

*Full Length Research Paper*

# Correlation and path coefficient studies in maize (*Zea mays* L.) genotypes under 40% soil moisture contents

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The present study pertaining to the estimation of genetic parameters and characters association in forty maize genotypes was conducted in the glasshouse of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the crop season in February 2009 at 40% moisture level. The data for various quantitative characters were recorded, statistically analyzed. The path-coefficients were computed to estimate the contribution of individual characters to the fresh shoot length. Investigations regarding path coefficient showed that fresh root length had maximum direct effect on fresh shoot length at 40% moisture level followed by dry root weight, root density, leaf temperature and dry shoot weight. It was concluded that fresh root length, dry root weight, root density, leaf temperature and dry shoot weight are the characters which contribute largely to fresh shoot length of maize seedlings and selection can be made on the basis of these characters.

**Key words:** *Zea mays*, correlation, path coefficient, genotypic, phenotypic, Pakistan.

## INTRODUCTION

Maize ranks third among the cereal crops worldwide after wheat and rice. In Pakistan, maize is grown on an area of 950 thousand hectares with total production of 3487 thousands tons (Anonymous, 2009, 2010) with an average yield of 2892 kg ha<sup>-1</sup>. It is consumed as food by human and feed for the livestock and poultry. It also fulfills the requirement of raw material in food, medicine and textile industries, which finally manufacture corn oil, corn flakes, dextrose, textile dyes etc. A plant may experience biotic and abiotic stresses in the field like diseases attack, water scarcity, water logging, salinity, high and low temperature extremes etc. either continuously or with some breaks at different times during the growing season (Trester and Bacic, 2005). Abiotic stresses limit crop productivity (Araus et al., 2002; Boyer, 1970).

Among various abiotic stresses drought is undoubtedly one of the worst natural enemy of life. It can occur in any region of the world, and can affect life from very basic personal inconvenience to nationwide. Drought can reduce crop yield, pasture deterioration and death of livestock. It strongly affects the production of cereals, and poses a serious threat to the food security of households. World food security is dependent on continuous crop improvement; in particular, the development of crops with increased tolerance to abiotic stresses especially drought and salinity (Denby and Gehring, 2005). The maize was grown at three levels of water availability (100, 75, or 60% of daily transpiration) during a period bracketing silking and at two plant densities (6 and 10 plants m<sup>-2</sup>) without nutrient limitations to generate a range of levels of resource availability of water (Echarte and Tollenaar, 2006). A study for water stress at 3 growth stages before silking, at silking and during grain filling growth stages caused a

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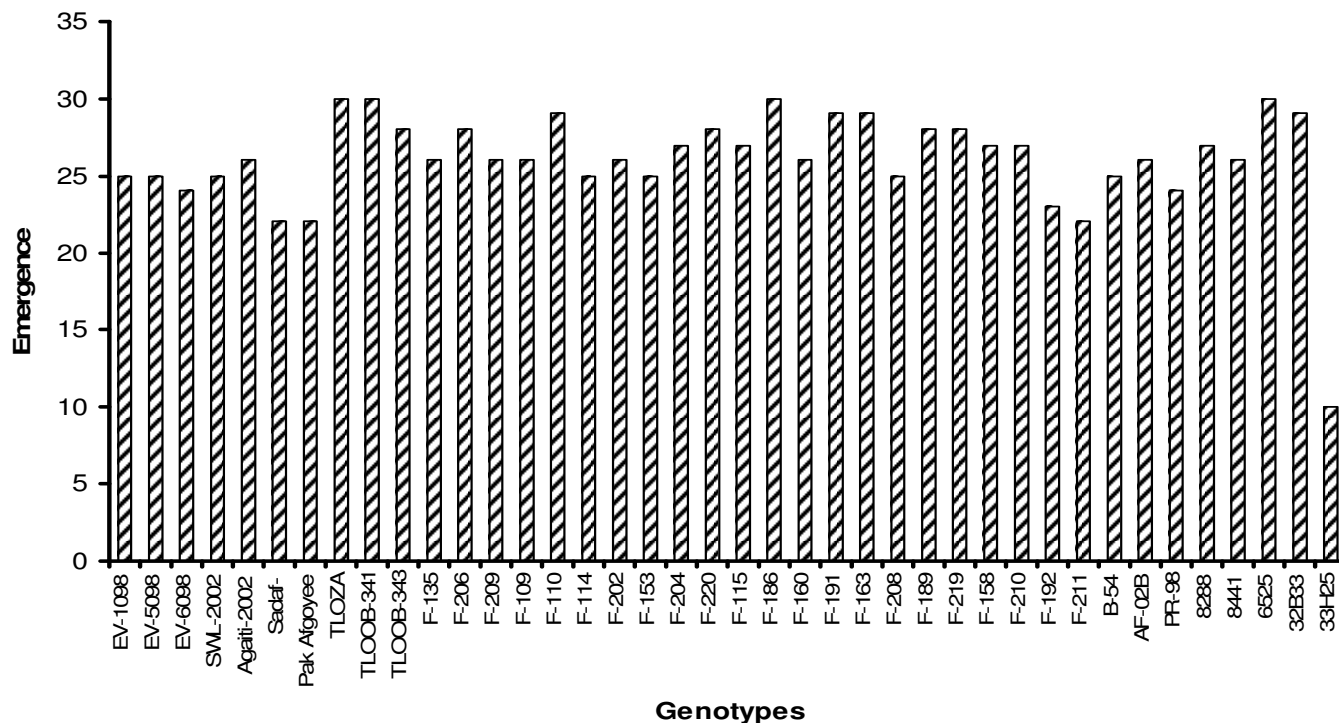


Figure 1. Emergence rate of different maize genotypes.

significant reduction in the different growth parameters studied at 90 days after planting as compared with the normal irrigation regime (Ghooshchi et al., 2008). Chlorophyll content measurements were performed on each leaf of several plants along the crop cycle (Moulin et al., 2009). Those measurements, as well as the surface measurements and the leaf insertion height measurements gave the vertical distribution of chlorophyll pigments within the canopy. The main objectives of the study were to identify the drought resistant maize genotypes. The study of traits which can help a plant breeder to select the better yield maize genotypes under drought stress conditions.

## MATERIALS AND METHODS

The proposed study was carried out in the glasshouse of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The experimental material consisted of 40 accessions namely: EV-1098, EV-5098, EV-6098, SWL-2002, Agaiti-2002, Sadaf, Pak Afgoyee, TLOZA, TLOOB-341, TLOOB-343, F-135, F-206, F-209, F-109, F-110, F-114, F-202, F-153, F-204, F-220, F-115, F-186, F-160, F-191, F-163, F-208, F-189, F-219, F-158, F-210, F-192, F-211, B-54, AF-02B, PR-98, 8288, 8441, 6525, 32B33 and 33H25.

These accessions were sown in polythene bags (18 × 9 cm) filled with sandy loam soil (pH 7.8 and EC 1.7 dS m<sup>-1</sup>) in the glasshouse of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Field capacity of the soil was determined before sowing. Two seeds per polythene bag were sown and thinned up one healthy seedling after emergence. After 21 days of

sowing the stress levels that is, 40% of the field capacity was applied. All the recommended agronomic and cultural practices were carried out. According to Jamieson et al. (1995) water requirement of maize at the time of tasseling is 135 mm/month (4.5 mm/day) and this requirement may increase up to 195 mm/month (6.5 mm/day) during hot windy conditions. The moisture level was maintained by volume on alternate days by using moisture meter ( $\Delta T$ -NH2, Cambridge, England). The data was recorded for traits, chlorophyll contents (Chl. C), fresh shoot length (FSL), fresh root length (FRL), dry shoot weight (DSW), dry root weight (DRW), root density (RD), leaf temperature (LT), survival rate (SR), root-shoot length ratio (RSLR) and root-shoot weight ratio (RSWR). The chlorophyll contents were calculated by using spectrophotometer (T-60) after crushing and dipping the sample leaves from each replication of each accession in 80% acetone at 663 nm and 645 nm OD's value according to the method of Bwinsma (1963). The data was analyzed statistically using analysis of variance technique (Steel et al., 1997) and Duncan multiple range (DMR) test at 1% significance level was used to compare the treatments means. Genotypic and phenotypic correlations will be calculated to observe the association between different traits (Kwon and Torrie, 1964). Path coefficient analysis will be performed (Dewey and Lu, 1959) to assess the direct and indirect effects on fresh shoot length using genotypic correlations where association of all the aforementioned traits were calculated by keeping one at a time as response variable and other contributing traits as causal variables.

## RESULTS AND DISCUSSION

It is clear from the graph (Figure 1) that the lines TLOZA, TLOOB-341, F-110, F-168, 6525 and 32B33 have greater value of emergence rate which shows the greater ability to tolerate the drought stress conditions while the

**Table 1.** Estimates of genetic components.

Traits	Genotypic coefficient variation (%)	Phenotypic coefficient variation (%)	Standard deviation	Genotypic variance	Phenotypic variance	Broad sense heritability $h^2$ BS (%)
Leaf temperature	20.713	22.74	1.554	17.636	21.257	83.0
Chlorophyll contents	135.41	135.547	0.017	0.208	0.209	99.80
Fresh shoot length	18.623	20.188	1.817	28.251	33.201	85.10
Root density	2.0204	2.309	0.192	0.565	0.62	91.10
Fresh root length	22.089	28.555	0.058	0.007	0.013	59.80
Root-shoot length ratio	34.29	40.612	0.579	1.248	1.751	71.30
Survival rate	40.642	42.435	4.872	394.792	430.403	91.70
Dry shoot weight	24.239	29.776	0.72	0.015	0.023	66.30
Dry root weight	20.205	30.544	0.254	0.075	0.172	43.80
Root-shoot weight ratio	20.418	23.256	0.066	0.022	0.028	77.10

genotype 33H25 has lowest value which means it has very less ability to tolerate the drought stress conditions (Ghooshch, et al., 2008). The genetic parameters as indicated in Table 1, it is clear that the higher genotypic and phenotypic variances SR, LT, and FSL as 394.792, 17.636, 28.251 and 430.403, 21.257, and 33.201 respectively, while lowest for FRL and RSWR 0.007, 0.013 and 0.022 and 0.023 respectively. The highest genotypic and phenotypic coefficients of variability for Chl.C and SR as 135.41, 40.642, 135.547 and 42.435% respectively, while lowest for RD as 2.0204 and 2.309 respectively. The highest value for standard deviation was for SR as 4.872 and lowest for Chl.C as 0.017. The higher values of genotypic variance and genotypic coefficient variance indicated that these traits can be used for selecting higher yielding maize genotypes. The same results were by Ojo et al. (2006). The highest heritability values were found for Chl.C, SR, and RD as 99.80, 91.70 and 91.10% respectively while DRW showed lowest heritability value as

43.80%. The higher values of heritabilities indicated that selection can be made on the bases of these traits (Dasgupta et al., 1992). The correlation coefficients (in Tables 2 and 3) a positive and significant genotypic and phenotypic correlation of Chl.C was found for RD and SR but negatively correlated with LT. The same results were by Veronica et al. (2009). The DRW and DSW were positively and significantly correlated with all traits except RSLR and FRL at genotypic and phenotypic levels but DSW was negatively and significantly correlated with all traits except RSWR at genotypic and phenotypic levels. The FRL was positively and significantly correlated with all traits except RSLR, Chl.C and DRW at genotypic and phenotypic levels but FRL was negatively and significantly correlated with LT and RSWR at genotypic and phenotypic levels. Similar results were by Ojo et al. (2006) and Malik et al. (2005). The LT was positively and significantly correlated with DRW, DSW, RSWR and FSL at genotypic and

phenotypic levels but LT was negatively and significantly correlated with traits except RSLR, SR, Chl.C and RD at genotypic and phenotypic levels. The same results were by Ojo et al. (2006) and Yousuf and Saleem (2001). The RD was positively and significantly correlated with all traits except RSWR and LT at genotypic and phenotypic which were negatively and significantly correlated RD. The RSLR was positively and significantly correlated with traits RSLR and SR at genotypic and phenotypic levels but RSLR was negatively and significantly correlated with RSWR, FSL and LT at genotypic and phenotypic levels. The other traits were non-significantly correlated with RSLR. Similar results were by Xu et al. (2007). The RSWR was positively and significantly correlated with traits LT at genotypic and phenotypic levels but RSLR, DSW, FRL, and RD were negatively and significantly correlated with RSWR at genotypic and phenotypic levels. The genotypic correlation of RSWR was significant for DRW but

**Table 2.** Genotypic correlation for different traits.

Variables	Chl.C	DRW	DSW	FRL	LT	RD	RSLR	RSWR	SR
DRW	0.0548								
DSW	0.1863	0.663 **							
FRL	0.1729	0.0408	0.2696						
LT	-0.6151 **	0.1471 **	0.1247 **	-0.1195 **					
RD	0.858 **	0.2034 **	0.2559 **	0.3389 *	-0.7781 **				
RSLR	0.1416	-0.3084	-0.1954	0.6737 **	-0.1698 **	0.2153 **			
RSWR	0.1182	0.5257 **	-0.3386 *	-0.2712 *	0.0974 *	-0.0408 *	-0.0969 *		
SR	0.7304 **	0.1495 *	0.2465 **	0.2633 **	-0.2719 **	0.6984 **	0.1705 **	-0.0309	
FSL	0.0317	0.3756**	0.5456 **	0.3708 *	0.0903 *	8.86E-02 *	-0.4513 **	0.1862 **	0.0408 **

DRW = Dry root weight, DSW = Dry shoot weight, FRL = Fresh root length, LT = Leaf temperature, Chl.C = Chlorophyll contents, RD = Root density, RSLR = Root-shoot length ratio, RSWR = Root-shoot weight ratio, SR = Survival rate and FSL = Fresh shoot length, \* = Significant, \*\* = Highly significant.

**Table 3.** Phenotypic correlation for different traits.

Variables	Chl.C	DRW	DSW	FRL	LT	RD	RSLR	RSWR	SR
DRW	0.0410								
DSW	0.1388	0.5100**							
FRL	0.1563	0.0491	0.2354						
LT	-0.5869**	0.1435**	0.1198**	-0.0936**					
RD	0.7211**	0.1833**	0.1206**	0.2428**		-0.6183**			
RSLR	0.1246	-0.2277	-0.1851	0.6372**	-0.1233**	0.1471**			
RSWR	-0.0721	0.428**	-0.4494**	-0.1622**	0.029*	-0.0322*	-0.0294**		
SR	0.6956**	0.1589**	0.1695**	0.2258**	-0.2523**	0.5852**	0.1345**	-0.0178**	
FSL	0.0261	0.3152 *	0.3994*	0.3293*	0.0814*	0.0991*	-0.4346**	0.1536 **	0.0523**

DRW = Dry root weight, DSW = Dry shoot weight, FRL = Fresh root length, LT = Leaf temperature, Chl.C = Chlorophyll contents, RD = Root density, RSLR = Root-shoot length ratio, RSWR = Root-shoot weight ratio, SR = Survival rate and FSL = Fresh shoot length, \* = Significant, \*\* = Highly significant.

but non-significant at phenotypic level. The SR was positively and significantly correlated with all traits except LT and RSWR at genotypic and

phenotypic levels but SR was negatively and non-significantly correlated with RSWR at genotypic. Similar results were found by Malik et al.

(2005). The FSL was positively and significantly correlated with all traits at genotypic and phenotypic levels but RSLR was negatively and

**Table 4.** Direct (In parenthesis) and indirect effect of various traits on FSL.

Variables	Chl.C	DRW	DSW	FRL	LT	RD	RSLR	RSWR	SR
Chl.C	(0.2892)	0.0371	-0.1205	0.1291	-0.027	-0.1916	-0.1762	0.0614	-0.06
DRW	0.0158	(0.6778)	-0.4287	0.0517	0.0065	-0.0454	0.3836	-0.2734	-0.0123
DSW	0.0539	0.4494	(-0.6466)	0.3416	0.0055	-0.0571	0.2431	0.1761	-0.0202
FRL	0.05	0.0277	-0.1743	(1.2671)	-0.0052	-0.0757	-0.8381	0.1411	-0.0216
LT	-0.1779	0.099	-0.0806	-0.1514	(0.0439)	0.1737	0.2112	-0.0506	0.0223
RD	0.2482	0.1379	-0.1654	0.4295	-0.0341	(-0.2233)	-0.2678	0.0212	-0.0574
RSLR	0.041	-0.209	0.1264	0.8536	-0.0074	-0.0481	(-1.2441)	0.0504	-0.014
RSWR	-0.0342	0.3563	0.2189	-0.3437	0.0043	0.0091	0.1206	(-0.5201)	0.0025
SR	0.2113	0.1013	-0.1594	0.3336	-0.0119	-0.1559	-0.2121	0.0161	(-0.0821)

DRW = Dry root weight, DSW = Dry shoot weight, FRL = Fresh root length, LT = Leaf temperature, Chl.C = Chlorophyll contents, RD = Root density, RSLR = Root-shoot length ratio, RSWR = Root-shoot weight ratio, SR = Survival rate and FSL = Fresh shoot length.

significantly correlated with FSL at genotypic and phenotypic levels.

The genotypic and phenotypic correlation of FSL was non-significant for Chl.C.

A perusal of the data given in Table 4 indicates that the genotypic correlation between leaf temperature and fresh shoot length was positive (0.0903). The direct effect of leaf temperature on fresh shoot length was positive (0.0439) whereas FSL has negative indirect effects through Chl. C, DSW, FRL, RSWR while DRW, RD and RSL ratio have positive indirect effects on FSL. The genotypic correlation between chlorophyll contents and fresh shoot length was positive (0.0317). The direct effect of Chl. C on fresh shoot length was positive (0.2892) whereas Chl. C has negative indirect effects through DSW, LT, RD, SR, RSL ratio while DRW, FRL and RSW ratio have positive indirect effects through Chl.C on FSL. Similar results were found by Boyer and Westgate (2004) and Asrar-ur-Rehman et al. (2007). The genotypic correlation between root density and fresh shoot length was positive (0.088). The direct effect of root density on fresh shoot length was

negative (-0.2233) whereas root density has negative indirect effects through DSW, LT, SR, RSL ratio while others have positive indirect effects through root density on FSL.

The genotypic correlation between fresh root length and fresh shoot length was positive (0.3708). The direct effect of fresh root length on fresh shoot length was positive (1.2671) whereas fresh root length has negative indirect effects through DSW, LT, RD, SR, RSL ratio while others have positive indirect effects through fresh root length on FSL. The genotypic correlation between root-shoot length ratio and fresh shoot length was negative (-0.4513). The direct effect root-shoot length ratio on fresh shoot length was higher but negative (-1.2441) whereas root-shoot length ratio has negative indirect effects through DRW, LT, RD and SR while others have positive indirect effects through root-shoot length ratio on FSL. The genotypic correlation between survival rate and fresh shoot length was positive (0.0408). The direct effect of survival rate on fresh shoot length was negative (-0.0821) whereas survival rate has negative indirect effects through DSW, LT, RD

and FRL while others have positive indirect effects through survival rate on FSL. The genotypic correlation between root dry weight and fresh shoot length was positive (0.3756). The direct effect of root dry weight on fresh shoot length was positive (0.6778) whereas root dry weight has negative indirect effects through DSW, RD, SR and RSL ratio while others have positive indirect effects through root dry weight on FSL. Similar findings were by Aslam and Tahir (2003) and Xu et al. (2007). The genotypic correlation between shoot dry weight and fresh shoot length was positive (0.5456). The direct effect of shoot dry weight on fresh shoot length was negative (-0.6466) whereas shoot dry weight has positive indirect effects through all traits except RD and SR while others have negative indirect effects through shoot dry weight on FSL, genotypic correlation between root-shoot weight ratio and fresh shoot length was negative (-0.1862). The direct effect of root-shoot weight ratio on fresh shoot length was negative (-0.5201) whereas root-shoot weight ratio has negative indirect effects through all traits except Chl.C and FRL while others have

positive indirect effects through shoot dry weight on FSL.

## Conclusions

The traits dry root weight, dry shoot weight, root density, survival rate and fresh shoot length were positively correlated at genotypic level could be used for the selection of better yielding lines under drought stress conditions. Investigations regarding path coefficient showed that fresh root length had maximum direct effect on fresh shoot length followed by dry root weight, root density, leaf temperature and dry shoot weight at three moisture levels. It was concluded that fresh root length, dry root weight, root density, leaf temperature and dry shoot weight are the characters which contribute largely to fresh shoot length of maize seedlings and selection can be made on the basis of these characters.

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