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Genetic Variability and Correlation among Seedling Traits of Wheat (*Triticum aestivum*) under Water Stress

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ABSTRACT

Purpose of the study was to determine the genetic variability and correlation among shoot length, root length, root-shoot ratio, fresh weight, dry weight, stomatal frequency and stomatal density of wheat seedlings under water stress. Significant differences were observed among genotypes for all the seedling traits studied under control (normal) and water stress. Under water stress length, fresh weight and dry weight of root and shoot, stomatal frequency and stomatal density decreased by 24.21, 1.27, 17.18, 25.00, 14.25 and 14.24%, respectively while root-shoot ratio increased by 31.18% over the control values. Correlation studies indicated that all the traits were significantly correlated except stomatal frequency with root length and between stomatal density and root length (r=0.054) under control conditions. All the traits were significantly correlated both under control and water stress. Root-shoot ratio showed negative correlation with all other traits.

Key Words: Genetic variability; Correlation; Wheat; Seedling traits

INTRODUCTION

Drought is arising threat of world. Most of the countries of the world are facing the problem of drought. It is the creeping disaster, slowly taking hold of an area and tightening its grip with time (Misra *et al.*, 2002). It can have devastating effects on agriculture and water supplies. Agriculture researchers are trying to develop crops that use water more efficiently i.e., with higher water use efficiency (WUE) (Misra, 1990 & 1994) and can perform better for yield even in water limited conditions. Wheat (*Triticum* spp.) is a worldwide cultivated grass from the Fertile Crescent region of the Near East. About 37% of the area of developing countries consists of semiarid environments in which available moisture constitutes a primary constraint on wheat production. Wheat is staple food of majority of the world. It is grown all over the world in arid and semiarid areas. There is dire need to make and select wheat genotypes that have no or only little effect of water stress.

Establishment of seedling is extremely important in determing the yield of crop in short period of time (Misra, 1990; Misra *et al*., 2002). Under rainfed conditions of arid and semiarid regions, low moisture is limiting factor during germination (Misra, 1990; Misra *et al.*, 2002). The rate and degree of seedling establishment are extremely important factors in determining both yield and time of maturity (Briggs & Aylenfisu, 1979). Seedling growth is also reported to be affected by limited water supply but effect is different for different cultivars (Ashraf & Abu-Shakra, 1978). Climatic variability greatly affects the performance of genotypes. Selection of genotypes with better performance in water stress conditions should increase production of rainfed areas (Rajaram, 2001; Rashidi & Seyfi, 2007).

Present study was carried out to determine the genetic variability among different genotypes of wheat and to compare them for association of different seedling parameters under normal and water stress conditions.

MATERIALS AND METHODS

Forty one diverse wheat genotypes collected from a gene pool maintained in the department of Plant Breeding and Genetics, University of Agriculture Faisalabad were taken for evaluation of different seedling traits under control and water stress conditions. The experiment was conducted in wire house in the department of Plant Breeding and Genetics, University of Agriculture Faisalabad. Lay out of completely randomized design with two replications was used for this experiment. Seeds were sown in 9" x 4" polythene bags in two environment i.e., control and water stress. Polythene bags were filled with sand. Nutrients were applied at first watering. Only one watering was applied to water stress environment after sowing and for control environment watering was applied at regular intervals. After six week data for the following parameter was taken.

Growth parameters: Shoot length was measured in centimeters (cm) from the base of shoot to the top. Length

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of three seedlings was measured from each replication and then average was calculated. Root length was measured in cm from base of shoot to tip to root. Root length of three seedlings was measured and then average was calculated. Root shoot ratio was measured by dividing root length to shoot length. Fresh seedlings were taken from the polythene bags and shoot weight of three seedlings from each replication was measured in grams (g) with the help of electronic balance. And then average was calculated. First seedlings were sun dried and then these were dried in oven for 72 h to attain constant shoot dry weight. Weight of three seedlings was measured in g with the help of electronic balance and then average was calculated.

Stomatal frequency: Three strips of about 4 cm length from the middle portion of the leaves collected at random from each replication in the morning when the leaves were fully turgid, were dipped into the Cornoy's solution for two days to arrest the stomatal structure and removal of chlorophyll content from the tissues. Acetone was used for washing out the chlorophyll from the strips, which were then stored in alcohol for data collection. Number of stomata per microscopic field (at 40 X magnifications) was counted from the upper portion of the strips from three different parts and average number of stomata per microscopic field was recorded.

Stomatal density: Stomatal density was measured as number of stomata/mm^2. Observations for stomata were made each from an area of 0.14862 mm^2 at 40× magnification. The average of three readings was converted to number of stomata/mm^2.

Statistical analysis: Data obtained was subjected to analysis of variance technique and simple correlation coefficients were calculated between the seedling traits and their significance was tested by using t-test (Steel & Torrie, 1980). The mean values of different traits were used to measure broad sense heritability (Burton & Devane, 1953).

RESULTS AND DISCUSSION

Analysis of variance showed presence of considerable variability among all genotypes as mean squares of all the genotypes were highly significant. Environment mean squares were significant for all the traits studied showing that the water stress has significant effect on seedling characters such as root length, shoot length, root-soot ratio, fresh weight, dry weight and stomatal frequency. G x E interaction was significant for all the traits except dry weight showing variation of genotypes over environments (Table I). This could provide scope for breeding for seedling characters, along with yield and its components, under drought stress conditions.

Table II showed that magnitude of mean performance for all the traits decreased in water stress environment except root-shoot ratio. Mean value of shoot length, root length, fresh weight, dry weight, stomatal frequency and stomatal density decreases 24.21, 1.27, 17.78, 25.00, 14.25 and 14.24%, respectively. Root length was very less affected by water stress. Thornley (1998) also reported no effect of water stress on root biomass, while value of root-shoot ratio increases by 31.18% under water stress environment. This may be due to more suppression of shoot length than root length under water stress conditions. So selection for higher root shoot ratio will be beneficial for selecting drought resistant genotypes. Reason for increased root-to-shoot length ratio under water stress may be the limited supply of water and nutrients to the shoot and some hormonal messages induced in roots when they encounter drought stress (Sharp & Davis, 1985; Misra, 1990 & 1994). Possible reason for decrease of mean value of seedling traits can be deficiency of water that slowed the physiological processes. The continued growth of roots in water stressed soil is particularly important to avoid the effect of water stress (Dhanda *et al*., 1995; Misra, 1990 & 1994). Stomatal frequency and stomatal density decreases under water stress conditions to avoid transpiration so that water losses would be minimum (Mehri *et al.,* 2009).

Table I: Mean squares of 41 wheat genotypes in control and water stress environments for various characters

Characters	Genotype (df = 40)	Environment (df = 1)	G × E (df = 40)	Error (df = 82)
Shoot Length	38.093**	950.024**	10.050**	0.444
Root length	9.396 **	4.764**	4.238**	0.407
Root-shoot ratio	0.066**	3.559**	0.039**	0.003
Fresh weight	0.024**	0.240**	0.005**	0.001
Dry weight	0.005**	0.013**	0.0004^{NS}	0.0003
Stomatal frequency	1.421**	15.244**	0.466**	0.075
Stomatal density	64.33**	689.743**	21.10**	3.417

** = Significant at 1%
^{NS} = Non-significant
df = degree of freedom
G × E = Genotype x Environment interaction

Broad sense heritability estimates among all the traits studied are very high under both control and water stress conditions. For root length and fresh weight broad sense heritability decreased under water stress conditions i.e., from 94.52 to 90.45 and from 94.59 to 91.29, respectively. While broad sense heritability remained round about constant for all other traits under both environments. Due to higher heritability estimates great benefits from selection might be expected for all the traits studied (Mehri *et al.*, 2009). However selection should be made very carefully as heritability is measured in broad sense, which may be influent. In addition to variability parameters correlation studies of these traits may enhance the efficiency of selection.

Correlation studies increases the possibility of indirect selection for different traits. This provides information to the breeder about importance of any trait. Simple correlation coefficient among all the traits was found significant under control environment except between stomatal frequency and root length and between stomatal density and root length (r = 0.054) where it was non-significant. Significant correlation was found between root-shoot ratio and root

Table II: Range, mean and percentage decrease under water stress (E_2) compared with control conditions (E_1) in bread wheat

Character	Environment	Range	Mean ± S.E	%decrease In E_2	$h^2_{B.S}$
Shoot length (cm)	E_1	12.95-29.00	19.86 ± 0.41	24.21	98.27
	E_2	9.00-22.50	15.05 ± 0.36		98.17
Root length (cm)	E_1	13.60-20.90	18.05 ± 0.20	1.27	94.52
	E_2	13.95-20.45	17.82 ± 0.18		90.45
Shoot root ratio	E_1	0.69-1.30	0.93 ± 0.01	-31.18	94.44
	E_2	0.87-1.63	1.22 ± 0.02		95.80
Fresh weight (g)	E_1	0.30-068	0.45 ± 0.01	17.78	94.59
	E_2	0.25-0.57	0.37 ± 0.01		91.29
Dry weight (g)	E_1	0.03-0.19	0.08 ± 0.00	25.00	96.72
	E_2	0.03-0.18	0.06 ± 0.00		95.12
Stomatal frequency	E_1	3.05-5.50	4.28 ± 0.08	14.25	96.52
	E_2	2.20-5.20	3.67 ± 0.08		97.57
Stomatal density	E_1	20.52-37.01	28.79 ± 0.51	14.24	96.52
	E_2	14.80-34.99	24.69 ± 0.51		97.57

S.E = standard error $h^2_{B.S}$ = broad sense heritability

Table III: Simple correlation coefficients of various characters among 41 genotypes under control conditions

Characters	Shoot length	Root length	Root-shoot ratio	Fresh weight	Dry weight	Stomatal frequency
Root length	0.715**					
Root-shoot ratio	-0.814**	-0.233*				
Fresh weight	0.585**	0.433**	-0.376**			
Dry weight	0.531**	0.330*	-0.420**	0.607**		
Stomatal frequency	0.265*	0.054^{NS}	-0.253*	0.431**	0.457**	
Stomatal density	0.265*	0.054^{NS}	-0.253*	0.431**	0.457**	1.00**

** = Significant at 1%
* = significant at 5%
^{NS} = Non-significant

Table IV: Simple correlation coefficients of various characters among 41 genotypes under water stress conditions

Characters	Shoot length	Root length	Root-shoot ratio	Fresh weight	Dry weight	Stomatal frequency
Root length	0.841**					
Root-shoot ratio	-0.948**	-0.681**				
Fresh weight	0.749**	0.633**	-0.631**			
Dry weight	0.640**	0.540**	-0.507**	0.781**		
Stomatal frequency	0.410**	0.419**	-0.317*	0.551**	0.415**	
Stomatal density	0.410**	0.419**	-0.317*	0.551**	0.415**	1.00**

** = Significant at 1%
* = significant at 5%
^{NS} = Non-significant

length (r = -0.233), between stomatal frequency and shoot length (r = 0.265), between stomatal density and shoot length (r = 0.265), between dry weight and root length (r = 0.330), between stomatal frequency and root- shoot ratio (r = -0.253) and between stomatal density and root-shoot ratio (-0.253). Root-shoot ratio was negatively correlated with all the traits, while all other traits were positively correlated. Value of correlation between root-shoot ratio and shoot length was highest but was negative, while correlation coefficient between stomatal frequency and root length and stomatal density and root length was minimum and non-significant. Stomatal frequency and stomatal density were linearly correlated having correlation value 1.00 (Table III).

Under water stress conditions correlation was highly significant for all the traits studied except stomatal frequency and root-shoot ratio (r = -0.317). Root-shoot ratio was negatively correlated with all the traits. Correlation between stomatal frequency and root length and between stomatal density and root length changes non-significant (r = 0.054) to highly significant (r = 0.419) under water stress conditions. While correlation between root-shoot ratio and root length (r = -0.233), between stomatal frequency and shoot length (r = 0.265), between stomatal density and shoot length (0.265) and between dry weight and root length (r = 0.330) changes significant to highly significant i.e., between root-shoot ratio and root length (r = -0.681), between stomatal frequency and shoot length (r = 0.410), between stomatal density and shoot length (r = 0.410) and between dry weight and root length (r = 0.540). Stomatal frequency and stomatal density were linearly correlated having correlation value 1.00 (Table III). Different response of traits under different environments for correlation may be due to different response of genotypes under different environments.

Results obtained are in accordance with Khan *et al.* (2002), Dhanda *et al.* (2004), Awan *et al.* (2007) and Rauf *et al.* (2007). As shoot length, root length, fresh weight, dry weight, stomatal frequency and stomatal density were positively correlated among themselves, therefore selection of anyone of these traits enhances the performance of other traits. As root-shoot ratio was negatively correlated with all other traits so selection for root-shoot ratio will decreases the performance of other seedling traits.

CONCLUSION

Analysis of variance indicates the variability of all the traits studied for all the genotypes. Genotypes with consistent performance in both environments should be selected for drought resistance. Higher values of broad sense heritability estimates showed that all the traits are highly heritable. Significant value of correlation showed that traits are strongly correlated. Significant negative correlation of root-shoot ratio indicates the importance of underground parts of plant. Strong correlation among all the traits under water stress conditions indicated the importance of these traits for future breeding programs of wheat under rain fed conditions. Selection should not be made for root-shoot ratio as it is negatively correlated with all other traits studied. These genotypes should also be evaluated under field conditions for correlation studies of yield related traits.

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