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GENOTYPE X ENVIRONMENT INTERACTION AND STABILITY PARAMETERS FOR GRAIN YIELD IN SOME PROMISING MAIZE HYBRIDS

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Eight maize single crosses i.e. SC Gz 123, SC Gz 124, SC Gz 134, SC Gz 135, SC Gz 136, SC Gz 230, SC SK 93, and SC SK 95 developed at the National Maize Research Program, along with two commercial check hybrids were evaluated in replicated yield trails at eleven locations i.e., Behaira , Kafr El Seikh , Dakahlia , Gharbia, Monofia, Kalubia , Sharkia , Beni Suief, Menia, Assiut, and Sohag to study genotype x environment interaction (GEI) and estimate their yield stability under different environments. Significant variances for environments, and genotype x environment interaction (GEI), demonstrated that the main cause of the differences among genotypes in terms of yield stability is the wide occurrence of GEI. Partitioning of GEI into G x Env linear and pooled deviation (non-linear) indicated significant of both effects when tested against pooled error, indicating that both components contributed for GEI. Genotypes x environments (linear) component was not-significant when tested against pooled deviation from regression indicating the equal importance of both predictable and unpredictable interaction of these materials. Regression of coefficient of all genotypes was not significantly different from unity. Estimates of environmental index showed that Monofia was the most favorable environment, which was linked to the highest mean grain yield, while Menia was the poorest yielding environment.

Key words: ***Zea mays, Maize, Genotype xEnvironment interaction, Stability***

INTRODUCTION

Developing high yielding maize hybrids (*Zea mays* L.) that are well adapted to a wide range of environments is a major objective of the National Maize Research Program and different seed production agencies. To achieve this breeding goal, it is essential that maize breeders use stability technique that will identify high stable yielding genotypes accurately in a multi-location yield trials conducted under different environmental conditions. This provides an adequate basis for general recommendations suitable for these new hybrids. However, stability performance is one of the most desirable properties for a particular genotype released as anew adapted variety for awide range of environments.

The regression approach (Finlay and Wilkinson 1963 and Eberhart and Russell 1966) is the widely-used method for detecting stable genotypes. However, Freeman and Perkins (1971), Hill (1975), Hill and Baylor (1983) and Westcott (1986) have pointed out that stability parameters determined for a given entry will vary according to the mean performance of the genotypes with which the entry is compared. On the other hand, many investigators proved that the environmental variation can be classified into predictable and unpredictable variations (Allard and Bradshaw, 1964, El-Nagouly *et al* 1980 and Mead *et al* 1986). The predictable ones caused by more permanent features, while the unpredictable variations are caused by year-to-year fluctuations in weather, insect infestation and disease infection.

To reduce the magnitude of genotype x environment interaction within aregion, Horner and Frey (1957) , George *et al* (1966), Murray and Vehalm (1970), Dhillon and Singh (1977) , Francis and Kannenberg (1987), Ibrahim *et al* (1984) and Ragheb *et al* (1993 a and b) suggested that the environmental variations can be minimized by locations grouping into regions of similar environmental conditions. They obtained a highly significant genotype x environment interaction, even after grouping the environments into regions of similar climatic conditions.

Several breeders used the regression analysis to estimate stability and adaptability for several genotypes of different crops such as wheat (Becker and Leon 1988), barley (Paroda and Hays 1971), soybean (Johnson *et* al 1955) and maize (Finlay and Wilkinson 1963, El-Nagouly *et al* 1980 and Ragheb *et al* 1993 a). However, the modified model of Eberhart and Russell (1966) was widely used by various investigators (Rowe and Andrew 1964, Eberhart and Russell 1969,Paroda and Hays 1971, El-Nagouly et al 1980, Ibrahim *et al* 1984, Ragheb *et al* 1993 a and b, Barakat and Abd El-Aal 2007 and El-Sherbieny *et al* 2008). On the other hand, Eberhart and Russell (1966) stressed that the most important stability parameter appeared to be the deviation mean square because all types of gene action were involved in this parameter. Lin *et al* (1986) reported that aparticular genotype may considered to be stable (i) if its among environments variance is small, (ii) if its response to environments is parallel to the mean response of all genotypes in the trial or (iii) if the residual mean squares from regression model on the environmental index is small.

The main objective of this investigation was to estimate stability parameters for grain yield of 10 elite maize hybrids evaluated across eleven locations in Egypt during 2009 summer season.

MATERIALS AND METHODS

Eight new yellow maize single crosses, i.e. Gz 123, Gz 124, Gz 134, Gz 135, Gz 136, Gz 230, SK 93, and SK 95 along with two check single cross (Gz 162, and Gz 166) were evaluated in 2009 season at eleven environments across Egypt i.e., Behaira , Kafr El Seikh, Dakahlia, Gharbia, Monofia, Kalubia, Sharkia , Beni Suief , Menia , Assiut , and Sohag. These hybrids were developed by the National Maize Research Program.

A randomized complete block design (RCBD) with 6 replications was used at each environment. Plot size consisted of 4 rows, 6 m long and 80 cm apart. The inner two rows were harvested (plot size = 1/500 feddan (fed), one fed = 4200 m^2). Planting was done in hills (2-3 kernels/hill) equally spaced 25 cm along the ridge. Thinning to one plant/hill was done 21 days after planting, giving a plant denesity of 21875 plants fed^{-1}. Nitrogen fertilizer was applied at the rate of 120 kg N/feddan in three equal doses, the first dose was applied at planting, the second after thinning, and the third before the second irrigation (36 days after planting). Pest control and other cultural practices were carried out as recommended. At harvest, 110-120 days after planting, weight of harvested ears/plot, shelling percentage and grain moisture were recorded. These data were used to calculate grain yield in ardab (ard fed^{-1}) adjusted to 15.5 % moisture. Statistical analysis of variance for each environment and combined across environments were computed to grain yield. Bartlett's test according to Steel and Torrie (1980) was also computed to test the homogeneity of variances prior to combined analysis. Stability analysis for grain yield across all locations was performed according to the following model of Eberhart and Russell (1966):

$$Yij = Ui + \beta iIj + Oij$$

where:

Yij = variety mean of the i^{th} variety at the j^{th} environment (location).

Ui = mean of the i^{th} variety across-all environments.

βi = regression coefficient that measures the response of the i^{th} variety to varying environments.

Ij = environmental index obtained as the mean of all varieties at the environment j^{th} minus the grand mean.

Oij= deviation from the regression of the i^{th} variety at the j^{th} environment.

This model interprets the variance of regression deviassion as a measure of environmental index. In this model mean (μ) and environmental index (Ij) are used as coeffecient. According to this model, an ideal genotype should have high mean, a unity regression coeffecient (b_i=1) and no deviation from linearity (S^2d_i=0). All statistical analyses were performed using the SAS program (SAS Institute 1999).

RESULTS AND DISCUSSION

Analysis of variance for grain yield revealed significant differences among genotypes and among environments (Table 1). Test of homogeneity of the error mean squares across all environments, indicating the possibility of conducting the combined analysis. Combined analysis revealed that genotypes differed significantly from an environment to another (Table 1). Significant mean squares among the tested environments, and genotype x environment interaction (GEI) were also detected. In this regard, Eberhart and Russell (1966) and Freeman and Perkins (1971) demonestrated that the main cause of the differences among genotypes in their yield stability trials was the wide occurrence of GEI. The presence of significant GEI showed the inconsistency of maize genotypes performance across the tested environments and advocated the adeqacy of stability analysis. Partitioning of GEI into G x Env (linear) and poold deviation (non-linear) indicated significance of both effects when tested against pooled error. This revealed that both components contributed to GEI. Similar results in maize have been reported by WURKU *et al* (2001), Rassul *et al* (2005), Soliman (2006), and El Sherbieny *et al* (2008). Genotype x environment (linear) component was non-significant when tested againest poold deviation from regression indicating equal importance of both predictable and unpredictable interactions in these materials. These results agree with the finding of El Sherbieny *et al* (2008) and Abdallh *et al* (2010).

Based on the combined analysis, avrage grain yield of all crosses ranged from 25.78 (Gz 124) to 28.78 (Gz 135) with an average of 27.10 ardabs $feddan^{-1}$ (Table 2). Two crosses, i.e. Gz 134 and Gz 135 were superior and surpassed the highest check hybrid Gz 166 (26.84 ardab $feddan^{-1}$), but they did not differ significantly from each other. Coeffecient of variation (CV%) was below 15% at all environments. In this regard, abd El Aziz (2000) and Soliman (2006) found that the differences in mean performance of a particular set of genotypes were considered to be mainly due to the new improved hybrids, the differences among environments, to the farmer factor, and the variation in soil fertility.

Estimates of environmental index (Table 3) showed that Monofia was the most favorable environment, which was linked to the heighest mean grain yield, while Menia was the poorest yielding environment. This suggests that the performance of the tested genotypes varied from one environment to another. Environmental means revealed that Monofia had the highest environmental average (32.25 ardabs $feddan^{-1}$), while Menia had the lowest average 21.15 ardabs $feddan^{-1}$).

In the present investigation, the simultaneous results of three stability parameters for the individual genotype revealed that the regression coeffeicients of all genotypes were not significantly different from unity. Therfore, the stable performance of the genotypes in this case is predicted on the basis of the other two parameters, i.e., deviation from regression and average yield across all environments (Zubair and ghafoor 2002). Out of the 10 evaluated genotypes, 8 genotypes had significant deviation mean squares from linear reggression, implying that these genotypes were unstable across environments (Table 4). The single cross Gz162 (check) had the highest S^2d_i value, indicating its sesitivity to environmental changes and an unpredictable grain yield (Eberhart and Russel, 1966), while the lowest value was shown by Gz 124. Similar results had been reported in maize by El Sherbieny *et al* (2008).

Table1. Analysis of variance for stability of grain yield for the 10 yellow single crosses evaluated at 11 locations in 2009 season.

S. O. V.	df	MS
Environment (Env)	10	693.29**
genotypes (G)	9	86.63**
G x Env (GE)	90	27.02**
Env,Env.G	100	93.76**
Env (linear)	1	6941.48**
G. Env (linear)	9	21.01**
Pooled Deviation	90	24.95**
SC Gz 123	9	15.67**
SC Gz 124	9	7.32 NS
SC Gz 134	9	21.20**
SC Gz 135	9	14.48*
SC Gz 136	9	16.17**
SC Gz 230	9	35.24**
SC SK 93	9	15.83**
SC SK 95	9	10.04 NS
SC162	9	97.40**
SC162	9	16.16**
Average Error	495	6.350

*,** Significant at 0.01 and 0.05 level of probability, respectively.

The single cross Gz 166 (check) had the highest value of regression coefficient (bi=1.14), indicating its responsiveness to favorable conditions and good environments. Single crosses Gz162 (check) and SK95 would be especially good for unfavorable environments. They had the lowest value of regression coefficient (bi=0.604 and 0.781, respectively). Genotypes with high mean grain yield combined with a regression coefficient equal to the unity (bi=1) and small deviation from regression ($S^2di=0$) are considered stable (Finlay and Wilkinson 1963 and Eberhart and Russell 1966).

Table 2. Average grain yield of 10 maize single crosses evaluated at 11 environments in 2009 season.

Single Cross	Behaira	Kafr El Seikh	Dakahlia	Gharbia	Monofia	Kalubia	Sharkia	Beni Suief	Menia	Assiut	Sohag
Gz 123	27.65	22.93	20.98	25.43	32.12	29.12	24.20	24.30	21.58	31.75	27.02
Gz 124	24.83	25.89	21.66	24.65	32.11	30.37	24.78	22.92	18.74	30.19	27.46
Gz 134	26.01	28.68	22.39	30.11	32.07	31.61	26.50	26.13	22.82	34.94	30.05
Gz 135	27.84	25.53	25.71	30.19	31.98	32.35	28.30	26.00	21.88	35.82	31.06
Gz 136	28.40	26.28	23.17	24.41	33.51	32.33	25.71	24.42	23.35	32.02	27.71
Gz 230	23.22	29.11	29.53	27.30	32.51	30.64	25.18	23.97	19.36	33.95	31.32
SK 93	28.13	27.80	26.27	28.18	32.03	28.92	24.33	24.07	20.97	34.46	31.59
SK 95	25.33	25.97	28.10	26.18	29.53	30.17	24.68	23.63	22.03	31.43	28.57
Gz162 (check)	27.05	24.36	27.40	29.16	32.66	30.66	20.80	21.98	21.53	20.54	21.54
Gz166(check)	28.96	22.51	25.71	26.63	33.98	30.92	24.76	24.73	19.47	31.32	26.28
Env. Average	26.74	25.91	25.09	27.22	32.25	30.71	24.92	24.22	21.15	31.64	28.26
LSD 0.05	3.51	2.06	2.41	2.67	2.92	2.33	3.03	3.40	2.79	3.03	3.61
C.V%	11.3	6.84	8.27	8.46	7.81	6.53	10.46	12.08	11.37	8.25	11.00

Table 3. Estimates of environmental index for grain yield at 11 environments

Environment	Environmental index
Behaira	-0.36
Kafr El Seikh	-1.19
Dakahlia	-2.01
Gharbia	0.12
Monofia	5.15
Kalubia	3.61
Sharkia	-2.18
Beni Suief	-2.88
Menia	-5.95
Assiut	4.54
Sohag	1.16

Table 4. Grain yield, regression coefficient (b_i), and deviation mean squares (S^2d_i) for 10 maize crosses evaluated across 11 locations.

Genotypes	Grain yield (ard fed^{-1})	Bi	S^2di
Gz 123	26.101	1.023	15.675**
Gz 124	25.783	1.140	7.324NS
Gz 134	28.303	1.027	21.200**
Gz 135	28.788	1.078	14.477*
Gz 136	27.411	1.010	16.172**
Gz 230	27.827	1.125	35.244**
SK 93	27.872	1.067	15.830**
SK 95	26.875	0.781	10.041NS
Gz162 (check)	25.244	0.604	97.397**
Gz166 (check)	26.843	1.145	16.163**
Mean	27.10	1	
LSD 0.05	0.86		

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التفاعل بين التركيب الوراثي والبيئة والثبات المظهري لمحصول الحبوب في بعض
الهجن المبشرة من الذرة الشامية

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قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

تم دراسة التفاعل بين التركيب الوراثي والبيئة وكذلك حساب الثبات المحصولي لعدد ٨ هجن من الـذرة الشامية الصفراء المبشرة والمستنبطة من خلال البرنامج القومي لبحوث الذرة الشامية بالإضـافة إلـى هجينـين تجاريين. وقد قيمت هذه الهجن في احد عشر موقعا بمحافظات البحيرة، كفر الشيخ، الدقهلية، الغربية، المنوفيـة، الشرقية، القليوبية، بني سويف، المنيا، أسيوط وسوهاج في تجارب تقييم المحصول. وقد أظهرت النتـائج وجـود اختلافات معنوية بين المواقع وكذلك كان التفاعل بين الهجن والمواقع معنويا مما يشير الى ان السـبب الأساسـي للاختلافات بين الهجن في الثبات المحصولي يرجع الى التفاعل بين التراكيب الوراثية والمواقع (التفاعل الخطـي) والانحراف x البيئة. وبتقسيم التباين الراجع الى التفاعل بين الهجن والمواقع إلى التفاعل الخطي و التفاعل غيـر الخطي أظهرت النتائج معنوية كل منهما مما يدل على مساهمة كل منهما في التفاعل بين البيئة والهجن. أوضـحت النتائج أن التفاعل بين الهجن والمواقع كان غير معنوي عند اختباره على أساس الانحراف القياسي للانحدار ممـا يدل على تساوي أهميتهما في التفاعل بين الهجن والمواقع. أظهرت قيم معامل الانحدار لكل الهجن عـدم معنويـة القيم مقارنة بالوحدة. كما أوضحت النتائج أن أعلى دليل للبيئة تم الحصول عليه من محافظة المنوفية ممـا يـدل على أنها الأفضل محصوليا بين المواقع بينما كانت محافظة المنيا اقل المواقع محصولا.

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