Research Article

Genetic Variability, Heritability and Correlation Studied for Yield and Yield Components in Maize Hybrids

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Abstract |The study was conducted in two locations, Faculty of Agriculture and Forestry, University of Duhok, Kurdistan Region-Iraq and second at FishKhabor, during spring season 2012. The experimental materials comprise seven F1 hybrids (sangaria, IK8 x zp-707, DK x Hs, zp-707 x un 44052, IK 8 x un44052, un 44052 x DK and polina). The experiment was laid out in randomized complete block design with three replications. The analysis of variance showed highly significant differences among maize hybrids for all the traits. The hybrid un44052 x DK took minimum days to tasseling (65.83 days) and silking (68.50 days). Hybrid zp-707 x un 44052 was short statured (155.59 cm) with desirable ear height of 62.93 cm. However, maximum leaf area produced by hybrid DK x Hs in both locations with averages 768.56, 670.26 and 719.42 cm^2, respectively, while hybrid sangaria recorded maximum value for 300 grains weight 68.16 g and the hybrid IK 8 x zp-707 showed highest rows ear^{-1} at both locations and their averages reached 19.33, 17.33 and 18.33, and the same hybrid produced highest yield $plant^{-1}$ at both location with average values of 146.94, 125.84 and 136.00 g, respectively. The value for genotypic variation ranged from 4.51 (rows ear^{-1}) to 3161.30 (leaf area) while the phenotypic variance ranged from 5.27 to 3473.97 for the same trait. High estimates for the broad sense heritability were found in various plant traits under study. The yield exhibited positive and significant relationship with grains row^{-1} (0.851) and row ear^{-1} (0.510). The grains row^{-1} had positive direct effect on grain yield $plant^{-1}$ and high positive indirect effect through some traits, so that these traits could be used as an index in the selection of high grain yield $plant^{-1}$.

Editor | Tahir Sarwar, The University of Agriculture, Peshawar, Pakistan
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Citation | Hussain, M. A, Hassan, Z. A. 2014. Genetic variability, heritability and correlation studied for yield and yield components in maize hybrids. *Sarhad Journal of Agriculture,* 30(4): 472-478.
Keywords | Maize hybrids, Heritability and genetic variability

Introduction

Maize (*Zea mays* L.) has markable productive potential among the cereals, it's the third most important grain crop after wheat and rice and accounts for 4.8% of the total cropped area and 3.5% of the value of agriculture output (Saleem et al., 2008). Genetic improvement in traits of economic important along with maintaining sufficient amount of variability is always the desired objective in maize breeding programs. (Hallauer and Scobs., 1973), and (Grzesiak, 2001) observed considerable genotypic variability among various maize genotypes for different traits, (Ihsan et al., 2005) also reported significant genetic differences for morphological traits of maize genotypes. This variability is a key for crop improvement (Welsh, 1981). Yield of maize is considered as a complex inherited trait, the introduction of hybrids was the most important task in the cultivation of maize. The first commercial sale of hybrid seed started in 1984. Inbred lines of maize show general deterioration in yield and vigour, but hybrid between two inbred immediately and completely recovers. In many cases, their yield exceed that of varieties from which

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inbred were derived (Shull, 1908).

Increased production per unit area is the primary objective in maize breeding programs. Of these, the grain yield is the most important trait with which the maize breeders work. Maize displays an orderly sequence of development of yield components namely ears plant $^{-1}$, grains row^{-1}, rows ear^{-1} and grain weight (Viola et al., 2003).

The appropriate knowledge of such interrelations between grain yield and its contributing components can significantly improve the efficiency of breeding programs through the use of appropriate selection indices (Mohammadia et al., 2003). One of the goals of this study was to confirm correlation between grain yield and morphological traits. The yield components are interrelated and developed sequentially at different growth stages. Correlation may not provide a clear picture of the importance of each component in determining grain yield, path coefficient analysis provides more information among variables than do correlation coefficient, since this analysis provides the direct effect of specific yield components on yield and indirect effect via other yield components (Garcia delmoral et al., 2003; Arshad et al., 2004; Aycicek and yildirim., 2006). Because of that, the goal of this study was also to find out the direct and indirect effect of morphological traits on grain yield. The present study also aimed to determine the genetic variability of yield, its components and morphological traits in different maize hybrids, and to formulate the genotypic and phenotypic correlations among important traits of maize hybrids.

Materials And Methods

The study was conducted at two locations, Faculty of Agriculture and Forestry, University of Duhok, Kurdistan Region-Iraq and second at FishKhabor during spring season 2012. The experimental materials comprise seven hybrids i. e., Sangaria, Ik8 x zp707, Dk x Hs, zp707 x un44052, Ik8 x un44052, un44052 x Dk and Polina. The experiment was laid out in randomized complete block design with three replications. Each plot consisted of three rows of three meter length. Spacing between rows and plants were 0.75 m. and 0.20 m., respectively. Seeds were sown manually in holes along the ridges at rate of three seeds hole^{-1} and then thinned to one plant hole^{-1} after three weeks of sowing. Sowing date was 15 March for the first location and 20 March for the second location. Standard agricultural practices were applied uniformly at both experimental sites.

The observations were recorded on ten randomly selected guarded plants from each sub plot for days to tasseling (DT), days to silking (DS), plant height (PH), ear height (EH), rows per ear (RE), leaf area (LA), grains per row (GR), 300 grain weight (300 GW) and grain yield per plant (GYP). Analysis of variance for all the traits was carried out according to (Steel and Torrie, 1984). Duncan's Multiple Range (DMR) test was applied to separate and compare the means of all genotypes for various traits. Genetic variance was calculated, genotypic and phenotypic correlation was also worked out among yield traits following (Singh and Chaudhary., 1985).

Results and Discussion

The analysis of variance showed highly significant differences among maize hybrids for all traits in all environments (locations) (Table 1). The combined analysis of hybrids for nine traits of maize revealed that mean square of hybrids and environments were highly significant for all studied traits. However, the interaction between hybrids × environments was not significant for majority traits except the leaf area and 300 grain weight which showed high significant variations.

The hybrid means for various traits are represented in table 2. The F1 hybrid un44052 x Dk had a short period to tasseling in comparison with hybrid polina in both environments and interaction between hybrids and environments, and this period ranged between 66.33 to 65.83 days for hybrids un44052 x Dk and 78.66 to 77.66 days for polina.

The hybrid un44052 x Dk was the earliest in days to 75% silking for both locations while the hybrid polina could be the latest which took 82.00 days (Table 2). However, significant differences were observed between the hybrids at the average of both locations and ranged between 167.9 to 172.52 days.

The hybrid zp-707 x un44052 was shorter than other hybrids in plant height (150.33) in Faculty of Agriculture and Forestry and 150.84 in FishKhabor while the hybrid polina was the tallest one with 18.73 cm and 183.75 cm in both locations respectively while their averages were 155.59 and

Table 1. *Mean squares for various traits of maize genotypes evaluated during spring season 2012.*

			Characters								
S.O.V.	**d.f.**		**M.s.**								
			DT	**DS**	**EH**	**PH**	**LA**	**300GW**	**NR/E**	**NG/R**	**GY**
Rep.	2	Location1	0.57	0.90	12.33	20.20	196.82	22.59	1.33	11.76	44.99
Hybrids	6		48.07**	45.65**	152.81**	250.33**	4315.61**	333.32**	9.26**	48.01**	434.37**
Error	12		0.29	0.46	11.39	15.75	531.09	5.13	0.88	6.92	34.87
Rep.	2	Location 2	4.33	4.33	0.74	3.98	73.11	0.64	0.19	17.19	56.53
Hybrids	6		51.52**	51.88**	195.57**	333.76**	7932.37**	294.98**	6.15**	80.71**	588.23**
Error	12		3.33	2.72	4.41	10.79	90.00	0.82	0.63	4.35	15.57
Location	1	Combine Analysis	130.38**	156.21**	285.84**	222.41**	53395.13**	255.74**	18.66**	396.21**	4074.35**
R x L	4		2.45	2.61	6.54	12.09	134.97	11.62	0.76	14.47	50.76
Hybrid	6		96.22**	103.04**	331.08**	558.72**	9800.70**	604.73**	14.31**	102.70**	942.96**
L x H	6		3.38	3.49	17.29	25.58	2447.28**	23.56**	1.11	26.10	79.64
Error	24		1.81	1.59	7.90	13.27	310.61	2.98	0.76	5.64	25.22

** Significant at 0.05 probability level; ** Significant at 0.01 probability level.*

Table 2. *Genotypic, phenotypic, environmental variance, heritability and genetic advance for various traits in different maize genotypes during spring 2012.*

	Characters								
	NDT	**NDS**	**PH**	**EH**	**LA**	**300 GW**	**NRE^{-1}**	**NGR^{-1}**	**Yd**
	Location 1								
GV	15.92	18.06	47.13	78.26	1261.50	109.39	2.79	13.72	133.16
GE	0.29	0.46	11.39	15.75	531.09	5.13	0.88	6.92	34.87
GP	16.21	18.52	58.52	94.01	1792.09	114.52	3.676	20.64	168.03
H.b.s.	0.98	0.97	0.80	0.83	0.70	0.95	0.75	0.66	0.79
G.D.	8.14	8.64	12.69	16.62	61.37	21.05	2.99	6.22	21.16
G.D.%	11.40	11.65	16.17	9.63	8.86	36.09	17.68	15.34	16.05
Mean	71.42	74.19	78.45	172.52	692.44	58.33	16.95	40.52	131.79
	Location 2								
GV	16.06	16.38	63.71	107.65	2614.07	98.05	1.84	25.45	190.88
GE	3.33	2.72	4.41	10.79	90.13	0.82	0.63	4.35	15.57
GP	19.39	19.10	68.12	118.44	2704.20	98.87	2.47	29.80	206.45
H.b.s.	0.82	0.85	0.93	0.90	0.96	0.99	0.74	0.85	0.92
G.D.	7.51	7.72	15.90	20.37	103.55	20.31	2.41	9.60	27.36
G.D.%	11.06	10.98	21.71	12.13	16.67	38.04	15.43	27.93	24.41
Mean	67.90	70.33	73.23	167.92	621.13	53.39	15.61	34.38	112.09
	Mean of Locations								
GV	31.46	33.81	107.72	181.81	31.63.36	200.58	4.51	32.35	305.91
GE	1.81	1.59	7.90	13.27	310.61	2.98	0.76	5.64	25.22
GP	33.27	35.40	115.62	195.08	3473.97	203.56	5.27	37.99	331.13
H.b.s.	0.94	0.95	0.93	0.93	0.91	0.98	0.85	0.85	0.92
G.D.	11.23	11.70	20.63	26.81	110.56	28.96	4.05	10.81	34.63
G.D.%	16.12	16.20	27.21	15.75	16.75	51.84	24.87	28.87	28.39
Mean	69.66	72.26	75.84	170.22	656.78	55.86	16.28	37.45	121.94

GV = Genotypic Variance; GE = Environment Variance; GP = Phenotypic Variance; H.b.s. = Heritability in Broad Sense; GD = Genetic Advance

Table 3. *Means of yield and growth traits for maize genotypes evaluated at two locations during spring season 2012.*

Characters										
GY	NG/R	NR/E	300 GW	LA	PH	EH	DS	DT		Hybrids
136.35 b	40.00 b	14.66 d	74.66 a	661.46 c	179.86 b	81.93 b	73.33 c	71.33 c	Location 1	Sangria
146.94 a	45.66 a	19.33 a	55.08 c	692.26 bc	176.66 b	79.80 bc	74.00 c	70.66 c		IK8 x Zp707
124.94 c	39.00 b	16.66 bc	45.97 d	768.56 a	169.40 c	73.53 c	75.66 b	72.66 b		DK x Hs
125.74 c	39.33 b	15.33 cd	46.39 d	678.07 bc	160.33 d	67.32 d	69.66 d	67.66 d		Zp707 x un 44052
147.50 a	43.33 ab	18.66 a	65.78 b	710.10 b	166.93 cd	76.06 bc	75.33 b	72.66 b		IK8 x un 44052
116.36 c	43.00 ab	16.00 cd	64.16 b	678.22 bc	167.33 cd	80.46 b	69.33 d	66.33 e		Un 44052 x DK
124.74 c	33.33 c	18.00 ab	56.25 c	658.44 c	187.13 a	90.03 a	82.00 a	78.66 a		Polina
103.01 cd	32.33 c	14.00 b	61.65 b	597.01 bc	175.80 a	7 1.30 bc	69.66 bcd	66.66 bc	Location 2	Sangria
125.84 b	40.00 ab	17.33 a	50.78 c	664.41 a	175.73 a	75.24 bc	67.66 cd	65.66 bc		IK8 x Zp707
105.56 cd	37.33 b	16.00 a	41.01 d	670.26 a	165.78 b	72.17 bc	70.66 bc	68.33 b		DK x Hs
103.27 cd	30.00 c	13.33 b	41.53 d	537.95 d	150.84 d	58.52 d	66.66 d	64.33 c		Zp707 x un 44052
137.05 a	41.66 a	16.66 a	65.63 a	675.74 a	168.61 b	74.08 bc	71.00 b	68.33 b		IK8 x un 44052
99.49 d	30.00 c	16.00 a	61.61 b	588.93 c	158.29 c	75.40 b	67.66 cd	65.33 bc		Un 44052 x DK
110.44 c	29.33 c	16.00a	51.52 c	613.60 b	180.37 a	85.90 a	79.00 a	76.66 a		Polina
119.68 b	36.16 bc	14.33 d	68.16 a	629.24 c	177.83 b	76.61 b	71.50 c	69 .00 bc	Both Locations	Sangria
136.39 a	42.83 a	18.33 a	52.93 d	678.34 b	176.19 b	77.52 b	70.83 c	68.16 c		IK8 x Zp707
115.25 b	38.16 b	16.33 c	43.49 e	719.42 a	167.59 c	72.85 c	73.16 b	70.50 b		DK x Hs
114.51 b	34.36 c	14.33 d	43.96 e	608.01 d	155.59 e	62.93 d	68.16 d	66.00 d		Zp707 x un 44052
142.28 a	42.50 a	17.66 ab	65.71 b	692.92 b	167.77 c	75.07 bc	73.16 b	70.50 b		IK8 x un 44052
107.92 c	36.50 bc	16.00 c	62.89 c	633.75 c	162.81 d	77.93 b	68.50 d	65.83 d		Un 44052 x DK
117.59 b	31.33 d	17.00 bc	53.89 d	636.02 c	183.75 a	87.96 a	80.50 a	77.66 a		Polina

Means followed by the same letter in the sam column have no significant difference.

183.75 cm for the two hybrid frequencies (Table 2).

Minimum ear height was recorded in hybrid zp-707 x un44052 in both locations and their averages reached 67.30, 58.52 and 62.93 cm, respectively, however, the maximum ear height was obtained by hybrid polina which exceed at Faculty of Agriculture and Forestry, and FishKhabor and their average were 90.03, 85.90 and 87.96 cm, respectively. The hybrid Dk x Hs produced maximum leaf area at both locations, Faculty of Agriculture and Forestry, and FishKhabor with averages 768.56, 670.26 and 719.42 cm^2, respectively. The hybrid Polina showed the minimum value for location 1(Faculty of Agriculture and Forestry) 658.44 cm^2, while hybrid zp-707 x un44052 recorded minimum value at location 2 and their averages reached to 537.9 and 608.01 cm^2, respectively.

At location 1, the hybrid Sangria produced maximum 300 grain weight (74.66 g), while the lowest value was 45.97 g showed by Dk x Hs. At the second location, the hybrid Ik8 x un44052 showed maximum value with 65.63 g, which exceed the hybrid Dk x Hs by 24.62, at the average of both locations. The hybrid sagria produced maximum 300 grain weight which resulted in 68.16 g while the hybrid Dk x Hs showed the lowest 300 grain weight (43.49 g). The hybrid Ik8 x zp-707 showed highest rows ear^{-1} at both locations and their averages reached to 19.33, 17.33 and 18.33 rows which exceeded the hybrids sangria and

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Table 4. *Phenotypic correlation between all traits of maize genotypes evaluated during spring season 2012.*

	NDT	NDS	PH	EH	LA	300 GW	NR/E	NK/R	GY
GY	0.120	0.124	0.084	0.255	0.407	0.274	0.618*	0.676*	1.000
N K/R	-0.367	-0.369	-0.182	-0.061	0.604	0.169	0.468	1.000	
NR/E	0.331	0.361	0.466	0.347	0.590	0.047	1.000		
300GW	0.014	0.006	0.395	0.308	-0.134	1.000			
LA	0.174	0.195	0.049	0.106	1.000				
EH	0.720**	0.724**	0.814**	1.00					
PH	0.689*	0.714**	1.00						
NDS	0.992**	1.00							
NDT	1.000								

** and ** indicated to significant at P= 0.05 and P = 0.01 respectively.*

Table 5. *Direct and indirect effect of all the studied traits.*

	NDT	NDS	PH	EH	LA	300GW	NR/E	NK/R	GY
Days to Tasselin	-0.5342	1.3316	-0.5668	0.1281	-0.0901	-0.0043	0.1693	-0.3129	0.1208
Days to Silking	-0.5299	1.3424	-0.5874	0.1288	-0.1012	0.0018	0.1843	-0.3142	0.1247
Ear Height	-0.3681	0.9686	-0.8226	0.1448	-0.0254	0.1148	0.2381	-0.1554	0.0849
Plant Height	-0.3848	0.9731	-0.6700	0.1778	-0.0552	0.0894	0.1776	-0.0524	0.2555
Leaf Area	-0.0929	0.2625	-0.0404	0.0189	-0.5178	-0.0391	0.3015	0.5144	0.4071
300 g Weight	-0.0079	0.0084	-0.3254	0.0547	0.0697	0.2903	0.0240	0.1440	0.2740
No. rows/ear	-0.1771	0.4846	-0.3836	0.0618	-0.3057	0.0136	0.5107	0.4140	0.6182
No. grains/row	0.1963	-0.4953	0.1501	-0.0109	-0.3128	0.0491	0.2483	0.8515	0.6762

zp-707 x un44052 by 4.84 and 6.00 rows, respectively. At Faculty of Agriculture and Forestry, the hybrid Ik8 x zp-707 produced maximum value of 45.66 for grains row^{-1} followed by hybrid Ik8 x zp707 and Ik8 x un4405 hybrids with values of 42.83 and 42.50 grains row^{-1} respectively. The hybrid polina exhibited the lowest grains number of 33.33, 29.33 and 31.33 at Faculty of Agriculture and Forestry, Fishkhabor, and their average, respectively. The hybrid Ik8 x zp-707 produced highest grain yield plant^{-1} at both locations, and their average values were 146.94 g, 125.84 g and 136.00 g , followed by the hybrid Ik8 x un44052, while the lowest value recoded by the hybrid un44052 x Dk with 116.36 g, 99.49 g and 107.93 g respectively (Table 2). Estimates of genotypic and phenotypic variance, heritability and genetic advance are shown in table 3. The value for genotypic variation ranged from 4.51 (rows ear^{-1}) to 3161.36 (leaf area), while the phenotypic variance ranged from 5.27 to 3473.97 for the same traits respectively.

High broad sense heritability estimates were observed for different traits under study (Table 3). The results showed that broad sense heritability estimates were for 300 grains weight (98%), days to 75% silking (95%), days to 75% tasseling (94%), plant height and ear height (93%), yield/plant (92%), leaf area (91%), rows ear^{-1} and grains ear^{-1} (85%), emphasizing that non-additive genetic variation was the major component of genetic variation in the inheritance for these traits and effectiveness of hybridization for improving these traits. The expected genetic advance values for nine traits of genotypes evaluated (Table 3). These values were expressed as percentage of the genotype mean of each trait so that comparison could be made among various traits, which have different units of measurement. High heritability along with high genetic resultant effect for selecting the best individuals, the 300 grain weight, grains/row, and grain yield/plant had high heritability accompanied with high genetic advance.

In selecting high yielding genotypes, the correlation studies revealed reliable information on the nature, extent and direction of the selection. The knowledge of correlation coefficient between different yield attributes helps the maize breeder to find out the nature and magnitude of the association between these traits which are mostly used to attain better yield of the crop. The significant and positive correlation coefficient were found between grain yield and rows ear^{-1} and grains $row^{-1}$with values 0.618 and 0.676, respectively (Table 4), and such results could help the breeder to formulate the high grain yield through selection of one or more of these traits. Other inter-traits correlation revealed that ear height revealed significant positive correlation for days to 75% tasseling, days to 75% silking and plant height with values of 0.720 and 0.724, respectively. Plant height exhibited significant and positive correlation with days to 75% tasseling and days to 75% silking. Similar results were reported by (Sadek et al., 2006), (Soegas et al., 2006) and (Aydin et al., 2007) and they indicated that the grains $row^{-1}$and 100 grain weight were the highest contributors to variation in grain yield directly or indirectly.

PThe results of path coefficient analysis presented in table 5 revealed that grains row^{-1}, rows ear^{-1}, 300 grain weight, plant height, and days to 75% silking were the key traits to increase the grain yield under mentioned conditions since they exhibited positive direct effect on yield. The grain row^{-1} yielded the highest positive direct influence (0.851) on grain yield followed by rows/ear (0.510) and 300 grain weight (0.290), however, the ear height and days to 75% tasseling exerted high negative direct effect (-0.822 and -0.534, respectively). Regarding the grain yield and days to 75% tasseling, which exhibited positive indirect effect through days to 75% silking, plant height and rows/ear, whereas negative indirect effect were observed through ear height, leaf area and grains/row. Days to 75% silking showed the positive indirect effect through plant height, 300 grain weight rows/ear and it had negative indirect effect through days to 75% tasseling, ear height and grains row^{-1}. However, the ear height had very high positive indirect effect. The rows/ear had high positive indirect effect for days to 75% silking and grains/row and the values reached to 0.484 and 0.414, respectively, and high negative indirect effect for ear height and leaf area. Finally, the grains/row recorded positive moderate indirect effect through rows/ear and negative indirect effect for days to 75% silking and leaf area, while the other traits appeared with positive or negative indirect effect, but not important for the grain yield/plant. The grains row^{-1} and rows ear^{-1} seemed to be the most important sources effecting grain yield variation, and consequently may be considered as important characters in selection programs aiming to maize yield improvement.

Conclusion and Recommendations

The maize hybrids have performed differently for yield and yield components. However, maize hybrids showed best performance in Kurdistan Region and other locations having similar climatic conditions.

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