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# STABILITY ANALYSIS FOR PROMISING YELLOW MAIZE HYBRIDS UNDER DIFFERENT LOCATIONS

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**ABSTRACT:** *Grain yield, stability for the new promising maize hybrids is an important target in breeding programs. The main objective of this study was identify the stable superior hybrids for grain yield under different locations. Twelve promising yellow three way crosses(TWC), in addition two cheek hybrids, i.e. TWC 352 and TWC353 were evaluated at five Agricultural Reserch Stations in Egypt i.e. Sakha (Sk), Gemmeza (Gm), Sids (Sd), Nubaria (Nub) and Mallawy (Mal) in 2012 summer growing season.*

*Highly significant differences among hybrids for all studied traits were detected in the combined analysis across locations. Variances due to locations and hybrids x locations interaction were highly significant for all studied traits. Linear and non linear components were significant or highly significant for all studied traits except H x L linear for plant height and grain yield.*

*The promising hybrids; TWC Sk 363 was stable for earliness and plant height while, TWC Sk 366 was stable for grain yield in addition to outyielded than the two check hybrids.*

***Key words**: Maize, Stability, Genotype x environment interaction.*

## INTRODUCTION

In the contemporary agriculture, man is not interested in the genotype that will adjust well to a given agro- ecological conditions in order to continue the species, but in the genotype with high yielding potential at several agro-ecological conditions, i. e. the good stability and adaptability.

Hybrid adaptability across diverse environments is usually tested by its interaction with different environments. A genotype is considered to be more adapted or stable if it has a high mean yield and low fluctuated in yielding ability across diverse environments. There are two possible strategies for developing low G x E interaction cultivars. The first is subdivision or stratification of a heterogeneous area into smaller, more homogenous sub-regions, with breeding programs aimed at developing cultivars for specific sub-regions. However, even with this refinement, the level of interaction can remain high because breeding area does not reduce the interaction of cultivars with locations over years. The second strategy for reducing G x E interaction involves selecting cultivars with better stability across a wide range of environments in order to better predict behavior ( Eberhart and Russell 1966, Tai 1971).The variety with a high mean, regression coefficient close to unity ( $b_i = 1$) and the deviations from regression as small as possible ($S^2d_i = 0$) was stable (Eberhart and Russell 1966). Tollenaar and Lee (2002) showed that high yielding maize hybrids can differ in yield stability, but results do not support the contention that yield stability and high grain yield are mutually exclusive. Lee et al (2003) stated that grain yield stability can be improved through recurrent selection by selecting solely for mean performance across multiple environments. Shehata *et al* (2005) constructed an index which combined the mean yield and two parameters of stability, i.e. $b_i$ and $S^2_{y.x}$ of the regression of variety mean on environmental index and it was designated as a superiority index. They reported that a superiority index could be used in estimating the degree of desirability for the different hybrids. Mosa *et al* (2012) found that genotype x environment (G x E) interaction and their partitions, E (linear), G x E (linear) and pooled deviations ( non-linear) were significant for grain yield. They added that the coefficient of determination ($R^2$) values ranged from 0.58 to 0.91for grain yield.

The objective of this study was to estimate degree of stability for some promising hybrids for number of days to 50% silking, plant height and high grain yield under varying environments.

## MATERIALS AND METHODS

Twelve yellow three way crosses, i.e. TWC Sk 355, TWC Sk 356,TWC Sk 357, TWC Sk 358, TWC Sk 359, TWC Sk 360, TWC Sk 361, TWC Sk 362, TWC Sk 363, TWC Sk 364, TWC Sk 365 and TWC Sk 366 developed from Maize Breeding Program at Sakha (Sk) Agricultural Research Station in 2011 growing season. These twelve hybrids, in addition to two commercial hybrids, i.e. TWC352 and TWC 353 were evaluated in five locations i.e. Sakha (Sk), Gemmeza (Gm),Sids (Sd), Nubaria (Nub) and Mallawy (Mal) Agricultural Research Stations. The mechanical and chemical analysis of soil for experimental sites are presented in Table (1). Air and soil temperature was recorded for May, June, July, August and September are presented in Table (2). A randomized complete block design with four replications was used at each location. Plot size consisted of four rows, 6m long, 0.8 m apart. Planting was made in hills spaced at 0.25m along the row at the rate of two kernels per hill, later thinned to one plant per hill. All recommended agricultural practices were followed through the growing season as recommended for maize cultivation. Data were collected for number of days to 50% silking , plant height (cm) and grain yield (ard./fed). (1 ardab = 140 kg , 1 feddan = 4200m$^2$) adjusted to 15.5% moisture content. Statistical analysis at each location was done according to Steel and Torrie (1980). Bartlett (1937) test was used to test the homogeneity of error mean squares. In case of homogeneity, combined analysis of variance across locations was done. Stability analysis across, the five locations was performed according to Eberhart and Russell (1966). Estimate coefficient of determination($R^2$) according to (Pinthus 1973).

**Table 1: Physical and chemical properties of soil samples before experiment in 2012 growing season.**

| Location | Sakha (Sk) | Gemmeza (Gm) | Sids (Sd) | Nubaria (Nub) | Mallawy (Mall) |
|---|---|---|---|---|---|
| Physical properties | | | | | |
| Coarse Sand % | 6.14 | 2.8 | 1.5 | 2.9 | 1.3 |
| Fine sand % | 18.04 | 23.1 | 14.7 | 51.0 | 20.3 |
| Silt | 25.7 | 23.07 | 32.1 | 20.8 | 27.4 |
| Clay | 50.12 | 51.03 | 51.7 | 25.3 | 51.0 |
| Texture | Clay | Clay | Clay | Sandy clay leom | Clay |
| Chemical properties | | | | | |
| Available N ppm | 59.3 | 48.0 | 43.0 | 26.3 | 53.1 |
| Available p ppm | 9.5 | 11.6 | 10.5 | 9.7 | 10.7 |
| Available k ppm | 290 | 290.3 | 275.3 | 425.0 | 263.3 |
| PH | 7.7 | 8.00 | 7.8 | 8.3 | 7.7 |
| EC (dS/m-2) | 1.4 | 0.93 | 0.48 | 2.21 | 0.52 |

**Table 2: Normal monthly climatic data at the five locations during growing periods of maize in 2012 growing season.**

| Climatic data | Months / location | May | June | July | August | September |
|---|---|---|---|---|---|---|
| Air Temperature($^oC$) (average) | Sakha (Sk) | 27.0 | 28.4 | 30.6 | 29.7 | 27.7 |
| | Gemmeza(Gm) | 27.8 | 29.6 | 31.4 | 30.6 | 28.6 |
| | Sids (Sd) | 27.6 | 30.6 | 32.0 | 31.2 | 29.4 |
| | Nubaria (Nub) | 26.6 | 28.8 | 30.6 | 29.4 | 26.4 |
| | Mallawy (Mall) | 27.2 | 31.0 | 32.6 | 31.6 | 29.7 |
| Soil Temperature($^oC$) | Sakha (Sk) | 26.5 | 27.8 | 30.2 | 30.5 | 28.2 |
| | Gemmeza(Gm) | 26.5 | 28.6 | 30.3 | 30.5 | 28.4 |
| | Sids (Sd) | 27.0 | 30.8 | 30.2 | 31.5 | 28.8 |
| | Nubaria (Nub) | 26.0 | 27.6 | 29.5 | 30.0 | 27.2 |
| | Mallawy (Mall) | 27.7 | 31.6 | 30.1 | 32.5 | 28.8 |

## RESULTS AND DISCUSSION

Analysis of variance for days to 50%silking, plant height and grain yield of the 14 hybrids across five locations are presented in Table (3). Differences among locations were found to be highly significant for the three studied traits suggesting marked differences between the five environments in their climatic and soil condition Table (1and 2). Highly significant differences among hybrids were detected for all studied traits. Also, all interactions between hybrids and environments (E x H) were highly significant for all studied traits, meaning that the performance of these hybrids markedly differed from one location to another. In this respect, Comstock and Moll (1963) defined the genotype x environment interaction as the differential response of phenotype to the change in environment. Eberhart and Russell (1966) and Freeman and Perkins (1971) demonstrated that the main cause of differences among genotypes in their yield stability trails were the wide occurrence of genotype x environment interaction. Current results are in agreement with those obtained by Ragheb *et al.* (1993), Mosa *et al*. (2009), Abdallah *et al.* (2011) , Mosa *et al*. (2012) and Khalil(2013).

Estimates of means for number days to 50% silking, plant height and grain yield at five locations in 2012 season are presented in Table (4). The results exhibited that, The highest means were obtained at Sakha and Mallawy locations for plant height and grain yield and Nubaria location for days to 50% silking while, the lowest means were obtained at Sakha for days to 50% silking and Nubaria for plant and grain yield. Fery (1964) and Fery and Maldonado (1967) defined the stressed environment as the non in which mean performance for a certain attribute is low and that stress for one trait does not mean stress for all traits under study.

**Table 3: Combined analysis of variance for 3 agronomic traits across five different locations (environments), during 2012 reason .**

| S.O.V. | d.f | Mean of squares | | |
|---|---|---|---|---|
| | | Days to 50% silking | Plant height (cm) | Grain yield (ard./ fed.) |
| Environments (E) | 4 | 235.271** | 24577.987** | 1131.866** |
| Rep/E (error a) | 15 | 6.256 | 448.302 | 8.837 |
| Hybrids (H) | 13 | 35.080** | 1667.113** | 48.149** |
| H x E. | 52 | 2.156** | 320.843** | 17.109** |
| Pooled error (error b) | 195 | 0.789 | 122.272 | 3.896 |

** significant at 0.01 level of probability

**Table 4: Average number of days to 50% silking, plant height and grain yield resulted in the five deferent locations ( environment ), during 2012 reason .**

| Location (environment) | Means | | |
|---|---|---|---|
| | Days to 50% silking (days) | Plant height (cm) | Grain yield (ard./ fed.) |
| Sakha | 58.08b | 281.23a | 30.81a |
| Gemmeza | 57.00c | 242.82c | 26.80c |
| Sids | 59.67a | 259.19b | 28.99b |
| Nubaria | 59.87a | 227.64d | 21.39d |
| Mallawy | 60.42a | 267.46b | 30.91a |

Means performance of the twelve promising three way crosses and two check hybrids across the five environments for the studied traits are presented in Table (5). The hybrids ranged from; 56.83 days for TWC Sk 362 to 61.91 days for TWC SK 364 for days to 50% silking, 267.44 cm for TWC SK 355 to 241.00 cm for TWC SK 362 for plant height and 25.07 ard./fed. for TWC 352 to 30.42 ard./fed. for TWC Sk 362 for grain yield. The results exhibited that the TWC Sk 362 was the best hybrid for earliness, sutable plant height and high grain yield (30.42 ard./fed.) and TWC Sk 366 for grain yield (30.27 ard./fed.), moreover thes two hybrids were higher than two checks in grain yield ( TWC 352 = 25.07 ard./fed. and TWC 353 = 28.281 ard./fed.).

Analysis of variance of days to 50% silking, plant height and grain yield stability parameters for the 14 hybrids across locations are presented in Table (6). Hybrids significantly differ for all studied traits. Hybrids x locations interaction component was further partitioned into linear (hybrids x locations) and non linear (pooled deviation) components. Mean squares for both components were tested against the pooled error mean squares. The linear and non linear components were highly significant for all studied traits except H x L (linear) was significant only for days to 50% silking, indicating that the linear (predictable) and non linear (unpredictable) components shared with hybrids x locations interaction. Also significant linear component means that the tested hybrids did not similarly respond to the varied locations, while significant pooled deviation, means that the deviation of all hybrids from linearity was significant. These results are in agreement with conclusions reached by Lee *et al* (2003) , Rasul *et al* (2005), El- Sherbieny *et al* (2008), Mosa *et al* (2009), Abdallah *et al* (2011) Mosa *et al* (2012) and Khalil (2013).

**Table 5: Mean performance of twelve promising and two check hybrids for three traits as an average across the five locations (environments).**

| Hybrid | Days to 50% silking (days) | Plant height (cm) | Grain yield (ard./ fed.) |
|---|---|---|---|
| TWC Sk 355 | 60.45 | 267.40 | 27.52 |
| TWC Sk 356 | 59.50 | 257.20 | 26.31 |
| TWC Sk 357 | 58.45 | 242.65 | 27.31 |
| TWC Sk 358 | 58.45 | 248.55 | 27.99 |
| TWC Sk 359 | 59.45 | 267.40 | 26.12 |
| TWC Sk 360 | 57.70 | 247.95 | 26.98 |
| TWC Sk 361 | 59.70 | 260.70 | 29.19 |
| TWC Sk 362 | 56.85 | 241.00 | 30.42 |
| TWC Sk 363 | 58.65 | 255.20 | 26.92 |
| TWC Sk 364 | 61.90 | 266.40 | 27.29 |
| TWC Sk 365 | 59.35 | 255.35 | 28.70 |
| TWC Sk 366 | 59.95 | 265.15 | 30.27 |
| TWC 352 | 57.40 | 246.90 | 25.07 |
| TWC 353 | 58.15 | 257.55 | 28.81 |
| C.V% | 1.51% | 4.32% | 7.10% |
| L.S.D 0.05 | 1.23 | 15.32 | 2.73 |

**Table 6: Stability analysis of variance for 14 hybrids evaluated at five different locations, during 2012 reason.**

| S. O. V. | d.f. | Days to 50% silking (days) | Plant height (cm) | Grain yield (ard./fed.) |
|---|---|---|---|---|
| Hybrid | 13 | 8.76** | 416.77** | 12.03 ** |
| E + (H x E) | 56 | 4.701** | 513.37** | 24.18** |
| Linear | 1 | 235.271** | 24577.98** | 1131.866** |
| H x L (linear) | 13 | 0.778* | 77.64 | 5.72 |
| Pooled deviation | 42 | 0.427** | 75.28** | 3.52** |
| TWC Sk 355 | 3 | 0.042 | 177.54** | 1.061 |
| TWC Sk 356 | 3 | 0.146 | 8.56 | 7.65** |
| TWC Sk 357 | 3 | 0.321 | 132.18** | 0.87 |
| TWC Sk 358 | 3 | 0.208 | 33.79 | 6.71** |
| TWC Sk 359 | 3 | 0.130 | 86.60* | 1.20 |
| TWC Sk 360 | 3 | 1.348** | 74.62 | 2.27 |
| TWC Sk 361 | 3 | 0.945** | 70.76 | 5.08** |
| TWC Sk 362 | 3 | 0.301 | 171.28** | 4.20** |
| TWC Sk 363 | 3 | 0.499 | 2.14 | 1.43 |
| TWC Sk 364 | 3 | 0.358 | 74.56 | 3.04* |
| TWC Sk 365 | 3 | 0.284 | 55.07 | 3.48* |
| TWC Sk 366 | 3 | 0.872** | 64.01 | 0.33 |
| TWC352 | 3 | 0.506 | 71.44 | 11.34** |
| TWC353 | 3 | 0.017 | 31.30 | 0.65 |
| Pooled error | 210 | 0.197 | 30.56 | 0.974 |

*,** significant at 0.05 and 0.01 levels of probability, respectively

Estimates of stability parameters of 14 hybrids for number of 50% silking, plant height and grain yield across five locations are presented in Table (7). The genotype have low mean number of days to 50% silking, plant height and high mean for grain yield than the grand mean, not significant for both regression coefficient ($b_i$ =1) and deviation from regression ($S^2d_i$ =0) with high coefficient of determination($R^2$) is stable according to Eberhart and Russel (1966) and Pinthus (1973).

**Table 7: Stability parameters for days to 50% silking and plant height for 14 hybrids under five different locations.**

| hybrid | Days to 50% silking | | | | Plant height (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | bi | $S^2$di | $R^2$ | X | bi | $S^2$di | $R^2$ |
| TWC Sk 355 | 60.45 | 0.981 | -0.154 | 99.22 | 267.4 | 0.806** | 146.98** | 68.19 |
| TWC Sk 356 | 59.5 | 0.606** | -0.050 | 93.38 | 257.2 | 0.925 | -22.00 | 98.31 |
| TWC Sk 357 | 58.45 | 0.784** | 0.124 | 91.45 | 242.65 | 0.965 | 101.62** | 80.48 |
| TWC Sk 358 | 58.45 | 0.864* | 0.011 | 95.25 | 248.55 | 0.788** | 3.22 | 91.49 |
| TWC Sk 359 | 59.45 | 0.976 | -0.066 | 97.62 | 267.34 | 0.811** | 56.04* | 81.66 |
| TWC Sk 360 | 57.7 | 1.299** | 1.151** | 87.52 | 247.95 | 1.163* | 44.05 | 91.39 |
| TWC Sk 361 | 59.7 | 1.284** | 0.748** | 90.71 | 260.7 | 0.534** | 40.19 | 70.25 |
| TWC Sk 362 | 56.85 | 1.119* | 0.104 | 95.87 | 241 | 1.120* | 140.71** | 81.08 |
| TWC Sk 363 | 58.65 | 1.054 | 0.302 | 92.57 | 255.2 | 1.085 | -28.41 | 99.68 |
| TWC Sk 364 | 61.9 | 1.352** | 0.161 | 96.62 | 266.4 | 1.277** | 44.00 | 92.75 |
| TWC Sk 365 | 59.35 | 0.789** | 0.087 | 92.45 | 255.35 | 1.229** | 24.51 | 94.14 |
| TWC Sk 366 | 59.95 | 0.851** | 0.675** | 82.32 | 265.15 | 1.147* | 33.44 | 92.32 |
| TWC352 | 57.4 | 1.011 | 0.309 | 91.87 | 246.9 | 0.976 | 40.88 | 88.65 |
| TWC353 | 58.15 | 1.024 | -0.179 | 99.70 | 257.55 | 1.169* | 0.74 | 96.23 |
| $\bar{X}$ | 58.99 | | | | 255.67 | | | |

**Table 7: Cont .**

| hybrid | Grain yield (ard./Fed.) | | | |
|---|---|---|---|---|
| | $\bar{X}$ | bi | $S^2$di | $R^2$ |
| TWC Sk 355 | 27.52 | 0.916 | 0.093 | 95.49 |
| TWC Sk 356 | 26.31 | 0.766 | 6.682** | 67.40 |
| TWC Sk 357 | 27.31 | 0.862 | -0.103 | 95.83 |
| TWC Sk 358 | 27.99 | 0.835 | 5.736** | 73.70 |
| TWC Sk 359 | 26.12 | 0.900 | 0.229 | 94.77 |
| TWC Sk 360 | 26.98 | 0.812 | 1.298 | 88.67 |
| TWC Sk 361 | 29.18 | 1.575* | 4.114** | 92.93 |
| TWC Sk 362 | 30.42 | 1.102 | 3.227** | 88.63 |
| TWC Sk 363 | 26.92 | 1.328 | 0.463 | 97.06 |
| TWC Sk 364 | 27.29 | 1.379 | 2.068* | 94.39 |
| TWC Sk 365 | 28.7 | 0.980 | 2.511* | 88.14 |
| TWC Sk 366 | 30.27 | 0.783 | -0.636 | 98.00 |
| TWC352 | 25.07 | 0.659 | 10.372** | 50.82 |
| TWC353 | 28.81 | 1.098 | -0.317 | 98.01 |
| $\bar{X}$ | 27.78 | | | |

The promising hybrid TWC 363 was stable for both days to 50% silking ($\bar{x}$ = 58.65 days, $b_i$ = 1.054, $S^2d_i$ = 0.302 and $R^2$ = 92.57%) and plant height ($\bar{x}$ = 255.2, $b_i$ = 1.08, $S^2d_i$ = -28.41, and $R^2$ = 990.68%) compared with the other hybrids and two checks, while the promising hybrid TWC SK 366 was stable for grain yield($\bar{x}$ = 30.27,$b_i$ = 0.783, $S^2d_i$ = -0.686 ,$R^2$ = 98.00%). Vargas *et al* (1999) reported that, multi-environment trials play an important role in selecting the best cultivars to be used in future years at different locations and in assessing cultivar stability across environments before its commercial release. Carvalho *et al* ( 2000) stated that the hybrids that gave coefficient of determination ($R^2$) more than 80% had good production stability in all of the environments .Tollenaar and Lee (2002) found that stability analysis showed that high yielding maize hybrid can differ in yield stability, but results did not support the contention that yield stability and high grain yield are mutually exclusive.

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# تحليل الثبات المظهري لبعض هجن الذرة الشامية الصفراء المبشرة تحت مواقع مختلفة

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## الملخص العربى

يعتبر ثبات صفة محصول الحبوب لهجن الذرة الشامية المبشرة الجديدة من الأهداف المهمة في برامج التربية. ولذلك يهدف هذا البحث إلى التعرف على الهجن المتفوقة و الثابتة في صفة محصول الحبوب تحت المواقع المختلفة. ولتحقيق هذا الهدف تم تقييم اثنا عشر هجين ثلاثي أصفر من الهجن المبشرة الجديدة (بالإضافة إلى اثنان من هجن المقارنة هما (هـ.ث٣٥٢ و هـ.ث٣٥٣) في خمس مواقع مختلفة بمحطات بحوث سخا و الجميزة و سدس و ملوى و النوبارية في موسم ٢٠١٢.

أظهر التحليل المشترك عبر المواقع المختلفة وجود اختلافات عالية المعنوية بين الهجن, و بين المواقع و التفاعل بين المواقع و الهجن لكل الصفات المدروسة, كما كانت مكونات التفاعل الخطى و غير الخطى معنوية أو عالية المعنوية لكل الصفات المدروسة عدا التفاعل الخطى بين الهجن والمواقع لصفتي ارتفاع النبات و محصول الحبوب.

أظهر كل من الهجين الثلاثي المبشر٣٦٣ ثباتا لصفتي عدد الأيام للوصول إلى ٥٠% حريره و ارتفاع النبات و الهجين الثلاثي المبشر ٣٦٦ ثباتا لصفة محصول الحبوب بالإضافة إلى تفوق الأخير محصوليا على هجيني المقارنة.