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Effect of drought stress on grain yield and yield attributing characters in wheat (*Triticum aestivum* L.) cultivars

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Abstract
Drought one of the environmental stresses, is the most significant factor restricting plant production in majority of the agricultural fields of the world. Drought often causes serious problems in wheat production areas. An experiment was conducted to assess yield and yield responses under three different level of field capacity *viz.* (100% FC, 75% FC, 35% FC) with a set of two tolerant and two susceptible genotypes of wheat (*Triticum aestivum* L.) at Department of Genetics and Plant breeding, Junagadh Agricultural University, Junagadh during Rabi 2019-20. Four wheat (*Triticum aestivum* L.) cultivars were grown in Black polythene bags of 8×5-inch size. The first factor involves drought stress condition at three levels such as 100% (Well-watered), 75% (Moderate stress), 35% (Severe stress). The second factor involves four varieties namely C-306, DBW 110, DBW 136, GW 451. The experiment was setup in Factorial Completely Randomized Design with four replications and the analysis were made. Observation were measured at booting and early grain filling stage. Yield and yield components were evaluated at harvesting stage. The water stress brings out a negative impact on yield and yield attributing characters. Most of the yield parameters were decreased under water stress. T1 (100% FC) recorded significantly highest value of number of grains/spike (25.00), number of effective tillers (5.00), biological yield (17.66 g), number of spikelet's/spike (20.31) grain yield per plant (10.45 g), test weight (42.59 g) and harvest index (37.51%). The highest yield data were observed under the genotype DBW 110.

Keywords: Drought, water stress, wheat, test weight

Introduction
One of the most important cereal crop is wheat (*Triticum aestivum* L.) belongs to Poaceae family which is considered to be staple food crop of the world and emerged as the backbone of India's food security. Wheat is having the specification as "King of Cereals". It belongs to the native of South West Asia (Turkey). Wheat possess 2n=42 chromosomes with self-pollination as a mode of pollination. The most extensively grown cereal crop in the world, is wheat, after maize and rice. Wheat is providing more than 50 per cent of the calories to the people who mainly depend on it. It is grown all over the world for its wider adaptability and high nutritive value. It is an important winter cereal contributing about 38 per cent of the total food grain production in India.

Plants are exposed to many biotic and abiotic stresses that affect their growth and productivity. These stresses may cause unfavorable changes at cellular and molecular level in plants. Among various stresses, drought stress is one of the major limitations to the crop productivity. Agricultural drought is the lack of ample moisture required for normal plant growth and development to complete the life cycle. Drought is the single largest abiotic stress factor leading to reduced crop yields, so high-yielding crops even in environmentally stressful conditions are essential. Drought is one of the most common environmental stresses that affect growth and development of plants. Water stress usually shortens the life cycle and grain filling period of crop, reducing photosynthesis and accelerating senescence (Chaves and Oliveira, 2004) [4].

Plant responses to drought stress are very complex and include adaptive changes or deleterious effects. As a consequence of severe climatic changes across the globe, threat of the occurrence of more frequent drought spells is predicted. Available water resources for successful crop production have been decreasing in recent years. Furthermore, in view of various climate change models scientists suggested that in many regions of the world, crop losses due to the increasing water shortage will further aggravate its impact. It is assumed that by the year 2025, around 1.8 billion people will face absolute water shortage and 65% of the world's population will live under water-stressed environments.

Water deficiency during different developmental stages can change the values of yield components. Drought stress reduces grain yield of wheat through negative affecting the yield components, i.e., number of plants per unit area, number of spikes and grains per plant, or unit area and single grain weight, which are determined at different stages of plant development. In other words, water deficiency in different stages of wheat growth can have different effects on physiological and morphological traits.

Improving drought tolerance and productivity is one of the most difficult tasks for breeders. Understanding plant responses to drought is of great importance and also a fundamental part of making crops stress tolerant. The development of crop plants tolerant to drought stress might be a promising approach, which helps in meeting food demands.

The objectives of this study, therefore, wheat varieties with high yield potential, yield components and quality traits were evaluated under water stress condition.

Materials and methods

The present investigation was carried out at Department of Genetics and Plant breeding, College of Agriculture, Junagadh Agricultural University, Junagadh during *Rabi* season, 2019-20. Two factors were taken into consideration and forty-eight treatment combinations were made. Four replications were taken for each treatment combination. The first factor involves drought stress condition at three levels such as 100% (Well-watered), 75% (Moderate stress), 35% (Severe stress). The second factor involves four varieties namely C-306, DBW 110, DBW 136, GW 451. The experiment was setup in Factorial Completely Randomized Design and the analysis were made. The sowing was done on Black polythene bags of 8×5-inch size. In each poly bag 10 seeds were kept. For calculating the field capacity, initially three sample bags were taken. The bags were filled with same soil which was used in the experiment. Soil was filled with water up to the level of saturation; initial weight was taken. The bag was left as such for 48 hrs, the final weight was taken once in every 12 hrs up to 15 days. By this method field capacity was calculated. Drought stress was induced at two stages once at booting stage and another at grain filling stage. Stress induction started a week before. On the first day initial weight of the bag was taken, then the water level was maintained at the rate of 100%, 75%, 35% up to one week.

Parameters such as, plant height, Grain yield (g/plant), Number of spikelet's/spikes, Number of tillers, Grain/spike (g), Test weight (g), Biological yield (g), Harvest index (%) were determined. Data were subjected to analy-sis of variance.

Results and discussion

There were significant differences between Grain yield (g/plant), Number of spikelet's/spikes, Number of tillers, Grain/spike (g), Test weight (g), Biological yield (g), Harvest index (%) in control conditions (Table-1).

Decrease in the yield attributes *viz*. grains per spike, number of tillers, biological yield, number of spikelet's/spikes, test weight, grain yield/plant and harvest index were observed in the crops grown under the water stress condition in our experiment. Loss of turgidity which affects the rates of the cell expansion and ultimately cell size brings out the negative effect on yield and its components under water stress.

Data regarding the number of tillers per plant (Fig. 1) recorded that significantly affected by different levels of drought stress in comparison to the control. The highest number of effective tillers was found in the genotype DBW 110(V_1) (4.33) which was statistically on par with C-306 (V_2) (4.08) and GW 451 (V_4) (4.00) and lower number of tillers was found in DBW 136 (V_3) (3.92). The number of tillers reduced due to reduced growth and photosynthesis processes of plant. The reduction of effective tillers production under low soil moisture might be due to limited supply of assimilate under water stress condition (Table- 1). These results agree with the early reports of Abid *et al*. (2018) [1], Singh *et al*. (2018) [12], Wang *et al*. (2017) [13].

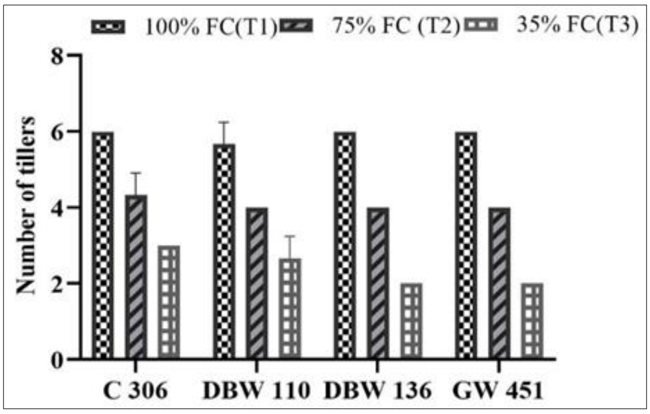

Fig 1: Number of tillers/plants

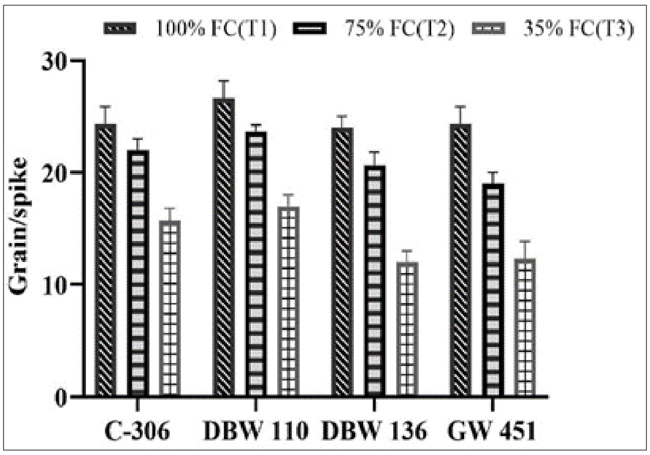

Fig 2: Number of grain/spikes

It was evident that the number of spikelet's/spikes (Fig. 3), grains/spike (Fig. 2) were drastically reduced under water stress in our experiment. Data- 1. Shows that genotype DBW 110 (V_1) (18.33) was recorded with highest number of spikelet's/spike; while GW 451 (V_4) (16.92) was recorded with lowest number of spikelet's/spike respectively. Number of grains/spike differed highly significant due to genotypes. Data- 1. Shows that genotype DBW 110 (V_1) (22) was recorded with highest number of grains while GW 451 (V_4) (18) was recorded with lowest number of grains respectively. This is because photosynthesis is inhibited by drought, grain filling becomes more dependent on mobilized pre anthesis stem reserves that buffer the grain yield against environmental stresses during grain filling, particularly in wheat.

The plants under severe stress exhibited earlier maturity with a shorter life cycle and had lower grain numbers and decreased weight per grain. The findings of lower final yields under drought stress are in accordance with previous reports of Hafez *et al.* (2016) [6], Moonmoon *et al.* (2017) [9] (Tab.1). Spike length and No. of spikelet's per spike are sensitive to water stress Hansan *et al*. (2007) [7].

Data concerning the grain yield per plant (Fig. 4), test weight was greatly reduced under T3 (35% FC) in our experiment. However, reductions in this yield parameters under drought treatments were less in the tolerant cultivar as compared to the sensitive cultivar. Maximum grain yield was found in the genotype DBW 110 (V_2) (7.14 g) and the lowest grain yield was found in GW 451 (V_3) (5.77 g). The data regarding the Table 1 indicated that wheat genotypes found highly significant influence on test weight. The highest and lowest test weight was found in the genotype DBW 110 (V_1) (39.16 g) and GW 451 (V_4) (33.04 g) respectively. It was found that severe decline in yield traits of wheat was due to the deficiency of water. This may probably be due to the of disruption leaf gas exchange properties which not only limit the source size and sink tissues but the phloem loading, assimilate translocation and dry matter portioning (Table- 1).

Table 1: Yield and yield attributes of four wheat genotypes influenced by drought

Treatments	Number of tiller/plant	Number of Spikelets/spike	Number of grains per spike	Grain yield/plant
Level of FC				
Control	5.88	20.31	25.00	10.01
Moderate stress (75% FC)	4.06	17.38	20.94	6.19
Severe stress (35% FC)	2.31	14.56	14.00	3.13
Genotype				
C-306	4.08	17.42	20.94	6.92
DBW 110	4.33	18.33	22.00	7.19
DBW 136	3.92	17.00	19.00	5.89
GW 451	4.00	16.92	18.00	5.77
V×T	NS	*	*	NS

Table 2: Yield and yield attributes of four wheat genotypes influenced by drought

Treatments	Biological yield (g)	Harvest index (%)	Test weight/plant
Level of FC			
Control	22.62	44.20	42.59
Moderate stress (75% FC)	16.77	36.86	38.85
Severe stress (35% FC)	11.14	26.45	26.93
Genotype			
C-306	17.66	37.73	37.21
DBW 110	18.44	37.55	39.16
DBW 136	15.29	34.16	35.09
GW 451	15.99	33.91	33.04
V×T	NS	NS	NS

Disturbed nutrient uptake efficiency and photosynthetic translocation within the plant decreases the 1000-grain weight. This decrease was due to reduced production of photosynthates under water deficit conditions. These results were in accordance with the reports of Farooq *et al.* (2009) [5], Kilic *et al.* (2010) [8]. The Harvest index, biological yield also affected by the water stress condition. From our experiment we found that the value of harvest index, biological yield was reduced significantly under drought condition. The pertaining of data in Table 2 elucidated that wheat genotypes found highly significant influence on harvest index.

The highest harvest index (Fig. 5) was found in the genotype DBW 110 (V_1) (37.73%) which was statistically on par with C-306 (V_2) (37.55%) and lowest harvest index was observed in genotype GW 451 (V_4) (33.91%). Because under water stress condition a decrease in water use efficiency in the unit and reduction in photosynthesis process reduced HI compared to the control condition (Table- 2).

The higher value of biological yield (Fig. 6) was found in the genotype DBW 110 (V_1) (18.44 g/plant) which was statistically on par with C-306 (V_2) (17.66 g/plant), lower value was found in the genotype DBW 136 (V_4) (15.29 g/plant). The significant decrease in yield attributes observed under water stress treatments may also be seems to have resulted on account of poor nutritional condition inside the plant. This is further evidenced from the fact that there was significant decrease in DMA at different growth stages which finally reflected in significant decreased in biological yield under water stress (Table- 2).

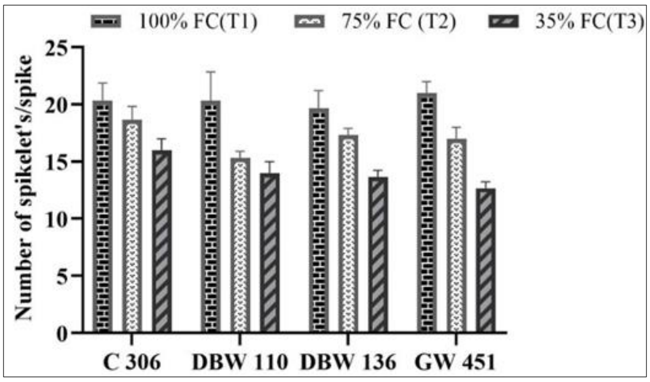

Fig 3: Number of spikelet's/spike

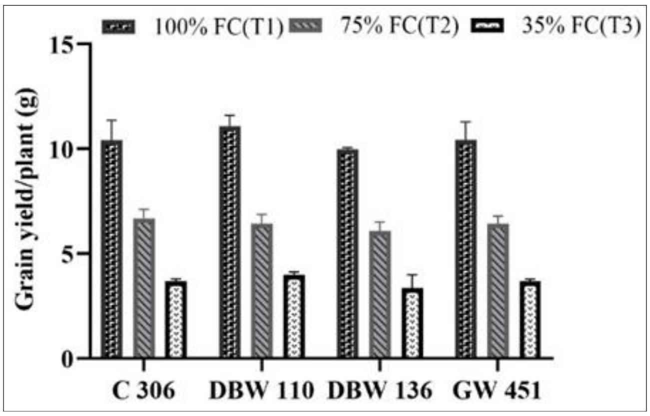

Fig 4: Grain yield/plant

This is because wheat genotypes increased the production of total biomass under irrigated condition than in dry environments. These results are in conformity with the reports of Chandra *et al.* (2005) [3]. Severe stress caused the plants to produce a small canopy and tended to senesce earlier, which hastened their life cycles and decreased grain number and harvest index. These results agree with the reports of Saeidi *et al*. (2015) [11], Bilal *et al.* (2015) [2], Nawaz *et al.* (2013) [10].

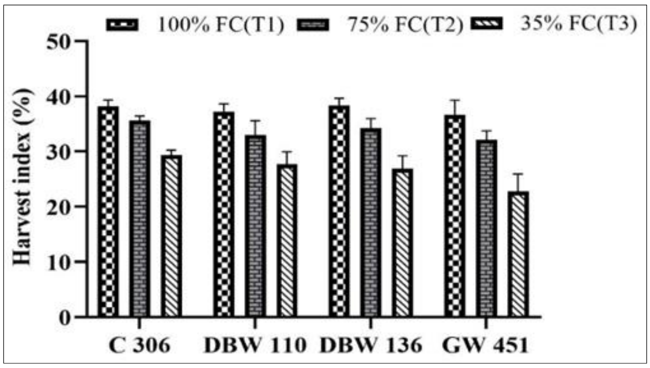

Fig 5: Harvest index

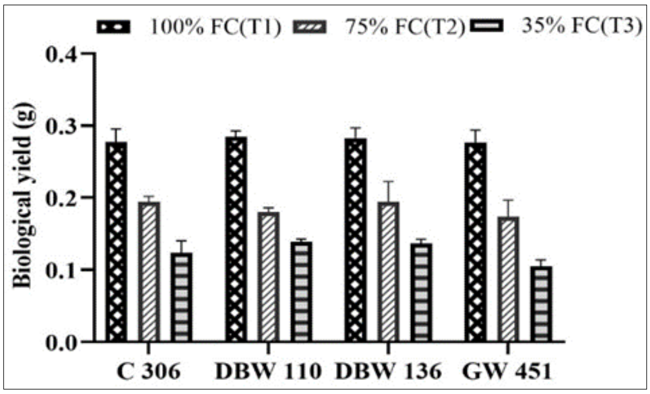

Fig 6: Biological yield

Conclusion

From the findings of the study, it may be concluded that DBW-110 genotypes and C-306 gave significantly higher yield than the other genotypes under study. Moreover, it was made out that drought stress at early grain filling was crucial regarding wheat yield; hence, at this growth stage drought stress may be avoided. More reduction was observed in early grain filling stage under the stress treatment. Because plants were better able to recover from stress imposed during the booting stage than the early grain filling stage, emphasizing the importance of drought timing in determining productivity. Yield attributing characters depends on the level of water stress, the length of time to which the plant is subjected to water stress, and the genotype of the plant. Because the plants subjected to 35% FC showed more reduction in yield parameters comparing to 75% FC. It is clear from the results obtained in this study that different levels of water stress affect the growth of wheat cultivars differently, which indicates that the wheat cultivars differed in their ability to tolerate different levels of water stress. Since, parameters like plant height, spikelet's per spike, dry matter, Test weight were found to be influenced by increasing water stress.

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