GENOTYPE-BY-ENVIRONMENT INTERACTION AND STABILITY PARAMETERS FOR SOME NEW MAIZE (*ZEA MAYS* L.) HYBRIDS

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Abstract

Three new white maize single-crosses, Nub104, 105 and 106, and seven new yellow maize single-crosses, Nub201 to Nub207, were developed during maize breeding program at Nubaria Agriculture Research Station during 2008 season. These hybrids along with two commercial hybrids, SC10 (white) and SC166 (yellow) were evaluated at five different environmental conditions in 2009 season. Results showed that differences among environments were significant ($P < 0.01$) and accounted for 42.5% of total variation for grain yield, 5.6% for number of days to mid-silking, 39.9% for plant height, 43.7% for ear position and 12.7% for late wilt resistance. Significant differences among hybrids were detected ($P < 0.01$) and accounted for 23.1% of total variation for grain yield, 77.4% for number of days to mid-silking, 28% for plant height, 8.5% for ear position and 17.7% for late wilt resistance. Significant differences were observed for environment x hybrid interactions ($P < 0.01$) and accounted for 14.5% of total variation for grain yield, 5.5% for number of days to mid-silking, 13.9% for plant height, 13.3% for ear position and 22.1% for late wilt resistance. Regarding to (bi), Nub106, Nub203, Nub205, Nub206 and Nub207 were more stable hybrids. According to ($S^2_{y.x}$), Nub201, Nub202, Nub203, Nub204, Nub205 and Nub206 were more stable hybrids. For the CV of each hybrid, Nub201, Nub202, Nub203 and Nub205 were the most stable hybrids. According to YS, Nub106 and Nub204 hybrids were identified as the most stable hybrids with high-yield, while Nub207 had high yield although it was unstable hybrid. Nub106 hybrid was significantly earlier than SC10, while, Nub204 and Nub207 hybrids were significantly earlier than the check hybrid SC166. According to these results, Nub106, Nub204 and Nub207 hybrids were adapted to widely environments. Significant correlation was found between Sakha and each of Gemmiza and Mallawy. Also, highest correlation was observed between Gemmiza and Mallawy. Significant relationships were detected between $S^2_{y.x}$ and both CV (positive) and r^2 (negative). Also, significant correlation was observed between CV and r^2. The importance of GE interactions and yield-stability analysis and regression analysis in determining adaptability of genotypes to a specific location or several locations was clearly reflected in this study. These results reflected that Nub106, Nub204 and Nub207 hybrids were adapted to widely different environments.

Key words: *maize, genotype x environment interaction, stability parameters, regression coefficient, yield-stability.*

Abbreviations: *SC, Single cross, GEI, genotype-environment interaction, b, regression coefficient, CV, Coefficient of variation, r^2, Coefficient of determation, YS, yield-stability,*

INTRODUCTION

The new promising maize hybrids, generally, need to be evaluated at different environments before release. The development of new genotypes involves breeding of genotypes with desired characteristics that add value to the product and the stability of these traits in target environments (Kang, 1998). Selection is ultimately the differential reproduction of genotypes. The purpose and the critical feature of artificial selection are to choose from a group of individuals those that will be allowed to reproduce so as to make selection as effective as possible (Hallauer and Miranda, 1988).

Gene expression is subjected to modification by the environment, therefore, genotypic expression of the phenotype is environmentally dependent (Kang, 1998). The development of new genotypes involves breeding of genotypes with desired characteristics such as high economic yield, tolerance or resistance to biotic and abiotic stresses, 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 moisture, soil type or fertility level from location to location and year to year are a function of genotype x environment (G x E) interaction. Genotype x environment interaction has been defined as the failure of genotypes to achieve the same relative performance in different environments (Baker, 1988). Identification of yield-contributing traits, knowledge of G x E interaction and yield stability are important for breeding new cultivars with improved adaptation to the environmental constraints prevailing in the target environments.

Multi-environment trials (MET) play an important role in selecting the best genotypes to be used in future years at different locations and in assessing a cultivar's stability across environments before its commercial release (Vargas et al. 1999). Also, multi-environment trials are important for testing general and specific cultivar adaptation. A cultivar grown in different environments will frequently show significant fluctuation in yield performance relative to other cultivars. These changes are influenced by the different environmental conditions and are referred to as genetic x environment interaction (G x E) (Carlos and Krzanowski, 2003). Presence of G x E rules out simple interpretative models that have only additive main effects of genotypes and environments (Crossa, 1990, and Kang and Magari, 1996). On the other hand, specific adaptations of genotypes to subsets of environments is a fundamental issue to be examined in plant breeding because one genotype may perform well under specific environmental conditions and may give a poor performance under other conditions.

The more widely used method for detecting stable genotypes is the regression approach (Finlay and Wilkinson, 1963). According to the definition of Eberhart and Russell (1966), a stable preferred hybrid would have, approximately, values of b=1, S^2_d=0 and a high mean performance. Kang (1993) suggested use of a simultaneous index that includes yield and stability parameters to select a hybrid from among many hybrids used in a study.

Many stability statistics have been used to determine whether or not cultivars evaluated in MET are stable (Lin *et. al.*, 1986, Huhn, 1996, Hussein et al., 2000, Robert, 2002, Sabaghnia *et. al.*, 2006). Because the most stable genotype(s) may not be the highest yielding, the use of methods that integrate yield performance and stability to select superior genotypes becomes important (Kang, 1998, Pham and Kang, 1988, Kang and Pham, 1991, Kang, 1993, Kang and Magari, 1996).

Yield-stability statistic (YS_i) (Kang, 1993) is based on Shukla's σ^2_i (Shukla, 1972), which belongs to Type 2 stability (Lin *et. al.*, 1986). Yield-stability statistic (YS_i) has been extensively used in MET analyses. The YS_i was first applied in maize by Magari and Kang, 1993, and then used by Fan et al., 2007.

The objectives of this study were to (*i*) evaluate ten promising maize hybrids at multi-environment trials and identify the hybrids with superior grain yield and other desired characters, (*ii*) investigate stability of performance of these hybrids tested across five environments using the stability parameters and the YS_i, ***(iii)*** estimate the correlations among the tested environments and the different stability parameters.

MATERIALS AND METHODS

Three new promising white maize single-crosses (SC) namely, Nub104, Nub105 and Nub.106 developed from Giza2 Synthetic population and seven promising yellow maize single-crosses, Nub201 to Nub207, were developed by maize breeding program at Nubaria Agriculture Research Station in 2008 season. These new promising hybrids along with two commercial hybrids, SC10 (white) and SC166 (yellow) as checks were evaluated at five locations, i.e., Sakha (North Delta), Gemmiza (Middle Delta), Sids (Middle Egypt), Nubaria (North West Delta), and Mallawy (Upper Egypt) Agriculture Research Stations in 2009 season.

A randomized complete block design, with four replications was used. Each plot consisted of four ridges, 6-m long with 80-cm wide. Hand sowing was done in hills spaced 25 cm along the ridge. All the recommended agricultural practices were applied through the growing season.

Data were recorded for grain yield, adjusted to moisture of 155 g kg^{-1}, and then converted to Mg ha^{-1}. Number of days to mid-silking (d), plant height (cm), ear position (%) and late wilt resistance under natural infection were also recorded (%).

Statistical analysis

The data of each location were subjected to statistical analyses using linear model procedures of SAS software (2002). Then the combined statistical analysis across locations were done, using Proc IML (SAS software, 2002), (Littell et al., 1996) as their error variances were homogenous across locations. Hybrid effects were regarded as a fixed effect, whereas locations and replicates were regarded as random effects. Test of hybrid differences was performed using location x hybrid as the error term.

Stability parameters

Stability analysis for grain yield was calculated for all hybrids, according to the following model of Eberhart and Russell (1966):

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

where:

Y_{ij} = the 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 the environmental index.

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

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

From the previous model two estimates of stability were calculated, i.e., b and $S^2_{y.x}$. The regression equation for each hybrid was calculated using Proc REG (SAS software, 2002). From this analysis three estimates of stability were calculated i.e., b, $S^2_{y.x}$ and r^2. Francis and Kannenberg (1978) suggested the use of a third estimate of stability as the C.V. of each genotype across the tested environments. The coefficient of determination (r^2) was also used as the fourth to estimate the stability.

Yield stability

Kang (1993) suggested another approach to combine the relative rank of yield with stability of the variety using σ^2_i suggested by Shukla (1972) and designated it as YS (yield-stability). This index (YS) was calculated by the software program "STABLE" developed by Kang and Magari (1995).

Rank phenotypic correlation coefficients were calculated among the tested environments and also among the stability parameters, using Proc CORR (SAS software, 2002).

RESULTS AND DISCUSSION

Analysis of variance

Combined analysis of variance for all studied traits across environments is presented in Table (1). The results showed that differences among environments were highly significant ($P < 0.01$) for all studied traits. These results indicate that the five environments differed in their environmental conditions. Highly significant differences among hybrids were found ($P < 0.01$) for all the studied traits. Significant differences were observed for hybrid x environment interactions ($P < 0.01$) for all the studied traits. The significant interaction of hybrids with the tested environments indicated that the studied hybrids performed differently at each of the five environments. These results indicated also that, it would be worthwhile to evaluate the new hybrids at many environments especially for grain yield, which is regarded as a complex polygenic trait (Darrah and Hallauer, 1972).

Hybrid x Environment Effects

The differences among environments were highly significant ($P < 0.01$) and accounted for 42.5% of total variation for grain yield, 5.6% for number of days to mid-silking, 39.9% for plant height, 43.7% for ear position and 12.7% for late wilt resistance (Table 1). Highly significant differences among hybrids were detected ($P < 0.01$) and accounted for 23.1% of total variation for grain yield, 77.4% for number of days to mid-silking, 28% for plant height, 8.5% for ear position and 17.7% for late wilt resistance.

Significant differences were observed for environment x hybrid interactions ($P < 0.01$) and accounted for 14.5% of total variation for grain yield, 5.5% for number of days to mid-silking, 13.9% for plant height, 13.3% for ear position and 22.1% for late wilt resistance. An environment x hybrid interaction was significant for grain yield ($P < 0.01$), indicating that ranking of hybrids was not consistent across the five environments.

Mean grain yield (Mg ha-1) for each environment is presented in Table (2). The average of grain yield for the studied hybrids differed greatly and significantly from one environment to another, therefore, ranking of yield differed between environments. The highest grain yield was observed at Sakha and Mallawy (9.44 Mg ha^{-1} for each), while the lowest yield was at Nubaria (6.99 Mg ha^{-1}), reflected the poor environment condition at Nubaria (Table 2). Grain yield ranged for the different environments from 6.01 (Nubaria) to 11.14 Mg ha^{-1} (Sakha). The average of grain yield at Gemmiza, Sids and Nubaria were less than overall mean (8.39 Mg ha^{-1}), due to some of climatic factors of these environments.

Table 1. Analysis of variance for grain yield and other traits for ten promising hybrids and two commercial hybrids evaluated under five environments in 2009.

S.O.V	df	Grain yield	Days to mid-silking	Plant height	Ear position	Late wilt † resistance
		Mg ha^{-1}	--- d ---	---- Cm ----	------------ %	------------
Environments (E)	4	53.37 **	23.77 **	13498.17 **	445.28 **	38.19 **
Rep / Env	15	1.08	1.12	175.64	13.51	6.68
Hybrids (H)	11	10.58 **	119.13 **	3445.26 **	31.62 *	19.28 **
H X E	44	1.67 **	2.11 *	427.55 **	12.33 **	6.01 **
Error	165	0.49	1.08	134.96	7.28	2.80
C.V.		8.4	1.7	4.4	4.8	1.7

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

† Data were transformed by arcsine.

Table 2. Mean of grain yield (Mg ha^{-1}) for ten hybrids and two commercial hybrids evaluated at five Locations in 2009.

Hybrid	Sakha	Gemmiza	Sids	Nubaria	Mallawy	Combined
Nub104	8.66	7.96	8.79 †	6.78 †	8.40	8.12
Nub105	8.90	7.19	9.00 †	7.57 †	9.07	8.35
Nub106	9.45 †	8.71 †	8.24 †	7.00 †	10.57 †	8.79 †
SC10	9.85	9.66	9.09	7.46	11.07	9.43
Nub201	8.00	6.84	6.72	6.74 †	7.31	7.12
Nub202	8.93	7.97 †	7.55 †	7.38 †	8.54	8.07
Nub203	8.60	7.10	6.98	6.03 †	8.04	7.35
Nub204	10.49 †	8.55 †	8.03 †	6.01 †	10.02 †	8.62 †
Nub205	9.11	7.83 †	7.37 †	6.97 †	9.03	8.06
Nub206	9.05	8.11 †	7.15	7.41 †	9.53	8.25
Nub207	11.10 †	9.45 †	7.65 †	7.85 *	10.93 †	9.40 †
SC166	11.14	8.66	8.30	6.67	10.76	9.11
LSD$_{(0.05)}$	0.86	1.04	1.09	1.04	0.93	0.86

* Significant different than the check hybrid at 0.05 level of probability.

† Not significantly different from the check hybrid.

The studied hybrids responded differently across environments, therefore, their ranks within environments indicated their specific adaptations. Average grain yield of the promising hybrids ranged from 6.01, for Nub204 at Nubaria location, to 11.10 Mg ha^{-1} for Nub207 at Sakha. The later hybrid had the highest grain yield and ranked first at all environments, except at Sids. Nub204 and Nub207 hybrids didn't significantly differ ($P < 0.05$) from the check hybrid SC166 at the tested environments and combined data (Table 2). Also, Nub106 hybrid didn't significantly differ ($P < 0.05$) from the check hybrid SC10 at the tested environments and combined data.

Stability parameters (Eberhart and Russell, 1966)

A hybrid is considered to be stable if its variance among-environment 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, Shehata *et. al.*, 2003, Shehata *et. al.*, 2005 and Habliza and Khalifa, 2006). A stable hybrid would have approximately $b = 1$, $S^2_d = 0$, CV is small, r^2 is high, in addition to its superiority in yield.

The criterion for superiority was the distance of a hybrid from the overall mean, using the $LSD_{0.05}$. According the mean of grain yield, the results showed that Nub106, Nub204 and Nub207 didn't significantly different from the check hybrids (Table 2), while Nub207 was significantly higher than the overall mean (Table 3).

For the stability parameters, the regression coefficients (bi), as the first criterion, was calculated and significantly tested by using ($S_b \times t_\alpha$) at 0.05 level of probability (Table 3). The results showed that Nub106, Nub203, Nub205, Nub206 and Nub207 had a regression coefficient of 1.0, therefore, they were considered more stable hybrids. On the other hand, the regression coefficients for the other hybrids were significant from 1.0, therefore they were considered unstable hybrids.

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 Nub201, Nub202, Nub203, Nub204, Nub205 and Nub206 had an estimate insignificant from the pooled error, suggesting that they were more stable hybrids, with respect to this parameter, while the other hybrids were significantly greater than the pooled error and may be considered unstable hybrids.

Table 3. Mean grain yield, regression coefficient (bi), variance of deviation from regression ($S^2_{y.x}$), coefficient of variation (CV), and coefficient of determination (r^2) for ten hybrids evaluated at five locations in 2009.

Hybrid	Mean grain yield	b_i	$S^2_{y.x}$	CV	r^2
	Mg ha^{-1}				
Nub104	8.12	0.55 €	0.429 ‡	8.07	0.51
Nub105	8.35	0.53 €	0.644 ‡	9.62	0.39
Nub106	8.79 †	1.20	0.225	5.40	0.90
Nub201	7.12	0.42 €	0.124	4.10	0.78
Nub202	8.07	0.56 €	0.052	1.43	0.97
Nub203	7.35	0.85	0.057	3.32	0.95
Nub204	8.62 †	1.50 €	0.116	5.68	0.94
Nub205	8.06	0.85	0.035	1.06	0.99
Nub206	8.25	0.83	0.252	5.23	0.86
Nub207	9.40 *	1.38	0.502 ‡	5.07	0.93
Mean	8.39	0.86	0.243	4.89	0.82

* Significantly different from the overall mean at 0.05 level of probability.
† Equal or more than the overall mean.
€ b values significantly different from 1 at 0.05 level of probability.
‡ $S^2_{y.x}$ significantly different from S^2_e at 0.05 level of probability.

The third criterion for stability was the coefficient of variation of a hybrid (CV), an indication for the stability consisting of the hybrid mean across environments. There is no critical equation of this parameter, however it was assumed if the CV value around 5% it would indicate the consistency of the hybrid across environments. The hybrids Nub201, Nub202, Nub203 and Nub205 had CV values less 5.0, therefore, these crosses were considered 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 low $S^2_{y.x}$. The results showed that Nub106, Nub202, Nub203, Nub204, Nub205 and Nub207 had the high values of r^2, therefore, they were considered the most stable hybrids.

Combing the results from the two stability parameters, b and $S^2_{y.x}$ and mean yield over the five environment, only Nub.106 was higher in yield than the mean of all hybrids, had b=1.0 and $S^2_{y.x}$ insignificant from S^2_e. Therefore, this hybrid is considered the superior hybrid as it combined high yield and stability.

Yield-stability (Kang, 1993)

Yield-stability (YS), which is an integrated measure of yield and stability of cultivars evaluated in performance trials, was used to identify cultivars that were high-yielding and relatively stable. The YS values computed across the five environments (Table 4) identified Nub207, Nub106 and Nub204 as the best three hybrids, while Nub201, Nub203 and Nub105 at the bottom three hybrids. In this stability analysis, the hybrids with significant S^2_H were penalized for instability. According to these results, Nub106 and Nub204 hybrids were identified as the most stable hybrids with high-yielding, while Nub207 had high yield, although it was less stable hybrid. It should be noticed the measure of stability is based upon S^2_H, which is similar to $S^2_{y.x}$ in the previous model. Both were affected by the micro change in the environment while the change in the macroenvironment was ignored. The modified superiority index suggested by Habliza and khalifa (2005) would be more efficient as it include both type of stability b (macroenvironment) and $S^2_{y.x}$ for microenvironment changes.

Mean performance of agronomic characters

For number of days to mid-silking, the earliest hybrid was Nub105 (55.3 d), as compared with the check SC10 (63.6 d). Also, Nub106 hybrid had 60.0 days to mid-silking and was significantly earlier than SC10, while Nub204 and Nub207 were significantly earlier than the check hybrid where they had 59.6 and 60.8 d compared with 63.2 d for SC166.

Plant height of the studied hybrids and the check hybrids is presented in Table (5). The results showed that SC10 was had the tallest plants (290.1 cm). The hybrids, Nub106, Nub204 and Nub207 didn't significantly differed from the check hybrids (SC10 and SC166) for plant height.

Ear position of the evaluated hybrids is presented in Table (5). The lowest ear position was observed for Nub105, while the highest ear position was found for SC166, although this hybrid had plant height less than the overall mean (258.3 cm). Nub106 hybrid didn't significant different than SC10, while Nub204 and Nub207 were significantly lower in ear position than SC166.

Mean late wilt resistance of the evaluated hybrids ranged from 96.4% for Nub105 to 100% of SC10. All the tested hybrids were more resistant hybrids under nature condition, where they had values more than 95%.

Table 4. Stability analyses of grain yield, their rank, stability variance (S^2_H) and yield-Stability (YS) for ten hybrids evaluated at five locations in 2009.

Hybrid	Mean yield	Yield rank	S^2_H	YS
	Mg ha^{-1}			
Nub207	9.40 *	10	0.501 ††	6
Nub106	8.79 †	9	0.225	4
Nub204	8.62 †	8	0.114	3
Nub105	8.35	7	0.645 ††	-5
Nub206	8.25	6	0.247	-1
Nub104	8.12	5	0.430 ††	-4
Nub202	8.07	4	0.051	-3
Nub205	8.06	3	0.035	-2
Nub203	7.35	2	0.057	-6
Nub201	7.12	1	0.123	-7

* Indicate significant at 0.05 level of probability.

† Equal or more than the overall mean.

†† indicate the significant of S^2_H from S^2_e at 0.05 and 0.01 level of probability, respectively.

Table 5. Mean performance and its rank for ten hybrids and two check hybrids for grain yield and other studied traits evaluated at five environments in 2009.

Hybrid	Days to mid-silking	Plant height	Ear Position	Late wilt resistance
	--- d ---	--- cm ---	-------------- %	---------------
Nub104	55.9	263.4	55.6	99.6
Nub105	55.3	265.2	53.8	96.4
Nub106	60.0	269.2	55.0	99.4
SC10	63.6	290.1	56.6	100.0
Nub201	58.1	245.8	55.2	98.0
Nub202	59.8	256.6	54.9	99.2
Nub203	61.0	237.9	55.1	99.4
Nub204	59.6	259.7	53.9	99.1
Nub205	60.3	250.8	56.1	98.4
Nub206	60.0	256.4	54.3	98.3
Nub207	60.8	268.1	55.6	98.0
SC166	63.2	258.3	58.4	99.4
$LSD_{(0.05)}$	0.92	13.1	2.2	1.5

Rank correlation among environments and stability parameters

Rank correlation among the tested environments is presented in Table (6). The results showed highly significant correlation between Sakha and both Gemmiza and Mallawy (r = 0.79** and 0.88**, respectively). Also, the highest correlation was observed between Gemmiza and Mallawy (r = 0.91**), while poor correlation values were observed between Nubaria and the other environments. Therefore, both Gemmiza and Mallawy were similar in the evaluation of hybrids and one of these two locations would be enough to evaluate the new hybrids for optimum maize production. The other environments are recommended for selection under less favorable environment.

Table 6. Correlation coefficient among tested locations and grain yield and Stability parameters for ten hybrids evaluated at five environments in 2009.

Correlation among locations					
Location	Sakha	Gemmiza	Sids	Nubaria	Mallawy
Sakha	1.00				
Gemmiza	0.79 **	1.00			
Sids	0.31	0.45	1.00		
Nubaria	0.11	0.36	0.25	1.00	
Mallawy	0.86 **	0.91 **	0.51	0.33	1.00
Correlation among stability parameters					
Trait	Grain yield	b_i	$S^2_{y.x}$	CV	r^2
Grain yield	1.00				
b_i	0.37	1.00			
$S^2_{y.x}$	0.57	0.05	1.00		
CV	0.56	0.21	0.78 **	1.00	
r^2	0.19	0.42	-0.76 **	0.79 **	1.00

** Significant at the 0.01 levels of probability.

Significant relationships were found between $S^2_{y.x}$ and both CV (positive) and r^2 (negative) (r = 0.78** and -0.76**, respectively). Also, significant correlation was observed between CV and r^2 (r = 0.74**). No relationship was observed between b_i and $S^2_{y.x}$ (r = 0.0.05), while low values of correlation were detected between b_i and CV (r = 0.0.21). It is worth to notice the two estimates of stability in the regression model were not significantly correlated, therefore both should be taken in the consideration with respect to stability.

The importance of G x E interactions and 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 genotype x environment interaction (different response in different locations), as well as their ranks changed with environment, indicating a specific adaptation (Table 2). These results reflected that Nub106, Nub204 and Nub207 hybrids were adapted to widely different environments.

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التفاعل الوراثى البيئى ومقاييس الثبات لبعض الهجن الجديدة من الذره الشاميه

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- تم إستنباط ثلاثة هجن فردية جديدة مبشرة بيضاء الحبوب معزولة من عشيرة جيزة٢ ، بالاضافة الى سبعة هجن فردية جديدة مبشرة صفراء الحبوب من الذره الشاميه بواسطة برنامج تربيه الذره الشاميه بمحطة بحوث النوباريه موسم ٢٠٠٨. تم تقييم هذه الهجن بالاضافة الى الهجن الفردية هـ ف١٠ أبيض الحبوب وهـ ف١٦٦ أصفر الحبوب كهجن مقارنة فى خمسة مواقع هى محطات البحوث الزراعيه بسخا و الجميزة وسدس و النوباريه وملوى خلال موسم ٢٠٠٩م.
- تهدف هذه الدراسه الى تقييم عدد من الهجن الجديدة المبشرة فى عدة مواقع متباينة وانتخاب الهجن المتميزة فى محصول الحبوب وكذلك فى درجة الثبات. تم قياس صفات محصول الحبوب وعدد الأيام للتزهير وإرتفاع النبات وموضع الكوز على النبات بالاضافة الى المقاومة لمرض الذبول المتأخر.

أوضحت الدراسه النتائج التالية:

- أظهرت النتائج وجود فروق معنوية بين مواقع الاختبار لكل الصفات تحت الدراسة وتحكمت فى حوالى ٤٢,٥% من حجم الاختلافات الكلية لصفة محصول الحبوب بالاضافة الى ٥,٦% لصفة عدد الأيام حتى منتصف التزهير و٣٩,٩% لصفة ارتفاع النبات و٤٣,٧% لصفة موقع الكوز و١٢,٧% لصفة المقاومة لمرض الذبول المتأخر ، كما وجدت فروق معنوية بين الهجن تحت الدراسة لكل الصفات المدروسه وتحكمت الهجن فى حوالى ٢٣,١ و٧٧,٤ و٢٨,٠ و٨,٥ و١٧,٧% من الاختلافات الكلية للصفات السابقة على التوالى ، بالاضافة الى وجود فروق معنويه للتفاعل بين الهجن والمواقع لكل الصفات

المدروسة حيث تحكمت فى حوالى ١٤,٥% من الاختلافات لـصفة محـصول الحبـوب و٥,٥و١٣,٩و١٣,٣ و٢٢,١% من الاختلافات الكلية لباقى الصفات السابقة على الترتيب.

- أعطت الهجن Nub106, Nub203, Nub205, Nub206, Nub207 قيما لمعامـل الارتـداد (bi) لم تختلف معنويا عن قيمة (1.0) وبالتالى فتعتبر هذه الهجن أكثر ثباتا بناءا على هـذا المقياس . بناءا على مقياس تباين الانحراف عن المتوسط ,($S^2_{y.x}$) ، كذلك أعطت الهجـن Nub201, Nub202, Nub203, Nub204, Nub205 قيما لم تختلف معنويا عن قيمة الخطـأ التجريبى مما يوضح أنها أكثر الهجن ثباتا . أعطت الهجن Nub201, Nub202, Nub203, Nub205 قيما لمعامل الاختلاف (CV) أقل من 5% وبالتالى فانها تعتبر أكثر الهجن ثباتا. بناءا على مقياس ثبات المحصول (YS) كانت الهجـن Nub106 و Nub204 هـى أكثـر الهجن ثباتا بالاضافة الى محصولها المرتفع بينما أعطى الهجين Nub207 محصولا مرتفعا الا أنة أقل ثباتا ، وتعتبر هذه الهجن الثلاثة أكثر الهجن موائمة لعدد من المواقـع خاصـة الجميزة والنوبارية.

- وجدت علاقة ارتباط معنوية بين موقع سخا وكل من الجميزة وملوى وأيضا بين الجميـزة وملوى. كما وجدت علاقة ارتباط معنوية موجبة بين $S^2_{y.x}$ و CV بينما كانت العلاقة معنوية سالبة بين $S^2_{y.x}$ و r^2 . أيضا كانت هناك علاقة ارتباط معنوية موجبة بين CV و r^2 .

- أوضحت هذه الدراسة أهمية التفاعل البيئى الوراثى (GE) وتحليل ثبات المحـصول (YS) وتحليل الارتداد (b) فى تحديد موائمة الهجن المختلفة لعدد من المواقع تحت الدراسة ، وقد أظهرت هذه الدراسة أن الهجن Nub207 و Nub204 و Nub106 هى أفضل الهجـن فـى محصول الحبوب بالاضافة الى درجة ثباتها العالية بمختلف مقاييس الثبـات وأنهـا أكثـر الهجن ملائمة للزراعة فى عدد من البيئات.