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Study on Some Quality and Morpho-Physiological Traits of Durum Wheat (*Triticum durum* L. Desf.) Genotypes

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Abstract

The study was carried out in the experimental field of the Department of Field Crops, Faculty of Agriculture, Tekirdağ Namık Kemal University in 2020-2021. In the study, totally 25 durum wheat genotypes (6 cultivars, 12 advanced lines, and 7 landraces) were used as experimental material. The experiment was conducted in a randomized complete block design with 3 replications. In the study, the grain quality and morpho-physiological traits such as canopy temperature, chlorophyll content, leaf area index, and plant height were investigated in some durum wheat genotypes. The canopy temperature ranged from 23.33-20.43 ^{O}C, chlorophyll content 52.53-43.17 SPAD, leaf area index 3.63-1.77, thousand-grain weight 34.67-41.83 g, protein content 14.23-16.33%, test weight 78.93-87.03 kg hl^{-1}, semolina colour 14.88-15.63 and plant height 99.00-75.33 cm in investigated durum wheat genotypes. Hacımestan and Sorgül genotypes for canopy temperature, Atkı 2, NZFM 1 and NZFM 7 genotypes for chlorophyll content, Atkı 2, NZFM 4 and NZFM 1 genotypes for leaf area index, Kıbrıs 2 and Ionia 3 genotypes for plant height, NZFM 1, NZFM 7 and Devedişi 2 genotypes for thousand-grain weight, Atkı 2 and Hacımestan 2 genotypes for protein content, Japiga and Boğacak 2 genotypes for test weight and Japiga, Boğacak, Kızıltan 91 and NZFM 7 genotypes for semolina colour were determined as promising genotypes.

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1.Introduction

Durum wheat (*Triticum turgidum* L. ssp. *durum*, genome AABB, 2*n* = 4× = 28) is the 10th most important and commonly cultivated cereal worldwide, representing 5% of total wheat production with a planting area of about 16 million hectares (Anonymous, 2020). It is also used in the production of different food products such as pasta, couscous, bulgur, etc., in different regions of the world. Durum wheat is one of the important agricultural products in Turkey. It is cultivated 1.2 million ha with an average production of 3.2 million tons in 2021 (Anonymous, 2021). Durum wheat is grown in regions where there is sufficient rainfall and the temperature is not too low, since it is extremely affected by abiotic stresses, especially low temperatures. Although it is possible to slightly increase the planted areas in order to meet the required demand in durum wheat production, it is possible to increase the irrigated area planted in the field, but providing an increase in yield under rain fed conditions emerges as the most important alternative (Laaboudi and Mouhouche, 2012; Haddad et al., 2016; Belagrouz et al., 2018). Yield increase in durum wheat production compared to bread wheat has not been reached to the desired levels yet. This is due to the low number of varieties in durum wheat breeding and the inadequacy of variation sources used in breeding. For this reason, it is important to use new genetic resources that have the desired characteristics in the breeding of durum wheat and are well compatible with each other in crossing (Alp, 2005). One of the easiest and most effective ways to enrich genetic diversity as a source of variation in variety breeding is to use landraces (Çoşkun et al., 2019; Demirel et al., 2019).

Landraces are considered to be important genetic sources in increasing genetic diversity for the varieties to be developed by showing better adaptation in regions where abiotic and biotic stress factors are located (Soriano and Royo, 2015; Maccaferri et al., 2019). In variety breeding studies, revealing the potential in landraces, varieties and lines is important in terms of the effectiveness of the studies that have been done and will be done. In wheat breeding, one of the most important breeding purposes along with yield and quality is resistance to abiotic stresses. Thus, it is very important to know the physiological traits that plants have and use against abiotic stress factors. The aim of the study is to investigate the status of the durum wheat landraces, varieties, and promising advanced lines for quality and tolerance/resistance to abiotic stresses, and also to reveal the status of the advanced lines according to the varieties and landraces in terms of morpho-physiological traits.

2.Materials and Methods

This study was carried out with 25 durum wheat genotypes (6 cultivars, 12 advanced lines, and 7 landraces) based on randomized complete block design with 3 replications at the experimental area of the Field Crops Department, Agricultural Faculty, Tekirdağ Namık Kemal University, Turkey, in 2020-2021 wheat growing season. Geographically, Tekirdağ district locates at latitude 40^o 36’- 40^o 31’ and longitude 26^o 43’- 28^o 08’. According to soil analysis results, the experimental area’s soil was clay-loam, slightly acidic (pH 6.5), limeless, and poor (1.08%) in organic matter. The temperature and the rainfall from sowing to harvest are presented in Table 1.

Table 1. Rainfall (mm) and mean temperature (°C) of Tekirdağ from sowing to harvest (2020 to 2021)

Months	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Total/Mean
Rainfall (mm)	1.2	37.7	127.8	53.5	45.3	43.6	57.6	54.7	3.4	424.8
Temperature (°C)	11.6	10.1	7.8	7.3	7.0	10.7	17.5	20.8	25.8	13.2

Seeds of each genotype were sown in 6 rows 5 m long with 0.17 m of inter-row spacing. The seeding rate used in sown was 500 seeds per m^2. The cultivation techniques recommended for the region were followed to raise a good crop. Twenty kg da^{-1} 20.20.0 fertilizer was applied just before sowing, and then 15 kg da^{-1} urea (46% N) and 15 kg da^{-1} ammonium nitrate (26% N) were broadcasted at the tillering and the pre-heading stages. Weeds were controlled chemically. In the study, plant height (cm), canopy temperature (°C), leaf area index, chlorophyll content (SPAD), thousand-grain weight (g), test weight kg hl^{-1}), protein content (%) and semolina colour were investigated. Canopy temperature was measured with a portable infrared thermometer (Extech Mini IR Thermometer Modell 42500) as °C (Reynolds et al., 2001). It was taken as two measurements per plot during the day between (11:00h to 14:00h). Chlorophyll content was measured with "Konica Minolta SPAD-502 Plus" portable chlorophyll meter in the fully-developed flag leaves and determined as "SPAD value". It was taken three averages of five leaves per plot, and were done from 11:00h to 14:00h. Leaf area index was measured with a portable leaf area meter at the heading stage (Pask et al., 2012). The data obtained from the advanced lines, varieties and landraces used as material in the study were analyzed separately by using the JUMP statistical package program. Mean values were compared using Duncan's Multiple Range Test (*p≤0.01*).

3.Results and Discussion

Data concerning canopy temperature, plant height, leaf area index, chlorophyll content, thousand grain weight, protein content, test weight and semolina colour are given in Table 2 and 3.

Table 2. Mean values and significance groups of canopy temperature, plant height, leaf area index, and chlorophyll content in durum wheat genotypes

Genotypes	Canopy temperature (°C)		Plant height (cm)		Leaf area index (LAI)		Chlorophyll content (SPAD)	
Landraces								
Kurtalan 24	21.333	bc	99.000	a	3.200	ab	47.733	ab
Devedişi	21.867	ab	79.000	cd	2.767	bc	45.333	bcd
Karakılçık	23.333	a	90.333	ab	3.633	a	43.867	cd
Atkı	21.400	bc	86.000	bc	2.433	cde	50.433	a
Hacımestan	20.800	cd	83.000	bcd	1.967	e	44.200	bcd
Sorgül	20.433	d	78.333	d	2.067	de	46.967	abc
Boğacak	21.067	cd	90.000	ab	2.500	cd	42.700	d
Mean	***21.46***		***86.52***		***2.65***		***45.89***	
Varieties								
Tunca-79	20.733	b	79.667	c	2.600	b	43.167	c
Zenit	21.700	ab	85.000	ab	2.900	ab	49.400	ab
Svevo	22.367	a	90.333	a	2.533	b	50.300	a
C-1252	22.433	a	91.333	a	3.633	a	50.100	ab
Japiga	21.667	ab	84.333	bc	2.867	ab	46.567	bc
Kızıltan-91	21.200	ab	80.667	bc	2.333	b	47.567	ab
Mean	***21.68***		***85.22***		***2.81***		***47.85***	
Advanced lines								
NZFM-13	21.833	b-e	84.000	d	2.900	bcd	46.700	cde
Hacımestan-2	21.200	f	88.000	bcd	2.500	def	43.667	e
Boğacak-2	21.667	c-f	96.000	a	2.633	cde	45.467	de
Atkı-2	21.467	def	92.333	ab	3.333	ab	52.533	a
NZFM-4	22.000	bcd	86.333	cd	3.533	a	47.833	bcd
NZFM-1	22.100	abc	94.333	a	3.033	abc	50.267	abc
NZFM-7	22.200	abc	93.000	ab	2.433	def	51.133	ab
Devedişi-2	22.333	ab	88.000	bcd	2.333	ef	46.500	cde
Ionia-3	22.700	a	75.333	e	2.167	fg	48.233	a-d
NZFM-8	21.533	def	90.333	abc	2.200	efg	47.433	b-e
Cyprus-2	22.000	bcd	75.667	e	2.433	def	47.200	b-e
Adana-2	21.333	ef	85.000	d	1.767	g	47.967	a-d
Mean	***21.86***		***87.36***		***2.61***		***47.91***	

3.1. Canopy temperature

The effect of genotype on canopy temperature was statistically significant (*p≤0.01*) (Table 2). Canopy temperatures varied between 20.43-23.33 °C in the landraces, 20.73-22.43 °C in varieties, and

21.20-22.70 °C in advanced lines (Table 2). This result is also in agreement with the findings of Gautam et al. (2015), who found that canopy temperatures of durum wheat genotypes ranged from 20.20-24.90 °C. The highest variation for canopy temperatures was determined in the landraces. Similar to our findings, Bahar et al. (2008) and Ray and Ahmad (2015) revealed that the canopy temperatures of durum wheat genotypes were significantly different. Among the landraces, the lowest canopy temperature was found in the Sorgül with 20.43 °C and a lower canopy temperature could not be obtained from the advanced lines and varieties. Tunca 79, Kızıltan 91, Japiga and Zenit cultivars with 20.73, 21.20, 21.67 and 21.70 °C canopy temperature values, Hacımestan 2, Adana 2, and NZFM 8 advanced lines with 21.20, 21.33, 21.53 °C canopy temperature values were identified as genotypes to be considered.

Table 3. Mean values and of significance groups of thousand-grain weight, protein content, test weight and semolina colour in durum wheat genotypes

Genotypes	Thousand-grain weight (g)		Protein content (%)		Test weight (kg hl^{-1})		Semolina colour	
Landraces								
Kurtalan 24	39.800	a	14.433	c	86.333	a	14.890	d
Devedişi	36.867	abc	14.833	bc	84.233	ab	15.007	cd
Karakılçık	33.600	c	15.833	a	82.467	bc	15.413	ab
Atkı	35.867	bc	15.267	ab	81.400	c	15.247	bc
Hacımestan	39.267	ab	15.433	ab	83.067	bc	15.310	ab
Sorgül	39.633	a	14.567	c	84.667	ab	15.487	ab
Boğacak	37.967	ab	14.533	c	86.100	a	15.567	a
Mean	***37.57***		***14.99***		***84.04***		***15.27***	
Varieties								
Tunca-79	32.967	c	15.500	ab	82.133	bc	15.380	a
Zenit	36.300	bc	15.567	ab	84.267	ab	15.423	a
Svevo	41.933	a	15.733	a	84.467	ab	14.890	b
Ç-1252	35.867	bc	15.200	bc	83.100	bc	15.433	a
Japiga	37.867	ab	14.967	c	87.033	a	15.603	a
Kızıltan-91	34.667	bc	14.900	c	80.367	c	15.627	a
Mean	***36.60***		***15.31***		***83.56***		***15.39***	
Advanced lines								
NZFM-13	37.833	c	15.567	bcd	84.767	ab	14.880	
Hacımestan-2	37.100	c	16.067	ab	83.033	b	15.093	
Boğacak-2	38.367	bc	15.167	de	86.900	a	15.133	
Atkı-2	35.433	c	16.333	a	78.933	c	15.240	
NZFM-4	38.267	bc	15.467	bcd	82.733	b	15.350	
NZFM-1	43.000	a	15.467	cd	83.967	ab	15.050	
NZFM-7	43.833	a	14.933	ef	84.733	ab	15.547	
Devedişi-2	41.800	ab	14.233	g	85.600	ab	15.047	
Ionia-3	37.933	c	14.467	fg	85.333	ab	14.663	
NZFM-8	37.867	c	15.733	abc	84.567	ab	14.923	
Cyprus-2	36.500	c	14.800	ef	85.600	ab	15.103	
Adana-2	36.900	c	15.467	cd	85.633	ab	15.343	
Mean	***38.74***		***15.31***		***84.32***		***15.11***	

Canopy temperature has been used as a selection criteria for tolerance to drought and high-temperature stress in wheat breeding (Bahar et al., 2008). When the average of the landraces, varieties, and advanced lines are examined, it is seen that the landraces show the lowest canopy temperature, this value increases slightly in the cultivars, and this value is the highest in the lines on average. It is understood that the effect of global climate change is felt more and the canopy temperature, which is one of the most important selection criteria for drought resistance in plants grown in arid areas, is not at the desired level in varieties and lines.

3.2. Plant height

According to variance analysis results, plant height was significantly affected by genotype (Table 2). Mean values of plant height in durum wheat genotypes varied between 78.33-99.00 cm in landraces, 79.67-91.33 cm in varieties, and 75.67-96.00 cm in advanced lines. In a study with landraces and modern varieties of durum wheat, it was determined that the plant height ranged from 94.00 to 126.00 cm (Royo et al., 2020). When landraces, varieties, and advanced lines were compared in terms of plant height, the mean plant height of varieties was shorter than the landraces. This result was similar to the finding of Royo et al. (2020). Also, Baykara et al. (2022) stated that the plant height of durum wheat varieties (103.9 cm) was significantly taller than modern varieties (94.7 cm). Considering the variation between 80-100 cm in terms of plant height in wheat, plant height values of varieties and advanced lines are within the desired limits.

3.3. Leaf area index

The number of leaves in the plant is an important factor in determining the amount of light absorbed by the canopy, which controls the photosynthetic rate. So, the leaf area index may be good tool to screen wheat genotypes under terminal heat stress conditions (Dhyani et al., 2017). In our study, the effect of genotype on leaf area index was statistically significant (Table 2). While durum wheat varieties gave higher values with an average leaf area index of 2.81, landraces and advanced lines gave lower and similar values with leaf area index values of 2.65 and 2.61. In the landraces, the highest area index was 3.63 in the Karakılçık, while the landraces of Hacımestan showed a low value of 1.97. In durum wheat varieties, Ç-1252 variety gave the highest leaf area index (3.63). Similar findings were reported that Bavec et al. (2008), who indicated that leaf area index varied between 2.5-6.5 in wheat. When the advanced lines are examined, there is no advanced line that exceeds the leaf area index of the landrace of Karakılçık and variety of Ç 1252. Among the advanced lines, Atkı-2, NZFM-4, NZFM-1 are genotypes with leaf area index values above 3.0. Adana-2 advanced line gave a very low value with 1.77 leaf area index. Dhyani et al. (2017) reported that the leaf area index in wheat changed from 2.96 to 5.82.

3.4. Chlorophyll content

Chlorophyll and carotenoid are two pigments related to the physiological functions of leaves that absorb light energy during photosynthesis. Chlorophyll provides photosynthesis in the plant and its amount is one of the main factors used in the evaluation of environmental and growing conditions for wheat. In our study, while the chlorophyll content was the lowest with 45.89 (SPAD) in landraces, it was determined as 47.85 and 47.91 (SPAD) values by increasing in varieties and lines. Among the genotypes examined, the highest chlorophyll content was found in Atkı 2 and NZFM 7 durum wheat lines with 52.53 and 51.13 (SPAD) values. Atkı landraces, Svevo variety, NZFM 1 advanced line and Ç 1252 durum wheat cultivar followed these lines with values of 50.43, 50.3, 50.27 and 50.1 (SPAD). The lowest chlorophyll content value was obtained in Boğacak landraces with 42.70. While the chlorophyll content in landraces was 45.89 on average, the chlorophyll content in cultivars and lines showed a remarkable increase, reaching 47.85 and 47.91 values. Similar to our results, Talebi (2011) stated that genotypes differ chlorophyll content values in durum wheat. Our results also show that the chlorophyll content in genotypes has increased significantly as a result of breeding studies.

3.5. Thousand-grain weight

The weight of one thousand grains of wheat is important in terms of giving an idea about the grain's size, fullness, thinness and flour yield. Results of our study show that according to the landraces and varieties of durum wheat, significant increases were achieved in terms of thousand-grain weight in the advanced lines. While the mean of thousand-grain weight was 35.57 g in landraces, it was determined as 36.60 g in the varieties and 38.74 g in advanced lines. Our findings are in agreement with the findings of Akan et al. (2021), who determined that the thousand-grain weight in durum wheat genotypes varied between 26.52-37.96 g. It is seen that these obtained values show a significant increase in varieties and especially in lines according to the landraces. While there was no genotype with a grain weight over 40.00 g in landraces, Svevo with 41.93 g thousand grain weight in cultivars, NZFM 7 line 43.83 g, NZFM 1 line 43.00 g and Devedisi 2 line 41.80 g were the genotypes with high thousand-grain weight.

3.6. Protein Content

It is known that protein content and composition are the most important factors determining the quality of wheat. Protein content varies depending on genetic and environmental factors, but protein composition is not affected by environmental factors (Autran and Bourdet, 1979). In the study, the mean of protein content was 14.99% in the landraces, while it was found to be 15.31% in varieties and lines. These obtained data show that an increase in protein content in varieties and lines is provided to landraces. Akan et al. (2021) determined that the protein content in durum wheat varieties varies between 15.85-19.40%. Among the landraces, the highest protein content was in the Karakılçık genotype with 15.83%. None of the varieties had higher protein content than Karakılçık genotype. However, Hacımestan-2 (16.07%) and Atkı-2 (16.33%) advanced lines had higher protein content than Karakılçık genotype. The obtained data reveal that the protein content increased in durum wheat advanced lines.

3.7. Test Weight

Test weight is expressed in kg of 100 litres of wheat. Test weight varies depending on the species, variety, sowing time, growing period and ecological conditions. In wheat, the shape and size of the grain, whether the shell is thin or thick, whether the abdomen is deep or flat, whether the shell is polished or not, affects the test weight. The test weight values of durum wheat genotypes are close to each other on average in landraces, cultivars and lines in this study. Among the landraces, Kurtalan 24 and Boğacak ranked first with a higher test weight of 86.33 and 86.10 kg hl^{-1}, and the Japiga variety with a test weight of 87.03 outperformed them. Among the forward lines, the Boğacak 2 genotype is the one that draws attention with a test weight of 86.9 kg/hl. While Atkı-2 gave a lower value of 78.93 kg hl^{-1} from the advanced lines, a significant part of the lines showed a test weight of 84-85 kg hl^{-1}.

3.8. Semolina Colour

Bright yellow colour in pasta or semolina is one of the most important quality parameters. Therefore, breeding of durum wheat varieties with high pigment content is an important breeding goal. It has been reported by different researchers that the content of yellow colour in durum wheat varies according to varieties (Şahin et al., 2006; Coşkun et al., 2010). In our study, the highest values for semolina colour were in varieties and the lowest values were obtained in advanced lines. There was no statistical difference between the advanced lines for semolina colour. All local varieties except Kurtalan 24 and all varieties had semolina colour over 15.00 in the study. While among the advanced lines, 9 lines gave semolina colour over 15.00, the highest semolina value colour was in NZFM 7, NZFM 4 and Adana 2 genotypes. The data obtained reveal that a significant part of the varieties and lines show similar characteristics with the landraces in terms of semolina colour.

4. Conclusion

In the study carried out with durum wheat landraces, varieties and lines, canopy temperature, plant height, leaf area index, chlorophyll content, thousand-grain weight, protein content, test weight, and semolina colour characteristics were investigated. While landraces have a lower value for canopy temperature, it is seen that the canopy temperature has increased slightly in varieties and lines. The advanced lines and cultivars have slightly longer plant heights than landraces. Leaf area index values were the highest in cultivars and showed similar values in landraces and lines. In terms of chlorophyll content, significant increases were achieved in varieties and lines compared to landraces. Advanced lines gave higher thousand grain weight than landraces and varieties. The protein content of varieties and advanced lines showed a significant increase compared to landraces. Test weight was lower in cultivars, and similar in landraces and advanced lines. The semolina colour was slightly higher in varieties compared to the landraces and advanced lines.

The results showed a significant increase in chlorophyll content, leaf area index, protein content and thousand-grain weight in varieties and advanced lines. In the canopy temperature, which is desired to be low, there was an increase in varieties and advanced lines. Test weight and semolina colour did not change significantly in breeding material and landraces.

In conclusion, Atkı-2, NZFM 1 and NZFM 7 advanced lines for examined traits were determined as promising genotypes.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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