GENETIC VARIABILITY AND TRAITS ASSOCIATION IN MAIZE (*ZEA MAYS* L.) ACCESSIONS UNDER DROUGHT STRESS

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ABSTRACT

A study was conducted in glass-house of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan during the crop season 2010 at 60 percent moisture level. The objective was to estimate genetic variability and trait association among 40 maize accessions under drought stress. Higher genetic advance and heritability were recorded for chlorophyll content and survival rate of seedlings. Path coefficient analysis indicated that fresh root length had maximum direct effect on fresh shoot length followed by survival rate, root density, leaf temperature, dry root weight and chlorophyll contents. It was concluded that fresh root length, fresh and dry root weight, root density, leaf temperature and dry shoot weight are the traits that contributed mainly to fresh shoot length and hence the selection for higher yielding maize genotypes can be made on the basis of these traits under drought stress.

KEYWORDS: ***Zea mays;*** **correlation; drought stress; path coefficient analysis; accessions; genotypic characters; phenotypic characters; Pakistan.**

INTRODUCTION

Maize (*Zea mays* L.) with a remarkable productive potential among cereals, is the third most important grain crop after wheat and rice. It accounts for 4.8 percent of total cropped area and 3.5 percent of value of agricultural output (22). In Pakistan, maize is grown on an area of 1083 thousand hectares with a total production of 3940 thousands tons and an average yield of 3638 kg per hectare (1). It is dual purpose crop being used as food for human and feed for livestock. It is also used as industrial raw material to manufacture different products. Maize has highly nutritive value having 72 percent starch, 10 percent protein, 4.80 percent oil, 8.50 percent fibre, 3.0

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percent sugar, and 1.70 percent ash (5). Its commercial products are corn oil, corn flakes, corn starch, tanning material for leather industry, custard, glucose, jelly, energile, etc. In recent years, increased quantities of corn have been used to manufacture shortening compounds, soaps, varnishes, paints and similar other products (16).

Maize is drought sensitive crop as it adversely affects yield and productivity of the crop. A crop plant may be affected by biotic and abiotic stresses including drought stress, water logging, salinity, heat stress and pathogenic diseases (24). The crop productivity is highly affected by abiotic stress conditions (2). Drought affects the maize yield and production adversely worldwide and causes reduction in grain yield (7). Echarte and Tollenaar (9) conducted an experiment on three levels of water availability to maize (100, 75 and 60% of daily transpiration) and concluded that adverse effect on maize was due to moisture stress at silking and grain filling stages. The water stress at silking and grain filling stages caused reduction in maize yield as compared to normal irrigation practices (11). The chlorophyll content in maize leaf was also affected due to decrease in moisture level (17).

The present study was conducted to evaluate maize accessions under drought stress for estimating their genetic variability and traits association.

MATERIALS AND METHODS

This study was conducted in the glass-house of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan during crop season 2010. The experimental material comprised 40 accessions including two hybrids viz. EV-5098, EV-1098, Pak Afgoyee, Agaiti-2002, SWL-2002, EV-6098, Sadaf, TLOOB-341, TLOOB-343, TLOZA, F-204, F-209, F-135, F-210, F-153, F-163, F-192, F-114, F-186, F-160, F-115, F-202, F-208, F-191, F-220, F-109, F-189, F-219, PR-98, F-211, B-54, F-158, AF-02B, F-206, F-110, 8288, 8441, 6525, 32B33 and 33H25. The accessions were grown in polythene bags of dimensions 18 × 9 cm filled with sandy loam soil having pH 7.8 and EC 1.7 dS/m. Field capacity of the soil was determined before sowing. After 30 days of sowing, 60 percent of field capacity was maintained by volume on alternate days using a moisture meter (ΔT-NH2, Cambridge, England). The data were recorded for traits including dry root weight, dry shoot weight, fresh root length, leaf temperature, chlorophyll contents, root density, root-shoot length ratio, root-shoot weight ratio, survival rate and fresh shoot length.

The data were analyzed using analysis of variance technique (23). Genotypic and phenotypic correlations were calculated as described by Kwon and Torrie (14). Path coefficient analysis was performed according to Dewey and Lu (8) to assess direct and indirect effects of all traits on fresh shoot length using genotypic correlations. Genetic advance was calculated following Falconer (10).

RESULTS AND DISCUSSION

Genetic components

The data (Table 1) depicted higher genotypic and phenotypic variances for survival rate, fresh shoot and root length against the lowest for root-shoot length ratio and root-shoot weight ratio. The highest genotypic and phenotypic coefficients of variation were recorded for chlorophyll contents and root density while the lowest for leaf temperature. The higher values of genotypic variance and genotypic coefficient variance indicated that these traits can be used for selecting higher yielding maize genotypes (9, 18, 21).

Table 1. Genetic components for maize accessions at seedling stage.

Traits	GCV%	PCV%	SD	GV	PV	$h^2_{BS\%}$	GA
Leaf temperature	2.073	3.195	0.638	0.444	1.054	42.10	0.759
Chlorophyll contents	131.809	132.061	0.023	0.206	0.207	99.60	13.795
Fresh root length	16.481	17.40	1.954	49.93	55.656	89.70	11.744
Root density	37.477	41.636	0.517	1.712	2.113	81.00	2.066
Fresh root length	17.177	19.256	1.531	13.703	17.219	79.60	5.797
Root-shoot length ratio	15.583	19.356	0.048	0.006	0.01	64.80	0.114
Survival rate	26.806	27.752	4.132	356.603	382.219	93.30	32.012
Dry shoot weight	21.533	27.535	0.085	0.017	0.028	61.20	0.179
Dry root weight	33.181	36.964	0.083	0.043	0.053	80.60	0.326
Root-shoot weight ratio	26.271	35.182	0.203	0.078	0.14	55.80	0.366

GCV = Genotypic coefficient of variance, PCV = Phenotypic coefficient of variance, SD = Standard deviation, GV = Genotypic variance, PV = Phenotypic variance, $h^2_{BS\%}$ = Broad sense heritability, GA = Genetic advance.

The highest heritability was found for chlorophyll contents (99.60) and survival rate (93.30), while leaf temperature (42.10) showed the lowest heritability value. The higher value of genetic advance was recorded for survival rate (32.012) and chlorophyll contents (13.795) of seedlings. The higher values of heritability and genetic advance indicated that selection can be made on the bases of these traits as has been observed by earlier scientists (6, 19, 21).

Correlation analysis

The data (Table 2) revealed a positive and significant correlation coefficient of leaf temperature for root-shoot weight ratio (0.1990 and 0.0837) and root-to-shoot length ratio (0.1090 and 0.0752) at both genotypic and phenotypic levels, respectively. Similar results have also been reported earlier (9, 18).

Leaf temperature had negative but significant genotypic and phenotypic correlation for root density (-0.8355 and -0.4790), survival rate (-0.4963 and -0.3857) and fresh shoot length (-0.1925 and -0.1646). Positive and significant correlation coefficients of chlorophyll contents were found with root density (0.7208 and 0.6411) and survival rate (0.5078 and 0.4851) at both genotypic and phenotypic levels which agree to the findings of Qayyum *et al.* (19) and Rezaeich and Eivazi (21).

Positive and significant correlation coefficient of fresh root length was found with fresh shoot length (0.6215 and 0.5529), root density (0.2404 and 0.1787) and survival rate (0.4585 and 0.3858) at genotypic and phenotypic levels (Table 2). A positive and significant genotypic correlation coefficient of fresh shoot length was observed with dry shoot (0.1722 and 0.1773) and dry root weight (0.1019 and 0.0873), root-shoot weight ratio (0.0312 and 0.0825), and survival rate (0.3629 and 0.3477). Similar results were reported by Echarte and Tollenaar (9), Ojo *et al*. (18), Qayyum *et al*. (19) Rezaeich and Eivazi (21). A positive and significant genotypic and phenotypic correlation coefficient of root-shoot length ratio was found with leaf temperature (0.1090 and 0.0752), fresh root length (0.5048 and 0.4280) and survival rate (0.1007 and 0.5764). A significant positive genotypic and phenotypic correlation coefficient of dry shoot weight was found with survival rate (0.4437 and 0.2529), dry root weight (0.5145 and 0.3734) and root density (0.3469 and 0.1908).

There was a negative but significant correlation coefficient of dry shoot weight with root-shoot weight ratio (-0.1782 and -0.3505) and leaf temperature (-0.2207 and -0.1251) both at genotypic and phenotypic levels. Similar results were reported by Malik *et al*., (15), Ojo *et al*. (18), Qayyum *et al*. (19) and Yousuf and Saleem (26). A significant positive genotypic and phenotypic correlation coefficient existed between root-shoot weight ratio with dry root weight (0.7788 and 0.6706), leaf temperature (0.1990 and 0.0837) and fresh shoot length (0.0312 and 0.0825). A significant positive genotypic and phenotypic correlation coefficient of survival rate was found with dry root (0.1738 and 0.1636) and shoot weight (0.4437 and 0.2529), chlorophyll contents (0.5078 and 0.4851), fresh root length (0.4585 7 0.3858), root density (0.6098 and 0.0837) and root-shoot length ratio (0.1007 and 0.5764). A significant positive genotypic and phenotypic correlation coefficient of root density with dry root (0.1665 and 0.1643) and shoot weight (0.3469 and 0.1908), chlorophyll contents (0.7208 and

Table 2. Genotypic and phenotypic correlation of various maize seedling traits.

Variables	r	CC	DRW	DSW	FRL	LT	RD	RSLR	RSWR	SR
Dry root weight (DRW)	G	0.0626								
	P	0.0595								
Dry shoot weight (DSW)	G	0.0854	0.5145 **							
	P	0.0692	0.3734**							
Fresh root length (FRL)	G	0.1813	-0.1518	-0.0792						
	P	0.1581	-0.1167	0.0110						
Leaf temperature (LT)	G	-0.5984 **	0.005 **	-0.2207 **	-0.1076 ** -					
	P	-0.3861**	0.0038**	-0.1251**	0.0510**					
Root density (RD)	G	0.7208 **	0.1665 **	0.3469 **	0.2404**	-0.8355**				
	P	0.6411**	0.1643**	0.1908**	0.1787**	-0.4790**				
Root-shoot length ratio (RSLR)	G	-0.203	-0.2855	-0.2671	0.5048 **	0.1090**	0.0893**			
	P	-0.0174	-0.2053	-0.1671	0.4280**	0.0752**	-0.4790**			
Root-shoot weight ratio (RSWR)	G	-0.0023	0.7788 **	-0.1782**	-0.1163**	0.1990*	-0.1045	-0.1611**		
	P	0.0086	0.6706**	-0.3505**	-0.0973**	0.0837**	-0.0752**	0.0517**		
Survival rate (SR)	G	0.5078 **	0.1738 **	0.4437 **	0.4585 **	-0.4963**	0.6098**	0.1007 **	-0.1785**	
	P	0.4851**	0.1636**	0.2529**	0.3858**	-0.3857*	0.0837**	0.5764**	-0.1317**	
Fresh shoot length (FSL)	G	0.2153	0.1019*	0.1722*	0.6215*	-0.1925*	0.1723*	-0.4305 **	0.0312**	0 .3629**
	P	0.2006	0.0873*	0.1773	0.5529 *	-0.1646**	-0.3857*	-0.4023**	0.0825**	0.3477**

*Significant, **Highly Significant

Table 3. Direct (in parenthesis) and indirect effect of various traits on FSL.

Traits	CC	DRW	DSW	FRL	LT	RD	RSLR	RSWR	SR
Chlorophyll contents (CC)	(0.0104)	0.0062	-0.005	0.2129	-0.0766	0.1023	0.0212	0.0003	-0.0563
Dry root weight (DRW)	0.0006	(0.0983)	-0.0299	-0.1782	0.0002	0.0236	0.2983	-0.0918	-0.0193
Dry shoot weight (DSW)	0.0009	0.0506	(-0.0582)	-0.0929	0.0283	0.0492	0.2791	0.0210	-0.0492
Fresh root length (FRL)	0.0019	-0.0149	0.0046	(1.1741)	-0.0138	0.0341	-0.5274	0.0137	-0.0508
Leaf temperature (LT)	-0.0062	0.0001	0.0128	-0.1264	(0.1280)	-0.1185	-0.1139	-0.0235	0.055
Root density (RD)	0.0075	0.0164	-0.0202	0.2823	-0.1070	(0.1419)	-0.0933	0.0123	-0.0676
Root-shoot length ratio (RSLR)	-0.0002	-0.0281	0.0155	0.5927	0.014	0.0127	(-1.0449)	0.019	-0.0112
Root-shoot weight ratio (RSWR)	0.0001	0.0766	0.0104	-0.1366	0.0255	-0.0148	0.1683	(-0.1179)	0.0198
Survival rate (SR)	0.0053	0.0171	-0.0258	0.5383	-0.0635	0.0086	-0.1052	0.210	(0.3629)

0.6411), survival rate (0.6098 and 0.0837) and fresh root length (0.2404 and 0.1787) was also recorded. A significant positive genotypic and phenotypic correlation was observed between coefficient of dry root weight with dry shoot weight (0.5145 and 0.3734), leaf temperature (0.0050 and 0.0038), root density (0.1665 and 0.1643), root-shoot weight ratio (0.7788 and 0.6706), survival rate (0.1738 and 0.1636) and fresh shoot length (0.1019 and 0.0873). These results indicated that selection can be made on the basis of dry root and shoot weights, fresh root length, root density and survival rate for higher yielding maize genotypes as already observed by earlier scientists (9, 15, 18, 19).

Path coefficient analysis

The results (Table 3) showed that direct effect of leaf temperature on fresh shoot length was positive (0.1280) but negative indirect effects were observed through all traits except dry root and shoot weights and survival rate that showed positive indirect effects. The direct effect of chlorophyll contents on fresh shoot length was positive (0.0104) while chlorophyll contents had negative indirect effects through leaf temperature, dry shoot weight and survival rate while traits showed positive indirect effects (9). The direct effect of root density on fresh shoot length was positive (0.1419) while root density had negative indirect effects through leaf temperature, dry shoot weight, survival rate and root-shoot length ratio but others had positive indirect effects. Previous workers (4, 18, 19, 20) have also reported similar results. The direct effect of fresh root length on fresh shoot length was positive (1.1741) but negative indirect effects through leaf temperature, dry root weight, survival rate and root-to-shoot length ratio while others traits were positive. Similar effects have been reported earlier (9, 12, 19, 20, 25). The direct effect root-shoot length ratio on fresh shoot length was higher but negative (-1.0449) while negative indirect effects were observed through dry root weight, chlorophyll contents and survival rate but others had positive indirect effects. The direct effect of survival rate on fresh shoot length was positive (0.3629) but negative indirect effects were noted through dry shoot weight, leaf temperature and root-shoot length ratio while others showed positive indirect effect (3, 4, 9, 13, 20, 25). The direct effect of root-shoot weight ratio on fresh shoot length was negative (-0.1179) whereas root-shoot weight ratio had negative indirect effects through all traits except root density and fresh root length which had indirect effects.

CONCLUSIONS

The study concludes that fresh root length, leaf temperature, root density, fresh root weight, dry root and shoot weight contributed mostly to fresh shoot length of maize seedlings. Selection for higher yielding genotypes can be made on the basis of these characters.

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