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Phenotypic and Genotypic Correlations, Heritability and Expected Gains from Selection for Some Traits of Maize under Two Plant Densities Conditions

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ABSTRACT

A half diallel set of crosses among six inbred lines of maize were evaluated under two plant densities (normal and stress densities) to study phenotypic and genotypic correlation coefficients, hertability and expected gains from direct and indirect for some flowering and vegetative and yield and yield components traits. Obtained results show: Expected gains in grain yield from indirect selection for flowering and vegetative traits under both plant densities and their percents to gain from direct selection were high values for Ear height and plant height and moderate values for ear leaf area. Expected gains in grain yield from indirect selection for yield and yield components under both plant densities and their percents to gain from direct selection were high values for Kernels number per row, 100 kernel weight and shelling percentage. Expected gains in grain yield from indirect selection for quality traits under both plant densities and their percents to gain from direct selection were high values for oil percentage. Grain yield plant^{-1} was positively and significantly correlated with stem diameter at normal plant density. Grain yield plant^{-1} was positively and significantly correlated with kernels No. row^{-1} at both plant densities. Genetic and environmental variances for flowering and vegetative traits at stress plant density were higher than that at normal plant density for plant height and ear height. Genetic and environmental variances for yield and yield component at stress plant density was higher than that at normal plant density for kernels number per row. Broad-sense heritability estimates was 99.9 for kernels No. row^{-1}, 100 kernels weight, shelling percentage, carotene percentage and 99.6 for plant height at both plant densities.

Key words: Corn, inbred lines, heritability, heterosis, correlation, selection gain, stress plant density

INTRODUCTION

Corn breeders give great and continuous efforts to improve and increase yielding ability of this crop. Many investigators use diallel analysis to study heritability and its interactions with plant density in maize to develop and release new single crosses characterized by high yielding ability. In this connection, El-Sheikh and Abdel-Mawgood (2000) indicated that the heritability values were high for grain yield for all the four populations and ranged from 72.1% for S.C.124 to 93.6% for Taba. Mahmood *et al*. (2004) in Pakistan, found that low, medium and high estimates of broad sense heritability were found in different plant characters under study. Highest heritability was found in grain yield plant^{-1} (99.3%) and plant height (99.0%). Values of genetic advance ranged between 43.80 for grain yield plant^{-1} to 1.33 for number of kernel rows ear^{-1}. Greater magnitude of broad sense heritability coupled with higher genetic advance in characters under study provided the evidence that these plant parameters were under the control. Hussein *et al.* (1981) reported that increasing plant density was accumpanied decreasing shelling percentage. Abd El-Dayem (1984) studied three plant populations, i.e., 20, 24 and 30 thousand plants fad^{-1}. He found that increasing plant population led to a reduction in number of ears plant^{-1}. Plant population of 30.000 plants fad^{-1}. produced the lowest number of ears plant^{-1} compared to 20.000 and 24.000 plants fad^{-1}. Also, found that number of rows ear^{-1} was significant. However, number of rows ear^{-1} tended to decrease as number of plants unit^{-1} area increased.

Wannows *et al.* (2010) found that grain yield plant^{-1} correlated positively and significantly associated with number of kernels per row, ear length and leaf area index. The path coefficient analysis was calculated to detect the relative importance of characters contributing. Ojo *et al.* (2006) studied 11 characters for six inbred lines. They found all characters evaluated, with the exception of tassel number per plant and 100 kernel weight, were positively associated with grain yield per plant. Of all characters, only total number of kernels per ear was positively and significantly correlated with grain yield whereas other characters not significant correlated with grain yield. Total number of kernels per ear had very low direct effect on grain yield and largest indirect effects of 87.27 through reduction of days from planting to silking. Therefore, the present investigation was desiged to estimate heritability, genotypic and phenotypic correlation under plant density and to compare these plant densities for environments based on expected genetic advance from direct and indirect selection.

MATERIALS AND METHODS

The genetic materials used in this study were six inbred lines of diverse genetic back ground. Source and grain color of these parental inbred lines are shown in Table 1. These inbred lines were obtained from Quality Tecno Seeds Company which were produced by using artificial selfing for 8 generations according to hill method.

In 2008 growing season, the six parental inbred lines were planted on April 30th and May 21st at expermintal farmof Agronomy Department, faculaty of Agriculture, Mansoura University. Each inbred line was grown in two ridges, to overcome the differences in flowering date and to secure enough hybrid seeds. During this season, all possible cross combinations, without reciprocals, were made giving a total of 15 F1 hybrids.

In 2009 growing season, 24 entries (15 F1's along with their 6 parental inbred lines and the three check cultivares; Pioneer 3062, S.C 155 and S.C 164) were grown in two experiments at Sherenkash Village, Talkha district, El-Dakahlia Governorate. The two experiments representc two different plant densities which were 23333 plant fad^{-1} (D1, normal) and 35000 plant fad^{-1}

Table 1: Names, source and grain color of the maize parental inbred lines

No.	Name	Source	Grain color
P1	R6	Locally product	Purple
P2	R9	Locally product	Purple
P3	R24	Locally product	Red
P4	R25	Locally product	Purple
P5	R27	Locally product	Red
P6	R39	Locally product	Dark red

Table 2: Mean squares and expected mean squares for variance and covariance components

S.V	d.f	MS	EMS	MP	EMP
Replicates(r)	r-1				
Crosses (c)	c-1	M2	σ^2 e+r σ^2 g	MP2	σe+rσij
Erorr	(r-1) (c-1)	M1	σ^2 e	MP1	Σe

(D2, stress) by using distance of 60 cm among ridges and 30 or 20 cm among hills, respectively. Each experiment was designated in a Randomized Complete Blocks Design (RCBD) with three replicates. Each plot consisted of one ridge three meters long. Hills were thinned after seedling emergence to one plant per hill. Each experiment was hoed twice, before the first and the second irrigation. Phosphorus in the form of calcium super phosphate (15.5% P_2O_5) at a rate of 200 kg fad^{-1}, was added to the soil during seedbed preparation and potassium sulphate (48% K_2O) at a level of 50 kg fad^{-1} was applied after thinning. Moreover, nitrogen in the form of Urea (46% N) at a rate of 120 kg N fad^{-1} was added in two equal split doses, before the first and the second irrigation. Other agriculture practices were applied as recommended. The studied traits were: Anthesis date (day), silking date (day), plant height (cm), ear height (cm), stem diameter (cm), ear leaf area $(cm)^2$, number of ears $plant^{-1}$, ear diameter, number of rows ear^{-1}, number of kernels row^{-1}, 100 kernel weight, Shelling percentage, grain yield per plant, Protein percentage, Oil percentage and Carotene percentage.

Data of entries in each experiment for each plant density treatments (D1 and D2) were subjected to separate analysis of variance of randomized complete blocks and analysis of covariance between grain yield and other traits in the forms given in Table 2.

Expected mean squares and mean products were used for estimating the following:

- **Broad-sense heritability (h^2b):** Genetic and phenotypic variances were estimated from expected mean squares as follows:

$$\sigma^2 G = (M2\text{-}M1)/r$$

$$\sigma^2 ph = \sigma^2 G+(\sigma^2 e/r)$$

The percentage of heritability of plot means was estimated as:

$$h^2b = (\sigma^2 G/\sigma^2 p)\times 100$$

- **Traits associations:** Phenotypic (rph) and genotypic (rg) correlations were calculated between grain yield per plant and other traits for normal plant density and stress plant density conditions by the equation (Banziger *et al.*, 1997):

$$rpij = MPij/(MSi\times MSj)^{1/2}$$

$$rgij = \sigma\ Gij/(\sigma^2\ Gi\times\sigma^2\ Gj)^{1/2}$$

where, MS refers to mean squares, MP mean products, σ^2 G genotypic variance, σ G genetic covariance and subscripts i and j refer to yield and correlated trait, respectively

- **Expected gain from selection:** Expected gain from direct selection for grain yield plant^{-1} at each plant density treatment was calculated by using the following equation:

$$\Delta S = K.\ h^2\ b.\ \sigma pi = K\ \sigma^2\ Gi/\sigma pi$$

where, K is the selection differential; σ^2Gi and σpi are the genotypic variance and phenotypic standard deviation for grain yield, respectively

Expected gain in grain yield from selection for a yield-related traits (indirect selection) was calculated by the following equation (Banziger and Lafitte, 1997):

$$\text{Indirect selection gain} = K\ \sigma\ Gij/\sigma pj$$

where, σ Gij is genetic covariance between grain i yield and related trait j, σpj is phenotypic standard deviation for trait j, A standard value of K = 1 was assumed for both direct and indirect selection.

RESULTS AND DISCUSSION

Expected gains from direct and indirect selection

Flowering and vegetative traits: Table 3 present expected gain in yield from indirect selection for maize traits and its percent to expected gain from direct selection under normal and stress plant densities.

Expected gains in grain yield from indirect selection for flowering and vegetative traits under normal plant density and their percents to gain from direct selection were high values for stem diameter (13.7, 0.581), Ear height (10.7, 0.455) and plant height (9.09, 0.386) and moderate values for ear leaf area (2.28, 0.097).

Table 3: Expected gain in yield from indirect selection for maize flowering and vegetative traits and indirect gain in percent gain from selection for grain yield under normal plant density and stress plant density

	Expected gain from indirect selection		Indirect gain/direct gain (%)	
Trait	N	S	N	S
Anthesis date	-16.000	0.405	-0.678	0.0450
Silking date	-12.990	-1.600	-0.552	-0.1780
Plant height	9.090	10.200	0.386	1.1300
Ear height	10.700	10.700	0.455	1.1900
Stem diameter	13.700	2.830	0.581	0.3150
Ear leaf area	2.280	1.600	0.097	0.1780
Ears No. plant^{-1}	0.967	7.300	0.041	0.8130
Rows No. ear^{-1}	-12.500	-2.150	-0.532	-0.2390
Kernels No. row^{-1}	11.700	9.070	0.497	1.0100
Ear diameter	-6.010	-2.290	-0.255	-0.2550
100 kernel weight	14.030	1.150	0.596	0.1280
Shelling (%)	6.030	5.700	0.256	0.6350
Protein (%)	-5.960	-0.973	-0.253	-0.1080
Oil (%)	4.870	0.481	0.207	0.0540
Carotene (%)	5.710	-0.008	0.242	-0.0009

*Expected gain from direct selection for grain yield under normal plant density was 23.5 g plant^{-1} and under stress plant density was 8.98 g plant^{-1}

Expected gains in grain yield from indirect selection for flowering and vegetative traits under stress plant density and their percents to gain from direct selection were high values for ear height (10.7, 1.19) and plant height (10.2, 1.13) and moderate values recorded by stem diameter (2.83, 0.315), ear leaf area (1.60, 0.178).

Yield and yield components traits: Data in Table 3 show that expected gains from direct selection for grain yield were 23.5 and 8.98 g plant^{-1} under normal and stress plant densities, respectively. Under normal plant density, the highest values of expected gains in grain yield from indirect selection for yield components traits and their percents to direct selection were recorded by 100-kernel weight (14.03, 0.596), kernels number per row (11.7, 0.497) and shelling percentage (6.03, 0.256) and low value recorded by ears number per plant (0.967, 0.041).

Under stress plant density, kernels number per row (9.07, 1.01), ears number per plant (7.30, 0.813), shelling percentage (5.70, 0.635) and 100 kernel weight (1.15, 0.128) recorded the highest values of expected gains in grain yield from indirect selection for yield components traits and their percents to direct selection.

Quality traits: Data in Table 3 show that the highest values of expected gains in grain yield from indirect selection for quality traits and their percents to direct selection were recorded for carotene percentage (5.71, 0.242) and oil percentage (4.87, 0.207) under normal plant density and oil percentage (0.481, 0.054) under stress plant density.

In generally, a value of 1.0 for indirect selection/direct selection (IR/R) indicates that indirect and direct selection are predicted to be equally efficient. While, when IR/R is less than 1.0, direct selection is predicted to be more efficient than indirect selection and vice versa when IR/R is more than 1.0. Thus, results show that direct selection for grain yield under both plant densities was likely to be more efficient than indirect selection for all studied traits except, plant height, ear height and kernels number per row under stress plant density, as shown in Table 3.

Similar results were showed by many others investigators such as Falconer (1981) and Lafitte and Edmeades (1994a-c).

ASSOCIATED TRAITS

Between grain yield and flowering and vegetative traits: Data presented in Table 4 show that grain yield plant^{-1} at normal plant density was positively and significantly correlated with stem diameter (rph = 0.58*, rg = 0.76**) but the correlation was negatively and highly significantly or significantly with anthesis date (rph = -0.68**, rg = -0.75**) and silking date (rph = -0.55*, rg = -0.61**). Under stress plant density, the correlation between grain yield plant^{-1} and flowering and vegetative traits was positively and highly significantly correlated with plant height (rph = 0.65**, rg = 0. 85**) and ear height (rph = 0.69**, rg = 0.89**).

Yield and yield components traits: Data presented in Table 4 show that grain yield plant^{-1} at normal plant density was positively and significantly correlated with kernels No. row^{-1} (rph = 0.50*, rg = 0.50*) and 100 kernel weight (rph = 0.59*, rg = 0.60*) but the correlation was negatively and significantly with rows No. ear^{-1} (rph = -0.53*, rg = -0.55*). Under stress plant density, the correlation between grain yield plant^{-1} and kernels No. row^{-1} (rph = 0. 56*, rg = 0. 76**) was positively and significantly. The results agree with those obtained by El-Lakany and Russell (1971), Moursi (1975), Nawar (1984), Noureldin *et al.* (1984) and Sarry *et al.* (1990).

Table 4: Phenotypic (rph) and genotypic (rg) correlations between grain yield plant^{-1} and all studied traits under normal and stress plant densities

		Grain yield plant^{-1}			
		Normal D		Stress D	
Traits	Plant density	rph	rg	rph	Rg
Flowering and vegetative	Anthesis date	-0.68**	-0.75**	0.060	0.070
	Silking date	-0.55*	-0.61*	-0.040	-0.140
	Plant height	0.39	0.39	0.650**	0.850**
	Ear height	0.45	0.47	0.690**	0.890**
	Stem diameter	0.58*	0.76**	0.160	0.240
	Ear leaf area	0.10	0.10	0.090	0.140
Yield and yield components	Ears No. plant^{-1}	0.04	0.04	0.430	0.830**
	Rows No. ear^{-1}	-0.53*	-0.55*	-0.160	-0.180
	Kernels No. row^{-1}	0.50*	0.50*	0.560*	0.760**
	Ear diameter	-0.25	-0.26	-0.150	-0.210
	100 kernel weight	0.59*	0.60*	0.080	0.100
	Shelling (%)	0.25	0.26	0.360	0.480*
Quality	Protein (%)	-0.25	-0.80**	-0.080	-0.190
	Oil (%)	0.21	0.28	-0.010	0.060
	Carotene (%)	0.24	0.24	-0.001	-0.001

*and **Significant at 5 and 1%, probability levels, respectively

Correlation between grain yield and quality traits: Data presented in Table 4 show that grain yield plant^{-1} not found positively and significantly correlated with quality traits under both plant densities.

GENETIC AND ENVIRONMENTAL VARIANCES AND HERITABILITY ESTIMATES

Flowering and vegetative traits: Data shown in Table 5 show that genetic variance (σ^2G) for studied crosses at stress plant density was lower than that at normal plant density for ear leaf area. However, genetic variance for studied crosses at stress plant density was higher than that at normal plant density for anthesis date, silking date, plant height, ear height and stem diameter. Regarding to the environmental variance, Table 5 show that environmental (σ^2e) variance for studied crosses at stress plant density was higher than that at normal plant density for plant height and ear height. However, environmental variance for crosses at stress plant density was lower than that at normal plant density for silking date, anthesis date, stem diameter and ear leaf area.

With respect to heritability estimates, results in Table 5 showed that broad-sense heritability estimates ranged from 58.3% for stem diameter at normal plant density to 99.4% for plant height at normal plant density and from 85.7% for silking date to 99.6% for plant height at stress plant density.

Yield and yield components traits: Data presented in Table 5 show that genetic variance (σ^2G) for studied crosses at stress plant density was lower than that at normal plant density for grain yield, ears No. plant^{-1}, ear diameter and 100 kernel weight. However, genetic variance for studied crosses at stress plant density was higher than that of normal plant density for rows No. ear^{-1}, kernels No. row^{-1} and shelling percentage.

Table 5: Genetic variance, environmental variance and heritability for all studied traits under normal plant density and stress plant density

Traits	Density	σ^2 g	σ^2 e	h^2 b
Flowering and vegetative				
Anthesis date	N	4.4700	1.0530	80.9
	S	8.4800	0.3470	96.1
Silking date	N	1.5100	0.3430	81.5
	S	2.0550	0.3420	85.7
Plant height	N	348.7000	2.0580	99.4
	S	588.2000	2.3500	99.6
Ear height	N	228.5000	2.7980	98.9
	S	318.3000	3.1000	99.0
Stem diameter	N	0.0070	0.0050	58.3
	S	0.0475	0.0020	96.0
Ear leaf area	N	5064.9000	128.2000	97.5
	S	2475.9000	58.2400	97.7
Yield and yield components traits				
Ears No. plant^{-1}	N	0.1200	0.0030	97.6
	S	0.0035	0.0030	53.8
Rows No. ear^{-1}	N	0.6610	0.0340	95.2
	S	1.0400	0.0320	97.0
Kernels No. row^{-1}	N	25.0500	0.0305	99.9
	S	38.9800	0.0725	99.8
Ear diameter	N	0.1905	0.0120	94.1
	S	0.0725	0.0120	86.3
100 kernel weight	N	23.9000	0.0190	99.9
	S	16.7700	0.0275	99.8
Grain yield	N	554.1000	0.0265	99.9
	S	143.6000	0.1020	56.2
Shelling (%)	N	39.9600	0.0215	99.9
	S	53.9300	0.1135	99.8
Quality				
Protein (%)	N	0.0220	0.1960	10.1
	S	0.0220	0.1015	17.8
Oil (%)	N	0.1240	0.1020	54.9

Regarding to the environmental variance, Table 5 show that environmental (σ^2 e) variance for studied crosses at stress plant density was higher than that at normal plant density for grain yield, kernels No. row^{-1}, 100 kernel weight and shelling percentage. However, environmental variance for crosses at stress plant density was lower than that at normal plant density for rows No. ear^{-1} and was equal for ears No. plant^{-1} and ear diameter.

Concerning to the heritability estimates, data presented in Table 5 show that broad-sense heritability estimates ranged from 94.1% for ear diameter to 99.9 for kernels No. row^{-1}, 100 kernel weight, grain yield and shelling percentage at normal plant density and from 53.8% for ears No. plant^{-1} to 99.8% for kernels No. row^{-1}, 100 kernel weight and shelling percentage at stress plant density.

Quality traits: Data in Table 5 show that genetic variance (σ^2G) for studied crosses at stress plant density were lower than that at normal plant density for oil percentage and carotene percentage.

Regarding to the environmental variance, Table 5 show that environmental (σ^2e) variance for studied crosses at stress plant density was higher than that at normal plant density for oil percentage and carotene percentage. However, environmental variance for crosses at stress plant density was lower than that at normal plant density for protein percentage.

With respect to heritability estimates, data presented in Table 5 show that broad-sense heritability estimates ranged from 10.1 and 17.8% for protein percentage at normal and stress plant density, respectively, to 99.9% for carotene percentage at both plant densities.

REFERENCES

Abd El-Dayem, A.F.B., 1984. Phsiological studies on maize crop. Ph.D. Thesis, Cairo University, Egypt.

Banziger, M. and H.R. Lafitte, 1997. Efficiency of secondary traits for improving maize for low-nitrogen target environments. Crop Sci., 37: 1110-1117.

Banziger, M., F.J. Betrain and H.R. Lafitte, 1997. Efficiency of high-nitrogen selection environments for improving maize for low-nitrogen target environments. Crop Sci., 37: 1103-1109.

El-Lakany, M.A. and W.A. Russell, 1971. Relationship of maize characters with yield in test crosses of inbreds at different plant densities. Crop Sci., 11: 693-701.

El-Sheikh, M.H. and A.L. Abdel-Mawgood, 2000. Estimation of genetic and environmental parameters in four maize populations. J. Agric. Sci. Mansoura Univ., 25: 3769-3779.

Falconer, D.S., 1981. Introduction to Quantitative Genetics. 2nd Edn., Longman Group Ltd., New York, pp: 340.

Hussein, M.A., M.M.F. Abdalla, M.A. El-Lakany and E.O. Ewies, 1981. Influence of plant density and distribution on yield and other characters of three maize varieties. Cairo Univ. Fac. Agric. Res. Bull., 32: 439-479.

Lafitte, H.R. and G.O. Edmeades, 1994a. Improvement for tolerance to low soil nitrogen in tropical maize II. Grain yield, biomass production and N accumulation. Field Crops Res., 39: 15-25.

Lafitte, H.R. and G.O. Edmeades, 1994b. Improvement for tolerance to low soil nitrogen in tropical maize. I. Selection criteria. Field Crop Res., 39: 1-14.

Lafitte, H.R. and G.O. Edmeades, 1994c. Improvement for tolerance to low soil nitrogen in tropical maize. III. Variation in yield across environments. Field Crops Res., 39: 27-38.

Mahmood, Z., S.R. Malik, R. Akhtar and T. Rafique, 2004. Heritability and genetic advance estimates from maize genotypes in shishi lusht a valley of Krakurm. Int. J. Agric. Biol., 6: 790-791.

Moursi, M.A., 1975. The contribution of some yield components to the grain yield of maize (*Zea mays* L.). Zagazig J. Agric., 2: 143-152.

Nawar, A.A., M.S. Rady and A.A. El Hosary, 1984. Genotypic variability and correlation coefficients of some quantitative characters in Egyptian maize (*Zea mays*, L.). Minofiya J. Agric. Res., 8: 123-139.

Noureldin, A.N., K.A. El-Shouny, M.S. Reiad and M.H. Ibrahim, 1984. Correlation and path coefficient analysis of leaf area index, net assimilation rate and yield components in maize (*Zea mays* L.). Egypt. J. Agron., 9: 39-51.

Ojo, D.K., O.A. Omikunle, O.A. Oduwaye, M.O. Ajala and S.S. Ogunbayo, 2006. Heritability, character correlation and path coefficient analysis among six inbred lines of maize (*Zee mays* L.). World J. Agric. Sci., 2: 352-358.

Sarry, G.A., A.A. El-Hosary, S.A. Mahamed and A.A. Abd El-Sattar, 1990. Studies on combining ability and heterosis in maize (*Zea mays* L.) III. Association studies. Egypt. J. Agron., 15: 1-8.

Wannows, A.A., H.K. Azzam and S.A. Al-Ahmad, 2010. Genetic variances, heritability, correlation and path coefficient analysis in yellow maize crosses (*Zea mays* L.). Agric. Biol. J. N. Am., 1: 630-637.