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Full Length Research Paper

Performance of wheat genotypes under osmotic stress at germination and early seedling growth stage

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Sixteen wheat genotypes including local varieties were tested in completely randomized design with three repeats. Data were recorded at four different moisture levels by using polyethylene glycol (PEG) 6000 on germination percentage, germination rate index, shoot length, root length, fresh weight of shoot, dry weight of shoot, fresh weight of root, dry weight of root, shoot/root ratio and analysed for significance. The genotypes differ significantly in response to the moisture stress. There were highly significant differences for all traits. PK-18199 gave the maximum germination percentage, germination rate index, shoot length root length, coleoptile length, fresh shoot weight, dry shoot weight, fresh root weight, dry root weight and root/shoot ratio under all four moisture stresses. PK-18175 showed maximum resistance against moisture stress while WAFAQ 2001 showed minimum resistance. AS-2002 and KC033 also gave the better performance under all four moisture levels for most of the traits at seedling stage. 99FJ03 gave maximum root/shoot length ratio while PK 18199 gave minimum value of root/shoot length ratio showing resistance against water stress.

Key words: Wheat genotypes, seedling traits, moisture stress, PEG-6000.

INTRODUCTION

Wheat is one of the most important cereal crops of the world. In most areas of the world, wheat is a principal food. In Pakistan, wheat is a staple food and thus occupies central position in farming and agriculture policies. It contributes 13.8% value added to agriculture and 3.4% to GDP. During 2003-04 wheat was cultivated on an area of 8176 thousand hectares, showing 1.8% increase over the previous year with the production of 19767 thousand tones which was 3.0% higher than the previous year (GOP, 2003-04).

Seed germination and vigor are prerequisites for the success of stand establishment of crop plants. Under rainfed conditions of arid and semiarid regions, low moisture is limiting factor during germination. The rate and degree of seedling establishment are extremely important factors in determining both yield and time of maturity (Brigg and Aylenfisu, 1979). Seed germination is major problem of wheat (*Triticum aestivum* L.) production. It is influenced by many environmental factors, but the availability of soil moisture has a major effect on germination and subsequent emergence. Besides the reduction in total germination, comparatively low soil moisture availability results in delayed emergence, a criterion of particular importance in the vigor and subsequent yielding ability of many crops (Azam and Allen, 1976). Germination rate and seedling growth have been reported to decrease at low moisture levels. The rate of decline was found to be obvious, varying with crop species and cultivars (Ashraf and Abu-Shakra, 1978).

The objectives of this study were to compare the response of spring wheat genotypes to water stress in the germination, seedling elongation, seedling fresh and dry weight and emergence of whole establishment period and to explore the relationship among water stress level and drought tolerance mechanism. This will provide a

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Table 1. List of wheat varieties and their source.

No.	Name of genotype	Source
V1	3C062	BARI, Chakwal
V2	33C065	BARI, Chakwal
V3	3C067	BARI, Chakwal
V4	1C001	BARI, Chakwal
V5	INQALAB	AARI, Faisalabad
V6	CHAKWAL 97	BARI, Chakwal
V7	GA 2002	BARI, Chakwal
V8	99 FJ03	BARS, FatehJang
V9	IQBAL 2000	AARI, Faisalabad
V10	UQAB 2000	AARI, Faisalabad
V11	AS 2002	AARI, Faisalabad
V12	2KC033	BARI, Chakwal
V13	WAFAQ 2001	NARC, Islamabad
V14	MARGALLA 99	NARC, Islamabad
V15	PK 18175	Indigenous line of Balochistan
V16	PK 18199	Indigenous line of Balochistan

theoretical basis on improving seedling drought resistance abilities of dryland farming in the semiarid regions.

MATERIALS AND METHODS

The experiment was conducted in laboratory of Department of Plant Breeding and Genetics, University of Arid Agriculture, Rawalpindi, Pakistan. It was laid out according to the completely randomized design with three repeats. Forty wheat genotypes (Table 1) were used to study the effect of low moisture stress by using polyethylene glycol (PEG) 6000. Solution was prepared according to weight by volume i.e. 0 (T_1, distilled water, control) 150 g (T_2), 200 g (T_3) and 250 g (T_4) PEG was dissolved in 850 ml, 800 ml and 750 ml of distilled water, respectively, along with control (distilled water). Seeds were placed on the moist germination papers and PEG solution was applied on the papers to provide appropriate moisture stress for seed germination (Afzal et al., 2004). The seeds were covered with another germination paper. The papers were folded and kept in growth chamber at 25°C.

Data were recorded at four different moisture levels on germination percentage, germination rate index, shoot length, root length, fresh weight of shoot, dry weight of shoot, fresh weight of root, dry weight of root, shoot/root ratio.

The data collected were analyzed statistically using analysis of variance techniques to workout significant differences among genotypes. Duncan's New Multiple Range Test was applied at 5 percent level of probability to compare the mean differences, as explained by Steel and Torrie (1980). Simple correlation coefficient between different traits at seedling stage was also computed. The significance of correlation was tested against the value of t-tabulate.

RESULTS AND DISCUSSION

Variation among genotypes

The differences among the water stress treatments for all the traits were highly significant (Table 2). There was decrease in germination percentage and seedling growth with increase in concentration of PEG. The maximum value for germination percentage, germination rate index, shoot length, root length, coleoptile length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight was observed in control (distilled water) and minimum value was observed in 25% PEG. The differences among genotypes were also highly significant for all the traits (Table 3). PK-18199 showed maximum values of germination percentage (98%), germination rate index (18.08), shoot length (8.69 cm), root length (9.92 cm), coleoptile length (4.37 cm), fresh shoot weight (0.329 g), dry shoot weight (0.177 g), fresh root weight (0.323 g) and dry root weight (0.12 g). Wafaq-2001 showed minimum values of germination percentage (86.7%), germination rate index (9.62), shoot length (4.61 cm) and root length (6.90 cm). 1C001 showed minimum coleoptile length i.e.1.75 cm. The genotype 3C062 showed minimum fresh shoot weight (0.189 g) and minimum dry shoot weight (0.098 g). Uqab-2000 had minimum fresh weight of root (0.175 g) and Inqalab-91 showed minimum dry root weight (0.059 g). The maximum root/shoot ratio was observed in 99FJ03 (2.15) and minimum root/shoot ratio (1.41) was shown by PK-18199.

Correlation studies among different characters

That germination percentage showed positive and highly significant correlation with shoot length, root length, coleoptile length, fresh weight of root and dry weight of root. Fresh shoot weight and dry shoot weight showed positive and significantly correlation with germination percentage. There was negative and no significant correlation between germination percentage and root/shoot length ratio. Germination rate index (GRI) showed highly significant and positive correlation with shoot length, root length, coleoptile length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight. While non-significant and negative correlation was observed betw-

Table 2. Mean value of various treatments of wheat genotypes under different stress levels tested at University of Arid Agriculture, Rawalpindi during 2004-2005.

Treatment	Germination percentage	GRI	Shoot length	Root length	Coleoptile length	Fresh shoot weight	Dry shoot weight	Fresh root weight	Dry root weight	root/shoot ratio
T1	98.8a	18.75a	12.0a	13.4a	4.1a	0.36a	0.205a	0.37a	0.15a	1.14c
T2	98.7b	16.64b	5.49b	9.6b	3.5b	0.25b	0.121b	0.24b	0.10b	1.85b
T3	96.4b	9.87c	3.91c	6.5c	2.0c	0.20c	0.103c	0.17c	.06c	1.81b
T4	77.1c	5.10d	1.43d	3.3d	1.1d	0.12d	0.058d	.05	.03d	2.32a

Table 3. Mean values for various traits of wheat genotypes under different stress levels tested at University of Arid Agriculture, Rawalpindi during 2004-2005.

Germination percentage	GRI	Shoot length	Root length	Coleoptile length	Fresh shoot weight	Dry shoot weight	Fresh root weight	Dry root weight	root/shoot ratio
90.7defg	10.12g	5.57f	7.41e	1.84j	0.189g	0.098h	0.213ef	0.078d	1.45g
90.7defg	12.30d	5.23g	8.47bcd	2.05i	0.217f	0.106gh	0.218de	0.083d	1.96b
93.3bcde	13.43bc	5.21gh	7.94d	2.08i	0.197g	0.113efg	0.213ef	0.078d	1.97b
89.3efg	11.73f	4.91ij	7.05e	1.75j	0.213f	0.122d	0.220de	0.082d	1.61ef
88.7fg	10.51g	4.66jk	7.23e	1.82j	0.252de	0.122d	0.183i	0.059d	1.69de
93.3bcde	12.16ef	4.94hi	7.97d	2.46h	0.220f	0.108fg	0.200gh	0.078d	2.02ab
91.3cdef	12.03ef	5.04ghi	8.38cd	2.60g	0.233de	0.114d-g	0.204fg	0.081d	2.02b
90.7defg	10.58g	5.26g	8.93bc	2.73f	0.241d	0.121de	0.226cd	0.083d	2.15da
97.0ab	13.23c	6.38c	8.58bc	3.07d	0.214f	0.107gh	0.201gh	0.075d	1.67def
90.3defg	12.77cd	5.73ef	8.77bd	2.91e	0.228e	0.113efg	0.175i	0.074e	1.83c
94.7abcd	12.88cd	6.15cd	8.43cd	3.38c	0.252c	0.129c	0.229c	0.090c	1.71de
97.3ab	14.12bc	5.93de	8.36cd	2.92e	0.243de	0.134c	0.191h	0.087c	1.64def
86.7g	9.62h	4.61k	6.90e	2.39h	0.233de	0.116def	0.181i	0.071e	1.74cd
94.3abcd	13.07cd	5.67ef	8.87bc	2.91e	0.252c	0.122d	0.198gh	0.074e	2.05ab
97.7ab	17.68a	7.39b	9.06b	3.71b	0.287b	0.153b	0.255b	0.10b	1.57f
98.0a	18.08a	8.69a	9.92a	4.37a	0.329a	0.177a	0.323a	0.12a	1.41g

Table 4. Correlation coefficient among various traits of wheat genotypes tested at University of Arid Agriculture, Rawalpindi during 2004-05.

	GRI	Shoot length	Root length	Coleoptile length	Fresh weight of shoot	Dry weight of shoot	Fresh weight of root	Dry weight of	root/shoot ratio
Germination %age	0.83**	0.80**	0.71**	0.76**	0.51*	0.57*	0.55**	0.66**	-0.28NS
GRI		0.90**	0.75**	0.80**	0.74**	0.79**	0.74**	0.84**	-0.39NS
Shoot length			0.78**	0.88**	0.78**	0.80**	0.80**	0.87**	-0.54*
Root length				0.84**	0.69**	0.58*	0.60**	0.69**	0.06NS
Coleoptile length					0.85**	0.78**	0.64**	0.77**	-0.27NS
Fresh weight of						0.94**	0.72**	0.76**	-0.30NS
Dry weight of shoot							0.77**	0.82**	-0.46NS
Fresh weight of root								0.92**	-0.38NS
Dry weight of root									-0.41NS

*, ** Significant at 0.05 and 0.01 probability level, respectively.
NSNon Significant.

een germination rate index (GRI) and root/shoot length ratio. Shoot length showed highly significant and positive correlation with root length, coleoptile length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight. There was significant and negative correlation between shoot length and root/shoot length ratio. These results are also supported by findings of Khan et al. (2002) that root length exhibited positive and significant correlation with coleoptile length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight. While the correlation between root length and root/shoot length ratio was negative and non-significant, coleoptile length showed highly significant and positive correlation with fresh shoot weight, dry shoot weight, fresh root weight and dry root weight. While there was non-significant and negative correlation between coleoptile length and root/shoot length ratio, fresh weight of shoot gave positive and highly significant correlation with dry shoot weight, fresh root weight and dry root weight. Non-significant and negative correlation was observed betw-een fresh shoot weight and root/shoot length ratio. Dry shoot weight showed highly significant and positive correlation with fresh weight of root and dry root weight. While there was non-significant and negative correlation between dry shoot weight and root/shoot length ratio, fresh weight of root had positive and highly significant correlation with dry root weight. There was non-significant and negative correlation between fresh root weight and root/shoot length ratio. Non significant and negative correlation between fresh root weight and root/shoot length ratio was observed (Table 4).

Other workers including Singh et al. (1994) Ambawatia (1995), Akram et al. (1998) Baalbaki et al. (1999), Rakesh et al. (1999), Moayyed (2001) and Khan et al. (2002) also conducted similar studies and showed that germination and growth of wheat seedlings were affected significantly with change in water stress levels. Traits of these genotypes can be incorporated in to other high yielding varieties to get maximum plant population and yield under low moisture levels such as barani areas of Punjab (Pakistan). Furthermore there is a need that these genotypes be evaluated under field conditions and correlated with these traits.

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