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Evaluation of yield and quality performance of some spring bread wheat (*Triticum aestivum L.)* genotypes under rainfall conditions

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Abstract

The study was conducted in randomized complete block design with four replications at two locations (Sanliurfa and Diyarbakir) under rainfall conditions during 2013-2014 growing season. The purpose of the study is to determine the bread wheat genotypes with high yield, large adaptation ability and high grain quality. Twenty advanced bread wheat lines and five check varieties were used as materials. The data were evaluated by using the variance and GGE biplot analysis methods. Significant differences among genotypes were determined for test weight (TW), thousand grain weight (TGW), grain yield (GY) and heading time (HT) at the significant level of 1%, while, less significant levels ($p \leq 5\%$) were found for wet gluten content (WG), zeleny sedimentation (ZS) and protein content (PR). According to GGE biplot analysis results, positive correlations were determined between TW and TGW, and also PR, WG and ZS. It has also been determined that there is a negative relationship between HT and TW, TGW. According to the stability graph, the genotypes of G23 and G8 were found to be highly efficient and moderately stable, and both could be candidate varieties. Additionally, Dinç variety and G11 advanced line can be used as genitors in bread wheat breeding programs for grain yield and quality.

Keywords: Bread wheat, GGE biplot, Stability, Yield

Introduction

Wheat is the first cultivated plant among cereals. Wheat's sowing area production and consumption are high around the world and in our country. In addition, wheat is a strategic cultivation plant with high adaptability. World wheat cultivation is 219 million hectares and production is 758 million tons. Yet, wheat production in the world is not sufficient to solve people's nutritional problems (IGC, 2018). Wheat sowing is 7.7 million hectares in Turkey. However, production is 21.5 million tons and wheat comes first in human nutrition (TUIK, 2017). Bread and other products made from wheat are the most important food sources for humans in Turkey. The annual wheat and wheat products consumed per person is above 200 kg in Turkey. Turkey ranks first in the world in terms of wheat consumption per person (Morgounov et al., 2016). The amount and quality of protein in wheat has been reported to be one of the important criteria in determining wheat quality. When protein ratios were classified; they are evaluated as very high for 14-17%, high for 11- 14% and middle class for 10-12% (Grausgruber et al., 2000; Kizilgeci et al., 2015).

Zeleny sedimentation in bread wheat is one of the methods used to determine protein quality. While quality parameters such as protein content, hectoliter weight and thousand grain weight are affected by environmental conditions, it is reported that zeleny sedimentation value is highly affected by genetic factors rather than environmental effects (Grausgruber et al., 2000; Kizilgeci et al., 2015). In recent years, GGE biplot analysis method has been used in many fields (Yan and Tinker, 2006; Aktas et al., 2017). One of the most important reasons for the intensive use of biplot analysis by researchers is the graphical representation of many features of genotypes in this analysis method.

Furthermore, it can be shown that this analysis method allows the visual comparison and interpretation of the correlation

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between both genotype and traits (Aktas et al., 2017). The aim of this study is to determine the adaptation ability, grain yield and quality characteristics of bread wheat genotypes which can be candidates for cultivar registration under rainfall conditions of Southeast Anatolia Region.

Materials and methods

The study was carried out in two locations (Diyarbakir and Sanliurfa) under rainfall conditions in 2013-2014 growing season. In the research, 20 advanced bread wheat lines with spring nature obtained from CIMMYT were used. In the experiment, Pehlivan with winter nature, Sagittario with alternative nature and Dinç, Cemre and Adana-99 cultivars with spring nature were used as standard. The pedigrees of all genotypes used in the experiment are shown in Table 1. The cultivars used as standard are commonly grown in the region. While the average long term rainfall in Diyarbakir was 495.0 mm, it fell 356.0 mm in the 2013-2014 wheat growing season. The rainfall was lower than the average of long-term (Figure 1). In Diyarbakir, the temperature in December of the 2013-2014 season was much lower than the average of long term (Figure 2). In Diyarbakir for long term the average temperature is 12.2 ^{0}C and the average relative humidity is 52.7% (Anonymous, 2014). In Sanliurfa long terms years, average rainfall is 430 mm, and 312.8 mm rainfall was recorded during the 2013-2014 season (Figure 3).

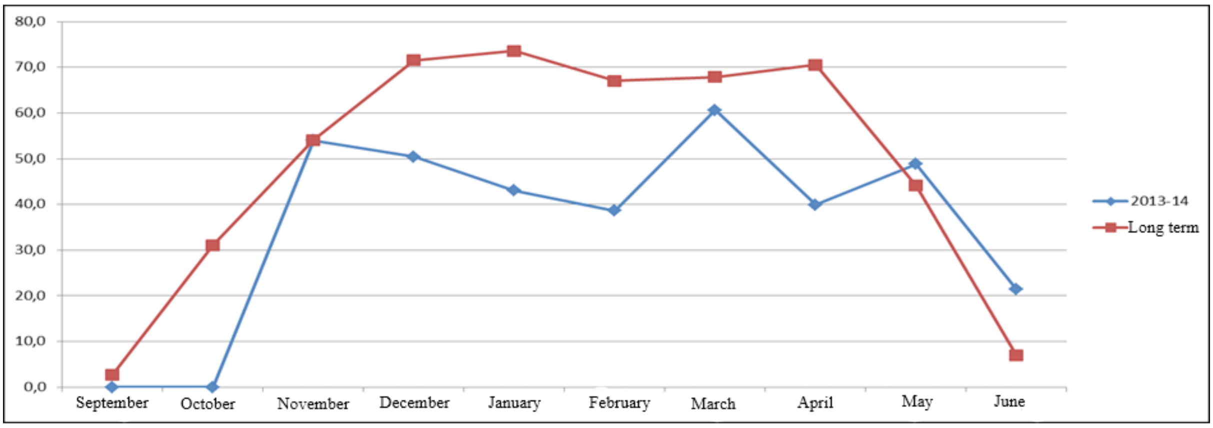

Figure 1. The rainfall graph of Diyarbakir province

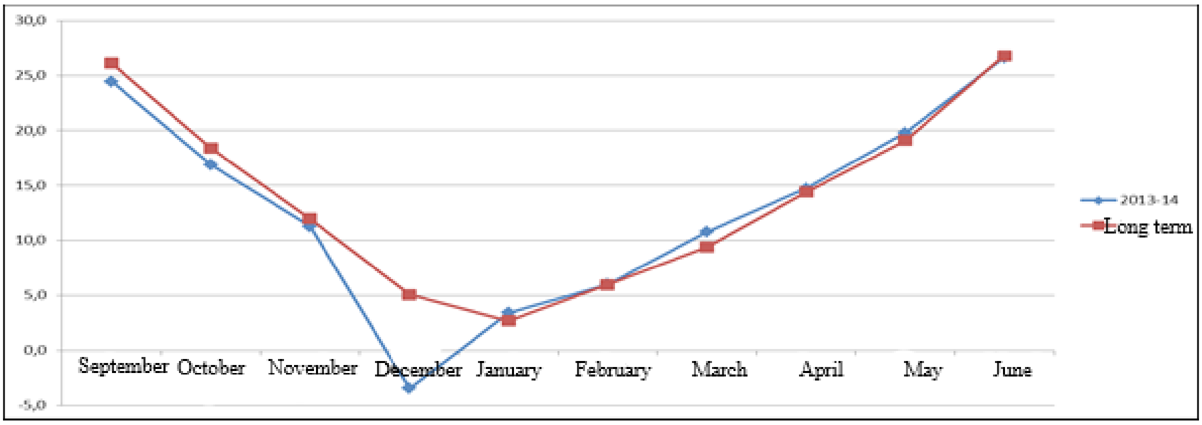

Figure 2. Temperature graph of Diyarbakir province

During the growing season, rainfall was lower than the long term average. In Şanliurfa, for long terms the average temperature was 18°C and the average relative humidity was determined as 58.2% (Anonymous, 2013). In Diyarbakir soil texture of the experiment area is clayey. Determined values were as follows: total salt content (%): 0.246, PH (s): 7.75 (slightly alkaline), lime content (%): 6.26, phosphorus content (kg ha^{-1}): 12.8, organic matter (%): 0.676 (soils poor by organic matter), saturation with water (%): 77. In Sanliurfa, water saturation was 50%, water saturated soil PH was 7.6 phosphorus (P_2O_5) 52 kg ha^{-1}, organic matter content was determined as 1.1% (Anonymous, 2013). Cultivation of the experiments was practiced with parcel seeder. Also, the harvest was made with parcel harvester. In the study, parcel length was set as 5 m and row spacing as 20 cm. In addition, each parcel consisted of 6 row. 450 seeds per square meter were planted with experiment seeder. 60 kg ha^{-1} pure nitrogen (N) and 60 kg ha^{-1} pure phosphorus were applied with sowing in the experiments. In addition, 80 kg ha^{-1} pure nitrogen (N) was given at the end of the tillering period. Experiment cultivation in both locations took place in November. In Sanliurfa location harvest was carried out one week earlier than Diyarbakir location.

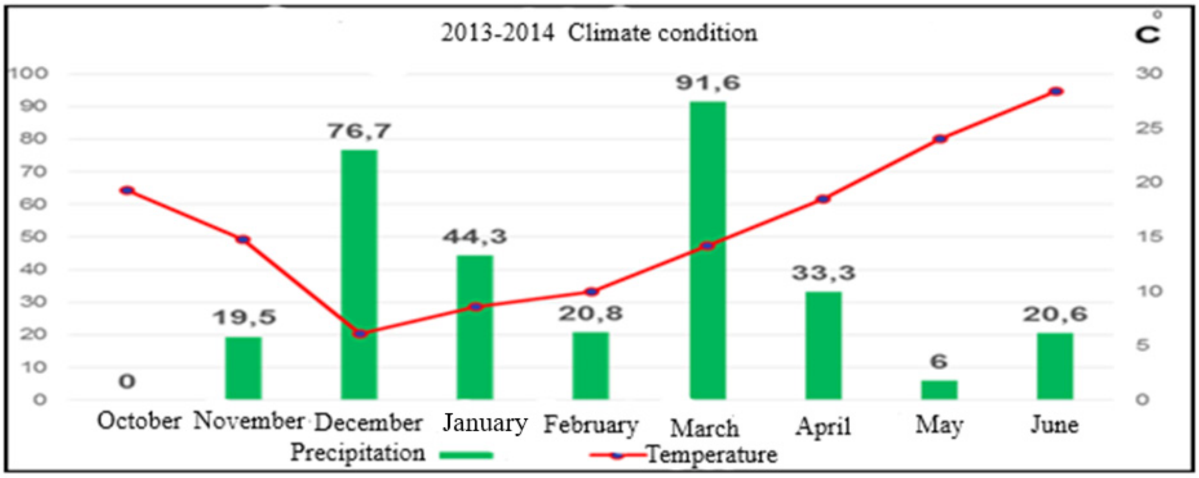

Figure 3. Temperature and precipitation graph of Sanliurfa province

Table 1. Pedigree and origin of bread wheat genotypes used in the study

Genotypes (G)	Pedigree	Breeding Organization or Origin
G1	Qamar-4 Cmss97m03159t-040y-0b-0ap-2ap-…	CIMMYT
G2	D67.2/Parana 66.270//Ae.Squarrosa (320)/3/…(synthetic)	CIMMYT
G3	Cno79//Pf70354/Mus/3/Pastor/4/Bav92/5/Mılan	CIMMYT
G4	Babax/Ks93u76//Babax/3/2*Sokoll Cmsa06m	CIMMYT
G5 (Dinç)	Standard	GAP UTAEM
G6	D67.2/Parana 66.270//Ae.Squarrosa (320)/3/(synthetic)	CIMMYT
G7	Krıchauff/2*Pastor/4/Mılan/Kauz//Prınıa/3/Bav	CIMMYT
G8	Heılo//Sunco/2*Pastor Cmsa06y00492s-040zty-	CIMMYT
G9	Chıh95.7.4//Inqalab 91*2/Kukuna Ptss06ghb..	CIMMYT
G10 (Pehlivan)	Standard	TTAEM
G11	Kachu #1/Kırıtatı//Kachu Cmss06y00778t-099..	CIMMYT
G12	Saual/Yanac//Saual Cmss06y00783t-099topm..	CIMMYT
G13	Prl/2*Pastor*2//Fh6-1-7 Cmss06y00793t-099…	CIMMYT
G14	Frncln/Rolf07cmss06b00013s-0y-099ztm-099y	CIMMYT
G15 (Cemre)	Standard	GAP UTAEM
G16	Becard/Kachu Cmss06b00169s-0y-099ztm-099.	CIMMYT
G17	Becard/Akurı Cmss06b00411s-0y-099ztm-099y	CIMMYT
G18	Rolf07*2/5/Reh/Hare//2*Bcn/3/Croc_1/Ae….	CIMMYT
G19	Usher-16 Crow's'/Bow's'-1994/95//Asfoor-5…	CIMMYT
G20 (Sagittario)	Standard	TASACO TARM.
G21	Croc_1/Ae.Squarrosa(213)//Pgo/3/Cmh81.38/2 (synthetic)	CIMMYT
G22	Chen/Aegılops Squarrosa (Taus)//Bcn/3/Bav92. (synthetic)	CIMMYT
G23	Mısket-12-Btı735/Achtar//Asfoor-1ıcw01-…	CIMMYT
G24	Rebwah-12/Zemamra-8-Rebwah-12/Zemamra-.	CIMMYT
G25 (Adana-99)	Standard	DATAE

In the study, the homogeneity of the variances was examined for all parameters involved, and locations were subjected to combined analysis because the variances were homogeneous. In addition, statistical analysis was performed on 4 replications for grain yield, and analysis of quality characteristics was performed on 2 replications due to labor and cost high.

The heading time (HT) was recorded as the number of days from the 1st of January. Grain yield (GY) was determined by weighing the product obtained after harvesting the whole parcel with a balance of 0.01 g. A thousand grain weight (TGW) was determined by weighing 1000 seeds of each genotype with a balance of 0.001 g. Test weight (TW) was determined by weighing 1 liter of seed and multiplying the value by 100. Protein content (PR) analysis was determined using Near Infrared model 6500 device in accordance with AACC 39-10 method (Anonymous, 1990). In zeleny sedimentation (ZS) analysis, ICC-No. 115 method was applied (Anonymous, 1982). The amount of wet gluten (WG) was reached by using Glumatik 2200 gluten washing device according to ICC standard 155/1 method (Anonymous, 1994). The research was carried out in randomized block design with 4 replications under rainfall conditions.

The variance analysis of the data obtained from the study was performed by using JMP 13.0 statistical package program. The differences between the means were examined by LSD test ($p \leq 0.01$ and $p \leq 0.05$) (Gomez and Gomez, 1984; Kalayci, 2005). GGE biplot analysis was performed using Genstat 12th (Genstat, 2009) statistical package program in order to evaluate the relationship between traits and genotype-traits, and all genotypes are shown visually in the graphics. In addition, prominent genotypes were evaluated.

Results and discussion

According to variance analysis (ANOVA), differences between the mean values of the characteristics examined were statistically significant ($p \leq 0.01$ or $p \leq 0.05$) (Table 3). In the study, the highest grain yield was obtained from Dinç variety (4070 kg ha^{-1}) and G23 advanced line (4085 kg ha^{-1}).

Table 2. Variance analysis table showing the mean of squares the investigated properties

	Average squares								
Variance resources	DF1	GY	DF2	TW	TGW	PR	ZS	WG	HT
Location	1	723.9	1	176.7*	53.7	405.2**	6021.8*	346.7*	1102.2**
Replication	6	12767.8	2	9.1	9.0	1.5	78.8	16.9	7.8
Genotype	24	7649.7**	24	10.1**	33.5**	1.1*	38.8*	13.1*	109.8**
Location*Genotype	24	9333.8**	24	1.1	7.8**	1.9**	66.3**	22.1**	1.8
CV (%)		11.1		1.2	5.4	4.8	11.7	7.6	3.4

**: statistically significant at the 0.01 level, *: statistically significant at the 0.05 level. DF1: degree of freedom for grain yield, DF2: degree of freedom for other properties other than grain yield, GY: grain yield, TW: test weight, TGW: thousand grain weight, PR: protein content, ZS: zeleny sedimentation, WG: wet gluten, HT: heading time

While the highest grain yield was obtained from Sagittario variety (4430 kg ha^{-1}) in Diyarbakir; in Sanliurfa the highest grain yield was obtained from G23 advanced line (4310 kg ha^{-1}) (Table 3). Because the rainfall in Diyarbakir is higher than Sanliurfa, and the weather conditions are cooler, Sagittario, which has an alternative nature, comes forward in this location. While it was determined that most of the existing materials were affected by the extreme cold weather conditions in Diyarbakir in March, this situation is thought to have a negative effect on grain yield values. Researchers reported that, the effect of wheat heredity on grain yield is great. Same researchers have also emphasized that, the soil structure (clay, loam, sandy), agronomic applications (seed bed preparation, fertilization, etc.) and climate conditions have great impact on grain yield, too (Doğan and Kendal, 2012; Kiliç et al., 2012a; Kendal, 2013; Ali, 2017). In the study, the average test weight ranged from 78.2 to 83.7 kg hl^{-1}. The mean highest test weight was obtained from the G7 forward line (83.7 kg hl^{-1}). The highest test weight was obtained from the G8 advanced line (85.0 kg hl^{-1}) in Diyarbakir, while the G11 advanced line (82.6 kg hl^{-1}) was obtained in Sanliurfa (Table 3). Test weight is significantly affected by the amount of precipitation received during the season and the distribution of precipitation on a monthly basis. As a matter of fact, Diyarbakir location receives more rainfall than Sanliurfa location. This was reflected on the test weight. Test weight has been reported to vary depending on the volume, shape and density of wheat grain (Protic, 2007). Also, in studies conducted in spring wheat, it was reported that test weight ranged from 75.4 to 80.0 kg hl^{-1} (Kilic et al., 2012b). Our findings obtained from the test weight are similar.

In the study, the average thousand grain weight ranged from 28.1 to 39.1 g, while the average of the experiment was found to be 32.8 g. The G12 advanced line (39.1 g) has the highest average value in terms of thousand grain weight. In the location of Diyarbakir, the highest thousand grain weights were obtained from G12 advanced line (39.3 g). In Sanliurfa location, G11 advanced line (39.8 g) had the highest thousand grain weight value (Table 3). Studies conducted in different years under Diyarbakir conditions reported an average of thousand grain weight between 22.6-34.6 g (Kilic et al., 2012a; Ali, 2017). Our findings are similar to those of the studies in terms of average thousand grains weight.

Table 3. Mean values of the investigated features

	GY(kg ha^{-1})			TW (kg hl^{-1})			TGW (g)		
Genotypes	DB	SU	Av.	DB	SU	Av.	DB	SU	Av.
G1	4300	3650	3975	81.7	78.8	80.3	32.1	29.3	30.7
G2	3970	3640	3805	84.6	80.3	82.5	29.9	31.9	30.9
G3	3510	3720	3615	84.7	81.3	83.0	37.0	36.0	36.5
G4	3830	4050	3940	82.4	78.7	80.5	31.4	27.9	29.6
Dinç	4330	3810	4070	84.3	81.5	82.9	31.1	29.5	30.3
G6	3410	3620	3515	81.9	79.4	80.7	34.4	31.3	32.8
G7	3650	3550	3600	84.9	82.5	83.7	34.9	34.6	34.8
G8	3900	4170	4035	85.0	81.1	83.1	31.6	27.8	29.7
G9	4210	3720	3965	82.9	80.6	81.8	33.8	31.3	32.5
Pehlivan	3160	2840	3000	82.0	79.4	80.7	33.8	32.8	33.3
G11	2270	3750	3010	83.0	82.6	82.8	35.4	39.8	37.6
G12	3050	4130	3590	80.8	79.1	80.0	39.3	39.0	39.1
G13	4150	3820	3985	81.3	76.7	79.0	37.3	33.1	35.2
G14	4380	3650	4015	80.5	77.7	79.1	33.0	32.4	32.7
Cemre	3910	2910	3410	82.6	79.6	81.1	35.6	27.5	31.6
G16	3170	4160	3665	84.0	81.8	82.9	37.6	38.6	38.1
G17	3650	3650	3650	81.7	78.2	79.9	32.9	31.3	32.1
G18	3490	3600	3545	80.6	77.2	78.9	30.8	29.6	30.2
G19	4280	3290	3785	79.6	76.9	78.2	29.3	27.0	28.1
Sagittario	4430	3520	3975	82.2	80.2	81.2	35.1	29.8	32.4
G21	3570	3890	3730	83.6	81.3	82.4	33.1	31.6	32.4
G22	2940	4050	3495	79.9	79.1	79.5	32.8	35.9	34.3
G23	3860	4310	4085	81.0	78.8	79.9	34.4	32.8	33.6
G24	3470	2960	3215	80.7	79.9	80.3	31.9	35.0	33.4
Adana-99	3890	3390	3640	84.5	81.2	82.9	30.5	26.6	28.6
Average	3711	3674	3693	82.4	79.8	81.1	33.5	32.1	32.8
$LSD_{(0.05)}$	586**	565**	404**	2.3**	2.4**	1.4**	4.2**	3.2**	2.5**

DB: Diyarbakir, SU: Sanliurfa, Av.: Average

The highest average protein content was obtained from the G11 forward line (17.5%). While the G11 forward line (17.3%) had the highest value in terms of protein ratio in Diyarbakir location, no significant difference was found between genotypes in the location of Sanliurfa (Table 4). In Sanliurfa, rainfall amount is lower than Diyarbakir, while high temperature and drought during the grain filling period is higher. Therefore, the deposition of starch in the grain is proportionally low in the location of Sanliurfa. Due to climatic factors, it is seen that the protein ratios are higher in Sanliurfa. It has been reported that, total precipitation amount, temperature and drought stress and total amount of pure nitrogen in wheat growing season during grain filling and season have an effect on protein content. (Porceddu, 1973; Karaman, 2017). Grain protein ratio is important in determining the quality of wheat, but there is a negative relationship between grain yield and protein ratio (Tekdal et al., 2014; Karaman, 2017).

In the study, mean zeleny sedimentation value ranged from 35.0 to 49.4 ml. In terms of zeleny sedimentation value, the highest mean value was obtained from G11 advanced line (49.4 ml). While the G11 advanced line (52.4 ml) was prominent in Diyarbakir location in terms of zeleny sedimentation, no statistically significant difference was observed between genotypes in Sanliurfa location (Table 4). Sahin et al. (2016), in a study of wheat under Konya conditions, reported that the average zeleny sedimentation value is 39.4 ml. Although the genotypes and environmental conditions used in the study were different, the results obtained were similar to the results obtained from our study.

In the study, the highest mean wet gluten amount was obtained from the G11 advanced line (40.0%), while the average of the experiment was found to be 34.3%.

In terms of wet gluten amount, the highest value was obtained from G11 advanced line (44.2%) in Diyarbakir location, but no significant difference was found between genotypes in the location of Sanliurfa (Table 4). It has been reported that gli-

Table 4. Means of the investigated properties and groups formed

Genotypes	PR (%)			ZS (ml)			WG (%)			HT (day)		
	DB	SU	Av.	DB	SU	Av.	DB	SU	Av.	DB	SU	Av.
G1	13.4	17.1	15.2	29.4	42.6	36.0	31.0	33.6	32.3	101.5	94.0	97.8
G2	13.3	18.2	15.7	28.5	50.0	39.2	30.9	37.4	34.1	107.5	100.5	104.0
G3	13.3	17.9	15.6	28.0	46.8	37.4	30.8	36.4	33.6	102.0	95.0	98.5
G4	12.9	17.3	15.1	26.8	43.1	35.0	29.4	34.1	31.7	104.5	97.5	101.0
Dinç	12.7	17.5	15.1	25.6	45.0	35.3	28.7	34.9	31.8	103.0	96.0	99.5
G6	13.1	17.6	15.4	27.4	45.7	36.6	30.1	35.4	32.7	103.0	96.0	99.5
G7	13.3	17.5	15.4	29.3	45.2	37.2	30.8	35.0	32.9	102.0	95.0	98.5
G8	13.8	18.0	15.9	32.6	48.5	40.5	32.3	36.6	34.4	105.5	103.0	104.3
G9	13.7	17.9	15.8	31.1	47.2	39.1	32.2	36.2	34.2	105.0	98.0	101.5
Pehlivan	13.6	19.4	16.5	30.9	56.5	43.7	31.6	41.6	36.6	115.5	108.5	112.0
G11	17.3	17.7	17.5	52.4	46.5	49.4	44.2	35.8	40.0	93.5	86.5	90.0
G12	14.1	17.0	15.5	32.1	45.9	39.0	33.3	33.2	33.2	98.0	91.0	94.5
G13	13.5	18.5	16.0	30.2	50.1	40.2	31.4	38.3	34.8	101.5	94.5	98.0
G14	14.3	17.7	16.0	34.6	46.6	40.6	33.9	35.8	34.9	102.0	95.0	98.5
Cemre	13.6	19.1	16.4	30.2	55.7	42.9	31.6	40.6	36.1	114.0	107.0	110.5
G16	15.6	16.9	16.2	42.2	40.4	41.3	38.7	32.8	35.7	95.5	88.5	92.0
G17	13.1	18.1	15.6	28.5	48.8	38.7	30.0	37.0	33.5	107.5	100.5	104.0
G18	14.2	18.4	16.3	34.3	50.2	42.2	33.6	38.0	35.8	101.5	94.5	98.0
G19	12.8	19.0	15.9	26.7	55.5	41.1	28.9	40.0	34.4	106.0	104.0	105.0
Sagittario	13.0	18.9	16.0	27.4	53.7	40.5	29.8	39.8	34.8	112.0	105.0	108.5
G21	14.8	17.4	16.1	38.0	44.4	41.2	35.9	34.5	35.2	102.5	95.5	99.0
G22	15.1	17.5	16.3	37.9	44.6	41.2	36.6	35.1	35.9	103.5	96.5	100.0
G23	13.7	17.0	15.3	30.4	42.5	36.5	31.9	33.1	32.5	107.5	100.5	104.0
G24	13.5	17.6	15.5	29.1	46.1	37.6	31.2	35.4	33.3	110.0	103.0	106.5
Adana-99	13.9	17.1	15.5	34.0	43.9	38.9	32.6	33.5	33.1	102.0	95.0	98.5
Average	13.8	17.8	15.8	31.9	47.4	39.6	32.4	36.1	34.3	104.3	97.6	100.9
LSD(0.05)	1.5**	n.s.	1.1*	9.1**	n.s.	6.6*	5.1**	n.s.	3.7*	7.6**	6.3**	4.9**

adin and glutenin proteins come together to form gluten, while gliadin proteins are effective on the fluency of the dough, and glutenin proteins have been reported to play a role in the elasticity of the dough (Kizilgeci et al., 2015). In studies conducted on the amount of gluten in different years and places, Altinbas et al. (2000), obtained a value of average 34.9%, Kızılgeçi et al. (2015), on the other hand, obtained wet gluten values ranging from 31.4-42.6%. Wet gluten content values obtained in our study were similar with the results of these researchers.

In study, in terms of mean heading time, the late heading time was obtained by Pehlivan (112 days) and the earliest heading was of the G11 advance line (90 days) (Table 4). Ali (2017), in his study carried out under Diyarbakir conditions using 20 advanced lines and 5 standard varieties in bread wheat, reported that there was a 8-9 day difference in the heading time between the earliest and latest genotypes. In addition, it has been reported that the environmental conditions that occur at different developmental stages of genotypes are effective on heading time (Araus et al., 2007; Rahman et al., 2009). In terms of heading time, there was a 22 day difference between the earliest genotype and the latest genotype as a differentiation from the previous studies. This may be due to the fact that the varieties included in the trial have a wide variation as a developmental nature, and that the distribution of rainfall on a monthly basis during the production season is irregular. In addition, genotypes may have reacted differently due to lack of total precipitation.

Evaluation of the parameters examined by GGE biplot analysis method

The GGE biplot analysis method provides a visual interpretation of the relationship between the genotypes and the environment, the characteristics studied, and the environment.

Therefore, it has been used extensively by researchers recently (Hagos, 2013). In GGE biplot analysis, PC1(principal component 1-1. main component) shows the efficiency of genotypes and PC2 (principal component 2-2. main component) shows the stability of genotypes (Yan et al., 2000). Therefore, it is desirable that an ideal genotype has a high PC1 value in terms of the studied characters and a PC2 value close to zero (0) (Farshadfar et al., 2013; Aktas, 2017).

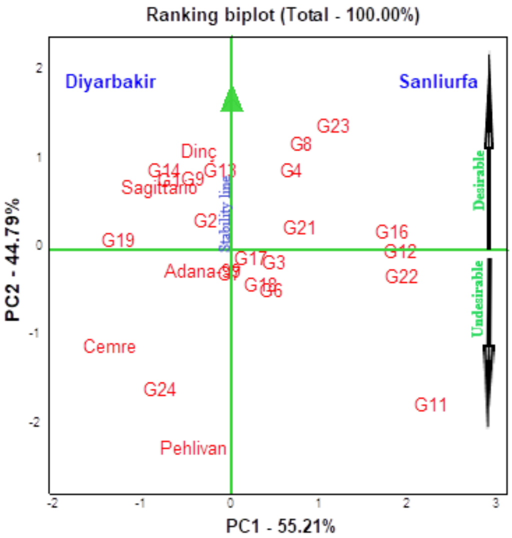

Figure 4. GGE-biplot graph showing the stability of genotypes

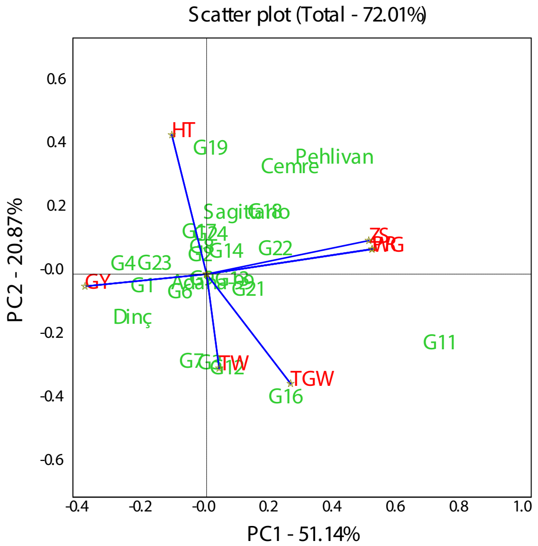

Figure 5. GGE-biplot graph showing genotype-property relationship

In Figure 4, a visual representation of the stability and yield order of genotypes is given, 55.21% of total variation is represented by PC1 and 44.79% by PC2. According to the AEC (average environment coordination) method, genotypes (PC1 value higher than zero), representing the average grain yield and located to the right of the line dividing the axis, had higher grain yield than the average. In addition, the remaining genotypes had lower grain yield values than the average (Figure 4).

The G23 advanced line is a genotype with the highest grain yield (PC1 value). The fact that G23 is close to the stability line indicates that it is moderately stable. Also; G4, Dinc, G8 and G13 can be said to be good in terms of grain yield. Genotypes close to the center of the axis (G17, G3, etc.) showed values close to the experimental average in terms of grain yield. Biplot analysis method, which presents the correlation between the examined parameters visually and enables the evaluation, has been used by many researchers recently. In addition, biplot analysis, which presents the correlation between genotype and traits as a whole, has big superiority over the correlation analysis showing only the relationship between two traits (Yan and Kang, 2002; Yan and Reid, 2008; Akcura, 2011; Kilic et al., 2012b). The relationship between the properties examined in the GGE biplot graph is given in Figure 5. 51.14% of the total variation, was represented by PC1 and 20.87% by PC2. From the features examined; since the vector angle is less than 90 degrees between TW and TGW, ZS and PR and WG, there is a high positive correlation between features. Also, since there is an inverse angle of about 180 degrees between the HT vector and the TW and TGW vectors, it can be said that there is a high negative correlation between HT and TW and TGW under the conditions of the study. It has been reported that, the variation of genotypes increases as the length of the vectors increases, and the length of the vectors representing the features or the distance of the vector from the origin indicates the variation of genotypes in terms of the relevant feature (Abate, 2015). As can be seen in Figure 5; HT, ZS, PR and WG vectors are long, GY and TW vectors are short. This shows that the variation between genotypes in GY and TW is lower than as in other parameters. The prominent genotypes shows in the study are as follows, respectively: Dinç, G8, G14 and G23 for GY; G11 for ZS, PR and WG; G12 and G16 for TGW; G7, G8 and G3 for TW (Figure 5). Genotypes located near the center of the axis showed values close to the trial average for all investigated properties.

Conclusion

According to the results of the research, there was a positive correlation between TW and TGW, ZS with PR and WG. Also, there was a negative relationship between HT and TW and TGW. In terms of GY; Dinç variety, G8, G14 and G23 advanced lines; for TW; Dinç variety, G3, G7, G8, G11, G16 advanced lines and Adana-99 variety; for TGW; G11, G12 and G16 advanced lines; for PR, ZS and WG; Pehlivan variety and G11 advanced line were in the front row. It is determined that G8 and G23 advanced lines have good adaptation ability and high grain yields in rainfed conditions in Southeastern Anatolia Region. Additionally, these lines may be candidate varieties because the quality values of these lines are above or close to the experiment average and are acceptable values. Also, It is concluded that Dinç and G11, which are prominent in terms of many features, should be used as genitors in breeding programs.

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

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