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Genotype x Environment Interaction in *Glycine max* (L.) Merrill Varietal Tests*

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Studies of 31 soybean cultivars grown at two locations under six bimonthly sowings revealed genotype x location interaction relatively large for plant height, number of nodes, pods and seeds and seed yield and highly significant for all the traits evaluated except for days to 50% flowering. Genotype x season interaction showed significance only for days to first flowering, 50 % flowering and maturity and plant height. A theoretical total variance of genotype means computed for seed yield indicated the importance of location effects in testing soybean cultivars.

Information regarding the adaptability of soybean cultivars to a range of available environments assumes prominent place in programmes of introduction and development of highly productive varieties, since genotype x environment interactions are of importance in selecting materials for high yield and wide adaptation.

Opportunity was presently taken to estimate and compare the various components of genotype x environment interactions and to consider the implications of these for efficient allocation of experimental resources to evaluate relative stability of genotypes over a range of environmental conditions obtaining at Coimbatore.

MATERIAL AND METHODS

Thirty - one ecogeographically and phenotypically diverse soybean cultivars were evaluated for different agronomic characteristics at Central Farm (black loam soil of good native fertility) and Millets Breeding Station (red sandy loam soil of poor fertility) of the Tamil Nadu Agricultural University, Coimbatore (11° N latitude) under six bimonthly sowings. Sowings were undertaken on 15 of September and November 1970, January, March, May and July 1971 and represented the range of environmental conditions encountered in the region. A randomized block design with two replicates was used for each test. The varietal plots were based on single row of 25 plants spaced 20cm. Rows were spaced 60 cm apart. A fertilizer dose of 20kg N, 80 kg P_2O_5 and 60 kg K_2O/ha was

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placed in row at planting. Except for the character days to 50 per cent flowering, which was recorded on the plot basis, measurements were taken on 10 random plants/plot in each test for characters seed yield (g), number of seeds, pods and nodes, plant height (cm) days to first flowering and days to maturity.

Variance components were obtained from the combined analysis of the data collected at two locations under six bi-monthly sowings. Components were estimated from the mean square expectations in the manner discussed by comstock and Robinson (1952) and Miller *et al.* (1959). All effects were assumed to be random. The following variance components were estimated :

- $\sigma^2 g$ – the genotypic component among lines
- $\sigma^2 gp$ – component arising from interaction of genotypes x locations
- $\sigma^2 gs$ – the genotype x season component
- $\sigma^2 gps$ – the genotype x location x season component
- $\sigma^2 e$ – plot error variance

To gather information as to the number of tests needed and the precision of variety evaluation in soybean, a theoretical total variance of genotype means ($G\bar{x}$) was computed using data on seed yield in the present tests. By substituting estimated values for variance components in the formula (Rasmusson and Lambert, 1961; Liang and Walter, 1966) as under :

$$G\bar{x} = \frac{\hat{\sigma}^2 gs}{s} + \frac{\hat{\sigma}^2 gy}{y} + \frac{\hat{\sigma}^2 gsy}{sy} \frac{\hat{\sigma}^2 e}{rsy},$$

the expected variance of a genotype mean was predicted for various combinations of locations, seasons and replicates. The smaller the variance of a genotype mean, the more precise are the estimates of genotype performance.

RESULTS AND DISCUSSION

The presence of significant genotype x location interaction component, greater in magnitude than the genotype x season and genotype x location x season interactions for the characters plant height, number of nodes, pods and seeds and seed yield (Table I) indicates that the genotypes responded differently at the two locations. The differential genotypic responses to the locations emphasizes the needs for increasing number of locations in testing and according to Matzinger (1963) restricting the evaluation to a subset of the original locations. Days to maturity and days to flowering also recorded a significant interaction with location, but the interactions were only the half the magnitude of genotype x season interaction component. The present data, as such, suggest the desirability of selecting or developing varieties adapted to different environments.

The significantly greater variance components for genotype x season interaction for days to first flowering, days to 50% flowering and days to maturity (Table I) suggests a differential varietal response to different seasons. Since the genotypes under evaluation have come from diverse sources of germplasm, the significant genotype x environment interactions obtained were somewhat expected as many of the varieties posses little adaptation in this area.

TABLE I. Estimates of variance components for 8 traits in soybean

Character	Variance components				
	σ^2_g +	σ^2_{gs}	σ^2_{gp}	σ^2_{gps}	σ^2_e
Seed yield/plant(g)	11.48**	−0.24	4.98**	−17.76	56.26
Number of seeds	2414.11**	−54.77	1053.69**	244.42*	940.36
Number of pods	602.78**	7.97	279.17**	74.97**	136.71
Number of nodes	15.49**	0.25	1.14**	0.87**	0.83
Height at maturity (cm)	333.36**	10.33**	56.30**	11.88**	23.09
Days to first flowering	25.42**	0.93**	0.50**	0.24	1.34
Days to 50% flowering	26.36**	0.58**	0.08	1.51**	0.39
Days to maturity	35.38**	5.50**	2.57**	2.25*	7.70

+ g,s,p and e refer to genotypes, seasons, locations and error, respectively.

* Significant at .05 level of probability

** Significant at .01 level of probability

Besides the above, plant height also showed significant genotype x season interaction. The lack of significance of genotype x season interactions, however, for number of nodes, pods and seeds and seed yield indicated that the varieties ranked essentially the same in performance in each of the six seasons of testing for the four traits listed (Miller, Robinson and Pope, 1962). It could be inferred that there would be little, advantage in evaluating the genotypes over a number of seasons for the above traits.

The second order of interaction of genotype x location x season was non-significant for seed yield and days to first flowering in the present study. For all other characters where significance was shown, it had a very low magnitude compared to that of genetic variance. This suggested that the performance of the genotypes with regard to these traits may be predictable over locations and seasons and that the genotypic difference- greatly over shadow genotype x environment effects.

The genotypic variance component for all the traits evaluated were highly significant (Table I) and had the highest value among all the estimates except in case of seed yield. This goes to show that the varietal performance for the seven traits generally was consistant enough and that the lines may be evaluated adequately by testing in only a few replicates and at a minimum of locations. For seed yield the significant genotype x location component and larger magnitude of error component emphasizes the need for multilocation testing with a large number of replicates.

The present results are in general agreement with other similar reports on soybean (Johnson *et al.*, 1955; Matzinger, 1963 and Schutz and Bernard, 1967) in that for yield the error component and

TABLE II. Comparison of theoretical and observed variance of genotype means for yield

Number of locations	2 sowing dates			3 sowing dates			4 sowing dates			6 sowing dates		
	2*	3	4	2	3	4	2	3	4	2	3	4
2	131	126	123	115	112	110	107	105	104	(100)	98	97
4	76	73	72	65	63	62	59	58	57	53	53	52
6	57	56	55	48	47	46	43	42	42	38	37	37
8	48	47	46	39	38	38	35	34	34	30	30	30

* 2–4: 2,3 and 4 replications, respectively

Observed variance for 6 sowing dates, 2 locations and replications in parentheses

the interaction components were larger in magnitude than the component due to genotypic differences. For the remaining seven traits, the error and interaction components were small and mostly unimportant as compared to the genotypic component. However, in the present study the first order genotype x location interaction component for yield and other characters excepting days to 50% flowering, had a higher value than the second order interaction of genotype x location x season indicating that the two locations include different environments.

Theoretical variances calculated for seed yield are presented in Table II, relative to the conditions of the present trials. Since the number of experimental sites selected was rather small, especially in view of the significant genotype x location interaction, an approximate calculation of the expected variance was made for 2, 4, 6 and 8 locations. The values for 'r' were assumed as 2,3 and 4 replicates in a randomized block design which is presented an accepted, predicted advance from selection in the hypothetical testing programme increases as more locations seems to have greater effect on the magnitude of expected variance. An increase by two locations decreases the expected variance of a genotype mean to 53 per cent, by four locations to 38 per cent and by six locations, to 30 per cent as compared to the present combination of two locations, six seasons and two replicates. This may suggest the importance of location effects in testing soybean cultivars. On the whole, increasing number of environments is much more effective in decreasing the expected variance of a genotype mean than increasing the number of replications. Sprague and Federer (1951) in maize and Miller, Robinson and Pope (1962) in cotton have reported similarly.

From the data in the present study, it is felt that a fairly good evaluation of the genotypes may be obtained from a six location, two season and two replication experimental arrangement under Coimbatore conditions.

According to Johnson, Robinson and Comstock (1955) interaction variances indicate the variability in the relative performance of genotypes in different environments, and their magnitude in comparison to genetic variances for various characters determine the need for replication in locations, years and individual tests in the accurate estimation of the means upto which selection is based. Allard and Bradshaw (1964) have stressed the need for developing "well buffered" varieties that are adapted to with stand unpredictable transient environmental variations will, thus, show low genotype-environment interaction for agriculturally important characters, particularly yield. They have stated that in self pollinated crops there is evidence that buffering can be a property of specific genotypes and varietal differences in degree of buffering exist. The varieties EC 7034, EC 39824, EC 39506, EC 14437 and EC 39822 that have significantly superceded the general mean in terms of productivity across 12 environments (six seasons and two locations) in the present tests under Coimbatore conditions (Kaw and Menon, 1978), could be recommended for cultivation till such time specific varieties are bred for specific environments.

It needs to be emphasized, however, that the parameters worked out presently have a limitation of being estimated on the basis of single row plots and that the magnitude of the estimates are plots and that the magnitude of the estimates are specific for the genotypes and geographic area sampled.

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