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Assessing the Impact of Drought Stress on Morpho-physiological Traits in Wheat (*Triticum aestivum* L.) genotypes in Jammu region

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ABSTRACT

In many regions of the world, particularly in arid and semi-arid climates, drought is a frequent abiotic stress that significantly affects the productivity of wheat (Triticum aestivum L.). As a result, maintaining an adequate yield during drought has taken on importance, especially in light of ongoing environmental changes and an increasing worldwide population. The present study was carried out on three wheat genotypes in the acrylic pipe in the Division of Plant Physiology SKUAST, J. The acrylic pipe experiment was carried out simultaneously in the control and treated conditions. The stress was imposed by holding water irrigation for 10 days at the booting stage. Sampling was taken at the booting stage after the exposure to drought stress. Analysis of Plant height, No. of tillers, Fresh weight of stem, roots, and leaves, Dry weight of stem, roots, and leaves SPAD, Relative leaf water content (%) and Relative stress injury (%)were recorded. The result showed that drought stress induced at the booting stage declined the Plant height, No. of tillers, Fresh weight, Dry weight, SPAD, and Relative leaf water content (%)in stress conditions. It was concluded that the PBW644 variety was tolerant followed by WH1080 and the PBW175 variety was susceptible to drought stress. This study implies that in wheat genotypes, drought stress has a significant impact on morphological and physiological processes that regulate plant growth and yield production. In drought-prone areas, this research has the potential to significantly increase wheat productivity, and in the face of climate change, it can improve food security.

Keywords: *Wheat, Drought stress, Plant height, Fresh weight of stem, roots, and leaves, Dry weight of stem, roots and leaves, SPAD, Relative leaf water content (%)*

Introduction

Wheat (*Triticum aestivum* L.) is the most crucial cereal crop for the majority of the world's population. It is the World's staple food crop and India's second-largest crop after rice. The enhancement in its productivity has played a role in making the country self-sufficient in food production [17]. Wheat belongs to the family Poaceae (Gramineae). The world [4], covers about 225 million hectares with a production of 772.64 million tons. In India, there are 31.5 million hectares under wheat cultivation, with production and productivity of around 108 million tons and 34 q/ha, respectively [5]. The entire area under wheat cultivation in Jammu & Kashmir (UT) is 2.88 lakh ha, with production and productivity of roughly 6.7 lakh tons and 23.3 q/ha, respectively [3]. Abiotic stress is a negative effect on an organism brought on by environmental conditions like drought, salinity, osmotic stress, and an abundance of metals. The productivity of wheat (*Triticum aestivum* L.) is adversely affected by drought, an abiotic state that occurs frequently, particularly in arid and semi-arid regions of the world. As a result, maintaining an adequate yield during droughts has gained importance, particularly in light of Huaqi *et al.*'s research on global environmental changes and the rise in world population [7]. Plants can be affected by drought stress growth inhibition, root depth, and extension, cuticle thickness, a decline in chlorophyll content, a decrease in transpiration, and osmotic changes in their organs [18];[21];[11]. These findings are used to predict a cultivar's sensitivity or tolerance, as well as the suitability of planting under drought-stress conditions. Because the booting stage in wheat is highly sensitive to drought stress, identifying the morpho-physiological features for drought resistance at the booting stage would be critical. The proposed study will assess the relative response of wheat genotypes to drought stress during the booting stages in relation to their differential drought sensitivity.

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Materials and Methods

Three wheat genotypes WH1080, PBW175, and PBW644 were studied with drought stress at the booting stage. The acrylic pipe experiment was carried out in the Division of Plant Physiology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha, Jammu-180009, J&K, in both control and treated conditions. The experimental location is located in the Shiwalik foothills of the North-Western Himalayas between 320-40' N latitude and 740-

58' E longitude, at an elevation of 332 m above mean sea level. During the booting stage, the stress was produced by withholding water irrigation for 10 days. After being exposed to drought stress, samples were collected during the booting stage. After drought stress, plant height, number of tillers, fresh and dry weight of stem, leaves, and roots, and physiological parameters such as SPAD value, relative leaf water content (%), and relative stress injury (%) were measured. The SPAD-502 apparatus was used to take SPAD (Soil Plant Analysis Development) measurements.

Methodology

Relative leaf water content (%)

For RLWC, the second or third completely grown leaf from the top of the plant was taken from the pipe and kept in polythene bags in an ice box. The twenty-leaf discs were immediately weighed on an electronic balance (Citizen Scale, CY510, Poland) to determine their fresh weight (FW). The weighted leaf discs were floated throughout the night in distilled water in a petri dish, then gently wiped and weighted again for the turgid weight (TW). The leaf discs were oven-dried at 80 C for 48 hours after taking turgid weight. The RLWC Was calculated using the formula of Weatherly (1950).

RWC % = (FW-DW)/(TW-DW) x 100

Relative stress injury (%)

The relative stress injury (RSI %) in leaves was evaluated by the method of Sullivan (1972). The third fully grown leaf from the top was taken and stored at 25°C in 20 ml vials with 10 ml de-ionized water. The water analysis kit (Naina, India Ltd., NDC 732) was used to measure the electrical conductivity (EC) of the solution after 4 hours, and the result was labelled as ECa. The samples were then immersed in a boiling water bath for 50 minutes to ensure complete tissue death. The EC of the solution was measured again after cooling, and ECb was assigned. The following formula was used to determine the relative stress injury (RSI %):

RSI (%) = 1- ECa / ECb x 100.

Statistical analysis: Three pots with three plants each were sampled at a time, making three replicates for each parameter. Completely Randomized Design (CRD) was used to analyze the data for two factors. Critical difference (CD) was used to compare treatments with a 5% level of significance. R software was used to analyze the data.

Results

For a plant to gauge its amount of stress, morphological characteristics are crucial. Three plants were currently chosen at random from each variety, and the information was recorded. From the plant's root system to the tip of the auxiliary shoot, the height of control and treated plants was measured (in cm). Data presented in (Table 1) showed that the mean value of plant height in three drought-tolerant wheat genotypes significantly reduced from 69.81cm to 52.97cm with increasing the intensity of drought stress at the booting stage from control to treated condition. The maximum plant height was observed in PBW644 (70.98 cm).

Similarly, in the control and drought stress studies, genotypes revealed substantial differences in the number of tillers, and dry weight of stem and leaves per plant. All of the morphological features under examination were dramatically lowered by drought stress. The mean number of tillers was less from control to treated condition i.e., 7.44 to 6.22 respectively (Fig 1). A maximum number of tillers was observed in PBW644 followed by WH1080 and a minimum in PBW175 genotypes.

Likewise, figure 2 and 3 depicts the fresh and dry weight of stem and leaves respectively. Fresh weight of stem, leaves and roots (g) was significantly decreased under drought stress (10.38g, 3.97g, and 12.61g) in all three wheat genotypes in compassion to control (11.78g, 5.46g, and 11.9g) showed in (Fig2) The maximum mean value of fresh weight of stem, leaves and roots were recorded in PBW644 (11.76g, 5.90g and 13.78g) followed by WH1080 (11.07g, 4.74g and 12.19g) and minimum mean value were recorded in 10.42g, 3.51g and 10.79g. Although in control similar trend was found. The dry weight of stem, leaves, and roots (g) was significantly decreased under drought stress (9.02g, 1.78g, and 11.63g) in all three wheat genotypes in compassion to control (9.68g, 2.09g, and 10.47g) depicted in (Fig 3). The maximum mean value of dry weight of stem, leaves, and roots was recorded in PBW644 (10.81g, 3.68g, and 12.89g) followed by WH1080 (9.22g, 2.74g, and 10.50g), and minimum mean values were recorded in PBW175 (8.01g, 1.93g, and 9.76g). SPAD value depicted in Table 2 shows a decrease under drought stress at the booting stage in all three drought-tolerant wheat genotypes and the value varied from control to treated condition (47.61 to 39.23). The maximum mean Spad value was observed in PBW644 (46.79) followed by WH1080 (43.18) and the minimum was observed in PBW175 (40.29) genotype.

Data presented in Table 3 showed the mean relative leaf water content (%) in three wheat genotypes significantly reduced from 80.03% to 70.31% under drought stress at the booting stage from control to treated condition. The maximum mean Relative leaf water content was noticed in PBW644 (78.64%) followed by WH1080 (74.21%) and the minimum mean was noticed in PBW175 (72.68%). The genotypic and drought differences were statistically significant.

Similarly, RSI increased significantly under drought stress at the booting stage in all three wheat genotypes from control to treated condition. i.e., 20.96% to 30.82% respectively. The maximum increase in RSI % was observed in PBW175 (25.06%) followed by WH080 (21.20%) and minimum was noticed in PBW644 (16.24%) in the control condition and in treated condition, the maximum increase in RSI% was observed in PBW175 (36.89%) followed by WH1080 (35.31%) and the minimum was found in PBW644 (21.34%).

Discussion

Plant indicators and their evaluation are frequently utilized to compare the maturity of various genotypes. Our findings showed that, under various conditions, the plant's height (Table 1), the number of tillers, fresh and dry weight of the leaves and stem (Table 1; Figs. 2, 3) varied significantly. Our results agree withMehraban *et al*.(13)reduction in plant height in all cultivars in response to drought stress as a result of protoplasm dehydration and a decline in relative turgidity, which are linked to turgor loss and decreased cell division and cell expansion. Kimurto *et al*. [10] explained that a lack of water during the booting stage reduced the formation of tillers, resulting in a decrease in crop yield. The plant's fresh and dry weight decreased under drought stress which was observed by Anjum *et al*., [2]. Similarly, chlorophyll content was also decreased which was studied [14], and found that chlorophyll content decreased when water availability was reduced.

The RLWC represents the leaf's water status and is considered an essential predictor of drought tolerance in plants [15]. In response to arid stress, the relative water content decreases significantly compared to the control. Our findings are consistent with those of other wheat stress-focused researchers. Li [21] demonstrated that the decrease in RLWC in plants under drought stress may be correlated with a reduction in plant vigor, as demonstrated by numerous genotypes studied by numerous research groups.

We noticed that electrolyte leakage was proportionate to the severity of the drought stress. The PBW175 has the highest electrolyte leakage, whereas the PBW644 genotype has the lowest. These findings were consistent with those of Gholamin and Khayatnezhad [6] also observed a reduction in membrane stability under conditions of drought stress. The results demonstrated that the integrity of the membrane was maintained in drought-tolerant genotypes compared to susceptible genotypes; this is consistent with previous findings that showed electrolyte leakage was associated with drought tolerance [12];[19];[1]. Cell membranes become more permeable when they are damaged, which led to the leakage [16].

Table 1: Changes in Plant height (cm) in wheat genotypes on exposure to drought stress at the booting stage.

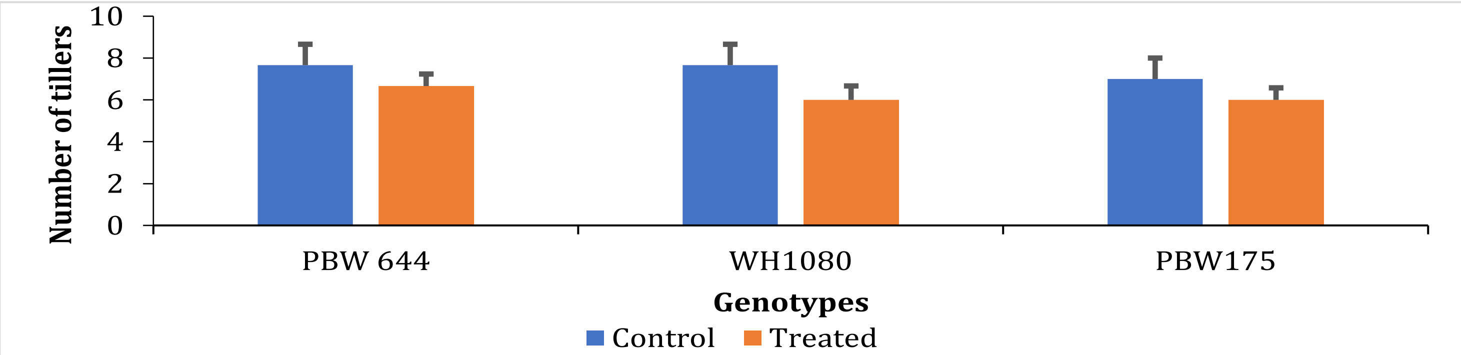
Plant Height (cm)			
Genotypes	**Control**	**Treated**	**Mean**
PBW 644	83.46±0.93	58.50±1.66	70.98
WH1080	64.11±0.93	50.63±0.45	57.37
PBW175	61.86±1.29	49.80±0.51	55.83
Mean	69.81	52.97	
CD at 5%	*Genotypes =2.28* *Treatment =1.86* *Genotype x Treatment =3.23*		

Table 2: Changes in SPAD value in wheat genotypes on exposureto drought stress at booting stage.

SPAD Value			
Genotypes	**Control**	**Treated**	**Mean**
PBW 644	50.73 ±0.58[a]	42.86±1.68[ed]	46.79
WH1080	47.36±108[ab]	39.10±1.53[de]	43.18
PBW175	44.76±0.70[bc]	35.83±0.85[e]	40.29
Mean	47.61	39.23	
CD at 5%	*Genotypes = 2.67* *Treatment = 2.18* *Genotype x Treatment = 3.78*		

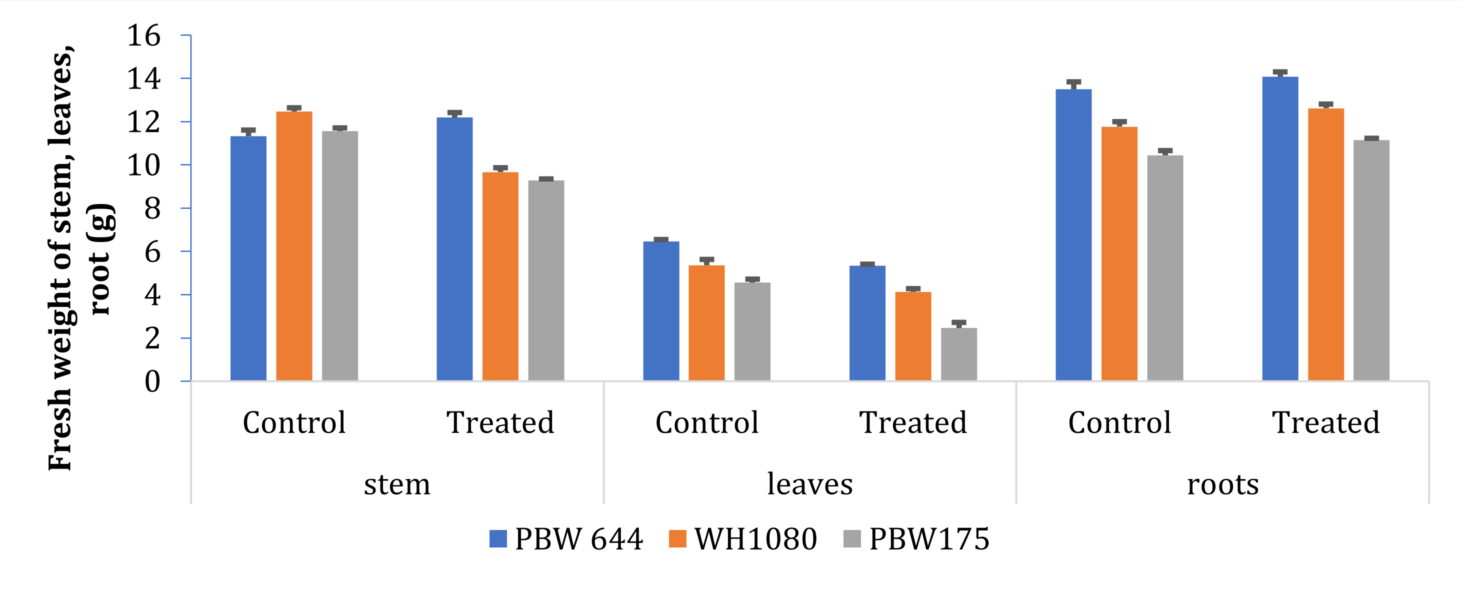
Table 3. Changes in relative leaf water content (%) in wheat genotypes on exposureto drought stress at booting stage.

Relative Leaf Water content (%)			
Genotypes	**Control**	**Treated**	**Mean**
PBW 644	83.76 ±1.84[a]	73.52±1.36[cd]	78.64
WH1080	79.36 ± 1.75[ab]	69.06 ±1.78[d]	74.21
PBW175	76.99 ± 0.59[bc]	68.37±2.40[d]	72.68
Mean	80.03	70.31	
CD at 5%	*Genotypes = 3.99* *Treatment = 3.17* *Genotype x Treatment = 5.50*		



CD at 5%	*Genotypes = 1.25* *Treatment = 1.02* *Genotype x Treatment = 1.77*

Fig 1: Changes in number of tillers in wheat genotypes on exposureto drought stress at booting stage.

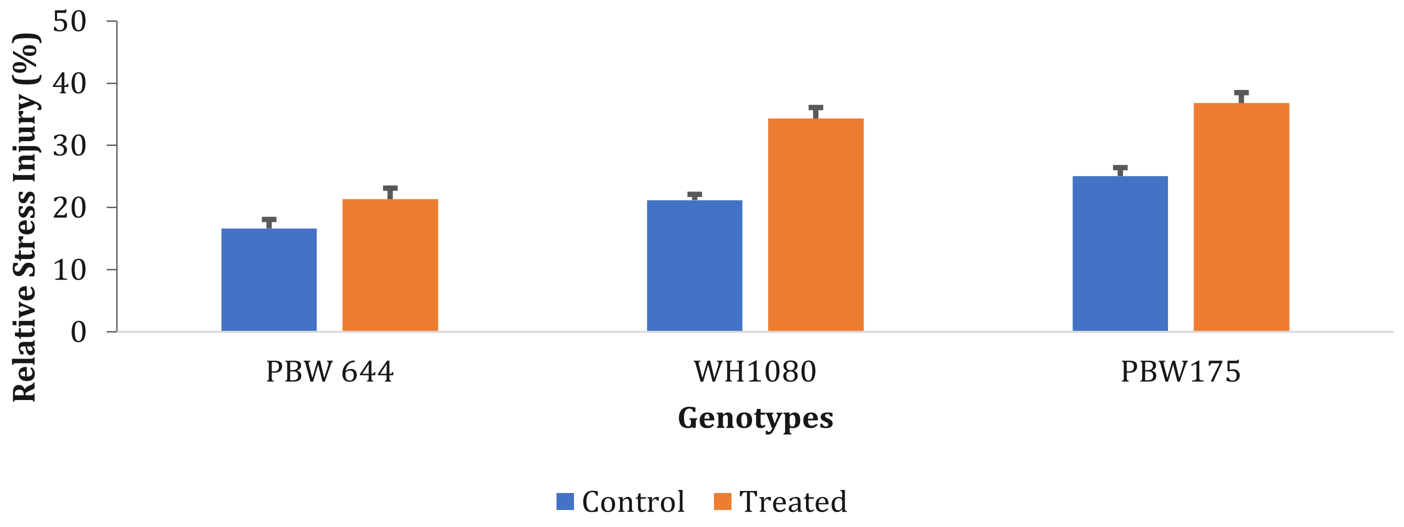


	Fresh weight of stem (g)	Fresh weight of leaves (g)	Fresh weight of roots (g)
CD at 5%	*Genotypes = 0.39* *Treatment = 0.32* *Genotype x Treatment = 0.55*	*Genotypes = 0.35* *Treatment = 0.28* *Genotype x Treatment = 0.50*	*Genotypes = 0.43* *Treatment = 0.35* *Genotype x Treatment = 0.61*

Fig 2: Changes in fresh weight of stem, leaves and roots (g) in wheat genotypes on exposure to drought stress at booting stage.

	Dry weight of stem (g)	Dry weight of leaves (g)	Dry weight of roots (g)
CD at 5%	*Genotypes = 0.76* *Treatment = 0.62* *Genotype x Treatment = 1.08*	*Genotypes = 0.37* *Treatment = 0.30* *Genotype x Treatment = 0.53*	*Genotypes = 0.70* *Treatment = 0.57* *Genotype x Treatment = 0.99*

Fig 3: Changes in dry weight of stem, leaves and roots (g) in wheat genotypes on exposureto drought stress at booting stage.



CD at 5%	*Genotypes = 3.32* *Treatment = 2.71* *Genotype x Treatment = 4.70*

Fig 4: Changes in relative stress injury (%) in wheat genotypes on exposure to drought stress at the booting stage.

Conclusion

In conclusion, the growth and yield of wheat are severely affected by diverse agro-eco conditions, with the impact of drought during the booting stage having the greatest impact on wheat yield. Wheat crop growth is negatively impacted by drought conditions during the early and later stages of its development. Among the genotypes analyzed, it was determined that genotype PBW644 demonstrated drought tolerance and can therefore be used as a donor genotype for drought tolerance. The genotype WH1080 was moderately drought-tolerant, whereas the genotype PBW175 was drought-sensitive.

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