Biological Sciences Section

Pak. j. sci. ind. res., vol. 40, nos.5-12, May-December 1997

ENVIRONMENTAL ADAPTATION ANALYSIS OF SEVERAL UPLAND COTTON VARIETIES

M. J. Baloch, W. A. Siddiqui and H. U. Bhutto

Cotton Research Institute, Sakrand-67210, District Nawabshah, Pakistan

(Received August 31, 1995; revised February 22, 1997)

Ten Pakistani upland cotton varieties, all *hirsutum* types were collated for their environmental adaptation in three sites over three years for seedcotton yield, lint % and fibre length. Stability parameters considered in this study were, regression coefficient (b), deviations from the regression line (S^2-d), mean over environments and coefficient of variability (CV). In a combined analysis of variance, variety x environment interaction factor was recorded significant for all the traits that allowed further partitioning of this factor into environment linear, variety x environment linear and pooled deviations from the regression. Environment linear and variety x environment linear were also significant for all the traits, connoted genetic differences among the varieties for their response to varying environments. Varieties Sarmast and NIAB-78 were comparatively more stable to variable environments for seedcotton yield, CRIS-9 and NIAB-78 for lint % and Qalandri, Shaheen, CIM-70 and CIM-109 for fibre length due to their means higher than the grand mean, regression coefficients equal or close to unit slope and smaller deviations from the regression line for respective traits. Whereas under specific environments of favourable nature, varieties CRIS-9, Shaheen and CIM-109 would be desirable for seedcotton yield and Shaheen, CIM-70 and MNH-93 for lint % and K-68-9 for fibre length. For less favourable environments, varieties Qalandri, Rehmani and CIM-70 would perform better for yield, Qalandri and K-68-9 for lint % and CRIS-9 for fibre length.

Key words: *G. hirsutum,* Seedcotton yield, Lint%, Fibre length.

Introduction

Genotype-environmental interactions are frequently confronted by cotton breeders that cause inconsistencies in relative performance of genotypes evaluated in variable environments [1-3]. Significant genotype-environmental interactions insinuate that genotypes necessitate testing in several locations and years. Thus, selection of genotypes that are consistently higher yielding in varying environments or in specific environments become prime objectives of the cotton breeders in evolving new varieties.

Since mid 1960s, much efforts have therefore been directed towards detecting and describing pattern of interaction effect. Pioneering work of Miller *et al.* [4], to estimate the genotype and environmental variances and covariance in upland cotton gave a real start to quantify and partition the genotype-environment interaction effects. Since then, Finlay and Wilkinson [5] and Eberhart and Russell [6] proposed a method of measuring individual cultivar's stability/adaptability in the performance relative to grandmean over a series of environments and also cultivars' own performance relative to their linear response. For this purpose, they used joint regression analysis by which cultivar's adaptability was determined by regressing varietal yield on environmental indexes calculated by subtracting the grandmean from the mean yield of all cultivars in each environment. The authors also recognized a stable variety as the one with a regression coefficient equal to unity (b=1.0) and the deviations from the regression equal to zero or as small as possible. A variety with regression coefficient equal to unit slope and minimum deviation from regression meant a variety would well adapt to varying environment, either poor or favourable whereas variety with regression coefficient less than the unit slope implies above average adaptability of a variety to poor or less favourable environments. While the variety with regression coefficient above the unit slope would be adapted to highly favourable environments. Bilbro and Ray [7] also believed that a more logical parameter for stability would be the one that measures the dispersion around the regression line and would, therefore, be related to the predictability and repeatability of varietal performance within the environments. Owing to overwhelming importance of zoning cotton varieties, present studies were initiated to test ten upland cotton varieties in three locations over three years.

Materials and Methods

Ten upland cotton varieties, six from Sindh (CRIS-9, Qalandri, Sarmast, K-68-9, Rehmani, and Shaheen) and four from Punjab (CIM-70, CIM-109, NIAB, MNH-93) were tested at three sites in three districts of Sindh province for three continuous years. The sites and years were considered as random samples from the population of environments and the analysis was carried-out accordingly. The experiments were conducted as comparative variety testing trials of Sindh and Punjab varieties from 1989 to 1991. In each year and at each site, the experiments were laid-out in a randomized complete block design accomodated in four repeats. At all test locations, the plot size in a repeat was four rows, each 50.0' long.

A two-way factorial analysis on the data combined over sites and years was performed following statistical procedures by Gomez and Gomez [8]. In the analysis of variance when variety by environment interaction was declared significant, then the means of varieties from particular years and sites were used for extrapolating stability parameters by adapting joint regression analysis of Eberhart and Russell's model [6]. In their statistical model, variety x environment interaction factor was partitioned into Environment Linear, Variety x Environment Linear and Pooled Deviations from the regression. The mean of individual variety was regressed on an environmental index calculated by subtracting the grandmean. Parameters like, regression coefficients and deviations mean squares from the regression slope were used as the measure of stability/adaptability of the varieties. Significance of regression coefficient was determined by "t" test whereas the deviations from their regression slope was tested against pooled error as denominator. The data for this study was recorded on seed cotton yield (kg ha^{-1}), Lint % and fibre length measured in millimeters.

Results and Discussion

In a combined analysis of variance, variety x environment interaction factor was established significant for all the three traits. These results signified that varietal performance fluctuated from one environment to another, thus emphasizing that, varieties require meticulous and repeated testing over several sites and years before they are recommended for particular set of environments. Several researchers have evaluated the genotype-environment interactions as linear function of the environments [5, 9-12].

Although genotype-environment interaction was significant, yet it did not provide information on the relative performance of a cultivar in the testing environments. Thus, to understand individual variety performance, Eberhart and Russell [6] proposed a method to determine the cultivar's adaptability by joint regression analysis.

In the regression analysis of variance (Table 1),the varieties were tested against the pooled deviations and it was significant for all the traits suggesting genetical differences in the performance of varieties. In Eberhart and Russell's model, environments and variety x environment interaction degrees of freedom were partitioned into environment linear, variety x environment linear and pooled deviations from the environmental linear. The significance between the regression of varieties for a particular trait was determined as both the mean squares i.e., for varieties (Var. MS) and mean for Env + Var x Env divided by the mean squares for pooled deviations (Pooled Dev. MS). If the ratio of these two mean squares is approximately equal, then it declares no significant differences between the regressions of the varieties for a particular character. In the present case, ratio of Var.MS is greater than the Env + Var x Env. MS for all the three traits implying that there existed significant differences among the varieties in their response to varying environmental indices. The mean squares for Env. Linear and Var x Env. Linear were tested against the pooled deviations and significance of all the traits connoted sizeable genetic differences among varieties for their regressions on the environmental indices. Similarly, Geng *et al.* [13] reported seasonal variations for fiber length and Patel *et al.* [14] and Alabi and Echekwu [15] for seedcotton yield. The pooled deviations mean square, tested against mean square for pooled error resulted non-significant F value implying that regression lines of the varieties did not differ from a unit slope (b=1.0). Individual variety deviation from regression line, tested against pooled error and its significance in CIM-70 for seedcotton yield and fiber length and in CIM-109 for only lint%, suggested that CIM-70 and CIM-109 were more sensitive and fluctuative for respective traits.

TABLE 1. ADAPTABILITY ANALYSIS OF TEN PAKISTANI UPLAND COTTON VARIETIES FOR SEEDCOTTON YIELD AND ITS COMPONENTS SAMPLED FROM THREE ENVIRONMENTS OVER THREE YEARS (1989-1991).

Source of variation	D.F.	Seedcotton yield kg ha^{-1}	Mean squares Lint %	Fibre length mm
Total	89	371860.25	0.982	1.242
Variety	9	819627.17*	2.857**	4.470**
Ent + Var x Ent.	80	321486.48**	0.772*	0.878**
Env. Linear	1	351710.57**	111.457**	207.353**
Var x Env. Linear	9	4004145.30**	1251.121**	792.242**
Pooled deviations	70	58531.25	0.561	0.509
Deviations from regression of each variety				
Variety CRIS-9	7	56563.17	0.802	0.414
Varriety Qalandri	7	11152.51	0.068	0.621
Variety Sarmast	7	10386.64	0.216	0.875
Variety K-68-9	7	70202.07	0.130	0.244
Variety Rehmani	7	70883.87	0.183	0.157
Variety Shaheen	7	39867.78	0.224	0.371
Variety CIM-70	7	152150.60*	0.752	1.122*
Variety CIM-109	7	26112.12	2.030**	0.289
Variety NIAB-78	7	54654.00	0.512	0.414
Variety MNH-93	7	93389.76	0.695	0.590
Pooled Error	80	58531.25	0.584	0.513

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

TABLE 2. MEANS, GRANDMEANS, AND STABILITY PARAMETERS OF TEN PAKISTANI UPLAND COTTON VARIETIES FOR COMPARING THEIR YIELD AND ITS COMPONENTS SAMPLED FROM THREE ENVIRONMENTS OVER THREE YEARS (1989-1991).

Character	Parameter	CRIS-9	Qalandri	Sarmast	K-68-9	Rehmani	Shaheen	CIM-70	CIM-109	NIAB-78	MNH-93
Seedcotton	x	2485.0	1735.3	1737.7	1709.8	1482.0	2027.4	1441.8	2023.4	1878.3	1739.1
yield	b	1.228	0.711	0.822	1.073	0.914	1.290	0.882	1.112	0.964	1.038
(kg^{-1}/ha)	S^2-d	395942	78067	72706	491414	595837	279074	1065054	182785	382578	653728
	CV	26.6	10.7	13.7	23.1	19.1	27.7	20.5	22.3	20.2	23.1
	x	1826.0									
Lint%	x	35.28	33.72	33.69	33.45	33.40	33.11	33.05	33.43	34.30	33.33
	b	1.151	0.545	1.558	0.618	1.107	3.735*	3.880*	1.354	0.934	3.416*
	S^2-d	5.614	0.480	1.510	0.912	1.279	10.369	5.261	14.208	3.855	4.867
	CV	2.7	1.1	1.0	3.0	1.5	1.6	2.9	3.2	2.1	3.7
	x	33.78									
Fibre	x	26.21	27.48	26.95	28.67	26.73	27.08	27.57	27.00	26.28	26.94
length	b	0.638	0.838	1.075	2.107	1.424	1.000	0.767	0.945	1.098	1.628
(mm)	S^2-d	2.896	4.349	6.123	1.708	1.102	2.594	7.854	2.028	2.898	4.131
	CV	2.5	2.7	3.9	4.7	3.2	3.1	3.9	2.6	3.0	4.1
	x	27.09									

x= mean of variety , b = regression coefficient, S^2-d = deviations from regression, CV = coefficient of variability, x = grandmean, * = significantly different from the unit slope.

The stability parameters, like mean of environments alongwith regression coefficients, deviations from regression and coefficients of variation are presented in Table 2. Consideration was given to those varieties that recorded means higher than the grandmean, deviations from regression (S^2-d) approaching to zero or as small as possible, regression coefficients close or equal to unit slope (b=1.0) and smaller coefficients of variation (CV). Not always, all these parameters are correlated and favour one variety, that means stability parameters are independent of each other. Consequently, regression coefficients and deviations from regression are mostly considered as the criteria measuring stability of a variety and others as supportive attributes. For seed-cotton yield, the stable varieties for a set of environments would be the Sarmast and NIAB-78 as their regression coefficients are close to unity, 0.822 and 0.964 respectively and have also minimum deviations from the regression. However, variety CRIS-9 performed the best in every environment (Fig. 1) and the varieties Shaheen and CIM-109 would only be desirable under specific environments of favourable nature as they secured mean yields of 36.1, 11.0 and 10.8 higher than the grandmean respectively. Their regression coefficients were also greater than the unit slope (b>1.0) with smaller deviations from the regression. The varieties better adaptive to poor environments were Qalandri, Rehmani and CIM-70 because of their means smaller than the grandmean, regression coefficients below the unit slope and larger deviations from the regression. Coefficient of variation (CV) did not show apparent relationship with any of the other stability parameters.

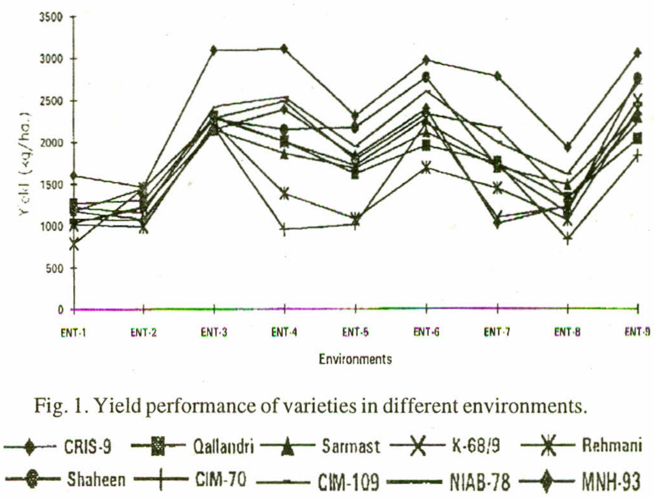

Fig. 1. Yield performance of varieties in different environments.

Similarly, the most stable varieties for lint% were CRIS-9 and NIAB-78 due to their means higher than the grandmean, regression coefficients closer to unity, CRIS-9 =1.15 and NIAB = 0.934 and also have smaller deviations from the regression. The varieties Shaheen, CIM-70 and MNH-93 were adaptive to only environments of highly favourable nature due to their regression coefficients greater than the unit slope and larger deviations from the regression line. Other varieties, like Qalandri and K-68-9 would produce better lint% in the environments of unfavourable nature based on the b value less than 1.0, means smaller than the grandmean and also minimum deviations from the regression line. For fiber length, varieties Qalandri, Shaheen, CIM-70 and CIM-109 would be desirable types in the situations where environments are variable due to their means equal or higher than the grandmean, regression coefficients close to unit slope and also smaller deviations from regression except CIM-70. The variety K-68-9 would be more productive for fibre length to climates of highly favourable nature as its mean is 5.8% higher than the grandmean, regression coefficient twice the unit slope (b = 2.107) and comparatively smaller deviation from the regression. Other varieties with b value less than 1.0 and means less than the grandmean will perform better in poor environments and variety CRIS-9 falls in this category. The varieties Sarmast, Rehmani, NIAB-78 and MNH-93 which recorded b value greater than 1.0 but means below the grandmean and higher deviations from regression would only be preferred where the environments are favourably controlled. Coefficient of variation again showed little or no relevancy with other stability parameters for fibre length, also.

References

1. W. C. Morrison and L. M. Verhalen, A study of genotype x environment interactions in cotton and their implications on future verieties and strains testing in Oklahoma. Proceedings of 1973, Beltwide Cotton Production and Research Conference, National Cotton Council of America, Memphis, Tennessee, U.S.A. pp.59-62 (1973).
2. S. S. Gill and T. H. Singh, Ind. Jour. Genet. & Plant Breed., **41** (2), 292 (1981).
3. S. Geng, Q. Zhang and D. M. Bassett, Agron. Jour., **82,** 514 (1990).
4. P. A. Miller, J. C. Williams, H. F. Robinson and R. E. Comstock, Agron. Jour., **50,** 126 (1958).
5. K. W. Finaly and G. N. Wilkinson, Aust. Jour. Agri. Res., **14,** 742 (1963).
6. S. A. Eberhart and W. A. Russell, Crop Sci., **6,** 36(1966).
7. J. D. Bilbro and L. L. Ray, Crop Sci., **16,** 821 (1976).
8. K. Z. Gomez and A. A. Gomez, *Statistical Procedures for Agricultural Research* (John Wiley and Sons, 1984), 2nd edn.
9. R. E. Comstock and R. H. Moll, *Genotype-Environment Interactions.* In, Statistical Genetics and Plant Breeding, W. D. Hanson and W. F. Robinson (eds), (Nat. Acad. Sci., National Research Council, Washington D.C., 1963) pp.6: 36-40.
10. F. L. Allen, R. E. Comstock and D. C. Ramussan, Crop Sci., **18,** 747 (1978).
11. K. D. Brown, M. E. Sorrells and W. R. Coffman, Crop Sci., **23** (5), 889 (1983).
12. Q. Zhang and S. Geng, Theo. and Appl. Genet.,**71,** 810 (1986).
13. S. Geng, Q. Zhang and D. M. Bassett, Crop Sci., **27,** 1004 (1987).
14. J. C. Patel, N. P. Mehta, U. G. Patel and A. T. Masuria, Ind. Jour. Agric. Sci. **60,** 486 (1990).
15. S. O. Alabi and C. A. Echekwu, Samaru. Jour. Agric. Res., **6,** 44 (1989).