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Article

Effect of Drought Stress on Bread Wheat (*Triticum aestivum L.*) Genotypes

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Abstract: Drought is one of the environmental stress factors and the most important factor limiting crop production, especially in rain-based agricultural areas. This research aimed to determine the effects of drought stress on some bread wheat genotypes and to determine drought tolerant genotypes among genotypes. In the research, 20 bread wheat genotypes were used as material. The experiment was carried out in fully controlled greenhouses belonging to the Faculty of Agriculture of Dicle University in 2022 according to the randomized blocks trial design with 4 replications. An artificial drought stress environment was constituted by irrigating the pots up to 40% of the field capacity. As a result of the research, as the plants belonging to five genotypes lost their vitality as a consequence of the drought effect, observations could not be taken and they were not subjected to statistical analysis. Among the investigated characteristics, the chlorophyll content (SPAD) value in the spiking stage, the chlorophyll content (SPAD) value in the flowering stage, the number of days spike, and the plant height were affected by the drought application at the level of 1%, while the spike height and the number of grains per spike were affected at the 5% level. It is noteworthy that line 6, which is the prominent genotype among the genotypes in terms of spike yield, is also the earliest, has the longest plant height, and is the genotype with the highest number of grains per spike.

Keywords: Drought stress; genotype; bread wheat; SPAD; phenological stage.

1. Introduction

Wheat is an important cereal plant that has been used in human nutrition and has been cultivated for thousands of years. Since the wheat cultivation areas in the world have reached the limit, meeting the wheat demand of the increasing world population depends on increasing the grain yield to be taken from the unit area. It has been determined in many studies that the physiological and morphological characteristics of wheat are directly or indirectly related to yield and quality [1]. Therefore, the main goals of breeders are to develop genotypes with good drought resistance, good yield, and quality, and increase production per unit area, especially for areas where agriculture is based on precipitation. To achieve this goal, high-yield or quality genotypes should be bred and their seeds should be offered to producers.

Global warming causes climate changes, and accordingly, changing rain regimes and increasing temperatures create a global drought threat. It is expected that climate change will play a role in reducing the negative effects on food production, food quality, and food safety [2-4]. Especially considering its role in human nutrition, it is estimated that the supply-demand relationship in the wheat plant may change negatively. Drought is one of the environmental stress factors and is the most important factor limiting crop production, especially in rain-based agriculture. All these developments encourage plant breeders to develop new drought-resistant varieties.

This study aimed to determine the effects of drought stress on some bread wheat genotypes and to determine drought tolerant genotypes among genotypes.

2. Materials and Methods

Experimental design

This research was carried out in the controlled greenhouses of Dicle University, Faculty of Agriculture, Department of Field Crops.

In the study, 20 different bread wheat genotypes were used as material, and random plots were established according to the 4-replication experimental design. Bread wheat genotypes were grown in 8 liter pots with 4 plants per pot. The field capacity of a pot containing 5 kg of soil, the difference between the wet soil weight and the dry soil weight was determined as the amount of water retained in the soil [5,6]. The field capacity was accepted as 100% and drought stress was created in 40% of this field. Water restriction was applied after the sowing process. Sowing was done on 09.03.2022 and harvesting was done on 03.06.2022 after 86 days. With sowing, 6 g/m² N and 6 g/m² P_2O_5 compound fertilizer were given, and 6 g/m² N urea fertilizer was given during tillering period. A drip irrigation system that can be controlled by solenoid valves with a timer was installed for the precise application of irrigation amounts.

The average temperature of 86 days (°C) in the greenhouse is given in Figure 1.

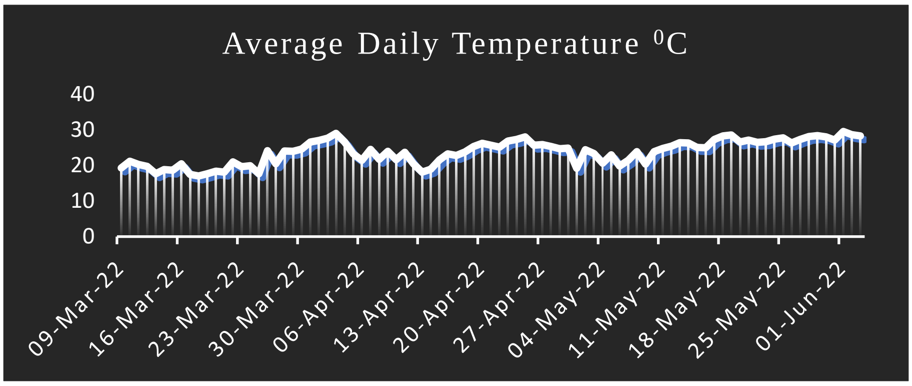

Figure 1. The average daily temperature of the greenhouse.

Table 1. Analysis results of the soil used in the study.

Soil Analysis Result										
Saturation (%)	Salinity (dS/m)	pH (%)	Organic Matter (%)	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	Fe (ppm)
63.20	1.03	8.15	0.77	0.04	6.00	493.26	10693.12	616.32	14.37	8.86

It is seen that the soil used in the study has a clay-loam structure, a slightly alkaline structure, and is rich in potassium, calcium, and iron, but poor in organic matter, nitrogen, and phosphorus (Table 1).

In the study, the chlorophyll content (SPAD) value in the spike stage, the chlorophyll content (SPAD) value in the flowering stage, the number of days to spike, the plant height, the spike height, the number of spikelets per spike, the number of grains per spike, the grain weight per spike and the main stem diameter were examined.

Statistical analysis

The variance analysis was performed in the JumpPro-13 statistical analysis program, scatter plot analysis of the data obtained from the characteristics examined in the study was performed in the

Genstat 12th (Copyright 2011, VSN International Ltd), and Pearson's correlation analysis was performed in the Python 3.8 program.

3. Results and Discussion

As a result of the study, since the plants belonging to five genotypes lost their vitality due to the effect of drought, observations could not be taken and they were not subjected to statistical analysis.

Among the investigated characteristics, the chlorophyll content (SPAD) value in the spike stage, the chlorophyll content (SPAD) value in the flowering period, the number of days to spike, and the plant height were affected by drought at the level of 1%, while the spike height and the number of grains per spike were affected at the level of 5%. The averages of the traits examined in the study; the chlorophyll content (SPAD) value in the spike stage is 52.7, the chlorophyll content (SPAD) value in the flowering stage is 55.38, the number of days spike is 55.35, the plant height is 41.83 cm, the spike height is 6.84 cm, the number of spikelets per spike is 13.56, the number of grains per spike is 16.54, the grain weight per spike is 0.428 g and the main stem diameter is determined as 2.71 cm (Table 2).

Table 2. Genotype averages of the examined traits and groups formed.

Genotype No	Spike stage SPAD	Flowering stage SPAD	Number of days to spike	Plant height (cm)	Spike height (cm)
1	49.93 c	53.45 c	53.50 def	39.13 b-e	7.38 ab
2	51.10 c	53.08 c	56.75 cd	42.58 a-d	6.69 ab
3	52.13 c	55.58 bc	57.25 cd	37.69 cde	6.88 ab
4	52.10 c	54.35 c	63.00 ab	31.49 e	4.57 c
5	57.13 ab	59.98 ab	57.50 cd	43.69 abc	7.69 ab
6	51.30 c	52.28 c	46.00 h	46.88 a	7.21 ab
7	59.83 a	63.95 a	55.25 cde	41.4 2 a-d	7.88 a
8	52.45 c	55.45 bc	56.50 cd	43.25 abc	6.92 ab
9	50.63 c	52.30 c	47.00 gh	44.33 abc	6.67 ab
10	51.88 c	55.70 bc	51.00 efg	43.75 abc	7.31 ab
11	53.23 bc	55.43 bc	58.75 bc	35.19 de	6.02 bc
12	53.25 bc	57.15 bc	55.00 cde	39.31 a-d	6.31 ab
13	53.90 bc	55.05 bc	49.50 fgh	46.79 ab	7.48 ab
14	51.53 c	54.48 c	58.00 c	45.13 abc	6.19 bc
15	50.15 c	52.55 c	65.25 a	46.90 a	7.46 ab
Average	52.7	55.38	55.35	41.83	6.84
CV %	5.75	6.62	5.49	12.90	17.14
LSD	2.14**	2.59**	2.14**	3.81**	0.82*

* - $p<0.05$; ** - $p<0.01$.

The chlorophyll content, which was examined in two different periods in the study, was 52.7 on average in the spiking period and 55.38 in the flowering period. Akın et al., in a study on drought stress in wheat; reported that SPAD values were between 51.21 and 56.10 at 100% field capacity, between 47.60 and 55.47 at 75% field capacity, between 47.70 and 55.71 at 50% field capacity, and between 43.81 and 49.00 at 25% field capacity [7]. Moreover, they reported that increasing water stress caused significant reductions in SPAD values compared to optimum growing conditions. Bayhan et al. [8] reported that the SPAD values were in the range of 42.22-52.8 during the spike period and in the range of 50.53-61.78 during the flowering period. Khayatnezhad et al. [9] reported that drought stress caused a decrease in grain yield and plant chlorophyll radiation. Yıldırım et al. [10] reported that the SPAD value measured during the spike period showed a strong relationship with grain yield and increased usability in selection breeding. Barutçular et al. [11] reported that the SPAD value is more affected by heat stress rather than drought.

When the number of days to spike feature is examined, the earliest spiked genotype was the genotype numbered 6 with 46.00 days, while the genotype numbered 15 was the latest with 65.25 days. Akın et al. [7] reported that increased drought causes an early spike in genotypes, Kirda et al. [12] reported that selection of early genotypes is an effective strategy to minimize yield loss caused by drought stress. Bilgin and Korkut [5], reported that grain filling time was prolonged in early spike-forming genotypes and there was an increase in the amount of nutrients going to the grain.

Table 2. Genotype averages of the examined traits and groups formed (*continued*).

Genotype No	Number of spikelets per spike	Number of grains per spike	Grain weight per spike (g)	Main stem diameter (cm)
1	13.38 abc	21.13 a	0.631 abc	2.77 ab
2	15.54 a	17.81 ab	0.410 bcd	2.72 ab
3	13.00 abc	17.19 ab	0.388 bcd	2.62 ab
4	13.01 abc	5.90 c	0.088 e	2.75 ab
5	15.00 ab	12.88 abc	0.319 de	2.79 ab
6	11.71 c	21.13 a	0.744 a	2.53 b
7	13.21 abc	19.92 ab	0.444 bcd	2.72 ab
8	14.11 abc	18.69 ab	0.437 bcd	3.00 ab
9	12.33 abc	20.83 a	0.676 ab	2.45 b
10	12.75 abc	14.63 abc	0.444 bcd	2.61 ab
11	15.21 a	16.00 ab	0.421 bcd	2.70 ab
12	14.00 abc	17.56 ab	0.363 cde	3.16 a
13	14.21 abc	12.77 abc	0.425 bcd	2.67 ab
14	14.13 abc	20.50 ab	0.344 cde	2.73 ab
15	11.88 bc	11.27 bc	0.283 de	2.40 b
Average	13.56	16.54	0.428	2.71
CV %	16.94	39.36	48.15	15.69
LSD	1.62	4.60	0.14*	0.30

* - $p<0.05$; ** - $p<0.01$.

The plant height from the examined traits ranged from 46.88 to 31.49 cm (Table 2). There were significant differences in plant height between genotypes due to drought stress. Özkan et al. [13] in a study conducted in a greenhouse environment, reported that the average plant height of bread wheat genotypes was 71.06 cm. Yorulmaz and Akıncı [14] reported, that plant height in bread wheat varied between 51.43 and 92.56 cm depending on the field conditions. Poulden et al. [15] reported that drought stress adversely affected plant height and well-watered genotypes had longer plant heights, and also reported that genotypes with high height experienced more yield reduction in arid conditions compared to genotypes with short height.

The average grain weight per spike was determined as 0.428 g among the properties examined. In the study, since the genotypes did not give siblings in any of the replications, grain weight per spike was evaluated as plant yield. While the highest plant yield was 0.744 g with genotype 6, the lowest plant yield was found in genotype 4 with 0.088 g. Dencic et al. [16] and Maleki et al. [17] reported that grain weight per spike and grain number per spike were the most sensitive features to drought stress.

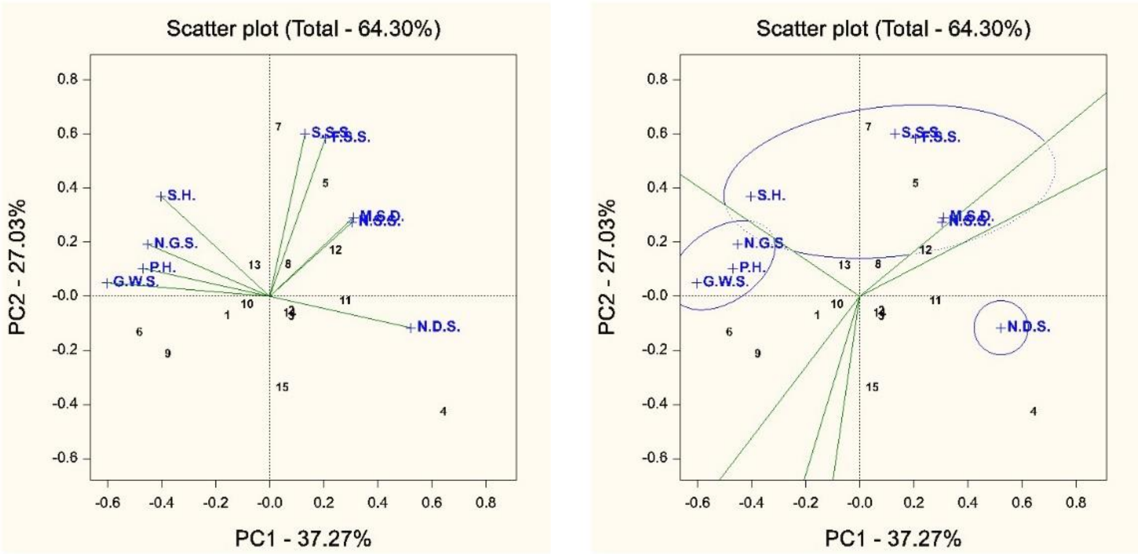

Figure 2. Scatter plot showing the relationship between features. S.S.S.: the chlorophyll content (SPAD) value in the spike stage, F.S.S.: the chlorophyll content (SPAD) value in the flowering stage, N.D.S.: the number of days to spike, P.H.: the plant height, S.H.: the spike height, N.S.S.: the number of spikelets per spike, N.G.S.: the number of grains per spike, G.W.S.: the grain weight per spike, M.S.D.: the main stem diameter.

According to the scatter plot graphic, as the angle between two vectors showing the features decrease (<90°), the relationship between them is positive, when the angle value is 90°, there is no relationship, and as the angle value increases (>90°), there is a negative relationship [18].

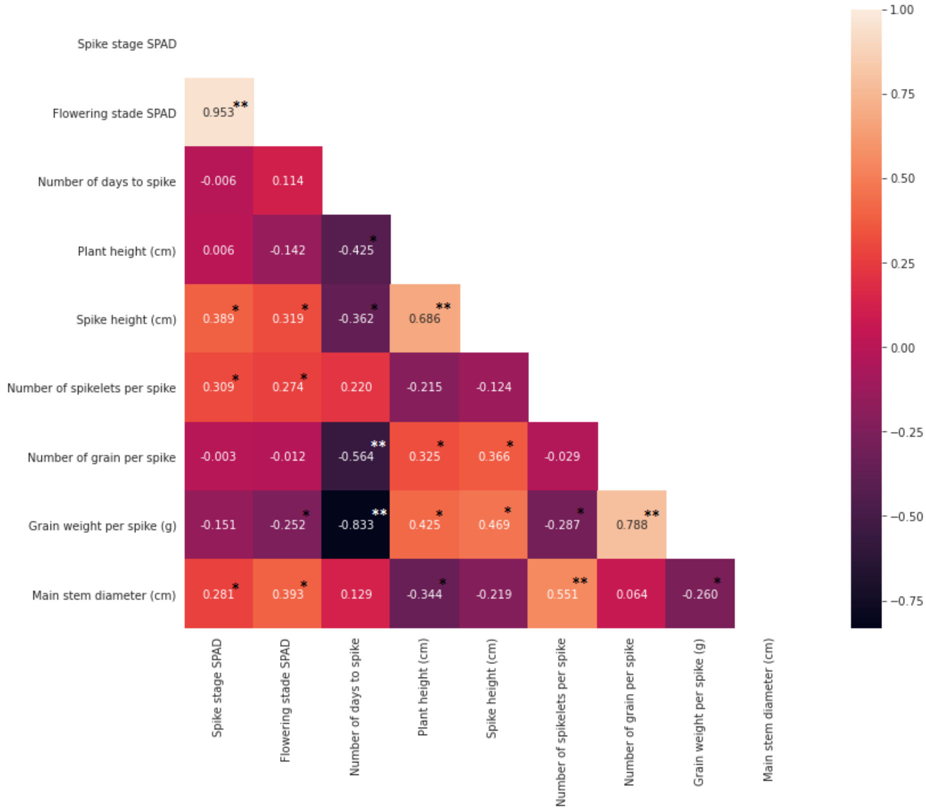

Figure 3. Correlation analysis of the investigated features. * - *p<0.05*; ** - *p<0.01*.

When the scatter plot showing the relationship between the characteristics given in Figure 2 is examined, it has been found that the number of days to spike feature has an inverse relationship with the grain weight feature per spike. Moreover, the features of plant height and grain number per spike are equally related to grain weight per spike.

When Pearson's correlation analysis given in Figure 3 is examined; It has been observed that the number of days to spike feature is negatively related to grain weight per spike, grain number per spike, plant height, and spike height. It has also been observed that early spike-forming genotypes are more advantageous than late spike-forming genotypes. Plant height was found to be negatively correlated with main stem thickness and positively correlated with grain weight per spike and grain number per spike. It was observed that the main stem thickness decreased as the plant height increased, and the grain weight per spike increased as the plant height increased. Bilateral relations and results of other features are given in Figure 3.

4. Conclusions

It was determined that five genotypes out of 20 genotypes included in the study lost their vitality against drought stress, and significant differences occurred between the remaining genotypes. It is noteworthy that line 6, which is the most prominent genotype among the genotypes in terms of spike yield, is also the earliest spike-forming genotype, has the longest plant height, and is the genotype with the highest number of grains per spike.

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Conflicts of Interest: The authors declare no conflict of interest.

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