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Stability analysis and genotype x environment interactions of some Egyptian cotton cultivars cultivated

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Stability analysis helps in understanding the adaptability of genotypes over different environmental conditions and the identification of adaptable genotypes. Three field experiments were carried out at the Faculty of Agriculture, El-Fayoum University, Fayoum, Egypt, to study the magnitude and nature of genotype × environment interaction and determine of stability of yield potentiality for five Egyptian cotton varieties. Significant differences were observed among cotton genotypes for seed cotton yield per plant, lint yield per plant, number of open bolls, boll weight, lint % and lint index. Combined analysis showed highly significant between the genotypes, between environments and for Gene–environment interaction of all traits under study. These results showed that genotypes of Giza 90 and Giza 80 were more stable genotypes. This implies therefore that there genotypes are low contribution to the genotypic by environment interaction. Our results showed that high yield genotypes can differ in yield stability, and suggest that yield stability and high mean yield are not mutually exclusive. Therefore, the genotypes Giza 90 and Giza 80 could be used as breeding stock that could be incorporated in crosses with the objectives of improving the previously mentioned traits.

Key words: Cotton cultivars, stability parameters, environment × genotype interactions, potentiality.

INTRODUCTION

Stable performance of varieties under different environments with regard to economic characters like seed and lint yields is one of the focal endeavors of Egyptian cotton (*Gossypium barbadense* L.) breeding programs. In order to initiate the development of stable genotypes, information on various stability aspects and their mode of transmission would be very essential. Efforts have been made to combine yield and performance stability into a single selection criterion (Kang, 1993; Kang and Magari, 1995).

Eberhart and Russell (1966) found that an ideal cultivar is one that has the highest yield over a broad range of environments. They defined a stable cultivar as that with regression coefficient (b) equals to one and with mean squares deviation from regression S^2d equal to zero. Apparently, a cultivar that did not meet both these qualifications would be classed as unstable. Lin et al. (1986) reported that a particular genotype may considered to be stable; (a) if it is among environments variance is small, (b) if it is response to environments is parallel to the mean response of all genotypes in the trail, or (c) if the residual mean square from regression model on the environmental index is small. The causes of yield stability or instability are often unclear, while physiological,

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Table 1. Pedigree of cotton genotypes.*

Genotype	Pedigree
Giza 90	Giza 83 x Dandara
Giza 88	Giza 77 x Giza 45
Giza 80	Giza 66 x Giza 73
Giza 86	Giza 75 x Giza 81
Giza 70	Giza 59A x Giza51B

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physiological, morphological and phonological mechanisms that impart stability are diverse (Abo El-Zahab et al., 1994).

Seyam et al. (1994) reported that average genotypic stability degree was found for seed index in Giza 80 and Giza 83, lint percentage in Giza 83 and lint index in Giza 81. Badr (1999) found average genotypic stability degree for seed and lint yields in Giza 86, Giza 87 and Giza 88, boll weight in Giza 85 and Giza 87 and seed index in Giza 85, Giza 86 and Giza 89. Various researches that is, Bakheit et al. *(*2009) in Egyptian clover, Mosa et al. (2009), Abd El-Moula (2011) and Abdallah et al. (2011) in maize, Darwish et al. (2011) in mungbean, El-Kadi et al. (2011) in lentil and Ghazy et al. (2012) in sorghum have been used different stability parameters to assess adaptation and yield stability of promising genotypes across environments to select the superior and adaptable genotypes. In the light of the previously mentioned aspects, the present study aimed to investigate the relative stability performance of five cotton genotypes over 6 different environments through comparing the stability parameters of those genotypes.

MATERIALS AND METHODS

The present study was carried out at the experimental farm of the Faculty of Agriculture, El-Fayoum Univ., Fayoum, Egypt. Two planting dates (1^{st} of March and 1^{st} of April) and three growing seasons (2009, 2010 and 2011) provided a total of 6 environments. Five varieties of Egyptian cotton (*Gossypium barbadense* L.) namely; Giza 90, Giza 88, Giza 80, Giza 86 and Giza 70 were evaluated under different six environments. Pedigree of cotton genotypes are shown in Table 1. The aforementioned varieties were grown in a split- plot design with five replications. Dates of sowing were assigned to main plots and varieties to sub-plots. The sub plot area was 3 × 7 m = 21 m^2 and contained 5 rows each of 60 cm wide and 7 m long. Distance between hills was 20 cm and each hill was thinned to two plants. All cultural practices were applied as usually done in the ordinary cotton fields, except for the variables under study. The characters studied were seed cotton yield per plant (g), lint yield per plant (g), number of open bolls, boll weight (g), lint % and lint index (g).

Statistical analysis

Data from each of six environments (combination of dates and years) were analysis. Test of homogeneity, commonly known as the Bartlet's test was made according to Gomez and Gomez (1984). Two stability techniques were used for comparing cotton genotypes as follows:

(1) Eberhart and Russel (1966), in this analysis two parameters were obtained, b and S^2d (regression coefficient and mean squares of deviation from regression, respectively) of the performance on environmental indices.
(2) The yield- stability statistic (YS_i) as developed by Kang (1993), the mechanism of yield stability (Kang, 1993) has been finalized through yield components. Yield- stability (YS_i) statistic was calculated using the program STABLE (a basic program for calculating stability and yield – stability statistic) after Kang and Magari (1995). Data of sowing dates and years were used for calculating the genotypes stability indices across all environments.

RESULTS AND DISCUSSION

Analysis of variance

The results of joint analysis of variance for all studied traits (Table 2) showed that the mean squares of environment × genotype interactions were highly significant for seed cotton yield per plant, lint yield per plant, boll weight, number of open boll, lint percentage and lint index traits. Thus, it appeared important to determine stability degree for each genotypes. Environment + genotypes × environment (linear) interactions were partitioned into environment (linear), genotypes × environment (linear) interaction (sum of squares due to regression, b_i) and unexplainable deviation from regression (pooled deviation mean squares, S^2d).

Mean squares due to environment (linear) and linear interaction genotypes × environment were highly significantly for all traits studied. The first effect means that differences on environments (sowing dates and years) will generate disparities on cultivar responses; while the later effect indicates that there are genetic divergences among cultivars taking into account their responses variation of environmental conditions. The main cause of the differences among genotypes in their yield stability trails was the wide occurrence of Gene–environment interaction (Eberhart and Russell, 1966; Freeman and Perkins, 1971). Similar results were found by (Ibrahim et al., 2000; Abdallah et al., 2011).

In other word, pooled of deviation mean squares were highly significantly for boll weight and lint index indicating that the major components for differences in stability were due to deviation from linear function. Therefore, it may be concluded that the relatively unpredictable components of the interaction may be more important than the predictable components. In this respect, the investigators proved that the environmental variation can be classified into predictable and unpredictable variation (Mead et al., 1986; Becker and Leon, 1988). The predictable once caused by more permanent features, while the unpredictable variations are caused by year to year fluctuations in weathers, insect infestation and

Table 2. Stability analysis of variance of five Egyptian cotton genotypes over six environments for the studied traits.

Sources of variance	d.f.	Seed cotton yield/plant	Lint yield /plant	Boll weight	Number open bolls	Lint percentage	Lint index
Genotypes (G)	4	666.26**	458.176**	1.157**	36.788**	27.404**	10.270**
G× E	20	12.966**	5.692**	0.0093**	1.118**	0.3744**	6.4E-02**
(G× E)+ Environment	25	49.111**	9.359**	0.0587**	97.095**	3.815**	0.8303**
Environment (Linear)	1	1141.32**	211.221**	1.406**	95.984**	92.902**	20.326**
G × E (Linear)	4	19.746**	5.485**	0.0057**	0.2152	0.0620	0.0964**
Pooled deviation	20	0.3831	0.0415	0.0020**	0.0125	0.1127	0.0023**
Giza 90	4	0.0787	0.0136	0.0003	0.0023	0.2717	0.0007
Giza 88	4	0.2181	0.0069	0.0001	0.0313	0.1537	0.0015
Giza 80	4	0.8705	0.0693	0.0065**	0.0008	0.0395	0.0002
Giza 86	4	0.4654	0.0968	0.0020**	0.0069	0.0407	0.0061
Giza 70	4	0.2839	0.0209	0.0011	0.0213	0.0577	0.0030
Pooled error	120	1.2189	0.1681	0.0002	0.1489	0.1763	0.0016

* ,**Significant differences at 0.05 and 0.01 levels of probability, respectively.

disease infections. These results were found by Abo El-Zahab et al. (1994); Abd El-Moula (2011) and Ghazy et al. (2012).

Conventional and yield stability

Estimates of various stability parameters of five cotton genotypes with respect to seed cotton yield per plant, lint yield per plant, boll weight, number of open boll, lint percentage and lint index traits are presented in (Table 3). Stability parameters are: (1) the average (x) for different traits, (2) the regression coefficient (b) of the performance on environmental indices, (3) the squared deviation (S^2d) from regression, and (4) a yield-stability statistic (YS_i) developed for simultaneous selection for yield and stability. Results indicated that the average values of all studied traits for all evaluated cotton genotypes greatly and significant differed from one environment to another.

Mean performance and yield stability statistic

Mean performance and yield stability statistic for the above mentioned traits are shown in (Table 3). Giza 90 followed by Giza 80 showed high mean performances for all the studied traits. Also, Giza 86 exhibited moderate mean performances of SCY, LY, BW , No.OB , L % , and LI , While Giza 88 and Giza 70 gave the lowest values. This means the two genotypes Giza 90 and Giza 80 may be used breeding materials in breeding cotton programs.
The presence of GE interaction (Table 2) indicated that conclusions based solely on genotypes means were not reliable. Genotypes responded differently to changes in environments; therefore, measure of stability (YS_i) was deemed appropriate (Table 3). Yield stability according to Kang (1993), revealed that Giza 90 and Giza 80 were stable for all studied traits. In the meantime, Giza 86 was stable for SCY, No. OB, and LI. But, Giza 88 was stable only for boll weight. Contrary, Giza 70 was unstable genotype for all studied traits according to Kang (1993). These results are in harmony with those obtained (Abo El-Zahab et al., 1994; Seyam et al., 1994; Badr, 1999). These results indicated that, the above mentioned two genotypes Giza 90 and Giza 80 are considered as ideal stable genotypes (according (YS_i) measurement) for all traits studied. Thus, may be used as a breeding materials that could be incorporated in crosses with the objectives of improving the previously traits mentioned. Similar conclusion was reported by Khalifa et al. (2010) when they estimated the stability of cotton genotypes using the methods of yield stability statistics according to model of Kang and Magari (1995).

Conventional stability parameters

Taking into account two parameters of stability (b_i and S^2d), it is interesting to note that the results in (Table 3), showed clearly that the regression of average mean performances of genotypes on the environmental index resulted in regression coefficients (b_i) values. The b values obtained did not deviate significantly from the unity for all genotypes in all studied traits.

In this respect, the two genotypes Giza 90 Giza 80 met the two criteria (b did not differ significantly from one and S^2d close significantly from zero or equal zero). Eberhart and Russell (1966) defined an ideal genotype of an annual crop as the one with the highest yield over a wide rang of environments, a regression coefficient of one and a deviation from regression close to zero as possible ($S^2d = 0$).

Table 3. Mean performance and stability parameters for different genotypes of Egyptian cotton over six environments.

Traits	Sta./Geno.	Giza 90	Giza 88	Giza 80	Giza 86	Giza 70	$LSD_{0.05}$
S.C.Y./P.	Mean	40.16	17.36	31.80	24.13	14.15	0.61
	b	0.61	1.27**	0.85	0.93**	1.31**	
	S2d	0.014	0.010	0.034	0.075	0.093**	
	YSi	0√	-9	-1√	0√	-10	
L.Y./P.	Mean	15.51	6.09	11.86	8.74	4.73	0.17
	b	0.56	1.30**	0.78	0.91**	1.43**	
	S2d	0.015	0.016	0.009	0.007	0.015**	
	YSi	0√	-9	-1√	0√	-10	
B.W.	Mean	2.86	1.90	2.48	2.23	1.77	0.007
	b	0.95	1.01	0.70	0.95	0.85**	
	S2d	0.00	0.00	0.006	0.002	0.001	
	YSi	8√	-1√	-1√	-8	-10	
No. 0.B.	Mean	13.89	8.89	12.38	10.64	7.83	0.21
	b	0.82	1.04**	0.95	1.05**	1.09**	
	S2d	0.014	0.011	0.015	0.013	0.017	
	YSi	0√	-9	-1√	2√	-10	
L.%	Mean	38.30	34.58	37.34	35.84	32.95	0.24
	b	1.01	0.92	0.97	0.98	1.08**	
	S2d	0.09	0.02	0.13	0.14	0.12	
	YSi	0√	-9	-1√	-4√	-10	
L.I.	Mean	6.21	3.16	5.25	4.35	2.91	0.02
	b	0.90	1.09	0.89	0.99	1.19**	
	S2d	0.001	0.00	0.001	0.004	0.001	
	YSi	0√	-9	-1√	-8	-10	

SCY/P, LY/P, BW, NO.OP, L% and LI: denote seed cotton yield per plant, lint yield per plant, boll weight, number open boll, lint % and lint index, respectively. √ = Stable genotypes on basis of yield stability statistics (YSi). ** Significant at P = 0.05 and 0.01, respectively, also indicates that the genotype performance across environments was unstable.

Also, Giza 90 and Giza 80 met criterion high (YS_i). According to these assumptions, it could be concluded that the two genotypes (Giza 90 and Giza 80) might exhibited not only broad adaptability to all environments but also highly predictable yields. This indicates that cotton breeders should consider environmental conditions and stability as a criterion for selecting high yielding cultivars. Similar conclusion was reported by Mosa et al. (2009); Abd El-Moula (2011) and Abdallah et al. (2011) when they estimated the stability parameters in different crops by using the model of Eberhart and Russell (1966).

Conclusion

(1) Among the genotypes used in this study, Giza 90 and Giza 80 showed high seed and lint yield and were found to be stable across the studied environments. Therefore, could be used in breeding programs, for development of high yield stable genotypes across environments for future use.

(2) Yield stability selection method was better than conventional selection in isolating and selecting the elite and adaptable genotypes when G x E interaction was significant.

(3) Our results showed that high yield genotypes can differ in yield stability, and suggest that yield stability and high mean yield are not mutually exclusive.

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