Pak. J. Agri. Sci., Vol. 51(2), 367-372; 2014
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

SCREENING OF SPRING WHEAT (*Triticum aestivum* L.) GENOTYPES FOR DROUGHT TOLERANCE ON THE BASIS OF SEEDLING TRAITS

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The studies were conducted to determine the genetic variability and correlation amongst root length shoot length, root-shoot ratio, shoot fresh and dry weight of wheat seedlings under normal and drought conditions for screening drought tolerant genotypes. Under drought condition root length, shoot length, shoot fresh and dry weight decreased by 26.19, 26.63, 44.26 and 58.78%, respectively. Significant and positive correlation was found among most of the seedling traits under both plantings except root-shoot ratio which exposed negative correlation with shoot length under both the conditions. Results revealed that all the seedling traits significantly differed among all genotypes of wheat under both environmental conditions. The varieties Chakwal-86, Chakwal-50 and line 6302 were screened as drought tolerant, while Faisalabad-08, Lasani-06 and Sehar-06 as drought susceptible.
Keywords: Wheat, genotypic variability, varietal screening, correlation, heritability

INTRODUCTION

Crop plants undergo several environmental stresses, which lead to significant reduction in production (Seki *et al*., 2003; Farooq *et al*., 2011). Among these environmental stresses drought is considered one of the most devastating factor, which cause significant reduction in crop productivity (Lambers *et al*., 2008; Noorka and Heslop-Harrison, 2013, 2014). It disrupts normal growth, impairs water relations and reduces water use efficiency in plants (Aroca, 2012). The main consequences of drought in crop plants are reduced rate of cell division and expansion, lower leaf size, slows down stem elongation and root proliferation. It also disturbs stomatal oscillations, plant water and nutrient relations with diminished crop productivity and water use efficiency (Rasool, 2008; Li *et al*., 2009; Farooq *et al*., 2009). Shortage of water accelerates the biosynthesis of abscisic acid (ABA), which decreases stomatal conductance to minimize transpirational losses (Yamaguchi-Shinozaki and Shinozaki, 2006). There is dire need to make selection of wheat genotypes that have no or only little effect of water stress.

Vigorous seedling is extremely important in determining the yield of crop in short period of time (Chowdhry *et al*., 1999; Misra *et al.,* 2002; Noorka and Khaliq, 2007). Under rainfed conditions of arid and semi-arid regions, low moisture is limiting factor during germination (Misra, 1990; Misra *et al.,* 2002; Amal *et al*., 2010). A variety with water stress tolerance has more impregnable rooting abilities to encourage the absorption of soil moisture and diminishes the effects of water shortfall on growth (Zhong and Wang, 2012). Root, the foremost part of wheat plant, is attacked first by water stress. Long roots ensure availability of moisture from depth of the soil and guarantee the adaptation in drought stress conditions. Root to shoot ratio and root length at early stages of plant development are valuable attributes for improving yield under arid and semiarid conditions (Dhanda *et al*., 2004; Shahbazi *et al*., 2012). Seedling growth is also reported to be affected by limited water supply but effect is different for different cultivars (Aziz *et al*., 2011; Noorka, 2014). Environmental variability greatly affects the performance of genotypes. Selection of genotypes with better performance in water stress condition could increase production of rainfed areas (Rajaram, 2001; Rashidi and Seyfi, 2007; Noorka and Teixeira da Silva, 2012; Waqas *et al*., 2013). Screening of genotypes on the basis of seedling traits is easy, less expensive and less laborious. Similarly, seedling traits exhibit moderate to high variability with additive gene action across environment (Rauf *et al.,* 2008), thus have a benefit of efficient selection at early stage.

The following study was conducted for screening of 50 diverse wheat genotypes for drought tolerance on the basis of seedling traits and to determine association of different seedling parameters under normal and water stress conditions.

MATERIALS AND METHODS

Fifty wheat genotypes were collected from National Agricultural Research Centre (NARC) Islamabad, Ayub Agriculture Research Institute (AARI) Faisalabad, Barani Agricultural Research Institute (BARI) Chakwal, Regional Agricultural Research Institute (RARI) Bahawalpur, Arid Zone Research Institute (AZRI) Bhakkar and University of Agriculture Faisalabad (UAF) and subjected to the screening experiments.

The genotypes were sown in two environmental conditions viz., normal and drought in the wire house of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad (Pakistan), using Complete Randomized Design with three replications during the crop season 2008-2009. The seeds were sown in polythene bags (18 × 9cm) filled with sandy loam soil (pH 7.8 and E.C 1.7dSm^{-1}). Fifteen plants of each genotype per replication per set of experiment were grown. After germination one seedling was maintained in one polythene bag. Plants under normal condition (control) were irrigated to maintain soil-water contents close to the field capacity. In the drought experiment the irrigation was withheld immediately after the completion of germination. Plants were harvested at three leave stage and cleaned carefully to remove soil from the seedlings and plants were kept in Kraft paper bags.

Data was collected on seedling traits viz., root length, shoot length, shoot fresh weight, shoot dry weight and root to shoot (length) ratio. Collected data was subjected to analysis of variance (Steel *et al*., 1997) and simple correlation coefficients (Pearson, 1920) were calculated between the seedling traits and their significance was tested. Broad sense heritability was estimated following method of Lush (1940).

RESULTS AND DISCUSSION

Analysis of variances (Table 1) depicted presence of genetic variability amongst all genotypes in both environmental conditions as mean squares of the genotypes were highly significant. Different genotypes responded differently under normal condition (Table 2) and ranged 9.350cm (line-9438) to maximum 19.998cm (Faisalabad-08) followed by 19.242cm (Lasani-08) and 18.462 cm (Sehar-06). Root length under drought condition was reduced and ranged 3.942 cm (AS-2002) and maximum 17.866cm (Chakwal-86) highest was followed by 17.469cm (Line-6302) and 15.281 cm (Chakwal-50). Shoot length in normal condition ranged 17.101 cm (AS-2002) to 33.502 cm (Faisalabad-08) the maximum value was followed by 32.792cm (Lasani-08) and 31.452 cm (Sehar-06) whereas under-shoot length like root length decreased and ranged 6.922cm (AS-2002) to 30.256 cm (Chakwal-86) which was followed by 29.203cm (6302) and 25.403 cm (Chakwal-50) under drought conduction. Genotype AS-2002 attained minimum value of shoot fresh weight (0.132g) and Faisalabad-08 maximum value (0.473g) and highest value was followed by Sehar-06 (0.466g) and Lasani-08 (0.465g) under normal condition. Whereas, minimum value (0.056g) was again possessed by AS-2002 as under normal condition and highest value (0.349g) for line-6302, the maximal value was followed by Chakwal-86 (0.335g) and chakwal-50 (0.225g) in drought condition. Dry shoot weight under normal condition ranged 0.010g for AS-2002 and line-9444, while maximum value 0.069g was displayed for Faisalabad-08 which was followed by 0.066g for Sehar-06 and 0.062g for Lasani-08. Whereas in drought condition dry shoot weight ranged minimum as 0.003g again for AS-2002 like normal condition and maximum value 0.041g for line- 6302 followed by 0.040g for Chakwal-86 and 0.030g for Chakwal-50 (Table 2).

Root length was less affected by water deficit as compared to other seedling traits. Similar findings were reported by Thornley (1998). Limited supply of water and nutrients under water stress condition often results growth inhibition of shoot than roots. Some hormonal messages are also induced in roots when they encountered drought stress (Sharp and Davis, 1985; Misra, 1990, 1994; Noorka *et al*., 2009). Possible reason for decrease in mean value of seedling traits may be water deficit that slowed down the physiological processes. The continuous growth of roots in water stressed soil is principally essential to avoid the effect of water stress (Misra, 1990, 1994; Dhanda *et al.,* 2004; Noorka and Teixeira da Silva, 2012). The mean performance of all the genotypes under normal and drought conditions are presented in Table 2. The maximum root length among all genotypes was attained by the genotype Faisalabad-08 followed by Lasani-08 and Sehar-06 under normal irrigation condition which deceased drastically under drought condition. Under water stress condition the genotype Chakwal-86 possessed maximum root length followed by genotypes 6302 and Chakwal-50. These genotypes also performed well under normal condition and showed tolerance under drought. Thus Faisalabad-08, Lasani-08 and Sehar-06 were screened as drought susceptible and Chakwal-86, line 6302 and Chakwal-50 as drought tolerant genotypes.

Table 1. Mean squares of 50 wheat genotypes under normal and drought conditions for various characters

Characters	Genotype (df = 49)	Environment (df = 1)	G × E (df = 49)	Error (df = 200)
Root length	37.65100**	942.5350**	8.66400**	1.48700000
Shoot Length	95.86000**	4019.2200**	26.64000**	2.16000000
Root-shoot ratio	0.02705**	0.0020 NS	0.00017 NS	0.00458000
Shoot fresh weight	0.02696**	1.3641**	0.00992**	0.00000250
Shoot dry weight	0.00072**	0.0400**	0.00026**	0.00000078

** = P >0.01 ,NS=Non-significant

Table 2. Mean values of seedling traits of 50 genotypes of wheat under normal and drought conditions.

Genotypes	Root length (cm)		Shoot length (cm)		Shoot fresh weight (g)		Shoot dry weight (g)		Root shoot ratio	
	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
2862	12.772	10.250	25.251	20.101	0.210	0.160	0.019	0.012	0.507	0.513
6206	15.500	13.351	28.552	23.750	0.282	0.195	0.041	0.020	0.543	0.562
6237	14.790	11.021	30.011	22.301	0.339	0.188	0.049	0.019	0.494	0.496
6238	12.703	8.450	29.501	19.151	0.345	0.154	0.056	0.013	0.432	0.444
6253	12.251	7.401	28.302	16.150	0.281	0.098	0.043	0.010	0.432	0.458
6284	12.451	10.251	26.470	21.352	0.255	0.179	0.023	0.014	0.470	0.482
6301	10.502	8.211	26.014	21.051	0.238	0.173	0.020	0.011	0.403	0.391
6302	18.042	17.469	30.852	29.203	0.424	0.349	0.061	0.041	0.586	0.599
6309	12.602	10.252	30.501	25.022	0.406	0.212	0.053	0.023	0.413	0.413
6312	13.252	11.154	29.600	25.151	0.366	0.221	0.049	0.021	0.450	0.444
6314	14.502	12.151	29.502	25.104	0.345	0.225	0.047	0.028	0.491	0.484
6316	13.852	5.522	25.122	10.231	0.200	0.098	0.018	0.008	0.553	0.556
6317	14.351	12.571	26.323	22.852	0.240	0.181	0.021	0.012	0.548	0.551
8186	12.252	10.502	26.504	22.251	0.241	0.186	0.023	0.012	0.466	0.474
8188	13.251	10.192	28.422	21.591	0.282	0.179	0.043	0.014	0.469	0.476
8191	14.428	10.995	28.251	20.753	0.278	0.169	0.042	0.014	0.511	0.535
9021	16.201	13.254	29.150	23.122	0.346	0.193	0.049	0.015	0.555	0.576
9189	11.404	8.758	23.504	17.754	0.189	0.118	0.014	0.008	0.486	0.496
9191	10.152	6.101	26.852	16.302	0.251	0.105	0.024	0.008	0.377	0.381
9193	9.501	8.102	28.551	23.961	0.283	0.201	0.046	0.021	0.334	0.339
9194	12.901	10.503	29.252	23.200	0.348	0.193	0.049	0.014	0.442	0.453
9244	15.502	12.502	27.507	21.451	0.325	0.179	0.039	0.019	0.565	0.584
9247	12.951	10.501	27.752	23.152	0.329	0.194	0.040	0.015	0.466	0.456
9381	12.002	10.202	22.252	18.251	0.185	0.142	0.015	0.007	0.542	0.559
9438	9.350	6.451	18.530	12.352	0.145	0.108	0.010	0.005	0.508	0.527
9444	15.001	12.162	30.011	24.251	0.419	0.209	0.054	0.021	0.502	0.504
9452	14.002	9.451	31.254	20.401	0.437	0.165	0.059	0.013	0.447	0.464
9476	13.322	7.228	24.252	13.152	0.198	0.116	0.017	0.009	0.550	0.552
AS-02	9.731	3.942	17.101	6.922	0.132	0.056	0.010	0.003	0.571	0.585
Aas	15.301	12.751	28.251	23.503	0.282	0.195	0.043	0.015	0.542	0.546
Chakwal-50	16.281	15.281	28.012	25.404	0.280	0.225	0.042	0.030	0.582	0.602
Chakwal-86	17.934	17.866	30.751	30.256	0.421	0.335	0.059	0.040	0.583	0.591
Chakwal-97	14.182	11.353	30.152	25.002	0.414	0.224	0.050	0.029	0.470	0.455
Faisalabad-08	19.988	9.692	33.502	16.733	0.473	0.109	0.069	0.009	0.597	0.585
Fareed-06	14.095	10.222	24.754	17.901	0.191	0.149	0.019	0.011	0.571	0.571
GA-02	10.057	6.063	20.001	12.011	0.168	0.104	0.017	0.007	0.505	0.512
Kohinoor-83	12.402	9.573	27.501	20.452	0.316	0.168	0.036	0.014	0.452	0.468
Lasani-08	19.242	6.477	32.792	11.161	0.465	0.098	0.062	0.011	0.588	0.580
Lu-26	16.451	13.701	30.251	25.350	0.419	0.225	0.061	0.029	0.544	0.542
Manthar-03	11.512	9.012	28.903	23.123	0.292	0.193	0.046	0.015	0.402	0.392
Meraj-08	14.351	11.251	30.501	23.481	0.424	0.199	0.050	0.017	0.472	0.481
Nesser	15.252	12.752	28.153	24.351	0.290	0.224	0.042	0.025	0.543	0.525
Pak 81	13.151	10.051	29.501	22.741	0.345	0.188	0.040	0.020	0.446	0.447
PBW	13.232	11.004	29.122	24.022	0.364	0.219	0.038	0.021	0.458	0.460
Perwaz-94	9.639	4.797	19.023	9.151	0.151	0.069	0.043	0.006	0.510	0.524
Punjab-81	11.663	9.388	20.752	16.562	0.173	0.104	0.020	0.009	0.566	0.569
Sehar-06	18.462	9.268	31.452	15.951	0.466	0.104	0.066	0.014	0.587	0.585
Shalimar-99	11.502	9.502	30.104	24.743	0.421	0.215	0.049	0.028	0.383	0.388
Ufaq-02	11.151	5.251	28.061	13.501	0.281	0.101	0.041	0.014	0.397	0.389
Uqab-00	11.351	5.312	27.782	12.753	0.278	0.098	0.039	0.015	0.409	0.416

S.E	0.70	0.71	0.90	0.79	0.00104	0.000704	0.0049	0.00049	0.030	0.046

Table 3 indicates that under normal condition root length, shoot length, root/shoot length ratio, shoot fresh weight and shoot dry weight ranged 9.350 to 19.998 cm, 17.101 to 33.502cm, 0.334 to 0.597cm, 0.132 to 0.473cm and 0.010 to 0.069cm, respectively. While under drought condition ranged 3.942 to 17.866 cm, 6.922 to 30.256cm, 0.339 to 0.599 cm, 0.056 to 0.349 cm, 0.0034 to 0.041 cm, respectively. Water stress affected seedling traits adversely, reduction in root length, shoot length, shoot fresh weight, shoot dry were recorded 26.19, 26.63, 44.26, 58.78%, respectively. Water stress has significant effect on seedling traits (root length, shoot length, shoot fresh and dry weight) as range of means in drought decreased in almost all traits except root shoot ratio which increased as compared to normal condition. Mean value of root length, shoot length, fresh weight and dry weight decreased 26.19, 26.63, 44.26 and 58.78 %, respectively (Table 3).

Broad sense heritability estimates for all traits under study were higher both under normal and drought conditions except for root-shoot ratio which appeared moderate under normal condition and low under drought condition. For root length, shoot length and shoot dry weight, broad sense heritability showed an increase under drought condition (Table 3) which resulted due to proportional increase in genetic variance in the total variance inherited for these traits. This is the natural behavior under drought where genetic factors become more proactive and sufficiently contribute towards total genetic variance. High heritability (broad sense) estimates under normal condition also showed preponderance of genetic variation in the total variability whereas medium to low heritability proposed that environmental effects accounted for a major portion of total phenotypic variation which was also reported by Farshdfar *et al.* (2000) and Khaliq *et al.* (2009).

Information about the association of seedling traits may further help to formulate the strategies for indirect selection. Under normal planting, simple correlation coefficients of root length with shoot length, shoot fresh weight, shoot dry weight and root shoot ratio were positive and significant. Correlation of shoot length with shoot fresh weight and dry weight was also found positive and significant whereas its relationship with root-shoot ratio was negative and non-significant. Association of shoot fresh weight with shoot dry weight was positive and significant while it was negative and non-significant with root shoot ratio. Relationship between shoot dry weight and root shoot ratio was negative and non-significant (Table 4).

Almost the same response was observed under drought condition. Positive and significant association of root length with shoot length, shoot fresh & dry weight and root-shoot ratio was found. Shoot length denoted positive and significant correlation with shoot fresh weight and shoot dry weight but negative and non-significant with root shoot ratio. Shoot fresh weight had positive and significant relationship with shoot dry weight and non-significant with root shoot ratio. Correlation between shoot dry weight and root shoot ratio was positive and non-significant (Table 5).

Table 3. Range, mean and percentage decrease under normal irrigation conditions (E1) and drought condition (E_2) in wheat

Character	Environment	Range	Mean ± S.E	%decrease In E2	h^2 (b.s.)
Root length (cm)	E1	9.350-19.998	13.534 ±0.700	26.19	80.28
	E2	3.942-17.866	9.989 ±0.708		84.91
Shoot length (cm)	E1	17.101-33.502	27.489 ±0.902	26.63	83.41
	E2	6.922-30.256	20.169 ±0.790		93.54
Root-Shoot ratio	E1	0.334-0.597	0.495 ±0.031	-1.01	55.43
	E2	0.339-0.599	0.500 ±0.0461		28.53
Shoot fresh weight (g)	E1	0.132-0.464	0.305 ±0.00104	44.26	98.96
	E2	0.0562-0.349	0.170 ±0.000746		98.95
Shoot dry weight (g)	E1	0.010-0.0686	0.0393 ±0.000521	58.78	96.86
	E2	0.0034-0.0415	0.0162 ±0.00498		98.94

S.E = Standard error, h^2 (b.s.) = broad sense heritability

Table 4. Simple correlation coefficients of between seedling traits of fifty wheat genotypes under normal condition

Characters	Shoot length	Shoot fresh weight	Shoot dry weight	Root-Shoot ratio
Root length	0.670**	0.677**	0.622**	0.646**
Shoot length		0.911**	0.831**	-0.131^{NS}
Shoot fresh weight			0.894**	-0.023^{NS}
Shoot dry weight				-0.019^{NS}

** = P≤ 0.01, NS = Non-significant

Table 5. Simple correlation coefficients between seedling traits of fifty wheat genotypes under drought condition

Characters	Shoot length	Shoot fresh weight	Shoot dry weight	Root-Shoot ratio
Root length	0.874**	0.882**	0.702**	0.360*
Shoot length		0.933**	0.711**	-0.123^{NS}
Shoot fresh weight			0.813**	0.014^{NS}
Shoot dry weight				0.047^{NS}

** = P≤ 0.01, NS = Non-significant

The strongest correlation was observed between shoot length and shoot fresh weight under both environmental conditions. Results obtained were in accordance with Khan *et al.* (2002), Dhanda *et al.* (2004), Awan *et al.* (2007) and Rauf *et al.* (2007). As root length had positive and significant correlation with shoot length, shoot fresh weight and dry weight under both environmental conditions therefore selection on root length basis was considered feasible.

***Conclusion*:** High broad sense heritability values indicated that all the seedling traits were highly heritable except root-shoot ratio. A strong association was observed for root length and shoot related traits except root shoot ratio. Negative relationship of root-shoot ratio with shoot length and positive with root length indicated the significance of underground part of plant under water deficit condition. Strong association amongst the characters under drought condition indicated the significance of these attributes for future wheat breeding programs for rainfed areas.

Selection for traits showing high heritability will be effective. The genotypes Chakwal-86, 6302 and Chakwal-50 were termed as drought tolerant and Faisalabad-08, Lasani-06 and Sehar-06 as drought susceptible genotypes.

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