المقدرة على التوافق لصفات الغلة الحبية والإزهار المؤنث وارتفاع النبات والعرنوس في الذرة الصفراء تحت بيئات مختلفة

Combining Ability for Grain Yield, Silking Date, Plant and Ear Height Traits in Maize (*Zea mays* L.) Under Different Environments

S. A. Al Ahmad (1) **A. A. Wannows** (1) **R. A. Alabd Al-Hade** (1)

M. M. Al- Ammareen (1) **M. S. Al-Yssa** (1)

(1) G.C.S.A.R. Crops Administration, Syria Dr_Samirr@yahoo.com

الملخّص

أجري هذا البحث بهدف دراسة القدرة العامّة والخاصّة على الائتلاف لبعض الصفات التطوريّة والشكليّة والغلّة الحبّيّة لخمسة عشر هجيناً فرديّاً من الذرة الصفراء أُنتجت باستخدام طريقة التهجين نصف المتبادل بين ستة سلالات مربّاة داخليّا خلال عام 2008، وذلك في قسم بحوث الذرة التابع للهيئة العامّة للبحوث العلميّة الزراعيّة السورية، وقيّمت الهجن الفرديّة في موسم 2009 في ثلاثة مواقع (مراكز البحوث العلميّة الزراعيّة في حماه، وحلب ودير الزور)، فتضمّن كل موقع تجربة وضعت بتصميم القطّاعات الكاملة العشوائيّة وبثلاثة مكررات. خلصت النتائج إلى أنّ التباين العائد للمواقع كان معنويّاً لكلّ الصفات المدروسة، مشيراً ذلك إلى اختلاف المواقع في تأثيرها البيئي في أداء هذه الهجن، كما كان تباين الهجن معنويّاً أيضاً، وهذا يشير إلى التباعد الوراثي بين هذه الهجن وبين السلالات الأبويّة المكوّنة لها. أظهر التباين العائد للتفاعل بين الهجن والمواقع معنويةً عاليةً لكلّ الصفات، ما يشير إلى أنّ أداء الهجن يختلف من موقع إلى آخر، كما أظهرت القدرة العامّة والخاصّة على الائتلاف تبايناً معنويّاً في كل الصفات، الأمر الذي يبيّن إسهام كلا الفعلين التراكمي واللاتراكمي في وراثة هذه الصفات، ومن ناحية أخرى كان تفاعل القدرة العامّة والخاصّة على الائتلاف مع المواقع معنويّاً في كل الصفات باستثناء تفاعل القدرة الخاصّة على الائتلاف مع المواقع لكلٍّ من صفة ارتفاع النبات والغلّة الحبّيّة، وأظهرت نسبة $\sigma^2_{GCA}/\sigma^2_{SCA}$ سيطرة الفعل الوراثي التراكمي على وراثة صفة الإزهار المؤنّث، في حين سيطر الفعل الوراثي اللاتراكمي على وراثة كلٍّ من صفة ارتفاع النبات والعرنوس والغلّة الحبّيّة، وكانت السلالة الرابعة (06-IL.358) ذات قدرة عامّة جيّدة على الائتلاف لصفة الغلّة الحبّيّة، كما أبدت ثلاثة هجن ($P_4 \times P_6$، $P_4 \times P_5$ و$P_2 \times P_6$) أعلى القيم من حيث القدرة الخاصّة على الائتلاف لصفة الغلّة الحبّيّة.

الكلمات المفتاحيّة : الذرة، التهجين نصف المتبادل، القابليّة على الائتلاف، التفاعل الوراثي البيئي.

Abstract

Three pheno-morphological and yield traits in a set of 15 F_1 hybrids of six inbred lines of maize (*Zea mays* L.) were produced in 2008 at the Maize Researches Department and evaluated in 2009 at three locations i.e. Agriculture Scientific Research Center at Hama, Dir Al-Zor and Aleppo. Mean squares of locations, hybrids and hybrids × locations were significant for all traits, it means that hybrid behavior changed from location to another. Mean squares of general (GCA) and specific (SCA) combining ability confirmed the high consequence of both additive and non-additive gene action on the inheritance of these traits. Also, interaction between GCA × locations and SCA × locations were significant for all studied traits except SCA × locations for plant height and grain yield suggesting that "location" is considered

ISSN:2305 - 5243

as a non-effective factor for declaring SCA effects for plant height and grain yield. The σ^2GCA/σ^2SCA ratios showed that non-additive gene effects played major role in inheritance of grain yield, plant and ear height, while additive gene effects were the most important in inheritance of silking date. GCA effects showed that the inbred line P4 (IL.358-06) was a good combiner for grain yield also, SCA effects indicated that the hybrids $P_4 \times P_6$, $P_4 \times P_5$ and $P_2 \times P_6$ were the best combinations for grain yield.
Key words: Maize, Half diallel cross, Combining ability, Genetic, Environments interaction.

Introduction

Breeding and releasing high yield maize hybrids are considered important objectives of the national maize breeding program to increase the national production of maize with the new development in quantitative genetics; new approaches were used to study the type of gene action responsible for yield heterosis in maize. This information is essential in planning programs for the development of improved hybrids of maize. Diallel analysis for estimating certain genetic parameters in terms of gene models has been developed and extensively used by plant breeders (Hayman. 1954 and Griffing, 1956). Hallauer and Miranda, (1988) discussed the relation between the type of gene action and the selection efficiency of breeding scheme; they concluded that all systems of selection are fruitful if gene action is entirely additive effect. The existence of the dominance variance is the justification for hybrid program. These findings support the need for studying the types of gene action prevailing in the breeding materials. El-Hosary et *al.,* (2001) studied and estimated general and specific combining ability and its role in the inheritance of grain yield and other agronomic traits. They found that both GCA and SCA effects were of equal importance in the inheritance of most of the studied traits. The main objectives of this investigation were to estimate general and specific combining ability effects and their interaction with locations using a set of 6 × 6 half diallel crosses among newly developed inbred lines for grain yield, silking date, plant and ear height.

Materials and methods

Six yellow maize (*Zea mays* L.) inbred lines i.e. IL.155-06 (P_1), IL.341-06 (P_2), IL.778-06 (P_3), IL.358-06 (P_4), IL.267-06 (P_5) and IL.263-06 (P_6) were isolated at Department of Maize Researches, (G.C.S.A.R), Ministry of Agriculture and Agrarian Reform, Damascus, Syria. In 2008 season, a half diallel set of crosses were made between the six parental inbred lines giving a total of 15 F_1 crosses. In 2009 season, the fifteen hybrids were evaluated at three locations i.e. Agriculture Scientific Research Center at Hama, Dir Al-Zor and Aleppo. A randomized complete block design with 3 replications was used in each location. Experimental plot was one raw, 6m long and 70 cm apart. Plants 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 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), ear height (EH). The general (GCA) and specific (SCA) combining ability estimates were calculated using Griffing (1956) method 4, model II for each studied traits. The $\sigma^2_{GCA}/\sigma^2_{SCA}$ ratio is used to reveal the nature of genetic variance involved, i.e. additive and non- additive effects.

Results and discussion

• Analysis of variance

The analysis of variance for all studied traits under three locations is presented in Table 1. Locations, hybrids, and the interaction between locations × hybrids mean squares were highly significant for all traits revealing that hybrids varied in their response to environmental conditions or they were inconsistent over location. However, these hybrids exhibited significant differences for all studied traits. These results have complied with those obtained by El-Kalla *et al.*, (2001); Barakat et *al*., (2003); Hag et *al*., (2010); EL-Shenawy et *al.,* (2009) and Gessa, (2008). The mean squares associated with GCA and SCA for all traits under three locations are also presented in Table 1.

Table 1. Mean squares due to hybrids (H), general (GCA) and specific (SCA) combining ability and their interactions with locations (L) for studied traits.

S.O.V	Silking date (day)	Plant height (cm)	Ear height (cm)	Grain yield (g)
L	44.36**	5036.30**	531.30**	501.34**
Rep./ L	0.70NS	173.89*	22.04NS	2.95NS
H	16.51**	769.23**	305.50**	18.37**
GCA	41.54**	1411.30**	451.57**	10.41*
SCA	2.59**	412.53**	224.35**	22.79**
H × L	3.74**	195.62**	217.80**	30.74**
GCA × L	4.04**	206.04**	121.25**	32.59**
SCA × L	2.15**	36.36NS	113.65**	3.49NS
Error	0.43	67.34	35.33	3.79
$\sigma^2_{GCA}/\sigma^2_{SCA}$	3.98	0.86	0.27	0.14
C.V%	1.20	4.75	6.81	16.87
Genetic components				
σ^2_{GCA}	9.74	249.68	56.81	3.05
σ^2_{SCA}	2.45	290.08	212.57	21.53
σ^2_{A}	19.48	499.36	113.62	6.1
σ^2_{D}	2.45	290.08	212.57	21.53

*، ** indicated to significant at P= 0.05 and P= 0.01 respectively. σ^2A and σ^2D indicated to additive and dominance gene action respectively.

Significant mean squares due to both GCA and SCA were detected for all studied traits indicating that both additive and non-additive gene effects were involved in determining the performance of single cross progeny. However, high $\sigma^2_{GCA}/\sigma^2_{SCA}$ ratio, which exceeded unity, was detected for silking date indicating that additive and additive by additive types of gene action were more important than non-additive gene effects and played the major role in the inheritance of this trait whereas, additive value was higher than dominance value. This result was in the same line of those reported by El-Bially, (2003) and EL-Shenawy et *al.,* (2009). On the other side, the ratio of $\sigma^2_{GCA}/\sigma^2_{SCA}$ was less than unity for plant and ear height also, grain yield indicating the prevalence of non-additive gene effects in the genetic control of these traits whereas, dominance value was higher than additive value for these traits. These results are in agreement with those reported by Abou-Deif, (2007); Hag et *al*., (2010); Barakat et al., (2003); Nass et *al*., (2000) while, El-Shenawy et *al.,* (2009) mentioned that non-additive gene effects were more important in inheritance of grain yield. The GCA × locations and SCA x locations interactions were significant for all studied traits except SCA x locations interactions for plant height and grain yield. Generally, the significant interactions between locations and GCA or SCA for the studied traits indicated that the behavior of these traits would be different from one location to another. However, insignificant variance interactions with locations indicated that estimated variance was consistent over locations. These were detected at the SCA x locations interactions for plant height and grain yield, suggesting that locations is considered as non-effective factor for declaring SCA effects for plant height and grain yield. The magnitude of the interaction was higher for the GCA x locations than the SCA x locations for all studied traits indicating higher sensitivity of GCA to locations than that of SCA for these traits. These results agree with those obtained by El-Hosary et *al.,* (1990 and 1994); El-Shenawy et *al*., (2009) and Gessa (2008) also, Bello and Alaoye, (2009) reported that GCA × environment interaction was larger than SCA x environment interactions for grain yield. On the other hand, Sadek et *al*., (2000) and Zelleke, (2000) stated that SCA x environment interaction was significantly larger than the GCA x environment interaction. Also, Bello and Alaoye, (2009) and Hefny (2010) found that SCA x environment interaction was significantly larger than the GCA x environment interaction for silking date and/ or plant height and grain yield.

- **General and specific combining ability effects**

The estimates of general combining ability effects ($\hat{g}_i$) of the parental inbred lines are presented in Table 2.

Table 2. Estimates of general combining ability effects for studied traits under three locations.

Inbreed lines	Silking date (day)	Plant height (cm)	Ear height (cm)	Grain yield (g)
P_1	-2.000**	-8.657**	-2.454**	0.477
P_2	0.944**	0.648	2.546**	-0.173
P_3	0.056	3.009*	-1.065	*-0.734
P_4	-0.083	-5.880**	-5.231**	*0.724
P_5	0.917**	2.454	1.991*	0.056
P_6	0.167	8.426**	4.213**	-0.349
$SE_{(gi)}$	**0.099**	**1.248**	**0.904**	**0.296**

P_1, P_2, P_3, P_4, P_5 and P_6 denote to IL.155 - 06, IL.341 - 06 , IL.778 - 06, IL.358 - 06, IL.267 - 06 and IL.263 - 06 respectively.
***, ** indicated to significant at P= 0.05 and P= 0.01 respectively.**

Positive GCA effects were desirable for all studied traits, except for silking date where, negative ones indicate tendency towards ear lines. Maize breeder preferred moderate plant height hybrids with low ear placement consequently, negative ($\hat{g}_i$) effects are also preferable for ear height therefore, it might be more resistance to stalk breakage and lodging. However, general combining ability effects ($\hat{g}_i$) in Table 2 showed that for silking date, the parental inbred lines P_1 (-2.000) exhibited negative and significant GCA effects (desirable value).

Table 3. Estimates of specific combining ability effects for studied traits under three locations.

hybrids	Silking date (day)	Plant height (cm)	Ear height (cm)	Grain yield (g)
$P_1 \times P_2$	-0.100	0.083	-6.833**	0.715
$P_1 \times P_3$	0.789**	-1.722	-1.556	-0.168
$P_1 \times P_4$	-0.628**	2.167	0.944	-0.369
$P_1 \times P_5$	0.039	6.611**	4.833**	0.404
$P_1 \times P_6$	-0.100	-7.139**	2.611	-0.582
$P_2 \times P_3$	-0.156	-5.472*	1.778	-0.753
$P_2 \times P_4$	0.650**	-7.694**	0.389	-1.708**
$P_2 \times P_5$	-0.128	2.306	-2.389	0.330
$P_2 \times P_6$	-0.267	10.778**	7.056**	1.416**
$P_3 \times P_4$	-0.017	4.944*	4.556**	-0.816
$P_3 \times P_5$	-0.017	1.056	1.778	1.007*
$P_3 \times P_6$	0.600**	-1.194	6.556**	-0.731
$P_4 \times P_5$	-0.433*	-2.278	-3.500	1.359**
$P_4 \times P_6$	0.428*	2.861	-2.389	1.534**
$P_5 \times P_6$	0.539**	-7.694**	-0.722	-3.099**
$SE_{(Sij)}$	**0.168**	**2.119**	**1.535**	**0.502**

P_1, P_2, P_3, P_4, P_5 and P_6 denote to IL.155 - 06, IL.341 - 06 , IL.778 - 06, IL.358 - 06, IL.267 - 06 and IL.263 - 06 respectively.
***, ** indicated to significant at P= 0.05 and P= 0.01 respectively.**

For plant height, the parental inbred lines P_6 (8.426) and P_3 (3.009) showed positive and significant GCA effects (desirable value). Regarding to ear height, the parental inbred lines P4 (-5.231), P_1 (-2.454) and P_3 (-1.065) showed negative and significant GCA effects (for P_4 and P_1) toward lower ear placement. With respect to grain yield, the parental inbred lines P_4 (0.724) had desirable significant GCA effects toward producing more grain yield. The above mentioned results revealed that the parental inbred lines P_4 and P_1 possessed favourable breeding estimates (good combiner) and it could be used as breeding materials in hybrids breeding program. Estimates of specific combining ability effects ($\hat{S}_{ij}$) for the F1's crosses are presented in Table 3. For silking date two hybrids ($P_1 \times P_4$) (-0.628) and ($P_4 \times P_5$) (-0.433) out of 15 hybrids exhibited negative and significant SCA effects. For plant height, three hybrids had positive and significant SCA effects (desirable estimates) i.e. ($P_1 \times P_5$) (6.611), ($P_2 \times P_6$) (10.778) and ($P_3 \times P_4$) (4.944). Regarding ear height negative and significant SCA effects (desirable estimate) was obtained by hybrid ($P1 \times P_2$) (-6.833). For grain yield positive and significant SCA effects were obtained by hybrids ($P_2 \times P_6$) (1.416), ($P_3 \times P_5$) (1.007), ($P_4 \times P_5$) (1.359) and ($P_4 \times P_6$) (1.534).

Conclusion

It can be concluded that non-additive gene effects contribute a major role in inheritance of grain yield, plant and ear height while, additive gene effects were the most important in inheritance of silking date trait.

References

- Abou Deif, M. H. 2007. Estimation of gene effects on agronomic characters in five hybrids and six population of maize (*Zea mays* L.).World. J. of. Agric. Sci. 3(1): 86–90.
- Barakat, A. A.; M. A. Abd EL–Moula and A. A. Abd EL–Aziz. 2003. Combining ability for maize grain yield and its attributes under different environments. Assiut. J. Agric. Sci. 34 (3): 15–25.
- Bello, O. B. and G. Olaoye 2009. Combining ability for maize grain yield and other agronomic characters in a typical southern guinea savanna ecology of Nigeria. African J. of Biotechnology V. 8 (11): 2518-2522.
- El-Beially, I . E. M. A. 2003. Genetic analysis of yield characters in yellow maize inbred lines. Zagazig. J. Agri . Res. 30 (3) : 677 – 689.
- El-Hosary, A. A.; G. A. Sary and A. A. Abd El- Sattar 1990. Studies on combining ability and heterosis in maize (*Zea mays* L.) I- Growth attributes. Egypt. J. Agron., 15(1-2): 23-34.
- El-Hosary, A. A.; M. K. Mohamed and S. A. Sedhom 1994. General and specific combining ability interaction with years in maize. Annals of Agric. Sci., Moshtohor, 32(1): 217-228.
- El-Hosary, A. A., A. M. Morsy, M. K. Khalifa and M. A. Abd El-Khalik 2001. Heterosis and combining ability in maize (*Zea mays* L.). The Second Plant Breeding Conf. October 2/ 2001. Assiut Univ.
- El-Kalla, S. E.; M.S. Sultan; M. S. Radwan and M. A. Abd El-Moneam 2001. Evaluation of combining ability of maize inbred lines under low and high N-fertilization. The second Pl. Breed. Conf. October. Assiut Univ.
- EL-Shenawy, A. A.; H. E. Mosa and A. A. Motawei 2009. Combining ability of nine white maize (*Zea mays* L.) inbred lines in diallel crosses and stability parameters of their single crosses. J. Agric. Res. Kafrelsheikh Univ., 35 (4): 940-953.
- Gessa, D. W. 2008. Genotypic variability and combining ability of quality protein maize inbred lines under stress and optimal conditions. Ph. D. Dep. of Plant Sci. Fac. of Nat. and Agri. Sci. Univ. of the Free State, South Africa.
- Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Australian J. Biol. Sci. 9:463–493.

- Hag .M. I.UL.; S. U. Ajmal.; M. munir and M. Gulfaraz 2010. Gene Action Studies of different quantitative traits in maize. Pak. J. Bot. 42(2): 1021-1030.
- Hayman, B. I. 1954. The theory and analysis of diallel cross. Genetics, 39:789–809.
- Hefny, M. 2010. Genetic control of flowering traits, yield and its components in maize (*Zea mays* L.) at different sowing dates. Asian J. of Crop Sci. 2(4): 236-249.
- Nass, L. L., M. Lima, R. Vencovesky and P. B. Gallo 2000. Combining ability of maize inbred lines evaluated in three environments in Brazil. Scientia Aric. Cola, 57 (1): 129 – 134.
- Sadek, E. S., H. E. Gado and M. S. M. Soliman 2000. Combining ability and type of gene action for maize grain yield and other attributes. J. Agric. Sci. Mansoura, Univ. 25 (5): 2491 – 2502.
- Zelleke 2000. Combining ability for grain yield and other agronomic characters in inbred lines of maize (Zea mays L.). India J. of Genetic and Plant Breeding. 60 (1): 63 –70.

Nº Ref- 281