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ADAPTABILITY AND STABILITY OF MAIZE HYBRIDS FOR GRAIN YIELD

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ABSTRACT

Six white promising single crosses and two commercial hybrids were evaluated under five locations for grain yield in 2021 season. The mean squares due to hybrids, locations, hybrids x locations interaction, linear and nonlinear components were highly significant for grain yield. The hybrids SC Sk 153, SC Sk 154 and SC Sd 18 were significant out-yielded two commercial hybrids, thus these hybrids have high adaptability. However the hybrid SC Sk 154 had high adaptability and stability (b_i =1 and S^2_{di} not significant) for grain yield. So the study prefers this hybrid.

Key words: ***Zea mays, environment interaction, crosses, plant performance*.**

INTRODUCTION

The main focus of the new maize hybrids now is to combine for a high and stable yield in both favorable and unfavorable growing conditions. Each environment has its own soil and characteristics and climatic conditions that can affect the productivity of crop production (Tardieu 2013 and Huang *et al* 2017). Thus, it is mandatory to take into consideration the effect of environment while investigating the most suitable cultivation. Quantitative characteristics that are economically and agronomical important such as grain yield is influenced by genetics, environment, and management approaches as well as their interplay (Messina *et al* 2009). The interaction of these two explanatory variables provides insight into genotypes that are appropriate for specific situations. The impact of the environment is usually a significant factor in overall variation (Blanche *et al* 2009). The genotype by environment interaction (GEI) is a phenomenon recognized globally by everyone involved to the goal of crop improvement and maintenance; it refers to the various responses of genotypes across a wide range of environments (Kang 1997 and 2004). When GEI is significant, its cause, nature and implications must be carefully considered (Kang and Govman 1989).

The (GEI) in multi-locations trials complicates the identification of superior genotypes for a single location, because magnitudes of genotypes by location interaction are often greater than genotype by year interaction (Badu *et al* 2003). This necessitates genotype evaluation in multi-environments trials (MET) in the advanced stages of selection (Fan *et al* 2007, Kang *et al* 2004 and Annicchiarico 2002). It can also help to identify different environments through the differences between genotypes with minimal replicates. Environments with better yield can distinguish superior genotypes in target environments (Yan *et al* 2011). Yield stability is one of the most desirable traits of a genotype that allows it to identify as a cultivar.

The construction of a large scale facility is required to study genotypes, referring to a specific adaptability. To achieve maximum production, it is essential to develop hybrids that best fit given target environments and have specific adaptability.

The objective of this study was to evaluate the performance, adaptability and yield stability of six promising hybrids.

MATERIALS AND METHODS

Six promising white single crosses i.e. SC Sk 152, SC Sk 153, SC Sk 154, SC Sd 3, SC Sd 18 and SC Sd 19 were used in this study. The crosses produced by maize breeding program at Sakha and Sids Agriculture Research stations, plus two checks, i.e. SC 10 and SC 128 were evaluated at five Research Stations, Sakha(Sk), Gemmeiza (Gm), Nubaria (Nub), Sids (Sd) and Mallawie (Mall) in 2021 growing summer season. A randomized complete block design with four replications was used for conducting the above hybrids evaluation trial. Each plot consisted of four rows measuring 6 meters in length with a spacing of 0.7 m between the rows, 0.25 m per hills and a density of 24000 plants per feddan. Management of fertilization and crop treatments were performed based on expectations of high yield. The fertilizer was applied at planting using 30 kg of P_2O_2 and 24 kg of K_2O per feddan (fed) while nitrogen fertilizer (N) at the rate of 120 Kg N/fed was splinted into two equal doses and was applied before the first and second irrigation in urea form. The data were recorded for grain yield in ardabs per feddan ard/fed (ardab= 140 Kg and one feddan = 4200 m^2) adjusted to 15.5% grain moisture in all trials. Statistical analysis of variance for above two traits were done for all experiments in the five locations, while the combined analysis of variance across five locations was done after homogeneity test according to Snedecor and Cochran (1980). Stability analysis across five locations was performed according to Eberhart and Russell (1966). Statistical Analysis System SAS, 2000 Version 8 was used to calculate variances meanwhile stability parameters were performed using GEA-R Genotype x Environment Analysis with R for windows) 2017 Version 4-1 Cimmyt.

RESULTS AND DISCUSSION

Analysis of variance for grain yield at five locations and across locations is showed in Table 1. Highly significant differences between locations (L) were observed for grain yield, meaning that each location has its own soil and characteristics and climatic conditions. Mean squares due hybrids (H) at each location and across locations were highly significant. It was inferred that there is variability among hybrids for this trait. Also it was found that the source of variation for the (HxL) interaction was highly significant, indicating that the hybrids had different responses in relation to the locations changes for grain yield. These findings were similar to those of Kafle *et al* (2020) and Shrestha *et al* (2021), who found differences between genotypes, environments, and their interaction for grain yield.

Mean performance of eight hybrids at five locations and across locations for grain yield (ard/fed) are shown in Table 2. The hybrid SC Sk 154 was the highest values at Gm, Mall, Nub and across locations, while, SC Sd 18 was the highest values at Sk and Sd. Meanwhile, the hybrid SC Sd 19 was the lowest values at five locations and combined.

Table 1. Analysis of variance for grain yield at five locations and across locations.

SOV	df		Grain yield					
	S.	Comb.	Sk.	Gm.	Sd.	Mall.	Nub.	Comb.
Location (L)	-	4	-	-	-	-	-	796.93**
Rep/L	3	15	4.22	7.18	7.47	25.65	2.68	9.44
Hybrids (H)	7	7	73.58**	70.76**	61.97**	51.91**	21.27**	191.35**
H × L	-	28	-	-	-	-	-	22.04**
Error	21	105	9.60	4.61	3.84	5.73	4.88	5.73

**** Significant at 0.01 level of probability.**

Sakha = Sk, Gemmeiza = Gm, Sids = Sd, Mallawie = Mall, Nubaria = Nub.

Table 2. Mean performance of the six promising white hybrids and two check hybrids at five locations for grain yield.

Hybrid	Grain yield (ard/fed)					
	Sk.	Gm.	Sd.	Mall.	Nub.	Comb.
SC Sk 152	35.65	38.74	18.71	32.36	33.76	31.84
SC Sk153	33.78	40.67	26.53	31.97	33.31	33.25
SC Sk154	37.28	42.12	28.17	32.73	34.78	35.01
SC Sd3	31.65	35.84	21.84	29.29	32.29	30.18
SC Sd18	41.10	37.83	30.27	31.08	32.74	34.60
SC Sd19	27.29	28.77	21.17	21.50	27.19	25.18
SC 128	37.57	34.35	23.46	30.22	32.21	31.56
SC 10	37.79	34.65	21.89	29.77	30.95	31.00
Mean	35.26	36.62	24.00	29.86	32.15	31.58
LSD 0.05	4.56	3.16	2.88	3.52	3.25	1.50

Sakha = Sk, Gemmeiza = Gm, Sids = Sd, Mallawie = Mall, Nubaria = Nub.

Superiority percentage for six promising hybrids relative to two commercial hybrids across locations for grain yield is presented in Table 3. The hybrids SC Sk 153, SC Sk 154 and SC Sd 18 were significant out yielded compared two checks. From above results the adaptability hybrids i.e. SC Sk 153, SC Sk 154 and SC Sd 18 are promoted to the next stage of evaluation according to the Egyptian hybrids registration protocol. Silva *et al* (2014) and Mosa *et al* (2015) stated that the adaptability is evaluated based on the average performance of genotype across environments. Environmental index for grain yield at five locations is shown in Table 4. The highest yield potential of the hybrids were obtained at Gemmeiza (Gm) followed Sakha (Sk) locations while the lowest values were obtained at Sids (Sd) followed Mallawy (Mall) locations, indicating that the environmental conditions at Gm and Sk were not stress while Sd and Mall were the stress environments. Stability is defined as the ability of the genotypes to exhipited a yield that is as constant as possible, depending on variations in the quality of the environment (Machado *et al* 2008).

Table 3. Superiority percentage for sex hybrids relative to two checks hybrid across five locations for grain yield.

Hybrid	Grain yield	
	SC 10	SC 128
SC Sk152	2.71	0.89
SC Sk153	7.26*	5.35*
SC Sk154	12.94*	10.93*
SC Sd3	-2.65	-4.37
SC Sd18	11.61*	9.63*
SC Sd19	-18.77*	-20.22*
LSD 0.05	1.48	

*** Significant at 0.05 level of probability.**

Table 4. Environmental index for grain yield at five locations.

Location	Grain yield	
	Mean	Environmental index
Sakha (Sk)	35.26	3.68
Gemmeiza (Gm)	36.62	5.04
Sids (Sd)	24.00	-7.58
Mallawie (Mall)	29.86	-1.72
Nubaria (Nub)	32.15	0.57
Average	31.58	-

Therefore, a genotype is considered to be stable if the performance is relatively constant under various environmental conditions (Alwala *et al*

2010). Elto and Hallauer (1980) stated that the selection of hybrids for mean yield across environments should be emphasized first and then the relative stability of elite hybrids across environments should be determined. Hence this study chose Eberhart and Russell (1966) method from different methods have been proposed to study the adaptability and stability of maize hybrids based on linear regression analysis which among its advantages includes ease of application and interpretation of results.

Stability analysis of variance of eight hybrids according to Eberhart and Russell for grain yield across five locations is presented in Table 5.

Table 5. Stability analysis according to Eberhart and Russell (1966) of 8 hybrids for grain yield across five locations.

SOV	df	Mean square
		Grain yield
H	7	47.85**
HxL+L	32	29.73**
L-Linear	1	797.12**
Hx L. Linear	7	6.33**
Pooled deviation	24	4.58**
SC Sk 152	3	5.73*
SC Sk 153	3	5.43*
SC Sk 154	3	2.60
SC Sd 3	3	2.97
SC Sd 18	3	8.74**
SC Sd 19	3	3.43
SC 128	3	3.65
SC 10	3	4.13*
Pooled error	120	1.55

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

Mean squares due to hybrids (H) were highly significant, indicating that they differed in yielding ability. Mean squares due to locations L (Linear) were highly significant, indicating a wide range of environment effects. Mean squares due to H x L (Linear) and pooled deviation (non-Linear) were highly significant, indicating that the portion of H x L should be linear, also the deviation mean squares for each hybrid was important for measuring yield stability H x L (Linear) was not significant when tested against pooled deviation, indicating equal important of both H x L (Linear) and pooled deviation interaction for grain yield in these hybrids. These results support the findings of Lee *et al* (2003) and Mosa *et al* (2015).

Estimates of stability parameters of eight hybrids for grain yield across five locations are shown in Table-6. The results showed that the SC Sk 152 had high grain yield more than grand mean and significant effects with $b_i > 1$.

Table 6 Estimates of stability parameters of eight hybrids for grain yield across five locations.

Hybrid	Grain yield (ard/fed)		
	$\dot{X}$	b_i	S^2_{di}
SC Sk 152	**31.84**	**1.49***	**4.18***
SC Sk 153	**33.25**	**0.93**	**3.88***
SC Sk 154	**35.01**	**1.00**	**1.05**
SC Sd 3	**30.18**	**1.00**	**1.42**
SC Sd 18	**34.60**	**0.78***	**7.19****
SC Sd 19	**25.18**	**0.64***	**1.88**
SC 128	**31.56**	**1.01**	**2.10**
SC 10	**31.00**	**1.15**	**2.58****
Grand mean	**31.58**		

This hybrid is scored as responsive to favorable environments while the hybrid SC Sd 18 had high grain yield more than grand mean and significant effects with $b_i < 1$. This hybrid is scored as tolerant to unfavorable environments. Also, SC Sk 152, SC Sk 153, SC Sd 18 and SC

10 showed significant for S^2_{di}, meaning, that these hybrids do not have a predictable response to environmental fluctuations or can respond or not to the new environment. Meanwhile SC Sk 154 had high grain yield more than grand mean, unit regression coefficient (b=1) and not significant of deviation from regression according to Eberhart and Russe (1966), this hybrid SC Sk 154 could be considered as yield stable. From above results this study prefers this hybrid because it combines between adaptability, stability and yield.

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التأقلم والثبات لهجن الذرةالشامية لمحصول الحبوب

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تم تقييم ٦ هجن فردية بيضاء مبشرة مع اثنين من الهجن التجارية فى خمسة مواقع بحثيةلصفة محصول الحبوب موسم ٢٠٢١. أظهر التباين الراجع الى الهجن والمواقع والتفاعل بينهما وكذلك الانحدار الخطى والانحراف عن خط الانحدار معنوية عاليةلصفة المحصول. أعطت الهجن الفردية سخا ١٥٣ و سخا ١٥٤ وسدس ١٨ محصولا أعلى من هجن المقارنة وبالتالى هذه الهجن لها قدرة عالية على التأقلم. الهجين الفردى سخا ١٥٤ له قدرة عالية على التأقلم والثباتلصفة المحصول (b_i ***=1 and*** S^2_{di} ***not significant) لذلك فضل الدراسة هذا الهجين.***

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