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Correlation and Path Coefficient Analysis of Different Morpho-Physiological Traits of Maize Inbreds under Water Stress Conditions

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ABSTRACT

Different morpho-physiological were recorded in 10 maize inbred lines under water stress conditions. The experiment was laid out following a randomized complete block design with three replications. Genotypic and phenotypic correlation coefficients and path coefficients were estimated to determine the association and direct and indirect effects of different characters on seed yield per plant. Seed yield per plant was strongly correlated with leaf venation at both the genotypic and phenotypic levels. Significant and positive correlations of seed yield at genotypic and phenotypic levels were recorded with survival rate at 25% field capacity moisture, root/shoot ratio and photosynthetically active radiations while stomatal frequency exhibited significant correlation with seed yield at genotypic level and net photosynthesis on phenotypic level only. Survival rate at 25% field capacity moisture had maximum direct effect on seed yield followed by photosynthetically active radiations. The highest positive indirect effect on seed yield was exerted by leaf venation via root/shoot ratio while net photosynthesis exerted the highest negative indirect effect via survival rate at 25% field capacity moisture. The results indicated that the selection on the base of survival rate at 25% field capacity moisture and photosynthetically active radiations will be more effective in improving yield per plant of maize under drought conditions.

Key Words: *Zea mays*; Inbred lines; Seedling; Physiological traits; Water stress; Correlation coefficients; Path coefficients

INTRODUCTION

Maize is very much sensitive to temperature and drought. Pakistan is very much less in yield due to casual high temperature at pollination stage, which leads to pollen desiccation and seed setting. Per hectare yield in Pakistan is very low (1511 kg ha^{-1}) compared with World's average 4230 kg/ha seed production. Therefore, there is a dire need to evolve varieties which must be highly tolerant to temperature shock. Correlation of particular character with other characters contributing to seed yield is of great importance for indirect selection of genotypes for higher seed yield. Photosynthetically active radiation, water potential and stomatal frequency is positively and significantly correlated with grain yield (Arshad, 1985).

Path coefficient analysis helps partitioning the correlation coefficient into its direct and indirect effects. The present work was carried out to estimate the genotypic and phenotypic correlations and direct and indirect contributions of different traits to seed yield under normal and water stress.

MATERIALS AND METHODS

The experimental material comprised of ten elite maize inbred lines viz. MO-17, DK-656, IZI-7103, SYP-31, AYP-17, H-93, B-73, A-660, IZI-4001 and KU-2301. The experiment was conducted in drought chamber (Designed to control different combinations of humidity, soil moisture and temperature) and in experimental area of the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Polythene bags (18 x 9 cm) were filled with fresh river sand washed with distilled water to make it free from nutrients. One seed of each inbred line was sown in each bag at a uniform depth of 3cm. The experiment was laid out in completely randomized design with three replications. Each replication consisted of 10 seedlings of each inbred line. At three leaf stage, the seedlings were placed in drought chamber. The soil moisture was replenished to a desired level by weighing the individual bags and restoring the deficit if any by adding water. The combinations of drought components (temperature, relative humidity and sand bag moisture) were used as follows:

Treatment	Temperature (^{o}C)	Moisture (% FC)	Humidity (%)
I	48	25	12
II	48	25	50-70
III	48	50	12
IV	48	50	60-70

FC = Field capacity

When there was 50% mortality, survived seedlings were taken out from drought chamber and Hoagland's solution was applied to the seedlings and their survival rate was recorded after 15 days. The survived seedlings were counted in each replication and the survival rate was calculated as:

Survival Rate (%) = 100 (Seedlings survived after 15 days/ Total number of seedlings)

Five seedlings of each inbred line from each treatment were chosen which survived drought shock. Polythene bags were carefully torn off, seedlings were shaken gently to shed off the sand, washed under tap water taking care that their shoots and roots were not damaged. Fresh roots and shoots were placed in kraft paper bag at 60^{o}C in an electronic oven till they became dry. Thereafter, samples were weighed in milligrams using an electronic balance. Root shoot ratio was determined as:

Root shoot ratio = DRW / DSW

These ten maize inbred lines were also grown in the field following a triplicate Randomized Complete Block Design. The stomatal frequency counts per unit area were made on the upper surface of the leaf under high power (40 X) microscopic field. The leaf samples were examined under low power (10 X) microscope for counting the number of parallel veins. Water potential of the selected plants was measured with the help of gas pressure chamber. The relative water contents were measured as:

Relative Water Contents (%) = 100{(Fresh weight - Dry weight) / (Turgid weight - Dry weight)}

Hydrophilic colloids were estimated indirectly by the leaf powder method. Transpiration rate, photosynthetically active radiations (PAR) and net photosynthesis were measured using Infra- Red Gas Analyzer (IRGA) Modul LCA-3.

The data recorded were subjected to correlation analysis to estimate genotypic and phenotypic correlation coefficients between different traits following the method described by Kwon and Torrie (1964). Path coefficients were determined following Dewey and Lu (1957).

RESULTS

The strongest correlation of yield per plant was observed with leaf venation at both genotypic (r_g = 0.692) and phenotypic (r_p = 0.623) levels (Table I).Yield per plant was positively and significantly correlated at genotypic level with survival rate at Treat-II (r_g = 0.190), root shoot ratio (r_g = 0.200), stomatal frequency (r_g = 0.107) and photosynthetically active radiations (r_g = 0.173). The results are in accordance with the findings of Ali (1994), Ashraf (1989) and Dai *et al*. (1990). Positive but non-significant genotypic correlations of yield per plant were observed with survival rate at Treat-II (r_g = 0.190), transpiration rate (r_g = 0.094) and net photosynthesis (r_g = 0.115). At phenotypic level, survival rate at Treat-II, root/shoot ratio, stomatal frequency, transpiration rate, photosynthetically active radiations and net photosynthesis exhibited positive but non-significant correlation with yield per plant. Yield per plant was positively and non-significantly correlated, at phenotypic level, with survival rate treatment-II (r_p = 0.185), root shoot ratio (r_p = 0.190), photosynthetically active radiation (r_p = 0.116) and net photosynthesis (r_p = 0.068). Similar findings have been reported by Brouwer *et al*. (1970) and Alam (1965).

Positive but non-significant correlations were observed between yield per plant and leaf venation (r_g = 0.094) and net photosynthesis (r_g = 0.115) at genotypic level. The highest correlation at genotypic level was observed between water potential and leaf venation (r_g = 0.982). The results are at par with the finding of Blum (1988). Leaf venation and water potential exhibited negative

Table I. Phenotypic (r_P) and genotypic (r_G) correlation coefficients among different characters of maize

Traits		SR II	SR III	SR IV	RSR	SF	LV	TR	WP	RWC	HC	PAR	NP	YPP
SR I	r_G	0.828*	0.63*	0.899*	0.278*	-0.203*	0.346*	-0.777*	0.190	0.276*	-0.143	-0.122*	-0.602*	-0.119*
	r_P	0.828**	0.63**	0.899**	0.275	-0.181	0.286	-0.684**	0.179	0.272	-0.143	-0.113	-0.434**	-0.166
SR II	r_G		0.634*	0.083*	0.360*	-0.597*	-0.153*	-0.654*	0.177	0.542*	-0.326*	0.256*	-0.571*	0.190
	r_P		0.634*	0.083	0.357	-0.533**	-0.127	-0.576**	0.161	0.535**	-0.326	0.236	-0.411**	0.185
SR III	r_G			0.788*	-0.005	-0.463*	0.377*	-0.232	0.557*	0.589*	-0.329*	0.021*	-0.926*	-0.289*
	r_P			0.788**	-0.004	-0.412**	0.313	-0.204	0.506**	0.581**	-0.329	0.018	-0.666**	-0.281
SR IV	r_G				0.341*	-0.478*	0.409	-0.417*	0.392	0.317*	-0.366*	0.195*	-0.865*	-0.220*
	r_P				0.377	-0.428**	0.337	-0.366**	0.356	0.313	-0.366**	0.180	-0.621**	-0.214
RSR	r_G					-0.340	-0.537*	-0.214	-0.597	-0.473*	0.570	0.280*	-0.429	0.200*
	r_P					-0.311	-0.442**	-0.164	-0.536**	-0.468**	-0.564**	0.237	-0.300	0.190
SF	r_G						0.223	0.331	-0.330	-0.402	0.422	-0.704	0.718	0.107*
	r_P						0.333	0.279	-0.399	-0.332	0.380**	-0.604**	0.441**	0.112
LV	r_G							0.066	0.982*	-0.021	0.404	-0.252*	-0.188	-0.692*
	r_P							0.053	0.598**	0.014	0.336	-0.164	-0.078	-0.623**
TR	r_G								0.130	-0.282	-0.204	0.331*	0.250	0.094
	r_P								0.207	-0.254	-0.180	0.356	0.042	0.098
WP	r_G									0.671*	0.393	0.416*	-0.106	-0.657*
	r_P									0.595**	0.356	0.378	-0.138	-0.610**
RWC	r_G										-0.067	0.263*	-0.184	-0.020
	r_P										-0.065	0.235	-0.160	-0.026
HC	r_G											-0.205*	0.882	-0.314
	r_P											-0.195	0.632**	-0.305
PAR	r_G												0.175*	0.173*
	r_P												0.012	0.116
NP	r_G													0.115
	r_P													0.068

*, ** Significant at 0.05 and 0.01 probability levels, respectively; SR I = Survival rate at treat. I, SR II = Survival rate at treat. II, SR III = Survival rate at treat. III, SR IV = Survival rate at treat. IV, RSR = Root/shoot ratio; SF = Stomatal frequency, LV = Leaf venation, TR = Transpiration rate, WP = Water potential, RWC = Relative water content, HC = Hygrophillic colloids; PAR = Photosynthetically active radiations, NP = Net photosynthesis, YPP = Yield per plant

Table II. Direct (bold diagonal values) and indirect effects of different character on grain yield per plant in maize

Traits	SR I	SR II	SR III	SR IV	RSR	SF	LV	TR	WP	RWC	HC	PAR	NP	YPP
SR I	**2.861**	5.138	0.661	-0.088	-1.428	-0.247	-0.332	1.026	-0.533	-0.196	-0.404	-0.620	0.939	-0.119*
SR II	2.691	**6.478**	0.134	0.071	-0.499	0.761	0.995	-1.823	-0.475	-0.419	0.389	1.065	11.648	0.190
SR III	1.488	0.684	**1.270**	-0.037	-0.239	-0.109	21.889	0.172	-1.496	-4.713	0.652	-0.663	0.854	-0.289*
SR IV	2.350	-4.309	0.443	**-0.107**	-1.685	-1.926	2.138	8.039	1.053	-0.753	-0.819	3.504	-2.570	-0.220*
RSR	1.133	0.897	0.084	-0.050	**-3.605**	-2.240	17.719	0.163	1.602	0.931	0.313	0.576	-0.193	0.200*
SF	-0.394	-2.754	-0.078	0.115	4.510	**1.790**	0.543	0.134	0.887	6.682	-0.248	-24.641	2.586	0.107*
LV	0.431	-2.925	-12.611	0.104	28.979	1.066	**-2.204**	5.321	-2.635	0.803	-13.747	-2.682	0.399	-0.692*
TR	-2.297	-9.243	0.171	-0.673	-0.459	0.187	-9.179	**1.278**	-0.347	0.887	-0.701	-1.216	1.135	0.094
WP	0.568	1.145	0.708	-0.042	2.152	-0.592	-2.164	0.165	**-2.685**	-0.919	0.718	1.261	0.171	-0.657*
RWC	0.408	1.982	4.365	-0.059	2.448	-8.725	1.291	-0.826	-1.800	**-1.371**	-0.750	-0.304	1.367	-0.020
HC	-0.632	-1.378	-0.453	0.048	-0.617	-0.243	16.578	-0.490	-1.054	0.562	**1.828**	-0.886	0.796	-0.314
PAR	-0.585	2.276	-0.278	-0.124	-0.685	0.233	1.950	-0.513	-1.117	0.138	-0.534	**3.031**	1.131	0.173*
NP	-1.663	-46.681	-0.671	-0.170	-0.429	-2.865	0.543	-0.898	0.285	1.159	-0.901	-2.121	**1.616**	0.115

SR I = Survival rate at treat. I, SR II = Survival rate at treat. II, SR III = Survival rate at treat. III, SR IV = Survival rate at treat. IV, RSR = Root/shoot ratio; SF = Stomatal frequency, LV = Leaf venation, TR = Transpiration rate, WP = Water potential, RWC = Relative water content, HC = Hygrophillic colloids; PAR = Photosynthetically active radiations, NP = Net photosynthesis, YPP = Yield per plant

and significant correlation with yield per plant at both genotypic and phenotypic levels.

Path coefficients (Table II) revealed that survival rate at treat-II had maximum direct effect (6.478) on yield per plant followed by photosynthetically active radiations (3.031). Arshad (1985) and Grzesiak (1991) also reported the similar results in their findings. Maximum positive indirect effect on yield per plant was exhibited by leaf venation via root/shoot ratio (28.979) followed by the indirect effect of survival rate at Treat-III via leaf venation (21.889), while maximum negative indirect effect was observed by net photosynthesis via survival rate at Treat-II (-46.681). The indirect effect of net photosynthesis on yield per plant via all other characters under study is positive except survival rate treatment-IV and root shoot ratio which is negative.

This emphasizes that selection on the base of survival rate at Treatment-II and photosynthetically active radiations will be more effective in improving yield per plant of maize under drought conditions.

DISCUSSION

Photosynthetically active radiation showed positive and significant correlation with most of the traits under study. When the photosynthetically active radiations are more, ultimately there will be more photosynthesis, therefore the correlation between photosynthetically active radiations and net photosynthesis is significant and positive. Ultimately as a result of more photosynthesis, food production for plant will be more, increasing the yield. This is exhibited by significant and positive correlation of photosynthetically active radiations with yield per plant at genotypic level. The significant and positive correlation of yield per plant with photosynthetically active radiations at genotypic level and positive correlation with transpiration rate and net photosynthesis at both genotypic and phenotypic level and their positive direct effects on yield per plant showed that the process of photosynthesis is more closely and significantly related with yield per plant (Alam, 1965). Photosynthetically active radiations and net photosynthesis also had positive direct effects on yield per plant

CONCLUSION

It is concluded that yield per plant mainly depends upon the process of photosynthesis. This emphasized that selection based on the characters which enhance the process of photosynthesis will be more effective in improving yield.

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