RESEARCH ARTICLE

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Determination of the tolerance of physiological, morphological, and yield parameters of landrace durum wheat (*Triticum durum* Desf.) to high-temperature stress

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Abstract
In the South-eastern Anatolia Region, where the climate is favorable to cultivation for durum wheat, there have been notable reductions in both yield and quality due to biotic and abiotic stress factors in the region. Primary one of these stresses is high-temperature stress. High-temperature stress, specifically during the late flowering stage and early grain filling stage, results in substantial reductions in both crop yield and quality. In this study, several practical, easily and rapidly quantifiable physiological, morphological, and yield-related parameters that may be used in durum wheat improvement programs in the region for high-temperature stress tolerance were investigated. Ninety landrace durum genotypes and 4 standard cultivars were used. The study was carried out at GAP (South-eastern Anatolia Project) International Agricultural Research and Training Centre in an air conditioning room according to an augmented design under optimum conditions and stressful conditions where high-temperature stress was created. Compared to optimum conditions, there were reductions in flag leaf greening time by 20%, days to maturity by 7%, spike length by 10%, peduncle length by 18%, grain filling time by 23%, number of spikelets on the spike by 12%, number of grains on the spike by 39%, and thousand-kernel weight by 33%, while grain filling rate increased under high-temperature stress conditions. The genotypes 82, 83, 87, 88, 99, and 103 and the standard varieties Artuklu and Sümerli prevailed in both optimum and stress conditions. The fact that leaf erectness, flag leaf greening time, grain filling time, and leaf chlorophyll content among morphological and physiological characteristics had a significant correlation with yield components under both conditions indicates that these characteristics can be used as selection criteria for tolerance to stressful conditions in the region.
Keywords: Landrace, Durum wheat, High-temperature stress, Tolerance, Selection

INTRODUCTION

Wheat provides about 20% of the calories required for human nutrition due to its nutrients and is the staple food of about 40 countries, accounting for 35% of the world's population (Dereli, 2016). The South-eastern Anatolia Region contains a diverse range of landrace wheat genotypes that may be used in improvement studies and enables the creation of a gene pool with a narrowed genetic base (Özberk et al., 2010). These landrace materials managed to survive in the region from the past to the present under the pressure of natural selection and reached the present day despite different biotic and abiotic stresses due to their extensive adaptation abilities (Özberk et al., 2005). The landrace genotypes, especially Bağacak, Sorgül, Beyaziye, Menceki, Iskenderi, and Havrani, have been still preferred by many farmers in the region, and they give a satisfactory yields from these genotypes. There are many stress factors that have negative effects on yield and yield components in wheat cultivation. High-temperature stress among these factors is primary one among the environmental factors that adversely affect the growth, development, and yield of wheat (Kılıç 2020). It has been reported that under high temperature stress conditions, grain filled duration, grain size, grain numbers per spike and maturatiy time are adversely affecting wheat yield. (Lal et al., 2021). Ullah et al., (2022) stated that temperatures above 30 °C during the flowering period of wheat shorten the grain filled duration, which causes pollen loss, reduces the starch and protein accumulation in the grain, and yield loss occurs. In fact, Asseng et al., (2011) reported that when the average temperature rose by 2 °C during the growth and development stages of wheat, there were losses in wheat yield of up to 50%. However, Gibson and Paulsen (1999), Yang et al., (2002) and Pradhan et al., (2012) found that wheat exposed to high-temperature stress at 35/20 °C (day/night) for 10 and 20 days after flowering, 35/20 °C (day/night) for 10 days after flowering, and 36/30 °C (day/night) for 21 days after flowering had losses of 18%–29%, 50%, and 39% in grain weight, respectively. It is very important to determine the morphological, physiological, and yield tolerance levels of wheat to high temperatures and to use genotypes with high tolerance levels in improvement in the cross-breeding studies to be carried out in the region. This study aimed to identify the reactions of some morphological, physiological, and yield components of 90 landrace and 4 standard durum wheat genotypes collected from the South-eastern Anatolia Region to high-temperature stress.

MATERIALS AND METHODS

This study was carried out in the air conditioning room of the Directorate of the GAP International Agricultural Research and Training Centre. 90 genotypes from the landrace durum wheat and 4 standard durum wheat cultivars (Diyarbakır-81, Fırat-93, Sümerli, and Artuklu) collected from different provinces of the South-eastern Anatolia Region and stored in the gene bank of the Directorate of GAP International Agricultural Research and Training Centre were used. The study was carried out in an augmented experimental design for one year. The materials used in the study to determine the genotypes tolerant to high temperatures were subjected to two treatments: optimum ambient conditions and stress conditions. Under optimum conditions, the genotypes were grown in a control environment with optimum environmental conditions (22/14 ± 1 °C Day/night) from the sowing period to the ripening period. Under stress conditions, the genotypes were grown in the control environment where optimum temperature conditions were provided from the sowing period until the end of the flowering period (Zadoks 70), and 10 days after the full flowering period and at the beginning of the grain filling period (39/26 ± 1 °C Day/night), they were divided into 4 groups for 3 days and exposed to temperature stress. The pots with dimensions of 20 x 20 cm and a volume of 5 liters were used during the sowing process of the study. The filling material was turf. Eight wheat grains were sowed in each pot from seeds previously blended from a single spike. After the stem elongation period, plants were thinned to leave five plants in each pot. Genotypes were treated with 6.5 g/pot of fertilizer 15-15-15 (N, P, and K) at a mixture of 1.3 g/kg/pot (5 x 1.3) before being sowed in pots. The plants were fertilized with 2 g/L water-soluble urea (46%), once at stem elongation and once at flowering, to provide adequate nutrition. The genotypes underwent an air conditioning setting with a 16-hour light and 8-hour darkness cycle. The moisture content of the pots was measured with a soil moisture meter at 3-day intervals to prevent drought stress in the genotypes, and when the moisture amount fell below 50%, the pots were irrigated. The characteristics studied are described below.

Figure 1. Sowing of genotypes in the air conditioning room

Chlorophyll content of flag leaf

Flag leaves of five plants were randomly selected from each pot and measured with the manual device SPAD-502 at the grain filling period before and immediately after the stress, and the data were averaged.

Days to heading

The number of days elapsed between plant emergence and the date when ½ of the spikes emerged from the flag leaf sheath in 70% of the plants in each pot was calculated.

Greening time of flag leaf

The number of days elapsed between the emergence of the flag leaf and the period when the leaf turned yellow at the rate of approximately 95% was determined in days.

Days to maturity

The number of days elapsed between the emergence date of the genotypes and the date when the genotypes in each pot turned yellow at the rate of 95% was calculated.

Plant height

The height of the stem with five random spikelets from each pot was determined by measuring from the soil level to the tip of the top spikelet.

Flag leaf area

The flag leaf area was determined in cm^2 by measuring the width and length of the flag leaf of five plants from each pot after the flag leaf on the main stem of the plants had fully developed and multiplied by a factor of 0.72.

Spike length

After the plants reached their physiological maturity, the spike length of the labelled plants was determined by measuring the distance from the lower node of the spike to the tip of the uppermost spikelet (excluding the awns).

Leaf erectness

The angle of 0-90° between the leaf blade and the stem was used as a scale in order for the plant to absorb the rays better and minimize negative effect of high temperature and it was measured visually during the heading period.

Peduncle length

The length between the upper node of the plant and the first spikelet node of the spike was calculated by taking the average of five plants selected from each pot at the yellow maturity period.

Grain filling duration

The number of days from the flowering date to physiological maturity was calculated.

Grain filling rate

This was calculated as the average single grain weight of the plant divided by the grain filling time.

Number of spikelets on the spike

This was determined by counting the number of spikelets on each spike in five spike samples collected from each pot.

Number of grains per spike

This was determined by counting the grains from five spike samples collected from each pot.

Thousand-kernel weight

This was calculated by counting 400 grains from each pot and multiplying the resulting weight by 2.5.

Data Assessment

Statistical analysis of the data was carried out using JMP 13.2 (Copyright © 2007 SAS Institute Inc.) software. A MSD test was used to compare the difference between averages. A pairwise correlation was analyzed by using the scatterplot matrix in the Jump-Pro13 software to determine the correlation between the characteristics.

RESULTS AND DISCUSSION

The study aimed to identify the reactions of some morphological, physiological, and yield components of 90 landrace and 4 standard durum wheat genotypes collected from the South-eastern Anatolia Region to high-temperature stress. The results of variance analyses showed statistically significant ($P \leq 0.01$) differences between the genotypes in terms of the studied characteristics (Table 1 and Table 2)

Under optimum conditions, the highest (55.3) flag leaf chlorophyll content was recorded in genotype no. 68, and the lowest (31.9) flag leaf chlorophyll content was recorded in genotype no. 47. Under stress conditions, genotype no. 13 had the highest leaf chlorophyll content (39.2), and genotype no. 36 had the lowest leaf chlorophyll content (8.4). However, 19 landrace genotypes exceeded the highest standard cultivar (Artuklu) under both optimum and high-temperature stress conditions. Compared to optimum conditions, leaf chlorophyll content declined significantly under stress conditions (Table 1). This suggests that such decline was mainly due to the acceleration of metabolism and consequently desiccation of the leaves in the genotypes exposed to 39 ºC high-temperature stress for 3 days. During the stress period, flag leaf chlorophyll content decreased linearly in all cultivars and high stress contitions flag leaf chlorophyll content was 80%–91% lower than the plants under control conditions (Mirosavljević et. al., (2021). Indeed, Nawaz et al., (2013) reported that high-temperature stress corrupted SPAD content in plants under controlled conditions. Similarly, Efeoğlu and Terzioglu (2009) reported that chlorophyll deposition was restricted in wheat cultivars exposed to 45 ºC for eight hours under high-temperature stress conditions, and 37 and 45 ºC temperatures significantly affected chlorophyll fluorescence and photosynthesis in the main leaves of wheat cultivars.

The days to heading showed very close values under optimum and stressful conditions. Under optimum conditions, genotype no. 88 headed the earliest (60.1 days), while genotype no. 46 headed the latest (104.8 days). Under stress conditions, genotypes 88 and 46 headed the earliest (61.3 days) and latest (104.6 days), respectively. Under optimum conditions, the number of landrace genotypes that exceeded the highest standard cultivar (Artuklu) was 84, while the number of landrace genotypes that exceeded the highest standard cultivar (Sümerli) under high-temperature stress conditions was

81 (Table 1). This study showed that the genotypes were late in heading compared to the standard cultivars. The early heading is an important criterion for wheat in the South-eastern Anatolia region, where wheat is frequently exposed to high-temperature stress. Indeed, Bilgin and Korkut (2005) reported that the grain filling duration was higher in early-headed genotypes, and accordingly, the amount of nutrients that entered the grain was higher. However, Karaman (2017) reported that late-headed genotypes were exposed to higher temperatures during the grain-filling period, and the yield of these genotypes was adversely affected.

Figure 2. Negative effect of high-temperature stress on the morphological and physiological characteristics of wheat

The longest (70.9 days) flag leaf greening time was recorded in genotype no. 87, and the shortest (46.7 days) flag leaf greening time was recorded in genotype no. 61 under optimum conditions. Under stress conditions, the longest flag leaf greening time (58.9 days) was recorded in genotype no. 54 and the shortest flag leaf greening time (37.7 days) in genotype no. 27. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 1, while under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 6. Compared to optimum conditions, the greening time for flag leaf under high-temperature stress conditions was 20% less in both landrace genotypes and standard cultivars (Table 1). This suggests that it resulted from the yellowing and wilting of the flag leaves, the death of the leaves, and their inability to photosynthesize after exposure to high-temperature stress for 3 days during the study. The findings of the present study are compatible with those of the study by Al-Khatib and Paulsen (1984) who reported that high temperatures above 30 °C inhibited the photosynthesis process, caused vegetative and generative growth to stop, accelerated senescence, and disrupted photosynthetic activities. Mirosavljević et al. (2020), higher crop greenness could be related to the additional increase of photosynthetic activity during the grain filling period, supporting a higher grain yield of crops.

The largest (39.59 cm^2) flag leaf area was recorded in genotype no. 45 and the smallest (12.67 cm^2) was recorded in genotype no. 49 under optimum conditions. Under stress conditions, the largest flag leaf area (23.0 cm^2) was recorded from genotype no. 24 and the smallest (2.37 cm^2) from genotype no. 49. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Fırat-93) was 29, while under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Fırat-93) was 13. Compared to optimum conditions, there was a reduction of approximately 100% under high-temperature stress conditions (Table 1). Bhuta (2006) reported a positive correlation between flag leaf area and yield. Öztürk (2011) also reported that wheat with a larger flag leaf area prevailed in terms of both biological and grain yield. Similarly, High temperatures at grain filling had a more negative effect on the photosynthetic-related parameters, resulting in higher grain weight and grain yield reduction (Mirosavljević et. al., (2021).

The highest flag leaf erectness was recorded in Artuklu, Sümerli, and Fırat-93 (81°) cultivars, while the lowest flag leaf erectness (53°) was recorded in genotype no. 11. There was no landrace genotype that exceeded the highest standard cultivars under both optimum and high-temperature stress conditions. During the period until the grain filling period, the same values were observed under optimum and stress conditions (Table 1).

The highest plant height (97.8 cm) was obtained from genotype no. 42 and the lowest plant height (45.3 cm) was recorded from genotype no. 47 under optimum conditions. Under stress conditions, the highest plant height (95.3 cm) was recorded from genotype no. 42 and the lowest plant height (42.8 cm) from genotype no. 87. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 87, while under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 79. The plant height of landrace genotypes was longer than the standard cultivars (Table 1). This suggests that the main reason why plant height showed no significant difference between optimum and stressful conditions was the generative period of wheat exposed to high-temperature stress, the completion of plant height development in wheat, and no effect of stress during the same period. Indeed, Tatar (2011) reported that the plant height of wheat was not affected by stress after the flowering period.

Genotype no. 22 showed the longest (27.7 cm) peduncle length and genotype no. 52 showed the shortest (5.8 cm) peduncle length under optimum conditions. Under stress conditions, genotype no. 19 had the longest peduncle length (23.6 cm); whereas, genotype no. 12 had the shortest peduncle length (3.9 cm). However, the number of landrace genotypes exceeding the highest standard cultivar (Diyarbakır-81) under optimum conditions was 73, while the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) under high-temperature stress conditions was 53 (Table 1). The landrace wheat genotypes prevailed over the standard cultivars with respect to the length of the peduncle, and when analyzed over the averages, the peduncle length decreased by 18% under high-temperature stress conditions compared to optimum conditions. Likewise, in the study by Çekiç (2007) reported that the upper internode length of wheat decreased by 31.6% under stress conditions compared to optimum conditions.

Genotype no. 34 showed the longest spike length (10.37 cm) and genotype no. 56 showed the shortest (4.07 cm) spike length under optimum conditions. Under stress conditions, the longest spike length (9.60 cm) was recorded in genotype no. 41 and the shortest spike length (3.30 cm) in genotype no. 56. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 67, while under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 44. It appears that high-temperature stress negatively affected the spike length, and when analyzed over the general averages, it was 10% shorter under high-temperature stress conditions compared to optimum conditions (Table 2). Findings of the present study are similar to the study by Al-Otayk (2010), who reported that temperature stress had a negative impact on the spike length, and the study by Roy et al., (2013), who reported that spike length was shorter under temperature stress conditions compared to optimum conditions.

Under optimum conditions, the longest (48.5 days) grain filling duration was recorded in genotype no. 97 and the shortest (23 days) grain filling duration was recorded in genotype no. 46. Under stress conditions, the longest grain filling duration (43.1 days) was obtained in genotype no. 97 and the shortest grain filling duration (15.4 days) was obtained in genotype no. 53. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 1, while under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 3 (Table 2). During grain filling, heat stress decreased wheat grain yields due to reduced individual grain weights (Kaur et al., 2021). Heat stress (35 °C) post - anthesis shortened the grain filling duration and limited resource allcation to grain (Bergkamp et. Al., 2018). In the study, grain filling duration of the genotypes exposed to high-temperature stress at 39–26 °C night/day for 3 days decreased by 23% compared to optimum conditions. Likewise, many studies have reported that grain filling duration is negatively affected under high-temperature conditions (Stone and Nicolas (1995); Castro et al., (2007); Nawaz et al., (2013); Modhej et al., (2015)).

The longest grain filling rate (1.39 mg/day) was recorded in genotype no. 46 and the shortest grain filling rate (0.56 mg/day) was recorded in genotype no. 36 under optimum conditions. Under stress conditions, the longest grain filling rate (1.59 mg/day) was recorded in genotype no. 21, and the shortest grain filling rate (0.45 days) was recorded in genotype no. 37. However, the number of landrace genotypes that exceeded the highest standard cultivar (Fırat-93) under optimum conditions was 30, while the number of landrace genotypes that exceeded the highest standard cultivar (Fırat-93) under high-temperature stress conditions was 26 (Table 2). In the study, genotypes exposed to high-temperature stress at 39–26 °C night/day for 3 days increased the grain filling rate compared to optimum conditions. The main reason here is predicted to be the avoidance of stress by the genotypes exposed to such stress in order to minimize the stress effect. However, it was found that the genotypes with a higher grain filling rate achieved better values for thousand-kernel weight. Similarly, the study conducted by Chinnusamy and Chopra (2003) to investigate the starch development in the grain during the grain-filling period under high-temperature stress conditions emphasized that grain-filling rate was an important characteristic under high-temperature conditions.

Under optimum conditions, the longest (142.4 days) days to maturity was obtained in genotype no. 42 and the shortest (113.1 days) days to maturity was obtained in genotype no. 47. Under stress conditions, the longest (128.9 days) days to maturity was recorded in genotype no. 46 and the shortest (104.4 days) was obtained in genotype no. 33 and 36. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 74, while under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 74. It was observed that landrace durum wheat genotypes had longer days to maturity periods than the standard cultivars (Table 2). However, a long days to maturity was not a desirable trait in the South-eastern Anatolia region where wheat is frequently exposed to high-temperature stress. This is because it is considered that genotypes with a longer days to maturity period would be exposed to more stress due to the high temperatures that occur in the region, especially during the grain-filling period, and this suggests that it would cause the grains of these genotypes to be weak and wrinkled. In the study, days to maturity of the genotypes that were exposed to high-temperature stress at 39–26 °C night/day for 3 days decreased by 7% compared to optimum conditions. Similarly, Alam et al., (2013) reported significant reductions in heading, flowering, and days to maturity under high-temperature stress conditions.

Under optimum conditions, the highest number of spikelets on the spike (18.6 pieces) was recorded in genotype no. 38, and the lowest (6.1 pieces) was recorded in genotype no. 61. Under stress conditions, the highest number of spikelets on the spike (17.1 pieces) was recorded in genotype no. 44 and the lowest (5.2 pieces) in genotype no. 61. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Sümerli) was 62; whereas, under high-temperature stress conditions, the number of landrace genotypes exceeding the highest standard cultivar (Sümerli) was 38. Landrace wheat genotypes had higher values in terms of the number of spikelets on the spike compared to standard cultivars (Table 2). The results of the study showed that the number of spikelets on the spike decreased by 12% in the genotypes which were exposed to high-temperature stress at 39–26 °C night/day for three days compared to optimum conditions. Pimentel et al., (2015) and Youldash (2017) reported that high temperatures reduced the number of spikelets on the spike by 21%.

Under optimum conditions, the highest number of grains on the spike (25.8 pieces) was observed in genotype no. 103 and the lowest (12.3 pieces) was observed in genotypes no. 6 and 47. Under stress conditions, the highest number of grains on the spike (19.1 pieces) was recorded in the Artuklu cultivar and the lowest (7.8 pieces) in genotypes no. 6 and 47. Under optimum conditions, the number of landrace genotypes exceeding the highest standard cultivar (Artuklu) was 1, but there was no landrace genotype exceeding the highest standard cultivar (Artuklu) under high-temperature stress conditions (Table 2). The results of the study showed that the genotypes that were exposed to high-temperature stress at 39- 26 °C night/day for three days decreased the number of grains on the spike by 41% compared to optimum conditions. Similarly, Pimentel et al., (2015) reported that the number of grains on the spike reduced by 39% due to the effect of high temperature, and the number of grains on the spike was the yield component that was affected mostly by high temperature. However, numerous researchers reported that high-temperature stress conditions negatively affected the number of grains on the spike (Al-Otayk, 2010; Youldash (2017) Tomás et al. (2020).

Under optimum conditions, the highest thousand-kernel weight (38.0 g) was obtained in the Fırat-93 cultivar and the lowest weight (19.1 g) was obtained in genotype no. 37. Under stress conditions, the highest thousand-kernel weight (33.9 g) was recorded in Fırat-93, and the lowest weight (14.8 g) was recorded in genotype no. 71 (Table 3). There was no landrace genotype that exceeded the highest standard cultivar (Fırat-93) under both optimum and high-temperature stress conditions (Table 2). The study showed that in the genotypes which were exposed to high-temperature stress at 39- 26 °C night/day for three days, high-temperature stress decreased the thousand-kernel weight by 33% compared to optimum conditions. This decrease is considered to be associated with the shorter generative period of the genotypes that were exposed to high temperatures during the grain-filling period in order to minimize such stress, which resulted in weak and spindly grains. Pimentel et al., (2015) reported that high temperatures reduced the thousand-kernel weight by 27%. Similarly, many researchers reported that high-temperature conditions caused substantial losses in thousand-kernel weight (Kaur and Behl, 2009; Castro et al., 2007; Modhej et al., 2015; Jamil et al., 2019)).

Assessment of the correlation between the characteristics studied under optimum conditions by correlation analysis

The results of the correlation analyses between the characteristics studied showed that there was a significant and positive correlation between the number of grains on the spike, which affected the grain yield under optimum conditions, and flag leaf erectness, flag leaf greening time, grain filling time, SPAD, and the number of spikelets on the spike, but a significant and negative correlation between the number of grains on the spike and peduncle length, plant height, and days to heading. While a significant and positive correlation was found between thousand-kernel weight another trait that affected grain yield and flag leaf erectness, grain filling rate, and SPAD, there was a significant and negative correlation between thousand-kernel weight and plant height. A negative correlation was found between plant height and characteristics such as grain filling time, the number of grains on the spike, and thousand-kernel weight, all of which have a direct effect on yield. A significant and positive correlation was found between flag leaf erectness and grain filling time, the number of grains on the spike, and thousand-kernel weight, but there was a significant and negative correlation between flag leaf erectness and days to maturity, plant height, and days to heading. Leaf erectness had a positive effect on yield and yield components (Table 3).

Assessment of the correlation between the characteristics studied under stress conditions by correlation analysis

The results of the correlation analyses between the characteristics studied showed that there was a significant and positive correlation between the number of grains on the spike, which affected the grain yield under high-temperature conditions, and flag leaf erectness, flag leaf greening time, grain filling time, SPAD, the number of spikelets on the spike and the thousand-kernel weight, but a significant and negative correlation between the number of grains on the spike and peduncle length, plant height, and days to heading. While a significant and positive correlation was found between thousand-kernel weight another trait that affected grain yield under high-temperature stress conditions and flag leaf erectness, flag leaf area, grain filling rate, and the number of spikelets on the spike, there was a significant and negative correlation between thousand-kernel weight and peduncle length, plant height, days to heading, and number of spikelets on the spike (Table 4).

Table 1. Results of analysis on the averages of the studied characteristics

Genotypes	SPAD		D.T.H. (day)		G.T.F.L (day)		F.LA. (cm²)		F.L.E. (0-90)		P.H. (cm)		P.L (cm)	
	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C
1	48,2	37,4	85,3	85,1	65,4	56,4	22,7	14,82	63	63	69	77,8	16	13,9
2	49,2	30,1	80,3	80,1	60,4	51,4	21,7	19,32	58	58	79	82,8	21	15,9
3	45,1	23,3	85,3	84,1	66,4	43,4	29,82	19,58	63	63	79	92,8	25,7	22,9
4	46,6	18	66,3	65,1	60,4	49,4	16,94	11,8	68	68	54	57,8	14,3	14,9
6	41	11,6	85,3	86,1	59,4	48,4	23,55	9,71	58	58	74	77,8	11,3	5,3
7	45,3	24,6	64,3	65,1	62,4	50,4	18,14	13,67	73	73	54	52,8	11	10,6
8	38,7	34	91,3	84,1	57,4	48,4	32,17	9,6	58	58	69	77,8	15,3	12,6
9	48,6	18,9	87,3	92,1	60,4	55,4	21,98	5,13	63	63	79	72,8	10	9,9
11	41,6	13,8	73,3	82,1	49,4	48,4	18,31	18,59	53	53	79	77,8	21	16,6
12	43,9	11,1	89,3	92,1	61,4	49,4	32,06	14,82	58	58	59	52,8	9,7	3,9
13	45,9	39,2	83,3	80,1	60,4	41,4	23,08	11,12	58	58	74	62,8	14,7	11,9
14	49,6	19,3	85,3	88,1	49,4	38,4	19,82	13,33	63	63	69	77,8	22,3	18,9
16	41,9	16,6	77,3	78,1	54,4	45,4	29,43	17,8	58	58	69	72,8	15,7	11,9
17	40,7	15,3	89,3	86,1	59,4	43,4	21,21	16,24	58	58	69	72,8	12	10,6
18	46,2	12,8	84,3	85,1	53,4	46,4	15,31	6,2	63	63	69	67,8	18,7	13,9
19	43,6	15,2	84,3	86,1	56,4	43,4	28,22	13,4	68	68	79	92,8	26,3	23,6
21	46	21,8	94,3	95,1	56,4	45,4	29,37	15,1	68	68	74	82,8	17	17,6
22	44,9	18,4	79,3	80,1	52,4	43,4	24,3	15,69	68	68	79	77,8	27,7	22,3
23	41,4	12,4	76,3	73,6	51,15	43,65	21,78	12,57	65,5	65,5	77,8	70,3	23	22
24	46,7	25,3	81,3	79,6	56,15	44,65	30,44	23	70,5	70,5	77,8	80,3	23	16,7
26	54,2	17,6	81,3	82,6	61,15	48,65	24,48	11,88	70,5	70,5	67,8	60,3	21,7	12
27	52,3	28,5	83,3	82,6	58,15	37,65	23,85	13,15	65,5	65,5	77,8	65,3	21,3	14
28	47,9	15,7	90,3	89,6	59,15	46,65	22,25	11,21	70,5	70,5	47,8	60,3	11,3	10
29	49,2	11,4	82,3	80,6	64,15	45,65	22,13	11,93	65,5	65,5	77,8	75,3	25,3	16
31	37,6	10,5	83,3	79,6	66,15	40,65	19,95	11,33	60,5	60,5	52,8	65,3	20,3	17,4
32	45,2	18,7	81,3	82,6	51,15	48,65	24,63	12,69	70,5	70,5	62,8	75,3	21,3	13,4
33	45,7	9,6	69,3	66,6	59,15	42,65	20,79	10,73	70,5	70,5	72,8	55,3	25,7	17,4
34	44,7	23,8	84,3	79,6	68,15	46,65	27,72	13,73	70,5	70,5	82,8	80,3	22,7	16
36	38,6	8,4	70,3	69,6	61,15	39,65	19,44	10,53	70,5	70,5	52,8	55,3	14,3	7,7
37	47,3	17,2	90,3	89,6	60,15	47,65	27,51	5,29	60,5	60,5	82,8	70,3	18	15,7
38	52,5	20,2	98,3	87,6	57,15	52,65	35,38	22,74	70,5	70,5	87,8	75,3	16,3	10,7
39	51	22,7	84,3	86,6	59,15	54,65	20,23	18,74	75,5	75,5	92,8	80,3	20,7	13,7
41	49,6	18,3	92,3	91,6	68,15	48,65	19,04	18,03	65,5	65,5	77,8	75,3	16	7,7
42	50,8	24,8	100,3	93,6	65,15	53,65	15,36	9,35	65,5	65,5	97,8	95,3	24,3	18,4
43	49	19,6	90,3	87,6	63,15	49,65	28,51	9,4	65,5	65,5	87,8	85,3	25,7	17
44	52,7	18	91,3	89,6	65,15	57,65	15,9	10,57	70,5	70,5	62,8	60,3	17	11,4
45	49,5	22,7	89,8	91,6	63,65	54,9	39,59	19,72	70,5	70,5	75,3	74	11,5	12,9

46	46,6	12	104,8	104,6	61,65	56,9	21,95	6,25	60,5	60,5	75,3	74	18,2	14,9
47	31,9	11,6	67,8	69,6	49,65	42,9	25,36	7,4	65,5	65,5	45,3	44	12,8	9,9
48	46	16,6	85,8	90,6	48,65	46,9	22,98	20,45	60,5	60,5	70,3	79	18,2	14,9
49	48,5	18	99,8	91,6	67,65	55,9	12,67	2,37	75,5	75,5	65,3	64	14,2	13,2
51	44,3	16,3	90,8	91,6	59,65	52,9	31,03	10,6	60,5	60,5	65,3	74	15,2	11,2
52	39,1	17,5	89,8	90,6	62,65	42,9	38,24	15,01	60,5	60,5	50,3	64	5,8	4,5
53	45,3	15,5	102,8	104,6	67,65	56,9	20,67	6,2	65,5	65,5	75,3	79	16,2	14,5
54	50,9	24,1	98,8	98,6	68,65	58,9	16,67	3,94	70,5	70,5	65,3	74	14,8	13,2
56	46,5	12,5	85,8	85,6	49,65	51,9	32,99	11,65	65,5	65,5	70,3	74	17,2	11,5
57	49,5	16,2	91,8	95,6	58,65	50,9	22,72	9,53	60,5	60,5	80,3	79	15,2	13,2
58	48,4	19	79,8	82,6	54,65	48,9	23,87	10,85	60,5	60,5	75,3	74	26,5	19,9
59	48,5	19,1	89,8	89,6	65,65	52,9	24,98	8,68	65,5	65,5	55,3	64	13,5	8,9
61	46,2	11,3	85,8	90,6	46,65	42,9	27,21	5,05	65,5	65,5	55,3	49	14,8	10,2
62	40,8	16,1	87,8	89,6	57,65	45,9	25,63	13,07	55,5	55,5	65,3	69	8,2	8,2
63	46,2	24,2	81,8	81,6	67,65	58,9	28,01	9,53	65,5	65,5	55,3	69	13,2	12,9
64	47,9	18,3	81,8	81,6	65,65	55,9	27,52	13,41	70,5	70,5	70,3	69	18,5	16,5
66	44,7	12,4	87,8	87,6	57,65	47,9	32,32	14,82	60,5	60,5	65,3	74	10,2	5,2
67	52,3	8,7	74,1	66,3	62,9	47,65	26,33	10,57	70,5	70,5	66,5	62,8	16,2	13,1
68	55,3	13,8	76,1	74,3	58,9	51,65	28,71	8,18	65,5	65,5	71,5	67,8	15,5	16,4
69	53,8	16,7	74,1	72,3	51,9	43,65	22,37	17,23	70,5	70,5	76,5	77,8	20,2	20,8
71	41,3	18,6	84,1	82,3	55,9	46,65	29,18	15,5	60,5	60,5	86,5	72,8	24,8	15,1
72	52,4	14,2	78,1	77,3	56,9	50,65	22,95	13,82	55,5	55,5	71,5	57,8	22,2	17,1
73	50,3	18,8	84,1	82,3	52,9	47,65	28,73	9,26	60,5	60,5	66,5	67,8	17,2	16,1
74	46,5	14,8	88,1	82,3	67,9	46,65	31,01	14,21	60,5	60,5	71,5	67,8	13,8	9,1
76	47,2	16,4	79,1	77,3	52,9	47,65	19,06	8,18	65,5	65,5	71,5	72,8	15,8	16,1
77	44,4	14,7	83,1	80,3	55,9	48,65	17,69	9,08	60,5	60,5	61,5	57,8	17,2	11,8
78	45,3	18,2	84,1	84,3	58,9	49,65	20,5	13,66	70,5	70,5	76,5	72,8	18,5	20,1
79	48,8	12,9	79,1	84,3	50,9	50,65	24,47	13,66	70,5	70,5	76,5	67,8	21,8	17,4
81	43,1	18,5	84,1	88,3	61,9	50,65	33,82	17,82	60,5	60,5	76,5	67,8	9,8	11,4
82	54,2	29,8	68,1	68,3	66,9	52,65	23,46	19,34	80,5	80,5	56,5	57,8	11,8	9,4
83	47,1	13	62,1	61,3	56,9	48,65	24,15	12,18	80,5	80,5	56,5	47,8	7,5	8,8
84	50,1	20,7	84,1	89,3	59,9	53,65	21,54	13,82	60,5	60,5	71,5	72,8	17,2	13,4
86	43,1	8,5	78,1	71,3	56,9	41,65	28,71	8,39	60,5	60,5	76,5	72,8	14,5	16,4
87	46,2	28,8	64,1	63,3	70,9	54,65	26,66	21,06	80,5	80,5	51,5	42,8	8,2	11,1
88	46,8	12,5	60,1	61,3	61,9	48,65	26,34	9,5	80,5	80,5	51,5	47,8	9,2	9,1
89	45,7	15,6	83,6	86,6	61,9	46,4	34,34	18,42	65,5	65,5	81,5	75,3	19,3	10,8
91	45,1	19	83,6	85,6	62,9	50,4	29,73	16,17	60,5	60,5	76,5	70,3	8,7	10,1
92	49,2	21,6	80,6	83,6	55,9	46,4	15,52	12,14	60,5	60,5	56,5	70,3	14,3	15,1
93	46,2	19,2	77,6	81,6	55,9	49,4	25,58	14,29	60,5	60,5	76,5	70,3	19	22,4
94	50,5	20,7	80,6	86,6	58,9	50,4	29,79	9,27	60,5	60,5	76,5	75,3	15,7	15,4
96	45	17,5	77,6	81,6	60,9	47,4	18,97	11,43	70,5	70,5	76,5	70,3	20	21,4
97	40,5	19,5	67,6	70,6	64,9	46,4	21,13	17,12	80,5	80,5	46,5	55,3	10,7	6,1
98	45,2	25,8	77,6	80,6	50,9	44,4	21,77	14,25	70,5	70,5	66,5	80,3	22	13,4
99	43,2	19,8	60,6	61,6	63,9	52,4	21,44	19,23	80,5	80,5	51,5	50,3	8	5,8
101	46,7	17	78,6	80,6	48,9	38,4	25,88	12,05	70,5	70,5	71,5	80,3	20,3	17,1
102	41,9	16,3	79,6	82,6	62,9	48,4	21,89	12,18	70,5	70,5	66,5	60,3	19,3	15,1

103	45,5	15,8	63,6	65,6	66,9	53,4	26,37	19,69	80,5	80,5	51,5	65,3	15	16,1
104	45,4	20,8	82,6	86,6	64,9	45,4	19,17	7,88	75,5	75,5	61,5	65,3	12,7	13,1
106	46,1	15,3	89,6	86,6	60,9	47,4	30,21	12,8	70,5	70,5	61,5	75,3	13	10,1
107	41,6	22,7	86,6	88,6	66,9	48,4	20,86	9,7	70,5	70,5	61,5	75,3	13	10,1
108	48,4	17,9	75,6	82,6	54,9	50,4	24,89	13,34	70,5	70,5	71,5	75,3	21,3	16,1
109	49,1	17,8	75,6	79,6	55,9	47,4	25,33	19,18	70,5	70,5	66,5	70,3	17,7	19,4
110	47,5	21,2	74,6	79,6	50,9	47,4	20,8	14,41	70,5	70,5	76,5	75,3	26	22,4
Artuklu	49,5	21,8	62,4	65	68,8	56	25,03	17,14	81	81	50	57	10,8	13
D. Bakır-81	44,7	18,7	64,2	64,6	63,6	49,4	24,55	15,35	79	79	50	55	11,8	12,3
Fırat-93	48,2	19,7	65,2	66,6	62,8	48,6	26,9	18,48	81	81	46	50	9	9,1
Sümerli	46,4	19,3	65,4	64	64,4	49,6	21,12	13,13	81	81	50	49	9,1	9,7
Ov. Av.	46,4	18,4	81,5	81,7	59,6	48,6	24,6	13,03	66,9	66,9	68,4	69,1	16,6	13,7
Land. Av.	46,4	18,3	82,2	82,4	59,37	48,5	24,57	12,89	66,4	66,4	69,2	69,7	16,9	13,8
Std. Cul Av.	47,2	19,8	64,3	65,1	64,9	50,9	24,4	16,1	80,5	80,5	49	52,7	10,2	11
Max. volue	55,3	39,2	104,8	104,6	70,9	58,9	39,59	23	81	81	97,8	95,3	27,7	23,6
Min volue	31,9	8,4	60,1	61,3	46,65	37,65	12,67	2,37	53	53	45,3	42,8	5,8	3,9
NLPHSC	19	19	84	81	1	6	29	13	0	0	87	79	74	53
Varyans	15,92	33,09	95,24	91,72	32,44	21,78	27,31	19,1	49	49	130,09	116,34	27,33	19,39
Std. Dev.	3,99	5,75	9,76	9,58	5,7	4,67	5,23	4,37	7	7	11,41	10,79	5,23	4,4
CV	3,87	11,75	3,63	3,63	1,83	4,77	8,4	10,27	3,24	3,24	5,87	6,78	11,99	14,03
$LSD_{(0.05)}$	5.55^{**}	6.74^{**}	8.82^{**}	8.86^{**}	3.41^{**}	7.19^{**}	6.35^{**}	4.26^{**}	6.89^{**}	6.89^{**}	11.85^{**}	13.92^{**}	5.78^{**}	5.75^{**}

**; İndicates Significant differences P≤0.01. Abbreviations; OC: Optimum conditions, SC: Stressful conditions, NLPHSC: Number of landrace genotypes, exceeding the highest standard cultivar, CV: Coefficient of variation, LSD: Least significant difference, SPAD: Flag leaf chlorophyll content, HT:Days to heading, GTFL: greening time of flag leaf, FLA: Flag leaf area, FLE: Flag leaf erectness, PH: Plant height, PL: Peduncle length. Ov. Av: overall average, Land. Av: landrace average, Std. Cul Av: Standard cultivar average, Std. Dev: standard Deviation

Table 2. The highest and lowest averages of the analyzed characteristics

Genotypes	S.L.(cm)		G.F.T. (day)		G.F.R. (mm/day)		D.T.M.(day)		N.S.S.		N.G.S.		T.G.W	
	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C	O.C	S.C
1	6,3	6,2	40,2	30,1	0,72	0,99	132,4	121,4	12,1	10,7	15,4	11	28,8	29,2
2	6,1	5,6	39,2	33,1	0,69	0,67	123,4	116,4	12,9	12,5	18,7	15	26,9	21
3	6,7	6,6	37,2	30,1	0,66	0,71	128,4	121,4	12,9	12,3	14,3	11	24,6	20,7
4	5,5	5,2	40,2	34,1	0,86	0,98	113,4	107,4	10,7	10,1	17,9	15	30,9	28,5
6	5,9	5,6	38,2	29,1	0,88	0,94	128,4	118,4	13,3	10,5	12,3	7,8	29,7	23,6
7	5,7	5,2	40,2	36,1	0,67	0,68	116,4	111,4	13,1	11,5	21,1	13	26,6	23,2
8	6,5	5,8	37,2	32,1	0,7	0,82	132,4	123,4	13,3	12,1	17,3	11	25,8	19,5
9	6,1	5,4	45,2	27,1	0,67	0,84	138,4	127,4	14,3	11,9	21	12	29,6	22,5
11	5,7	5,6	35,2	23,1	0,83	1,13	113,4	110,4	13,5	13,1	19	10	27,6	21,6
12	8,3	8	31,2	23,1	1,11	0,98	127,4	118,4	14,9	14,1	18,2	12	35,6	23
13	6,9	6,8	33,2	24,1	0,89	0,7	123,4	109,4	12,1	11,1	12,9	8,3	29,9	20,7
14	4,5	3,8	35,2	28,1	0,71	0,82	126,4	119,4	13,5	10,1	16	12	30,1	22,5
16	5,5	4,4	36,2	31,1	0,79	0,87	120,4	113,4	11,5	9,3	16,1	8,8	28,9	26,2
17	5,5	5,2	35,2	25,1	0,8	0,81	129,4	116,4	15,3	12,7	17,1	13	28,4	20,3
18	5,1	5	31,2	27,1	1,21	1,02	123,4	118,4	11,5	10,9	13,9	9,9	33,9	27,6
19	5,7	5,2	32,2	26,1	0,94	0,73	122,4	116,4	14,9	14,3	17,7	16	31	20,7
21	6,1	5,8	36,2	19,1	0,84	1,59	136,4	118,4	15,3	12,1	18,7	12	30,7	26,5

22	7,9	7,8	36,2	32,1	0,81	0,85	122,4	118,4	14,5	13,9	17,1	13	29,5	27,3
23	6,4	6,2	32,5	27,1	0,83	0,61	117,4	110,4	12,4	11,3	17,8	13	28,1	18,1
24	4,8	4,6	35,5	28,1	0,73	0,7	122,4	115,4	15,8	14,7	19,4	17	25,7	21,3
26	6,8	5,8	36,5	28,1	0,89	0,73	125,4	117,4	12,6	11,9	19,1	9,5	32,4	22,1
27	6,6	5,8	41,5	21,1	0,75	0,94	130,4	110,4	13,4	13,3	21,1	11	30,9	21,5
28	8	6,6	36,5	24,1	0,88	0,73	132,4	120,4	14,8	14,1	21,6	17	32,1	19,2
29	6,4	5,6	41,5	25,1	0,91	0,77	130,4	113,4	12,2	11,3	17,8	12	31,9	20,8
31	6,6	6,2	42,5	17,1	0,7	1,33	133,4	106,4	13,4	12,1	17,3	10	29,5	24,7
32	6	5,6	34,5	33,1	1	0,7	123,4	122,4	14	11,1	17,1	9,6	34,5	24,7
33	7	6,2	37,5	26,1	0,56	0,64	114,4	104,4	13,2	12,3	20,8	12	25,9	18,2
34	10,4	8,6	39,5	27,1	0,79	0,58	128,4	113,4	15,6	15,1	19,7	12	31,2	17,2
36	7,2	6,6	39,5	24,1	0,54	0,6	119,4	104,4	15,2	13,9	18,7	15	21,2	15,8
37	4,4	4	29,5	28,1	0,65	0,45	123,4	122,4	12,6	11,9	17,8	11	19,1	15,9
38	9,8	8,6	26,5	23,1	1,08	0,99	131,4	118,4	18,6	15,1	20,6	13	28,8	24,7
39	9,6	9,2	39,5	31,1	0,83	0,9	130,4	123,4	16,8	16,1	19,9	16	31,7	25,7
41	10,2	9,6	41,5	28,1	0,75	0,89	139,4	126,4	15,6	14,9	19,2	13	31,1	26,7
42	7,2	6,4	33,5	25,1	0,85	0,69	142,4	125,4	15,2	13,7	21,7	14	28,6	18,7
43	7,6	6,8	34,5	24,1	0,88	0,78	130,4	117,4	16,6	16,5	19,8	15	30,4	20,4
44	7	6,6	33,5	25,1	0,99	0,8	130,4	123,4	17,4	17,1	21,2	13	29,3	21,6
45	8,5	7,5	35	28,4	0,94	0,89	129,1	123,9	18,3	15,6	19	15	33,2	24,6
46	6,9	4,7	23	19,4	1,39	1,26	134,1	128,9	15,1	11,6	18,7	16	31,6	23,6
47	5,3	4,7	37	34,4	0,66	0,69	113,1	108,9	11,5	7,6	12,3	7,8	25,2	23
48	7,5	6,5	35	17,4	0,75	1,14	125,1	112,9	13,1	12,4	19	15	26,8	19,1
49	6,3	5,9	27	26,4	1,15	0,82	133,1	121,9	15,5	15	18	15	30,9	21,1
51	6,5	5,5	36	27,4	0,74	0,66	130,1	119,9	16,1	15,2	14,9	13	27,2	17,4
52	8,7	8,3	35	24,4	0,93	1,23	132,1	120,9	15,5	12,4	18,6	9,6	32,9	29,2
53	6,1	5,5	31	15,4	1,07	1,02	139,1	123,9	14,9	13,8	20,8	14	33,5	15
54	7,5	7,1	33	18,4	0,76	0,87	140,1	123,9	18,3	16,4	19,9	12	25,6	15,4
56	4,1	3,3	42	31,4	0,6	0,79	132,1	119,9	13,1	10,8	16,2	12	29,4	24,1
57	6,3	5,7	38	21,4	0,81	0,9	137,1	121,9	15,7	15	18,3	11	31,4	18,5
58	6,5	6,1	37	28,4	0,72	0,89	123,1	116,9	14,3	11,8	17,5	11	27,3	24,5
59	8,1	6,3	39	26,4	0,71	0,88	133,1	118,9	17,3	16,2	19,3	16	28,7	22,5
61	5,1	4,5	32	23,4	0,99	1,1	124,1	118,9	6,1	5,2	17,4	11	32,1	25
62	6,1	5,3	37	26,4	0,78	0,85	129,1	118,9	12,3	11	16,6	13	29,5	21,8
63	5,9	5,3	44	34,4	0,58	0,58	132,1	121,9	13,1	12	16	11	26,6	19,1
64	6,7	5,9	35	32,4	0,8	0,77	124,1	119,9	14,3	11,4	14,8	14	28,6	24,3
66	6,3	5,9	33	29,4	0,93	0,8	125,1	119,9	15,7	13,4	14,4	10	31,1	17,7
67	6,2	5,6	38	36,4	0,91	0,76	124,4	116,9	12	11,8	21,5	12	34	24,4
68	6,6	5,6	39	35,4	0,79	0,79	125,4	120,9	12,8	10,6	20,8	13	30,3	23,8
69	6,4	5,4	38	31,4	0,75	0,66	117,4	108,9	13,8	12,2	17,3	14	27,8	20,5
71	6	4,8	34	24,4	0,74	0,63	122,4	111,9	14,8	12,6	17,3	9,8	27,3	14,8
72	6,4	5,4	38	26,4	0,73	0,73	122,4	111,9	13	11,2	14,4	13	27,1	18,8
73	6,6	5,4	43	25,4	0,68	0,86	129,4	110,9	12,6	11,2	17,8	9,4	31,6	21
74	6,6	6,4	43	29,4	0,69	0,73	135,4	116,9	13	13,2	17,8	9,6	29,4	21
76	6,6	6	40	33,4	0,66	0,59	124,4	118,9	12,2	12,4	19,3	13	30,8	19,5
77	5,8	5,6	39	33,4	0,6	0,62	124,4	118,9	12	12	18,3	11	23	20,7

78	6,2	5,8	39	24,4	0,68	0,96	127,4	113,9	14,6	13,2	17,1	13	25,9	22,3
79	7,6	6,6	39	30,4	0,8	0,8	123,4	119,9	13,8	9,6	17,8	10	30,5	23,7
81	7,8	5,6	37	31,4	0,84	0,72	123,4	120,9	16,2	12,4	16,5	11	30,4	22,3
82	6,6	6	43	38,4	0,8	0,79	117,4	113,9	15	14	21,1	19	33,7	30,2
83	5,6	5,4	44	37,4	0,72	0,78	114,4	107,9	13,6	12,6	23,9	18	31,3	29,2
84	6,4	5,6	37	31,4	1,03	0,97	125,4	122,9	11	11,4	14,3	12	37,3	29,8
86	7,2	6,2	36	34,4	0,7	0,6	118,4	116,9	15	12,6	16,8	12	24,7	20,7
87	5,8	5,2	46	42,4	0,7	0,59	117,4	112,9	12,6	12,4	22,5	17	31,6	25,5
88	6,4	5,6	45	38,4	0,67	0,67	113,4	109,9	14,6	13,8	23,9	18	29,9	25,9
89	6,5	5,6	39,5	31,1	0,68	0,67	127,9	123,4	14	12,3	17,1	12	26,8	21
91	7,3	6	37,5	28,1	0,9	0,71	124,9	117,4	14,6	11,5	14,7	10	28,4	20
92	5,3	4,6	35,5	33,1	0,97	0,6	122,9	124,4	12	8,9	15,7	12	33,9	19,8
93	7,1	6,6	42,5	39,1	0,83	0,54	124,9	126,4	14,8	11,5	14,5	13	31	21,5
94	6,3	5	38,5	33,1	0,83	0,66	122,9	124,4	13,2	10,9	15,8	13	31,4	22
96	5,3	4,8	41,5	29,1	0,73	0,84	123,9	118,4	12,6	8,9	14,9	13	30,1	24,5
97	5,1	5	48,5	43,1	0,61	0,54	121,9	119,4	14,2	12,9	21,6	17	29,4	24
98	6,3	4,2	32,5	25,1	1	1,05	116,9	114,4	12,6	9,3	15,4	11	32	26,1
99	5,5	5	45,5	43,1	0,78	0,74	114,9	114,4	14,8	13,5	23,1	19	33,1	32,5
101	5,3	4,8	33,5	26,1	0,99	1,04	116,9	114,4	13,8	11,7	17	12	32,7	27
102	5,9	5,6	41,5	31,1	0,76	0,76	127,9	121,4	11	9,3	16,1	13	31,3	23,7
103	6,3	6,4	47,5	39,1	0,67	0,64	117,9	113,4	15,4	14,9	25,8	18	31,6	25,4
104	6,3	6	42,5	25,1	0,69	0,97	130,9	116,4	13,4	12,9	20,3	16	28,9	24,2
106	10,1	9,2	34,5	25,1	1,11	1,14	128,9	117,4	12,4	11,9	15,5	12	37,6	28,4
107	6,5	5,6	35,5	27,1	0,81	0,76	128,9	119,4	15,8	12,5	16,2	13	31,4	20,5
108	6,3	6	41,5	30,1	0,76	0,78	122,9	119,4	12,4	11,3	17,4	14	31,1	23,5
109	5,9	4,8	37,5	27,1	0,89	0,9	118,9	117,4	14,4	12,9	20,3	10	33,1	24,3
110	6,1	6	40,5	24,1	0,92	0,91	121,9	113,4	12,4	11,5	19,3	11	34,9	21,6
Artuklu	5,9	5,7	48,2	39,4	0,69	0,8	118,6	112,4	12,6	11,7	25,7	19	32,9	30,8
D. Bakır-81	5,8	5,4	41	36,8	0,76	0,79	113,2	109,8	12,7	11,8	23,2	18	30,6	28,3
Fırat-93	5,4	5,2	45	38,2	0,85	0,89	117,4	112	12,4	11,3	21,5	17	38	33,9
Sümerli	5,2	5	45,6	39	0,71	0,76	117,2	111,4	12,9	12,4	23,2	18	31,5	29
Ov. Av.	6,52	5,86	37,86	29,14	0,81	0,82	125,4	117,2	13,85	12,36	18,29	13	30,01	22,91
Land. Av..	6,5	5,9	37,5	28,7	0,81	0,82	125,8	117,5	13,9	12,4	18	13	29,9	22,6
Std. Cul Av	5,8	5,3	44,9	38,3	0,75	0,81	116,6	111,4	12,65	11,8	23,4	18	33,25	30,5
Max. volue	10,4	9,6	48,5	43,1	1,69	1,59	142,4	128,9	18,6	17,1	25,8	19	38	33,9
Min. volue	4,1	3,3	23	15,4	0,54	0,45	113,1	104,4	6,1	5,2	12,3	7,8	19,1	14,8
NLPHSC	67	44	1	3	29	25	74	74	62	38	1	0	0	0
Varyans	1,45	1,27	22,51	34,71	0,02	0,03	47,14	28,53	3,48	3,88	7,99	7	10,39	15,47
Std. Dev.	1,2	1,13	4,74	5,89	0,15	0,19	6,87	5,34	1,87	1,97	2,83	2,7	3,22	3,93
CV	4,95	5,42	5,74	6,59	7,73	12,9	1,42	1,41	2,95	4,77	4,53	4,8	5,2	8,57
LSD $_{(0.05)}$	0.97**	0.96**	6.88**	6.19**	0.19**	0.32**	5.43**	5.06**	1.24**	1.80**	2.65**	2**	4.89**	6.34**

**: İndicates Significant differences P≤0.01. Abbreviations; OC: Optimum conditions, SC: Stressful conditions, NLPHSC: Number of landrace genotypes, exceeding the highest standard cultivar, CV: Coefficient of variation, LSD: Least significant difference, SL: Spike length, GFT: Grain filling time, GFR: Grain filling rate, DTM: Days to maturity, NSS: Number of spikelets on the spike, NGS: Number of grains per spike, TGW: Thousand-kernel weight, Ov. Av: overall average, Land. Av: landrace average, Std. Cul Av: Standard cultivar average, Std. Dev: standard Deviation

Table 3. The results of the correlation analysis of the characteristics studied under optimum conditions

Characteristics	SPAD	G.F.T	G.F.R	D.T.H	G.T.F.L	D.T.M	P.H	P.L	F.L.A	F.L.E	S.L	N.S.S	N.G.S
G.F.T	0,009												
G.F.R	0,17	-0,665**											
D.T.H	0,103	-0,667**	0,434**										
G.T.F.L	0,097	0,275**	-0,084	0,061									
D.T.M	0,17	-0,235*	0,172	0,859**	0,318**								
P.H	0,273**	-0,391**	0,138	0,500**	-0,196	0,356**							
P.L.	0,189	-0,270**	0,024	0,175	-0,352**	0,046	0,633**						
F.L.A	-0,1	-0,042	-0,015	0,096	-0,032	0,034	0,094	-0,163					
F.L.E	0,195	0,429**	-0,105	-0,526**	0,320**	-0,339**	-0,427**	-0,205*	-0,148				
S.L	0,16	-0,167	0,221*	0,352**	0,267**	0,363**	0,256*	0,021	0,224*	-0,028			
N.S.S	0,114	-0,194	0,077	0,366**	0,330**	0,355**	0,244*	-0,049	0,176	0,103	0,495**		
N.G.S	0,284**	0,386**	-0,163	-0,341**	0,339**	-0,126	-0,271**	-0,220*	-0,112	0,657**	0,061	0,224*	
T.G.W	0,264*	0,082	0,603**	-0,06	0,052	0,009	-0,203*	-0,187	0,035	0,280**	0,146	-0,108	0,151

İndicates Significant differences ***:** $p<0.05$, ****:** $P\leq0.01$. Abbreviations; SPAD: Flag leaf chlorophyll content, GFT: Grain filling time, GFR: Grain filling rate, DTH: Days to heading, GTFL: Greening Time of flag leaf, DTM: Days to maturity, PH: Plant height, PL: Peduncle length, FLA: Flag leaf area, FLE: Flag leaf erectness, SL: Spike length, NSS: Number of spikelets on the spike, NGS: Number of grains on the spike, TGW: Thousand-kernel weight.

Table 4. The results of the correlation analysis of the characteristics studied under high-temperature stress conditions

Characteristics	SPAD	G.F.T	G.F.R	D.T.H	G.T.F.L	D.T.M	P.H	P.L	F.L.A.	F.L.E	S.L	N.S.S	N.G.S
G.F.T	0,109												
G.F.R	-0,053	-0,555**											
D.T.H	0,039	-0,731**	0,396**										
G.T.F.L	0,213*	0,17	-0,045	0,191									
D.T.M	0,131	-0,088	0,031	0,703**	0,466**								
P.H	0,189	-0,442**	0,164	0,588**	-0,025	0,428**							
P.L	0,058	-0,159	-0,04	0,036	-0,156	-0,037	0,499**						
F.L.A	0,257*	0,263*	0,006	-0,276**	-0,063	-0,199	0,075	0,008					
F.L.E	0,09	0,475**	-0,132	-0,541**	0,188	-0,250*	-0,423**	-0,098	0,185				
S.L	0,081	-0,204*	0,152	0,195	0,112	0,139	0,153	-0,106	0,194	0,044			
N.S.S	0,111	-0,163	-0,074	0,176	0,313**	0,121	0,197	-0,1	0,157	0,198	0,519**		
N.G.S	0,069	0,389**	-0,133	-0,366**	0,289**	-0,125	-0,268**	-0,072	0,231*	0,700**	0,032	0,392**	
T.G.W	0,104	0,462**	0,384**	-0,390**	0,077	-0,114	-0,336**	-0,215*	0,316**	0,467**	0,019	-0,214*	0,321**

İndicates Significant differences ***:** $p<0.05$, ****:** $P\leq0.01$. Abbreviations; SPAD: Flag leaf chlorophyll content, GFT: Grain filling time, GFR: Grain filling rate, HT: Days to Heading, GTFL: Greening time of flag leaf, DTM: Days to maturity, PH: Plant height, USL: Peduncle length, FLA: Flag leaf area, FLE: Flag leaf erectness, SL: Spike length, NSS: Number of spikelets on the spike, NGS: Number of grains on the spike, TGW: Thousand-kernel weight.

CONCLUSION

The study revealed that there are landrace genotypes that may have the potential to tolerate high-temperature stress one of the main causes of yield losses in the South-eastern Anatolia Region. Under high-temperature stress conditions, the genotypes with early heading time, longer flag leaf greening time, more erect flag leaf, longer grain filling time, and higher grain filling rate prevailed in terms of the characteristics that affected the yield, such as the thousand-kernel weight and number of grains on the spike. Therefore, the preference of genotypes with these parameters in the improvement programs to minimize the effect of high-temperature stress in the South-eastern Anatolia Region is considered to increase improvement success. Besides, it is recommended that practical, easy, and fast-measurable characteristics such as days to heading, flag leaf erectness, flag leaf greening time, grain filling time, and grain filling rate be utilized as selection criteria in identifying genotypes tolerant to high-temperature stress in the region. Furthermore, it is thought that landrace durum genotypes 82, 83, 87, 88, 99, and 103, as well as Artuklu and Sümerli, standard durum wheat, distinguished by their morphological and physiological parameters that positively affect grain yield and yield components that are directly associated with grain yield, can be included as parents in crossbreeding programs in the development of cultivars tolerant to high-temperature stress.

COMPLIANCE WITH ETHICAL STANDARDS

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

Ethics committee approval

Ethics committee approval is not required. This article does not contain any studies with human participants or animals performed by any of the authors.

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Data availability

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

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