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# Genotype X Environment (GxE) Interactions in Cotton (*Gossypium hirsutum* L.) Genotypes

Sawan Laghari, M. Mureed Kandhro, H. Munir Ahmed, M. Ali Sial and M.Z. Shad
Nuclear Institute of Agriculture, Tandojam 70060, Sindh, Pakistan

**Abstract:** Stability in yield of seed cotton over wide range of environments has long been desired by plant breeders. To determine the possible effects of environment and genotypic differences for yield, three advanced strains/genotypes of cotton viz. AEHM-4/4/89, AEH-2/90, AENB-10/87 alongwith two commercial checks viz., NIAB-78 and Rehmani were tested over different environments in Sindh. Genotypes, locations and genotype x environment (GxE) interactions were highly significant ($P \leq 0.01$) indicating genetic variability between genotypes by changing environments. Stability parameters calculated were regression coefficient (b), S.E. and deviation from regression ($S^2d$). Genotypes, AENB-10/87, NIAB-78 and AEH-2/90 had the highest mean seed cotton yield, regression coefficient (b) less than or close to unity (0.749, -0.295, 0.215, respectively), the lowest deviation from regression ($S^2d$) (0.083, 0.025, 0.071 respectively) suggesting above average stability and adaptability over environments. AEHM-4/4/89 and commercial check Rehmani produced low mean yields than the grand mean with the highest regression coefficient (b) and the highest deviation from regression coefficient ($S^2d$) had below average stability and are specifically adapted to favourable environments.

**Key words:** *Gossypium hirsutum* L., GxE interaction, seedcotton yield, adaptability

## Introduction

Cotton (*Gossypium hirsutum* L.) is an essential fibre as well as edible oil crop of Pakistan. It plays an important role in the economy of the country and has remained the central theme of self sufficiency programme. In Pakistan, cotton is grown on area of about 2.98 m $ha^{-1}$ among which, Sindh shares 0.63 m $ha^{-1}$ (Anonymous. 2000). Stability studies in cotton is an essential part of breeding programme prior to the release of new variety, usually number of locations and years are necessary for adequate evaluation of cultivars.

Finlay and Wilkinson (1963), suggested that the mean yield and regression coefficient (b) of yield of genotypes over environments provides information for selecting cultivars with broad adaptability. Eberhart and Russell (1966), described that a desirable cultivar is one, which has high mean yield, a regression coefficient (b) close to unity and a small (close to zero) variance due to deviation from regression ($S^2d$). Selection of cultivar and interpretation of findings from the evaluation trials can be difficult, if there is significant interaction between genotype and environment (GxE). However, differential response of cotton varieties to different environments had led plant breeders to determine the phenotypic stability among genotypes by using some statistical devices such as joint regression analysis (Brown *et al.*, 1983; Eberhart and Russell, 1966; Finlay and Wilkinson, 1963; Geng *et al.*, 1990; Sial *et al.,* 2001; Baloch , 2001), cluster analysis (Gauch, 1988), principal component analysis (PCA) and additive main effects and multiplicative interactions (AMMI) (Basford and Cooper, 1998). If a crop responds to favourable environments linearly within a range of conditions, it provides alternative index, which helps to interpret the GxE interaction. The present study leads to better understanding of the stability and adaptability among cotton genotypes/advance strains over different environments in the province of Sindh.

## Materials and Methods

The performance of three cotton (*Gossypium hirsutum* L.) strains viz., AENB-10/87 , AEH-2/90 and AENS-18/87 alongwith two commercial check varieties, NIAB-78 and Rehmani were evaluated in zonal varietal trials at three different sites in Sindh. The data were recorded for seed cotton yield (Kg/plot) at each site. The experiments were sown in randomized complete block design (RCBD) in triplicate fashion. Plot size for each genotype was 27 $m^2$ (4.50x6.00 m). Recommended distances of 75 cm between rows and 30 cm between plants were kept. Data were statistically analyzed by using analysis of variance (ANOVA) suggested by Steel and Torrie (1980) method over environments to determine the significance of genotypes, environments and genotype x environment (GxE) interactions. The joint regression analysis method proposed by Perkins and Jinks (1968), Finlay and Wilkinson (1963) and Eberhart and Russell (1966) was used to calculate the regression coefficient (b), S.E. and variance due to deviation from regression ($S^2d$) as a parameters of stability and adaptability .

## Results and Discussion

Pooled analysis of variance for seed cotton yield showed highly significant ($P \leq 0.05$) differences between genotypes (G), environments (E) and genotype x environment (GxE) interaction (Table 1). Significant GxE interaction suggested the linear function of the additive environment effects (Mather and Jinks, 1982) and was reflected by the change in the ranking order of genotypes under varying environments. However, overall performance of genotypes depends upon the magnitude of genotype x environment interaction. Mean yield of genotypes over environmental index ranged from 8.13 Kg in Rehmani to 10.18 kg in AENB-10/87. Genotype AENB-10/87 produced the highest seed cotton yield over environments viz., 10.38 kg at Sakrand, 10.36 kg at NIA, TandoJam and 9.80 kg at Ghotki (Table 2). The commercial check variety NIAB-78 remained the second highest yielding (9.34 kg) genotype over all the locations followed by AEH-2/90 and AEHM-4/4/89 (8.53 and 8.41 kg respectively). The highest site mean yield (9.22 kg) was recorded at NIA, TandoJam and the lowest at Ghotki (8.45 kg) but the difference was non significant.

Stability analysis results are presented in Table 3. The wide variation in regression coefficient (b) values for seed cotton yield among genotypes was observed, ranging from -0.295 in NIAB-78 to 1.845 in AEHM-4/4/89. Three genotypes AEH-2/90, AENB-10/87 and NIAB-78 had the highest mean seed cotton yield, regression coefficient (b) less than or close to unity (0.215, 0.749, -0.295, respectively) the lowest deviation from regression (0.071, 0.083, 0.025 respectively), suggesting above average stability and adaptability over environments according to stability definitions proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966). Lin and Binns (1985) suggested that the genotypes with the lowest regression coefficient (b) values (< 0.70) were considered unresponsive to different environments or had above average stability i.e. between 0.70 and 1.30 (b value) had average stability and with more than (>1.30) regression coefficient were considered responsive to favourable (high yielding) environments or had below average stability.

Genotype AENB-10/87 produced significantly the highest mean yield than rest of the entries, with regression coefficient (b) value less than unity (b= 0.749) and deviation from regression ($S^2d$) close to zero (0.083). These findings indicate that this genotype is high yielding as well as stable over environments. Finlay and Wilkinson, 1963 suggested that the genotype with maximum yield potential over environments, regression coefficient b= 1 would be stable. Whereas, Eberhart and Russell (1966) proposed that the deviation from regression ($S^2d$) is the parameter of stability and regression coefficient (b) is the parameter of response and suggested that a cultivar with low ($S^2d$) value (close to zero) and b value close to unity (b= 1) is said to be highly stable with wide adaptation. Baloch *et al.* (1997), also reported that the consideration should be given to those varieties which produced higher mean yields than the grand mean, regression coefficients close or equal to unity (b= 1), deviation from regression coefficient ($S^2d$) approaching to zero or as small as possible and smaller coefficient of variation (CV).

The commercial check NIAB-78 had second best yield after AENB-10/87 and proved to be the most stable variety in this group of comparison, as its regression coefficient (b) is very small approaching to unity (b= -0.295) and have also small deviation from regression (($S^2d$= 0.025). Geng *et al.* (1987) suggested that the cultivars with exceptionally small regression coefficients (b= 0.01 to 0.20) would be the highly stable over different environments. Similar results of genotype x environment interaction analysis for yield and other associated

Table 1: Analysis of variance (ANOVA) of seed cotton yield (Kg plot$^{-1}$) of cotton genotypes

| Source of variation | D.F | M.S. | F-value | Prob. |
|---|---|---|---|---|
| Locations (L) | 2 | 2.970 | 17.84*** | 0.000 |
| Genotypes (G) | 4 | 7.831 | 45.86*** | 0.000 |
| Genotype x environment (GxE) | 8 | 0.379 | 2.22* | 0.04 |
| Error | 36 | 9.171 | - | |

*, *** Levels of significance at 5% and 1% respectively

Table 2: Overall mean seed cotton yield (Kg plot$^{-1}$) of cotton genotypes

| | Locations | | | |
|---|---|---|---|---|
| Genotypes | NIA, Tandojam | CRI, Sakrand | CRS Ghotki | Mean over all locations |
| AEHM-4/4/89 | 9.27b | 8.13c | 7.82bc | 8.41cd |
| AEH-2/90 | 8.70c | 8.38c | 8.52b | 8.53c |
| AENB-10/87 | 10.36a | 10.38a | 9.80a | 10.18a |
| NIAB-78 | 9.27b | 9.25b | 9.49b | 9.34b |
| Rehmani | 8.51c | 8.25c | 9.63c | 8.13d |
| Site mean | 9.22 | 8.87 | 8.45 | |

Values sharing common letters do not differ significantly from each other

Table 3: Stability parameters for seed cotton yield

| Genotypes | Mean yield (Kg plot$^{-1}$) | Regression coefficient b± s.e (b) | Variance due to deviation from regression ($S^2d$) |
|---|---|---|---|
| AEHM-4/4/89 | 8.41 | 1.845 ± 0.719 | 0.246 |
| AEH-2/90 | 8.53 | 0.215 ± 0.356 | 0.071 |
| AENB-10/87 | 10.18 | 0.749 ± 0.411 | 0.083 |
| NIAB-78 | 9.34 | -0.295 ± 0.179 | 0.025 |
| Rehmani | 8.13 | 1.154 ± 0.209 | 0.218 |

characters have also been reported in many other crop plants by other investigators (Baker, 1990; Chakroun *et al.*, 1990; Voltas *et al.*, 1999; Sial *et al.*, 1999; 2000, 2001). The genotype AEHM-4/4/89 and check variety Rehmani produced low mean yields than the grand mean, the highest regression coefficient (b= 1.845 and 1.154, respectively) and the highest deviation from regression coefficient ($S^2d$= 0.246 and 0.218, respectively) suggests that these both lines/varieties had below average stability and are specifically adapted to favourable (good) environments. Similar results have been observed by various researchers (Baloch *et al.*, 1994; 1997; Qayyum *et al.*, 2000; Geng *et al.*, 1987; Bilboro and Ray, 1976).

In conclusion, the present study has provided an evaluation of the genotypic and environmental performance of newly developed cotton advanced strains/genotypes over different environments. Stability analysis has demonstrated that two newly developed cotton lines (AEH-2/90 and AENB-10/87) are less responsive to changed environmental conditions, having more stability and adaptation and can be grown over range of environments in the Province of Sindh. Contrary, two genotypes with low mean yield were shown to be very sensitive to environmental changes.

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