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STABILITY AND ADAPTABILITY ANALYSIS OF SOME QUANTITATIVE TRAITS IN UPLAND COTTON VARIETIES

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Five cotton varieties, all *hirsutum* types were compared for their adaptability and stability parameters in six environments over three year period for seed cotton yield, lint percentage and fibre length. The regression coefficient (b) was used as a factor for adaptability whereas the terms coefficient of determination (r^2) and sum of squared deviations (S^2d) from regression were used as a measure of stability parameters. Varieties, CRIS-121 and CRIS-5A were considered well adapted to all types of environments, Rehmani and NIAB-78, to less favourable environments and BH-89, to highly favourable environments. CRIS-121 and CRIS-5A were adaptable to highly favourable environments and other three varieties, to less favourable environments for lint . In respect of fibre length, CRIS-5A and Rehmani preferred highly favourable environments and other varieties, to less favourable environments. All the varieties had good stability in the test environments for yield and were more stable for lint percentage as compared to fibre length. CRIS-121 was generally more adaptable as well as stable for all the traits in test environments.

Key words: Adaptability and Stability Parameters, Genotype-environment interaction, Cotton.

Introduction

Several methods are used for measuring the stability and adaptability of genotypes across different environments. Earlier the regression analysis was the commonly used method (Yates and Cochram 1938; Finlay and Wilkinson 1963; Eberhart and Russel 1966). However, there were some limitations in this procedure (Crossa, 1988). Lin *et al* (1986) revised 10 commonly used parameters and presented the concepts of stability and adptability to be different approaches of statistics that measure the same phenomenon. Thus the parameters of stability were concised and grouped in three major concepts based on deviation of average performance of genotype, or the genotype environment interaction (G * E), or regression environmental index arbitration. Lin *et al* (1986) however tried multivariate analysis to ensure complete elucidation of the response of a cultivar by these three classifications of stability. Bilbro and Ray (1976), by regressing each variety over environmental index, maintained b to be a measure of adaptability whereas r^2 and S^2d, as measures of stability. Geng *et al* (1987) confirmed a positive correlation between the average performance of a cultivar and the regression coefficient confirming that cotton cultivars giving higher yields are, in general, lower in adaptability. Considering the variable performance of cotton varieties to changing environments, the present studies were undertaken to insinuate the adaptability and stability of some newly evolved cotton cultivars tested in various locations over a period of three years.

Materials and Methods

Five cotton varieties, three from Sindh Province (CRIS-121, CRIS-5A and Rehmani) of which CRIS-121 and CRIS-5A are newly evolved varieties and two from Punjab (NIAB-78 and BH-89) were compared for their adaptability and stability. These varieties were grown in six cotton growing districts of Sindh Province for three consecutive years i.e., from 1994 to 1996. The experiment was accomplished in a randomized complete block design with four replications accommodated in a plot size of 12.5 x 45.0 at each test location. The generally recommended distance of 2.5 between row to row and 9.0 between plant to plant were adapted. Regular inputs like fertilizer, irrigation and insecticides were given as and when required. Seed cotton yield (kg ha^{-1}), lint percentage as the ratio of seed and lint and fibre length at 50% span length were recorded.

The combined analysis of variance over locations (the terms 'test sites' and 'environments' are interchangeable) and years were carried out before determining any of the stability and adaptability parameters (Eberhart and Russell 1966). Genotype x environment interaction was significant in calculating the stability and adaptability parameters. Linear regression coefficient (b) and sum of squared deviations (S^2d) were calculated as suggested by Bilbro and Ray (1979). In addition to the above parameters, coefficient of variability (CV%) , means and grand means of varieties were also considered as stability parameters.

Results and Discussion

In the combined analysis of variances, variety-environment interaction was significant for all the three traits studied allowing further partitioning of this factor into environment linear, variety x environment linear and pooled deviations from environment linear Table 1. The sites and years were considered as random samples from the population of environments and the analysis was carried out accordingly. The significance of variety mean square for all the traits connoted presence of genetic differences in the varietal performance. These results thus suggest that varieties should be thoroughly tested before recommending them for general cultivation in all the test environments or to specific environments.

Thus regression analysis should also be carried out using Eberhart and Russells, (1966) and Bilbro and Ray, (1976) statistical models. The environment linear mean square is used to detect at least part of interaction effect which can be attributed to linear functions of environmental effect. Based on it, prediction can be made about interaction of certain genotypes with certain environments and thus their performance. In the present situation, significance of environmental linear term tested against pooled deviation mean squares implied the presence of gentic differences among the varieties for their regression on the environmental index. Similarly, these mean squares for all the traits were significant suggesting differences in regression coefficients also. The pooled deviations mean square tested against pooled error mean square were not significant demonstrating that regression lines of the varieties were not different from the unit slope.

The stability and adaptability parameters for all the three traits of five cotton varieties are presented in Table 2. The regression coefficient (b) was used as a factor of adaptability whereas coefficient of determination (r^2), sum of squared deviation (S^2d) from regression and coefficient of variability (CV%) were used as measures of dispersion, thus factors for stability. A variety with b close or equal to unit slope (b=1.0) is considered suitable to all types of environments, with b>1 more adaptive to highly favourable environments and b<1 indicates better yields in less favourable environments. The regression coefficient (b) values of CRIS-121 and CRIS-5A (both newly evolved varieties) for yield of 1.062 and 1.004, respectively, suggest that these varieties are well adapted to all types of environments connoting wider adaptability (Table 2). The mean yield of these varieties is also approximately equal to grand mean which is another parameter of their wider adaptability. Varieties Rehmani and NIAB-78, having regression coefficient below unit slope, suggest that both varieties have above average adaptability and are suited to unfavourable environments. Variety BH-89 having regression coefficient above unit slope is predicted to perform well in highly favourable environment. Baloch *et al* (1994; 1997) also made similar interpretation of cotton varieties based on their regression coefficient values.

The coefficient of determination (r^2) and sum of squared deviations (S^2d), considered as indices of stability and predictability of performance, are presented in Table 2. A cultivar

Table 1

Adaptability and stability analysis of some quantitative traits in upland cotton varieties tested in six environments over three years (1994-1996)

Source of variation	Degrees of freedom	Mean squares		
		Seed cotton yield	Lint (%)	Fibre length
Total	89	5666661.506	5.732	0.904
Variety	4	333786.472**	59.395**	1.838**
Env. + Var. + Ent.	85	577620.331**	3.207**	1.860**
Env. Linear	1	1218901.700**	248.685**	136.589**
Var + Env. Linear	4	7425687.672**	1489.975**	820.252**
Pooled deviations	80	73122.640	1.890	0.386
Deviations from regression of each variety				
Variety CRIS-121	16	77709.344	1.320	0.256
Variety CRIS-5A	16	89883.838	1.343	0.153
Variety Rehmani	16	119260.013	2.540	0.387
Variety NIAB-78	16	20476.968	1.421	0.241
Variety BH-89	16	58283.036	2.825	0.892*
Pooled error	12	88645.624	2.396	0.453

, * significant at 5 and 1% probability levels, respectively.

Table 2

Means, grand-means, adaptability and stability attributes of some quantitative traits in upland cotton varieties tested in six envrionments over three year (1994-1996)

Varieties			Seedcotton yield (kg ha^{-1})			
	X	b	S^2d	r^2	CV (%)	$\bar{X}$
CRIS-121	2182.8	1.062	1243349.5	0 .8139	25.7	2122.7
CRIS-5A	2270.4	1.004	1438141.4	0.8044	26.2	-
Rehmani	1956.4	0.958	1908160.2	0.8044	31.7	-
NIAB-78	2001.4	0.819	327631.5	0.9459	18.1	-
BH-89	2202.5	1.155	932528.6	0.9244	30.1	-
			Lint percentage			
	X	b	S^2d	r^2	CV (%)	$\bar{X}$
CRIS-121	34.4	1.257	12.12	0.4315	6.6	35.17
CRIS-5 A	33.8	0.554	21.48	0.1789	7.5	-
Rehmani	34.0	1.984	40.64	0.6555	7.5	-
NIAB-78	35.3	0.933	22.74	0.4238	4.3	-
B H-89	38.2	0.859	45.20	0.4367	5.3	-
			Fibre length (mm)			
	X	b	S^2d	r^2	CV (%)	$\bar{X}$
CRIS-121	26.48	0.910	4.09	0.5776	2.9	26.72
CRIS-5A	26.60	1.300	2.44	0.8358	3.5	-
Rehmani	27.17	1.362	6.19	0.6861	4.0	-
NIAB-78	26.93	0.859	3.85	0.5679	2.7	-
B H-89	26.42	0.941.	14.27	0.2958	4.1	-

X=Mean; b=regression coefficient,S^2d=sum of squared deviations, r^2coefficient of determination, CV=coefficient of variability and X=grand mean.

is not considered very stable if it has a low r^2 value and therefore a high S^2d (Bilbro and Ray 1976). For yield, the coefficient of determination (r^2) for all the varieties are fairly high, ranging from 0.8139 to 0.9459 suggesting fairly stable varieties for this trait. However, for lint percentage, these values are generally small, ranging from 0.1789 to 0.6555 and for staple length, the r^2 values are higher, ranging from 0.2958 to 0.8358 indicating greater stability of the varieties for staple length as compared to lint percentage. Considering sum of squared deviations (S^2d) as a stability parameter (Eberhart and Russell 1966), with high r^2 and minimum S^2d for yield of variety BH-89 suggest, its higher stability but the value of its b earlier suggested it to be best suited to highly favorable environments. Such contrary results had been noted in past (Baloch *et al* 1994; 1997; Geng *et al* 1987). However, it was also observed that b and S^2d are independent of each other and both the parameters do not always favour one variety over the others. The varieties CRIS-121 and CRIS-5A with the next and third minimum S^2d as well as favourable values of b for yield suggest the varieties having wider suitablity to varying climatic conditions.

Regarding lint percentage, b>1 of CRIS-121 and CRIS-5A suggest that these varieties are suited to highly favourable environments, whereas other three varieties with b<1 indicate that these varieties are adapted to less favourable environments. The minimum value of S^2d for lint percentage of varieties CRIS-121 and CRIS-5A suggest to be fairly stable varieties for this trait. However the variety Rehmani with b>1 and large S^2d for lint percentage is suited to highly favourable environments.

In respect of fibre length CRIS-5A and Rehmani had b>1 whereas CRIS-121, NIAB-78 and BH-89 had less than 1.0, suggesting that the first two prefer highly favourable environments and other varieties perform very well in less favourable environments. CRIS-121, CRIS-5A and NIAB-78 had smaller S^2d for fibre length as compared to Rehmani and BH-89 suggesting that the newly evolved variety CRIS-121 was more adaptable for fibre length to varying environments compared to other varieties in the test.

Correlation coefficient (r) matrix between the stability and adaptability parameters for all the three traits are presented in

Table 3
Correlation coefficients (r) matrix between adaptability and stability parameters

Parameter	Seed cotton parameter			Lint percentage parameter			Fibre length parameter		
	1	2	3	1	2	3	1	2	3
1. Regression Coefficient (b)	1.0000	0.3067	-0.1795	1.0000	0.3993	0.0920	1.0000	-0.2420	0.6877
2. Sum of Squared deviations (S^2d)	- -	1.0000	-0.8860*	- -	1.0000	0.1915	- -	1.0000	-0.8610*
3. Coefficient of determination (r^2)	- -	- -	1.0000	- -	- -	1.0000	- -	- -	1.0000

*Significant at 5% probability

Table 3. Significant and negative correlations between coefficient of determination (r^2) and sum of squared deviations for yield ($r = -0.8860$) and for fibre length ($r = -0.8610$) were obtained. Similar results have also been reported by Gutierrez *et al* (1994) in their studies on 18 cotton cultivars. These results suggest that with the increase of r^2, S^2d from the regression decreases. Such observations in these studies are encouraging about the performance of varieties tested.

However, no significant correlations between the other stability and adaptability parameters were obtained in the present study. The lack of correlation between regression coefficient (b) and sum of squared deviations (S^2d) are in consonance with the results of Becker (1981). These results further suggested that selection of varieties for higher yield with better stability and wider adaptability in performance is possible and could be based on more important parameters.

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