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REGULAR ARTICLE

Gene action and some genetic parameters for grain yield, its components and growth traits of corn in full diallel cross

Salih Hadi Farhood Al- Salim[1], Dheya P. Yousif[2], Mahdi S. M. Alzrgani[3] and Abbas Lateef Abdulrahman[1,4]*

[1]*Ministry of Agriculture, Thiqar Province Agriculture, Iraq.*

[2]*Center of Plant Breeding & Genetics, Agricultural and Food Technology Directorate, Baghdad, Iraq.*

[3]*Department of Crop Science, College of Agriculture, Al-Muthanna University, Samawah, Al Muthanna Province, Iraq.*

[4]*Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.*

Abstract

The objective of this study was to quantify gene action and some genetic parameters for grain yield, its components and other traits of six varietal hybrids and its parents (AM-145 (A), AM-153 (B) and AM-200 (C) obtained from Ministry of Agriculture, Iraq). All hybrids and their parental entries in full diallel cross were tested at Al-Gharraf suburb, 25 Km north of Al-Nasyria City, Iraq during fall 2013 in RCBD with three replications according to Griffing's fixed model, method for grain yield, its components and other agronomic traits. Gene action, general and specific combining abilities and broad and narrow sense heritability were estimated. Results showed significant differences among entries for almost all traits except ears/plant, and kernels weight. In addition to GCA and SCA significant variances, GCA variances were more important than SCA variances for all traits except ears/plant, which resulting the more importance of the additive genetic effects. SCA variances suggesting the importance the effects of non-additive effects for ears/plant which demonstrating entries could produce prolificacy plants. Additive genetic variances reflect its importance for all traits except female flowering and grain yield/plant. In general, the dominance degree average for all traits except grain yield/plant showed the over dominant effect and the narrow sense heritability ranged between 0.44-0.64 for female flowering and grain yield, respectively. Grain yield/plant ranged between 97.54- 68.44 g for B x A and C x B, respectively. Cytoplasmic heredity revealed its importance studying for all traits and 2GCA/SCA estimates ranged between 1.86 and 35.9 for ears/plant and female flowering, respectively.

Key words: *Zea mays*, full diallel cross, grain yield, agronomic and qualitative traits

Introduction

Plant breeders generally strive to identify elite parents of germplasm to be combined well and produce productive progenies (Viana & Matta, 2003), maize breeder in Iraq has used sophisticated methodologies to achieve gene pool improvement throughout useful sources of variation for yield potential, heterotic patterns and biotic and abiotic resistance

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*Corresponding Authors

Abbas Lateef Abdulrahman

Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Email: agriman26@yahoo.com

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(Badu-Apraku et al., 2013; Yousif, 2001; Yousif et al., 2003). The success of identifying such parents mainly depends on the gene action that controls the trait under improvement (Brown, 1960; Vasal et al., 1993; Wellhausen, 1965). Genetic diversity exploitation for any plant has been recognized as a potential source of new genes to increase the genetic variability and heterosis are referred to its breeding method and the genetic base (Goodman, 1985; Vasal et al., 1992). Crossa and Gardner (1987) and Michelini (1991) indicated that populations with 25- 50% exotic germplasm don't differ significantly for grain yield, and have greater genetic variability than adapted sources. Vasal et al. (1992, 1993) provided maize breeders valuable information on the combining ability and heterotic patterns of CIMMYT's maize germplasm. The genetic basis and its utilization in breeding programs concentrated the evident about using some criteria of genetic distances (Fountain & Hallauer, 1996). Significant useful heterosis was estimated by Abel and Pollak (1991) for flowering and grain yield.

Ordás (1991) and Yousif et al., 2003) found significant heterotic patterns for ear height and grain yield and reported that general combining ability (GCA) mean squares were greater than specific combining ability (SCA) mean squares for silking and grain yield that interpreters the predominance of additive variation.

The objective of this study was to determine the combining abilities for the inbred lines and its single crosses, assessing their crosses per se, and to exploit their genes action for yield potential, heterosis, and other genetic parameters.

Materials and methods

Three different maize genotypes obtained from Ministry of Agriculture, possessing wide range of genetic diversity (Table 1) were crossed in a full diallel mating pattern during spring 2013 at the farmer land, Al-Gharraf suburb, North of Al-Nasiriya Center, Iraq (Table 2). three of Inter varietal hybrids, its reciprocals and their parents were grown in randomized complete block design with three replications in four row plots of 7m length having 75 x 25cms crop geometry. Planting date was on 30 of July, 2013. Two seeds per hill were planted then thinned to one when seedlings were about three to four leaf stage. The final stand was approximately 53 thousand plant ha^{-1}. All cultural practices concerned land preparing were done as recommended. NP fertilizer (27: 27) and urea (46% N) were applied at the rate of 400 and 480 kg/ha, respectively. Table (2) reveals the physical and chemical characterization of the field soil experiment.

Table 1. Genetic material and qualification for maize entries cultivated at Al-Gharraf suburb, North of Al-Nasiriya during fall of 2013.

Symbol	Inbred/ hybrid	Qualification	Source
A	AM-145		
B	AM-153	Inbred	USA
C	AM-200		
AXC	145X200		
BXA	153X145		
AXB	145X153	Hybrid	Locally produced at spring 2013
CXA	200X145		
BXC	153X200		
CXB	200X153		

Table 2. The physical and chemical characterization of the soil experiment.

Item	Value	Item	Unit
Sand	120 g/kg	Electrical conductivity (EC)	3.75dS/m
Loam	560 g/kg	Organic matter	21.8ppm
Clay	320 g/kg	Total nitrogen	%0.75
Texture	Loamy-clay sand	Phosphorus available	%0.95
pH	7.78	Potassium available	%1.42

Data recorded for each plot were on complete male and female flowering, plant and ear height, ears/plant, rows/ear, kernel/row, kernel weight, grain yield/plant and protein and carbohydrate content. Data analyzed with RCBD and combining ability analysis was conducted using method 1 model 1 of Griffing (1956). All genetic parameters concerned additive genetic variance (σA), no-additive genetic variance (σD) and dominant degree average (â) were estimated according to Kempthorne & Curnow (1961), which are as follows:

$\Sigma gca = (MS_{gca} - MS_e)/ 2P$ and $\sigma sca = (MS_{sca} - MS_e)$

Where: P means parents, MS_e, MS_{gca} and $MS_{sca}$are the mean square of error, general combining ability and specific combining ability. Additive genetic variance (σA), no-additive genetic variance (σD) and environmental variance (σe) were estimated throughout variance components of mean squares according to Griffing (1956).

Result and discussion

Analysis of variance revealed significant differences among entries for all traits under investigation except the ears/plant (Table 3). The wide range of genetics and geographical diversities among the parental entries may interpreters these effects (Table 1). Partitioning the mean squares of entries into their components indicated the highly significant the GCA variance for all traits under study except ears/plant, whereas, the

Ear height and protein percentage showed the high significant SCA variance (Table 3). Similar results have also been reported by Joshi et al. (1998) for grain yield. The proportion of $\sigma^2 g/\sigma^2 s$ which exceeded one reflected the highly significant additive genetic variance for all traits under investigation except ears/plant. Similar results obtained by Al-Azawi (2002), Paul & Debanth (1999) and Yousif et al. (2001, 2003).

Table 3. The analysis of variance as mean squares of growth traits, grain yield and its components of maize inbred lines and their F_1 hybrids on fall 2013 at Al-Gharraf suburb, North of Al-Nasiriya, Iraq.

Entries	df	Days to 50% flowering male	Days to 50% flowering female	Plant height (cm)	Ear height (cm)	Ears. $Plant^{-1}$	Rows. ear^{-1}	Kernels Row^{-1}	Grain yield $Plant^{-1}$(g)	Protein %
Treat.	8	125.44*	122.41**	703.97*	614.12*	304.71	128.04*	4.23**	3761.3*	5.32**
GCA	2	118.05*	115.95*	623.8*	546.23*	146.91	79.71*	3.8*	3585.8*	4.65**
SCA	6	7.39	6.46	80.17	67.89*	157.80	48.33	0.43	245.5	0.67*
$\sigma^2 g/\sigma^2 s$		15.97	17.95	7.78	8.05	0.93	1.65	8.84	14.61	6.94
Error	16	14.6	14.1	31.62	27.83	235.6	56.38	0.19	303.0	0.31

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

Table 4. Average performance of the F_1 intervareital hybrids, reciprocals and their parents for grain yield, its components and some growth traits, of maize cultivated on fall 2013 at Al-Gharraf suburb, North of Al-Nasiriya, Iraq.

Inbred / hybrid	Days to 50% flowering male	Days to 50% flowering female	Plant height (cm)	Ear height (cm)	Ears. $Plant^{-1}$	Rows. ear^{-1}	Kernel Row^{-1}	Kernel Wieght (g)	Grain yield. $Plant^{-1}$(g)	% Protein
A	69.0	72.3	95.0	46.7	1.30	10.3	16.2	0.21	46.09	14.31
B	75.0	79.0	88.9	39.4	1.43	10.9	18.3	0.20	56.84	13.12
C	62.7	65.3	110.0	61.1	1.42	12.4	15.0	0,17	44.77	15.46
A x B	62.3	66.7	116.7	63.3	1.54	12.9	18.2	0.24	86.34	15.63
A x C	61.0	64.7	145.6	87.2	1.22	13.8	24.2	0.21	82.29	15.76
B x A	61.7	65.7	138.3	61.7	1.20	14.7	26.0	0.21	97.54	18.58
B x C	62.3	65.0	133.9	67.8	1.42	13.6	23.1	0.20	88.88	18.03
C x A	61.0	65.0	146.7	83.3	1.43	13.8	24.4	0.19	88.39	16.14
C x B	61.0	65.0	136.8	70.6	1.20	14.4	20.6	0.19	68.44	15.97
mean	64.0	65.0	123.5	64.6	1.35	13.0	20.7	0.20		

Table 4 showed the extent range of the means of the parental entries and it's hybrids for tasseling and silking, plant and ear height, grain yield and protein percentage. This results reflected on the yield *per se* for the parental lines in comparison with their hybrids and agreed with Badu-Apraku, (2013) which suggests the characterization of the genetic variability in population crosses. The A x C and C x A hybrids was the earliest in tasseling, whereas, none of all hybrids gave an average lowest than its parental average. On the other hand, no cytoplasmic heredity, at least for A x C and C x A hybrids. The A x B hybrid gave the lowest plant and ear height, while, A x C and C x A hybrids gave the highest (145.6, 146.7 cm, for plant height and87.2, 83.3 cm for ear height, respectively). In general, grand mean of F_1yield hybrids (74.44 g) was exceeded their parent's grand mean (48.57 g) and the similar results for plant and ear height, and rowsear^{-1}. However, B x A hybrid out yielded the highest grain yield plant^{-1} (97.54 g). The interpretation may agree with Yousif et al. (2001, 2003) and Fountain & Hallauer (1996) when stated "plant breeder's choice of source germplasm determines the potential improvement for trait(s) under selection".

Table (5) showed a perusal of GCA effects and each parental entry was good general combiner for specific trait(s). On other hand, none of the parental entries were good general combiner for almost all traits in this study. In general, AM-145 (A) and AM-153 (B) were good general combiner for plant height, row ear^{-1}, kernels row^{-1} and grain yield plant^{-1}, whatever, all the three parental lines reveals its good general combining ability for row ear^{-1} and kernels row^{-1}and reflects its utilization in improving these traits. The grand mean of the population showed good response to combine generally the parental lines under investigation with each other to decrease plant and ear height, whereas long period for tasseling and silking, row ear^{-1} and kernels row^{-1}and grin yield were noticed for all population. Like these results were reported by Joshi et al. (1998) and yousif et al. (2001, 2003).

Estimation of some genetic parameters of corn hybrids and its reciprocals (Table 6) reveals that general combining ability is more important than specific combining ability for all traits studied. The exceeding of the additive genetic variances on the non-additives reflects the ability of introducing these entries in breeding program to exploit its genetic potential for improving the local gene pool. Table (7) showed that the degree of dominance (ā) was more than one for all traits except grain yield which is the function of its components and indicate the more important of the additive genetic effect.

Table 5. Estimates of general combining ability effect (gi) for some agronomic traits, grain yield, and its components of Parental genotypes of corn cultivated on fall 2013 at Al-Gharraf suburb, North of Al-Nasiriya, Iraq.

Genotype	Days to 50%		Height (cm)		Ears	Rows	Kernel	Grain yield	%
	Tass.	Silk.	plant	ear	plant^{-1}	ear^{-1}	row^{-1}	plant^{-1}(g)	protein
AM-145 (A)	0.33	-0.09	-3.46*	-1.06	0.08	-0.496*	0.458*	-3.823*	0. 49*
AM-153 (B)	0.09	0.67*	-2.88*	2.75*	0.00	-0.52*	0.727**	-2.331*	0.282
AM-200 (C)	0.41	0.21	-1.41	-0.42	0.03*	0.402*	-0.867*	1.363	0.566*
μ	68.88	72.22	101.29	49.06	1.38	11.22	16.49	49.23	14.30

*, ** means significant at P ≤0.05, and 0.01, respectively.

Table 6. Estimation of some genetic parameters of corn hybrids and its reciprocals cultivated on fall 2013 at Al-Gharraf suburb, North of Al-Nasiriya, Iraq.

Trait	H^2. narrow sense	H^2. broad sense	Degree of dominantā	σ^2 D	σ^2A	σ^2e
Male flowering	0.56	0.91	1.13	6.62	10.28	1.59
Female flowering	0.44	0.92	1.45	8.25	7.76	1.47
Plant hieght	0.57	0.92	1.09	83.07	138.36	19.65
Ears plant^{-1}	0.51	0.79	1.12	45.22	83.34	34.36
Rows ear^{-1}	0.46	0.74	1.03	67.35	109.47	61.29
Seeds row^{-1}	0.60	0.83	1.12	77.33	198.34	55.70
Grain yield plant^{-1}	0.65	0.91	0.90	0.46	1.13	0.16
% protein	0.5891	0.9122	1.11	22.13	40.36	6.01

Table 7. estimates of specific combining ability effect for each intervarietal hybrids of some agronomic traits, grain yield, and its components of maize cultivated on fall 2013 at Al-Gharraf suburb, North of Al-Nasiriya, Iraq.

Genotype	Days to 50%		Height (cm)		Ears plant^{-1}	Rows ear^{-1}	Kernel row^{-1}	Grain yield plant^{-1} (g)	% protein
	Tasseling	Silking	plant	ear					
AM-145 (A) x AM-153 (B)	-8.21	-7.8	22.8	35.7	7.69	18.38	-0.54	51.90	9.22
AM-145 (A) x AM-200 (C)	-2.64	-1.0	32.33	42.7	-14.08	10.69	49.87**	78.54*	1.94
AM-153 (B x AM-145 (A)	-10.6*	-9.2*	45.61	32.1	-16.08	34.74*	41.86**	71.60*	29.83**
AM-153 (B) x AM-200 (C)	-0.52	-0.5	21.72	10.9	-0.69	8.92	26.09*	56.36	16.62*
AM-200 (C) x AM-145 (A)	-2.64	-0.5	33.33	36.4	0.70	10.69	51.23**	91.77**	4.39
AM-200 (C) x AM-153 (B)	-2.64	-0.5	24.34	15.5	-16.08	16.07	12.17	20.4	3.29

*, ** means significant at P ≤ 0.05, and 0.01, respectively.

Conclusion

Characterization of the genetic variability in population crosses is important for the evaluation of the effectiveness and progress expected from selection methods. Due to the positive results investigated in this study, it is very important to introduce exotic inbred lines with the local selected to combine the genetic diversity with the genetically un related parents for maize hybrid production and to test in different growing environment in Iraq to exploit the genetic variability and to develop non-conventional stable hybrids that are relatively high grain yield potential to identify and breed local inbred lines with specific quantitative characters.

Author contribution

All authors contributed equally in the present study. All authors approved the final version of the manuscript for publication.

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