EVALUATION OF BREAD WHEAT GENOTYPES IN IRRIGATED AND RAINFED CONDITIONS USING BIPLOT ANALYSIS

KARAMAN, M.

Department of Plant Production Technologies, Faculty of Applied Sciences
Mus Alparslan University, Mus,Turkey
(e-mail: karaman2178@hotmail.com; phone:+90-530-600-9136; fax: +90-436-231-2201)

(Received 23rd Oct 2018; accepted 20th Dec 2018)

Abstract. This study was carried out in 2015-2016 and 2016-2017 seasons under supplemented irrigation (IC) and rainfall conditions (RC) of Diyarbakir in Turkey, was to determine high adaptive yielding with high quality bread wheat genotypes. The obtained data were analyzed using variance and GGE-biplot analysis methods, and the genotypes (G) were evaluated for drought tolerance indices. The average grain yield of two year ranged from 5820 to 6950 kg ha^{-1} on rainfall conditions and 7880 to 9050 kg ha^{-1}under supplemented irrigation conditions. The GGE biplot graph showed that G3, G6 and G21 were best genotypes for grain yield. Although G23 did not have the highest grain yield, it was determined that it represented the most stable line. Furthermore, G12 and G16 were determined as suitable genotypes for irrigated conditions and G21 for rainfall condition. It was determined that mean productivity (MP), stress tolerant index (STI), geometric mean productivity (GMP) and harmonic mean (HM) parameters were related with Yp (supplemented irrigation yield) and Ys (rainfall condition yield). Also, yield index (YI), drought resistance index (DRI), yield stability index (YSI) was related with Ys. In the study concluded that the lines G6, G12, G16 and G21 could be candidates for registration.

Keywords: *wheat, drought, GGE-biplot, yield components, stability*

Introduction

Bread wheat (*Triticum aestivum* L.) is highly adaptable to different ecological areas and has an important role in human nutrition (Dhanda et al., 2004; Nazar et al., 2012). It is reported that the global wheat cultivation is approximately 222.9 million hectares and world wheat production is around 720 million tons by Food Agriculture Organization (FAO, 2015). In Turkey, with a planting area of 7.8 million hectares and production of 22.6 million tons, wheat ranks first in grain production according to Turkish Statistical Institute (TSI, 2015). The rapidly growing world population has made it necessary to increase grain yield per unit area, particularly in light of the gradually reduced agricultural areas. Consumers' expectations concerning the quality of wheat vary; therefore, development of different quality wheat has become a requirement. However, to date, wheat breeding studies have aimed to produce varieties with high grain yield; thus, quality traits desired by the industry and consumers have not been among priority targets. For this reason, wheat imports have increased to meet the high-quality raw material needs of the industry and supply cheap raw materials. In order to keep these imports to a minimum, there is a need to develop new wheat varieties with both the desired quality characteristics and high yield (Erkul, 2006; Yazar et al., 2013).

In Turkey and around the world, wheat cultivation is generally undertaken in rainfed conditions dominated by general drought stress, but in rarer cases, it is also rarely supported by irrigation, which makes it crucial to identify genotypes suitable for both rainfed and irrigated conditions. For this purpose, wheat breeders and agronomists cultivate existing genotypes under both irrigated and rainfed conditions and use the results of these experiments to determine the specific requirements of genotypes based

DOI: http://dx.doi.org/10.15666/aeer/1701_14311450

on mathematical formulas (Farshadfar, 2012; Aktaş, 2017). In studies investigating the tolerability of drought in durum wheat, it is observed that genotypes with low values for yield stability index (YSI), drought resistance index (DRI) and yield index (YI) parameters favor limited watering conditions whereas those with high values harmonic mean (HM), geometric mean productivity (GMP) and mean productivity (MP) values have higher grain yield potential under conditions of no water stress. (Mohammadi et al., 2011; Nouri et al., 2011).

It has been reported that the effect of drought stress on plant growth and grain yield in wheat is dependent on the stage, severity and duration of drought stress, and the main reason for grain yield loss is the negative effect of drought on spike formation and leaf area duration after flowering (Öztürk, 1999). In wheat breeding programs, the selection parameters for varieties suitable for irrigated conditions include grain yield, number of grains per spike, grain weight per spike, and spike per square meter while those for rainfed conditions are plant height, number of spikes per square meter, and spike length (Ozturk and Korkut, 2018).

In this study, genotypes were tested in two different growing seasons under rainfed and irrigated conditions to determine suitable candidates for cultivation in the Southeastern Anatolia Region of Turkey by taking into account the responses of genotypes to these different conditions and the effects on grain yield, quality, yield, and yield components.

Materials and methods

In this study, 20 advanced lines were used as material and five registered varieties intensely cultivated in the Southeastern Anatolia Region in Turkey were utilized as standard (*Table 1*). The experiments were based on a randomized block design with four replications (R), and were conducted in Diyarbakır province, Turkey (37°56' N; 40°15' E; 599 m altitude) under irrigated and rainfed conditions in the 2015-16 and 2016-17 growing seasons (*Figure 1*).

First year, trials were planted on November 11. Harvest was made on June 11 and June 26 in rainfall and irrigation conditions respectively. Second year, trials were planted on November 10. Harvest was made on June 20 and July 01 in rainfall and irrigation conditions respectively. In irrigated trials, the plants were irrigated once at the end of flowering period. It was used 100 mm water per square meter with keel irrigation method. Sowing was performed on parcels of 6 m^2, 450 seeds per square meter using a sowing machine. Fertilization was under taken with 60 kg ha^{-1} pure nitrogen (N) and 60 kg ha^{-1} pure phosphorus (P_2O_5) during sowing and 80 kg ha^{-1} nitrogen (N) during the tillering period. Harvest was by plot combine harvester. In the area where the experiment was carried out, the soil characteristics were determined as follows: texture = clay, pH = 7.87 (slightly alkaline), organic matter ratio = 0.86 %, salt ratio = 0.32, and lime ratio ($CaCO_3$) = 8.12 % kg da^{-1}. The total amount of rainfall was 417 mm and 453 mm in the first and second growing seasons of the study (*Table 2*). Both of these values were lower than the long-term average amount of rain (482 mm) (Anonim, 2017). Protein ratio (%) was determination according to (NIR) AACC 39-10 (Anonymous, 1990). Measurement of the spikes per square meter was made over 1 m length and 20 cm width on a row, then multiplied by 5 to calculate the spike number in the area of 1 square meter.

Table 1. *Pedigree and Origin of Bread Wheat Genotypes Used in The Study*

Genotypes	**Symbol**	**Pedigree**	**Breeding Institution or Origin**
1	G1	Worrakatta/2*Pastor//Danphe #1 Cmsa07m00403s-040ztm-040zty-15ztm-010y-01b-0ymxi11-12\M21sawyt\41	CIMMYT
2	G2	Ka/Nac//Trch/3/Danphe #1 Cmsa07m00445s-040m-0nj-0nj-4y-0b Mxi11-12\M21sawyt\112	CIMMYT
3	G3	Bav92//Irena/Kauz/3/Huites/4/2*Rolf07 Cmss06y00875t-099Topm-099y-099ztm-099y-099m-25wgy-0b Mxi11-12\Msawyt \32	CIMMYT
4	G4	Fret2/Tukuru//Fret2/3/Munia/Chto//Amsel/4/Fret2/Tukuru//Fret2 Cmss06y00878t-099topm-099y-099ztm-099y-099m-17wgy-0b Mxi11-12\Msawyt\33	CIMMYT
Dinç	G5	**Check**	GAP UTAEM in Turkey
6	G6	Wbll1/Fret2//Pastor*2/3/Murga Cmss06y00937t-099topm-099y-099ztm-099y-099m-10wgy-0b Mxi11-12\Msawyt\44	CIMMYT
7	G7	Frncln*2/Tecue #1 Cmss07y00941t-099topm-099y-099m-099y-11m-0wgy Mxi11-12\M34eswyt\67	CIMMYT
8	G8	Ceyhan99//Tuj"s"/Onelto See06032	CIMMYT
9	G9	Bav92//Irena/Kauz/3/Huites/4/Doll Cmss05b00188s-099y-099m-099y-099ztm-18wgy-0b	CIMMYT
Pehlivan	G10	**Check**	TTAEM in Turkey
11	G11	Attila/Bav92//Pastor/3/Attila*2/Pbw65 Cmsa04m00070s-040ztb-040zty-040ztm-040sy-13ztm-04y-0b	CIMMYT
12	G12	Cunningham/4/Sni/Trap#1/3/Kauz*2/Trap//Kauz Cmsa04m00088s-040ztb-040zty-040ztm-040sy-3ztm-01y-0	CIMMYT
13	G13	Sokoll/Excalibur Cmsa04y00612s-25ztp0y-010m-010sy-4m-03y-0b	CIMMYT
14	G14	Wbll1*2/Kkts//Pastor/Kukunacmss05b00525s-099y-099m-099y-099ztm-3wgy-0b	CIMMYT
Aday-12	G15	**Check**	GAP UTAEM in Turkey
16	G16	Kachu/5/Nac/Th.Ac//3*Pvn/3/Mirlo/Buc/4/2*Pastor Cmss05b00584s-099y-099m-099y-099ztm-8wgy-0b	CIMMYT
17	G17	B.Hashi+B764ta/5/Dove/Inia/4/4777/(2)//Fkn/Gb/3/Pvn See060149-0s-0s-0sd	CIMMYT
18	G18	Krichauff/2*Pastor/4/Milan/Kauz//Prinia/3/Bav92 Cmsa06y00337s-040ztp0y-040ztm-040p0y-4ztm-0y-0b	CIMMYT
19	G19	Heilo//Sunco/2*Pastorcmsa06y00492s-040zty-040ztm-040sy-2ztm-0y-0b	CIMMYT
Tekin	G20	**Check**	GAP UTAEM in Turkey
21	G21	Frncln/Rolf07cmss06b00013s-0y-099ztm-099y-099m-2wgy-0b	CIMMYT
22	G22	Becard/Kachu Cmss06b00169s-0y-099ztm-099y-099m-28wgy-0b	CIMMYT
23	G23	Rolf07*2/5/Reh/Hare//2*Bcn/3/Croc_1/Ae.Squarrosa (213)//Pgo/4/Huites Cmss06b00704t-099topy-099ztm-099y-099m-23wgy-0b	CIMMYT
24	G24	Usher-16 Crow's'/Bow's'-1994/95//Asfoor-5 Icw01-00257-0ap-8ap-0ap/0ts-0ap-12ap-0ap	CIMMYT
Ceyhan-99	G25	**Check**	DATAE in Turkey

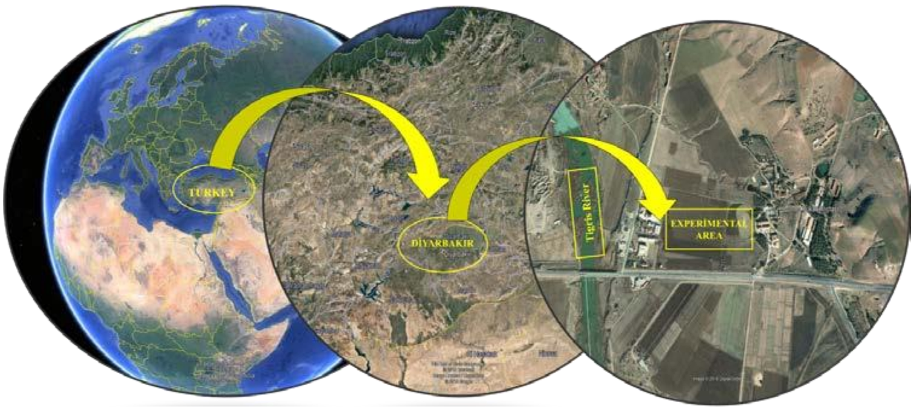

Figure 1. *Experimental Area (US Dep of State Geopraphy © 2018 Google image landset/Copernics)*

Table 2. *Climate data province of 2015-2016 and 2016-2017 wheat growing season in Diyarbakır*

Month	**Average of Temperature (^{0}C)**			**Precipitation (mm)**		
	2015-2016	**2016-2017**	**Long-Term**	**2015-2016**	**2016-2017**	**Long-Term**
September	27.4	24.2	24.8	0.0	5.2	4.1
October	18.4	18.8	17.2	84.2	13.6	34.7
November	9.8	8.2	9.2	10.4	52.0	51.8
December	3.9	2.4	4.0	31.6	135.6	71.4
January	1.1	1.5	1.8	77.2	20.6	68.0
February	7.9	1.5	3.5	69.2	3.8	68.8
March	9.7	9.4	8.5	55.6	90.2	67.3
April	15.7	12.8	13.8	29.0	98.8	68.7
May	19.9	18.8	19.3	41.4	30.6	41.3
June	26.8	26.9	26.3	18.4	2.6	7.9
Total				417.0	453.0	484.0

Drought tolerance parameters were calculated using the following formulas (Equation= 1, 2, 3, 4, 5, 6,7 and 8) developed by previous researchers:
Stress tolerant index (Fernandez, 1992):

$$(STI) = (Yp*Ys)/ \bar{Y}p^{2} \qquad (Eq.1)$$

Tolerance (Hossain et al., 1990):

$$(TOL) = Yp-Ys \qquad (Eq.2)$$

Geometric Mean Productivity (Fernandez, 1992):

$$(GMP) = \sqrt{}(Yp*Ys) \qquad (Eq.3)$$

Mean Productivity (Rosielle and Hambline, 1981):

$$(MP) = (Yp+Ys)/2 \qquad (Eq.4)$$

Harmonic Mean (Chakherchaman et al., 2009):

$$(HM) = 2*(Yp*Ys)/(Yp+Ys) \qquad \text{(Eq.5)}$$

Yield Stability Index (Bouslama and Schapaugh, 1984):

$$(YSI) = Ys/Yp \qquad \text{(Eq.6)}$$

Yield Index (Gavuzzi et al., 1997):

$$(YI) = Ys/ \bar{Y}s \qquad \text{(Eq.7)}$$

Drought Resistance Index (Lan, 1998):

$$(DRI) = Ys \, x(Ys/Yp)/ \bar{Y}s \qquad \text{(Eq.8)}$$

Statistical analysis of data

An analysis of variance (ANOVA) was performed using JMP 5.0 software and genotype by environment interaction (GGE) biplot analysis using GenStat statistical package program 12th Edition (GenStat, 2009). The differences between the averages were examined by a least significant difference (LSD) test ($p < 0.01$ and $p < 0.05$) (Gomez and Gomez, 1984).

Results and discussion

The ANOVA analysis revealed statistically significant differences in the mean grain yield and other quality traits between rainfed (Ys) and irrigated (Yp) conditions ($p < 0.01$ and $p < 0.05$) (*Table 3*).

Grain yield (GY) (kg ha^{-1})

According to the results of ANOVA, year, genotype and genotype*year were found to have a statistically significant effect ($p < 0.01$) on grain yield in both rainfed and irrigated conditions. The mean grain yield over the two growing seasons was 8520 kg ha^{-1} and 6080 kg ha^{-1} for irrigated and rainfed trails, respectively. The highest grain yield was obtained from G12 (9050 kg ha^{-1}) and G16 (9010 kg ha^{-1}) in irrigated trials and G21 (6950 kg ha^{-1}) in rainfed conditions. It has previously been reported that the main factor affecting yield in wheat is the genetic structure of the plant (Gebeyehou et al., 1982). Therefore, genotypes should be evaluated in different environments; i.e., in multiple locations or over different years to determine the grain yield potential. Not only hereditary but also abiotic and biotic stress factors have a role in the variation of genotype responses in different climates and soil structures. High or low levels of precipitation and higher or lower temperatures further increase the effect of GGE (Blum, 1998; Chamurliyski et al., 2015; Kılıç et al., 2018). However, grain yield in wheat is more affected by the distribution of rainfall throughout the growing season, rather than the total amount of precipitation (Çetin et al., 1999).

Table 3. *Results of variance analysis*

Rainfall Conditions										
Squares Mean										
Resources	**DF**	**GY**	**HW**	**TGW**	**PR**	**ZS**	**SPSM**	**SL**	**FSPS**	**GPS**
Y	1	163947**	653.6**	1693.46**	15.71**	14413.4**	6042.9**	0.1$^{n.s}$	2.0$^{n.s}$	189.2*
R[Y]	6	69803.6**	2.9$^{n.s}$	0.67$^{n.s}$	0.07$^{n.s}$	24.5$^{n.s}$	112.08$^{n.s}$	1.4$^{n.s}$	5.6$^{n.s}$	12.9*
G	24	233534**	358.7**	643.05**	34.13$^{n.s}$	946.54**	7227.7**	69.2**	86.9**	2809.1$^{n.s}$
Y*G	24	237439**	67.2$^{n.s}$	132.96$^{n.s}$	9.72$^{n.s}$	946.54**	7529.8**	17.8$^{n.s}$	39.3$^{n.s}$	2816.1**
CV(%)		6.9	1.9	6.8	7.8	8.6	7.9	7.2	6.2	13.9

Irrigation Conditions										
Squares Mean										
Resources	**DF**	**GY**	**HW**	**TGW**	**PR**	**ZS**	**SPSM**	**SL**	**FSPS**	**GPS**
Y	1	63937.7**	145.2**	764.8**	0.02^{ns}	331.2**	3433.9**	3.9^{ns}	20.4^{ns}	12.8^{ns}
R[Y]	6	8141.8^{ns}	0.34^{ns}	0.4^{ns}	0.02^{ns}	11.7^{ns}	15.8^{ns}	1.4^{ns}	4.5^{ns}	87.6^{ns}
G	24	176936**	139.4**	564.4**	18.9*	1530.9**	6958.6*	34.6**	63.1**	1896.3^{ns}
Y*G	24	316624**	6.7$^{n.s}$	99.1**	15.6*	297.8**	5772.0^{ns}	27.9*	25.5$^{n.s}$	1671.5^{ns}
CV(%)		4.2	0.5	3.5	4.6	5.8	11.3	7.6	5.4	15.3$^{n.s}$

GY: Grain yield, HW: Hectoliter weight, TGW: Thousand grain weight, PR: Protein ratio, ZS: Zeleny sedimentation, SPSM: Number of spikes per square meter, SL: Spike length, FSPS: Number of fertile spikelets per spike, GPS: Number of grains per spike, DF: Degree of freedom, R: Replication, Y: Year, G: Genotype **: Statistically significant at 0.01, *: Statistically significant at 0.05, ns: not significant

Hectoliter weight (HW) (kg hl^{-1})

ANOVA revealed statistically significant differences between growing seasons and genotypes in terms of mean HW under rainfed and irrigated conditions ($p < 0.01$). Considering the mean values obtained from the two growing seasons, Tekin variety had the highest HW (84.8-81.7 kg hl^{-1}) under both experimental conditions. This trait is influenced by several factors, such as environment, physical properties of grain (e.g., homogeneity and endosperm cavity), and endosperm structure. Studies conducted in this area have reported that HW varies according to hereditary factors (Genç et al., 1993) and different climatic conditions (Atlı et al., 1993).

Thousand grain weight (TGW) (g)

According to the two-year average values, the highest TGW values were obtained from the Pehlivan (42.9 g) and Aday-12 (42.7 g) standards in irrigated trials and from the G3 (34.2 g) under rainfed conditions. Flour industrialists attach special importance to TGW since there is a significant positive correlation between this trait and flour yield (Yazar et al., 2013). Despite the consensus on the significant correlation between TGW and quality and grain yield, there are contradictory results concerning the direction of this correlation, with some researchers suggesting that it is positive (Bohac and Cermin, 1969; Knott and Talukdar, 1971) while others reporting a negative correlation (Thorne, 1966). In the current study, TGW was found to have a positive correlation with HW and negative correlation with protein ratio (PR) and zeleny sedimentation (ZS).

Protein ratio (PR) (%)

The mean PR was calculated as 13.1% and 14.5% for irrigated and rainfed conditions, respectively. This indicates that PR is affected by not only environmental conditions but also hereditary factors. While the highest PR belonged to G13 in irrigated conditions, for rainfed trials, no significant difference was observed between the protein ratios of genotypes. In Turkey, it has been reported that protein content of wheat varies ranging between 6 and 22% depending on type, variety, environmental factors, and cultivation conditions (Doğan and Kendal, 2013). These ranges are in agreement with the results obtained in the current study concerning PR. Similarly, in another study conducted in Konya, Turkey, PR in bread wheat was found to vary between 12.62 and 14.16% in rainfed conditions, and 11.53 and 13.85% in irrigated conditions (Şahin et al., 2008; Aydoğan and Soylu, 2017).

Zeleny sedimentation (ZS) (ml)

Year, genotype, and year x genotype interactions had a statistically significant effect on ZS under rainfed and irrigated conditions ($p < 0.01$). Sedimentation is of great importance in determining protein quality in wheat (Peterson et al., 1992). In this study, the highest ZS value was obtained from G6 and G17 genotypes in irrigated conditions and from G6 in rainfed conditions. Ozturk and Aydin (2004) reported the sedimentation values in different environments as 32.2 ml for irrigated, 35.7 for rainfed, 34.0 ml for early water stress, 35.0 ml for late water stress and 37.5 ml for continuous water stress conditions. Compared to their study, we found similar values in irrigated conditions but higher values in rainfed conditions. This is considered to be due to environmental conditions and differences in plant material.

Spikes per square meter (SPSM) (Number)

There were statistically significant differences between years and genotypes in terms of SPSM in both rainfed and irrigated conditions ($p < 0.01$ or $p < 0.05$). The highest number of SPSM was observed in genotype G21 in irrigated trials and G9 in rainfed conditions. Researchers have previously reported that the number of SPSM varies according to sowing norms, variety, sowing time, available water, and climate and soil conditions (Kılıç et al., 2010; Kızılgeçi et al., 2016). Although heredity also has a significant role in determining SPSM, this parameter is also influenced by resistance of genotypes to adverse environmental conditions, such as temperature, drought stress, and frost. Studies conducted in various environments suggested that to achieve favorable results concerning grain yield, genotypes having high potential of a greater number of SPSM should be selected (Öztürk and Akten, 1999; Sönmez et al., 1999; Erekul and Köhn, 2006; Karaman, 2017).

Spike length (SL) (cm)

Genotypes G6 and G9 ranked first in terms of SL under irrigated and rainfed conditions, respectively. Aydoğan and Soylu (2017) reported the average SL from their rainfed experiments as 9.75 cm. Similarly, our average measurement of SL was 10.4 cm for rainfed trials; however, we observed that SL was shorter in irrigated conditions (9.9 cm). This may be attributed to genotypes producing more tillers under irrigation.

Fertile spikelet per spike (FSPS) (Number)

FSPS statistically significantly differed between genotypes under irrigated and rainfed conditions ($p < 0.01$). The highest number of FSPS was seen in the Pehlivan variety in irrigated trials whereas for rainfed conditions, many genotypes were included in the same group despite the differences in FSPS. In one of the two previous studies on bread wheat, it was shown that the number of FSPS ranged from 16 to 21 (Genç, 1974), while the other reported no statistically significant difference in this parameter with the values varying between 18.5 and 21.1 (Karaman, 2013).

Grains per spike (GPS) (Number)

According under rainfed conditions, the number of GPS was statistically significantly affected by year ($p < 0.05$) and year*genotype interaction ($p < 0.01$), and the highest value was identified in genotype G9. It has been reported that in wheat, a sufficient amount of nutrients is accumulated in grain after fertilization and greater grain yield is obtained from varieties with a higher number of GPS (Yıldırım et al., 2005). In another study conducted with 14 bread wheat varieties under rainfed conditions in Konya, it was found that the number of GPS ranged from 31.2 to 44.9 and the average of all trials was 37.9 (Aydoğan and Soylu, 2017). In the current study, the average number of GPS was higher (53.5) in rainfed conditions, which may be due to the differences in genotypes and agronomic applications.

Evaluation of yield and other investigated traits using GGE-biplot analysis

It has been reported that GGE biplot analysis is very important because it presents the genotype environmental interaction visually (Kendal, 2015; Sayar, 2017). *Figures 2 to 5* present the results of GGE-biplot analysis of grain yield (*Tables 4 and 5*) and other traits of 25 bread wheat genotypes evaluated in the 2015-16 and 2016-17 growing seasons under irrigated (IC1, IC2) and rainfed (RC1 and RC2) conditions. The analysis of grain yield revealed that the total variation was 73.38%, of which 44.99% was explained by principal component 1 (PC1) and 28.39% by PC2 (Figure 2 and Figure 3). According to the results of GGE-biplot analysis, the highest grain yield belonged to G3, G6 and G21 in RC1; G3, G7, G11, G21and G23 in IC1; G1 and Dinç in RC2; and G1, G2, G12 and G16 in IC2. Furthermore, genotypes located closer to the center of the axis had values similar to the experimental mean (*Figure 2*).

In the biplot graph demonstrating the stability capabilities of genotypes (*Figure 3*), The G3 line located at the far right of the line dividing the graph has the highest grain yield, and the G6, G7, G21 and G23 lines appear to be more prominent than the remaining genotypes concerning grain yield. Although G23 did not have the highest grain yield, it was determined that it represented the most stable line. Furthermore, based on the results IC1 can be considered as the environment that provided the best conditions for genotypes to demonstrate their potential.

If the angle of the vector was less than 90°, there was a positive correlation between the features, if the angle is more than 90° there is no correlation between features (Yan and Thinker, 2006; Dogan et al., 2016; Oral, 2018). As revealed by the biplot graph showing the correlations between genotype traits under rainfed conditions (*Figure 4*), GY was positively correlated with SL, FSPS, TGW and HW; and SPSM with ZS, GPS and PR; whereas PR had a negative correlation with TGW and HW. Furthermore, G6 and G21 were more prominent for GY; G8 and Tekin for HW; G3 and Pehlivan for TGW; G6 and G23 for ZS; G9, G11 and G21 for SPSM; G6 and G9 for SL; G6, G8, G11, G14 and Pehlivan for FSPS; and G9 and G11 for GPS.

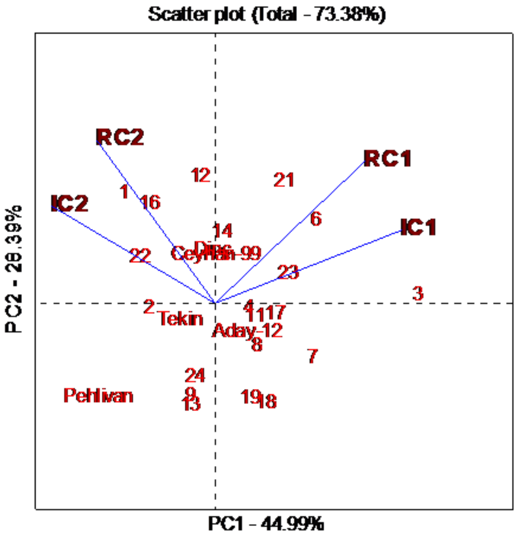

Figure 2. *GGE-biplot of grain yield*

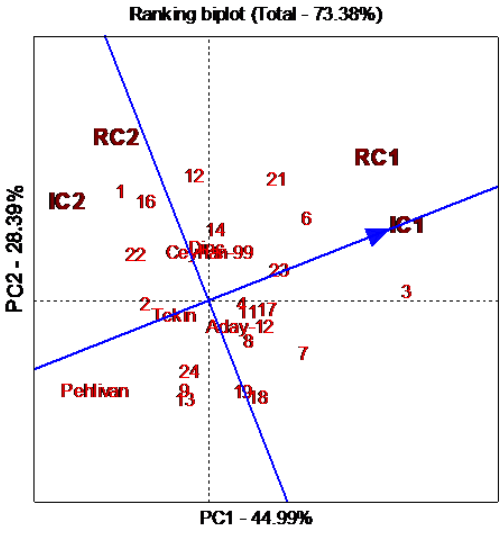

Figure 3. *Stability of genotypes in terms of grain yield*

For all parameters, the lines closer to the center of the axis showed similar values to the experimental average. According to the biplot graph showing the relationship between the genotype traits under irrigated conditions (*Figure 5*), there was a significant positive relationship between TGW and SL and FSPS; GY and GPS; SPSM, ZS and PR, and a significant negative correlation between HW, SPSM, PR and ZS. Under these conditions, the most promising genotypes were found to be G3, G12 and G16 for GY;

DOI: http://dx.doi.org/10.15666/aeer/1701_14311450

G18 and Tekin for HW; G8, Pehlivan and Aday-12 for TGW; G13 and G21 for PR; G1, G6, G17 and G23 for ZS; G21 and G24 for SPSM; G4, G6 and G18 for SL; and G6, Pehlivan, Aday-12 and G24 for FSPS; G9 and G23 had values similar to the average.

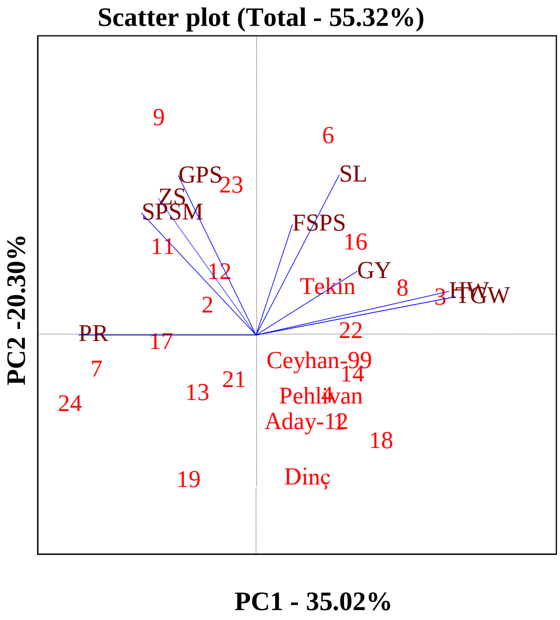

Figure 4. *Biplot graph of genotype trait correlations in rainfed conditions*

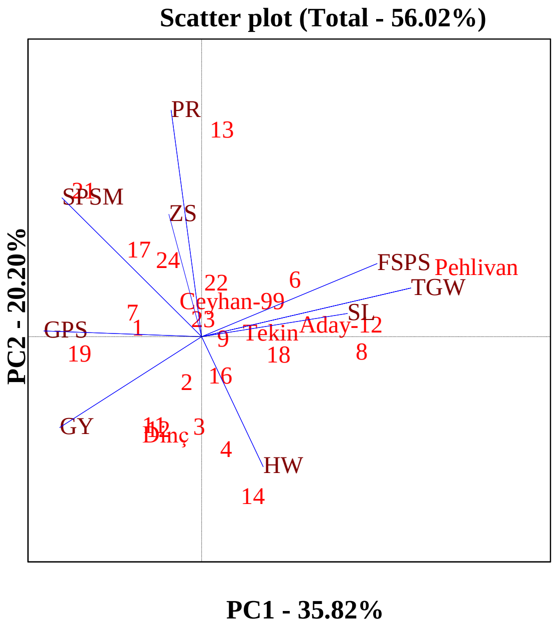

Figure 5. *Biplot graph of genotype trait correlations in irrigated conditions*

Table 4. *The mean grain yield values obtained from the 2015-16 and 2016-17 growing seasons*

	2015-16 (kg ha^{-1})					**2016-17 (kg ha^{-1})**					**Average of two seasons (kg ha^{-1})**				
	IC1		**RC1**		**% Lost**	**IC2**		**RC2**		**%Lost**	**IC**		**RC**		**% Lost**
G1	7810	f-h	6720	c-e	14	9160	ab	6820	a	26	8480	d-ı	6770	a-c	20
G2	7230	ıj	6870	b-d	5	9160	ab	5740	h-l	37	8190	h-j	6300	d-h	23
G3	9600	a	7700	a	20	8230	gh	5170	m	37	8910	ab	6440	c-g	28
G4	8830	bc	6610	c-f	25	8890	a-e	5620	j-m	37	8860	a-c	6110	g-ı	31
Dinç	8540	b-e	6390	c-g	25	8560	c-g	6730	ab	21	8550	c-g	6560	a-f	23
G6	8580	b-e	7810	a	9	8410	e-h	6050	d-j	28	8500	d-ı	6930	ab	18
G7	8940	b	6650	c-f	26	8250	gh	5550	j-m	33	8590	b-f	6100	g-ı	29
G8	7780	gh	6820	b-d	12	7980	h	6130	c-ı	23	7880	j	6480	c-g	18
G9	7920	f-h	5960	f-h	25	8500	d-g	5830	g-l	31	8210	g-j	5890	hı	28
Pehlivan	6830	j	5690	h	17	9040	a-c	5980	e-k	34	7930	j	5830	ı	27
G11	8930	b	6200	d-h	31	8350	f-h	6240	b-h	25	8640	b-f	6220	e-ı	28
G12	8790	b-d	6950	bc	21	9310	a	6370	a-f	32	9050	a	6660	a-d	26
G13	7590	hı	6270	c-h	17	8780	b-f	5400	lm	39	8180	ıj	5830	ı	29
G14	8510	b-e	6840	b-d	20	8800	b-f	6380	a-f	27	8650	b-f	6610	a-e	24
Aday-12	8280	d-g	6500	c-g	22	8800	b-f	5720	ı-l	35	8540	c-h	6110	g-ı	28
G16	8650	b-d	6360	c-h	26	9380	a	6540	a-d	30	9010	a	6450	c-g	28
G17	8820	bc	6780	b-d	23	8790	b-f	5500	k-m	37	8800	a-d	6140	f-ı	30
G18	8450	b-e	6250	c-h	26	8370	f-h	5460	k-m	35	8410	e-ı	5860	ı	30
G19	8530	b-e	6070	e-h	29	8430	e-h	5580	j-m	34	8480	d-ı	5820	ı	31
Tekin	7900	f-h	6170	d-h	22	8700	b-g	6300	b-g	28	8300	f-ı	6230	d-ı	25
G21	8930	b	7430	ab	17	8610	c-g	6470	a-e	25	8770	a-d	6950	a	21
G22	7740	hı	6440	c-g	17	8940	a-d	6580	a-c	26	8340	f-ı	6510	b-g	22
G23	8940	b	6940	bc	22	8570	c-g	5930	f-k	31	8750	a-e	6430	c-g	26
G24	8320	c-f	5850	gh	30	8690	b-g	5830	g-l	33	8500	d-ı	5840	ı	31
Ceyhan-99	8070	e-h	6560	c-f	19	8740	b-f	6560	a-d	25	8410	e-ı	6560	a-f	22
Average	8340	a	6590	b	21	8700	a	6020	b	31	8520	a	6080	b	26
Lsd(0.05)	51.9**		69.8**			49.3**		51.5**			12.7**		37.3**		

Letters in the same column from top to bottom are statistically different at the level of $p < 0.01$ or $p < 0.05$. IC1: Irrigated conditions in the first season, IC2: Irrigated conditions in the second season, RC1: Rainfed conditions in the first season, RC2: Rainfed conditions in the second season, IC: Irrigated conditions, RC: Rainfed conditions, **: Statistically significant at 0.01, *: Statistically significant at 0.05

DOI: http://dx.doi.org/10.15666/aeer/1701_14311450

Table 5. *The results of the combined analysis of both growing seasons for the investigated parameters and the groups formed*

	IC		**RC**		**IC**		**RC**		**IC**		**RC**	
	GY		**GY**		**HW**		**HW**		**TGW**		**TGW**	
G1	8480	d-ı	6770	a-c	82.7	jk	79.8	a-g	37.4	e-h	31.3	b-g
G2	8190	h-j	6300	d-h	83.2	g-j	78.6	e-j	35.9	h-k	28.6	g-j
G3	8910	ab	6440	c-g	83.7	e-g	80.8	a-d	39.9	bc	34.2	a
G4	8860	a-c	6110	g-ı	83.3	f-ı	79.4	b-h	35.8	h-l	30.2	d-g
Dinç	8550	c-g	6560	a-f	83.8	d-f	79.7	a-g	34.0	l	27.0	ı-k
G6	8500	d-ı	6930	ab	84.4	a-d	81.1	a-c	39.8	bc	31.2	c-g
G7	8590	b-f	6100	g-ı	81.9	l	74.7	l	36.8	f-ı	26.2	jk
G8	7880	j	6480	c-g	84.5	a-c	81.4	ab	40.7	b	33.2	a-c
G9	8210	g-j	5890	hı	83.4	e-ı	78.3	g-k	37.1	e-h	28.8	f-j
Pehlivan	7930	j	5830	ı	82.8	jk	79.0	c-ı	42.9	a	34.1	ab
G11	8640	b-f	6220	e-ı	83.6	e-h	78.6	e-j	34.5	j-l	26.4	ı-k
G12	9050	a	6660	a-d	82.7	jk	78.4	f-k	36.3	f-j	29.0	f-j
G13	8180	ıj	5830	ı	81.3	mn	76.6	j-l	37.8	d-g	30.2	d-g
G14	8650	b-f	6610	a-e	83.1	h-k	78.9	d-ı	36.7	f-ı	28.9	f-j
Aday-12	8540	c-h	6110	g-ı	81.5	l-n	76.4	kl	42.7	a	32.0	a-e
G16	9010	a	6450	c-g	83.9	c-e	80.7	a-e	39.9	bc	32.9	a-d
G17	8800	a-d	6140	f-ı	83.4	f-ı	77.5	h-k	36.1	g-j	26.3	ı-k
G18	8410	e-ı	5860	ı	84.6	ab	80.5	a-f	39.5	b-d	31.6	a-f
G19	8480	d-ı	5820	ı	84.3	b-d	80.2	a-g	34.2	kl	27.3	h-j
Tekin	8300	f-ı	6230	d-ı	84.8	a	81.7	a	37.2	e-h	30.1	d-h
G21	8770	a-d	6950	a	81.0	n	77.1	ı-k	36.3	f-j	29.1	f-ı
G22	8340	f-ı	6510	b-g	82.9	ı-k	80.7	a-e	38.1	c-f	32.1	a-e
G23	8750	a-e	6430	c-g	81.7	lm	77.6	h-k	38.8	b-e	30.5	c-g
G24	8500	d-ı	5840	ı	80.2	o	74.7	l	35.0	ı-l	24.4	k
Ceyhan-99	8410	e-ı	6560	a-f	82.6	k	79.6	a-h	36.0	g-k	29.2	e-j
Average	8520		6310		83.0		79		37.6		29.8	
Lsd(0.05)	35.5**		43.0**		0.6**		2.1**		1.9**		2.9**	

	IC		**RC**	**IC**		**RC**		**IC**		**RC**	
	PR		**PR**	**ZS**		**ZS**		**SPSM**		**SPSM**	
G1	13.2	b-e	14.0	38.0	ab	42.3	b-f	104.3	c-e	91.3	j
G2	12.6	d-g	14.7	31.5	g-ı	43.5	a-e	113.8	b-e	111.0	b-f
G3	12.8	c-g	13.3	32.8	e-h	39.0	e-g	103.8	c-e	99.0	g-j
G4	12.5	e-g	14.2	30.5	hı	40.0	d-g	104.8	c-e	93.5	ıj
Dinç	12.8	c-g	14.2	29.8	ıj	38.0	fg	103.8	c-e	101.3	e-j
G6	13.2	b-f	14.4	39.3	a	47.5	a	111.5	b-e	112.5	a-e
G7	13.1	b-f	15.2	35.8	b-d	46.0	a-c	110.8	b-e	105.8	c-h
G8	12.8	c-g	13.7	34.8	d-f	42.3	b-f	101.5	de	105.3	c-ı
G9	12.9	b-g	14.8	32.8	e-h	45.0	a-d	112.0	b-e	124.3	a
Pehlivan	13.4	a-d	15.4	32.3	f-ı	40.0	d-g	97.0	e	113.3	a-d
G11	12.4	fg	14.4	32.3	f-ı	42.8	a-f	112.8	b-e	119.3	ab
G12	13.1	b-f	15.2	30.3	h-j	44.5	a-d	102.3	c-e	109.8	b-g
G13	14.2	a	15.7	36.5	b-d	40.3	d-g	119.8	a-c	101.5	d-j
G14	12.1	g	13.8	24.5	l	36.5	g	107.0	c-e	102.3	d-j
Aday-12	12.9	c-g	14.0	29.8	ıj	40.3	d-g	103.3	c-e	103.3	d-ı
G16	13.1	b-f	14.2	30.0	ıj	42.3	b-f	113.0	b-e	108.5	b-h
G17	13.6	a-c	15.1	39.8	a	45.5	a-c	116.0	b-d	97.0	h-j
G18	13.2	b-f	14.1	31.8	g-ı	36.8	g	107.8	c-e	91.0	j
G19	13.3	a-e	14.7	35.3	c-e	45.0	a-d	116.5	b-d	105.8	c-h
Tekin	13.4	a-e	14.7	34.5	d-f	44.5	a-d	108.0	c-e	99.5	f-j
G21	13.8	ab	14.2	34.0	d-g	41.5	c-g	131.8	a	120.3	ab
G22	13.5	a-c	14.8	27.8	jk	38.8	e-g	119.8	bc	108.5	b-h
G23	13.2	b-f	14.8	38.0	ab	46.8	ab	98.3	e	109.3	b-g
G24	13.0	b-g	15.4	26.3	kl	39.3	e-g	127.8	ab	115.3	a-c
Ceyhan-99	13.0	b-f	14.0	37.8	a-c	45.3	a-d	112.8	b-e	111.4	a-g
Average	13.1		14.5	33.0		42.1		110.4		106.4	
Lsd(0.05)	0.9*		Ö.D.	2.7**		5.2**		17.6*		11.9**	

DOI: http://dx.doi.org/10.15666/aeer/1701_14311450

	IC		**RC**		**IC**		**RC**		**IC**	**RC**	
	SL		**SL**		**FSPS**		**FSPS**		**GPS**	**GPS**	
G1	9.1	e-g	9.5	g-ı	17.8	d-f	17.7	cd	55.5	55.3	bc
G2	8.7	g	9.9	e-ı	19.0	b-d	19.5	ab	49.5	56.9	a-c
G3	10.0	a-e	11.6	a-c	18.0	c-f	18.9	a-c	54.4	56.8	a-c
G4	10.8	ab	10.5	d-g	18.7	b-e	20.0	a	49.3	51.4	c
Dinç	9.1	e-g	9.3	hı	18.9	b-d	19.0	a-c	55.9	48.3	cd
G6	10.9	a	11.7	ab	20.0	ab	20.1	a	52.1	55.2	bc
G7	9.6	c-g	10.6	c-f	18.1	c-f	17.9	b-d	56.2	53.6	c
G8	10.3	a-c	10.7	b-e	19.4	a-c	20.5	a	47.7	49.7	cd
G9	10.4	a-c	11.9	a	18.6	b-f	19.7	a	53.3	66.3	a
Pehlivan	10.0	a-e	10.4	d-h	20.6	a	20.6	a	39.0	40.1	d
G11	9.2	d-g	9.3	hı	19.5	a-c	20.3	a	55.7	65.3	ab
G12	9.7	b-g	10.6	c-g	17.3	ef	19.4	ab	47.1	55.1	bc
G13	10.0	a-e	10.8	a-e	19.0	b-d	19.8	a	47.4	50.1	cd
G14	10.3	a-c	10.4	d-g	18.7	b-e	20.6	a	46.7	51.1	c
Aday-12	10.4	a-c	9.5	g-ı	19.9	ab	19.5	ab	55.2	51.9	c
G16	10.4	a-c	11.2	a-d	18.7	b-e	19.7	a	53.0	56.0	a-c
G17	10.3	a-c	9.8	e-ı	19.2	a-d	19.7	a	60.2	58.5	a-c
G18	10.7	ab	11.1	a-d	18.9	b-d	18.9	a-c	53.7	50.7	c
G19	8.9	fg	8.9	ı	17.2	f	16.9	d	53.5	50.4	c-d
Tekin	10.2	a-d	11.1	a-d	18.8	b-d	19.1	a-c	50.1	55.1	bc
G21	9.6	c-g	9.6	f-ı	18.2	c-f	17.6	cd	52.9	51.0	c
G22	10.0	a-e	11.3	a-d	19.1	a-d	19.1	a-c	53.5	49.8	cd
G23	9.9	a-f	11.4	a-d	18.9	b-d	20.0	a	56.3	58.7	a-c
G24	10.3	a-c	10.0	e-h	20.0	ab	19.5	ab	55.4	54.2	c
Ceyhan-99	9.4	c-g	9.4	f-ı	18.9	b-d	19.2	a-c	48.4	47.2	c-d
Average	9.9		10.4		18.8		19.3		52.1	53.5	
Lsd(0.05)	1.1**		1.1**		1.3**		1.7**		Ö.D	10.6*	

Evaluation of genotypes in terms of drought tolerance

Table 6 presents the drought tolerance parameters of the genotypes based on the average values over the two growing seasons.

Table 6. *Two year averages of drought tolerance parameters*

	Yp	**Ys**	**TOL**	**STI**	**GMP**	**MP**	**HM**	**YSI**	**YI**	**DRI**
G1	8480	6770	1710	0.79	757.9	763	753	0.80	1.07	0.86
G2	8190	6300	1890	0.71	718.6	725	712	0.77	1.00	0.77
G3	8910	6440	2480	0.79	757.5	768	748	0.72	1.02	0.74
G4	8860	6110	2750	0.75	735.9	749	723	0.69	0.97	0.67
Dinç	8550	6560	1990	0.77	748.8	755	742	0.77	1.04	0.80
G6	8500	6930	1570	0.81	767.2	771	763	0.82	1.10	0.90
G7	8590	6100	2490	0.72	723.9	735	713	0.71	0.97	0.69
G8	7880	6480	1400	0.70	714.3	718	711	0.82	1.03	0.84
G9	8210	5890	2320	0.67	695.7	705	686	0.72	0.93	0.67
Pehlivan	7930	5830	2100	0.64	680.2	688	672	0.73	0.92	0.68
G11	8640	6220	2420	0.74	732.9	743	723	0.72	0.99	0.71
G12	9050	6660	2390	0.83	776.3	785	767	0.74	1.06	0.78
G13	8180	5830	2350	0.66	690.8	701	681	0.71	0.92	0.66
G14	8650	6610	2040	0.79	756.4	763	750	0.76	1.05	0.80
Aday-12	8540	6110	2430	0.72	722.3	732	712	0.72	0.97	0.69
G16	9010	6450	2560	0.80	762.6	773	752	0.72	1.02	0.73
G17	8800	6140	2660	0.75	735.4	747	724	0.70	0.97	0.68
G18	8410	5860	2550	0.68	701.8	713	690	0.70	0.93	0.65
G19	8480	5820	2660	0.68	702.8	715	691	0.69	0.92	0.63
Tekin	8300	6230	2070	0.71	719.3	727	712	0.75	0.99	0.74
G21	8770	6950	1820	0.84	780.5	786	775	0.79	1.10	0.87
G22	8340	6510	1830	0.75	737.0	743	731	0.78	1.03	0.81
G23	8750	6430	2320	0.78	750.6	759	742	0.74	1.02	0.75
G24	8500	5840	2660	0.68	704.7	717	692	0.69	0.93	0.64
Ceyhan-99	8410	6560	1850	0.76	742.7	748	737	0.78	1.04	0.81
Average	**8520**	**6310**	**2210**	**0.74**	**732.7**	**741**	**724**	**0.74**	**1.0**	**0.74**

Yp: Grain yield in irrigated conditions, Ys: Grain yield in rainfed conditions, TOL: Tolerance, STI: Stress tolerance index, GMP: Geometric mean productivity (GMP), MP: Mean productivity, HM: Harmonic mean, YSI: Yield stability index, YI: Yield index, DRI: Drought resistance index.

Table 6 shows the results of drought tolerant parameters obtained by grain yield formulas under irrigated and rainfed conditions with the highest grain yield being obtained from G12 (9050 kg ha^{-1}) and G21 (6950 kg ha^{-1}), respectively. The tolerance index (TOL) indicates the yield differences between the best and worst conditions for genotypes. The lowest TOL was found in G8 and the highest in G4. G8 with the lowest TOL had higher grain yield than the experimental average for rainfed conditions but did not have better grain yield potential in irrigated conditions compared to other genotypes. Therefore, it can be stated that the performance of some genotypes does not greatly vary in favorable or poor environmental conditions. G4 can be considered as the genotype with the most favorable response to irrigation.

In addition, G17, G19 and G24 with high TOL values were identified as genotypes that had a positive response to irrigation, which significantly increased their yield potential. Although their TOL value was high, G3, G12 and G16 had high grain yields both rainfed and irrigated conditions. This shows that these genotypes well adapted to both environments. Many researchers have reported that high values of STI, GMP, MP, HM and YI are indicative of the increased drought tolerance of genotypes (Fernandez, 1992; Ramirez and Kelly, 1998; Akçura et al., 2011; Aktaş, 2017).

In the current study, the highest values for these parameters were obtained from G6, G12, G16 and G21, suggesting that these genotypes had good grain yields under both irrigated and rainfed conditions. The remaining two drought parameters investigated in the study were YSI and DRI, which, at low levels, have been shown to indicate drought tolerance (Lan, 1998; Bouslama and Schapaugh, 1984). In the current study, the lowest YSI values belonged to G4 (0.69), G17 (0.70), G18 (0.70), G19 (0.69) and G24 (0.69) and the lowest DRI values were observed in G18 (0.65), G19 (0.63) and G24 (0.64). Anwar et al. (2011) and Aktaş (2017) reported that YI is associated with average yield in conditions presenting with water stress and can therefore be used in drought resistance studies. G6 and G21 were more prominent in terms of YI.

According to the biplot graph demonstrating the status of genotypes in terms of drought parameters and the relationship between these parameters (*Figure 6*); there was a significant positive relationship between; MP, STI, GMP and HM; YI and grain yield in irrigated conditions; DRI and YI and grain yield in rainfed conditions; and DRI and YSI. The best performing genotypes were found to be G12 and G16 for grain yield in irrigated conditions; G12 and G21 for MP, STI, GMP and HM; G21 for YI and grain yield in rainfed conditions; G6 for DRI and YSI; and G4, G19 and G24 for TOL. Furthermore, the MP, STI, GMP and HM parameters were found to be associated with grain yield in irrigated and rainfed conditions. Whereas YI, DRI and YSI were correlated with grain yield in rainfed conditions.

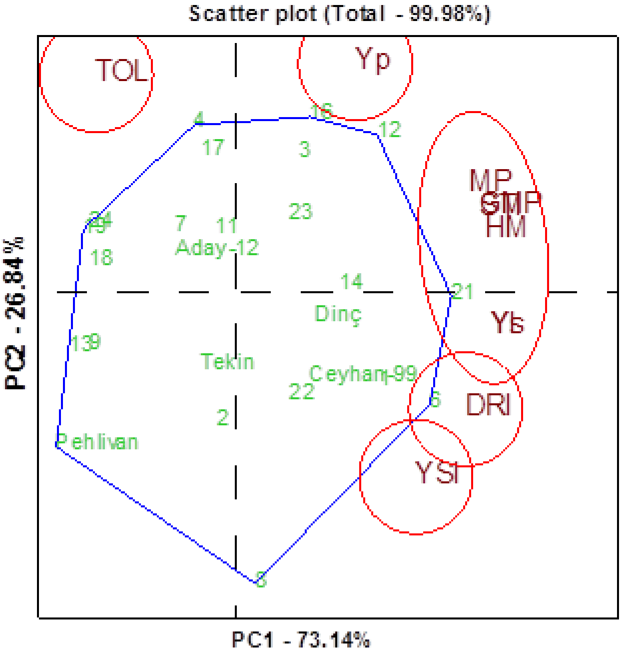

Figure 6. GGE-biplot of the correlation between genotypes and drought tolerance parameters

Conclusion

The results of ANOVA and GGE-biplot analyses of the experiments conducted in two growing seasons under different environmental conditions revealed that the prominent genotypes were G1, Dinç, G6, G12, G14, G21 and Ceyhan-99 for the rainfed conditions and G3, G4, G12, G16, G17, G21 and G23 genotypes for the irrigated conditions. G12 and G21 lines produced favorable results under both rainfed and irrigated conditions, which suggests that these lines better adapt to different climatic conditions than other genotypes. In addition, particularly in rainfed conditions, the G3 line performed better in both yield components (FSPS and SL) and technological quality parameters (TGW and HW). This line (G3) can be used as a parent in breeding studies. Concerning drought parameters, there was a significant positive relationship between MP, STI, GMP and HM, and a significant negative correlation between TOL and YSI. It was also determined that MP, STI, GMP and HM parameters can be used in the selection of genotypes suitable for irrigated and rainfed conditions and YI, DRI and YSI can assist in choosing the best genotypes for rainfed conditions presenting with water stress.

Based on the results of the study, we conclude that G6, G12, G16 and G21 are promising candidate lines for registration.

REFERENCES

[1] Akçura, M., Partigoç, F., Kaya, Y. (2011): Evaluating of drought stress tolerance based on selection indices in Turkish bread wheat landraces. – The Journal of Animal & Plant Sciences 21(4): 700-709.

[2] Aktas, H. (2017): Türkiye’de yoğun ekim alanına sahip bazı arpa (hordeum vulgare l.) çeşitlerinin destek sulamalı ve yağışa dayalı koşullarda değerlendirilmesi. – Tekirdağ Ziraat Fakültesi Dergisi 14(03): 86-97.

[3] Anonim (2017): Diyarbakır Meteoroloji Bölge Müdürlüğü Kayıtları. – Https://www.mgm.gov.tr/Veri değerlendirme/İl-ve-İlceler-İstatistik.Aspx?=Diyarbakır.

[4] Anonymous (1990): Approved Methods of the American Association of Cereal Chemists. – American Association of Cereal Chemists, Approved Methods Committee, USA.

[5] Anwar, J., Ghulam, M. S., Makhdoom, H., Javed, A., Mujahid, H., Munir, M. (2011): Drought tolerance indices and their correlation with yield in exotic wheat genotypes. – Pakistan Journal Botany 43(3): 1527-1530.

[6] Atlı, A., Koçak, N., Aktan, M. (1993): Ülkemiz çevre koşullarının kaliteli makarnalık buğday yetiştirmeye uygunluk yönünden değerlendirilmesi. – Orta Anadolu’da Hububat Tarımının Sorunları ve Çözüm Yolları Sempozyumu, Konya: 345-351.

[7] Aydoğan, S., Soylu, S. (2017): Ekmeklik buğday çeşitlerinin verim ve verim öğeleri ile bazı kalite özelliklerinin belirlenmesi. – Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi 26(1): 24-30.

[8] Blum, A. (1998): Plant Breeding for Stress Environments. – CRC Press, Boca Raton, Florida.

[9] Bohac, J., Cermin, L. (1969): A Study of The Correlation Between Factors Determining The Productivity of Wheat Ears. – Plant Breed. Abs. 39(1): 58.

[10] Bouslama, M., Schapaugh, W. T. (1984): Stress tolerance in soybean. Evaluation of three screening techniques for heat and drought tolerance. – Crop Science 24: 933-937.

[11] Chakherchaman, S. A., Mostafaei, H., Imanparastand, L., Eivazian, M. R. (2009): Evaluation of drought tolerance in lentil advanced genotypes in Ardabil region. – Iran J. Food Agriculture Environment 7(3-4): 283-288.

[12] Chamurliyski, P., Atanasova, D., Penchev, E. (2015): Productivity of foreign common winter wheat cultivars (Triticum aestivum L.) under the conditions of dobrudzha region. – Agriculture & Forestry, Podgorica 61(1): 77-83.

[13] Çetin, Ö., Uygan, D., Boyacı, H., Öğretir, K. (1999): Kışlık buğdayda sulama-azot ve bazı önemli iklim özellikleri arasındaki ilişkiler. – Türkiye III. Tarla Bitkileri Kongresi, Cilt I, 151-156, Adana.

[14] Dhanda, S. S., Sethi, G. S., Behl, R. K. (2004): Indices of drought tolerance in wheat genotypes at early stages of plant growth. – J. Agronomy & Crop Science 190: 6-12.

[15] Doğan, Y., Kendal, E. (2013): Diyarbakır koşullarında bazı ekmeklik buğday *(Triticum Aestivum* L.) genotiplerinin tane verimi ve bazı kalite özelliklerinin belirlenmesi. – YYÜ Tarım Bilimleri Dergisi 23(3): 199-208.

[16] Doğan, Y., Kendal, E., Oral, E. (2016): Identifying of relationship between traits and grain yield in spring Barley by GGE biplot analysis. – Agriculture and Forestry 6(24): 239-252.

[17] Erekul, O., Köhn, W. (2006): Effect of weather and soil conditions on yield components and bread-making quality of winter wheat (*Triticum aestivum* L.) and winter triticale (*Triticosecale Wittm*.) varieties in North-East Germany. – J. Agronomy and Crop Science 192: 452-464.

[18] Erkul, E. (2006): Sulamalı koşullarda ileri ekmeklik buğday hatlarının tane verimi ve bazı kalite özelliklerinin belirlenmesi. – ADÜ Ziraat Fakültesi Dergisi 3(1): 27-32.

[19] FAO. (2015): Food Agriculture Organization. – http://www.fao.org/index_en.htm.

[20] Farshadfar, E., Jamshid, B., Aghaee, M. (2012): Biplot analysis of drought tolerance indicators in bread wheat lanraces of Iran. – International Journal of Agriculture and Crop Sciences. IJACS/2012/4-5/226-233.

[21] Fernandez, G. C. J. (1992): Effective selection criteria for assessing plant stress tolerance. – Proceedings of The İnternational Symposium on Adaptation of Vegetable And Other Food Crops in Temperature and Water Stress, Taiwan: 257-270.

[22] Gavuzzi, P., Rizza, F., Palumbo, M., Campaline, R. G., Ricciardiand, G. L., Borghi, B. (1997): Evaluation of field and laboratory predictors of drought and heat tolerance in winter cereals. – Plant Science 77: 523-531.

[23] Gebeyehou, G., Knott, D. R., Baker, R. J. (1982): Relations among durations of vegetative and grain filling phases, yield components and grain yield in durum wheat cultivars. – CropSci 22: 287-290.

[24] Genç, İ. (1974): Yerli ve Yabancı Ekmeklik ve Makarnalık Buğday Çeşitlerinde Verim ve Verime Etkili Başlıca Karakterler Üzerinde Araştırmalar. – Çukurova Üniversitesi Ziraat Fakültesi Yayınları, Yayın No: 82. Adana.

[25] GENSTAT. (2009): GenStat for Windows (12th Edition) Introduction. – VSN International, Hemel Hempstead.

[26] Gomez, K., Gomez, A. A. (1984): Statistical Procedures for Agricultural Research. – 2nd Edition. John Wiley and Sons. New York. 680 pp.

[27] Hossain, A. B. S., Sears, A. G., Coxand, T. S., Paulsen, G. M. (1990): Desiccation tolerance and its relationship to assimilate partitioning in winter wheat. – CropScience 30: 622-627.

[28] Karaman, M. (2013): Investigation of some physiological and morphological parameters in some bread wheat (triticum aestivum l.) varieties. – Master Thesıs, Dicle University.

[29] Karaman, M. (2017): Determination of physiological and morphological parameters associated with grain yield and quality traits in durum wheat. – Ph.D. Thesis, Dicle University.

[30] Kendal, E. (2015): Relationship between chlorophyll and other features in durum wheat (Triticum turgidum L. var. durum) using SPAD and biplot analyses. – Journal of Agricultural Science and Technology 17: 1873-1886.

[31] Kılıç, H., Akar, T., Kendal, E., Sayım, I. (2010): Evaluation of grain yield and quality of barley varieties under rainfed conditions. – African Journal of Biotechnology 9(46): 7825-7830.

[32] Kılıç, H., Kendal, E., Aktaş, H. (2018): Evaluation of yield and some quality characters of winter barley (hordeum vulgare l.) genotypes using biplot analysis. – Agriculture & Forestry 64(3): 101-111. Podgorica.DOI: 10.17707/Agricultural Forest.64.3.09.

[33] Kızılgeçi, F., Yıldırım, M., Akıncı, C., Albayrak, Ö. (2016): Bazı arpa genotiplerinin Diyarbakır ve Mardin koşullarında verim ve kalite parametrelerinin incelenmesi. – Iğdır Üniversitesi Fen Bilimleri Enstitüsü. Dergisi 6(3): 161-169.

[34] Knott, D. R., Talukdar, B. (1971): Increasing seed weight wheat yield and it's effects on yield components and quality. – Crop Sci. 11(2): 280-283.

[35] Lan, J. (1998): Comparison of Evaluating Methods for Agronomic Drought resistance in Crops. – Acta Agricultural Boreali-Occidentalis Sinica 7: 85-87.

[36] Mohammadi, M., Karimizadeh, R., Abdipour, M. (2011): Evaluation of drought tolerance in bread wheat genotypes under dryland and supplemental irrigation conditions. – Australian Journal of Crop Sciences 5(4): 487-493.

[37] Nazar, H., Erekul, E., Koca, Y. O. (2012): Ekmeklik buğday çeşitlerinin tane verimi ve kalitesi üzerine farklı yaprak gübresi uygulamalarının etkisi. – Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi 9(2): 5-12.

[38] Nouri, A., Etminan, A., Teixeira da Silva, J. A., Mohammadi, R. (2011): Assessment of yield, yield-related traits and drought tolerance of durum wheat genotypes (Triticum turjidum var. durum Desf.). – Aust. J. Crop Sci. 5(1): 8-16.

[39] Oral, E. (2018): Effect of nitrogen fertilization levels on grain yield and yield components in triticale based on AMMI and GGE bıplot analysis. – Applied Ecology And Environmental Research 16(4): 4865-4878.

[40] Öztürk, A., Akten, G. (1999): Some morpho-physiological characters in winter wheat and their effects on grain yield. – Tr. J. of Agriculture and Forestry 23 (Ek sayı 2): 409-422.

[41] Öztürk, A., Aydin, F. (2004): Effect of water stress at various growth stages on some quality characteristics of winter wheat. – Journal of Agronomy and Crop Science 190(2): 93-99.

[42] Öztürk, İ., Korkut, K. Z. (2018): Ekmeklik buğday (TriticumaestivumL)'ın farklı gelişme dönemlerinde kuraklığın verim ve verim unsurlarına etkisi. – Tekirdağ Ziraat Fakültesi Dergisi 15(2): 128-137.

[43] Peterson, C. J., Graybosch, R. A., Baenziger, P. S., Grombacher, A. W. (1992): Genotype and environment effects on quality characteristics of hard red winter wheat. – Crop Sci. 32: 98-103.

[44] Ramirez, P., Kelly, J. D. (1998): Traits Related to Drought Resistance in Common Bean. – Euphytica 99: 127-136.

[45] Rosielle, A. A., Hambline, J. (1981): Theoretical aspects of selection for yield in stres and non- stres environment. – CropScience 21: 943-946.

[46] Sayar, M. S. (2017): Additive main effects and multiplicative interactions (AMMI) analysis for fresh forage yield in common vetch (Vicia sativa L.) genotypes. – Agriculture and Forestry 63(1): 119-127.

[47] Sönmez, F., Ülker, M., Yılmaz, N., Ege, H., Bürün, B., Apak, R. (1999): Relationship between grain yield and some yield components in Tir wheat. – Tr. J. of Agric. and Forestry 23: 45-52.

[48] Şahin, M., Göçmen Akçacık, A., Aydoğan, S. (2008): Orta anadolu kuru ve sulu koşulları için tescil edilmiş ekmeklik buğday çeşitlerinin verim ve bazı kalite özellikleri yönünden performanslarının belirlenmesi. – Ülkesel Tahıl Sempozyumu. Konya: 390-400.

[49] Thorne, G. N. (1966): Physiological Aspects of Grain Yield in Cereals. – Growth of Cereals and Grasses. Batter Worths.: 88-106.

[50] TSI. (2015): Türkiye İstatistik Kurumu. – Bitkisel Üretim İstatistikleri, tuik.gov.tr

[51] Yan, W., Tinker, N. A. (2006): Biplot analysis of multi-environment trial data. Principles and applications. – Canadian Journal of Plant Science 86: 623-645.
[52] Yazar, S., Salantur, A., Özdemir, B., Alyamaç, M. E., Kaplan Evlice, E., Pehlivan, A., Akan, K., Aydoğan, S. (2013): Orta anadolu bölgesi ekmeklik buğday ıslah çalışmalarında bazı tarımsal karakterlerin araştırılması. – Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi 22(1): 32-40.
[53] Yıldırım, A., Sakin, M. A., Gökmen, S. (2005): Tokat Kazova koşullarında bazı ekmeklik buğday çeşit ve hatlarının verim ve verim unsurları yönünden değerlendirilmesi. – GOÜ. Ziraat Fakültesi Dergisi 22(1): 63-72.

DOI: http://dx.doi.org/10.15666/aeer/1701_14311450