13

Stability Performance of Some New Yellow Maize Genotypes Across Four Locations

Moshera S.E. Sadek, H.M. Abd El-Ghany[*] and M.A. Abd El Moula
Maize Department, Field Corps Res. Inst., Agricultural Research Center and [*]Field Corps Research Department, National Research Centre Giza, Egypt.

T HIS STUDY aimed to investigate the performance and stability across four environments *i.e.* Gemmeiza, Sakha, Sids and Mallawy of eighteen genotypes of maize and two commercial checks hybrids (SC 155 and SC 3084). Combined analysis of variance of stability across environments indicated that significant genetic variability for all studied traits, as well as the environment indicating differential effect of each environment. Sakha location produced the highest grain yield. Most of the hybrids had a significant deviation mean square from linear regression for grain yield implying that these hybrids were unstable across environments except for seven hybrids Gm 1, Gm 2, Gm 6, Gm 9, Gm 14, Gm 17 and Gm 18 which showed small and insignificant S^2d_i estimates, indicating that these hybrids could be considered to be stable hybrids. It could be concluded that the five hybrids; SC Gm 1, SC Gm 5, SC Gm 8, SC Gm 3 and SC Gm 4 can be selected since they produced the highest grain yield, and were earlier than the two check crosses . Moreover they achieved reasonable degree of stability across the four locations Gemmeiza, Sakha, Sids and Mallawy. These hybrids have to undergo progressive evaluations.

Keywords: Stability, Adaptability, Yellow Maize Environment.

In Egypt, Maize considered one of the most strategic crops either for feeding animals or human consumption. Most Egyptian cultivars have white grains; while small area is grown by yellow hybrids that their grain are used for poultry feed. To expand new yellow maize cultivars, they should characterize with high productivity and adaptability over different environmental conditions in Egypt so can be specified stable.

Maize genotypes vary in their response to variable environmental conditions. So, one of the most widely approaches in maize breeding programs is detecting the new improved hybrids for continuous and stable performance through evaluating them over these environmental conditions. Therefore, the most adapted hybrids can be identified and designate other hybrids to locations having suitable environments. Successful development of improved maize hybrids is dependent upon the accurate evaluation of genotypes performance in different locations.

The development of genotypes varieties, and/or new hybrids which can be adapted to a wide range of diversified environments is the ultimate goal of plant breeders in a crop improvement program. Therefore, the existence of genotype-environment (GE) interaction requires extensive yield testing in order to identify genotypes that react less with environment. A good method to measure stability was previously proposed (Finlay & Wilkinson, 1963) and was later improved by Eberhart & Russel (1966) who proposed a model to test the stability of varieties under various environments. Elto & Hallauer (1980) found that the simple correlations between mean yield and regression coefficient and mean yield and deviation from regression were highly significant.

The concept of stability has been defined in several ways and several biometrical methods including univariate and multivariate ones which have been developed to assess stability (Lin *et al*., 1986, Becker & Leon, 1988 and Crossa, 1990). The most widely used one is the regression method, based on regressing the mean value of each genotype on the environmental index or marginal means of environments (Romagosa & Fox, 1993 and Tesemma *et al*., 1998). Vargas *et al.* (l999) reported that, multi-environments trials play an important role in selection the best cultivars to be used in future years at different locations and in assessing cultivars stability across environments before its commercial release. Pixley & Bjarnason (2002) compared the genotype x environment interaction and the squares of deviation from linear regression (S^2d_i) for grain yield and arranged tested cultivars in descending manner according to their estimates single cross hybrids followed by three way, double-cross and open pollinated cultivars. Obviously the type stability related to heterogeneity level. Tollenaar & Lee (2002) estimated stability parameters which indicated that high yielding maize hybrids can differ in yield stability but his results do not support the contention that yield stability and high grain yield are mutually exclusive. So stability parameters are useful for breeding programs.

The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological condition (Ali *et al*., 2003). Therefore, the adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is planted (Arshad *et al*., 2003). Soliman (2006) found that, the genotypes x environment interaction was highly significant for days to 50% silking and grain yield. As well as a large portion of this interaction was accounted for the linear regression on the environmental means. Plus, the magnitude of nonlinear components was considerably small. EI-Sherbieny *et al*. (2008) mentioned that, the high yielding potential and average stability are due mainly to the most attributes involved in determining the wide adaptation of new genotypes. Also, Abdallah *et al*. (2010) studied various stability parameters of the maize hybrids with respect to grain yield, days to 50% silking and plant and ear heights. Their results demonstrated that stability parameters of hybrids were different for each studied trait.

The objective of this investigation was to identify the superior stable hybrids for number of days to 50% silking, ear position and grain yield of new promising yellow maize across four different locations in Egypt.

Materials and Methods

Eighteen yellow maize hybrids were used as new materials in this study. These genetic materials were developed at Gemmieza Agricultural Research Station, Agricultural Research Center (ARC), Egypt. These promising hybrids with two commercial yellow checks *i.e.*, SC 155 and SC 3084 were evaluated in 2007 growing season at four locations (Gemmeiza, Sakha, Sids and Mallawy Agricultural Research Stations) in randomized complete block design with four replications in each location. Plot size was four rows, 6 m long and 80 cm apart and hills spaced 25 cm along the row. Two kernels were planted per hill and thinned later to one plant per hill to provide a population density of 21,000 plants/fed (feddan = 4200 m^2). All recommended agricultural practices for maize production were applied.

At maturity, two central rows from each plot were harvested to record grain yield of each genotype. Each location was considered as an independent environment in the statistical analysis and macro-environments. The recorded data were number of days from planting to 50% silking, ear position and grain yield (ardab / fedddan). The analysis of variance was performed according to Steel & Torrie (1980) for each location and its combined was done after the homogeneity test (Bartlett, 1937). The hybrid effect was assumed to be fixed while the location effect was considered random. The procedures of stability analysis for these traits over locations were performed according to Eberhart & Russell (1966). According to this model, an ideal genotype should have high mean $(X > \mu)$, a unit regression coefficient $(b_i = 1)$ and no deviation from linearity $(S^2d_i = 0)$.

The stability parameter postulated by Wricke (1962) depends on the $(GE)_{lk}$ effects, which squared and summed across all environments that was denoted as ecovalence (W_i). It may be estimated as follows:

$$W_i = \sum (X_{lk} - X_{l.} - X_{.k} + X..)^2 / (E - 1)$$

X_{lk} = The interaction of genotype l with environment k,
$X_{l.}$ = The genotype mean for l genotype across used environments,
$X_{.k}$ = The environmental mean for k environment or genotypes mean in this environment
$X..$ = The general overall mean.

Results and Discussion

The pooled analysis of variance (Table 1) exposed highly significant hybrid and linear environment effect mean square for all studied traits indicating the important roles of genetic variability, and differential effect of environments. The mean square due to the linear response of hybrids to environmental indices

was found to be significant for grain yield while non-significant for silking and ear position. On the other side, the pooled deviation mean square was highly significant for ear position and grain yield, while it was non-significant for days to 50% silking. Similar results in maize have been reported by Worku *et al.* (2001), El-Sherbieny *et al.* (2008) Mosa *et al.* (2011) and Abdallah *et al.* (2011).

TABLE 1. The joint analysis of variance for days to 50% silking, ear position and grain yield traits across four locations.

S.O.V.	d.f.	Mean squares		
		Days to 50% silking	Ear position	Grain yield
Hybrids (H)	19	44.14**	65.25**	80.43**
Env, Env.V	60	16.65	22.46**	121.70**
E (linear)	1	784.92**	254.31**	5878.70**
H x E (linear)	19	6.00	8.74	25.29**
Pooled Deviation	40	2.37	23.18**	23.57**
Gm 1	2	2.81	20.08	9.17
Gm 2	2	0.42	35.90*	4.26
Gm 3	2	2.74	14.62	16.36**
Gm 4	2	4.94	1.65	24.44**
Gm 5	2	1.57	31.95*	52.69**
Gm 6	2	8.16	9.23	1.15
Gm 7	2	1.72	6.29	20.09**
Gm 8	2	3.93	7.02	59.83**
Gm 9	2	2.73	16.78	2.77
Gm 10	2	0.71	15.62	33.76**
Gm 11	2	3.65	9.01	68.02**
Gm 12	2	2.02	23.21	23.12**
Gm 13	2	0.94	59.61**	24.17**
Gm 14	2	0.93	5.11	6.72
Gm 15	2	0.77	18.04	44.23**
Gm 16	2	5.38	90.36**	10.74*
Gm 17	2	1.34	36.75**	2.96
Gm 18	2	0.10	0.67	6.37
SC 155	2	1.82	47.62**	19.42**
SC 3084	2	0.60	14.00	41.01**
Pooled error	228	12.98	7.79	3.11

*, ** significant and highly significant at 0.05 and 0.01 probability, respectively.

The average of all studied traits at four environments in 2007 season is presented in Table 2. The results demonstrated that, Sakha location produced the highest mean value of grain yield. However, the earliest silking date was detected at Mallawy. Gemmeiza and Sids locations exhibited the lowest average of ear position character. These results indicated that, the performance of the hybrids varied from location to another.

Estimates of environmental index (Table 2) showed that Sakha location have the highest environmental index (6.29). So, Sakha location was the most favorable environment and the representative one for yield potential, contrary, Mallawy showed the lowest environmental index (-5.81) so, it was the poorest yielding environment. Nevertheless, Mallawy was the most representative location for earliness. Regarding, ear position trait, the most favorable locations were Gemmeiza and Sids.

TABLE 2. Average of all studied traits and environmental index under four environments.

Traits / Environments	Days to 50% silking		Ear position %		Grain yield ard/fed	
	Mean	Environmental index	Mean	Environmental index	Mean	Environmental index
Gemmmeiza	58.93	-0.773	53.36	-0.85	21.74	-0.11
Sakha	64.11	4.408	55.49	1.28	28.14	6.29
Sids	59.08	-0.623	53.39	-0.82	21.49	-0.36
Mallawy	56.69	-3.013	54.6	0.39	16.04	-5.81
L.S.D. at 5%	1.96		1.06		0.67	

Mean performance for the studied traits of all studied genotypes including checks across the four locations is presented in Table 3. Eight of the evaluated eighteen hybrids Viz., Gm 11, Gm 13, Gm 10, Gm 1, Gm 16, Gm 12, Gm 3 and Gm 6 were earlier than the best check SC 155 their days to 50% to flowering were 56.63, 56.81, 57.25, 57.50, 57.69, 58.25, 58.75 and 58.81 days, arranged in ascending manner and respectively. Respecting ear position, also eight hybrids among the tested hybrids had significant advantage attributed to lower ear position than the two check hybrids. These hybrids were .Gm 11, Gm 15, Gm 10, Gm 16, Gm 7, Gm 12, Gm 13 and Gm 2, in ascending arrangement. Moreover, the other ten single crosses had ear position statistically equal to the best check. The results showed that, the mean grain yield of the evaluated hybrids across four locations ranged from 26.01 ardab per feddan for SC Gm 1 to 17.44 ardab per feddan for SC Gm 9. The best single crosses for grain yield were SC Gm 1, SC Gm 5 and SC Gm 8 which significantly outweighed of the check SC 155 (22.31) and produced 26.01, 25.80 and 25.07 ard/fed, respectively. It is worth to mention that, The SC Gm 1 considered the best cross which gave the highest grain yield and in the same time was early hybrid.

Stability parameters estimates for silking date, ear position and grain yield for all genotypes under study which evaluated across the four locations are presented in Table 4. According to Eberhart & Russell (1966), the genotype with a high combined mean over a range of environments, has a regression coefficient equal to the unity ($b_i = 1$) and small deviation from regression ($S^2 d_i = 0$) will be considered a stable genotype. Most tested hybrids showed b_i estimates around unity therefore, these hybrids were considered stable for silking. But three hybrids (Gm 2, Gm13 and Gm 14) donated significant estimated and showed their interaction with environments. All the $S^2 d_i$ estimates for days to 50% silking were non-significant indicating that the evaluated hybrids were stable. The ecovalence (W_i) estimates calculated according to Wricke (1962) as the sum of squares of genotype environment interaction effects of a particular genotype divided by the degree of freedom (the number of environments minus 1) it can be considered as a whole estimates for stability. The estimates of W_i for silking were not significant for all evaluating hybrids.

TABLE 3. Mean performance and rank for silking date, ear position and grain yield for all maize genotypes tested under four environments.

Traits Hybrids	Days to 50% silking	Rank	Ear position %	Rank	Grain yield ard/fed	Rank
Gm 1	57.50	4	54.75	12	26.01	1
Gm 2	59.06	12	53.56	8	22.10	11
Gm 3	58.75	7	54.25	9	23.10	4
Gm 4	59.19	13	54.50	10	22.77	5
Gm 5	59.19	14	57.56	20	25.80	2
Gm 6	58.81	8	57.00	19	18.46	19
Gm 7	59.69	17	52.88	5	22.51	7
Gm 8	58.88	10	55.88	16	25.07	3
Gm 9	58.81	9	54.63	11	17.44	20
Gm 10	57.25	3	51.94	3	19.61	17
Gm 11	56.63	1	50.06	1	22.19	9
Gm 12	58.25	6	52.88	6	21.33	14
Gm 13	56.81	2	53.00	7	22.55	6
Gm 14	59.50	16	54.81	13	21.98	12
Gm 15	59.19	15	50.63	2	19.26	18
Gm 16	57.69	5	52.50	4	21.81	13
Gm 17	60.63	19	55.63	15	20.90	15
Gm 18	58.94	11	55.38	14	22.16	10
SC 155	59.75	18	56.13	17	22.31	8
SC 3084	64.50	20	56.25	18	19.71	16
L.S.D at 5%	2.91		2.24		1.46	

TABLE 4. Regression coefficient (b_i), mean square deviation (S^2d_i) and ecovalence (W_i) for all maize genotypes tested under four environments.

Traits Estimates Hybrids	Days to 50% silking			Ear position			Grain yield ard/fed		
	b_i	S^2d_i	W_i	b_i	S^2d_i	W_i	b_i	S^2d_i	W_i
Gm 1	1.315	2.812	0.79	0.945	20.076	3.35	1.158	9.173	2.14
Gm 2	0.333**	0.424	1.53	-0.681	35.895*	8.98	1.158	4.265	1.32
Gm 3	1.195	2.742	0.58	0.982	14.618	2.44	1.021	16.361**	2.74
Gm 4	0.827	4.939	0.92	-0.125	1.651	1.62	1.132	24.435**	4.50
Gm 5	0.609	1.574	0.76	0.942	31.952*	5.33	1.034	52.695**	8.81*
Gm 6	1.093	8.160	1.39	0.058	9.229	2.48	0.632*	1.153	3.51
Gm 7	0.498	1.718	1.11	1.475	6.292	1.29	1.212	20.092**	4.45
Gm 8	1.358	3.932	1.07	1.664	7.025	1.64	1.099	59.831**	10.21*
Gm 9	0.833	2.731	0.55	0.850	16.783	2.82	0.559*	2.766	5.21
Gm 10	1.135	0.715	0.18	1.870	15.623	3.40	0.207	33.762**	21.01**
Gm 11	1.658	3.653	2.03	0.112	9.014	2.34	0.826	68.024**	12.08*
Gm 12	1.134	2.021	0.40	2.545	23.208	6.40	0.967	23.125**	3.88
Gm 13	1.461*	0.941	0.85	1.451	59.615**	10.15	0.750	24.166**	5.56
Gm 14	1.641*	0.933	1.50	0.971	5.105	0.85	1.294	6.721	3.23
Gm 15	0.725	0.773	0.38	1.906	18.037	3.88	0.886	44.230**	7.69
Gm 16	1.251	5.380	1.10	1.041	90.360**	15.06	1.370	10.742*	5.15
Gm 17	0.630	1.345	0.67	0.242	36.752**	6.73	0.906	2.955	0.71
Gm 18	0.790	0.101	0.16	1.848*	0.671	0.87	1.225	6.375	2.30
SC 155	1.069	1.817	0.32	1.706	47.619**	8.46	1.228	19.420**	4.51
SC 3084	0.446**	0.598	1.10	0.200	13.997	3.01	1.334	41.014**	9.57*

*, ** significant and highly significant at 0.05 and 0.01 probability, respectively.

Regarding ear position, only the single cross Gm 18 showed significant b_i value (1.848*) while the other hybrids ensured their stability for this trait. The estimates of S^2d_i categorized the crosses to two groups. The first group consisted of thirteen crosses that characterized as stable, *i.e.,* Gm1, Gm 3, Gm 4, Gm 6, Gm 7, Gm 8, Gm 9, Gm 10, Gm 11, Gm 12, Gm 14, Gm 15 and Gm 18. The second group consisted of five crosses that showed significant S^2d_i estimates and characterized as unstable crosses. Respecting the W_i estimates of all the crosses, all the evaluated hybrids showed non-significant estimates revealed that ear position were the more stable trait.

For grain yield, two significant estimates of regression coefficients (b_i) were outcome for Gm 6 and Gm 9, while other tested crosses didn't differ from the unity indicating their stability. Contrary, eleven hybrids had a significant deviation mean square S^2d_i from linear regression implying that these hybrids were unstable across environments, whereas seven hybrids Gm 1, Gm 2, Gm 6, Gm 9, Gm 14, Gm 17 and Gm 18 showed insignificant S^2d_i estimates, indicating that these hybrids proved their stability. The non-significant W_i estimates that were calculated for the hybrids Gm 17, Gm 2, Gm 1, Gm 18, Gm 3, Gm 14, Gm 6, Gm 12 and Gm 4 indicated that these hybrids were stable across studied environments. In this respect Worku *et al*. (2001) demonstrated in general that when the adaptability parameters *i.e.,* mean yield regression coefficient and deviation mean square from the liner regression were considered none of the genotypes exhibited general adaptability.

Finally, the results of this investigation concluded that the five hybrids Gm 1, Gm 5, Gm 8, Gm 3 and Gm 4 which produced the highest grain yield, moreover, these hybrids flowered earlier than the two check crosses (SC 155 and SC 3084) and achieved reasonable degree of stability across the four locations Gemmeiza, Sakha, Sids and Mallawy. So these hybrids should be selected for advanced evaluation stages.

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سلوك الثبات الوراثى لبعض تراكيب الذرة الشامية الصفراء الجديدة فى أربع مناطق

مشيرة صادق الشحات صادق، حاتم محمد على عبد الغنى* و مجدي احمد عبد المولى

قسم الذرة الشامية ـ معهد المحاصيل الحقلية ـ مركز البحوث الزراعية و* قسم بحوث المحاصيل الحقلية ـ المركز القومى للبحوث ـ الجيزة ـ مصر.

تختلف التراكيب الوراثية من الذرة الشامية فى مدى استجابتها للظروف البيئية المتغيرة. لذلك يساعد تحليل الثبات الوراثى فى البيئات المتباينة على معرفة قدرة هذه التراكيب الوراثية المختلفة على الإنتاجية الفعالة تحت مدى واسع من الظروف البيئيه المختلفة. كما يمكن الاستفادة من هذه التراكيب الوراثية التى تتميز بالثبات الوراثى عبر العديد من البيئات حيث يمكن إستخدامها مباشرة كهجن تجارية متميزة من الذرة الشامية تتسم بالثبات المظهرى العالى. ومن ثم كان الهدف من هذا البحث هو إختبار وتحليل الأداء والثبات لثمانية عشر تركيب وراثى من الذرة الشامية تحت ظروف أربعة بيئات زراعية مختلفة هى الجميزة، سخا، سدس و ملوى ومقارنتها بهجينين تجاريين هما (هـ ف ١٥٥ و هـ ف ٣٠٨٤) تحت نفس الظروف البيئية. أظهرت نتائج تحليل التباين المشترك وجود إختلافات وراثية معنوية لجميع الصفات تحت الدراسة على مستوى البيئات الأربعة. كما أظهرت النتائج وجود تأثيرات بيئية مختلفة. تم الحصول على أعلى محصول من الحبوب تحت ظروف سخا. أظهرت جميع التراكيب الوراثية إنحرافا معنويا عن الإنحدار الخطى لصفة محصول الحبوب مما يدل على عدم ثباتها تحت الظروف البيئية فيما عدا سبعة هجن فردية هى جميزة ١، جميزة ٢، جميزة ٦، جميزة ٩، جميزة ١٤، جميزة ١٧ و جميزة ١٨ والتى أظهرت إنحراف صغير وغير معنوى عن الإنحدار الخطى، ولهذا يمكن إعتبار هذه التراكيب الوراثية هى الأكثر ثباتا. أظهرت الدراسة إنه يمكن إنتخاب خمسة هجن هى جميزة ١، جميزة ٥، جميزة ٨، جميزة ٣ و جميزة ٤ حيث كانت جمعيها عالية المحصول ومبكرة التزهير عن الهجن التجارية موضع المقارنة. هذا بالإضافة إلى كونها على درجة عالية من الثبات الوراثى على مستوى البيئات تحت الدراسة. ومن ثم يمكن إدخالها فى مراحل التقييم المتقدمة لتسجيل ما يتأكد إستمرارية تفوقة فى الإنتاجية والتبكير و المقاومة للأمراض من هذه المواد المبشرة وإطلاقها كهجن صفراء جديدة.