RESEARCH ARTICLE

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Investigation of Durum Wheat Genotypes (*Triticum durum* Desf.) in Terms of Quality and Some Agronomic Traits

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Abstract

Türkiye is one of the origin centers of durum wheat and among the important producer countries of durum wheat. The aim of this study is to examine some durum wheat genotypes with different characteristics in terms of some agronomic and quality characteristics and to determine the relationships between features. The study was carried out in four different environments with supplementary irrigated and based of rainfed in Diyarbakir province conditions. Trial design carry out according to Randomized Complete Blocks Split Plots Experiment Design and three replications. It was determined that there were significant differences at the $p<0.01$ level between genotypes in all the traits examined. According to the research results, change range of average values in durum wheat varieties were determined as; heading time (HT) 170.33-178.42 days, plant height (PH) 93.0-139.2 cm, the number of spikes per square meter (SN) 441.50-567.50 spikes/m^2, the number of grains per spike (GN) 40.7-65.5 grains/spike, thousand grain weight (TGW) 32.4-47.0 g, test weight (TW) 77.5-85.6 kg/hl, protein ratio (PR) 12.72-17.21%, sedimentation amount (SA) 9.58-25.08 ml, b yellowness value (YV) 18.27-27.90, vitreousness ratio (VR) 75.42%-85.42%. Plant height exhibited a positive correlation with protein content (r = 0.728**), and sedimentation amount also demonstrated a positive correlation with the b yellowness value (r = 0.649**). As a general trend, genotypes with spring attributes were positioned ahead of those with winter characteristics. It has been observed that winter genotypes have a heading time 5-6 days later than that of spring genotypes. Since Fırat-93 (TGW), Kunduru 1149 (PR), Urfa 2005 (TW and VR) and Candidate 1 (SA and YV) genotypes are at the forefront in terms of quality parameters. It would be beneficial to use these genotypes as parents and to protect them as genitor.

Keywords: Durum wheat, Agronomy, Quality, *Triticum durum* Desf.

INTRODUCTION

It has been reported that the origin center of wheat is the Mesopotamian region called the Fertile Crescent, it spread to Western Europe from here, and the Karacadağ region, which is located in the Diyarbakır, Mardin, and Şanlıurfa triangle, is one of the origine centers of wild wheat (Heun et al., 1997; Yıldırım and Atasoy, 2020).

Wheat production continues its potential to be a strategic product with 736 million tons according to 2018 statistical data. In addition, Russia, China, India, Ukraine, USA, Kazakhistan, Canada, Australia and Türkiye are the countries that draw attention with their durum wheat production amounts (FAO, 2019). Durum wheat can be consumed raw or processed into different products. As a matter

of fact, it is used extensively in the production of flour, semolina, bread, pasta, couscous, bulgur, and freekeh (Branković et al., 2018).

Some regions of Türkiye are ecologically very suitable for the cultivation of high quality durum wheat. In some years, unfavorable climatic conditions negatively affect durum wheat cultivation, but genetic structure, ecological conditions, agronomic practices are significantly effective on the quality durum wheat (Pehlivan and Ünver İkincikarakaya, 2017). It has been emphasized that wheat is one of the most important energy and protein sources of people in daily life, and 21% of the world population's protein needs and 19% of their calorie needs are met by wheat (Ali, 2017; Yıldırım and Atasoy, 2020).

Protein ratio is one of the important quality parameters in durum wheat and it has a positive and significant effect on grain vitreousness (Porceddu et al., 1973; Karaman, 2017). In durum wheat, test weight and thousand grain weight, which are the most important grain physical properties, affect the product and milling quality of the wheat and important for the flour and bulgur industry (Karababa and Ercan 1995; Karaman, 2017). In another study; it was emphasized that protein content, sedimentation amount, grain color and vitreousness are important features in categorizing wheat grain and flour (Turnbull and Rahman, 2002; Yıldırım and Atasoy, 2020). It was emphasized that plant height in durum wheat differs depending on the effect of climatic conditions, short wheat varieties are resistant to lodging and mostly early varieties, while plant height between 70-100 cm is reported to be optimum (Aykut et al., 2005; Özen and Akman, 2015).

The primary goal of this study is to assess different durum wheat genotypes, including spring, winter, and landrace varieties, for various agronomic and quality traits in the specific conditions of Diyarbakir province.

MATERIAL AND METHOD

The experiment was established in the Diyarbakir province and in total 4 environments (214-2015 based of rainfed and supplementary irrigated, 2015-2016 based of rainfed and supplementary irrigated) in based of rainfed and supplementary irrigated conditions in the 2014-2016 growing seasons. According to Randomized Complete Blocks Split Plots Experiment Design and three replications the main plots were designed as irrigation and the sub plots were designed as variety. Study material; 25 genotypes were created, including 20 modern, 1 landrace durum wheat cultivar and 4 candidate durum wheat lines. Durum wheat genotypes were planted in 7.2 m^2 plots with a six-row with trial seeder on 500 seeds per square meter. In the plots included in the irrigated application, irrigation was carried out once in the milk grain development stage in the 2014-2015 season, and twice in the 2015-2016 season, in the booting and milk grain development stage, in order to eliminate the drought stress. In the irrigated trials, water was given until the soil was saturated with water.

In rainfed and irrigated applications, 6 kg/da N + 6 kg/da P_2O_5 was given over the pure substance at the base with sowing. In addition, 8 kg/da N was applied as top fertilizer on the pure substance in the period between the end of tillering period and stem elongation. Harvesting was done with a parcel combine harvester on a net 6 m^2 area. In the table containing information on durum wheat material, the first 7 varieties have winter characteristics. Other genotypes are of spring character (Table 1).

In the first year of the study, the amount of precipitation was above the long-term average and in the second year it was below (Table 2). In addition, it was determined that the distribution of precipitation on a monthly basis was irregular in both seasons.

It has been determined that the soils of the trial area have a clay-loam texture, slightly alkaline and poor in terms of organic matter content (Table 3).

The heading time (day) was determined on the basis of the number of days until the period when 70% of the plants were spike at the rate of ½. Plant height (cm) was determined by measuring the part from the soil level to the top of the top spikelet of the 10 plant randomly selected from each plot in the dough formation period, in centimeters (Yürür et al., 1987). For the number of spike (piece) per square meter, the spike were counted before harvesting, taking into account 1 m length and 20 cm width on a row, and then the number of spike per 1 square meter was calculated by multiplying by 5. The number of grains (piece) per spike was determined by counting and averaging the grains obtained from 10 spike samples collected before harvest in each plot.

In order to determine the thousand grain weight (g), 4x100 kernels were counted and weighed separately and the average was multiplied by 10 (Williams et al., 1988). Test weight and protein ratio were determined by using NID In Model 9500 device and reading on the grain surface. For the sedimentation amount (ml), 3.2 g flour sample was weighed and placed in a 100 ml glass measuring cup, then 50 ml of bromine phenol solution was added and the homogeneous suspension obtained was shaken by hand several times. The prepared suspension was quickly placed in the device and shaken for 5 minutes. Then, 25 ml of the prepared lactic acid solution was added and it was shaken for another 5 minutes, the device was turned off and the tube was left on a flat surface for 5 minutes and the precipitation value was read in ml at eye level (ICC, 2008). Yellowness values (b value) of durum wheat genotypes were determined using semolina by Minolta Color Analyzer (CM-6220t). Vitreousness ratio (%) was determined by Grobecker sectioning tool. Vitreous grains were expressed as %.

In the study, variance analysis, LSD and correlation

Table 1. Information on the durum wheat genotypes used in the study

Variety/Candidate	Spring or Winter	Breeder Organization or Origin
Gökgöl-79	Winter	DTARI
Tunca 79	Winter	DTARI
Kunduru 1149	Winter	TZARI
Yelken 2000	Winter	TZARI
Meram-2002	Winter	BDIARI
Selçuklu-97	Winter	BDIARI
Dumlupınar	Winter	TZARI
Güneyyıldızı	Spring	GAP IARTCD
Artuklu	Spring	GAP IARTCD
Fırat-93	Spring	GAP IARTCD
Aydın-93	Spring	GAP IARTCD
Altıntoprak-98	Spring	GAP IARTCD
Ceylan-95	Spring	GAP IARTCD
Diyarbakır-81	Spring	GAP IARTCD
Fuatbey 2000	Spring	EMARI
Sham-1	Spring	EMARI
Sarıbaşak	Spring	EMARI
Pitagora	Spring	MAI
Urfa 2005	Spring	HUFA
Cesare	Spring	PSI
Sorgül	Spring	Landrace variety
Candidate 1	Spring	CIMMYT
Candidate 2	Spring	CIMMYT
Candidate 3	Spring	CIMMYT
Candidate 4	Spring	CIMMYT

GAP IARTCD: GAP International Agricultural Research and Training Center Directorate, PSI: Progen Seed Inc., TZARI: Transitional Zone Agricultural Research Institute, DTARI: Directorate of Trakya Agricultural Research Institute, BDIARI: Bahri Dagdas International Agricultural Research Institute, EMARI: Eastern Mediterranean Agricultural Research Institute, HUFA: Harran University Faculty of Agriculture, MAI: Maro Agriculture Inc. CIMMYT: The International Maize and Wheat Improvement Center

Table 2. Climate data of Diyarbakir province

	Maximum and minimum temperature (°C)		Average temperature long years (°C)	Precipitation (mm)		
Months	**2014-2015**	**2015-2016**		**2014-2015**	**2015-2016**	**Long years (mm)**
September	39.8-10.5	39.1-14.0	24.8	27.4	0.0	4.1
October	30.0-4.7	32.1-7.5	17.2	34.2	84.2	34.7
November	19.7-(-3.6)	21.0-(-1.8)	9.2	97.6	10.4	51.8
December	16.0-(-4.2)	17.0-(-5.9)	4.0	73.6	31.6	71.4
January	13.0-(-10.1)	11.2-(-19.0)	1.8	64.6	77.4	68.0
February	15.3-(-3.1)	21.8-(-5.6)	3.5	55.2	69.2	68.8
March	20.0-(-4.4)	21.1-(-5.1)	8.5	127.0	55.6	67.3
April	27.5-1.2	28.8-(-0.3)	13.8	48.6	29.0	68.7
May	34.2-4.7	32.9-5.2	19.3	48.2	41.4	41.3
June	39.3-9.2	40.5-11.6	26.3	7.4	18.4	7.9
Total				**583.8**	**417.2**	**484.0**

Table 3. The soils analysis results of 2014-2016 experiment areas

Soil Structure	Total Salt (%)	Ph	Lime CaCO3 (%)	Phosphorus P_2O_5 (kg/da)	Organic Matter (%)	Saturation with water (%)
Clayey- loamy	0.25-0.06	7.8-7.9	6.3-13.1	1.28-2.36	0.676-1.33	77-64

analyzes were performed in the J.M.P (5.0.1) package program and the differences between the groups were evaluated at the level of $p<0.01$ or $p<0.05$ according to the LSD test (Kalaycı, 2005). Also, since the variances of the years were homogeneous, the combined analysis was performed.

RESULTS AND DISCUSSION

In the study, it was determined that there was a significant difference at the level of 1% between genotypes in all the traits examined (Table 4, 5 ve 6).

In the study, the mean of heading time varied between 170.33 and 178.42 days. It was observed that the mean of heading time (177.83 days) for the winter genotypes was 5-6 days late more than the spring genotypes (172.39 days). Yelken 2000 durum wheat variety was the latest and Artuklu was the earliest durum wheat variety. Regarding the time to heading time, Sakin et al. (2004) 191.7-205.0 days, Şahinter (2015) 154.4 days, Tanrikulu (2018) 103.50-107.75 days, Enes et al. (2021) 128.00-141.00 days reported that. Differences between wheat genotypes in terms of heading times are highly related to heredity, but the effect of ecological conditions is also important (Yıldırım et al., 2005).

In the experiment, the average plant height differed between 93.0 and 139.2 cm. It was determined that the mean plant height of winter genotypes (110.7 cm) was 8.6 cm longer than spring genotypes (102.1 cm). Kunduru 1149 durum wheat variety gave the longest and Candidate 3 gave the shortest plant height. Regarding plant height; Ertekin (2011) 84.5-98.3 cm, Enes et al. (2021) stated that it is 71.75-117.00 cm reported that. It has been reported that the effect of heredity on plant height is high, but it is shaped under environmental conditions. In addition, it was emphasized that plant height had an indirect effect on yield and yield components (Sakin et al., 2004).

The average number of spikes per square meter varied between 441.50 and 567.50 spikes. It has been determined that the average number of spikes per square meter is 20 spikes less in winter genotypes (489.5 spikes/m^2) compared to spring genotypes (509.5 spikes/m^2). Candidate 1 had the highest number of spike and Dumlupınar durum wheat variety had the lowest number of spike. Regarding the number of spikes per square meter; Özen and Akman (2015) 423-492 spikes/m^2, Naneli et al. (2015) 428.3-565.0 spikes/m^2, Doruk Kahraman and Gökmen (2022) 217.7-462.7 spikes/m^2 reported that.

The average values for the number of grains per spike differed between 40.7 and 65.5 grains. It was determined that the average number of grains per spike of winter genotypes (51.7 grains/spike) was 1.9 grain less than the spring genotypes (53.6 grains/spike). It was determined that Candidate 2 had the highest number of grains per spike, while the Sorgül (40.7 grains/spike) landrace durum wheat variety was the least (Table 5). The number of grains in the spike; Özen and Akman (2015) 21.9-45.9 grains, Doruk Kahraman and Gökmen (2022) 9-23 grains reported that. Higher values were observed in our study. It is thought that this situation is caused by variety, ecological differences and agronomic practices.

Thousand grain weight changed between 32.4 and 47.0 g. It was observed that the average thousand grain weight of the winter genotypes (36.5 g) was 2.7 g lower than the spring genotypes (39.2 g). Fırat-93 variety gave the highest thousand grain weight and Tunca 79 variety gave the lowest thousand grain weight. Thousand grain weight; Güngör and Akgül (2015); 30.5-42.7 g, Yıldırım and Atasoy (2020); 47.18-53.82 g, Enes et al. (2021); it has determined that it differs between 26.52-37.96 g reported that. In the study, the average test weight was between 77.5 and 85.6 kg/hl. Average test weight of the winter genotypes was 3.3 kg less than the spring genotypes. Urfa 2005 durum wheat variety gave the highest test weight and Selcuklu-97 variety gave the lowest weight. Regarding the test weight; Yıldırım and Atasoy (2020) 81.75-84.71 kg/hl, Enes et al. (2021) 67.40-72.20 kg/hl, Bayhan (2022) 82.52-89.74 kg/hl reported that. High test weight in durum wheat indicates a low and healthy grain structure of disease and pest damage (Atlı et al., 2010).

In the study, the average protein content varied between 12.72% and 17.21%. The average protein content in winter genotypes was 1.31% higher than in spring genotypes. The highest protein content was observed in Kunduru 1149 durum wheat variety and the lowest protein content in Candidate 2. Regarding the protein ratio; Altay et al. (2021) 14.85-17.00%, Enes et al. (2021) reported values ranging between 15.85-19.40%, and Bayhan (2022) varying between 12.45-19.74%.

In the study, the average sedimentation amount varied between 9.58 and 25.08 ml. It was observed that the sedimentation amount of winter durum wheat was 0.92 ml lower than the spring genotypes (Table 6). The sedimentation amount of Candidate 1 was the highest and the Ceylan-95 durum wheat variety was the lowest. It was emphasized that the samples with a sedimentation amount of <15 ml were very weak, between 16-24 ml weak, between 25-36 ml good, and those with >36 ml very good gluten quality (Elgün et al., 2002). Regarding the amount of sedimentation; Doğan and Cetiz (2015) 13.3-27.6 ml, Yıldırım and Atasoy (2020) 13.00-29.00 ml, Enes et al. (2021) 18.50-25.00 ml and Bayhan (2022) 8.70-29.70 ml reported that. In the study, b yellowness value was found to differ between 18.27 and 27.90. It was observed that the b yellowness value of winter durum wheat varieties was 0.5 units less than spring varieties. While Candidate 1 had the highest b yellowness value, Diyarbakır-81 durum wheat variety had the lowest value. For the yellowness value (b); Bayhan (2022) 18.41-29.42%, Altay et al. (2021) reported that it was 19.63-21.63%.

Table 4. Mean values and groups of investigated characteristics

Genotypes	HT (day) Irrigation * Genotype				PH (cm) Irrigation * Genotype				SN (spikes /m²) Irrigation * Genotype			
	Rainfed	İrrigated	Mean		Rainfed	İrrigated	Mean		Rainfed	İrrigated	Mean	
Gökgöl 79	176.20	178.20	177.17	b	97.5	105.8	101.7	gh	470.8	618.3	544.58	ab
Tunca 79	175.50	177.30	176.42	b	93.3	103.3	98.4	h-j	431.7	560.8	496.25	b-h
Kunduru 1149	177.30	179.20	178.25	a	133.3	145.1	139.2	a	394.2	568.3	481.25	d-ı
Yelken 2000	178.00	178.80	178.42	a	102.5	110.8	106.8	ef	435.0	508.3	471.67	f-ı
Meram-2002	177.30	179.00	178.17	a	97.5	106.7	102.1	gh	495.0	528.3	511.67	b-g
Selçuklu-97	177.50	179.20	178.33	a	89.2	103.3	96.3	ı-k	405.0	554.2	479.58	d-ı
Dumlupınar	177.00	179.20	178.08	a	128.3	134.2	131.2	b	399.2	483.8	441.50	ı
Güney Yıldızı	169.80	171.50	170.67	j	98.3	107.5	102.4	gh	405.0	515.0	460.00	h-ı
Artuklu	169.30	171.30	170.33	j	90.8	101.7	104.4	e	460.8	567.5	514.17	b-g
Fırat-93	169.70	172.50	171.08	ıj	95.8	105.3	96.2	jk	450.8	508.3	479.58	d-ı
Aydın-93	171.80	173.30	172.58	fg	96.7	107.5	110.6	d	535.0	503.3	519.17	a-f
Altıntoprak 98	169.30	171.70	170.50	j	101.7	112.5	102.1	gh	427.2	524.2	475.67	e-ı
Ceylan-95	172.70	175.20	173.92	de	88.3	100.8	109.0	d	388.0	545.0	466.50	g-ı
Diyarbakır-81	172.50	176.20	174.33	cd	111.7	115.8	112.2	d	415.0	668.3	541.67	ab
Fuatbey 2000	171.50	175.00	173.25	ef	94.2	106.7	102.3	fg	459.2	583.8	521.50	a-f
Sham-1	170.70	172.30	171.50	hı	106.7	120.8	100.7	ı-k	485.8	519.2	502.50	b-h
Sarı Başak	171.00	173.50	172.25	gh	106.7	116.7	103.4	gh	460.0	565.0	512.50	b-g
Pitagora	168.80	172.20	170.50	j	90.8	98.3	94.6	jk	462.5	515.8	489.17	c-ı
Urfa 2005	171.70	173.80	172.75	fg	106.7	113.3	110.1	de	490.5	508.0	499.25	b-h
Cesare	173.80	176.20	175.00	c	94.2	103.3	98.8	hı	440.0	538.3	489.17	c-ı
Sorgül	172.70	175.00	173.83	de	118.3	127.5	123.0	c	463.3	594.7	529.00	a-d
Candidate 1	170.70	172.80	171.75	hı	85.6	92.5	88.9	l	446.7	688.3	567.50	a
Candidate 2	172.50	173.80	173.17	ef	89.2	97.5	93.5	k	485.0	565.0	525.00	a-e
Candidate 3	171.80	173.50	172.67	fg	86.7	99.2	93.0	k	468.0	603.3	535.67	a-c
Candidate 4	171.80	174.00	172.92	fg	89.2	99.2	94.2	k	475.0	612.2	543.58	ab
Av. of winter gen. (1-7)	178.70	176.97	177.83	a	105.9	115.6	110.7		433.0	546.0	489.5	
Av. of spring gen. (8-25)	173.54	171.23	172.39	b	97.3	107	102.1		456.5	562.5	509.5	
Year		**				**				*		
Irrigation		**				**				**		
Year* Irrigation		**				**				ns		
Genotype		**				**				**		
Year * Genotype		**				**				**		
Irrigation * Genotype		ns				ns				**		
Year* Irrigation * Genotype		*				**				**		
CV (%)	0.6				4.9				12.6			

*, 5%, and **, significant at 1%, ns: not significant, Av. of winter gen.: Average of winter genotype, Av. of spring gen.: Average of spring genotype

HT: Heading time, PH: Plant height, SN: Number of fertile spike per square meter

Table 5. Mean values and groups of investigated characteristics

Genotypes	GN (grains/spike) Irrigation * Genotype				TGW (g) Irrigation * Genotype				TW (kg/hl) Irrigation * Genotype				PR (%) Irrigation * Genotype			
	Rain.	Irrig.	Mean		Rain.	Irrig.	Mean		Rain.	Irrig.	Mean		Rain.	Irrig.	Mean	
Gökgöl 79	62.0	49.4	55.7	c-e	32.6	36.1	34.4 lm		79.3	81.2	80.3	j	16.13	13.63	14.88	c-f
Tunca 79	54.0	48.0	51.0	e-h	30.6	34.2	32.4 n		79.8	81.8	80.8	j	16.02	13.67	14.84	c-g
Kunduru 1149	52.7	45.7	49.2	f-h	40.9	44.5	42.7 c		81.9	82.7	82.3	h	18.35	16.07	17.21	a
Yelken 2000	55.9	48.2	52.0	d-h	35.4	41.5	38.5 fg		80.6	83.8	82.2	h	17.03	13.27	15.15	cd
Meram-2002	55.0	50.1	52.6	c-g	33.3	38.4	35.8 jk		77.9	80.4	79.2	k	17.43	12.52	14.98	c-e
Selçuklu-97	53.6	52.8	53.2	c-g	27.7	31.6	29.6 o		75.7	79.2	77.5	l	17.85	12.52	15.18	c
Dumlupınar	52.4	43.9	48.2	g-ı	39.7	44.5	42.1 cd		80.0	81.4	80.7	j	18.70	15.65	17.18	a
Güney Yıldızı	52.1	53.5	52.8	c-g	34.3	39.8	37.1 h-j		82.2	84.9	83.6	ef	15.68	13.35	14.52	d-j
Artuklu	52.6	52.8	52.7	c-g	37.8	43.5	40.6 e		84.1	86.3	85.2	a-c	15.05	12.77	13.91	j-l
Fırat-93	40.5	45.9	43.2	ıj	44.5	49.5	47.0 a		83.5	85.4	84.4	d	15.88	14.57	15.23	c
Aydın-93	49.0	57.7	53.4	c-g	36.0	40.8	38.4 f-h		84.7	85.9	85.3	ab	15.27	13.72	14.49	e-k
Altıntoprak 98	49.0	43.9	46.5	h-j	39.0	46.6	42.8 c		82.2	84.4	83.3	ef	15.57	13.95	14.76	c-h
Ceylan-95	55.1	55.0	55.0	c-f	37.5	44.6	41.0 de		82.3	85.1	83.7	ef	15.20	12.42	13.81	l
Diyarbakır-81	56.1	49.3	52.7	c-g	37.8	44.9	41.4 de		80.8	84.5	82.7	gh	15.27	12.43	13.85	kl
Fuatbey 2000	56.7	54.9	55.8	c-e	40.3	43.8	42.1 cd		84.1	84.9	84.5	d	15.22	13.23	14.23	g-l
Sham-1	55.2	52.6	53.9	c-g	31.6	39.0	35.3 kl		81.7	84.7	83.2	fg	16.20	13.35	14.78	c-h
Sarı Başak	64.1	63.7	63.9	ab	32.8	39.2	36.0 ı-k		83.2	86.2	84.7	cd	15.33	12.60	13.97	jl
Pitagora	57.2	50.1	53.7	c-g	35.2	40.8	38.0 f-h		82.8	84.9	83.8	ef	15.47	13.15	14.31	f-l
Urfa 2005	57.0	59.2	58.1	bc	35.0	39.6	37.3 g-ı		84.8	86.3	85.6	a	15.45	13.38	14.42	e-l
Cesare	57.2	57.8	57.5	cd	36.9	44.1	40.5 e		83.9	86.0	85.0	b-d	15.10	12.73	13.92	j-l
Sorgül	41.6	39.9	40.7	j	36.5	41.1	38.8 f		79.7	81.0	80.3	j	17.13	14.87	16.00	b
Candidate 1	55.3	53.6	54.5	c-f	29.5	36.9	33.2 mn		79.9	84.4	82.2	h	15.97	12.02	13.99	ı-l
Candidate 2	66.3	64.7	65.5	a	29.1	37.2	33.2 mn		79.6	83.6	81.6	ı	14.45	10.98	12.72	m
Candidate 3	55.2	54.8	55.0	c-f	33.5	42.3	37.9 f-h		81.3	85.6	83.5	ef	16.13	12.18	14.16	h-l
Candidate 4	49.2	51.0	50.1	e-h	41.5	47.6	44.5 b		82.5	84.8	83.6	ef	16.12	13.12	14.62	c-ı
Av. of winter gen. (1-7)	55.1	48.3	51.7		34.3	38.7	36.5		79.3	81.5	80.4		17.36	13.90	15.63	
Av. of spring gen.(8-25)	53.8	53.4	53.6		36.0	42.3	39.2		82.4	84.9	83.7		15.58	13.1	14.32	
Year		*				**				**				**		
Irrigation		ns				**				**				**		
Year* Irrigation		ns				**				ns				**		
Genotype		**				**				**				**		
Year * Genotype		ns				**				**				**		
Irrigation * Genotype		ns				**				**				**		
Year* Irrigation * Genotype		ns				**				**				ns		
CV (%)	13.7				4.2				4.2				5.4			

*, 5%, and **, significant at 1%, ns: not significant, Av. of winter gen.: Average of winter genotype, Av. of spring gen.: Average of spring genotype, Rain.: Rainfed, Irrig.: Irrigated, Av.: Average, GN: Number of grains per spike, TW: Test weight, TGW: Thousand grain weight, PR: Protein ratio

Table 6. Mean values and groups of investigated characteristics

Genotypes	SA (ml) Irrigation * Genotype				YV(b value) Irrigation * Genotype				VR (%) Irrigation * Genotype			
	Rainfed	İrrigated	Mean		Rainfed	İrrigated	Mean		Rainfed	İrrigated	Mean	
Gökgöl 79	15.17	16.50	15.83	fg	23.54	22.19	22.86	ef	81.50	81.17	81.33	a-e
Tunca 79	17.50	16.00	16.75	ef	24.33	23.59	23.96	c	82.83	81.50	82.17	a-e
Kunduru 1149	10.50	11.17	10.83	ıj	22.32	21.87	22.10	fg	82.17	80.17	81.17	a-e
Yelken 2000	14.33	13.67	14.00	h	24.36	23.17	23.77	cd	84.00	82.67	83.33	a-d
Meram-2002	20.00	17.67	18.83	cd	19.26	19.26	19.26	kl	82.00	76.50	79.25	c-f
Selçuklu-97	19.00	15.67	17.33	d-f	22.57	21.73	22.15	fg	85.33	82.67	84.00	a-c
Dumlupınar	18.83	17.33	18.08	de	20.86	20.08	20.47	j	79.33	80.50	79.92	b-f
Güney Yıldızı	19.67	17.17	18.42	cd	24.97	24.08	24.52	c	86.17	83.50	84.83	a
Artuklu	16.17	13.83	15.00	gh	22.30	20.75	21.52	gh	81.83	85.17	83.50	a-c
Fırat-93	15.67	16.17	15.92	fg	20.14	19.91	20.02	jk	75.00	75.83	75.42	f
Aydın-93	16.50	13.33	14.92	gh	22.90	21.58	22.24	fg	89.67	80.83	85.25	a
Altıntoprak 98	22.00	19.67	20.83	b	22.93	21.70	22.31	fg	83.83	80.83	82.33	a-e
Ceylan-95	9.83	9.33	9.58	j	19.42	17.95	18.69	lm	81.50	82.83	82.17	a-e
Diyarbakır-81	9.50	10.00	9.75	ıj	19.17	17.37	18.27	m	80.00	76.33	78.17	ef
Fuatbey 2000	10.83	10.33	10.58	ıj	21.02	21.53	21.27	hı	86.50	82.00	84.25	ab
Sham-1	12.33	10.33	11.33	ı	23.16	22.02	22.59	ef	83.17	83.00	83.08	a-d
Sarı Başak	20.83	15.67	18.25	c-e	20.92	20.22	20.57	ıj	81.33	87.50	84.42	ab
Pitagora	22.17	17.33	19.75	bc	26.33	26.40	26.36	b	85.17	84.00	84.58	ab
Urfa 2005	15.33	13.33	14.33	gh	22.82	22.00	22.41	ef	89.00	81.83	85.42	a
Cesare	25.83	21.50	23.67	a	26.21	25.11	25.66	b	79.67	79.17	79.42	c-f
Sorgül	13.33	14.00	13.67	h	21.19	20.06	20.63	ıj	80.17	77.17	78.67	d-f
Candidate 1	28.00	22.17	25.08	a	28.59	27.21	27.90	a	83.33	80.00	81.67	a-e
Candidate 2	24.50	18.00	21.25	b	23.34	23.00	23.17	de	82.50	82.83	82.67	a-e
Candidate 3	20.83	14.83	17.83	de	24.43	23.33	23.88	cd	85.17	84.17	84.67	ab
Candidate 4	26.67	20.50	23.58	a	24.64	24.23	24.44	c	78.67	85.17	81.92	a-e
Av. of winter gen. (1-7)	16.48	15.43	15.95		22.46	21.70	22.08		82.45	80.74	81.60	
Av. of spring gen. (8-25)	18.33	15.42	16.87		23.03	22.14	22.58		82.93	81.79	82.36	
Year		*				ns				**		
Irrigation		**				**				ns		
Year* Irrigation		ns				ns				**		
Genotype		**				**				**		
Year * Genotype		**				ns				ns		
Irrigation * Genotype		**				ns				ns		
Year* Irrigation * Genotype		ns				ns				ns		
CV (%)	12.3				4.4					7.2		

*, 5%, and **, significant at 1%, ns: not significant , Av. of winter gen.: Average of winter genotype, Av. of spring gen.: Average of spring genotype, SA. Sedimentation amount, YV(b): b yellowness value, VR: Vitreousness ratio

Table 7. Correlation results for the investigated traits

Features	HT	PH	SN	GN	TGW	TW	PR	SA	YV (b)
PH	0.421*								
SN	-0.2012	-0.3662							
GN	-0.0652	-0.3668	0.2322						
TGW	-0.2226	0.3493	-0.218	-0.477*					
TW	-0.688**	-0.0945	0.0175	0.2182	0.512**				
PR	0.527**	0.728**	-0.433*	-0.673**	0.2529	-0.3952			
SA	-0.1706	-0.530**	0.1624	0.1566	-0.1916	-0.0643	-0.2224		
YV(b)	-0.2124	-0.471*	0.1833	0.1882	-0.3165	0.1113	-0.191	0.649**	
VR	-0.2383	-0.2075	-0.0097	0.526**	-0.409*	0.27	-0.313	0.0074	0.37

*, 5%, and **, significant at 1%, HT: Heading time, PH: Plant height, SN: Number of fertile spike per square meter, GN: Number of grains per spike, TGW: Thousand grain weight, TW: Test weight, PR: Protein ratio, SA. Sedimentation amount, YV(b): b yellowness value, VR: Vitreousness ratio

In the durum wheat, b yellowness value was reported to be associated with heredity at the rate of 86.6%, and it was shaped under the influence of ecological conditions at the rate of 8.5% (Manthey, 2001).

In the study, the average vitreousness ratio varied between 75.42% and 85.42%. Average vitreousness ratio of spring durum wheat varieties was 0.76% higher than winter genotypes. Urfa 2005 durum wheat variety had the highest, Fırat-93 variety had the lowest vitreousness. Regarding the vitreousness ratio; Altay et al. (2021) determined that it was 90.25-97.25% and Bayhan (2022) 85.08-99.68%. Grain hardness in durum wheat; it was emphasized that associated with protein, starch ratio and grain vitreousness (Stenvert and Kingswood, 1977; El-Khayat et al., 2006).

According to the results of the correlation analysis, it was determined that the heading time (r=-0.688**) was negatively correlated with the test weight and positively correlated with the protein ratio (r=0.527**). This situation can be explained by the fact that the genotypes are exposed to more heat stress during the grain filling period and cause the grain to become wrinkled as the heading period is prolonged in the region. It was observed that plant height was positively correlated with protein ratio (r=0.728**) and negatively correlated with sedimentation (r=-0.530**) and yellowness value (b) (r=-0.471*). The number of spike per square meter (r=-0.433*) and the number of grains per spike (r=-0.673**) were negatively correlated with the protein ratio (Table 7). In addition, the sedimentation amount (r=0.649**) was positively related to the b yellowness value, and the vitreousness ratio (r=-0.409*) was negatively related to the thousand grain weight (Bayhan, 2022).

CONCLUSION

As a general trend, genotypes with spring attributes were positioned ahead of those with winter characteristics. It has been observed that there are 5-6 day difference between winter and spring genotypes in terms of the heading time. It is noteworthy that Fırat-93 has high thousand-grain weight, Kunduru 1149 protein content, Urfa 2005's vitreousness, Candidate 1's sedimentation, b yellowness values and spike number per squar meter are well above the trial average. In the study; it was found that plant height was positively correlated with protein ratio (r= 0.728**), and b yellowness value (r= -0471**) was negatively correlated. In addition, it was determined that the vitreousness ratio was negatively (r= -0.409) related to the thousand grain weight. In quality-oriented breeding programs; it was concluded that it would be beneficial to use Fırat-93, Kunduru 1149, Urfa 2005 and Candidate 1 genotypes as parents and to protect as genitor. Especially the fact that Candidate 1 is in the first place in terms of sedimentation amount, yellowness value (b value) and number of spikes per square meter strengthens its being a variety candidate.

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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