الأهمية النسبية الوراثية لبعض الصفات الشكلية والتطورية في هجن نصف تبادلية من الذرة الصفراء (*Zea mays* L.) تحت بيئات مختلفة

Genetic Relative Importance of Some Pheno-Morphological Traits in Half Diallel Crosses of Yellow Maize (*Zea mays* L.) Under Different Environments

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الملخّص

تمّ في هذا البحث تقدير مكونات التباين الوراثي ودرجة التوريث لبعض الصفات التطورية والشكلية والغلّة الحبّيّة، لخمسة عشر هجيناً فردياً من الذرة الصفراء، أنتجت باستخدام طريقة التهجين نصف المتبادل بين ست سلالات مربّاة داخلياً خلال الموسم الزراعي 2008، وقيّمت الهجن الفرديّة خلال الموسم الزراعي 2009 في ثلاثة مواقع (حماه، وحلب، ودير الزور). أظهرت النتائج أنّ تباين الفعل الوراثي التراكمي والسيادي كان معنوياً لمعظم الصفات المدروسة في المواقع الثلاثة عدا صفتي ارتفاع النبات والغلّة الحبيّة في الموقع الثاني، ولصفة ارتفاع العرنوس في الموقعين الثاني والثالث. وكان تباين الفعل الوراثي التراكمي (V_A) أكثر أهميّةً من تباين الفعل الوراثي السيادي (V_D) في جميع المواقع المدروسة، والتحليل التجميعي للمواقع لصفة الإزهار المؤنث، في حين أدّى تباين الفعل الوراثي السيادي (V_D) دوراً مهمّاً في وراثة صفة ارتفاع النبات في المواقع كافّة، وأيضاً التحليل التجميعي للمواقع. ولوحظ من ناحيةٍ أخرى أنّ تباين الفعل الوراثي التراكمي (V_A) كان أكبر من تباين الفعل الوراثي السيادي (V_D) في المواقع الثلاثة، وأيضاً التحليل التجميعي للمواقع لكلٍّ من صفتي ارتفاع النبات والغلّة الحبّيّة، باستثناء صفة ارتفاع النبات في الموقعين الأوّل والثالث، وصفة الغلّة الحبّيّة في الموقع الثالث، والتحليل التجميعي للمواقع، حيث أظهرت هاتان الصفتان قيماً عاليةً للفعل الوراثي السيادي (V_D) بالمقارنة مع الفعل الوراثي التراكمي (V_A). أظهرت النتائج أنّ قيم درجة التوريث بالمفهوم الضيّق كانت متوسطةً إلى مرتفعةً نسبيّاً في صفة الإزهار المؤنّث في المواقع الثلاثة (52 %، 70 % و85 %) على التوالي، ومنخفضة إلى متوسطة في صفة ارتفاع النبات (36 %، 31 %، و62 %)، وصفة ارتفاع العرنوس (31 %، 9 %، و4 %)، وصفة الغلّة الحبّيّة (53 %، 12 %، و21 %) في حماه وحلب ودير الزور على التوالي. وأكّدت نتائج معاملي الارتباط المظهري وتحليل المسار أنّ مجمل الصفات المدروسة امتلكت أهمّيّة نسبيّة منخفضة، الأمر الذي يتطلّب دراسة صفات أخرى، ولاسيما مكوّنات الغلّة الحبية.

الكلمات المفتاحيّة: الذرة الصفراء، الفعل الوراثي، درجة التوريث، معامل الارتباط والمرور.

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Abstract

Three pheno-morphological and yield properties in a set of 15 F_1 hybrids directed from six inbred lines of maize (*Zea mays* L.) produced in 2008 at the Maize Researches Department and evaluated in 2009 at three Agriculture Scientific Research Centers at Hama (L_1), Aleppo (L_2) and Dir Al-Zour (L_3). The results indicated that all estimates of additive (V_A) and dominance (V_D) variance were significant for most of the investigated traits at the three locations except at L_2 for plant height and grain yield as well as ear height at L_2 and L_3. However, the magnitude of V_D values were larger than V_A at all environments and data where combined, for plant height and grain yield except plant height at L_1, L_3 and in combined data where V_D values larger than of V_A. Moderate to high narrow sense heritability estimates for silking date at three locations (52%, 70% and 85% for L_1, L_2 and L_3, respectively). While, such estimates were moderate to low in most cases for plant height (36%, 31% and 62% for L_1, L_3 and L_3, respectively), as well as ear height (31%, 9% and 4% for L_1, L_2 and L_3, respectively) and grain yield (53%, 12% and 21% for L_1, L_3, respectively). Results of phenotypic correlation and path coefficient analysis showed that the characteristics studied had low relative importance however, it was probably due to other factors not included in this study especially yield components.

Keywords: Corn, Gene action, Heritability, Correlation and path coefficient.

Introduction

The presence of morpho-genetic variations in some of agronomic characters of a corn would be a considerable importance in determining the best method needed to improve the yield of maize (Hayes et *al.*, 1955). The association between different plant characters is very important and gives useful information to maize breeders. If two characters are significantly correlated, either positively or negatively, the selection for any of them will cause change in the other depending on the correlation strength, so when two desirable characters are associated to each other, it is an advantage, but the association between desirable and undesirable characters represents a problem in the breeding program, especially if the correlation is a results of genetic linkage (Najeeb et *al.,* 2009). The magnitude of association between yield attributing characters, in terms of their direct and indirect effects on maize grain yield per plant is of great value for maize breeding program (Najeeb et *al.,* 2009). Environmental fluctuations have a great influence on the phenotypic expression of quantitative characters and consequently different estimates of variability and co-variability may have an effect on various characters which are highly affected by environmental conditions. Therefore testing the genotypes across different locations would provide breeders with important information about genetic variability and the relative importance of different traits in contribution to grain yield variation, which can help to decide the proper selection method for the improvement of maize. Several researchers El-Hefnawy and El-Zier (1991); Mohamed (1993) and El-Shouny et *al.,* (2005) studied the environmental effects on variability and co-variability in maize populations and determined the associations among different characters in corn under different environments. Katta et *al.,* (1976) found positive and significant correlations between grain yield and each of plant height and yield components, but these correlations were inconsistent under different locations and seasons. The path coefficient analysis indicates the most promising yield attributes which directly contribute to the final yield. Soliman et *al.,* (1999); Ibrahim (2004); Sadik et *al.,* (2006); Sofi et *al.,* (2007); and Abd Al-Hadi (2010) indicated that plant height and/ or ear height were among the highest contributors to the variation in grain yield directly or indirectly. However, direct selection for yield may not be efficient method for its improvement, but the indirect selection for the yield related traits, which directly affect the yield and of high heritability will be more effective. Several researchers such as El-Agamy et *al.,* (1992); Mourad et *al.,*(1992); Amer and Mosa (2004); and Wannows et *al.*, (2010) reported that heritability estimates in narrow sense were high to moderate values for silking date, plant and ear height.

The aims of this investigation were to study the gene action and relative importance for studied traits and , to identify some traits as selection criteria that may be lead to improve grain yield in yellow maize.

Materials and methods

Six yellow maize (*Zea mays* L.) inbred lines isolated in the Department of Maize Researches, General Commission for Scientific Agriculture Researches (G.C.S.A.R.) Damascus, Syria, during 2008 season (Table 1). The inbred lines were crossed at Department of Maize Researches, a half diallel set of crosses were made between the six parents giving a total of 15 F_1 crosses. In 2009 season the fifteen hybrids were evaluated at three locations i. e. [Hama (L_1), Aleppo (L_2) and Dir Al-Zour (L_3)].

Table 1. The name, source and origin of inbred lines.

IL	Name	Source	Origin
P_1	$IL._{155-06}$	Early agaiti	Pakistan
P_2	$IL._{341-06}$	pablo	France
P_3	$IL._{778-06}$	LE_{64}	Egypt
P_4	$IL._{358-06}$	$NSSC_{640}$	Yugoslavia
P_5	$IL._{267-06}$	Veltro	U.S.A.
P_6	$IL._{263-06}$	Veltro	U.S.A.

A randomized complete block design with 3 replications was used. Experimental plot was one raw, 6m long and 70 cm apart. Seeds were spaced at 25 cm within ridge and thinned at one plant per hill after about 21 days of planting. Other recommended cultural practices for maize production in each region were applied during the growing season. Observations and measurements were recorded on 10 guarded plants chosen at random from each plot for the following traits grain yield (GY), silking date (Silk) plant height (PH) and ear height (EH). Griffing (1956) approach was used to estimate genetic variance components (additive variance V_A, dominance variance V_D and residual variance V_E). Estimates of V_A/V_P resulted in an estimate of narrow- sense heritability (h^2). The phenotypic correlation coefficients were calculated as described by Snedecor and Cochran (1981) for all possible pairs of the studied characters. The path coefficient analysis was performed for all crosses in order to obtain more information about the relative contribution of the studied characters to grain yield.. Partitioning correlation coefficients into direct and indirect effects at phenotypic level was made by determining path coefficients using the method proposed by Wright (1934) and utilized by Dewey and Lu (1959).

Results and discussion

• Analysis of variance

The results of the present study will be displayed according to the calculated parameters as follows:

1. Variability and heritability

Variance components of general (V_{GCA}) and specific (V_{SCA}) combining abilities calculated for each location and their combined analysis and translated in terms of additive (V_A) and dominance (V_D) genetic variance according to Griffing (1956) are summarized in Table 2. Results indicated that all estimates of V_A and V_D were significant for all characters at the three locations and their combined analysis except V_A and V_D at the Aleppo location for plant height and grain yield, also V_A for ear height, which was not significant this might be attributed to large magnitude of error variance of these traits. However, the magnitude of V_A was consistently larger than that of V_D within the three environments and their combined data for silking date, while V_D values were larger than V_A within the three environments and their combined data for ear height. The, V_A values were larger than V_D values at all environments and in combined data for plant height and grain yield except plant height at Hama and Dir Al-Zour locations as well as grain yield at Dir Al-Zour location. This finding shows that the additive genetic variance was more important than the dominance variance in the inheritance of silking date and indicating the effectiveness of selection in the early segregating generations, while dominance variance played major role in inheritance of ear height indicating the effectiveness of selection in the late generations. On the other hand, no clear trend was observed between the magnitude of the genetic variance components and locations for plant height and grain yield. Estimates of the additive, dominance, and error variances were used to calculate the heritability values in narrow sense at each location and combined data for the different traits (Table 2). Results showed that high narrow sense heritability estimates were detected for silking date at the three locations and having the values of (52%, 70% and 85% for L_1, L_2 and L_3 respectively) and the values of (88 %) for combined data. These results emphasize that the additive genetic variance was the major components of genetic variation in the inheritance of this trait and the effectiveness for selection in the early generation in order to improving silking date.

Table 2. Heritability (h^2), additive (V_A), dominance (V_D), environment (V_E) and phenotypic variance (V_P) for studied traits at three locations.

Parameters	Silking date				Plant height			
	L_1	L_2	L_3	Comb.	L_1	L_2	L_3	Comb.
V_A	1.06**	2.91**	3.40**	19.48**	60.11*	102.07	29.74**	499.36**
V_D	0.73*	1.11**	0.56**	2.45**	91.46**	37.54	58.51**	290.08**
V_E	0.24	0.14	0.04	0.14	17.64	42.96	6.73	22.45
V_P	2.03**	4.16**	4.00**	22.07**	169.20**	182.57**	94.98**	811.89**
h^2	0.52	0.70	0.85	0.88	0.36	-	0.31	0.62
Parameters	**Ear height**				**Grain yield**			
	L_1	L_2	L_3	Comb.	L_1	L_2	L_3	Comb.
V_A	28.96*	9.51	2.77	113.62**	9.02**	1.78	1.43**	6.10**
V_D	56.07**	78.61**	51.56**	212.57**	6.23**	0.16	10.01**	21.53**
V_E	8.16	18.48	8.69	11.78	1.80	1.20	0.31	1.26
V_P	93.20**	106.6**	63.02**	337.97**	17.05**	3.14**	11.75**	28.89**
h^2	0.31	0.09	0.04	0.34	0.53	-	0.12	0.21

In the three respective locations, such estimates were low in most cases for plant height (36%, 31% and 62%), ear height (31%, 9% and 4%), and for grain yield results were only in L1 and L3 (53% and 12%, respectively). Also, the same results hold in the combined analysis for ear height (34%) and grain yield (21%) which indicates that the dominance genetic variance played a major role in inheritance of these traits and the effectiveness of selection in the late generation of the studied hybrids for improving these traits. Our findings were in line with those reported by Mourad et *al.,* (1992); Amer and Mosa (2004) and Wannows et *al.,* (2010).

2.Correlation among characters

In selecting high yielding genotypes correlation studies supply reliable information on the nature, extent and direction of selection. Values of phenotypic correlation coefficient estimated for all pairs of studied characters including grain yield at the three locations and combined data are presented in Table 3. The data showed that significantly positive correlations coefficients were found between grain yield and each of plant height at L_2 and combined data as well as ear height at L_1, L_2 and combined data. Such results could help the breeder to select high grain yield through selection for one or more of these traits. However, significant and negative correlations were mentioned between grain yield and silking date at L_1 and combined data. However, Katta et *al.,* (1976) found positive and significant correlation between grain yield and plant height but this correlation was inconsistent under different locations.

Other correlations revealed that plant height had significant and positive correlations with ear height at the three locations and combined data. Therefore, it could be concluded that breeding for lateness hybrids resulted in tallness in plant height especially those having suitable and moderate ear position on plant will be associated with greater means of grain yield. Similar, results were found by Matta et *al.,* (1996); Soliman and Sadek (1998); Dora et *al.,* (1999); El-Banna (2001); Okporie and Oselebe (2007) and Abd Al-Hadi (2010).

Table 3. Phenotypic correlation between studied traits at three locations.

Characters	Env.	Silking date	Plant height	Ear height
Grain yield	L_1	-0.455**	0.261	0.421**
	L_2	0.160	0.376*	0.337*
	L_3	0.116	0.174	0.147
	Comb.	-0.240**	0.427**	0.252**
Silking date	L_1		-0.174	-0.131
	L_2		0.269	0.127
	L_3		0.571**	0.238
	Comb.		-0.093	-0.028
Plant height	L_1			0.396**
	L_2			0.511**
	L_3			0.640**
	Comb.			0.518**

3.Path coefficient analysis

The analysis of path coefficient has been made to identify the relative importance of yield attributes by estimating the direct effects of the contributing characters to yield and separating the direct from the indirect effects through other related characters by partitioning of the correlation coefficient and finding out the relative importance of different characters as selection criteria. The estimates of direct and indirect effects of the three characters viz; silking date, plant and ear height at the three locations and combined data are presented in Table 4.

Table 4. Direct and indirect effects of silking date, plant and ear height vs. grain yield at three locations.

Sources of variation	Effects			
Silking date vs. grain yield	L_1	L_2	L_3	Comb.
Direct effects	-0.401	0.066	0.038	-0.203
Indirect effects via plant height	-0.009	0.069	0.062	-0.036
Indirect effects via ear height	-0.045	0.025	0.016	-0.001
Total	-0.455	0.160	0.116	-0.240
Plant height vs. grain yield				
Direct effects	0.054	0.257	0.109	0.383
Indirect effects via silking date	0.070	0.018	0.022	0.019
Indirect effects via ear height	0.137	0.101	0.043	0.025
Total	0.261	0.376	0.174	0.427
Ear height vs. grain yield				
Direct effects	0.347	0.197	0.068	0.048
Indirect effects via silking date	0.053	0.008	0.009	0.006
Indirect effects via plant height	0.021	0.132	0.070	0.198
Total	0.421	0.337	0.147	0.252

The data showed that the direct and indirect effects of silking date on grain yield were negligible or negative at the three locations and combined data. Plant height proved to have low to moderate direct effects on grain yield. The indirect effects of this character through silking date were negligible at three locations and combined data. For the indirect effects of plant height through silking date the effects were low at L_1 and L_2 (0.137 and 0.101 respectively) and negligible values at L_3 and combined data. Ear height seemed to have high to moderate direct effects on grain yield at L_1 and L_2 (0.347 and 0.198 respectively) while, its direct effects was negligible at L_3 and combined data (0.067 and 0.049 respectively). In most locations, the indirect effect through silking date and plant height was negligible. The components of the grain yield variation determined directly and jointly by each factor are presented in Table 5. The data showed that at L_1 the main sources of grain yield variation in order of importance were the direct effect of silking date (16.00%), the direct effect of ear height (12.04%), and the joint effect of silking date with ear height (3.64%) followed by joint effect of plant height with ear height (1.48%). Small effects were contributed by the joint effect for silking date with plant height (0.75%) and the direct effect of plant height (0.29%).

It is obvious that these three characters and their interactions account for 34.30% of grain yield variation at L_1 while, the residual effect amounted to about 65.70% of the total variation. Concerning the L_2 the mean sources of grain yield variation in order of importance were the direct effect of plant height (6.66%) followed by direct effect of ear height (3.88). Small effects were contributed by the direct effect of silking date, joint effect for silking date with plant height (0.92%) and its joint effect with ear height (0.33%). Regarding the L_3, all sources of grain yield variation effects were very small where the total contribution of the three studied characters was 3.4% of the total variation at L_3. Our results coincide with those obtained by Soliman et *al.,* (1999); Sadic et *al.,* (2006) and Sofi et *al.,* (2007).

Table 5. Relative importance (direct and joint effects) in percent of grain yield variation at three locations.

Sources of variation	L_1		L_2		L_3		Comb.	
	CD	RI%	CD	RI%	CD	RI%	CD	RI%
Silking date (X_1)	0.1600	16.00	0.0044	0.44	0.0014	0.14	0.0412	4.12
Plant height (X_2)	0.0029	0.29	0.0666	6.66	0.0119	1.19	0.1470	14.70
Ear height (X_3)	0.1204	12.04	0.0388	3.88	0.0046	0.46	0.0023	0.23
(X_1) × (X_2)	0.0075	0.75	0.0092	0.92	0.0047	0.47	0.0145	1.45
(X_1) × (X_3)	0.0364	3.64	0.0033	0.33	0.0012	0.12	0.0005	0.05
(X_2) × (X_3)	0.0148	1.48	0.0519	5.19	0.0095	0.95	0.0190	1.90
Residual	0.6580	65.80	0.8259	82.59	0.9666	96.66	0.7755	77.55
Total relative importance		34.20		17.41		3.40		22.45

CD denote coefficient of determination, RI% denote relative Importance

Conclusion

The previous results revealed that silking date, plant and ear height had low relative importance. However, it was probably due to other factors which are not included in this study especially yield components such as ear length and ear diameter.

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