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Correlation analysis for various grain contributing traits of *Zea mays*

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For the study of genetic variability and correlation analysis among grain yield and its contributing traits an experiment was conducted in the research area of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan during crop season of 2011. The heritability was found 96.06 to 99.99% while genetic advance was from 15.939 to 63.439%. Significant genotypic correlation was found for grain yield per plant with stem diameter, cob diameter, cob length, cob weight, 100-seed weight, dry matter yield, leaves per plant, chlorophyll contents, grain rows per cob and cobs per plant. It was accomplished that higher heritability and genetic advance was found. It was suggested that selection of higher grain yielding genotypes may be helpful to enhance crop yield and productivity.

Key words: *Zea mays*, heritability, genetic advance, genotypic, phenotypic, correlation.

INTRODUCTION

Maize (*Zea mays* L) is an imperative cereal food crop all over the world with extra impact for developing countries like Pakistan. Maize is the third essential cereal in Pakistan following to wheat and rice. It contributes 5.67% in the worth of agriculture outputs. It was grown on 1083 thousands hectares with annual production of 4271 thousands tons and average yield 3940 kg/ha (Anonymous, 2011-12). Maize is dilapidated as food for human while feed for livestock and also worn as an industrial raw material to produce various types of by-products. It has highest 9.9% crude protein at early and at full blooming stages that lower down to 7% at milk stage (grain formation stage) and to 6% at maturity. It contains 72% starch, 10% protein, 4.80% oil, 9.50% fiber, 3.0% sugar, 1.70% ash, 82% endosperm, 12% embryo, 5% testa bran and 1% tip cap (Chaudhary, 1983; Bureau of Chemistry, U.S., 2010). Maize production of Pakistan is lower as compared to other maize growing countries due to non-availability of quality inputs and timely availability. Grain yield is related with diverse physiological, morphological and agronomic traits of maize. By improving these traits the production of maize genotypes may be improved. Heritability, genetic advance and genotypic correlation provide a great prospect to a plant breeder to select genotypes on the basis of strong correlation among grain yield and its contributing traits (Mehdi and Ahsan, 1999; Mehdi and Ahsan, 2000a; Grzesiak et al., 2007; Ali et al., 2011; Ali et al., 2012a, b, 2013a, b). On the basis of above said views, present study was conducted to evaluate maize accessions for morphological and physiological traits of maize for grain yield.

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Table 1. Genetic components for various grain yielding and its contributing traits of maize.

Source of variation	Cobs per plant	Grain rows per cob	Cob length (cm)	Cob diameter (cm)	Cob weight (g)	100-seed weight (g)	Stover weight (g)	Grain yield per plant (g)	Leaves per plant	Stem diameter (cm)	Chlorophyll contents (mgg^{-1}fr.wt.)	Total dry matter (g/m^2)
M.S	0.53629*	7.283**	21.786**	0.0409**	3029.114**	17.773**	160.501**	2118.833**	2.661*	0.0491*	79.655**	241213.392**
G.M	1.989	14.113	18.848	1.515	121.845	31.141	33.823	90.185	11.333	0.856	45.735	1091.501
S.E	0.05477	0.09747	0.1049	0.03162	5.244	0.5177	0.3536	0.7071	0.1936	0.0413	1.00	4.703
G.V	0.265	3.632	10.887	0.0197	1514.816	8.599	80.175	1059.381	1.293	0.0244	39.291	120584.6
GCV	25.89	13.50	17.51	9.26	31.94	9.42	26.47	36.09	10.03	18.25	13.71	31.81
PV	0.268	3.642	10.898	0.0205	1514.856	8.867	80.251	1059.417	1.330	0.0245	39.827	120606.7
PCV	26.03	13.52	17.51	9.44	31.94	9.56	26.49	36.09	10.180	18.30	13.80	31.82
EV	0.0031	0.00938	0.011	0.0008	0.0393	0.268	0.0756	0.0357	0.038	0.000133	0.537	22.115
ECV	2.79	0.69	0.56	1.87	0.16	1.66	0.81	0.21	1.71	1.35	1.60	0.43
$h^2_{bs\ \%}$	98.88	99.72	99.89	96.09	99.99	96.97	99.90	99.99	97.20	99.50	98.65	99.98
S.E h^2_{bs}	0.2157	0.0583	0.0337	0.7917	0.002855	0.03787	0.0124	0.003414	0.0977	0.711	0.017724	0.00032
GA%	45.167	23.667	30.712	15.939	56.059	16.274	46.439	63.439	17.362	31.960	23.891	56.465

** = Significance at 5% level, * = Significance at 1% level, mean sum of squares (M.S), grand mean (G.M), standard error (S.E), genotypic variance (GV), genotypic coefficient of variance (GCV %), phenotypic variance (PV), phenotypic coefficient of variance (PCV %), environmental Variance (EV), environmental coefficient of variance (ECV %), broad sense heritability ($h^2_{bs\ \%}$), Standard error for broad sense heritability (S.E h^2_{bs}), genetic advance (GA).

MATERIALS AND METHODS

The current study was carried out in the experimental field area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad to levy the maize genotypes for fodder yielding traits for the period of the crop season in February 2011. The experimental material was comprising of 80 accessions including ten check varieties namely: F-150, F-142, EV-334, EV-330, EV-343, BF-248, EV-338, B-314, F-147, BF-212, B-308, F-118, B-304, F-143, F-113, F-111, F-105, F-121, F-130, F-140, F-128, EV-347, F-96, F-134, F-135, F-117, B-326, BF-236, B-312, EV-344, E-352, F-148, E-341, E-351, E-349, B-121, E-336, F-122, B-316, EV-324, EV-335, EV-310, EV-323, B-321, F-151, Pop/209, B-306, B-303, B-313, EV-342, B-305, Sh-139, F-114, F-136, BF-238, B-15, E-322, Sh-213, F-98, B-96, F-146, B-303, B-327, BF-337, VB-06, EV-329, EV-340, E-346, B-11, SWL-2002, Pak-Afgoee, Islamabad W, EV-7004Q, EV-1097, Raka-Poshi, VB-51, Gold Isalamabad, Sawan-3, BS-2 and Pop/2007). The accessions were grown in the field following three replications incompletely randomized block design. The plant-to-plant and row-to-row distances were kept 25 and 75 cm, respectively. The data of 10 randomly selected plants were recorded for stem diameter, cob diameter, cob length measured by vernier caliper (Model RS232), plant height measured by using meter rod, cob weight, 100-seed weight, grain yield per plant, dry matter yield, stover weight measured with the help of electronic balance (OHAUS-GT4000, USA), chlorophyll contents by using chlorophyll meter, grain rows per cob, leaves per plant and cobs per plant. The data was statistically analyzed by using analysis of variance technique (Steel et al., 1997). The genotypic and phenotypic correlations were calculated as given by Kwon and Torrie (1964). The genetic advance was calculated as described by Falconer (1989). Heritability was computed according to Burton (1951).

RESULTS AND DISCUSSION

It was suggested from Table 1 that significant differences were found for all traits. It was persuaded that higher heritability (98.88%) and genetic advance (45.167%) was found for leaves per plant, cob length (h^2=99.89%, GA=30.712%), cob weight (h^2=99.99%, GA=56.059%), stover weight (h^2=99.90%, GA=46.439%), grain yield per plant (h^2=99.99%, GA=63.439%) and total dry matter (h^2=99.98%, GA=56.465%), respectively. Higher heritability and genetic advance indicated that selection of higher grain and fodder yield may be helpful to perk up crop yield and production. The genotypes that showed higher cob weight, cob length and cob diameter indicated that grain may be improved by selecting such genotypes. Higher leaves per plant, stover weight and total dry matter indicated that the genotypes may be selected for the improvement of fodder yield of maize. The findings were similar as reported by Mehdi and Ahsan (1999), Mehdi and Ahsan (2000a, 2000b), Afarinesh et al. (2005), Ali et al.

Table 2. Genotypic correlations of various morphological and physiological and grain yielding traits of maize.

Traits	NGRPC	CL	CD	CW	HSW	SW	SD	TDM	Chl.C	NLP	PH	GYP
NCP	0.2215**	0.3269*	0.1959*	0.3543*	-0.1199	0.1063*	0.1454	0.1179*	0.2706*	0.1754	0.2923*	0.3150*
NGRPC		0.0333	0.5933*	0.4712*	-0.2172*	-0.0246	0.1019	0.1705*	0.3182*	0.1437*	0.2096*	0.4245*
CL			0.2022*	0.4497*	0.1831*	0.2962*	0.1815*	0.1364*	0.1676*	0.1772*	0.3014*	0.3061*
CD				0.7592*	0.0640	0.3262*	0.1699*	0.1599*	0.4141*	0.2467*	0.1383*	0.6166*
CW					0.2352*	0.2772*	0.1947*	0.1905*	0.5088*	0.2302*	0.3563*	0.8933*
HSW						0.1264*	0.1173	0.0622	-0.1462	-0.0516	0.1110*	0.2075*
SW							0.3545*	0.0409	-0.0118	0.4089*	0.0114	0.0067
SD								0.2210*	0.1960*	0.4471*	0.2919*	0.0866
TDM									0.1722*	0.062	0.3495*	0.1267*
Chl.C										0.0923	0.3754*	0.4505*
NLP											0.3069*	0.0640
PH												0.3512*

** = Significance at 5% level; * = significance at 1% level; NLP = leaves per plant; PH = plant height; SD = stem diameter; Chl. C = chlorophyll contents; NCP = Cobs per plant; NGRPC = grain rows per cob; CL = Cob length; CD = Cob diameter; CW = Cob weight; SW = Stover weight; HSW = 100-seed weight; GYP = grain yield per plant; TDM = total dry matter.

(2013), Grzesiak et al. (2007), Ali et al. (2011) and Ali et al. (2012a, b).

It was convinced from Tables 2 and 3 that significant positive genotypic and phenotypic correlation coefficients of chlorophyll contents were found with leaves per plant, cob weight, stem diameter, grain yield per plant, total dry matter, plant height, cobs per plant, grain rows per cob and cob diameter while leaves per plant were significantly correlated at genotypic and phenotypic levels with cob weight, stem diameter, chlorophyll contents, grain yield per plant, total dry matter, plant height, grain rows per cob and cob diameter. Higher and significant correlation of chlorophyll contents with leaves per plant, plant height and total dry matter indicated that photosynthetic rate was higher that caused for the accumulation of organic compounds in the plant body and hence helped in the improvement of grain yield (Jension et al., 1981; Mehdi and Ahsan, 2000a; Afarinesh et al., 2005; Grzesiak et al., 2007; Moulin et al., 2009; Ali et al., 2011; Ali et al., 2012a; Ali et al., 2013). Plant height was positively and significantly correlated at genotypic and phenotypic levels with all traits while non-significant at phenotypic level with 100-seed weight and stover weight. Higher 100-seed weight indicated that overall grain yield per plant increased. Total dry matter was positively and significantly correlated at genotypic and phenotypic levels with all traits but non-significant with 100-seed weight, cobs per plant and stover weight. The significant correlation of total dry matter with grain yield, grain rows per cob and chlorophyll contents suggested that the crop plant vigor is higher that may be helpful to improve grain yield. Results were found similar as reported by Jension et al. (1981); Mehdi and Ahsan (2000a); Mehdi and Ahsan (2000b); Afarinesh et al. (2005), Ali et al. (2013), Grzesiak et al. (2007), Moulin et al. (2009); Ali and Ahsan (2011), Ali et al. (2011) and Ali et al. (2014a, b, c). It was persuaded that stem diameter was positively and significantly correlated at genotypic and phenotypic levels with leaves per plant while with cob weight, chlorophyll contents, grain yield per plant, total dry matter, stover weight, plant height, cob weight, leaves per plant and cob diameter while stover weight was positively and significantly correlated with cob weight, cob length, 100-seed weight, grain yield per plant, total dry matter, cob diameter and plant height. The genotypes with higher stem diameter indicated that photosynthetic rate is higher that caused in the increase of accumulation of organic compounds, leaves per plant, total dry matter and hence the crop yield and productivity. Selection of genotypes on the basis of stem diameter may be helpful to improve maize grain yield. The cob diameter and cob weight also contributed great role in the grain yield per plant. Greater diameter, greater will be the grain rows per cob and grain yield per plant. Findings were similar as reported by Mehdi and

Table 3. Phenotypic correlations of various morphological and physiological and grain yielding traits of maize.

Traits	NGRPC	CL	CD	CW	HSW	SW	SD	TDM	Chl.C	NLP	PH	GYP
NCP	0.2189**	0.3251**	0.1935*	0.3532**	-0.1192	0.1062	0.1448	0.1170	0.2669**	0.1716*	0.2905**	0.3133**
NGRPC		0.0328	0.5816**	0.4706**	-0.2128**	-0.0247	0.1016	0.1703*	0.3135**	0.1413	0.2093**	0.4239**
CL			0.1975*	0.4494**	0.1806*	0.2961*	0.1808*	0.1364	0.1655*	0.1745*	0.3011**	0.3060**
CD				0.7441**	0.0629	0.3190**	0.1663*	0.1566*	0.4034**	0.2412**	0.1356	0.6044**
CW					0.2316**	0.2771**	0.1941*	0.1905*	0.5053**	0.2270**	0.3562**	0.8932**
HSW						0.1241	0.1150	0.0610	-0.1408	-0.0513	0.1089	0.2044**
SW							0.3536**	0.0408	-0.0120	0.4031**	0.0113	0.0067
SD								0.2205**	0.1956*	0.4374**	0.2911**	0.0864
TDM									0.1706*	0.0619	0.3494**	0.1267
Chl.C										0.0926	0.3731**	0.4473**
NLP											0.3026**	0.0632
PH												0.3511**

** = Significance at 5% level; * = significance at 1% level; NLP = leaves per plant; PH = plant height; SD = stem diameter; Chl. C = chlorophyll contents; NCP = Cobs per plant; NGRPC = grain rows per cob; CL = Cob length; CD = Cob diameter; CW = Cob weight; SW = Stover weight; HSW = 100-seed weight; GYP = grain yield per plant; TDM = total dry matter.

Ahsan (2000a); Afarinesh et al. (2005); Wang et al. (2007); Ali et al. (2013) and Ali et al. (2012a, b). 100-seed weight was positively and significantly correlated with cob length, cob weight and grain yield per plant. Cob weight and cob diameter were positively and significantly correlated with each other and also with stem diameter, cob length, 100-seed weight, dry matter yield, leaves per plant, chlorophyll contents, grain rows per cob and cobs per plant. Higher 100-seed weight indicated that the individual grain size was higher. 100-seed weight directly effect grain yield per plant and selection on the basis of 100-seed weight may be helpful to improve crop plant yield and production. Cob length was positively and significant correlated with all traits at genotypic and phenotypic levels expect grain rows per cob while cobs per plant was significantly correlated with grain rows per cob, cob length, cob diameter, cob weight, stem diameter, chlorophyll contents, plant height, grain yield per plant and total dry matter. The genotypes with higher cob length indicated that the grain rows per cob may be higher, due to which the grains per cob will also be increased. Due to increase in grain rows and grains per ear row the overall grain yield may be improved and selection of genotypes on the basis of cob length, grain rows per cob, grains per ear row, 100-seed weight and grain yield per plant may be helpful to improve crop yield and production (Mehdi and Ahsan, 1999, 2000a; Afarinesh et al., 2005; Ali et al., 2013; Grzesiak et al., 2007; Ali and Ahsan, 2011; Ali et al., 2014b, c; Ali et al., 2012a, b).

Conclusions

It was concluded from present study that higher heritability and genetic advance was found for grain yield per plant and its contributing traits leaves per plant, cob length, cob weight, stover weight and total dry matter. Positive and significant genotypic correlation was found for grain yield per plant with stem diameter, cob diameter, cob length, cob weight, 100-seed weight, dry matter yield, leaves per plant, chlorophyll contents, grain rows per cob and cobs per plant. Hence selection of higher grain yielding maize genotypes may be useful on the basis of these traits.

Conflict of Interest

The authors have not declared any conflict of interest.

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