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EVALUATION OF STABILITY PARAMETERS FOR DISCRIMINATION OF ADAPTABLE, STABLE AND HIGH YIELDING MAIZE HYBRIDS

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ABSTRACT

The Main focus of the plant breeders now is to develop new hybrids with high and stable yield in both favorable and unfavorable growing conditions. Three yellow promising maize hybrids and two commercial hybrids were evaluated in trial (D) in season 2022 at eleven locations. Trial-D was the last stage evaluation of new maize hybrids registration for grain yield in Egypt. A randomized complete block design with six replications was used. A separate analysis for each location, a combined analysis across locations, parametric and nonparametric statistics and rank correlation among them were performed for grain yield. Mean squares due to hybrids (H) at each location and combined across locations were highly significant, also the mean squares due to locations (L) and hybrids× locations interaction (HLI) were highly significant for grain yield. The proportion of the total variation was 90.42% for (L), 2.54% for (H) and 7.04% for (HLI). The highest hybrids for grain yield were SC-Sk139 at Kafr El-Sheikh, Giza, Beni-Sueif, Minia, Assuit and Sohag, SC-Sk147 at Behera, Dakahlia, Menufyia and Sharkia and SC168 at Gharbia. These hybrids can be used specifically for these regions. The results combined across locations exhibited that the two promising hybrids SC-Sk139 and SC-Sk147 were significantly superior for grain yield relative to the two checks, also these two hybrids were the highest for grain yield under favorable and unfavorable environments in addition SC-Sk147 was the most stable hybrid based on (S^2, CV%, b_i, S^2d_i, R^2, δ^2, W_i^2 and P_i) stability parameters and SC-Sk139 was stable based on R^2, P_i and $S_i^{(1)}$. So this study recommended these two hybrids to be released as new commercial hybrids in Egypt. The correlation coefficient was significant and positive between (mean grain yield with $S_i^{(2)}$), (S^2 with CV%), (S^2 with b_i), (CV% with b_i), (S^2d_i with δ^2), (S^2d_i with W_i^2) and (δ^2 with W_i^2). Meanwhile the correlation coefficient was significant and negative between (mean grain yield with P_i), (S^2d_i with R^2), (δ^2 with R^2) and (R^2 with W_i^2).

Key word: ***Zea mays, Multi-location trials, favorable and unfavorable environments, adaptability and correlation coefficient.***

INTRODUTION

Maize (*Zea mays* L.) is a crop of great diversity that may be cultivated in many different agroecological zones (Ferdu *et al* 2002). The identification of hybrids with high yield potential coupled with wide adaptability and stability is a key target of maize breeding programs in Egypt. Plant breeder is evaluating genotypes in multi-environment trials (MET), including favorable and unfavorable environmental conditions. Also MET variance analysis provides reasonable estimates of the critical effects of genotype (G), environment (E) and genotype × environment interaction (GEI), where the effects of G, E and GEI mainly lead to a cultivar evaluation. The multi-location trials (MLT) are necessary to evaluate the stability and high grain yield performance of corn genotypes. The MLT guidance breeder is selecting superior genotypes based on high yield performance and stability across environments (Crossa 1990). The MLT plays important role in proving the crop as it can produce reliable results by evaluating the genotypes in certain periods and in different environments (Katsenios *et al* 2021). Furthermore, it can allocate specific and discriminating environments by differentiating the genotype performance within minimal replications (Choudhary *et al* 2019). Selection based on yield only may not always be adequate when genotype by environment interaction is significant (Kang *et al* 1991). The significant interaction between genotype and environment complicates the interpretation of the results obtained and reduces the efficiency of selecting the best genotype (Solonechnyi *et al* 2015 and Smith and Cullis 2018). The concept of stability was first used in regional performance test in 1917(Scapim *et al* 2000 and Berzsenyi *et al* 2007). Stability of yield refers to the ability of genotype to avoid substantial fluctuations in yield across a range of environments (Heinrich *et al* 1983). All methods of stability are valid, although they are based on very different concepts (Flores *et al* 1998). The adaptability and stability are analyzed to allow the identification of the genotypes with predictable behavior that may respond to the prevailing environmental variations under specific or general conditions (Cruz *et al* 2004). Based on the nature of the interaction between genotype and environment, plant breeders have proposed different methods for statistical analysis of MET data, including parametric and nonparametric methods (Richter *et al* 2010 and Raza *et al* 2017). Different responses of genotypes to changing environmental conditions are used to estimate the mean yield and identify high yielding and stable genotype (Moghaddam *et al* 2012 and Tsegaye *et al* 2012). Through the responses of corn genotypes across different environments, genotypes having stable yield across growing environments or specifically adapted to a specific growing area could be useful in making varietal recommendations to farmers (Anuada *et al* 2022). The objectives of this study were to identify the adapted hybrid for each region and the hybrids that have high grain yield and stability across locations as well as to investigate the relationships among different parametric and nonparametric stability statistics.

MATERIALS AND METHODS

In this study, three promising yellow maize single crosses, *i.e.* SC-Sk139, SC-Sk143 and SC-Sk147 produced by maize breeding program at Sakha (Sk) Agricultural Research Station plus the two checks SC162 and SC168 were tested at farmer fields (D-trial) in 2022 season. This trial was the last evaluation stage of new maize hybrids registration at eleven regions across Egypt, *i.e.* Behera, Kafr El-Sheikh, Dakahlia, Gharbia, Menufyia, Sharkia, Giza, Beni-Sueif, Minia, Assuit and Sohag. This experiment was held uniformly in all areas using a randomized complete block design with six replications. Each plot consisted of four rows 6 m in length, with a spacing of 0.7 m between the rows and 0.25 m between hills. Managements of fertilization and crop treatments were preformed based on expectations of high yield. The fertilizer was applied at planting using 30 kg of P_2O_5 and 24 kg of K_2O per feddan (fed). Meanwhile the nitrogen fertilizer was applied at the rate of 120 kg N/fed splitted into two equal doses and was added before the first and second irrigation in urea form (46.5%). The inner two rows of each plot were harvested and yield in ardab per feddan (ard/fed) were measured based on 15.5% of grain moisture (ardab = 140 kg and feddan = 4200 m^2).

The statistical analysis was done at each location and the combined analysis across locations was done after performing the homogeneity test according to Snedecor and Cochran (1989). Calculation of analysis of variance and Fisher's protected LSD test were carried out by using computer application of Statistical Analysis System (SAS, 2008). Stability parameters were performed according to Roemer (1917) for the variance of genotypes across environments (S^2), Francis and Kannenberg (1978) for coefficient of variation (CV%), Eberhart and Russel (1966) for both regression coefficient (b_i) and deviation from regression (S^2d_i), Pinthus (1973) for coefficient of determination (R^2), Shukla (1972) for stability variance (δ^2), Wricke (1962) for ecovalence (W_i^2), Lin and Binns (1988) for superiority measure (P_i), Nassar and Huehn (1987) for genotype absolute rank difference mean as tested across environments ($S_i^{(1)}$) and for variances between the ranks across environments ($S_i^{(2)}$). Stability parameters were performed using GEA-R 2017 (Genotype Environment Analysis with R for Windows).

RESULTS AND DISCUSSION

Analysis of variance for grain yield at eleven locations is presented in Table (1). Significant or highly significant mean squares due to hybrids were observed at all locations except for Assuit and Sohag locations, indicating that wide differences exist among hybrids for grain yield.

Table 1. Analysis of variance for grain yield at eleven locations.

SOV	df	Mean squares					
		Behera	Kafr EL-Sheikh	Dakahlia	Gharbia	Menofiya	Sharkia
Replications	5	13.71*	11.11**	7.40	18.12	2.43	20.07**
Hybrids	4	21.25**	37.67**	25.78**	51.88**	26.36**	16.53**
Error	20	3.35	2.14	4.56	8.58	3.60	2.43
SOV	df	Mean squares					
		Giza	Beni Sueif	Minia	Assuit	Sohag	
Replications	5	10.77	55.86**	23.33	14.82	30.00	
Hybrids	4	18.27*	29.06**	48.65*	25.54	27.87	
Error	20	6.09	6.08	14.45	12.31	16.04	

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

Analysis of variance for grain yield across eleven locations in Table (2), showed that the effects of hybrid (H), location (L) and hybrid × location interaction (HLI) were highly significant for grain yield, with the proportion of the total variation was 90.42% for L, 2.54% for H and 7.04% for HLI. According to Gauch and Zobel (1996), in standard multi-location trials, 80% of the total treatment variation is environment effects, 10% effect of genotype and 10% effect of genotype × environment. Kaya and Ozer (2014) found that E which explained 88.6% of total variation (G+E+GEI), whereas G and GEI accounted for 3.2% and 8.3%, respectively. Meanwhile, Mosa *et al* (2019) stated that H, E and HEI accounted for 56.70%, 20.47% and 22.78% from total variation, respectively. Shojaei *et al* (2021) and Mosa *et al* (2022) found that H, L and their interaction HLI were significant for grain yield.

Table 2. Analysis of variance for grain yield combined across eleven locations.

SOV	df	S.S.	M.S.	Explained%
Locations (L)	10	12419.58	1241.96**	90.42
Rep/L	55	1038.18	18.88	
Hybrids (H)	4	348.58	87.14**	2.54
H × L	40	966.87	24.17**	7.04
Error	220	1592.83	7.24	

** Significant at 0.01 level of probability.**

Mean performance of the five hybrids for grain yield at eleven location is presented in Table (3). The average grain yield was the highest for hybrids SC-Sk139 at Kafr El-Sheikh, Giza, Beni-Sueif, Minia, Assuit and Sohag, SC-Sk147 at Behera, Dakahlia, Menufyia and Sharkia and SC168 at Gharbia. These hybrids can be used specifically for these regions.

Table 3. Mean performance for grain yield (ard/fed) of five hybrids at eleven locations.

Hybrid	Behera	Kafr EL-Sheikh	Dakahlia	Gharbia	Menofiya	Sharkia
SCSk-139	35.57	40.23	34.44	24.17	27.12	23.17
SCSk-143	38.82	38.46	35.22	22.92	25.84	21.47
SCSk-147	39.85	39.28	37.73	25.90	30.26	25.35
SC162	38.18	33.76	31.94	24.67	26.34	21.21
SC168	35.81	38.56	35.16	30.54	30.08	22.52
LSD 005	2.21	1.76	2.57	3.53	2.29	1.88
Hybrid	**Giza**	**Beni Sueif**	**Minia**	**Assuit**	**Sohag**	
SCSk-139	29.85	34.79	39.97	45.76	42.83	
SCSk-143	28.17	32.25	36.99	40.69	37.16	
SCSk-147	25.56	34.12	38.63	41.39	38.24	
SC162	26.04	29.87	35.31	41.76	38.74	
SC168	26.76	30.31	32.70	43.71	38.85	
LSD 005	2.97	2.97	4.58	4.23	4.82	

A large yield variation explained by locations indicated that the locations were diverse in climatic conditions along with characteristics.

Locations grain yield ranged from 22.75 ard/fed at Sharkia to 42.66 ard/fed for Assuit Table (4). Also Assuit, Sohag, Kafr El-Sheikh, Behera, Minia and Dakahlia gave high values for mean, environmental index and range, meaning that the environmental conditions at these locations were considered as non-stress and exhibited the differences among hybrids while the other locations, Gharbia, Menufyia, Sharkia, Giza and Beni-Sueif showed low values for mean and environmental index, indicating that these locations were stressed environments. Frey and Maldomado (1967) and Mosa *et al* (2019) reported that under optimum environment, the tested genotypes were fully expressed leading to an enlargement in genotypic variance, while the stress conditions curtail genetic differences among genotypes.

Table 4. Mean, environmental index, maximum, minimum values and range for grain yield (ard/fed) at eleven locations.

Location	Mean (ard/fed)	Environmental index	Maximum value	Minimum value	Range
Behera	37.64	4.46	39.85	35.57	4.28
Kafr El-Sheikh	38.06	4.88	40.23	33.76	6.47
Dakahlia	34.90	1.72	37.73	31.94	5.79
Gharbia	25.64	-7.54	30.54	22.92	7.62
Menufiya	27.93	-5.25	30.26	25.84	4.42
Sharkia	22.75	-10.44	25.35	21.21	4.14
Giza	27.28	-5.91	29.85	25.56	4.29
Beni-Sueif	32.27	-0.91	34.79	29.87	4.92
Minia	36.72	3.54	39.97	32.70	7.27
Assiut	42.66	9.48	45.76	40.69	5.07
Sohag	39.16	5.98	42.83	37.16	5.67
Average	33.18				

Mean performance of three promising hybrids and two checks and their superiority percentage relative to checks across eleven locations are given in Table (5). The hybrids yield ranged from 31.62 ard/fed for SC162 to 34.36 ard/fed for SC-Sk139 with a mean of 33.18 ard/fed. The two promising hybrids SC-Sk139 and SC-Sk147 showed significant superiority for grain yield relative to the two checks SC162 and SC168 with a percentage of 8.65% and 3.54% for SC-Sk139 and 8.19% and 3.10% for SC-Sk147, respectively. Meanwhile, the hybrid SC-Sk143 exhibited significant superiority for grain yield relative to the check SC162 (2.92%). According to maize registration rules in Egypt, the promising hybrids could be recommended to release as new commercial hybrids when they did not significantly out-yield the commercial check across eleven locations. Hence the two promising hybrids SC-Sk139 and SC-Sk147 might be recommended to be released as new commercial hybrids.

Table 5. Mean performance of the three promising yellow hybrids, two check hybrids and superiority percentage relative to the two checks across eleven locations.

Hybrid	Grain yield (ard/fed)		
	Mean	Superiority% relative to checks	
		SC162	SC168
SCSk-139	34.36	8.65*	3.54*
SCSk-143	32.54	2.92*	-1.92
SCSk-147	34.21	8.19*	3.10*
SC162	31.62	-	-
SC168	33.18	-	-
LSD 0.05	0.92	-	-

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

Dispersion diagram of the five hybrids for grain yield (ard/fed) in the favorable and unfavorable environments in Figure (1), showed that the upper right quadrant included the hybrids SC-Sk139 and SC-Sk147 with superior performance in both groups, *i.e* the favorable and unfavorable environments, indicating adaptability to these environments and high stability.

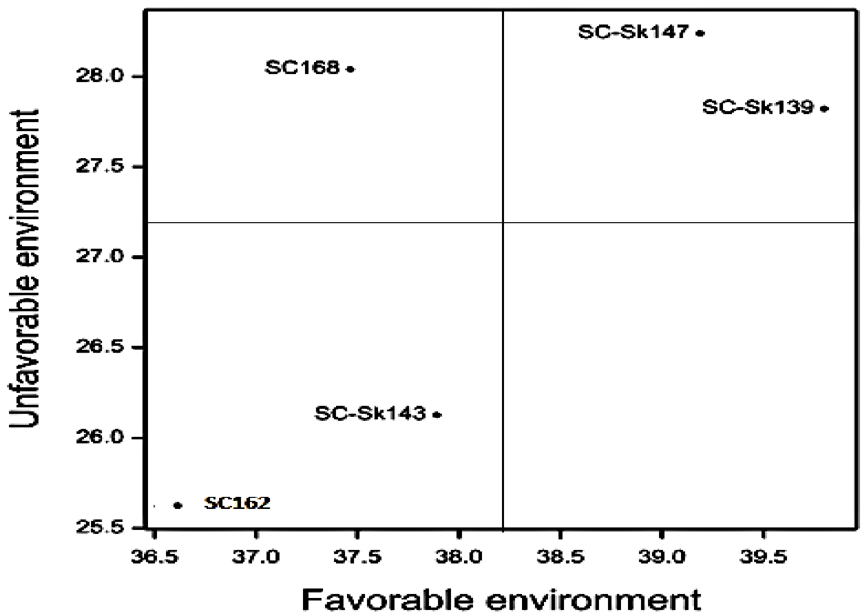

Fig. 1. Disperion diagram of the five hybrids for grain yield for favorable and unfavorable environments.

The upper lift quadrant grouped hybrid SC168 with specific adaptability to unfavorable environments while the lower left quadrant included the hybrids SC-Sk143 and SC162 have poorer performance in both groups of environments and low yield stability. Therefore, aside from the high yield new hybrids must have yield stability and adaptability or particular suitability for target regions.

Estimates of stability parameters of the five hybrids for grain yield are presented in Table (6). According to Roemer (1917) as reported by Backer and Leon (1988) for estimated environmental variance (S^2) a stable genotype has small variance. Hence SC168, SC-Sk147 and SC162 were stable with the lowest (S^2). Francis and Kannenberg (1978) stated that CV% was employed to group genotypes on the basis of their mean yield and their coefficient of variation (CV%) relative to the grand mean and average CV%.

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

Hybrid	Mean (ard/fed)	S^2	CV%	b_i	S^2d_i	R^2	δ^2	W_i^2	P_i	$S_i^{(1)}$	$S_i^{(2)}$
SC-Sk139	34.36	57.10	22.00	1.14*	2.79*	0.94	5.94	43.69	3.83	0.18	2.40
SC-Sk143	32.54	46.85	21.03	1.04	0.86	0.96	1.88	19.34	8.15	0.24	1.80
SC-Sk147	34.21	39.51	18.37	0.94	1.71	0.93	3.24	27.53	3.78	0.27	2.10
SC162	31.62	43.36	20.82	1.00	0.65	0.96	1.45	16.75	10.83	0.16	0.80
SC168	33.18	36.28	18.15	0.87*	4.04**	0.87	7.63	53.84	6.20	0.16	1.30
Mean	33.18	44.62	20.08	1.00	2.01	0.93	4.03	32.23	6.56	0.20	1.68

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

Hence the two hybrids SC-Sk147 and SC168 as most desirable with higher than average yield and smaller than average CV%. Eberhart and Russell (1966) described a desirable genotype as one with a high mean yield > grand mean, b = 1.0 or not significant and S^2d_i = 0 or not significant. Considering this definition, SC-Sk147 could be considered as the most desirable one from the five hybrids. According to Pinthus (1973) coefficient of determination R^2 values for the hybrids, indicated that SC-Sk139, SC-Sk143, SC-Sk147 and SC162 were stable taking into account that it had R^2 values close to 1. Shukla (1972) stated that the stable genotypes are lower in stability variance (δ^2) values, hence the hybrids SC-Sk143, SC-Sk147 and SC162 were considered stable. Wricke (1962) proposed the ecovalence W_i^2 as a stability parameter, the genotype with the smallest value is stable, hence the hybrids SC-Sk143, SC-Sk147 and SC162 were considered as stable. Lin and Binns (1988) suggested using superiority measure (P_i) as a stability parameter. According to this stability parameter, genotype with high grain yield and low P_i values than the average is stable. Hence the hybrids SC-Sk139, SC-Sk147 and SC168 were considered stable. According Nassar and Huehn (1987) for genotype absolute rank difference mean as tested across environments ($S_i^{(1)}$) and for variances ranks across environments ($S_i^{(2)}$), the stable genotype has smallest value in both two stability parameters, hence the hybrids SC-Sk139, SC162 and SC168 were stable for $S_i^{(1)}$ and SC162 and SC168 were stable for $S_i^{(2)}$. From above mentioned results, the new promising hybrid SC-Sk147 had high grain yield (34.21 ard/fed) and was the most stable hybrid based on (S^2, CV%, b_i, S^2d_i, R^2, δ^2, W_i^2 and P_i) out of 10 stability statistics. Meanwhile, the new promising SC-Sk139 had the highest grain yield and was stable for R^2, P_i and $S_i^{(1)}$. The identification of genotypes with a high yield potential coupled with wide adaptability and stability, is a key target of the maize breeding programs. So this study recommended these two hybrids to be released as new commercial hybrid in Egypt. Genotypes having stable yield across growing environments or specifically adapted to the specific growing area could be useful in making varietal recommendations to farmers (Anuada *et al* 2022).

Several models for statistical measurement of the stability have been proposed each of which reflects different aspects of stability and no single method can adequately explain cultivar performance across environments (Mohebodini *et al* 2006). Therefore, it was necessary to study the relationships among stability measures. The correlation coefficients (r) among different stability parameters for grain yield are presented in Table (7). The means of hybrids grain yield was negatively correlated to the stability parameter P_i ($r = -0.996^{**}$), meaning that selection for high grain yield hybrids by decreasing the P_i, thus would lead to the selection of hybrids with general adaptation. Meanwhile, the means of hybrids grain yield was positively correlated to the stability parameter $S_i^{(2)}$ ($r = -0.878^{*}$), meaning that selection for high grain yield hybrids by increasing that $S_i^{(2)}$, thus would lead to the selection of hybrids with specific adaptation ability. Mosa *et al* (2019) found that $r = -0.99^{**}$ between (grain yield with P_i) and = -0.26^{**} between (grain yield with $S_i^{(2)}$).

The correlation coefficients between (S^2 with CV%), (S^2d_i with δ^2), (S^2d_i with W_i^2) and (δ^2 with W_i^2) were significant and positive (0.906^{*}, 0.995^{**}, 0.995^{**} and 1.00^{**}, respectively), indicating that the stabile hybrids under different environments had lower values for first and second stability parameters, hence the two measures are similar in classifying the hybrids. Therefore, only one of those two measures of stability is sufficient for the selection of stable hybrids in breeding programs. Kaya and Ozer (2014) found that the correlation coefficient between (S^2d_i with W_i^2), (S^2d_i with δ^2), and (δ^2 with W_i^2) were significant and positive for grain yield and Letta

(2007) found that the correlation between (S^2 with CV%) was significant and positive.

Table 7. The correlation coefficients among different stability parameters for grain yield.

Parameter	Mean	S^2	CV (%)	b_i	S^2d_i	R^2	δ^2	W_i^2	P_i	$S_i^{(1)}$
S^2	0.269									
CV (%)	-0.162	0.906**								
b_i	0.154	0.981**	0.944**							
S^2d_i	0.532	-0.144	-0.414	-0.333						
R^2	-0.330	0.501	0.687	0.659	-0.927*					
δ^2	0.557	-0.044	-0.323	-0.236	0.995**	-0.885*				
W_i^2	0.557	-0.044	-0.323	-0.236	0.995**	-0.885*	1.00**			
P_i	-0.996**	-0.194	0.238	-0.075	-0.568	0.391	-0.585	-0.585		
$S_i^{(1)}$	0.370	-0.083	-0.210	-0.001	-0.387	0.327	-0.410	-0.410	-0.386	
$S_i^{(2)}$	0.878*	0.556	0.195	0.493	0.199	0.057	0.248	0.248	-0.856	0.548

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

The stability parameter b_i had significant and positive correlation with parameters S^2 ($r = 0.981^{**}$) and CV% ($r = 0.944^{**}$), meaning that stable hybrids with lower values for S^2 and CV% had small b_i value thus, it has the ability to adapt to all environments especially for poor environments. These results are in agreement with Frshadfar *et al* (2012) for r between (b_i with S^2) and Alberts (2004) for r between (b_i with CV%).

The stability parameter R^2 had a significant and negative correlation with parameters S^2d_i ($r = -0.927^{*}$), δ^2 ($r = -0.885^{*}$) and W_i^2 ($r = -0.885^{*}$), indicating that stable hybrids with high value for R^2 had small values for S^2d_i, δ^2 and W_i^2, which indicates that either of these two parameters could be used independently from each other without influencing estimation. These results are in agreement with Mohebodini *et al* (2006) for r between (R^2 with S^2d_i), Mekbib (2003) for r between (R^2 with δ^2) and Akcura *et al* (2006) for r between (R^2 with W_i^2).

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تقييم مقاييس ثبات للتمييز بين هجن الذرة الشامية للتأقلم والثبات والإنتاجية العالية

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

فى الوقت الحالى ينصب التركيز الرئيسى للهجن الجديدة على أن تعطى محصول مرتفع وثابت تحت كل من ظروف النمو الملائمة وغير الملائمة. تم تقييم ثلاثة هجن مبشرة صفراء واثنين من الهجن التجارية فى تجربة المرحلة (D) موسم ٢٠٢٢ فى أحد عشر موقعا. تجربة المرحلة (D) هى الأخيرة من مراحل التقييم قبل تسجيل هجن الذرة الشامية الجديدة لمحصول الحبوب فى مصر. تم إستخدام تصميم القطاعات الكاملة العشوائية فى ستة مكررات. تم التحليل المنفرد لكل موقع وكذلك التحليل المجمع عبر المواقع وتم تقدير للإحصاءات البارامترية وغير البارامترية والتلازم المظهرى فيما بينها لصفة محصول الحبوب. كان التباين بين الهجن عالى المعنوية فى كل موقع وعبر المواقع ، كما كان التباين بين المواقع وتفاعل المواقع مع الهجن عالى المعنوية لصفة محصول الحبوب. ساهمت الإختلافات الراجعة إلى المواقع بنسبة ٩٠,٤٢٪ والراجعة إلى الهجن بنسبة ٢,٥٤٪ والتفاعل بين الهجن والمواقع بنسبة ٧,٠٤٪ من الإختلافات الكلية. أعطى الهجين الفردى الأصفر (SC-Sk139) أعلى محصول حبوب فى مواقع كفر الشيخ والجيزة وبني سويف والمنيا وأسيوط وسوهاج، كما أعطى الهجين الفردى الأصفر (SC-Sk147) أعلى محصول حبوب فى مواقع البحيرة والدقهلية والمنوفية والشرقية، بينما أعطى الهجين الفردى الأصفر SC168 أعلى محصول حبوب بموقع الغربية. وعليه يمكن تخصيص هذه الهجن لهذه المناطق. أظهرت النتائج عبر المواقع أن الهجينين الواعدين SC-Sk139 و SC-Sk147 كانا يتفوقان معنوياً على هجن المقارنة فى صفة محصول الحبوب، كما أن هذين الهجينين كانا الأعلى فى محصول الحبوب فى البيئات الملائمة وغير الملائمة بالإضافة إلى أن الهجين SC-Sk147 كان الأكثر ثباتاً بالإعتماد على مقاييس الثبات التالية: (S^2، CV%، b_i ، S^2d_i، R^2، δ^2، W_i^2، P_i)، كما أظهرالهجين SC-Sk139 ثباتا بالإعتماد على مقاييس الثبات التالية: (R^2، P_i، $S_i^{(1)}$). لذلك أوصت هذه الدراسة بتسجيل هذين الهجينين كهجن تجارية جديدة فى مصر. كان معامل التلازم المظهرى موجباً ومعنوياً بين كلا من: (mean grain yield with $S_i^{(2)}$)، (S^2 with CV%)، (S^2 with b_i)، (CV% with b_i)، (S^2d_i with δ^2)، (S^2d_i with W_i^2)، (δ^2 with W_i^2)، بينما كان معامل التلازم سالباً ومعنويا بين كلاً من: (mean grain yield with P_i)، (S^2d_i with R^2)، (δ^2 with R^2)، (R^2 with W_i^2).

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