EXPRESSION OF VARIOUS PHYSIOLOGICAL TRAITS IN BREAD WHEAT AGAINST DROUGHT STRESS

ABSTRACT

Wheat, the world's third important cereal, is cultivated in Pakistan both in irrigated and rainfed areas. One of the major constraints of wheat production in rainfed area is drought that needs to be addressed. Although many genotypes were released that were tolerant to drought stress by improving various physiological traits but there is a need to lessen the effects of drought to boost wheat productivity. The present study was designed to evaluate different genotypes by analyzing various physiological traits such as proline content, cell membrane stability, relative water content and chlorophyll content to check their association with drought stress in different wheat genotypes. The research material consisted of sixteen different wheat genotypes. The experiment was planted during Rabi 2013-14 following Randomized Complete Block Design with three replications. Drought stress was induced by withholding water for 30 days at heading and anthesis stage. Data of various physiological traits were recorded; statistically analyzed and interpreted. Significant variation was observed for studied traits which revealed that selection can be performed to improve the genotypes. Among tested wheat genotypes, Maxi-Pak was found to be potential variety that can be used in future wheat breeding programme for rainfed conditions.

Key words: Wheat, cell membrane stability, proline content, chlorophyll content, drought.

INTRODUCTION

Triticum aestivum L., a cereal grain, is the third most produced cereal after maize and rice. Improvement in wheat yield came through dwarfing genes which was first used by Japanese wheat breeders and it was major cause of green revolution. Dwarf varieties prevent losses that occur from lodging. Wheat is grown as a food crop for human but 10 % is saved for seed and industry purpose. Earlier selection was done for improving those characters which were associated with domesticated wheat improvement. Wheat is a complex crop as regards the selection and breeding. Water stress is worldwide issue which predicts the sustainable agricultural production [1]. Drought leads to stomata closure and reduction of water content, turgor loss. Sometime it leads to death of plant by disturbance of metabolism [2]. Drought affects the physiological traits of wheat crop. Efforts have been made to improve the yield of wheat crop under rainfed condition by improving the traits which are affected by drought. Main problem faced by wheat growers in rainfed region is water stress. Water stress not only affects the morphological traits but also affects the physiological traits; severity of stress depends on

cultivar, growth stage, duration and intensity of stress. All the stages respond differently to water stress, some stages can cope with the stress by maintaining its water potential or turgor pressure or efficient utilization of water. Water stress can reduce the biomass, tillering ability, grain size etc. Photosynthesis is the process that is affected by drought first; various factors that contribute to photosynthesis include chlorophyll content, relative water content and various pigments. Drought causes leaf senescence in various wheat genotypes thus causing the chlorophyll degradation. Proline is an amino acid, which accumulates during various stresses as an osmo-regulatory protein, genotypes that accumulate more proline shows tolerance towards stress by maintaining the plant water potential. The present study was conducted to evaluate response of different wheat genotypes for various physiological traits under drought stress.

MATERIALS AND METHODS

The present study was conducted in the field area of the Department of Plant Breeding and Genetics, PMAS Arid Agriculture University Rawapindi. A set of sixteen different genotypes of wheat, maintained in the department, were planted in the rain-shelter during growing season 2013-14, following Randomized Complete Block Design with three replications. Seed was sown with the help of dibbler having two rows of each genotype. Drought stress was induced by withholding water for 30 days at the heading and anthesis stages. At the end of stress periods, re-watering to the field capacity was carried out. The control plants were irrigated to the field capacity during the stress period, and all plants were left to grow until grain maturation under normal irrigation. Data for physiological traits like cell membrane stability, relative water content, chlorophyll content and proline content were determined following the published protocols of other researchers. Chlorophyll content was determined as chlorophyll index using Chlorophyll Meter (SPAD-502). Proline content was determined by the method of Bates *et al.* (1973) [3]. Analysis of variance was worked out following Steel *et al.* (1997) [4] to determine differences among different physiological traits under drought stress in wheat and correlation coefficients were carried out following the method used by Kwon and Torrie (1964) [5].

RESULTS AND DISCUSSION

Relative water content

Highly significant variation was present among the genotypes sown in the tunnel for this trait as presented in Table 1, all these genotypes were not uniform for relative water content. There were 5 groups (A, B, etc.) in which the means were not significantly different from one another. Genotype WC-20 had maximum mean of 81.92 % and minimum value for this trait was 64.88 % in

genotype WC-24, while mean value for this trait was 72.36 % (Table 3).

GV value was 18.924 and PV value was 29.623, difference between these values showed that environmental influence was present. Little difference between GCV and PCV values was depicted from the table which showed that that phenotype was representative of genotypic factor and environmental factor influence is less on the trait. Broad sense heritability was high for this trait which mean that greater proportion of variability was due to genetic factor but environmental influence was also present (Table 2). These findings are in accordance to those of Ahmed *et al.,* (2014) [6].

Proline Content

Analysis of variance depicted that proline content was highly significant for the genotypes under study which revealed that selection can be done for this trait (Table 1). Range for this trait was 0.02 mg/g-0.15 mg/g with mean value of 0.09 mg/g. Maxi-pak showed minimum proline content while Chenab-70 showed maximum proline content (Table 3). Genotypes having maximum proline content would be able to survive under drought stress conditions as it protects the membranes from damage under stress and can be used for the development of varieties for rainfed areas.

The value for GV was not different from the PV value as depicted from the Table 2. GCV value was 46.778 % and PCV value was 53.753%, which showed

Table 1: Analysis of variance for physiological traits of different wheat genotypes under rainfed conditions

	RWC	PC	CMS	CC	Yield
MS(VAR / TR)	67.47	0.006	429.752	3.339	455315
MS (REPLICATES)	47.016	0	0.641	2.914	670800
MS (ERROR)	10.699	0.001	11.014	1.486	411858
F.RATIO (V)	6.306 **	10.363 **	39.017 **	2.246 *	1.106 ^{ns}
F.RATIO (R)	4.395 *	.68 ^{ns}	.058 ^{ns}	1.96 ^{ns}	1.629 ^{ns}

** = highly significant, * =significant, ns = non-significant, RWC = Relative water content, PC = Proline content, CMS = Cell membrane stability, CC = Chlorophyll content, Yield = Yield per hectare

Table 2: Components of variation for physiological traits of different wheat genotypes under rainfed conditions

	RWC	PC	CMS	CC	Yield
GV	18.924	0.002	139.579	0.617	14485.5
PV	29.623	0.002	150.594	2.104	426343.8
GCoV	6.012	46.778	17.088	1.944	6.273
PCoV	7.522	53.753	17.75	3.589	34.03
CoH	0.639	0.757	0.927	0.293	0.034

GV= Genotypic variance, PV= Phenotypic variance, GCoV= Genotypic Coefficient of Variation, PCoV= Phenotypic Coefficient of Variation, CoH= Coeffecient of Heritability, RWC= Relative Water Content, PC= Proline Content, CMS= Cell Membrane Stability, CC= Chlorophyll Content, Yield= Yield per Hectare.

Table 3: Mean values of physiological traits for different wheat genotypes under rainfed conditions

GENOTYPE	RWC	PC	CMS	CC	Yield
99FJ-03	70.76cd	0.12ab	62.42f	38e	1720ab
Marvi-2000	80.71a	0.04de	73.12df	39.67bcde	1750ab
WC-13	67.72de	0.05de	63.51f	40.19abcd	1780ab
WC-24	64.88e	0.07d	50.17g	41.11abc	2090ab
WC-19	69.52cde	0.07cd	79.62bc	41.29abc	1610b
Faisalabad-85	70.36cd	0.11bc	64.91f	39.91bcde	1770ab
Kaghan	70.98cd	0.12ab	72e	39.28cde	1450b
Bahawalpur	70.83cd	0.05de	54.38g	40.55abcd	1660b
Zarlashta	77.79ab	0.07cd	55.67g	40.98abcd	1350b
Punjab-96	71.31cd	0.15a	78.57cd	40.22abcd	2140ab
Shafaq	69.2cde	0.03de	83.6abc	41.09abc	1570b
Maxi-pak	77.45ab	0.02e	85.62a	42.14a	2310ab
WC-20	81.92a	0.12ab	84.72ab	40.91abcd	2040ab
Chenab-70	68.89cde	0.15a	55.56g	41.52ab	2290ab
AUR-0809	71.92cd	0.12ab	80bc	40.81abcd	2400ab
Chakwal-50	73.49bc	0.13ab	62.32f	39de	2770a
Average	72.36	0.09	69.14	40.42	1918.75
LSD 0.05	5.45	0.04	5.53	2.03	1070

RWC = Relative water content, PC = Proline content, CMS = Cell membrane stability, CC = Chlorophyll content, Yield = Yield per hectare.

that environmental effect was present for this trait. High heritability value was 75 % which predicted that trait as under less influence of environmental variation (Table 2), these results were similar to Rad *et al.* (2013) [7] who reported 97 % of heritability for this trait. Selection for this trait would be helpful in future for improvement of drought tolerant varieties for rainfed area.

Cell Membrane Stability

ANOVA table showed that variation between genotypes was highly significant and the genotypes under study were not uniform for this trait suggesting selection can be done for this trait for the improvement (Table 1). Range for this trait was 50.17-85.62. Genotype WC-24 showed minimum value while Maxi-pak showed maximum value for this trait (Table 3). Genotypes that would be able to maintain their stability under drought stress shows more tolerance towards drought.

GV and PV value was 139.579 and 150.594 respectively, which showed that environmental variation was present for this trait which create variation in expression of trait. GCV and PCV values showed little difference between them. Under environmental conditions different genotypes behave differently, those genotypes which showed stable cell membrane stability can be used for further breeding programs aimed at improving drought tolerance. High broad sense heritability was observed for this trait, which showed that selection would be effective (Table 2).

Similar results were also discussed in Bayoumi *et al.,* (2008) [8] and Naeem *et al.,* (2015) [9].

Chlorophyll Content

ANOVA table showed that this trait had significant variation in the genotype means for this trait and selection could be done to obtain desirable results (Table 1). Range for this trait was 38-42.14 with the mean of 40.42. 99FJ-03 and Maxi-pak were the genotypes with minimum and maximum value for chlorophyll content respectively (Table 3).

GV and PV value for this trait was 0.617 and 2.104 respectively. While the GCV value was 1.944 % and PCV value was 3.589 %, these values depict that more variation in this trait was due to environmental factor. Selection for this trait should be done with great care for development of drought tolerant cultivars. Broad sense heritability for this trait was low (29 %) and low heritability estimates for trait revealed that character has low genetic potential (Table 2). Similar findings were also observed by (Keyvan, 2010)[10].

CONCLUSION

Genotypes possessed significant variation for studied traits suggesting that selection can be performed to improve the genotypes for physiological traits. Traits that help to reduce the drought stress and maintain drought tolerance under rainfed condition like relative water content, proline content and cell membrane stability can be used in further wheat breeding programs.

High heritability, observed for relative water content, proline content and cell membrane stability, indicated that selection would be effective for these traits as they are heritable to next generation.

As different genotypes were evaluated for physiological traits under drought stress, one can improve and develop drought tolerant cultivars by improving the traits like proline content, relative water content and cell membrane stability that would help to overcome the drought stress under rainfed condition to obtain maximum yield. Among tested wheat genotypes, Maxi-Pak was found to be potential variety for relative water content, cell membrane stability, chlorophyll content and yield. Hence it can be used in future wheat breeding programme for rainfed conditions.

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