Journal of
Biotechnology, Fieldcrop and
Molecular Sciences
An Open Access, Peer Reviewed Journal

Research Article

Influence of drought stress on Grain Yield, Yield Components of wheat cultivars under controlled condition

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Citation | Batyrbek, M., M. Akhtar, S. Memon, M. Saleem, R. Larik, A.E. Abdelghany, A.G. Khoso and M. Anwar (2023). Infuence of drought stress on Grain Yield, Yield Components of Wheat cultivars under controlled condition. Journal of Botanical Fieldcrop Management Sciences, 1(1): 44-52

Abstract | Throughout world Drought, one of the environmental stresses is the most significant factor restricting plant production in the majority of agricultural fields of the world. Wheat is generally grown on arid-agricultural fields. Drought often causes serious problems in wheat production areas. The experiment was laid out at the field under controlled condition. Six different wheat cultivars grown for tested their genetically performance for drought tolerance under controlled condition, wheat grown season in order to evaluate genotypes for yield, yield components and some quality traits. There were some Six different wheat cultivars i.e., IBWSN-1010, IBWSN -1025, TD-1, ESW-9525 along with two local cultivars were set as checks Khirman and Chakwal-86 grown with two treatments (T1 control normal four irrigations) and (T2 Terminal drought T. Drought) conditions. Morphological traits were measured at after harvest and yield, yield components and quality traits were evaluated after the harvest. The results indicated significant differences at P≤0.05.that all the agronomical parameters decreased with decrease in water stress. It was observed with the cultivar ESW-9525 revealed maximum seed index (g), grain weight (g),straw weight (g), number of tillers, spike length (cm), plant height (cm) at both control and terminal drought environment as compared to both check varieties significantly

Keywords | Wheat; drought; Crop yield; Agronomic traits; Screening
Keyfindings | It was observed with the cultivar ESW-9525 revealed significant performance at both control and terminal drought environment as compared to both check varieties significantly

Received: 24/12/2022 Accepted: 12/01/2022 Published: 18/01/2023

1. Introduction

Wheat (*Triticum aestivum* L.) belongs to the family Poaceae, wheat is one of the most important cereal crops grown worldwide (Salwa *et al*., 2014). From centuries till now, wheat has been considered as the 'King of cereals' (Pavithra and Patil, 2013). After rice, it is the second most important cereal crop, where about more than 35 percent of the world population relies on wheat in different styles. Along with its need, it is nutritious providing 1.80% mineral fiber, fat 2%, crude fiber 2.20%, protein 12%, water 12%, and carbohydrates 70% (Shewry, 2007).Accordingly in the world, the major wheat production countries include China, India, United States, France, Russia Australia, Canada, Pakistan, Germany and Turkey (FAO, 2013).Whereas, Pakistan occupies 8th position around the largest wheat production countries. About 2.5 billion people of developing and under developed world survive on wheat as an element source of energy (FAO, 2010).Being a staple food of the economy; it stands a central position in farming and agriculture. Its diverse consumption by the population of Pakistan has been averagely used for about 60 percent of daily diet of common man with an average per capita consumption of 125 kg (Khan *et al*., 2003).Consequently, the agricultural value has experienced a growth of 0.3 percent in the fiscal year 2015-16 against the growth of 8.0 percent during the same period of last year on account of revised production estimates of wheat crop (GOP, 2016).

Water scarcity is one of the most key environmental factors and is a global constraint restricting plant survival in infertile regions (Kafi and Salehi, 2012; Nemat *et al*., 2015). The effects of drought on crop yield leads to severity and ultimately affects each stage on plant growth. Moreover, the germination potential, coleoptile length and vigour are reduced (Farooq *et al*., 2009). Semi-arid regions and low moisture areas are the main limiting factors of germination. Hence, the rate and seedling formation are exceedingly important factors to determine both yield and time of maturity (Rauf *et al*., 2007). The effects of drought on crop yield results in severity and in the end influences each level of plant decrease. Drought stress tolerance varies from species to species or even inside species. Water deficit and salt stress are international problems that affect the survival of agriculture vegetation and sustainable meals manufacturing (Jaleel *et al*., 2009). In crops, modifications in anatomical and physio-biochemical traits due to drought resistances might be used to develop new genotypes and to obtain better production under water stress condition (Martinez *et al*., 2007). However, understanding and selection of the biochemical and physiological basis of water stress tolerance in plants is important for breeding the crop (Soomro *et al*., 2014).In reference to stress tolerance, physiological processes are mandatory for a successful breeding program and this type of study will provide a selective criterion for wheat germ plasm in respective to stress condition.

The objectives of this study, therefore, were to screen wheat varieties with high yield potential, stability, yield components and quality traits under water stress conditions and to determine suitable selection criteria for selecting genotypes tolerant to drought stress conditions.

2. Materials and Methods

The present study was conducted at Plant Physiology Division of Nuclear Institute of Agriculture (NIA), (Tandojam, Latitude: 25.433. Longitude: 68.533). The experiment was laid out at filed of NIA Tandojam under controlled conditions. There were six wheat cultivars i.e., IBWSN-1010, IBWSN -1025, TD-1, ESW-9525 wheat cultivars grown for tested their genetically performance for drought tolerance under controlled condition at NIA field, whereas two drought tolerant genotypes i.e., Khirman and Chakwal-86 were also included as local check as compare among the genotypes under control (normal four irrigations) and Terminal drought (T. Drought) conditions. The experiment was set as Randomized Complete Block Design (RCBD) with three replications. The spacing between row-row and plant-plant were 0.5 x 0.06 meter. Nitrogen and phosphorous fertilizers were applied in the form of urea @ 120 kg ha$_{-1}$ and DAP (Di Ammonium Phosphate) @ 70 kg P_2O_5 ha$_{-1}$ at surface prior to sowing. Drought treatment was imposed in plot by withholding irrigation water after sowing, whereas control plots were irrigated normally (four irrigations). Soil moisture content was monitored regularly till harvesting.

Following growth parameters were under observations:

Plant height (cm): The height of each selected plant was measured in centimeters from the surface of the soil till the tip of spike excluding awns at the time of maturity and the mean plant height per genotype was calculated.

Spike length (cm): Length of the spike of main tillers was measured in centimeters from the base of the spike to the upper most spikelet's excluding awns.

Number of Tiller: The numbers of productive tillers were counted randomly of selected plants at the time of maturity and total fertile tillers from each plant were recorded.

Straw weight/plant (g): The weight of the straw without the spike and roots was measure on weighing balance.

100 Grain weight (g): After harvesting, each plant was threshed one by one by hand and grains were weighed in an electronic balance and the data was recorded in grams.

Seed index (g): Thousand seeds were counted and weighed in grams with the help of electronic balance in laboratory.

Days to 75% heading: Days were counted when crop reached at heading, boot appeared.

Days to 75% maturity: Days to maturity plants showed was taken when yellow peduncle, and reached to 75% physiological maturity.

Statistical analysis: The data recorded were subjected to analysis of variance to discriminate the superiority of treatment means and LSD test were applied by the following method of Gomez and Gomez (1984) to compare the means

3. Results

The mean squares from analysis of variance in pot experiment for plant height and straw weight, whereas for other morphological traits viz. 75% days to heading, 75% days to maturity, number of tillers plant^{-1}, spike length , straw weight plant^{-1}, 100 grain weight plant^{-1} and 1000 grain weight indicated significant differences at $P \leq 0.05$. For the treatments grain weight revealed to be non-significant, whereas days to 75% heading and days to 75% maturity was significant at $P \leq 0.05$. The interaction (genotype x treatment) was non-significant for all the traits except straw weight ($P \leq 0.01$).

Agronomical Characters										
Source of variation	DF	Seed index	Grain weight	Straw weight	Number of tillersplant^{-1}	Spike length	Plant height	Number of spike Plant^{-1}	Days to heading	Days to maturity
Replication	2	15.739	176.765	5.14	2.5833	0.8679	12.25	2.5833	5.14	0.8679
Treatments	1	701.279**	7.618^{ns}	3035.46**	56.25**	56.0252**	1736.11**	56.25**	47.83*	56.25*
Genotype	5	44.849**	139.315*	134.78**	18.45**	20.0494**	640.27**	18.45**	61.388*	72.733*
Genotype x Treatment	5	5.703	109.394^{ns}	33.62*	0.45^{ns}	0.4875^{ns}	65.18**	0.45^{ns}	0.4875*	33.62*
Error	20	13.127	119.399	13.16	1.6333	0.8765	13.76	1.6333	8.39	5.703

**= significant at P<0.01probability level, *= Significant at P<0.05probability level and ns= Non-significant

Plant height (cm)

For the trait plant height (cm), most of the genotypes reduced their height at terminal drought as compared to control treatment. The genotypeTD-1 produced shorter height and recorded as 52.7cm at control condition, whereas the genotype ESW-9525 revealed taller plant having height of79.7cm, respectively as compared with the check varieties, Chakwal-86 and Khirman with height recorded as 81.0 and 91.3cm, respectively under control condition. The genotype TD-1 produced minimum plant height at highest water stress terminal drought and recorded as 46.00 cm. Moreover, the genotype ESW-9525 produced taller plant height and observed as 66.3cm, respectively. Comparison with the check varieties Chakwal-86 and Khirman produced plant height of 63.0 and 69.7 cm, respectively at terminal drought.

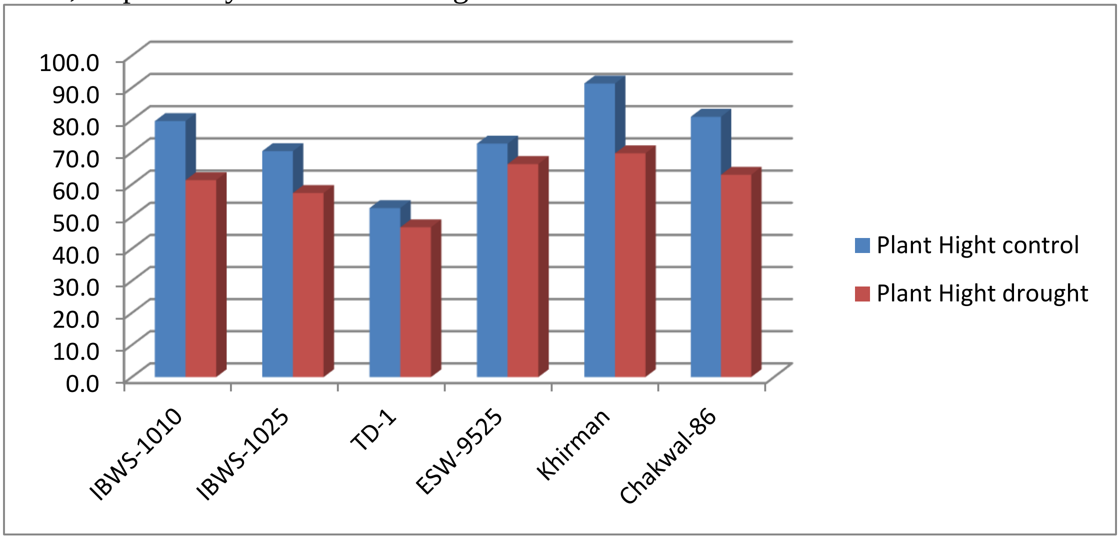

Figure 1. Plant height affected by water stress in different genotypes

Spike length (cm)

Among all the wheat genotypes, the spike length were reduced at water stress level. The genotypeTD-1 produced shortest spike length and recorded as 10.8 cm at control condition, whereas the genotypeESW-9525 produced longest spike length as (14.7) cm. Comparison with the check varieties, Chakwal-86 and Khirman produced spike length as 13.8 and 14.7 cm, respectively under the controlled condition. Moreover, the genotype TD-1produced minimum spike length at highest water stress (terminal drought) and recorded as7.6 cm, whereas the genotype ESW-9525 produced maximum spike length (13.2cm)as compared with the check varieties Chakwal-86and Khirman having spike length of 11.3 and 12.1, respectively at terminal drought.

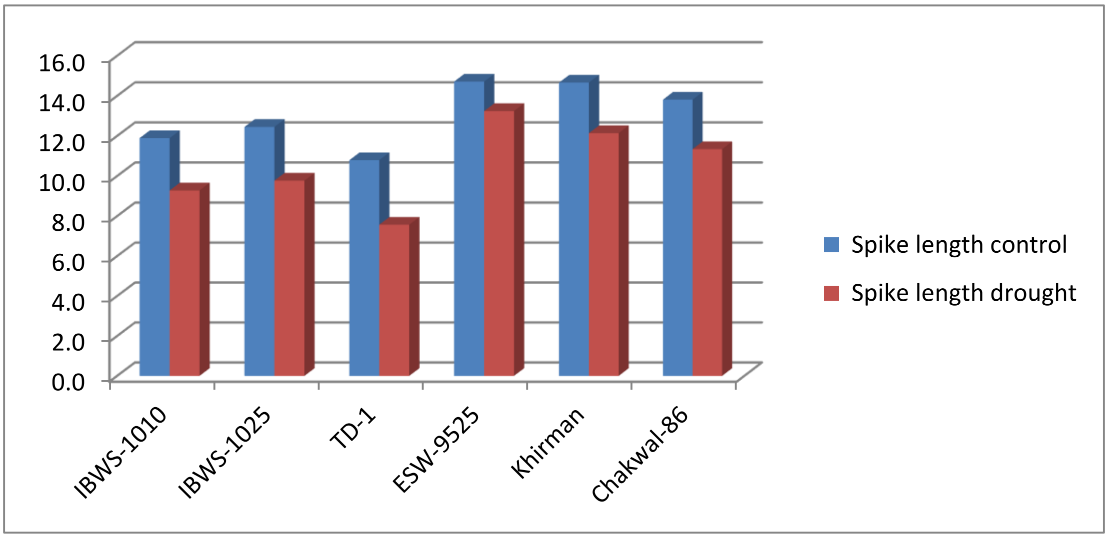

Figure 2. Spike length affected by water stress in different genotypes.

Number of tillers plant^{-1}

Among all the wheat genotypes the number of tillers plant^{-1} also reduced at water stress level (Terminal drought) as compared to control treatment. The genotypes IBWSN-1010 produced minimum number of tillers plant^{-1}and recorded as 8.0 tillersplant^{-1}at control condition, whereas the genotype ESW-9525 produced maximum number of tillers plant^{-1}(12.0), respectively. Comparison with the check varieties, Chakwal-86 and Khirman produced number of tillers as 12.0 and 12.0, respectively under control condition. However, the genotype IBWSN-1010 produced minimum number of tillers plant^{-1} at highest water stress (5.0)The genotype ESW-9525 produced maximum number of tillers plant^{-1}and recorded as 10.0, compare with the check varieties Chakwal-86 and Khirman having number of tillers 10.0 and 10.0,respectively at terminal drought.

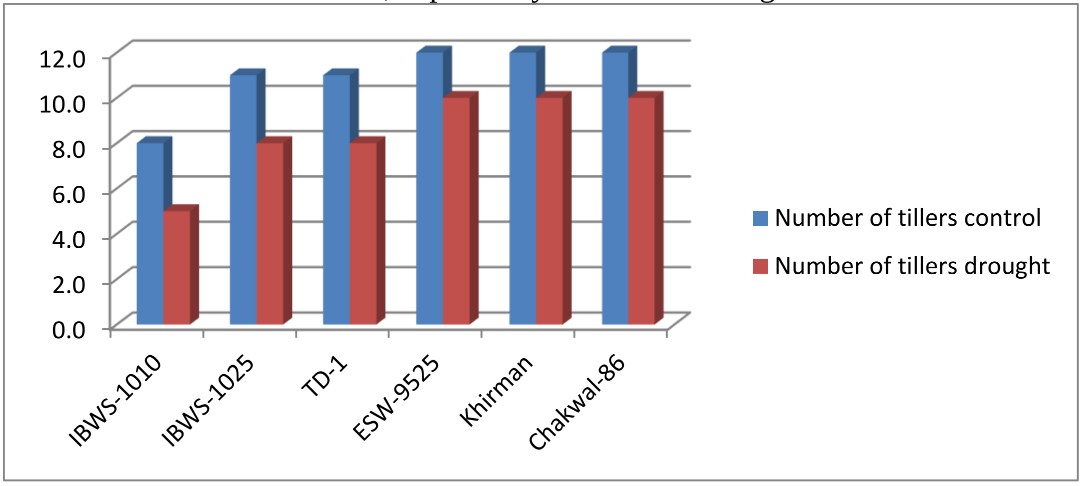

Figure 3. Number of tillers affected by water stress in different genotypes

Straw weight (g)

The straw weight also reduced during water stress level. The reduction was more at the terminal drought stress as compare to control treatments. The genotypes IBWSN-1010 produced minimum straw weight (g) as 20.1 gm at control condition, whereas the genotype ESW-9525 produced maximum straw weight (g) as 39.1 gm, respectively, compared to the check varieties, Chakwal-86 and Khirman influenced moderate straw weight as 30.3and 36.2 gm, respectively under the controlled condition, respectively. The genotype IBWSN-1010 produced minimum straw weight (g) at (terminal drought) and recorded as 8.4 g. However, the genotype ESW-9525 revealed maximum straw weight gm(14.3 g).Comparison with the check varieties, Chakwal-86 and Khirman produced straw weight as 11.2and 13.7 gm, respectively at highest water stress (Terminal drought).

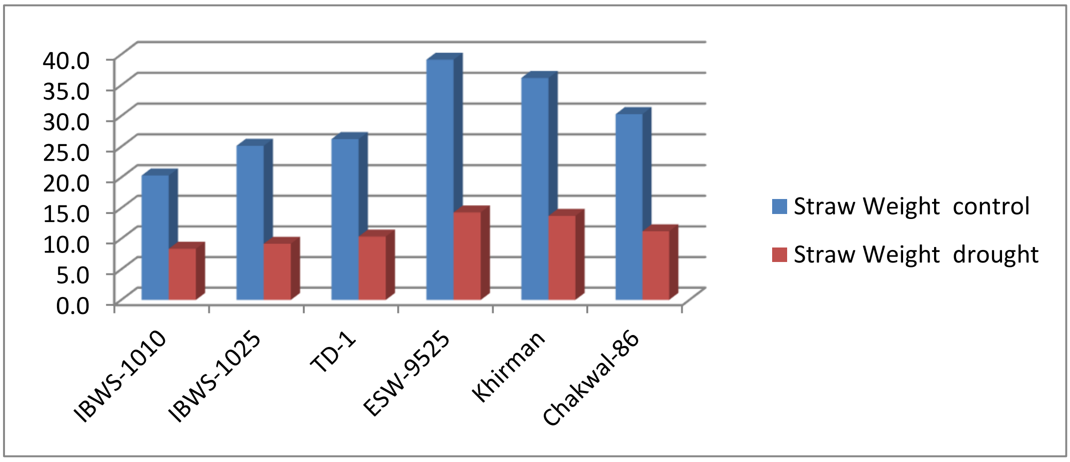

Figure 4. Straw weight affected by water stress in different genotype

100 Grain weight (g)

Overall wheat genotypes showed that the grain weight also reduced at water stress level (Terminal drought) as compared to control treatment. The genotypeTD-1 produced reduced grain weight and recorded as 19.7 gm at control conditions, whereas the genotype ESW-9525 produced more grain weight as 23.3 gm, respectively. Comparison with the check varieties, Chakwal-86 and Khirman produced grain weight as 21.3 and 23.4 gm, respectively under the controlled condition. The genotype IBWSN-1010produced minimum grain weight at highest water stress (terminal drought) and recorded as 14.8gm. However, the genotype ESW-9525 produced maximum grain weight (19.7 gm) as compared to the check varieties Chakwal-86, and Khirman, having grain weight (17.2 and 19.2 gm), respectively at highest water stress (Terminal drought).

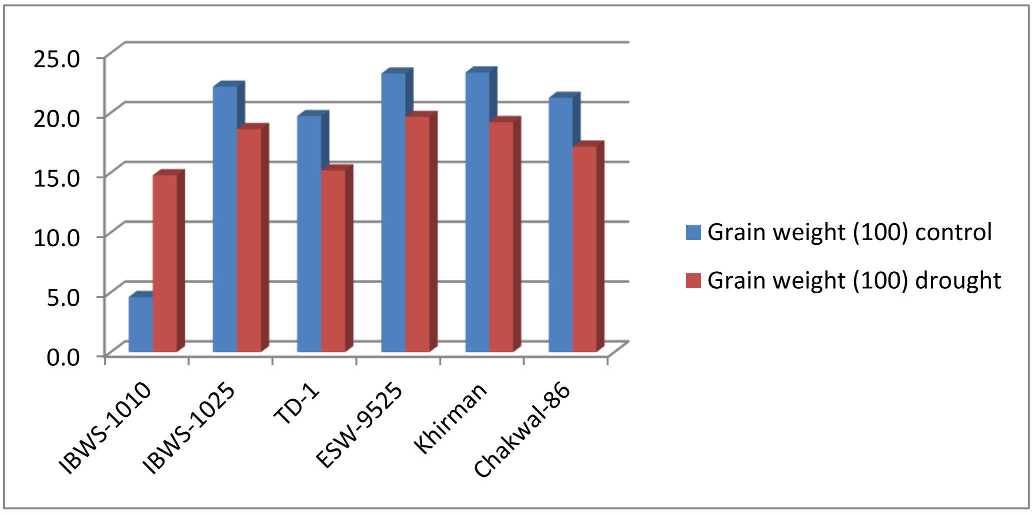

Figure 5. Grain weight affected by water stress in different genotypes

Seed index (g)

Among all the wheat genotypes, the seed index reduced in water stress level as compare to control treatment. The genotype TD-1recorded minimum seed index (41.6gm)at control condition, whereas the genotypeESW-9525 and IBWS-1010 revealed maximum (39.4 and 37.8 gm), respectively seed index as compared to the check varieties, Chakwal-86 and Khirman having seed index of45.5and45.7gm, respectively under the controlled condition. During terminal drought, the genotype TD-1produced less seed index at terminal drought and recorded 29.1 gm, whereas the genotype ESW-9525 produced more seed index (39.4 gm). Comparison with the check varieties Chakwal-86, and Khirman produced seed index (37.3 and 37.7 gm) respectively at highest water stress.

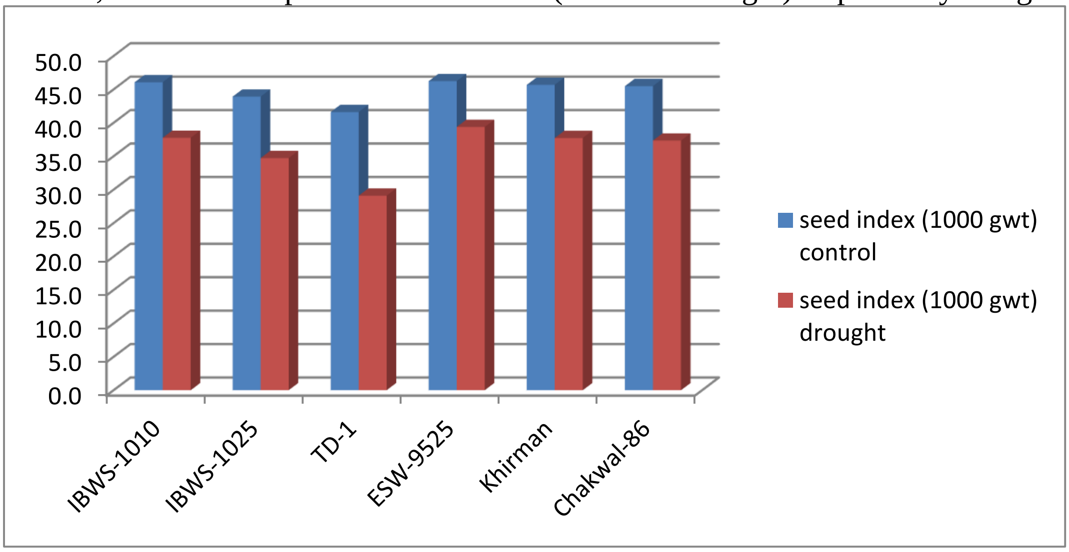

Figure 6. Seed index affected by water stress in different genotypes

Days to 75% heading

For the trait days to heading, most of the genotypes heading reduced at terminal drought as compare to control treatment. The genotypes ESW-952 head earlier (78.2) at control condition, whereas the genotype IBWS-1010 mature lately (92.7), as compared with the check varieties, Chakwal-86 and Khirman. The genotype ESW-9525also produced earlier (84.83) at terminal drought. Compare to the check varieties Chakwal-86 and Khirman also produced earlier heading as 73.5 and 78.5 at terminal drought.

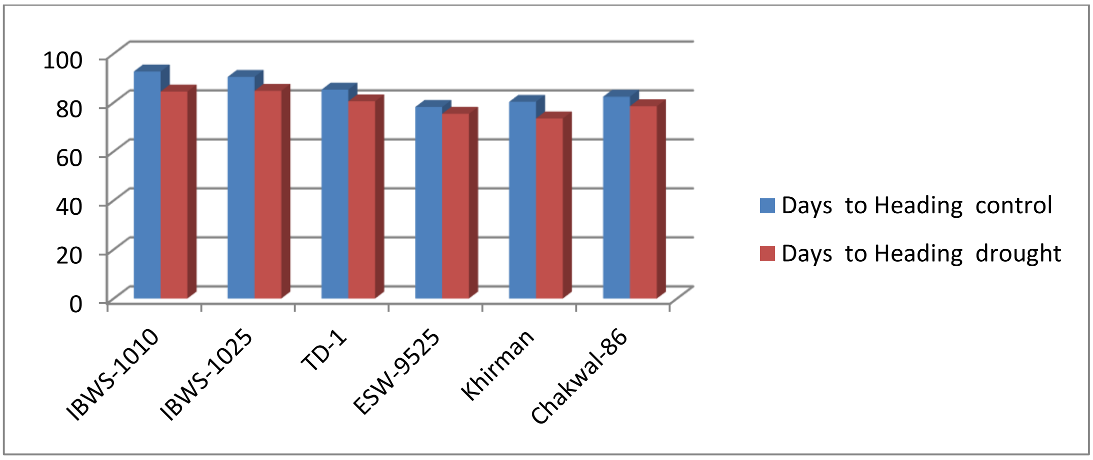

Figure 7. Days to heading affected by water stress in different genotypes

Days to 75% maturity

For the trait days to maturity, most of the genotypes reduced maturity at terminal drought as compare to control treatment. The genotypes IBWS-1010 matured earlier (118.7) at control condition, whereas the genotype ESW-952 matured late (122.1), as compared with the check varieties, Chakwal-86 and Khirman. The genotype ESW-952 matured earlier (113.7) at terminal drought as compared with both the check varieties Chakwal-86 and Khirman (113.8 and 115.8).

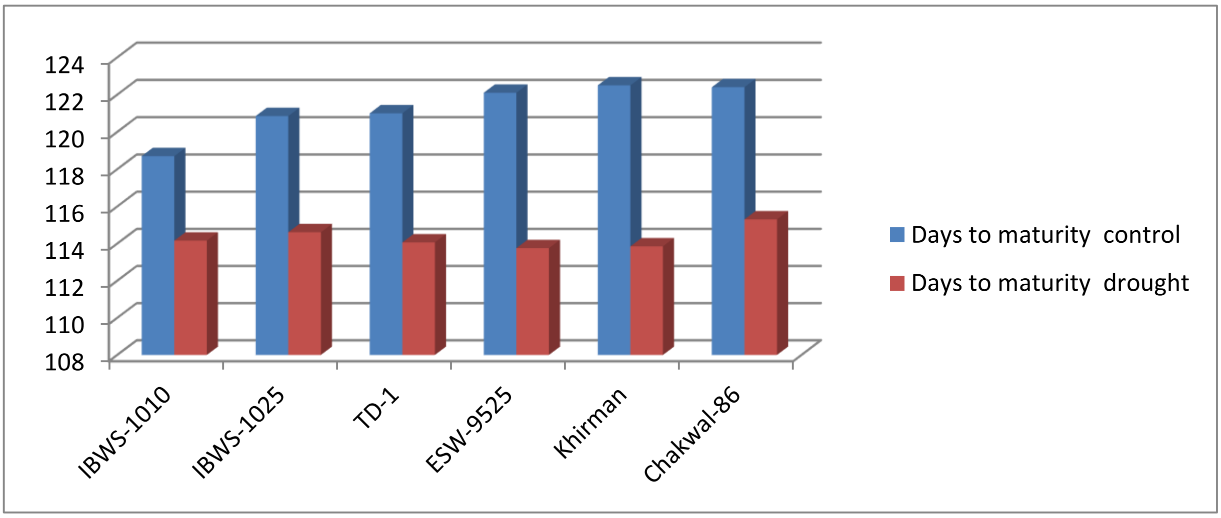

Figure 8. Days to maturity by affected water stress in different genotypes

4. Discussion

Among abiotic stresses, water scarcity is one of the most key environmental factors that restricting plant survival and crop manufacturing in infertile regions (Kafiand Salehi, 2012). Drought in all likelihood has the most extensive outcome on growth and yield which vegetation is probably come upon in both herbal and agricultural systems (Bartels and Sunkar, 2005). Hence, it is a crucial to examine the mechanism of drought risk in plant species and increase their agronomic characters to make viable cultivar with increased resistance. The study of drought has been one of the global complexes physical and chemical process in which severity occurs at the stage of plant growth (Khakwani and Munir 2011). Hence, the yield and vigour is affected diversely. Under semiarid regions, low moisture is often a limiting factor during plant growth (Khakwani and Munir 2011). The analysis of variance at seedling stage revealed to have highly significant at $P \leq 0.01$ plant height (cm) and straw weight (cm) at $P \leq 0.01$, whereas for other morphological traits viz. days to 75% heading, days to 75% maturity, .number of tillers plant^{-1}, spike length (cm), straw weight plant^{-1}, grain weight plant^{-1}, and 1000 grain weight (g) indicated significant differences at $P \leq 0.05$.The results indicated that days to maturity and days to heading predicted significant positive association with plant height (cm), and spike length (cm). Khan *et al.*, (2013) also predicted significant and positive association reflecting that as the days of heading and maturity increased the plant height (cm) and spike length (cm) will increase ultimately. Genetic correlation coefficient analysis confirms that early maturity is positively correlated with yield components (Abinasa *et al.*, 2011). However, negative and positive associations were observed with grains weight, plant height and tillers plant^{-1}, spike length, grain weight, 1000 grain weight and straw weight. Plant height possessed negative and positive association with tillers plant^{-1}, spike length, grain weight, 1000 grain weight and straw weight. Albokari *et al*., (2016) observed similar results as plant height showed highly significant positive correlation with number of leaves plant^{-1} and number of tillers plant^{-1}. At partial stress, 1000-grain weight showed highly significant correlation with grain yield and maturity time. Grain weight (g) and 1000 grain weight possessed negative and positive and significant straw weight.

5. Conclusions

It is concluded from the results of this study that water stress reduced wheat yield and some yield components in all cultivars. The differential response of cultivars to imposed water stress condition indicates the drought tolerance ability of wheat cultivars. On an overall, our results and the findings of others show that a strategy of selecting should take into consideration seed index (g), grain weight (g),straw weight (g), number of tillers, spike length (cm), plant height (cm), high spike weight and short spike length for increasing yields under drought conditions. Cultivars ‘ESW-9525, IBWSN-1010, IBWSN-1025 and TD-1 showed high yield potential and stability under drought stress and they maintained their yield across a range of water availabilities.

Data Availability Statement: In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study.

Acknowledgments: The authors would like to extend their sincere appreciation to the College of Life Sciences and Oceanography, Shenzhen University P.R China

Conflicts of Interest: The authors declare no conflict of interest

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