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EFFECT OF DROUGHT STRESS ON DIFFERENT PHYSIOLOGICAL TRAITS IN BREAD WHEAT

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ABSTRACT

The present study was designed to evaluate the changes in different physiological traits such as proline content, cell membrane stability, relative water content and chlorophyll content under drought stress in sixteen wheat genotypes. Wheat genotypes (99FJ-03, Marvi-2000, WC-13, WC-24, WC-19, Faisalabad-85, Kaghan, Bahawalpur, Zarlashta, Punjab-96, Shafaq, Maxi-pak, WC-20, Chenab-70, AUR-0809, Chakwal) were sown during *rabi*season of 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. Genotypes were significant for different physiological traits like relative water content, proline content, cell membrane stability and chlorophyll content under drought stress which indicated that some genotypes were more tolerant against drought stress than others. 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 developing drought tolerant genotypes.

Keywords: Wheat, cell membrane stability, chlorophyll content, drought, proline content, relative water content.

INTRODUCTION

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 different physiological traits to boost wheat productivity. Improvement in wheat yield came through dwarfing genes which was first used by Japanese wheat breeders.

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Water stress is a worldwide issue which predicts the sustainable agricultural production (Jaleel et al., 2007). Drought leads to stomata closure and reduction of water content, turgor loss. Sometime it leads to death of plant by disturbing metabolism (Jaleel et al., 2008). 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. 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. Different 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 as well as various factors that contribute to photosynthesis like chlorophyll content, relative water content and various pigments is affected by drought. 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 against stress by maintaining the plant water potential. However, literature regarding physiological traits in wheat genotypes affected by drought stress is very limited. Hence, the present experiment was conducted to evaluate the changes in physiological traits in wheat genotypes under drought stress condition.

MATERIALS AND METHODS

A field experiment was undertaken during *rabi* season of 2013-14 at PMAS Arid Agriculture University Rawalpindi, Pakistan on loamy soil having moderate fertility. A set of sixteen genotypes of bread wheat (99FJ-03, Marvi-2000, WC-13, WC-24, WC-19, Faisalabad-85, Kaghan, Bahawalpur, Zarlashta, Punjab-96, Shafaq, Maxi-Pak, WC-20, Chenab-70, AUR-0809, Chakwal) were planted in the rain-out-shelter following Randomized Complete Block Design with three replications. Seeds were sown on November 03, 2013 with the help of dibbler having two rows of each genotype. Fertilizer was applied at the rate of 42-34-25 NPK kg ha^{-1} at the time of sowing. Drought stress was induced by withholding water for 30 days at the heading and anthesis stages. At the end of stress periods, irrigation was given up to field capacity. The control plants were irrigated 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). Analysis of variance was worked out following Steel et al. (1997) to determine differences among different physiological traits under drought stress in wheat. Correlation coefficients were carried out following the method used by Kwon and Torrie (1964).

RESULTS AND DISCUSSION

Relative water content

Highly significant variation was present among the genotypes sown in the tunnel for this trait (Table 1). Genotype WC-20 had maximum value of 81.92 % which was statistically identical with Marvi-2000, Zarlashta and Maxi-Pak while the minimum value (64.88 %) for this trait was recorded in genotype WC-24(Table 3).

Difference between GV value (18.924) and PV value (29.623) indicated that environmental influence was present. Little difference between GCoV and PCoV values showed that the phenotype was representative of genotypic factor and influence of environmental factor was less on the trait. Broad sense heritability was high for this trait showed that greater proportion of variability was due to genetic factor (Table 2). These findings are in accordance to those of Ahmed et al. (2014).

Proline content

Proline content was highly significant for the genotypes and the range for this trait was 0.02 mg g^{-1} - 0.15 mg g^{-1}(Table 1). Maxi-Pak had minimum proline content while Chenab-70 and Punjab-96 had maximum proline content which was similar to 99FJ-03, Kaghan, WC-20, AUR-0809 and Chakwal-50 (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.

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

	RWC	PC	CMS	CC	Yield
MS(VAR / TR)	67.470	0.006	429.752	3.339	455315
MS (REPLICATES)	47.016	0.000	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 *	0.680NS	0.058NS	1.960NS	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 =Coefficient 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 (mg g^{-1})	CMS	CC	Yield (kg ha^{-1})
99FJ-03	70.76cd	0.12ab	62.42f	38.00e	1720
Marvi-2000	80.71a	0.04de	73.12df	39.67bcde	1750
WC-13	67.72de	0.05de	63.51f	40.19abcd	1780
WC-24	64.88e	0.07d	50.17g	41.11abc	2090
WC-19	69.52cde	0.07cd	79.62bc	41.29abc	1610
Faisalabad-85	70.36cd	0.11bc	64.91f	39.91bcde	1770
Kaghan	70.98cd	0.12ab	72.00 e	39.28cde	1450
Bahawalpur	70.83cd	0.05de	54.38g	40.55abcd	1660
Zarlashta	77.79ab	0.07cd	55.67g	40.98abcd	1350
Punjab-96	71.31cd	0.15a	78.57cd	40.22abcd	2140
Shafaq	69.20 cde	0.03de	83.6abc	41.09abc	1570
Maxi-pak	77.45ab	0.02e	85.62a	42.14a	2310
WC-20	81.92a	0.12ab	84.72ab	40.91abcd	2040
Chenab-70	68.89cde	0.15a	55.56g	41.52ab	2290
AUR-0809	71.92cd	0.12ab	80.00 bc	40.81abcd	2400
Chakwal-50	73.49bc	0.13ab	62.32f	39.00de	2770

RWC = Relative water content, PC = Proline content, CMS = Cell membrane stability, CC = Chlorophyll content, Yield = Yield per hectare. Same letter(s) in a column indicate statistically identical at0.05 level of probability according to DMRT test

Value for GV was not different from the PV value (Table 2). Little difference between GCoV value (46.778%) and PCoV value (53.753%) showed that environmental effect was less on this trait. High heritability value (75%) predicted that influence of environmental variation was less on this trait (Table 2).These results were similar to the findings of Rad et al. (2013) who reported 97% heritability for proline content. Proline content would be helpful for selecting drought tolerant genotypes.

Cell membrane stability

Variation among genotypes was highly significant for this trait under drought stress suggested that selection of drought tolerant genotypes could be done on the basis of this trait (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 which was at par with Shafaq and WC-20 (Table 3). Genotypes that would be able to maintain their cell membrane stability under drought stress shows more tolerance against drought.

GV and PV value was 139.579 and 150.594 respectively, which showed that environmental influence was present on this trait under drought condition. GCoV and PCoV values showed little difference between them. Under drought conditions, different genotypes behaved differently. Those genotypes which showed more cell membrane stability could be selected for further breeding programs aimed at improving drought tolerance. High broad sense heritability was observed for this trait, which indicated that selection would be effective (Table 2). Similar results were also discussed by Bayoumi et al. (2008) and Naeem et al. (2015).

Chlorophyll content

Significant variation in genotypes for this trait depicted that selection could be done to obtain drought tolerant genotypes (Table 1). Range for this trait was 38.00-42.14. 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. GCoV value (1.944 %) and PCoV value (3.589 %) depicted that more variation in this trait was due to environmental factor. Based on this trait selection of genotypes should be done with great care for development of drought tolerant genotypes. Broad sense heritability for this trait was low (29 %) and low heritability for this trait revealed that character has low genetic potential (Table 2). Similar findings were also reported by Keyvan (2010).

CONCLUSION

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

Variation in physiological traits like proline content, relative water content and cell membrane stability in wheat genotypes studied under drought stress revealed that some genotypes could be selected for future breeding programme to develop drought tolerant, high yielding wheat genotypes. Among tested wheat genotypes, Maxi-Pak was found to be potential variety considering relative water content, cell membrane stability, chlorophyll content and yield. Hence, it can be used in future wheat breeding programme for developing drought tolerant varieties.

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