2d). The lines BS-60, BS-15 and BAU-23 were found stable for plant height. The lines C.O.-1 and SAO-Luiz were identified most suitable for number of pods per plant. In case of number of seeds per pod the genotypes BAU-23 and BS-15 were observed stable but the genotype BS-12, Sohag and TGX-843, were found stable for percentage of pod per plant but the lines BS-60 and AGS-160 were found stable for 100-seed weight. It was revealed that lines BS-60 and TGX-843 were found stable for most of the characters. It is therefore suggested that the identified stable genotypes with respect of different characters might be used in breeding programme to transmit desirable trait (s) to develop stable genotype of Soybean.

Key words: Glycine max L., genotype, environment, stability parameters, interaction

Introduction

Bangladesh predominantly a rice producing country, put major thrust for her food materials on rice. But the production of rice is not sufficient enough to nourish her burgeoning population. Nevertheless, it is the reality the climatic hazards like flood, cyclone, drought etc. visit every year and causes colossal damage of standing crops. It will become difficult to feed for vast population by our running trend of cereal production. So it is impressive to pay attention for massive augmentation in more nutritive value rich food. In these circumstances, Soybean can play a vital role for substantial food production in the country. Bangladesh is also a flood prone country, of which about two million hectares of land remain idle. Once flood water recedes in char and haor areas, soybean can be grown in these areas under no-tillage and minimum inputs. In winter seasons, soybean may compete with wheat, pulses, oil seeds and other rabi crops, but during summer it can be grown in the northern districts of Bangladesh without affecting transplanted aman rice, the major rice crop of our country.

Recently there was a continuous awareness about the importance of genotype × environment interactions affecting varietal performance as well as the breeding programme. The breeders aim normally at producing stable varieties, that can withstand unpredictable fluctuation in the environment (Wein and Smithson, 1979). Moreover Eagles and Frey (1977) emphasized the study of genotype environment interaction in developing improved varieties. Because such interaction confined the selection of superior cultivators by altering their relative productiveness in different environment. In the presence of unpredictable climatic factors, the combination of two abilities of any cultivar, better growth in unfavourable environments and positive reactions to favourable environments seems to be attractive. These objectives can be achieved by genetic recombinations when parental types are available for specific traits (Eenink and Smeets, 1978).

Selection of suitable genotype over environments may be possible by stratification of environments. Such technique has been used effectively to reduce G × E interaction. Eberhart and Russell (1966) studied and observed that even with this stratification technique, little interaction of genotype with location in a sub-regions and with environments differed frequently in different years but still some progress has been achieved in reducing G × E interaction.

So wider adaptability and stability are prime consideration in formulating efficient breeding programme. It is well established that crop performance regarding yields are positively correlated with favourable environment condition (Nor and Candy, 1979). But modern agricultural technology demands a cultivar with satisfactory average yield, over a wide range of environment. Stability parameters can be used for varietal recommendations to minimize risk and to give better return for the growers. S the study was undertaken to investigate the performance of individual varieties/lines for specific date of sowing and G × E interactions.

Materials and Methods

The research was conducted at the experimental farm of the department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, Bangladesh during the rabi season 1992-1993. Ten genotypes namely, BAU-23, BS-12, BS-15, TGX-843, C.O.-1, AGS-160, Jupitar BS-60, SAU-LUIZ and Sohag as a check were taken for the experiment.

The experiment was conducted with randomized complete block design (RCBD) and replicated thrice. The size of each unit plot was 1.5x3 m^2. The genotypes were sown randomly one after another as per design. There were five dates of sowing Viz., 15-11-92, 30-11-92, 15-12-92, 30-12-92 and 15-01-92 and a specific plant spacing (30 × 5 cm^2) in each sowing date. Each sowing date in specific plots considered as a single environment. The land was prepared by repeated ploughing. Cross ploughing and laddering to have it in a good tilth. Cowdung, Urea, TSP and MP were applied @ 5 t ha^{-1}, 40 Kg ha^{-1}, 150 Kg ha^{-1} and 50 Kg ha^{-1} respectively. Soybean inoculum was used @ 30 gm kg^{-1} seeds. Seeds were sown in line keeping 30 cm apace between row and 5 cm between seed to seed and total about 300 seeds $plot^{-1}$.

Ten plants were randomly selected from the middle portion of each unit plot. For the present study twelve characters were taken into consideration eg., days to 80% germination, plant height, number of pods per plants, number of seeds pods, seed yield per plant, 100 seed weight and harvest index.

The collected data were statistically analyzed, including analysis of variance for different characters for each environment (sowing time) separately, determination of polled analysis of variance and analysis of variance for mean data averaged over replications following procedure as described in Steel and Torrie (1960), Singh and Chowdhury (1979), Gomez and Gomez (1976). For stability analysis, the procedure out lined by Finlay and Wilkinson (1963) and Eberhart and Russel (1966) were followed.

Results and Discussion

Days to 80% germination

From the present investigation it can was observed those days to 80% germination of each genotype with the change of environment. Significant difference among the genotypes was observed in every sowing date. The days to 80% germination as influenced by genotypes under specific sowing date ranged from 3.67 to 5.67 in 1st sowing, 6.00 to 8.33 in 2nd sowing date, 7.00 to 8.33 in 3rd sowing date, 7.57 to 9.67 in 4th sowing date and 10.00 to 13.00 in 5th sowing (Table 4). Most of the genotypes germinated early in 1st sowing and all genotypes were late in 5th sowing. In over all sowing dates, line BS-15 took minimum days to germinate (7.33) and the line TGX-843 took maximum days (8.73).

The genotype × environment interaction (linear) and deviation from regression (non linear) for this traits were also significant (Table 3). Talukder and Knowar (1984) studied 10 genotypes of soybean in six environments and observed that both linear and non-linear components of genotype × environment interaction were significant for field germination, which confirmed the present result.

The test of stability parameters, regression coefficient (b) and deviation from regression (s^2d) of the individual genotypes and non-linear component in four genotypes, which was indicated that the effect of the non-linear components were more than the linear component.

From the simultaneous consideration of three stability parameters (p,b and s^2d), it was observed that variety Sohag was most stable genotype having slight above average response ($b \approx 1.0$) with non significant deviation from regression . The line Jupitar had very low regression co-efficient (b˜0.69) with non-significant s^2d, indicating least response to environmental changes and may be considered suitable genotype for the favourable environment. The line BAU-23 and with high b value may be considered suitable for favourable environment for early germinated cultivars. Prediction about the lines with significant s^2d was not possible although some had regression value near unity.

Table 1: Mean some square of some characters of soybean for each date of sowing (environment) separately

	Sowing dates				
Parameters	1	2	3	4	5
Days to 80% germination	98.32**	84.53**	90.16**	77.60**	57.87**
Plant height (cm)	42.63**	52.20**	65.19**	48.46**	51.38**
Pods/Plant	372.33**	416.24**	298.56**	318.07**	405.59**
Seeds/Pod	2.94**	4.12**	2.29	3.33**	2.85*
100-seed weight	52.65**	49.11**	76.18**	56.61**	71.20**
Yield/plant (g)	217.21**	315.02**	259.40**	269.42**	295.86**

* and ** significant at 5% and 1% level of probability respectively. Source of variation = Genotype. Df = 9.

Table 2: Mean some squares from pooled analysis of variance for some characters of soybean at different date of sowing (environment)

Source of variation	sowing date	Genotype	Genotypes x sowing date	Rep. in sowing date	Error
df	4	9	36	10	90
Days to 80% germination	64.32**	21.59**	9.62**	4.43	2.94
Plant height (cm)	248.2**	84.12**	31.30**	16.47	13.72
Pods/Plant	719.41**	322.15**	98.59**	42.48	19.80
Seeds/Pod	22.76**	14.37**	7.67**	5.92	4.98
100-seed weight	115.58**	65.13**	28.38**	11.84	9.55
Yield/plant (g)	56.95**	37.33**	21.00**	8.85	6.18

* and ** significant at 5% and 1% level of probability respectively

Table 3: Combined analysis of variance of twelve characters in some characters of soybean evaluated across the five dates of sowing (environment)

Source of variation	Sowing date	Genotype	Sowing date x sowing date	Genotype (linear)	Genotype x sowing date(linear)	pooled deviation	Pooled error
df	4	9	36	1	9	30	100
Days to 80% germination	16.39**	5.48**	3.75**	85.13**	4.49**	2.25	1.48
Plant height (cm)	72.42**	25.20**	18.56**	321.72**	13.19**	8.38*	5.21
Pods/Plant	198.31**	135.78**	62.58**	355.27**	32.39**	24.14**	10.12
Seeds/Pod	5.64**	3.48**	1.86**	11.66**	2.49**	2.05**	1.03
100-seed weight	27.89**	8.45**	5.73**	92.08**	5.36	5.81*	3.16
Yield/plant (g)	12.46**	6.46**	4.50**	65.89**	4.21*	4.30**	2.00

* and ** significant at 5% and 1% level of probability respectively

Plant height

The average plant height for different environments together with the estimated response and stability parameters are presented in Table 5. Plant height was significantly influenced by genotype, environment and the interaction between genotypes and environments (Table 3). The average plant height was recorded highest (59.88 cm) in 1st sowing and lowest (39.31 cm) at 5th sowing. The plant height was high in 1st sowing with highest yield, indicating the highest plant height is expected for good yield. Differences exist among genotypes for this trait ranged from

Table 4: Average days to 80% germination response and stability parameters of ten genotypes of soybean evaluated across five different dates of sowing

Name of genotypes	Sowing time 1st	2nd	3rd	4th	5th	Mean (Y)	Phenotypic index (pi)	regression coefficient (bi)	Deviation from regression (s^2d)
BAU-23	4.67	7.67	8.33	8.33	12.00	8.20	0.21	5.240	1.928
BS-12	4.33	7.33	7.00	8.00	11.00	7.532	-0.46	0.936	0.027**
BS-15	4.00	6.33	7.33	7.67	11.33	7.332	-0.66	3.515	1.005
Sohag	4.33	7.00	8.00	8.67	11.67	7.934	-0.059	1.081	2.401
TGX-843	5.00	8.00	8.33	9.33	13.00	8.732	0.72	0.557	0.989**
C.O.-1	4.33	6.67	7.00	7.67	12.33	7.60	-o.39	4.436	3.603
AGS-160	5.33	7.33	8.33	7.67	12.33	8.198	0.21	-1.754	-0.488
Jupitar	3.67	7.33	7.33	8.67	10.00	7.40	-0.59	0.685	1.171
BS-60	5.00	6.00	8.33	9.67	13.00	8.40	0.41	-2.407	3.325**
SAO-LUIZ	5.67	8.33	8.00	9.00	12.00	9.60	0.61	1.019	4.049**
Environmental (mean)	4.63	7.20	7.80	8.47	11.87	97.99			
Environmental (index)	-3.360	-0.744	-0.195	0.475	3.873				

Table 5 Average plant height (cm), response and stability parameters of ten genotypes of soybean evaluated across five different dates of sowing

Name of genotypes	Sowing time 1st	2nd	3rd	4th	5th	Mean(Y)	Phenotypic index (pi)	Regression coefficient (bi)	Deviation from regression (s^2d)
BAU-23	67.03	58.13	50.83	48.63	48.54	54.63	4.15	1.230	-1.154
BS-12	32.02	34.35	36.83	33.50	26.92	32.72	-17.76	1.008	0.085**
BS-15	31.98	34.47	42.73	38.28	34.28	36.35	-14.14	0.986	0.222
Sohag	31.27	37.93	30.17	36.88	26.76	32.60	17.88	2.334	1.566**
TGX-843	60.43	59.13	42.59	38.86	33.92	46.99	3.50	0.402	2.514
C.O.-1	111.47	96.24	66.42	62.48	43.50	76.022	25.54	8.123	3.202**
AGS-160	61.13	64.81	50.90	44.58	34.92	51.27	0.78	2.815	1.211
Jupitar	124.80	89.45	98.23	112.16	89.52	102.83	52.35	0.242	0.495
BS-60	45.95	46.03	37.90	33.27	26.20	37.87	-12.62	1.190	1.200
SAO-LUIZ	32.68	39.93	35.67	31.08	28.53	33.58	-16.91	-2.000	0.367**
Environmental mean	59.88	56.05	49.22	47.972	39.31	50.49			
Environmental index	9.389	5.560	-1.259	-2.514	-11.177				

31.27 to 124.80 cm in 1st sowing 34.35 to 96.24 cm in second sowing, 30.17 to 98.23 cm in 3rd sowing, 31.08 to 112.16 cm in 4th sowing and 26.20 to 89.52 cm in 5th sowing. The highest plant height (102.83 cm) was observed in the line Jupitar and lowest (32.60 cm) in variety Sohag (Table 5).

The test of significance for the two measures of G × E interaction namely, b and s^2d; of the individual genotype with respect to plant height showed absence of linear components for all the genotype and presence of non-linear component for four genotypes among the ten genotypes. Genotypes with significant s^2d were unstable and as such, prediction about them across the environments would not be possible. The genotype C.O.-1 had high b value (b ˜ 8.12) with significant s^2d, indicating that the line was highly responsible to environmental changes and

Table 6: Average number of pods per plant response and stability parameters of ten genotypes of soybean evaluated across five different dates of sowing

Name of genotypes	Sowing time 1st	2nd	3rd	4th	5th	Mean(Y)	Phenotypic index (pi)	Regression coefficient (bi)	Deviation from regression (s^2d)
BAU-23	51.47	51.97	55.53	59.93	42.47	52.27	7.71	2.444	1.121**
BS-12	32.40	31.37	33.70	32.60	31.37	32.29	-12.27	0.390	0.284
BS-15	30.33	27.80	35.23	34.37	25.20	30.59	-13.97	-3.025	-1.399**
Sohag	26.77	28.97	25.57	39.09	37.93	31.66	-12.91	-1.634	1.283**
TGX-843	49.83	46.63	55.37	57.97	64.17	54.80	10.23	4.098	2.141**
C.O.-1	81.70	62.07	39.20	44.20	42.77	53.99	9.43	0.560	1.224
AGS-160	47.90	43.53	32.70	47.57	52.23	44.80	0.23	5.713	-1.567
Jupitar	66.37	71.20	65.18	50.07	62.40	63.04	18.48	2.779	0.842**
BS-60	35.10	37.33	41.27	33.77	34.83	36.46	-8.10	0.892	1.066**
SAO-LUIZ	38.60	47.71	48.33	49.43	44.53	45.72	1.16	0.498	2.205
Environmental (mean)	46.05	44.86	43.21	44.90	43.79	44.56			
Environmental (index)	1.488	0.297	-1.351	0.335	-0.769				

Table 7: Average seeds per pod response and stability parameters of ten genotypes of soybean evaluated across five different dates of sowing

Name of genotypes	Sowing time 1st	2nd	3rd	4th	5th	Mean(Y)	Phenotypic index (pi)	Regression coefficient (bi)	Deviation from regression (s^2d)
BAU-23	1.84	1.87	1.77	1.68	1.62	1.76	-0.046	1.285	1.120
BS-12	1.68	2.21	1.76	1.66	1.92	1.85	0.044	0.492	0.739**
BS-15	1.66	2.30	1.62	1.74	1.77	1.82	0.016	0.741	1.040
Sohag	1.51	1.73	1.74	1.37	1.73	1.62	-0.186	0.066	0.002**
TGX-843	1.71	1.75	1.85	1.67	1.70	1.74	-0.066	-0.184	0.205**
C.O.-1	1.88	2.05	1.76	1.65	1.82	1.83	0.03	2.026	1.111
AGS-160	1.85	1.88	1.83	1.64	1.65	1.70	-0.032	0.573	-0.245**
Jupitar	2.37	2.07	1.83	1.89	1.54	1.93	0.13	0.072	-1.354
BS-60	2.14	1.95	1.91	2.00	1.77	1.95	0.152	2.658	1.616**
SAO-LUIZ	1.67	1.93	1.90	1.75	1.55	1.76	-0.042	1.120	0.751**
Environmental mean	1.83	1.97	1.79	1.71	1.71	1.802			
Environmental index	0.020	0.174	-0.009	-0.997		-0.997			

may be considered unstable genotype over the environmental changes whereas the line SAO-LUIZ had negative b value with significant s^2d, was inverse response to environmental changes and unstable to the environment. Considering all the parameters (p,b and s^2d), the lines within one standard deviation from grand mean and average regression co-efficient ($b\tilde{}1.0$) with non-significant s^2d were considered stable genotypes. Out of all these lines BAU-23, BS-15, BS-60, were found stable and the genotype BS-15 was found most suitable with below average plant height.

Table 8: Average 100 seed weight (g), response and stability parameters of their genotypes of soybean evaluated across five different dates of sowing

Name of genotypes	Sowing time 1st	2nd	3rd	4th	5th	Mean(Y)	Phenotypic index (pi)	Regression coefficient (bi)	Deviation from regression (s^2d)
BAU-23	17.30	16.37	14.33	13.97	8.83	14.16	0.84	0.164	1.154**
BS-12	17.47	15.43	16.07	15.17	14.50	15.73	2.41	1.118	0.527**
BS-15	17.60	14.57	16.47	15.90	15.70	16.05	2.73	-1.020	-0.305
Sohag	14.83	13.47	13.93	13.43	12.27	13.59	0.27	-0.714	0.492
TGX-843	12.63	13.83	14.10	13.40	12.00	13.19	-0.13	0.285	0.622
C.O.-1	9.73	9.45	9.17	7.83	8.17	8.87	-4.45	0.169	0.457**
AGS-160	13.07	12.33	14.90	14.93	11.00	13.25	-0.07	1.355	1.009
Jupitar	7.03	7.07	6.80	6.47	5.80	6.63	-6.68	0.849	0.466**
BS-60	20.60	17.93	19.20	19.03	15.10	18.37	5.05	0.577	0.156
SAO-LUIZ	14.50	14.53	13.70	13.13	10.87	13.35	0.03	0.569	0.202**
Environmental mean	14.48	13.50	13.87	13.33	11.42	13.32			
Environmental index	1.158	0.179	0.549	0.01	-1.894				

Table 9: Average seed yield per plant (g), response and stability parameters of their genotypes of soybean evaluated across five different dates of sowing

Name of genotypes	Sowing time 1st	2nd	3rd	4th	5th	Mean(Y)	Phenotypic index (pi)	Regression coefficient (bi)	Deviation from regression (s^2d)
BAU-23	16.43	15.88	13.78	14.05	13.81	13.81	3.52	-1.265	-1.193
BS-12	9.50	10.61	9.39	9.45	9.532	9.532	-0.75	0.817	2.432
BS-15	8.84	9.19	8.81	9.79	8.718	8.718	-1.75	0.394	0.539
Sohag	6.10	6.89	6.25	7.17	6.89	6.89	-3.40	0.276	0.683**
TGX-843	10.38	11.18	14.35	12.73	12.34	12.34	2.06	1.131	2.130
C.O.-1	14.62	12.38	7.55	5.43	9.62	9.62	-0.67	1.336	1.451
AGS-160	11.56	9.95	8.83	10.31	10.01	10.01	-0.28	0.618	1.256
Jupitar	10.92	10.12	7.78	6.12	8.07	8.07	-2.21	1.544	1.360**
BS-60	15.57	12.92	14.85	12.62	13.19	13.19	2.90	0.898	0.277
SAO-LUIZ	9.16	13.14	12.34	11.92	10.67	10.67	0.40	1.158	1.331
Environmental mean	11.31	11.23	10.39	9.90	10.29	10.29			
Environmental index	1.022	0.940	0.107	-0.390					

Number of pods/plant

Analysis of variance showed significant differences among the genotypes in respect to number of pods per plant in all sowing dates (Table 1). The combined analysis also showed significant differences among the environments, genotype and G × E interaction.

Table 6, showed environmental means ranged from 43.21 to 46.05 while genotypic means ranged from 30.59 to 63.04 for over all environments. Genotypes BAU-23, TGX-843, C.O- 1, Jupitar, SAO-LUIZ showed best performance over the environments as their mean pod number exceeded the grand mean. Line BAU-23 has non significant b(2.44) value and significant s^2d, indicating above average responsiveness to the favourable environment but not stable to overall environment, though it bore considerably higher pods per plant. Genotype BS-15 and Sohag having lowest b values -3.025, -1.634) accordingly with significant s^2d value, suggesting that this two genotypes were less responsive but not stable among the genotypes. Over the environments the highest number of pods (63.04) per plant was recorded in the line Jupitar (highest yielder) and lowest number of pods per plant (30.59) in the line Sohag (poorest yielder).

Considering stability parameters, the line AGS-160 having high regression coefficient ($b \approx 5.71$) with non-significant deviation from regression (s^2d), response highly to the change in environment was considered suitable for favourable environment.

The genotype within one standard deviation from average regression coefficient and grand mean with non-significant s^2d, was considered as most stable but in strict sense, the line with regression co-efficient nearly unity ($b \approx 1$), positive phenotypic index ($p>0$) with non-significant s^2d ; were considered stable lines. In such sense, the lines TGX-843 and SAO-LUIZ were better stable line. Das ***et al.*** (1983) studied with four soybean varieties and found that the genotype × environment interaction were accounted both the linear and non-linear functions of the environmental means for pods/plant. On the basis of mean, response and stability selection of varieties, some varieties were effective for all environments. The study satisfied the presented result.

Seeds per pod

Significant difference were observed among genotypes and G × E interactions for the seeds per pods (Table 3). The genotypic mean ranged from 1.51 to 2.37 seeds per pod in 1st sowing, 1.73 to 2.30 in 2nd sowing 1.62 to 1.91 in 3rd sowing, 1.37 to 2.00 in 4th date and 1.54 to 1.92 in 5th sowing. The genotypes differently reacted to different environments but majority of them produced higher number of seeds per pod in 2nd sowing (1.97). Overall the locations, the highest seeds per pod(1.95) was obtained from line BS-60) and lowest (1.62) from Sohag (Table 7)

Considering the stability parameters, it was observed that 50% of the genotypes had negative phenotypic indices, indicating the seed production per pod below the grand mean. Out of 10 genotypes, G × E interaction (linear), six genotypes showed non-linear response for this trait. No genotype showed combined response that meant those either linear or non-linear components alone was responsible for significant G × E interaction. Genotype Bs-60 had the highest b value with highly significant s^2d, indicating this variety was highly responsive to different environments and unstable to the favourable environment.

On the other hand, genotype TGX-843 had lowest b value (-.184) with highly significant s^2d indicating low responsiveness and instable to the over all environments. Genotype C.O.-1 had the 2nd highest b value (2.026) with non significant s^2d, indicating this variety was more responsive to different environments and stable the favourable environments.

This lines BAU-23 and BS-15 have the b value nearly unity (1.0) and non significant s^2d, indicating that these two lines were more stable lines among all the lines.

100 seed weight (g)

Genotypes, environments and their interactions differed significantly in respect to this character (Table 1 & 3). Most of the genotypes produced maximum 100- seed weight in 1st sowing lowest in 5th sowing. The environmental mean ranged from 7.03 to 20.60 g in 1st sowing 7.07 to 17.93 g in 2nd sowing, 6.8 to 19.20 g in 3rd sowing 6.47 to 19.03 g in 4th sowing, 5.80 to 15.70 g in 5th sowing. Overall the locations the highest 100-seed weight 20.60 g was produced by the line BS-60 and lowest (5.80 g) by the line Jupitar (Table 8). Five genotypes showed individual non-linear response, indicating that non-linear components were mainly responsible for significant genotype × environment interaction.

Considering the stability parameters, the lines AGS-160 and BS-60 were found most stable among the genotypes having value near unity ($b \approx 1$) with non significant s^2d. Between these lines BS-60 had more responsiveness to environmental changes and was considered suitable for favourable environment. On the other hand, line TGX-843 having lowest b value with non significant s^2d, indicating least responsive to environmental may be considered suitable for unfavourable environment

Seed yield per plant (g)

The yield of a given genotype changed with the changes of environment. Therefore the evaluation of genotype over a wide range of environments needs to be emphasized in relation to individual traits or a combination of traits to yield. It was revealed from the study that the yield potential of each genotype changed with the varying environment (sowing dates).

Significance differences in yield were observed among the genotypes in each dates of sowing (Table 1) separately. Also significant difference were observed among locations indicating the dissimilarity of the environments (sowing dates) and significant G × E interaction meant that the genotype responded significantly in different environment (Table 9). Such characteristics of Soybean genotype was also reported by Punto (1982), Khurana and Yadava (1982), Tawar ***et al.*** (1985). In ground nut it was also reported by Yadava and Kumar (1979b) but only Joshi ***et al.*** (1972) did not find any significant interaction in variety × year, variety × place, variety × place × year.

The yield as influenced by genotypes under specific environment ranged from 6.10 to 16.43 g in 1st sowing, 6.89 to 15.88 g 2nd sowing, 6.25 to 14.85 g in 3rd sowing, 6.12 to 14.05 g in 4th sowing and 5.43 to 13.07 g in 5th sowing per plant (Table 9). The most favourable environment as indicated by the environmental index was lst sowing date and the unfavourable environment for most of the genotypes was in 5th sowing. Overall the sowing dates, the highest yielding line BAU-23, produced top most yield (16.43 g per plant) in 1st sowing, considering the most favourable environment.

Most of the genotypes produced higher yield either in 1st sowing or in 2nd sowing but only the line Sohag and TGX-843 produced higher yield in 5th and 3rd sowing and gave less yield in other sowing (Table 8). Therefore, the nature of response the line Sohag and TGX-843 was quite different from those of other genotypes used.

The stability parameter viz., phenotypic index (p), regression coefficient (b), deviation from regression (s^2d) with mean yield performance of different genotypes at different locations have been presented in Table 9. The line BAU-23 gave the highest yield (13.81) over all the location and Sohag gave lowest pod yield (6.88 g per plant). From the phenotypic index (p), it was observed that more genotype exhibited negative indices except the line BAU-23, TGX-843, BS-60 and SAO-LUIZ.

Considering other two parameters (b, s^2d) of the individual genotype, it was observed that all the lines showed non-significant linear components (regression coefficient) and only two genotypes, Sohag and Jupitar showed significant s^2d. Most of the genotypes showed non-significant linear and non-linear components indicating least genotype x environment interactions. No genotype showed combined (both b and s^2d) significance, indicating that either linear or non-linear component alone was responsible genotype x environment interactions.

Among the genotypes Jupitar had the highest b value ($b \approx 1.544$) with significant s^2d indicating the highest degree of response to the change in the environments and not stable. On the other hand, the line BAU-23 had the negative b value ($b \approx -1.265$) with non-significant s^2d indicating s^2d indicating the least response to environmental change and stable genotype. Most of the genotypes produced higher seed yield in 1st sowing, which meant that the genotypes had the capacity to exploit the most favourable environment for, increased the yield.

The line TGX-843 and BS-60 had b value nearly unity (b-1.0) and their deviation from regression (s^2d) was non significant , therefore these lines may be considered more stable and their mean performance was not highest but comparatively better . Miah (1980) with mungbean reported that varieties/lines with high mean yield had less stability, that is yield and stability were inversely related. But this study supports this statement.

In fine genotypes TGX-843 and BS-60 may be suggested as suitable genotypes among the genotypes. The line BAU-23 having highest phenotypic index lowest b value with non-significant s^2d indicating highest yielding, low responsiveness and stable genotype. It was suggested that genotype was most suitable for unfavourable environment.

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