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SUPERIORTY INDEX COMBINING YIELD AND DIFFERENT STABILITY PARAMETERS OF SOME MAIZE (*Zea Mays* L.) HYBRIDS

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ABSTRACT

Seven new white promising maize hybrids,(five single crosses; i.e., Gm 2019, 2028, 2042, 2043, 2044, and two three-way crosses; i.e., Gm 3014, 3022). These hybrids and four white commercial hybrids (SC's Gz 10, 124 and TWC's Gz 321, 324) were evaluated at five locations in 2003 season. Data were recorded for grain yield (Mg ha^{-1}), number of days to mid-silking (d) and plant height (cm). Data were analyzed for individual location and combined.

The results showed the following:

1- *The combined analysis of variance showed that the differences among hybrids were significant for the three characters under study. Also, the environments x hybrids interaction were significant, indicating that the ranking of hybrids was not consistent across the five environments.*
2- *Mean grain yield for the five environments ranged from 5.88 (Nubaria) to 9.59 Mg ha^{-1} (Gemmiza), while it ranged for hybrids from 4.77 for SC Gm 2042 (at Nubaria) to 11.02 Mg ha^{-1} for SC Gm 2028 at Gemmiza. For the combined analysis, SC Gm 2043 had the highest mean grain yield, followed by SC Gz 10 (8.66, 8.53 Mg ha^{-1}, respectively). Also, days to mid-silking and plant height were affected by environments and hybrids.*
3- *The interactions between hybrids and environments were quantitatively expressed, using the model developed by Eberhart and Russell (1964). Out of this regression model, four stability parameters were estimated; i.e, regression coefficient (b), variance from regression ($S^2_{y.x}$), variance of residual error ($S^2_{y.x}$ - $S^2_{\bar{y}}$) and determination coefficient (r^2). A fifth estimate was the C.V for hybrid mean across environments.*
4- *Rank correlation among the five estimates indicated that both b and $S^2_{y.x}$ were the least correlated among the five stability parameters. Mean yield was independent from the b values and was significantly correlated with $S^2_{y.x}$ and C.V values, but highly significant with r^2.*
5- *In order to identify the most desirable hybrid, it should be high in yield and, at the same time, with a b value of 1.0 and $S^2_{y.x}$ equals to pooled error ($S^2_{\bar{y}}$). Therefore, a superiority index was constructed, using the three parameters; mean grain yield, b (regression coefficient) and $S^2_{y.x}$. A score was given for each of the three parameters and the total of the three score constitutes the superiority index.*
6- *The eleven hybrids, under study, were categorized in three groups. The super group, which was high in yield and stable, had a score ranging from 12 to 14 and included SC Gm 2043 and Gz 10. The intermediate group included SC Gz 124 and TWC Gz 321, Gz 324 and Gm 3019, with a score from 4 to 5. The poor group included TWC Gm 3022 and SC Gm 2019, 2028, 2042 and 2044, with a score ranging from 0 to -8.*
7- *This study indicated that a superiority index could be used in estimating the degree of desirability for the different hybrids.*

Key words: *Maize, Corn, Stability, Multi-criteria, Regression coefficient, Deviation from regression, Variance, Coefficient of determination, Coefficient of variation.*

INTRODUCTION

Newly developed cultivars, generally, need to be evaluated at many locations and for several years before being recommended for a given zone. To achieve this goal, multi-environment trials from the core of varietal testing program should be conducted. These programs have to face the recurring problem of genotype x environment (GE) interaction. Indeed, differential genotypic responses to variable environmental conditions, especially when associated with changes in genotypic ranking, limit the identification of superior and stable hybrids.

Gene expression is subjected to modification by the environment, therefore, genotypic expression is environmentally dependent (Kang, 1998). The development of new cultivars involves breeding of cultivars with desired characteristics, such as high economic yield, traits that add value to the product, and the stability of these traits in target environments. Inconsistent genotypic responses to environmental factors, such as temperature, soil type or fertility level from location to location and year to year, are functions of genotype x environment (EG) interactions. Genotypes x environment interactions have been defined as the failure of genotypes to achieve the same relative performance in different environments (Baker, 1988).

The reliability of cultivar performance across locations and years, can be an important consideration in plant breeding. Some cultivars are adapted to a broad range of environmental conditions, while others are more limited in their potential distribution.

Identification of yield-contributing traits and knowledge of GE interactions and yield stability are important for breeding new cultivars with improved adaptation to the environmental constraints, prevailing in the target environments (Rao *et al*, 2002). It is now possible to develop improved cultivars for target environments by exploiting GE interactions and marker-based selection, integrated with traditional plant breeding (Kang, 1998; Boerma and Mian, 1998).

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The multi-criterion procedure, developed by Lefkovitch (1985), uses a cluster algorithm that permits more than one measure of pair-wise relationship. He defined dissimilarity of genotypes by three measures; namely, the mean over all environments (x_i), the variance across environments (S^2i), and among environments pattern distance (d_{ij}), and pointed out that extension of this list to include additional measures involved no new principle. The use of more than one criterion is made possible by the conditional clustering procedure (Lefkovitch 1980, 1982), and that genotypes can be grouped, using all measures either sequentially or simultaneously to decide on group homogeneity.

The objectives of this study were to: *(i)* identify new maize genotypes with superior yield across different environments, *(ii)* identify the most useful criterion that could be used to estimate yield stability in maize and *(iii)* construct a simple index combining stability parameters and yield to evaluate eleven hybrids across five locations.

MATERIALS AND METHODS

Seven new promising white maize hybrids were developed by the breeding program at Gemmiza Research Station. These promising hybrids; namely, the single crosses: SC's Gm 2019, 2028, 2042, 2043, 2044, and three-way crosses: TWC's Gm 3014, 3022. These promising hybrids and the four commercial hybrids (SC's SC 10, SC 124, TWC Gz 321 TWC 324) were evaluated at five locations; i.e., Sakha (North Delta), Gemmiza (Mid Delta), Sids (Mid Egypt), Nubaria (North Coastal Zone) and Mallawy (Upper Egypt) Agriculture Research Stations in 2003 season, representing the different maize production zones of Egypt.

At each location, the eleven hybrids were planted on the optimum date, using a randomized complete block design, with four replications. Each plot consisted of four rows, spaced 0.8 m apart with row length of 6 m. Hand sowing was done in hills spaced at 25 cm along the row. All recommended agricultural practices were followed through the growing season.

Data were recorded for grain yield, adjusted to 15.5% grain moisture and converted to ton/hectare (Mg ha^{-1}), number of days to mid-silking (d) and plant height (cm).

Statistical Analysis

Data for individual location were analyzed, using Proc ANOVA (SAS software, 1997) for the studied characters, according to Steel and Torrie, (1980). The data were subjected to combined statistical analysis across locations, using Proc IML (SAS software, 1997) and Proc MIXED (Littell *et al.*, 1996). Hybrid effects were considered fixed and locations random in the analysis of variance.

Stability parameters

Stability analysis for studied characters was performed, according to the following model of Eberhart and Russell (1966):

$$Y_{ij} = U_i + B_i I_j + S_{ij}$$

Where:

Y_{ij} = the hybrid mean of the i^{th} hybrid at the j^{th} environment.

U_i = mean of the i^{th} hybrid over all environments.

B_i = regression coefficient for the response of the i^{th} hybrid to varying environments.

I_j = environmental index obtained as the mean of all hybrids at the environment minus the grand mean.

S_{ij} = the deviation from regression of i^{th} hybrid and j^{th} environment.

Simple linear regression analysis, using Proc REG (SAS software, 1997), was used to estimate Eberhart and Russell (1966) parameters for genotypic stability of hybrids across environments.

From the regression analysis, the following four estimates of stability parameters were calculated; i.e., b, S^2_{yx}, S^2_d (S^2_{yx}- S^2_e), and r^2 (determination coefficient). Francis and Kannenberg (1978) suggested the use of C.V of each genotype as a measure of stability. Therefore, the C.V for each hybrid was calculated as a 4^{th} measure of stability. The association among the five estimates of stability was measured by calculating the rank correlation coefficient among the five estimates. The best estimates of stability, in addition to the mean of hybrid yield, were included in an index, designated as superiority index.

Superiority index

An index was developed to include both yield and stability parameters. The following three criteria were included in the index:

1- The *first* criterion was the distance of a genotype from the overall mean, using the LSD from the ANOVA at p = (not significant, 0.10, 0.05, 0.01, 0.001) and a yield score (I = 0, 2, 4, 6, 8 + if above mean, or - if below) to score the hybrid rank.

2- The *second* criterion was a regression coefficient, estimated in the usual manner as:

$$b_i = \sum_j Y_{ij} I_j / \sum_j I^2_j$$

The distance of hybrid regression coefficient (b) from 1 divided by the (t_a S_b) represented a regression score of 4, 3, 2, 1, 0 for probability < ns, 0.1, 0.05, 0.01 0.001, respectively. The value of S^2_b was calculated from the S^2_a divided by the S.S. for environment index. The pooled standard error of the regression coefficient was the square root of pooled S^2_b.

3- The *third* criterion was the variance of deviation from regression ($S^2_{y.x}$) divided by the pooled MS of error (S^2_e) with a score of 4, 3, 2, 1, 0, corresponding to ns, 0.1, 0.05, 0.01, 0.001 probability levels.

The total of the three scores value would represent the superiority index, which combined both yield and stability parameters and was used to rank the hybrids under study.

RESULTS AND DISCUSSION

Mean performance

The combined analysis of variance showed that the difference among hybrids was significant for the three characters under study (Table 1). Also, the interaction was significant between environment and hybrids indicating that the ranking of hybrids was not consistent across the five environments.

Mean performance of grain yield for each environment is presented in Table 2. The average of grain yield for the studied hybrids differed greatly and significantly from environment to another. Therefore, the ranking of yield differed within and between environments. Grain yield ranged for the different environments from 5.88 (Nubaria) to 9.59 Mg h^{-1} (Gemmiza) (Table 2). The average of grain yield at Sids, Nubaria and Mallawy were less than overall mean, due to low soil fertility and some of climatic factors of these environments. This would suggest that the Nubaria and Mallawy were stress environments, while the rest were optimum environments.

The studied hybrids responded differently across environments, therefore, their ranks within environments indicated their specific adaptations.

Average grain yield of hybrids ranged from 4.77, for SC Gm 2042 at Nubaria, to 11.02 Mg ha^{-1} for SC Gm 2028 at Gemmiza. On the other hand, SC Gm 2043 had the highest grain yield and ranked first at all environments, except at Gemmiza.

For days to mid-silking, the average of studied hybrids significantly differed between and within environments (Table 2). The earliest was 58.7 d at Gemmiza, while the latest was 66.6 d at Mallawy. Single-cross Gm 2042 was the earliest hybrid at each environment and its overall mean was 61.6 d, while TWC Gz 324 was the latest hybrid with 65.6 d.

Plant height of the studied hybrids, also, significantly differed between and within environments (Table 2). Average of plant height ranged from 206.4 at Nubaria to 301.0 cm at Gemmiza, while SC Gm 2042 was the shortest hybrid (235.4 cm) and SC Gz 10 was the tallest one (283.3 cm).

Stability parameters

A hybrid is considered to be stable if its among-environment variance is small, or if its response to environments is parallel to the mean response of all genotypes within trial, and the residual MS from the regression model on the environmental index ($S^2_{y.x}$) is small.

The modified model of Eberhart and Russell (1966) was used by several investigators (El. Nagouly *et al*, 1980); Ragheb *et al*, 1993; El-Zeir *et al*, 1999, Abdel-Hamid, 2001 and Shehata *et al*, 2003). A stable preferred hybrid would have approximately b = 1, S^2_d = 0, in addition to its superiority in yield.

The regression coefficients (bi's) were calculated and significantly tested by using (S_b x t_α) at different level of probability (Table 3). The results showed that SC's Gm 2019, Gm 2028, Gm 2042, Gm 2044, Gz 124 and TWC Gz 321 had a regression coefficient significantly different from 1.0, therefore, they were considered unstable. On the other hand, the regression coefficients for the other hybrids were not significant and were not different from 1.0 and were considered stable.

Variance of deviation from regression on environment index ($S^2_{y.x}$) was the second criterion for stability. This criterion was highly related to S^2_d. The results showed that SC's Gm 2043 and Gz 124 had an estimate insignificant from the pooled error, suggesting that they were considered stable, with respect to this parameter, while the other hybrids were significantly greater than the pooled error.

The third criterion was the coefficient of variation of hybrid (CV), it is an indication of the fraction of the hybrid mean across environments. The hybrid with the lowest CV would be the most stable, therefore, SC's Gm 2043 and Gz 124 were the most stable hybrids (Table 3).

The fourth criterion was the coefficient of determination (r^2) value for each hybrid. The high value of r^2 would be associated with the hybrid with low $S^2_{y.x}$. The results showed that SC's Gm 2043 and Gz 124 had the high values of r^2, therefore, they were considered the most stable hybrids. This criterion was highly correlated with $S^2_{y.x}$.

Correlation among stability parameters

Rank correlation among the stability parameters and mean of grain yield were calculated in order to exclude the highly correlated parameters. Mean of grain yield was moderately correlated with S^2_d, $S^2_{y.x}$, CV and r^2 and was independent from b-value (Table 4).

Among the five stability parameters, perfect correlation coefficient of around 1.0 was indicated between $S^2_{y.x}$ and both CV and r^2. Also, it was perfect between CV and r^2. Therefore, $S^2_{y.x}$ could present the other two parameters (CV and r^2). Also, S^2_d was highly correlated with $S^2_{y.x}$, CV and r^2.

Table 1. Mean squares of stability analysis for grain yield, days to mid-silking and plant height for eleven hybrids evaluated under different environmental conditions.

S.O.V		D.F.	Grain yield (Mg ha^{-1})	Days to mid-silking (d)	Plant height (cm)
Environments (Env)		4	99.615 **	453.234 **	52665.71 **
Rep / Env		15	0.759	2.523	419.32
Hybrids (HY)		10	3.297 **	33.065 **	3738.49 **
HY X Env		40	1.875 **	2.682 **	313.63 **
Pooled error		150	0.186	0.759	87.83
Hybrids (HY)		10	3.297 **	33.065 **	3738.49 **
Env + (HY x Env)		44	2.693 **	10.910 **	1268.31 **
Env (linear)		1	99.288 **	453.23 **	52672.62 **
HY x Env (linear)		10	0.483	0.357	58.569
Pooled deviations		33	0.435	0.705	77.195
Hybrids	– SC.Gm.2019	3	1.289 **	0.373	34.299
	– SC.Gm.2028	3	0.697 **	0.219	12.737
	– SC.Gm.2042	3	0.543 **	2.010	86.904 **
	– SC.Gm.2043	3	0.017	0.351	78.511 **
	– SC.Gm.2044	3	0.415 **	0.302	23.348
	– TWC.Gm.3019	3	0.698 **	1.587 **	185.592 **
	– TWC.Gm.3022	3	0.401 **	0.396	123.110 **
	– SC.Gz.10	3	0.249 **	0.406	87.441 **
	– SC.Gz.124	3	0.088	1.494 **	22.346
	– TWC.Gz.321	3	0.186 **	0.240	58.692 *
	– TWC.Gz.324	3	0.203 **	0.380	136.164 **
Pooled error for hybrid mean		150	0.0465	0.173	19.961
C.V.			5.4	1.4	3.7

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

Table 2. Mean performance and rank of grain yield (Mg ha^{-1}), days to mid-silking and plant height for 11 hybrids evaluated at 5 environments and combined data.

Hybrid	SAKHA		GEMMIZA		SIDS		NUBARIA		MALLAWY		COMBIND	
Grain yield (Mg ha^{-1})												
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
SC.Gm.2019	8.79	10	7.15	11	7.82	5	5.55	9	8.22	2	7.51	10
SC.Gm.2028	9.40	6	11.02	1	7.83	4	6.07	3	6.72	10	8.21	4
SC.Gm.2042	9.11	7	8.34	9	7.48	7	4.77	11	7.76	6	7.49	11
SC.Gm.2043	9.92	2	9.84	7	8.36	2	6.88	1	8.32	1	8.66	1
SC.Gm.2044	9.04	8	8.34	10	6.87	10	5.90	5	8.09	3	7.65	8
TWC.Gm.3019	8.96	9	10.28	3	6.35	11	5.90	6	7.88	5	7.87	7
TWC.Gm.3022	8.60	11	10.05	5	7.00	9	5.83	7	6.70	11	7.64	9
SC.Gz.10	9.59	3	10.18	4	8.67	1	6.68	2	7.49	7	8.53	2
SC.Gz.124	9.93	1	9.79	8	7.46	8	5.50	10	7.95	4	8.13	5
TWC.Gz.321	9.57	4	10.69	2	8.22	3	5.61	8	7.47	8	8.31	3
TWC.Gz.324	9.41	5	9.86	6	7.65	6	6.00	4	6.84	9	7.95	6
Mean	9.30		9.59		7.61		5.88		7.59		7.99	
$LSD_{(0.05)}$ – HY.	0.72		0.41		0.56		0.67		0.70		0.27	
$LSD_{(0.05)}$ – Env.					0.18							
Days to mid-silking (d)												
Hybrid	SAKHA		GEMMIZA		SIDS		NUBARIA		MALLAWY		COMBIND	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
SC.Gm.2019	65.5	4	60.0	9	66.3	6	65.8	8	67.5	8	65.0	7
SC.Gm.2028	67.3	9	59.8	6	67.5	10	66.0	11	67.8	9	65.7	10
SC.Gm.2042	62.5	1	56.3	1	61.3	1	64.3	2	63.5	1	61.6	1
SC.Gm.2043	65.8	5	57.3	3	64.0	3	64.5	3	66.3	4	63.6	3
SC.Gm.2044	66.8	7	59.8	7	65.5	5	65.3	5	66.0	3	64.7	6
TWC.Gm.3019	66.3	6	58.0	4	67.5	11	64.0	1	66.8	6	64.5	5
TWC.Gm.3022	64.5	2	58.3	5	65.3	4	65.0	4	66.5	5	63.9	4
SC.Gz.10	67.8	10	60.0	10	67.0	9	65.5	7	67.8	10	65.6	9
SC.Gz.124	64.5	3	57.0	2	63.5	2	65.8	9	64.8	2	63.1	2
TWC.Gz.321	66.8	8	59.8	8	66.8	7	65.3	6	67.0	7	65.1	8
TWC.Gz.324	67.8	11	60.0	11	66.8	8	65.8	10	68.5	11	65.8	11
Mean	65.9		58.7		65.6		65.2		66.6		64.4	
$LSD_{(0.05)}$ – HY.	1.2		1.2		1.5		1.3		1.0		0.5	
$LSD_{(0.05)}$ – Env.					0.4							
Plant height (cm)												
Hybrid	SAKHA		GEMMIZA		SIDS		NUBARIA		MALLAWY		COMBIND	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
SC.Gm.2019	248.0	2	288.3	3	246.8	2	198..0	3	224.3	1	241.1	2
SC.Gm.2028	272.5	7	307.0	8	269.5	8	206.3	6	252.5	7	261.6	8
SC.Gm.2042	242.5	1	272.5	1	253.0	4	184.0	1	224.8	2	235.4	1
SC.Gm.2043	279.3	9	291.3	4	254.0	5	211.0	8	239.8	4	255.1	5
SC.Gm.2044	265.8	6	301.8	6	260.5	7	219.0	10	243.8	5	258.2	7
TWC.Gm.3019	249.8	4	309.0	9	256.8	6	203.5	5	256.3	9	255.1	6
TWC.Gm.3022	263.8	5	277.5	2	240.0	1	217.5	9	248.0	6	253.4	4
SC.Gz.10	306.0	11	333.0	11	287.8	11	232.0	11	257.8	10	283.3	11
SC.Gz.124	249.0	3	294.3	5	248.0	3	187.8	2	233.0	3	242.4	3
TWC.Gz.321	276.5	8	304.3	7	275.0	10	202.3	4	255.0	8	262.6	9
TWC.Gz.324	301.3	10	312.5	10	270.0	9	209.0	7	258.3	11	270.2	10
Mean	268.6		301.0		260.1		206.4		244.8		256.2	
$LSD_{(0.05)}$ – HY.	18.5		9.2		14.4		13.8		9.7		5.9	
$LSD_{(0.05)}$ – Env.					4.0							

Table 3. Mean grain yield; stability parameters, b, $S^2_{y.x}$, CV, and r^2 and the superiority index for eleven maize hybrids evaluated at 5 environments.

Hybrid	Grain yield (Mg ha^{-1})			Regression coefficient (b)			Variance of deviation from regression ($S^2_{y.x}$)			Superiority index		Coefficient of variation		Coefficient of determination	
	Mean	I	Select	b_i	I	Select	$S^2_{y.x}$	I	Select	Total	Select	CV	Rank	r^2	Rank †
SC.Gm 2019	7.51	- 8	*No*	0.533 **	0	*No*	1.289 **	0	*No*	- 8	*No*	14.7	1	0.42	1
SC.Gm 2028	8.21	0	*Yes*	1.251 **	0	*No*	0.697 **	0	*No*	0	*No*	10.1	3	0.87*	5
SC.Gm 2042	7.49	- 8	*No*	1.009	4	*Yes*	0.543 **	0	*No*	- 4	*No*	9.9	4	0.85*	4
SC.Gm 2043	8.66	+ 8	*Yes*	0.834 *	2	*Yes*	0.017	4	*Yes*	14	*Yes*	1.6	11	0.99**	11
SC.Gm 2044	7.65	- 4	*No*	0.744 **	0	*No*	0.415 **	0	*No*	- 4	*No*	8.5	5	0.80*	2
TWC.Gm 3019	7.87	0	*Yes*	1.107	4	*Yes*	0.698 **	0	*No*	4	*No*	10.5	2	0.84*	3
TWC.Gm 3022	7.64	- 4	*No*	1.056	4	*Yes*	0.401 **	0	*No*	0	*No*	8.2	6	0.89*	6
SC.Gz 10	8.53	+ 8	*Yes*	0.916	4	*Yes*	0.249 **	0	*No*	12	*No*	6.0	7	0.91*	7
SC.Gz 124	8.13	0	*Yes*	1.205 **	1	*No*	0.088	4	*Yes*	5	*No*	3.7	10	0.98**	10
TWC.Gz 321	8.31	+ 4	*Yes*	1.276 **	0	*No*	0.186 **	1	*No*	5	*No*	5.1	9	0.96**	9
TWC.Gz 324	7.95	0	*Yes*	1.065	4	*Yes*	0.203 **	1	*No*	5	*No*	5.7	8	0.94**	8
Mean	7.99			0.999			0.435					7.6		0.86	
	LSD_a			$S_b \times t_a$			$S^2e \times F_a$								
	0.1 = 0.23			0.1 = 0.12 (3)			0.1 = 0.11								
	0.05 = 0.27			0.05 = 0.14 (2)			0.05 = 0.14								
	0.01 = 0.36			0.01 = 0.19 (1)			0.01 = 0.18								
	0.001 = 0.46			0.001 = 0.24 (0)			0.001 = 0.21								

*, ** Indicates significance at the 0.05 and 0.01 levels of probability, respectively.

† Rank 11 for the best, while 1 for the poorest.

Table 4. Rank correlation for yield, regression coefficient (b_i), deviation from regression (S^2_d), variance of deviation from regression ($S^2_{y.x}$), coefficient of variation (CV) and coefficient of determination (r^2), and correlation coefficient for yield, days to mid-silking and plant height for eleven hybrids evaluated at five environments.

	Yield	b_i	S^2_d	$S^2_{y.x}$	CV
b_i	- 0.587				
S^2_d	- 0.671 *	0.863 **			
$S^2_{y.x}$	0.655 *	0.815 **	0.894 **		
CV	0.655 *	- 0.815 **	- 0.894 **	1.000 **	
r^2	0.736 **	- 0.881 **	- 0.894 **	0.936 **	0.936 **
Correlation among characters					

	Yield	Days to mid-Silk	Plant height
Days to mid-Silk	- 0.401 **	——	
Plant height	0.773 **	- 0.409 **	——

*, ** Indicates significance at the 0.05 and 0.01 levels of probability, respectively.

The regression coefficient (b) was highly significant with previous stability parameters, however, it was less correlated than S^2_d. Therefore, both $S^2_{y.x}$ and b could be chosen as the two parameters which could be chosen to express the stability of hybrid.

The regression coefficient (b) would measure the response to the macro feature of the environment while $S^2_{y.x}$ would be a function of the microelements of the environment (Eberhart and Russell, 1966).

In order to construct an index for the superiority of a hybrid, Kang (1993) suggested the calculation of simultaneous index that included yield and stability parameters to select the best hybrid among the hybrids under test.

Stability analysis for days to mid-silking and plant height showed that SC Gm 2028 had a bi value ≈ 1.0. $S^2_{y.x}$ and S^2_d were not significant (data not shown), therefore, this hybrid was more stable for these traits. Also, TWC Gz 321 and Sc Gz 124 were stable hybrids for days to mid-silking and plant height, respectively. Although SC's Gm 2043, Gz 10, and TWC's 321, 324 were stable hybrids of grain yield, they were later for days to mid-silking and taller for plant height.

The importance of GE interactions, yield stability analysis and regression analysis in determining adaptability of genotypes to a specific location or several locations was clearly reflected in this study. The studied hybrids showed interaction (different response in different locations), as well as their ranks changed with environment, indicating a specific adaptation (Table 2). These results reflected that SC Gm 2043 was adapted to several locations, especially Nubaria and Mallawy.

Superiority index

In order to differentiate among the tested hybrids, a superiority index was calculated, using grain yield, regression coefficient and variance of deviation from regression. Grain yield was given a double weight, ranging from -8 to +8, while both parameter of stability was given a score from 0 to 4, as indicated in the materials and methods. This score was associated with probability level, ranging from < 0.1 to > 0.001. The total of the three scores given to each hybrid was designated by superiority index and is presented in Table 3.

The eleven hybrids under study were categorized in three groups. The super group, which was high in yield and stable had a score ranging from 12 to 14 and included SC's Gm 2043 and Gz 10. The intermediate category included SC Gz 124 and TWC's Gz 321, Gz 324 and Gm 3019 and had a score from 4 to 5. The third category included TWC Gm 3022 and SC's Gm 2019, 2028, 2042 and 2044 had a score from 0 to -8 and were considered the poor group.

This superiority index combines both yield and stability and it is simpler than the cluster analysis, suggested by Lefkovitch (1985).

Correlation among characters

Negative correlation was observed for grain yield with days to mid-silking (-0.401), and, also, days to mid-silking with plant height (-0.409), while grain yield was significantly and positively correlated with plant height (0.773).

REFERENCES

Abdel-Hamid,M.S. 2001. Genotype x environment interaction and stability parameters for grain yield and other agronomic traits of white maize hybrids. J. Agric. Sci. 26: 3367-3379, Mansoura Univ.

Baker,R.J. 1988. Testes for crossover genotype x environment interaction. Can. J. Plant Sci. 68:405-410.

Boerma,H.R., and M.A.R.Mian. 1998. Application of DNA markers for selection of interactable soybean traits. Korea Soybean Digest 15:106-121.

Eberhart,S.A. and W.A.Russell. 1966. Stability parameters for comparing varieties. Crop Sci. 5: 36-40.

El-Nagouly,O.O.; M.A.Khalifa, E.M.Shokr and E.A.Mahmoud. 1980. Estimates of stability for yield and some yield components of maize (*Zea mays*. L.) under different treatments of irrigation. Annals Agric. Sci. 14:75-85, Moshtohor.

El-Zeir,F.A.A, A.M.Shehata and F.H.Soliman. 1999. Phynotypic stability for grain yield and other agronomic characters of maize (*Zea mays*. L.) hybrids under different environmental conditions. J. Agric. Sci. 24:5271-5283, Mansoura Univ.

Francis,T.R. and L.W.Kannenberg. 1978. Yield stability studies in short-season maize. 1. A descriptive method for grouping genotypes. Can. J. Plant Sci. 58:1029-1034.

Kang,M.S. 1993. Simultaneous selection for yield and stability in crop performance trials: Consequences for growers. Agron. J. 85:754-757.

Kang,M.S. 1998. Using genotype-by-environment interaction for crop cultivar development. Adv. Agron. 35:199-240.

Lefkovitch,L.P. 1980. Conditional clustering. Biometrics 36:43-58.

Lefkovitch,L.P. 1982. Conditional clustering, musters, and probability. Math. Biosci. 60:207-234.

Lefkovitch,L.P. 1985. Multi-criteria clustering in genotype-environment interaction problems. Theor. Appl. Genet. 70:585-589.

Littell,R., G.Milliken, W.Stroup, and R.Wolfinger. 1996. SAS system for MIXED models. SAS Inst., Cary, NC.

Ragheb,M.M., A.A.Bedeer, A.Sh.Gouda and Sh.F.Abo-Elsaad. 1993. Phenotypic stability parameters for grain yield and other agronomic characters of white maize hybrids under different environmental conditions. Zagazig J. agric. Res. 20:1447-1461.

Rao,M.S.S., B.G.Mullinix, M.Rangappa, E.Cebert, A.S.Bhagsari, V.T.Sapra, J.M.Joshi and R.B.Dadson. 2002. Genotype x Environment interaction and yield stability of food-grade soybean genotypes. Agron. J. 94:72-80.

SAS Software. 1997. SAS/STAT user's guide. Release 6.12. SAS Inst., Cary, NC.

Shehata,A.M., E.A.Amer, A.A.Barakat and A.A.El-Shenawy. 2003. Stability parameters for grain yield and some other agronomic traits of new white and yellow maize hybrids (*Zea mays*. L.). Egypt. J. Appl. Sci. 18:495-509.

Steel,R.G.D. and T.H.Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill Book Company, NY, USA.

الملخص العربى

معامل المفاضلة بين بعض الهجن من الذره الشاميه باستخدام المحصول ومعايير الثبات المختلفه

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تم تقييم سبعة هجن مبشرة بيضاء الحبوب من الذرة الشامية ، خمس هجن منها فردية (هـ ف جميزة ٢٠١٩، ٢٠٢٨، ٢٠٤٢، ٢٠٤٣، ٢٠٤٤) وهجينين ثلاثيين (هـ ث جميزة ٣٠١٤ ، ٣٠٢٢). تم تقييم هذه الهجن بالإضافة إلى الهجن المنزرعة (هـ ف جيزة ١٠، ١٢٤، و هـ ث جيزة ٣٢١ ، ٣٢٤) في خمس محطات بحثية وهي: سخا والجميزة وسدس والنوبارية وملوي. تم قياس صفة محصول الحبوب (طن/هكتار) وكذلك صفتي عدد الأيام للتزهير وارتفاع النباتات. وقد تم عمل التحليل الإحصائي لكل منطقة علي حدة وكذلك تحليل المناطق مجتمعة.

وقد أوضحت النتائج ما يلي:

١- بين تحليل التباين المشترك أن الاختلافات بين الهجن كانت معنوية وذلك لكل الصفات تحت الدراسة ، كما كان تفاعل المناطق مع الهجن معنويا. ويوضح هذا أن ترتيب الهجن كان غير ثابت في الخمس مناطق تحت الدراسة.

٢- تراوح متوسط محصول الحبوب للخمس مناطق من ٥,٨٨ (النوبارية) الى ٩,٥٩ طن/هكتار (الجميزه) ، بينما تراوح متوسط محصول الهجن تحت الدراسة من ٤,٧٧ للهجين الفردي "جميزة ٢٠٢٤" (النوبارية) إلى ١١,٠٢ طن/هكتار للهجين الفردي "جميزة ٢٠٢٨" في الجميزة. أعطي الهجين الفردي "جميزة ٢٠٤٣" أعلي متوسط لمحصول الحبوب (٨,٦٦ طن/هـ) يليه الهجين الفردى "جيزه ١٠" (٨,٥٣ طن/ هـ). كما اختلفت نتائج صفتي عدد الأيام للتزهير ومتوسط ارتفاع النبات كثيرا بالبيئات تحت الدراسة.

٣- عبر كميا عن التفاعل بين المناطق والهجن مستعينا بنموذج تحليل الانحدار المقترح بواسطة Eberhart & Russell (1964) ومن هذا النموذج أربعة دلائل للثبات وهى: معامل الانحدار (b) وتباين الانحراف عن خط الانحدار ($S^2_{y.x}$) ومعامل التقدير (r^2) وتباين الخطأ التجريبى المتبقى ($S^2_{y.x}-S^2_{e}$). وأضيف الى الدلائل الأربع دليل خامس وهو قيمة CV لكل هجين خلال مناطق الاختبار.

٤- عند حساب معامل الارتباط بين الخمس معايير السابقة أوضحت النتائج أن كلا من معامل الانحدار (b) وتباين الانحراف عن الانحدار ($S^2_{y.x}$) أعطت أقل قيم تلازم بين الخمس معايير. كذلك كان متوسط المحصول مستقلا عن معامل الانحدار (b) بينما كانت له علاقة ارتباط معنوية مع تباين الانحراف عن الانحدار ($S^2_{y.x}$) ومعامل الاختلاف (CV) وكانت العلاقة عالية المعنوية للمحصول مع معامل التقدير (r^2).

٥- لتحديد أفضل الهجن تحت الدراسه يجب أن يجمع بين المحصول العالي وفى نفس الوقت تكون قيمة b=1 وأيضا قيمة $S^2_{y.x}$ تساوى S^2_{e} وعلى ذلك فان معامل المفاضلة بين الهجن يجب أن يشمل ثلاث معايير وهى متوسط المحصول ومعامل الانحدار (b) و تباين الانحراف عن الانحدار ($S^2_{y.x}$). تم حساب نقاط لكل معيار على حده ثم جمعت نقاط المعايير الثلاثة معا لتكون معامل المفاضلة.

٦- تم ترتيب الهجن فى ثلاث مجموعات بناء على معامل المفاضلة شملت المجموعة المتميزة الهجن ذات المحصول المرتفع ودرجة الثبات العالية واحتوت هذه المجموعة على الهجينين الفرديين "جميزه ٢٠٤٣ وجيزه ١٠" وحققت من ١٢ الى ١٤ نقطة وشملت المجموعة المتوسطة الهجين الفردى "جيزه ١٢٤" والهجن الثلاثية "جيزه ٣٢١ وجيزه ٣٢٤ وجميزه ٣٠١٩" وحققت من ٤ – ٥ نقاط بينما شملت المجموعة المنخفضة الهجين الثلاثى "جميزه ٣٠٢٢" والهجن الفرديه "جميزه ٢٠١٩ ، ٢٠٢٨ ، ٢٠٤٢ و٢٠٤٤" وحققت من صفر الى -٨ نقاط.

٧- من محصلة هذه الدراسة يمكن استخدام معامل المفاضلة في قياس درجة الثبات للهجن المختلفة.