COMPARISON OF BREAD WHEAT (*Triticum aestivum* L.) LINES WITH REGISTERED CULTIVARS IN TERMS OF YIELD AND QUALITY CHARACTERISTICS

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Abstract. The study was carried out under rainfall conditions during the 2011-2012 and 2012-2013 growing seasons in Diyarbakir province of Turkey. The experiment had designed as a randomized block design with 3 replications. The aim of the study was to determine the lines that were superior in terms of yield and quality to the varieties. The experimental material consisted of 20 bread wheat lines and 5 standard varieties. According to the results of variance analysis; significant differences were observed between genotypes in all features at 1%. Grain yield (GY) had a significant positive relationship with test weight (TW), and a significant negative relationship with wet gluten (WG). Also, grain hardness (GH) (PSI: Particle size index) had significant negative relationship with TW, and a significant positive relationship with plant height (PH) and heading time (HT). 4 lines in grain yield, 3 lines in test weight, 1 line in protein content, 4 lines in zeleny sedimentation and 1 line in wet gluten showed superior performance than all standards. It is concluded that the G19 and G24 lines may be candidates for registration.
Keywords: *correlation, grain hardness, protein content, wet gluten*

Introduction

Wheat has been a main source of nutrient throughout the ages, and it continues to strengthen its role in human life. 23.4 million hectare of agricultural land is cultivated in Turkey, It is reported that the area allocated for agricultural activities except fallow areas is 66.4%. Also, it is reported that cereal sowing amount has 71% share in this area and wheat cultivation takes first place among cereals in proportion (TSI, 2018).

The center of origin of wheat in the world and also the first place where wheat and barley cultivation is made is called fertile crescent. Southeast Anatolia Region is located in fertile crescent region. So, of Turkey it is considered to have a significant track record in wheat breeding and commissioning culture of wheat (Cıvgın, 2016; Aktas, 2017).

Central Anatolia Region in wheat production in Turkey takes first place with rate of 33.5%. Southeastern Anatolia Region ranks second in wheat production with a rate of 16.5% (TSI, 2018). Diyarbakir is one of the important provinces of Southeastern Anatolia Region in wheat production. 1.1 million tons of wheat is produced in Diyarbakir. This amount constitutes 3.5% of the total wheat production in Turkey (TSI, 2018). The annual per capita wheat consumption in Turkey is over 200 kg. Due to the high daily consumption per capita and being one of the most important caloric sources of Turkish people, wheat maintains its strategic importance (Morgounov et al., 2016).

It has been reported that the amount of protein in the grain is affected significantly by environmental conditions (climate, fertilizer amount, irrigation, etc.) and also the

inheritance factor is an important determinant on quality parameters in wheat grown in both irrigated and rainfall conditions (Grausgruber et al., 2000; Souza et al., 2004).

It is emphasized that the amount of protein in bread wheat is important in determining quality. However, since the amount of protein alone is not sufficient, it has been reported that the amount of sedimentation and gluten should be taken into account (Gooding et al., 2003). Plant breeders aim to develop genotypes with high grain yield, quality and ability to adapt to different environments (Kendal and Sener, 2015).

With this purpose, study was conducted in Diyarbakir conditions in Turkey. After comparing the wheat lines of abroad origin with registered varieties in terms of yield and quality characteristics, the lines that can be high performance candidates were determined.

Materials and methods

The study was carried out under rainfall conditions in Diyarbakir province of Turkey in 2011-2012 and 2012-2013 growing seasons with 5 standard varieties and 20 advanced bread wheat lines (*Fig. 1; Table 1*).

Table 1. Origins of bread wheat genotypes used in the research

Genotypes (G)	Character	Pedigree	Origin
G1	Spring	Attila-7 (Check) Ndvg9144//Kal/Bb/37yaco/4/Vee#5 Cm85836...	CIMMYT
G2	Spring	Nadia-15 Van's'/3/Cndr's/Ana//Cndr's/Mus's/4/Tevee-5 Icw99…	CIMMYT
G3	Spring	Sisaban-4shuha-5/Asfoor-1 Icw00-0207-0ap-0ap-0ap-56ap-0ap...	CIMMYT
G4	Spring	Morsud-22bt1735//Achtar//Hubara-8 Icw01-00162-0ap-3ap-0ap..	CIMMYT
Nurkent	Spring	Check	GAP UTAEM
G6	Spring	Qafzah-14/Asfoor-1 Icw01-00223-0ap-11ap-0ap-0ap-1ap-0ap…	CIMMYT
G7	Spring	Usher-16 Crow's'/Bow's'-1994/95//Asfoor-5 Icw01-00257-0ap…	CIMMYT
G8	Spring	Pastor//Hxl7573/2*Bau/3/Sokoll/Wbll1 Ptss02b00098t-0topy…	CIMMYT
G9	Spring	Croc_1/Ae.Squarrosa(213)//Pgo/3/Cmh81.38/2*Kauz/4/Berkut…	CIMMYT
Pehlivan	Winter	Check	TTAEM
G11	Spring	Croc_1/Ae.Squarrosa(213)//Pgo/3/Cmh81.38/2*Kauz/4/Berkut…	CIMMYT
G12	Spring	Chen/Aegılops Squarrosa (Taus)//Bcn/3/Bav92/4/Berkut Cmsa…	CIMMYT
G13	Spring	Serı//Au/Up301/3/Je93 7.20/4/Mılan/Amsel See02528-0s-0s-0sd.	CIMMYT
G14	Spring	Opata*2/Wulp/3/Sara1/Yaco//Attıla/4/Har 1685 See02556-0tops.	CIMMYT
Cemre	Spring	Check	GAP UTAEM
G16	Spring	V763.2312/V879.C8.11.11/Sn.64/Hn.4//Rex/3/Edch/Mex/4/…	CIMMYT
G17	Spring	Basribey/3/Agri/Nacozari-Sd…	CIMMYT
G18	Spring	Tam200/Pastor//Toba97Cmss99y02667t-060m-040y-040m…	CIMMYT
G19	Spring	Oasis/Skauz//4*Bcn/3/Pastor/4/Kauz*2/Yaco//Kauzcmss…	CIMMYT
Sagittario	Alternative	Check	TASACO TARM.
G21	Spring	Qafzah-31(Check) Sha5//Carc/Auk/3/Vee//5//Dobuc's Cmss93…	CIMMYT
G22	Spring	Misket-12-Bti735//Achtar//Asfoor-1 Icw01-00164-0ap-1ap-0ap...	CIMMYT
G23	Spring	Rebwah-12/Zemamra-8-Rebwah-12/Zemamra-8 Icw01-00193…	CIMMYT
G24	Spring	Qafzah-14/Asfoor-1-Qafzah-14/Asfoor-1 Icw-0100223-0ap…	CIMMYT
Adana-99	Spring	Check	DATAE

G: Genotypes, CIMMYT: International Maize and Wheat Improvement Center, GAP UTAEM: GAP International Agricultural Research and Training Center, DATAE: Eastern Mediterranean Agricultural Research Institute, TASACO TARM.: Tasaco Agriculture, TTAEM: Directorate of Trakya Agricultural Research Institute

Figure 1. Experiment location's place in the Turkey map

In the first year of the study, rainfall was below the average of long years, while in the second year there was rainfall above the average of long years (*Fig. 2*).
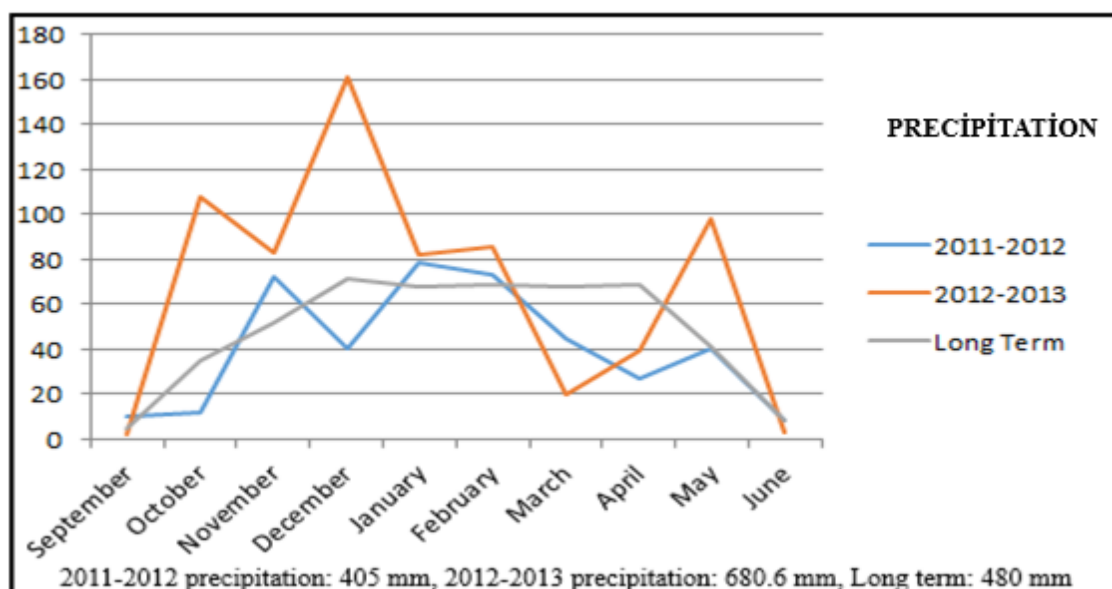

Figure 2. The amount of precipitation of Diyarbakir's in 2011-2012 and 2012-2013 growing seasons and long terms (mm)

However, it was determined that the amount of precipitation was not reflected to the grain yield at the expected level since the distribution of rainfall was irregular on months basis.

In the first year of the study, the average temperatures based on months were below long years. However, the second year has been more than long years (*Fig. 3*).

The experiment was conducted in randomized block design with 3 replications. All of the lines used in the study are of spring nature. Additionally, Pehlivan winter, Sagittario alternative, Nurkent, Cemre and Adana-99 varieties are of spring character. 450 seeds were sowed in the square meter and the size of the parcel was 6 m^2.
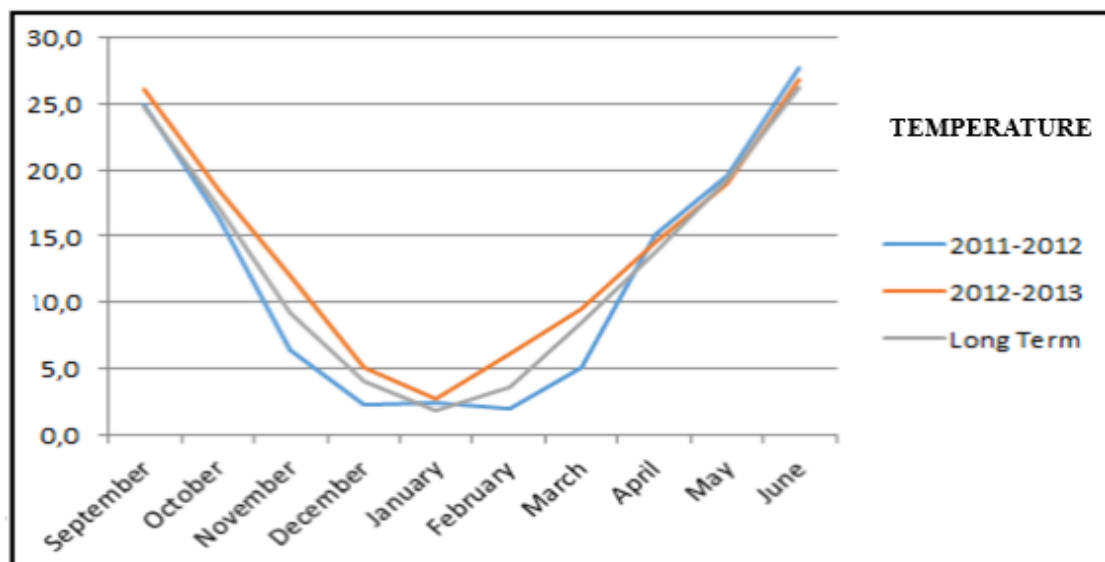
Figure 3. *Average temperature of Diyarbakir's in 2011-2012 and 2012-2013 growing seasons and long terms (°C)*

The amount of fertilizer to be used in the experiment was calculated over 120 kg ha^{-1} pure nitrogen (N) and 60 kg ha^{-1} pure phosphorus (P$_2$O$_5$). Half of the total nitrogen and all of the phosphorus were used with sowing and the remaining half of the nitrogen was given at the end of the tillering period. Experiment was sowed in the first week of November and harvesting was done with the combine harvester in the second week of June. The study area is 37° 56 north latitude and 43° 15 east longitude and has a height of 599 m. It is determined that the soil formation class is clayey, the salt content is 0.25%, PH: 7.8, the amount of organic matter is 0.68% and the saturation rate with water is 77%. (Anonymous, 2013).

In the study, heading time (HT) was determined as the number of days as of January 1, taking into account the date when 50% of the plants in each parcel were spiked. When determining plant height (PH), 10 plants were randomly selected per plot. Then, the length from soil level to the highest spikelet except for awns was measured in cm. Grain yield (GY) was determined by turning the yield in kg ha^{-1} after the whole parcel was harvested. When determining the thousand grain weight (TGW), 100 seeds were counted 4 times and weighed on a 0.01 precision scale, then averaged and multiplied by 10 and determined in grams.

To determine the test weight (TW), the seed obtained from each parcel after harvest was weighed after being put into a 1-L container and its weight was multiplied by 100. Protein content (PR) was determined with the Near Infrared Model 6500 device according to the AACC 39-10 method (Anonymous, 1990). Amount of zeleny sedimentation (ZS) ICC-No. according to the 115 was determined (Anonymous, 1982). Wet gluten (WG) ratio was determined by the Glutomatic 2200 device according to ICC standard 155/1 method (Anonymous, 1994). Grain hardness (GH) (Particle size index) was made according to the AACC 39-70 A method (Anonymous, 2000). In the research, variance analysis of the data was performed with JMP 13.0 statistical package program. Differences in mean values were examined by LSD test (p $\leq$ 0.01 or p $\leq$ 0.05) (Gomez and Gomez, 1984).

Results and discussion

According to the results of ANOVA analysis, of squares mean and significance levels of the investigated features are given in *Tables 2* and *3*. In terms of other features, except for grain yield (n.s.) and zeleny sedimantasyon (5%), between years were observed significant differences at the level of 1%. In addition, except for grain hardness, it is seen that the responses (YxG) of genotypes by years are different from each other (*Tables 2* and 3).

Table 2. Mean of squares according to variance analysis results

Variance resources	Degree of freedom	Heading time	Plant height	Grain yield	Test weight	Thousand grain weight
Y	1	3591.7**	8816.6**	994762.5 n.s.	77.3**	518.1**
R	4	12.0**	110.9**	1695965.4**	2.5**	4.1 n.s
G	24	28.2**	228.5**	1007080.0**	8.5**	19.9**
Y*G	24	19.7**	101.6**	1330460.1**	9.5**	36.4**
CV (%)		0.7	1.8	9.5	0.7	8.2

**: 0.01 level, *: 0.05 level statistically significant, Y: Year, R: Replication, G: Genotype, Y * G:: Year * Genotype interaction, n.s.: not significant

Table 3. Mean of squares according to variance analysis results

Variance resources	Degree of freedom	Protein content	Zeleny sedimantasyon	Wet gluten	Grain hardness (PSI)
Y	1	77.6**	468.8*	141.7**	949.0**
R	4	0.2n.s.	48.9**	1.1n.s.	3.9n.s.
G	24	0.5**	51.6**	4.7**	134.0**
Y*G	24	0.6**	30.6**	6.4**	0.07n.s.
CV (%)		2.9	10.3	4.1	4.1

In the study, the average values of heading time are given in *Table 4*. The average experiment of heading time was 119.4 days. While the early heading genotypes were G14 (115.3 days) and G22 (115.3 days), in terms of heading time means, Pehlivan (124.0 days) was the late heading genotype. In terms of heading time, it was determined that all lines were earlier heading than the earliest heading standard cultivar (Adana-99; 121.2 days).

Because temperature stress is an important problem in the Southeastern Anatolia Region, early heading genotypes not exposed to heat stress are preferred. In this case, early heading varieties rather than late heading varieties are in demand (Tekdal and Yildirim, 2017). In the selection study, early heading and medium early heading varieties were selected. Kiseleva and Salina (2018) reported that many genes interact for determination of heading time in bread wheat. Also, they emphasized that the genes that affect the heading time of wheat are not studied sufficiently, but the number of studies is increasing day by day.

Average plant height was determined as 99.4 cm. Cemre cultivar had the longest plant length with 110.8 cm and Sagittario cultivar had the shortest plant height with 80.8 cm (*Table 4*). In studies conducted on wheat under different conditions, it was

determined that heredity had a significant effect on plant height. In addition, climate, soil structure and agronomical application (fertilization, soil processing, etc.) has been reported to be effective on plant height (Caierao, 2006).

Table 4. Statistical significance groups for heading time, plant height and grain yield

Genotypes	HT (day)			PH (cm)			GY (kg ha^{-1})		
	1. year	2. year l	Av.	1. year	2. year	Av.	1 year	2. year	Av.
G1	124.0 [f]	113.7 [gh]	118.8 [fh]	97.7 [f]	96.0 [b-d]	96.8 [j-k]	7258[ab]	7338 [a-d]	7298[ab]
G2	125.0 [e]	114.0 [f-h]	119.5 [e-g]	102.7 [e]	100.0 [a]	101.3[f-1]	6148 [b-e]	6272 [fg]	6210 [g-h]
G3	123.8 [f]	117.9 [abc]	120.9 [cd]	95.7 [f]	99.7 [abc]	97.7 [j]	6096 [cde]	6474 [d-g]	6285 [fgh]
G4	124.0 [f]	115.0 [d-g]	119.5 [e-g]	107.7 [d]	92.7 [def]	100.2[hi]	6558 [abc]	6280 [fg]	6419 [efg]
Nurkent	127.0 [d]	118.3[ab]	122.7 [b]	117.5 [b]	97.9 [abc]	107.7 [b]	6104 [cde]	7188 [b-f]	6646 [bg]
G6	121.0 [1]	116.7[bcd]	118.8 [f-h]	112.7 [c]	87.7 [h]	100.2 [hi]	6992 [abc]	7291 [a-e]	7142 [a-e]
G7	120.0 [j]	115.7[def]	117.8 [ij]	97.5 [f]	88.5 [gh]	93.0 [lm]	7028 [abc]	5875 [g]	6452 [d-g]
G8	122.5 [g]	114.8 [e-g]	118.7 [g-1]	111.7 [c]	92.7 [e-g]	102.2 [e-h]	7562 [a]	6349 [d-g]	6956 [a-f]
G9	122.0 [h]	114.3 [e-g]	118.2 [h-j]	112.2 [c]	88.8 [gh]	100.5 [g1]	6689 [abc]	6327[efg]	6508 [c-f]
Pehlivan	129.0 [b]	119.0 [a]	124.0 [a]	112.6 [c]	95.1 [cde]	103.9 [de]	6737 [abc]	7069 [b-f]	6903 [a-g]
G11	122.0 [h]	114.3 [e-g]	118.2 [h-j]	112.4 [c]	93.6 [de]	103.0 [ef]	7019 [abc]	6547 [d-g]	6783 [a-g]
G12	122.0 [h]	114.7 [e-g]	118.3 [h-j]	112.8 [c]	94.2 [cde]	103.5 [de]	7178 [abc]	5858 [g]	6518 [c-g]
G13	121.0 [1]	114.3 [e-g]	117.7 [j]	117.6 [b]	92.8 [def]	105.2 [cd]	6866 [abc]	6452 [d-g]	6659 [b-g]
G14	117.3 [k]	113.3 [g-h]	115.3 [k]	112.3 [c]	92.3 [def]	102.3 [e-g]	7444 [a]	7127 [b-f]	7286 [ab]
Cemre	130.0 [a]	116.7 [bcd]	123.3 [ab]	122.7 [a]	99.0 [ab]	110.8 [a]	6558 [abc]	7816 [ab]	7187 [a-d]
G16	125.0 [e]	112.3 [h]	118.7 [g-1]	102.4 [e]	89.3 [f-h]	95.9 [jk]	5138 [de]	8227 [a]	6683 [bg]
G17	125.0 [e]	114.3 [e-g]	119.7 [e-f]	97.9 [f]	87.5 [h]	92.7 [m]	6508 [abc]	6636 [d-g]	6572 [bg]
G18	124.0 [f]	113.3 [gh]	118.7 [g-1]	97.4 [f]	92.6 [def]	95.0 [kl]	7242 [ab]	6669 [c-g]	6955 [a-f]
G19	124.0 [f]	113.7 [gh]	118.8 [f-h]	102.3 [e]	87.3 [h]	94.8 [kl]	6672 [abc]	7811 [ab]	7242 [abc]
Sagittario	130.0 [a]	116.0 [c-e]	123.0 [b]	82.7 [g]	79.0 [1]	80.8 [n]	5083 [e]	6230 [fg]	5657 [h]
G21	128.0 [c]	108.3 [1]	118.2 [h-j]	97.3 [f]	89.0 [f-h]	93.2 [lm]	6514 [abc]	6805 [c-g]	6660 [b-g]
G22	123.3 [fg]	107.3 [1]	115.3 [k]	108.3 [d]	81.7 [1]	95.0 [kl]	7014 [abc]	6730 [c-g]	6872 [a-g]
G23	125.2 [e]	114.8 [e-g]	120.0 [de]	112.3 [c]	87.7 [h]	100.0 [1]	6211 [b-d]	7058 [b-f]	6635 [b-g]
G24	123.3 [fg]	114.3 [e-g]	118.8 [f-h]	112.2 [c]	100.5 [a]	106.4 [bc]	7239 [ab]	7658 [abc]	7449 [a]
Adana-99	126.7 [d]	115.7 [d-f]	121.2 [c]	112.7 [c]	92.3 [def]	102.5 [e-g]	7225 [ab]	7069 [b-f]	7147 [a-e]
Average	124.0	114.5	119.4	107.0	91.7	99.4	6683	6846	6765
Passed of check	19	17	20	0	0	0	5	1	4
LSD (0.05)	0.7**	1.9**	1.0**	1.3**	3.9**	2.1**	1120**	990.0**	738.1**

In terms of grain yield, the experiment average was 6765 kg ha^{-1} and G24 (7449 kg ha^{-1}) line had the highest grain yield. In terms of grain yield, 4 lines passed the standard variety with the highest grain yield (Cemre; 7187 kg ha^{-1}) (*Table 4*). It has been reported that grain yield and quality parameters in wheat are generally affected by genotypes, environmental conditions and genotype environment interaction. (Barutcular et al., 2016; Kizilkeci, 2019).

The average experiment for test weight was 81.7 kg hl^{-1}. In addition, G14 (83.1 kg hl^{-1}), G18 (83.1 kg hl^{-1}) and G21 (83.1 kg hl^{-1}) lines by share the same group and were the highest test weight (*Table 5*). In terms of test weight, 3 lines showed higher performance than the highest standard variety (Adana-99; 83.0 kg hl^{-1}) (*Table 5*). In a

study conducted on bread wheat in India conditions, it was reported that the weight of test ranged from 70.0 to 84.6 kg hl^{-1}. In this study, the results were similar since the average test weight was 81.7 kg hl^{-1} (Panghal et al., 2019).

Table 5. Test weight, thousand grain weight and protein content values obtained

Genotypes	TW (kg hl^{-1})			TGW (g)			PR (%)		
	1. year	2. year	Av.	1. year	2. year	Av.	1. year	2. year	Av.
G1	82.1 [de]	82.6 [b-g]	82.4 [bcd]	28.4 [ı]	45.6 [a]	37.0 [a-d]	13.8 [h-j]	12.9 [a-e]	13.3 [d-h]
G2	79.2 [ıj]	82.0 [f-k]	80.6 [gh]	29.6 [hı]	39.5 [bcd]	34.6 [c-g]	13.8 [g-j]	13.1 [a-d]	13.5 [cg]
G3	77.6 [lm]	81.9 [f-k]	79.8 [ıj]	34.3 [b-g]	38.3 [b-f]	36.3 [b-f]	14.7 [bc]	13.1 [a-d]	13.9 [abc]
G4	83.5 [ab]	81.8 [g-k]	82.6 [abc]	32.5 [f-ı]	34.0 [e-f]	33.3 [fg]	14.1 [e-h]	13.0 [a-e]	13.5 [c-g]
Nurkent	76.2 [n]	83.5 [abc]	79.9 [ıj]	33.4 [d-h]	35.4 [def]	34.4 [c-g]	14.2 [c-h]	12.6 [c-f]	13.4 [d-h]
G6	82.5 [cd]	83.3 [a-d]	82.9 [ab]	31.6 [f-ı]	33.9 [e-f]	32.8 [g]	14.2 [c-h]	12.5 [c-f]	13.4 [d-h]
G7	77.8 [lm]	82.5 [c-h]	80.2 [hı]	34.3 [b-g]	36.8 [c-f]	35.5 [c-g]	14.3 [c-g]	12.4 [def]	13.4 [d-h]
G8	81.1 [fg]	83.0 [a-f]	82.0 [cde]	31.1 [ghı]	37.9 [b-f]	34.5 [c-g]	13.8 [h-j]	12.3 [e-f]	13.0 [h]
G9	81.8 [d-f]	81.2 [k]	81.5 [e-f]	37.4 [a-d]	35.9 [c-f]	36.6 [b-e]	14.7 [bcd]	13.6 [a]	14.1 [a]
Pehlivan	82.0 [d-f]	83.3 [a-d]	82.7 [abc]	36.9 [a-e]	37.8 [b-f]	37.3 [abc]	14.1 [e-h]	12.7 [c-f]	13.4 [d-h]
G11	83.7 [a]	81.3 [j-k]	82.5 [a-d]	34.0 [b-g]	35.3 [def]	34.7 [c-g]	13.4 [j]	13.1 [a-d]	13.3 [f-h]
G12	81.5 [e-g]	81.6 [h-k]	81.5 [e-f]	39.4 [a]	39.1 [b-e]	39.3 [ab]	13.8 [h-j]	13.5 [ab]	13.6 [b-f]
G13	84.2 [a]	81.3 [k]	82.7 [abc]	32.3 [f-ı]	38.8 [b-e]	35.5 [c-g]	15.0 [ab]	13.0 [a-e]	14.0 [ab]
G14	84.0 [a]	82.2 [e-k]	83.1 [a]	37.7 [abc]	33.1 [f]	35.4 [c-g]	14.4 [c-f]	12.1 [f]	13.3 [f-h]
Cemre	79.8 [ııj]	83.2 [a-e]	81.5 [e-f]	39.4 [a]	40.9 [abc]	40.1 [a]	14.4 [c-f]	12.4 [def]	13.4 [d-h]
G16	77.1 [mn]	81.5 [h-k]	79.3 [j]	29.8 [hı]	40.8 [abc]	35.3 [c-g]	14.5 [b-e]	12.4 [def]	13.5 [c-g]
G17	78.2 [kl]	83.2 [a-e]	80.7 [gh]	30.8 [ghı]	35.9 [cdf]	33.4 [e-g]	14.3 [c-f]	13.1 [a-d]	13.7 [a-e]
G18	82.5 [cd]	83.8 [a]	83.1 [a]	33.6 [c-h]	40.2 [bcd]	36.9 [a-d]	14.3 [c-g]	12.8 [b-f]	13.6 [b-g]
G19	82.0 [df]	81.8 [g-k]	81.9 [def]	37.9 [ab]	33.1 [f]	35.5 [c-g]	14.7 [bcd]	12.6 [c-f]	13.7 [b-f]
Sagittario	79.0 [jk]	81.5 [ı-k]	80.2 [hı]	33.5 [c-h]	39.6 [bcd]	36.6 [b-f]	15.4 [a]	12.6 [c-f]	14.0 [ab]
G21	83.3 [abc]	82.9 [a-f]	83.1 [a]	33.5 [c-h]	33.1 [f]	33.3 [e-g]	13.5 [ııj]	13.1 [a-d]	13.3 [e-h]
G22	80.8 [gh]	82.4 [d-ı]	81.6 [e-f]	34.3 [b-g]	38.0 [b-f]	36.1 [b-f]	14.2 [d-h]	12.5 [c-f]	13.3 [d-h]
G23	80.1 [hı]	82.3 [d-j]	81.2 [fg]	35.8 [a-f]	36.5 [c-f]	36.2 [b-f]	14.5 [b-e]	13.0 [a-e]	13.7 [a-d]
G24	82.6 [b-d]	82.8 [a-g]	82.7 [abc]	32.8 [e-h]	42.5 [ab]	37.7 [abc]	14.3 [c-g]	13.2 [abc]	13.8 [a-d]
Adana-99	82.4 [de]	83.6 [ab]	83.0 [ab]	31.3 [gı]	36.0 [c-f]	33.7 [d-g]	13.9 [f-ı]	12.5 [c-f]	13.2 [g-h]
Average	81.0	82.4	81.7	33.8	37.5	35.7	14.2	12.8	13.5
Passed of check	8	1	3	0	2	0	0	13	1
LSD (0.05)	0.9**	1.0**	0.7**	4.2**	5.4**	3.4**	0.5**	0.7*	0.5**

Av: Average

Cemre (40.1 g) cultivar took the first place in terms of thousand grain weight (*Table 5*). In a study carried out in bread wheat related to thousand grain weight, it was reported that thousand grain weight ranged between 29.6 and 53.8 g, and the average was 40.7 g. In this study, a thousand grain weight ranged between 32.8 and 40.1 g. The average of the experiment was 35.7 g. The results of the studies are similar (Panghal et al., 2019).

The average of protein content was 13.5%. The highest protein content was obtained from G9 (14.1%) line. In addition, the highest value in terms of protein content of the varieties used as standard in the study was obtained from Sagittario cultivar with 14.0%

(*Table 5*). Karaman (2019), in his study based on precipitation conditions in bread wheat has reported that the average protein rate is 14.5%. Also, there is a significant relationship between protein content and grain hardness. This has been reported to result from the strong interaction between carbohydrates and proteins. This result was confirmed by our study. (*Table 5*) (Preston, 1998; Dobraszczyk et al., 2002; Pasha et al., 2010; Baslar et al., 2012).

The average amount of zeleny sedimentation was 28.5 ml and the G12 (35.1 ml) line have the highest sedimentation amount. In addition, it was determined that 4 lines had higher sedimentation amount than the highest standard variety (Sagittario; 31.6 ml) (*Table 6*). In the study of Koçak et al. (1992), the sedimentation value ranged from 18.8 to 43.8 ml, reported that the hereditary effect in sedimentation is higher than the effect of environmental factors. The obtained values are similar to our findings. It is emphasized that the amount of sedimentation is of great importance in determination of protein quality in bread wheat (Peterson et al., 1992).

Table 6. *Zeleny sedimentation, wet gluten and grain hardness values*

Genotypes	ZS (ml)			WG (%)			GH (PSI)		
	1. year	2. year	Av.	1. year	2. year	Av.	1. year	2. year	Av.
G1	24.0 def	34.5 bcd	29.3 d-g	29.9 e-h	29.4 a-f	29.6 d-g	52.1 h	47.0 gh	49.6 h
G2	36.5 a	29.0 h-k	32.8 abc	29.4 g-h	30.1 a-e	29.8 d-g	56.2 d-g	51.2 def	53.7 def
G3	28.5 b-e	31.0 e-h	29.8 c-f	32.7 bc	29.9 a-e	31.3 abc	57.2 c-e	52.2 c-e	54.7 cd
G4	23.5 ef	31.7 e-g	27.6 e-k	29.9 e-h	29.6 a-f	29.7 d-g	49.0 iij	43.9 hı	46.5 ı
Nurkent	25.5 c-f	28.3 e-k	26.9 f-k	30.7 def	28.3 c-g	29.5 d-g	48.8 iij	43.7 hı	46.3 ı
G6	24.0 def	26.7 k	25.3 j-k	30.7 d-g	28.1 c-g	29.4 efg	56.2 d-g	51.2 def	53.7 def
G7	35.0 a	33.3 b-e	34.2 ab	31.5 cd	27.7 d-g	29.6 d-g	54.1 e-h	49.1 efg	51.6 fgh
G8	23.5 ef	30.7 f-ı	27.1 f-k	29.6 f-h	27.6 efg	28.6 g	59.0 bcd	54.0 bcd	56.5 bc
G9	30.3 a-d	29.7 g-j	30.0 c-f	31.6 b-d	31.7 a	31.6 a	52.7 h	47.7 g	50.2 gh
Pehlivan	23.5 ef	28.8 h-k	26.2 g-k	30.2 e-h	28.5 c-g	29.3 efg	54.8 e-h	49.7 efg	52.3 e-g
G11	32.5 ab	33.0 c-f	32.8 abc	28.0 ı	30.2 a-d	29.1 efg	49.1 iij	44.0 hı	46.6 ı
G12	35.0 a	35.2 abc	35.1 a	29.2 hı	31.4 ab	30.3 a-f	60.7 ab	55.7 ab	58.2 b
G13	25.5 c-f	28.7 h-k	27.1 f-k	32.8 ab	29.6 a-f	31.2 abc	47.6 j	42.6 ı	45.1 ı
G14	22.0 f	27.0 k	24.5 k	31.5 cd	26.5 g	29.0 fg	47.7 j	42.6 ı	45.2 ı
Cemre	24.0 def	27.8 jk	25.9 g-k	32.4 bc	27.8 d-g	30.1 b-f	63.8 a	58.8 a	61.3 a
G16	24.5 def	27.0 k	25.8 h-k	31.1 de	27.6 e-g	29.3 e-g	53.5 gh	48.9 efg	51.2 gh
G17	31.0 abc	27.0 k	29.0 d-ı	30.8 def	28.3 c-g	29.5 d-g	56.4 d-g	51.4 def	53.9 def
G18	24.0 def	37.6 a	30.8 b-e	32.6 bc	29.1 b-g	30.8 a-d	53.7 fh	48.7 fg	51.2 gh
G19	23.0 ef	29.0 h-k	26.0 g-k	31.6 bcd	28.3 c-g	29.9 c-g	48.9 iij	43.9 hı	46.4 ı
Sagittario	27.5 b-f	35.7 ab	31.6 b-d	34.1 a	29.0 b-g	31.5 a	60.3 bc	55.3 bc	57.8 b
G21	24.5 def	28.0 jk	26.3 g-k	29.5 f-h	30.4 abc	30.0 b-g	48.2 j	43.2 ı	45.7 ı
G22	24.0 def	27.3 jk	25.7 ı-k	30.5 d-g	27.5 e-g	29.0 fg	48.4 j	42.4 ı	45.4 ı
G23	26.5 b-f	27.0 k	26.8 f-k	31.6 bcd	31.1 ab	31.4 ab	56.3 d-g	51.3 def	53.8 def
G24	25.0 c-f	31.7 e-g	28.3 d-j	31.0 de	30.0 a-e	30.5 a-e	57.1 c-f	52.1 c-f	54.6 cde
Adana-99	26.0 c-f	32.2 def	29.1 d-h	30.6 d-g	27.3 fg	28.9 f-g	59.4 bcd	54.4 b-d	56.9 bc
Average	26.8	30.3	28.5	30.9	29.0	30.0	54.0	49.0	51.5
Passed of check	7	1	4	0	12	1	0	0	0
LSD (0.05)	6.4**	2.4**	3.4**	1.3**	2.6**	1.4**	3.4**	3.4**	2.4**

The mean of wet gluten ratio was found to be 30.0%, while G9 (31.6%) and Sagittario (31.5%) had the highest value by sharing the same group (*Table 6*). It has been reported that wet gluten ratio in bread wheat is important and the amount of gluten formed as a result of swelling of gliadin and gluten, which are subcomponents of protein, by absorbing water, is affected significantly by environmental conditions. The researchers reported that wet gluten content varied between 11.3 and 45.2% (Keçeli et al., 2017).

In the study, the mean experiment value of grain hardness was found to be 51.5 (PSI). Nurkent (46.3 PSI) had the hardest grain type and Cemre (61.3 PSI) had the softest grain type. In the interpretation of the grain hardness parameter, it is interpreted that the grain hardness increases with decreasing PSI value and decreases with increasing PSI value (Sahin et al., 2017). According to this, G13 (45.1) was found to be the genotype with the highest grain hardness. G4 (46.5), Nurkent (46.3), G11 (46.6), G14 (45.2), G19 (46.4), G21 (45.7) and G22 (45.4) lines were also good genotypes for grain hardness (*Table 6*). Because grain hardness is positively associated with protein (*Table 7*).

Grain hardness (PSI) parameter is important in bread wheat. Especially when flour is obtained from hard wheat, starch damage is more than soft wheat. It was emphasized that this was not preferred by bakers. Also, dough made from a high damaged starch content flour was reported to have more water-holding capacity (Khan and Shewry, 2009; Sahin et al., 2017).

Correlation analysis

Respect to correlation analysis, there was a positive correlation between grain yield and test weight and a negative correlation with wet gluten ratio. While test weight increased, wet gluten ratio and grain hardness (PSI) values were found to decrease. Thousand grain weight was found to be inversely related to protein content and wet gluten ratio. In addition, the content of protein and wet gluten was found to be inversely related to the amount of zeleny sedimentation (*Table 7*). This situation is contrary to the literature. Because many researchers have reported that the amount of zeleny sedimentation positively correlated with protein content and wet gluten ratio (Surma et al., 2012; Keceli et al., 2017).

Table 7. Correlation coefficients and significance levels between parameters

Features	GY	TW	TGW	PR	ZS	WG	GH	HT
TW	0.325**							
TGW	0.096	0.227**						
PR	-0.149	-0.432**	-0.329**					
ZS	-0.146	-0.070	0.256	-0.284**				
WG	-0.201*	-0.364**	-0.185*	0.860**	-0.165*			
GH	0.037	-0.274**	-0.047	0.397**	-0.076	0.323**		
HT	-0.091	-0.394**	-0.368**	0.703**	-0.356**	0.459**	0.565**	
PH	0.093	-0.105	-0.147	0.540**	-0.342**	0.295**	0.350**	0.629**

** 1%, * 5% important

This may be due to the low protein quality despite the high protein content of the genotypes or vice versa. Additionally, grain hardness (PSI) was positively correlated with heading time and plant height. Kılıç et al. (2014) obtained similar results in their study.

Conclusion

In the study, early heading cultivars were found to be prominent in terms of grain yield and test weight. However, it was determined that the same situation was not observed in terms of quality parameters. It was found that there was a positive correlation between grain yield and test weight and a negative correlation with wet gluten. There was a negative correlation between grain hardness (PSI) and test weight and a positive correlation between plant height and heading time. G1, G14, G19, G24 for grain yield, G14, G18, G21 for test weight; G9 for protein ratio and wet gluten amount, G2, G7, G11, G12, for zeleny sedimentation outperformed all standards. In the study, it is determined that the lines which are superior to standard varieties in terms of one or a few features should be taken into consideration in grain yield or quality-oriented breeding studies. It was concluded that G19 and G24, which have superior features, can be registered candidates. In the future, if collaboration with modern breeding (molecular) is done, genotypes of superior will be studied and the results will shed light on future research.

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