

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/349085296>

EFFECTS OF ECOLOGICAL FACTORS ON SPRING BARLEY GENOTYPES

Chapter · February 2021

CITATIONS

0

READS

66

1 author:



Enver Kendal

Mardin Artuklu University

48 PUBLICATIONS 186 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Barley Breeding Project [View project](#)



TAGEM/TBAD/ A12/P05/008 [View project](#)

Chapter 3

EFFECTS OF ECOLOGICAL FACTORS ON SPRING BARLEY GENOTYPES

Enver Kendal*

Mardin Artuklu University, Kızıltepe Vocational Training High School,
Department of Crops and Animal Production, Kızıltepe,
Mardin, Turkey

ABSTRACT

Late spring frosts and drought are the most important abiotic stress factors that definite the yield and quality performance of spring barley genotypes in breeding programs. For this purpose, a total of 25 spring barley genotypes were used in the study, including 20 advanced line and 5 standard varieties. The 2013/14 growing season, in which the late spring frosts were effective, and the 2012/13 growing season were compared with the biplot technique in terms of yield, quality and other features. Depending on the late spring frosts, significant differences were determined between the genotypes in terms of grain yield, quality parameters and other characteristics between the two growing seasons. Late spring frosts caused a significant reducing in grain yield (GY) by 26.2%, hectoliter weight (HW) by 6.3%, and in thousand grain weight

* Corresponding Author's E-mail: enver21_1@hotmail.com, enverkendal@artuklu.edu.tr.

(TGW) by 18.6%, while increasing protein content (PC) by 18.3%. It has been determined that the early spiked spring barley genotypes are more affected than the late spiked genotypes from late spring frosts, in terms of GY, TW, TGW and PC. The GGE biplot analysis showed that four distinct groups of traits were occurred in the 2012/2013 and five in 2013/2014 growing seasons, respectively. The result of GGE biplot indicated that G14, G19, G21 and Samyeli variety were stable and ideal genotypes for all of the traits in the 2012/2013 season, and G3, G4, G7 and G8 were stable and ideal for the 2013/2014 season. On the other hand; G3 was the best genotype against late spring frost based on GY. In addition, results from the AMMI (Additive Main Effects and Multiplicative Interaction) analysis revealed that genotypes G7, G8, and G22 were more stable and higher yielding, compared to the other genotypes.

Keywords: biplot, AMMI, quality, yield, stress

INTRODUCTION

Nowadays, the effects of global climate change differ from region to region and occur in different products and differently in each region. The impact of ecological factors is increasing at an alarming rate and important percentage of the cereal areas needs to overcome for this negative impact. These effects are known as drought, temperature stress, irregular precipitation, hail, frost and they are changing from region to region. Late spring frosts are one of the most important abiotic stress factors that reduce the agricultural yield by limiting the development of genotypes in spring barley breeding studies among ecological factors effects [1].

A considerable problem in several areas of world is late spring frost damage of spring type cereals. In barley cultivation, the effects of winter frosts are low due to the fact that the plants are at rest during the winter months. Even if the plants are damaged, they can recover later. However, frosts occurring in late spring have a high effect. Plants are highly damaged in this period as they are in the period of stalking or spitting. Even if the effect of frost passes, these plants cannot recover again and cause high yield losses [2]. Generally in spring, the plants continue to

develop as the temperature rises throughout the day, sometimes the temperature values suddenly drop at night, or sometimes the temperatures drop locally for a short time. Even for a short time, late spring frosts occur and cause serious damage [3]. Farmers make some applications (late sowing, late feeding of nitrogenous fertilizers, deep sowing, rolling, choose different varieties) to protect the plants from late spring bars [4].

Barley plants, affected by frost, first turn into a dark green color, and after a few days they begin to look as if they are soaked in water. In the following days, necrotic spots appear on the leaves and sometimes die completely depending on the severity of the frost. However, this does not mean that the plant is completely dead. If the plant has survived, it will begin to produce new leaves after 4-5 days in hot conditions [5]. If new leaves are not developing, it is necessary to check the root area and the growth point by digging around the plant. If the growth note is green, these plants can bloom again, if not, it means that the plants are completely dead. Therefore, observing the plants in detail and obtaining detailed information about their condition will make it easier for us to find the solution.

Cold stress can cause late spitting of seedlings injuries due to damage to the spikes, thus decreasing yield and decreasing quality [6], and cold damage can also greatly prevent the growth and reproduction of plants, which can lead to damage to the leaves, and to increase chlorous wounds on the leaf [5]. The stress caused by late spring frosts causes great changes in the biochemistry and physiology of plants [7]. In generally; the physiological process due to photosynthesis is highly affected by the late spring frosts, which affects the development of the plant and reduces the efficiency of the plant [8]. On the other hand; the observation for frost tolerance of heading time should remain a high priority despite global warming [3].

Southe-astern Anatolia Region of Turkey is a region where yield and quality are negatively affected in barley cultivation due to cold damage, temperature stress, drought, hail and similar environmental risks. However, farmers are not very conscious about this issue and see the development of barley as an indicator of yield in the early period, so they make nitrogen fertilization early and often planting early. This situation invites late spring

frosts. However, plant breeders, on the one hand, are conducting researches to develop frost-resistant varieties with genotype environmental impact; on the other hand, they are working to raise awareness of farmers for practical applications.

The study aimed to apply a GGE biplot to evaluate 25 spring barley genotypes (including 20 promising line, five varieties) tested in two seasons (one normal, second affected from cold and drought damage), and to investigate the effect of late spring frosts on yield and quality of spring barley genotypes by comparing both growing seasons for registration in Southe-astern Anatolia.

EXPERIMENTAL

This Plant Material and Experimental Arrangement

As material, a total of 25 spring barley genotypes were used in the study, including 20 advanced line and 5 standard varieties (Table 1). The study was conducted in the 2013/14 growing season (in which the late spring frosts were effective, and 2012/13 growing season (normal season) in the conditions of Diyarbakir of Turkey. The information's about genotypes used as material in the study is indicated in the Table 1.

The experiments were conducted in a randomized block design with three replications. The seeding rates were 450 seeds m^{-2} . In the study, the amount of seed count for each plot was calculated according to the thousand grain weight. Trial plots size was calculated as 1.2 m x 6 m = 7.2 m^2 with 6 rows. In both seasons, trial planting was done with a trial drill in November, which was found suitable for research. As a base fertilizer, 20-20-0 ammonium phosphate fertilizer was found suitable and applied on pure fertilizer with 60 kg/ha (P₂O₅) and nitrogen (N) dose. Ammonium nitrate (33%) was applied in the tillering period at 60 kg/ha over pure nitrogen. As chemicals Granstar (TRIBENURON-METHYL) and illoxaan (DICLOFOP-METHYL) were applied by mixing against narrow and broad leaf weeds in period which the weeds have 2-4 leaf.

Table 1. The names, origins and pedigrees of the genotypes used as material in the study

Number	The name of Variety or Pedigree of Genotypes	Orjin	Spike type
G1	ICB102607/4/ZDM1275//Gloria'S'/Copal'S'/3/..... SEA-002-07-0SD-0SD--0SD-0SD-0SD	SEA	6 row
G2	SG//WIESELBURGER/AHOR 1303-61/4/ ... SEA-002-31-0SD-0SD--3SD-0SD-0SD-0SD	SEA	6 row
G3	SG//WIESELBURGER/AHOR 1303-61/4/ .. SEA-002-31-0SD-0SD--4SD-0SD-0SD-0SD	SEA	6 row
G4	Rod/Opera/7/ HARMA-02//11012-2/CM 67/3... SEA-002-131-0SD-0SD--2SD-0SD-0SD-0SD	SEA	6 row
Dara	DARA(CONTROL)	TURKEY	6 row
G6	Alanda/Hamra//Alanda-01/3/Assala-04 ICB03-1530-4AP-0AP-0SD-0SD-0SD	ICARDA	6 row
G7	WI2291/5Alger/Ceres//SlS/3/ER/Apm/4..-ICB00-0077-0AP-1AP-3AP-0AP-0SD-0SD-0SD	ICARDA	6 row
G8	Arar/Lignee527//AC_Bacon ICB02-0832-0AP-6AP-0AP-0SD-0SD-0SD	ICARDA	6 row
G9	Pamir-036/Victoria ICBH96-0203-0AP-17AP-0AP-0SD-0SD-0SD	ICARDA	6 row
Kendal	ALTIKAT (CONTROL)	TURKEY	6 row
G11	CWB117-9-7/3/Roho//Alger/Ceres362-1-1 Plot-98-3 Sel,40AP-1AP-0AP -0SD-0SD-0SD	ICARDA	2 row
G12	Plaisant/Radical ICBH93-0200-0AP-0AP-8AP-0AP-5AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G13	ICB-103351/Arta//GkOmega/Tokak ---ICBH98-0156-0AP-8AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G14	24569/5/F2/Radical/Karat/3/Radical/4/Xemus ICB02-2537-8AP-0AP-0SD-0SD-0SD	ICARDA	6 row
Altakat	SAMYELİ (CONTROL)	TURKEY	6 row
G16	Mall-4-3094-2//Alpha/Cum/3/Victoria/Mall-. ICB01-1368-0AP-16AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G17	CWB117-5-9-5//Rhn-03/ ICHB94-0001-0AP-0AP-4AP-0AP-10AP-6AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G18	Pamir-168/Sadik-01-----ICB00-1661-14AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G19	Ardak/3/Alpha/Dura//CWB117-77-9-7----ICB00-2174-8AP-0AP-0SD-0SD-0SD	ICARDA	2 row
Samyeli	ŞAHİN-91 (CONTROL)	TURKEY	2 row
G21	Nure--- ITALY-0SD-0SD-0SD	ICARDA	6 row
G22	CWB117-77-9-7//Alpha/Dura(TH) --ICBH89-0178-2AP-0AP-6AP-0AP-10AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G23	Aths/Lignee686//Orge905/Cr289-53-2/3/UC566/.... ICB02-0276-0AP-6AP-0AP-0SD-0SD-0SD	ICARDA	2 row
G24	Merzaga(Orge007)/Alanda-01---ICB98-0908-0AP-13AP-0AP-4TR-8AP-0AP-0SD-0SD-0SD	ICARDA	2 row
Şahin	VAMIKHOCA (CONTROL)	TURKEY	2 row

CIMMYT: International Maize and Wheat Improvement Center, AARI: Aegean Agricultural Research Institute

Trial plots were harvested on $1.2 \times 5 = 6$ m² with Hege trial combine. Quality analyzes were done on NIT (Near-infrared transmittance) as called Near IR Spectroscopy device.

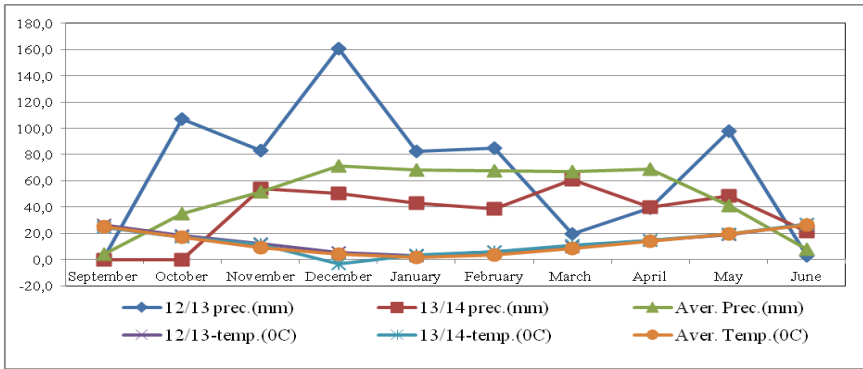


Figure 1. The values of meteorological data.

Although there were not observed any ecological stress in 2012/13, the late frost damage and drought were observed in 2013/14 growing season. Late frost damage happened in plant stem elongation stage (30 March 2014). After, drought occurred in April and May (Figure 1). In barley cultivation, April and May temperature and precipitation rates and the late spring frost that occurred in April significantly affected the final yield and quality parameters and other yield characteristics in conditions of Southeastern Anatolia region of Turkey.

Statistical Analyses (GGE)

The data analyzed respectively for each location and combined by using the JMP 5.0. Statistical software package [9], and the differences between means were compared using a least significant difference (LSD) test at the 0.05 probability level [10].

GGE biplot analysis also allows comparison growing seasons in terms of their discriminating ability and representativeness. For this purpose GGE biplot analyses were used to compare the seasons [11, 12]. On the

other hand the AMMI analysis used to evaluate the grain yield based on two growing season. Because the AMMI biplot analysis illustrating grain yield performance and stability status of genotypes and growing seasons (Figure 2).

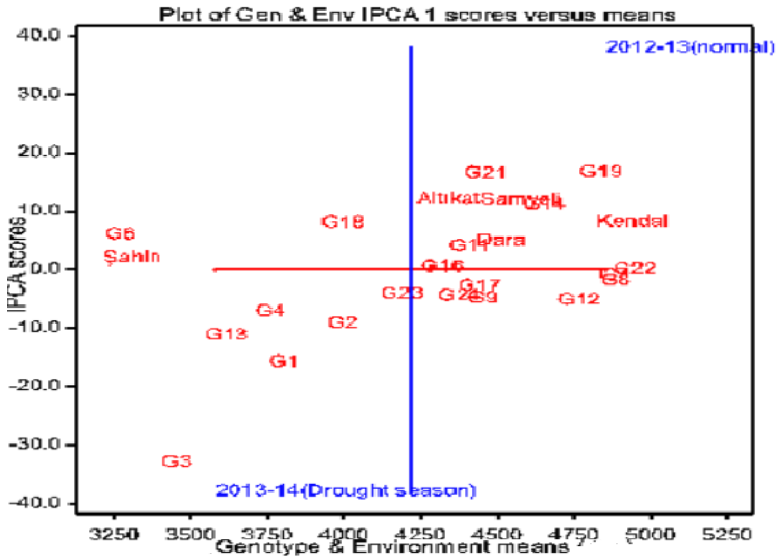


Figure 2. AMMI analysis of grain yield of 25 genotypes in years (kg ha⁻¹).

RESULTS AND DISCUSSION

The combined ANOVA revealed highly significant differences among the growing seasons and genotypes for all traits ($P < 0.01$), as shown in Table 2 and Table 3. Moreover, Genotypes \times Season's Interaction (GSI) were found to be highly significant ($P < 0.01$) for GY, HT, HW and TGW, while for PC was found significant ($P < 0.05$), it was not significant for PH, GS. The results indicated that interaction was significant, because of late spring frost and late drought of 2013/14. Similarly, there were significant among genotypes in terms of majority traits. On the other hand, the effect of different ecological conditions of the two growing seasons led to different rankings of the genotypes for traits (Table 3, Table 4, Table 5).

Generally, plant breeders are preferred genotypes with stable, low fluctuations in yield, yield characteristics and quality parameters.

Table 2. Analysis of variance for investigated mean grain yield of seasons

Source	df	SS	MS	F	Explained(%)
Total	149	161087305	1081123		
Treatments	49	122471166	2499412	7.07	9.78
Genotypes	24	37075445	1544810	4.37**	6.05
Environments	1	60579038	60579038	51.64**	71.46
Block	4	4692667	1173167	3.32	4.59
Interactions	24	24816684	1034029	2.93**	4.05
IPCA	24	24816684	1034029	2.93**	4.05
Error	96	33923472	353369		

** : Value significant at 0.01 probability level,

The Results of the Data Reviewed

The grain yield of the barley genotypes, ranged from 2790(G3) to 6032(G19) kg/ha in 2012/13 growing season (normal), and the average grain yield of this season was 4852 kg/ha (Table 3). The GY ranged from 2503 (Şahin) to 4273(G8) kg/ha in 2013/14 growing season which late frost effect was happened, and average GY of the genotypes was 3581 kg/ha in this season. Moreover, there were not significant differences among G8 and G7, G12, G16, G19, G22 in 2013/14 season. Compared to both seasons in terms of GY, during the 2013/14 growing season, where late spring frosts and drought were effective, GY decreased by 26.2%. In this growing season, depending on the genotypes, GY decreased between 1.7(G1) and 44.6(G21) %, while only G3 increased by 44.1%. On the other hand; Compared to both growing seasons, a high GY was obtained from the 2012/13 growing season and there was a 27.2% decrease in GY with the effect of late spring frosts that were effective in the 2013/14 growing season (Figure 1). According to the average of both years, G22 reached the highest GY with 4872 kg/ha, and G7 and G8 genotypes shared the same group and there was no statistically significant difference between them.

[13], reported that wheat plants are most susceptible to frost damage during and after flowering and are also vulnerable at the earlier stages of booting (Zadoks Growth Scale stage from GS39 to GS71), and in some cases, frost is costing WA growers average yield losses of up to 10-20 percent per year across their total cropping programs in a 10-year period. Moreover, after the plants start to develop in the spring, both their green parts increase and their sensitivity to cold increases, so late spring frosts can cause serious yield losses [14, 15]. Moreover [16], reported that it may be possible to select genotypes with improved frost resistance based on low-temperature conditions, and supported this study. [17], reported that, more detailed studies are needed to both increase and stabilize of grain yield by increasing resistance and improving genetics for cold tolerance.

The heading time of the barley genotypes, ranged from 97(Samyeli) to 120(Şahin) day in 2012/13 growing season(normal), and the average HT of this season was 108 day (Table 4). The HT genotypes ranged from 98(G12) to 117(Şahin) day in 2013/14 growing season which late frost effect was happened, and average HT of the genotypes were 105 day in this season. Compared to both seasons in terms of HT, plants were spiked 4 days earlier in 2013/14, therefore barley genotypes were more effected from late spring frosts. According to the average of both years, Şahin variety reached the highest HT with 118 day, and some genotypes. Many genotypes were found to be earlier than the Şahin variety cultivated at the latest. Moderate early varieties are preferred in the Southe-astern Anatolia Region because moderate earliness is an indicator of high productivity in this region. Because, medium early genotypes are not affected by both late spring frosts and late drought. The study results revealed that early heading genotypes (Samyeli) were more adversely affected from cold damage than those of late heading ones. [18] reported that losses in wheat grain yield and quality due to frost primarily occur between stem elongation and late grain filling. Moreover the researchers reported that post head-emergence frost causes substantial losses for Australian barley producers [3]. Cold stress may cause various seedling injuries, delay heading, and reduce GY due to spikelet sterility [6].

Table 3. The AMMI-estimates, ranked, mean and IPCA of genotypes in seasons(kg h⁻¹)

No	G. Yield		G. Yield Differences		G. Yield Mean (kg/ha ⁻¹)	2012/13 (Year 1)		2013/14 (Year 2)		IPCA (G)
	2012/2013	2013/2014	(2012/13)-(2013/14) = (kg/ha ⁻¹) (%)			AMMI-estimates	Ranked	AMMI-estimates	Ranked	
G1	3787	3722	65	1.7	3755	G19	6032	G8	4272	- 1.590.1
G2	4231	3659	572	13.5	3945	Kendal	5769	G12	4260	- 922.1
G3	2790	4020	+1230	+44.1	3405	G21	5650	G22	4240	- 3.297.5
G4	4069	3350	719	17.7	3710	G14	5639	G7	4232	- 727.2
Dara	5253	3609	1644	31.3	4431	Samyeli	5529	G3	4020	491.7
G6	4082	2360	1722	42.2	3221	G22	5513	G9	3957	594.9
G7	5427	4232	1194	22.0	4829	G7	5427	Kendal	3878	- 100.9
G8	5398	4272	1126	20.9	4835	G8	5398	G17	3843	- 191.0
G9	4848	3957	891	18.4	4402	Altukat	5328	G24	3842	- 500.9
Kendal	5769	3878	1891	32.8	4824	Dara	5253	G1	3722	817.6
G11	5126	3556	1571	30.6	4341	G12	5129	G2	3659	395.0
G12	5129	4260	869	17.0	4695	G11	5126	G23	3641	- 529.5
G13	3752	3338	414	11.0	3545	G16	4901	Dara	3609	- 1.130.1
G14	5639	3523	2116	37.5	4581	G17	4898	G16	3598	1.114.3
Altukat	5328	3146	2182	40.9	4237	G18	4863	G11	3556	1.200.7
G16	4901	3598	1303	26.6	4249	G9	4848	G14	3523	0.419
G17	4898	3843	1054	21.5	4371	G24	4768	G19	3499	- 285.5
G18	4863	2989	1874	38.5	3926	G23	4594	Samyeli	3356	794.9
G19	6032	3499	2533	42.0	4766	G2	4231	G4	3350	1.663.7
Samyeli	5529	3356	2173	39.3	4443	G6	4082	G13	3338	1.189.0

No	G. Yield		G. Yield Differences		G. Yield Mean (kg/ha ⁻¹)	2012/13 (Year 1)		2013/14 (Year 2)		IPCA (G)
	2012/2013	2013/2014	(2012/13)-(2013/14) = (kg/ha ⁻¹) (%)			AMMI-estimates	Ranked	AMMI-estimates	Ranked	
G21	5650	3132	2518	44.6	4391	G4	4069	Altikat	3146	1.643.9
G22	5513	4240	1273	23.1	4876	Şahin	3925	G21	3132	0.02344
G23	4594	3722	953	20.7	4118	G1	3787	G18	2989	- 418.8
G24	4768	3659	926	19.4	4305	G13	3752	Şahin	2503	- 455.5
Şahin	3925	4020	1422	36.2	3214	G3	2790	G6	2360	199.9
Average	4852	3581								
LSD (0.5)	95.7**	99.4*	68.1**							
CV(%)	12.0	16.9								

** Value significant at 001 probability level, *Value significant at 005 probability level

Table 4. The PCA scores of seasons for grain yield trait and first four genotypes for each year

Seasons	Season mean	IPCAe[1]	Score	1	2	3	4
2012/13	4852	37.92195	37.92	G19	G10	G21	G14
2013/14	3581	- 37.92195	- 37.92	G8	G12	G22	G7

The plant height of the barley genotypes ranged from 80(G1) to 120 (G7, G16) cm in 2012/13 growing season(normal), and the average PH of this season 102 cm (Table 4). The PH ranged from 95(G12) to 120(G7) cm in 2013/14 season which late frost effect was happened, and average PH of the genotypes were 101 cm in the 2013/14 growing season. In terms of PH, genotypes showed a high variation, but there was no high difference between years and the average of both years had close values. Results revealed that the growing seasons did not very affect PH and the genetic structure of genotypes played a determining role in plant height [19].

The hectoliter weight of the barley genotypes, ranged from 65.1(G6) to 76.1(G19) kg/hl in 2012/13 growing season (normal), and the average HW of this season was 71.5 kg/hl (Table 4). The hectoliter weight genotypes ranged from 56.1(G6) to 71.7(G16) kg/hl in 2013/14 growing season which late frost effect was happened, and average HW of the genotypes were 67.0 kg/hl in this season. Compared to both seasons in terms of HW, during the 2013/14 growing season, where late spring frosts and drought were effective, HW decreased by 6.3%. According to the average of both years, G19 variety reached the highest HW with 73.5 kg/hl, and some genotypes (G12, G16, G22 and G24) shared the same group and there was no statistically significant difference between them. HW of the lines showed a high variation. In terms of HW, majority of the lines had high values than controls. High hectolitre weight is a desired feature in breeding programs. Some researchers reported that depending on the climate factors and the genetic structure of the genotypes in the growing season, may change the HW depending on the grain characteristics (endosperm structure, uniformity of the grains) e and hectoliter weight differences [20, 21].

Table 5. The means of the genotypes in four environments for traits

Genotypes	Protein content(%)			Grain moisture (%)			Cold damage	Scor		
	12/13	13/14	Mean	12/13	13/14	Mean	12/13	12/13	13/14	Mean
G1	12.6	14.7	13.7	7.8	7.9	7.8	4	4	4	4
G2	12.2	14.5	13.3	7.7	8.1	7.9	4	3	4	4
G3	12.0	13.8	12.9	7.9	8.1	8.0	4	2	5	3
G4	12.2	13.5	12.9	7.7	8.2	8.0	4	4	5	5
Dara	12.3	15.8	14.0	7.8	7.9	7.9	4	4	4	4
G6	12.8	16.4	14.6	7.8	7.8	7.8	2	4	3	4
G7	11.7	14.8	13.2	7.7	8.0	7.8	2	5	4	5
G8	12.8	14.7	13.7	7.6	7.9	7.8	3	5	5	5
G9	14.6	15.9	15.3	7.5	7.9	7.7	3	4	5	5
Kendal	12.6	15.4	14.0	7.7	8.0	7.8	2	5	5	5
G11	12.7	15.6	14.1	7.7	7.9	7.8	2	5	5	5
G12	13.6	16.1	14.8	7.9	7.9	7.9	2	4	5	5
G13	15.1	17.5	16.3	7.7	7.8	7.8	2	5	5	5
G14	12.5	13.8	13.2	7.9	7.9	7.9	1	5	3	4
Altukat	11.6	14.7	13.1	7.7	7.8	7.8	1	5	5	5
G16	13.1	16.3	14.7	7.9	7.7	7.8	2	5	4	5
G17	14.5	15.3	14.9	8.1	7.9	8.0	2	5	5	5
G18	14.2	16.8	15.5	7.8	7.8	7.8	2	4	4	4
G19	14.4	16.5	15.4	7.7	7.7	7.7	2	5	5	5
Samyeli	12.5	16.3	14.4	8.3	7.7	8.0	2	5	4	5
G21	12.5	15.5	14.0	8.1	8.0	8.1	3	5	5	5

Table 5. (Continued)

Genotypes	Protein content(%)			Grain moisture (%)			Cold damage	Scor		
	12/13	13/14	Mean	12/13	13/14	Mean	12/13	12/13	13/14	Mean
G22	13.3	15.7	14.5	7.8	7.8	7.8	3	4	5	5
G23	13.6	16.4	15.0	7.8	7.8	7.8	2	4	4	4
G24	13.1	14.6	13.8	7.8	7.8	7.8	3	4	4	4
Şahin	14.3	17.9	16.1	7.4	7.7	7.6	1	4	3	4
Average	13.1	15.5		7.8	7.9					
LSD (0.5)	1.5*	2.1*	1.3*	0.6ns	0.2ns	0.3ns				
CV(%)	5.6	6.6	6.2	3.7	2.0	3.0				

** Value significant at 001 probability level, *Value significant at 005 probability level, ns: not significant.

The thousand grain weight of the barley genotypes, ranged from 34.6(G6) to 46.0(G24) g in 2012/13 growing season (normal), and the average TGW of this season was 40.8 g (Table 4). The TGW of genotypes ranged from 27.8(G6) to 38.5(G12, G16) g in 2013/14 growing season which late frost effect was happened, and average TGW of the genotypes were 33.2 g in this season. Compared to both seasons in terms of test weight, during the 2013/14 growing season, where late spring frosts and drought were effective, TGW decreased by 18.6%. It means that TGW is more affected by climatic condition of growing season. According to the average of both years, G24 genotype reached the highest TGW with 42.1g, and some genotypes (G18, G19 and Şahin variety) shared the same group and there were no statistically significant difference between them. In terms of a TGW, the lines showed a high variation, and three lines had high TGW than Şahin variety. High TGW is a desired quality parameter in breeding studies. TGW may vary depending on climate conditions and variety characteristics. The differences between the genotypes in terms of TGW change depending on the environmental factors, but rather the genetics of the genotypes [19].

The protein content of the barley genotypes, ranged from 11.6(Altıkat) to 15.1% (G13) in 2012/13 growing season (normal), and the average PC of this season was 13.1% (Table 5). The PC of genotypes ranged from 13.6(G4) to 18.0% (Şahin) in 2013/14 growing season which late frost effect was happened, and average PC of the genotypes were 15.5% in this season. Compared to both seasons in terms of test weight, during the 2013/14 growing season, where late spring frosts and drought were effective, whereas the other trait and GY; PC increased by 18.3%. It means that PC is more affected positively by late frost damage and drought of growing season. According to the average of both years, G13 genotype reached the highest PC with 16.3%, and some genotypes (G12, G16 and Şahin variety) shared the same group and there was no statistically significant difference between them. In terms of a PC, the lines showed a high variation, and three lines had high PC than Şahin variety (best variety in terms of PC). High PC is a desired quality parameter in breeding studies. The protein PC may vary depending on climatic conditions, variety

characteristics and agronomic applications (nitrogen rate). On the other hand; in terms of PC, the differences between genotypes vary depending on environmental factors and mostly depending on the genetic characteristics of genotypes [1].

The grain moisture (GM) of genotypes, averaged over two seasons, ranged from 7.7% for more genotypes variety) to 8.3% for Samyeli variety. The overall mean GM was 7.8% (Table 5). The GM of genotypes in 2012/2013 ranged from 7.1% (G21) to 8.3% g (G1), and the average GM in that season was 7.8%. The GM from the 2013/2014 season ranged from 7.7% (G7) to 8.2% (G4), and the average PC was 7.9%. The GM of G21 was high based on mean of two growing seasons. Grain moisture content depends on the moisture content of the grains in the harvest period, and the grain moisture content of high-yielding genotypes is generally high. It is not desirable that the moisture content in the harvest period is more than 13%. It is not suitable for storage if it exceeds this rate.

The AMMI Model Showing GEI Means of GY and Stability

The Additive Main Effect and Multiplicative Interaction (AMMI) polygon view of the stability of 25 genotypes was based on GY data averaged over years (Tables 2, 3 and Figure 2). In the AMMI model, the x-axis represents the G and year (Y) main effects, and the y-axis represents the GEI effects. According to the results of AMMI analysis, the effect of the environment (71.46%) was found to be higher than the genotype (6.5%) and the interaction (4.59%) effect (Table 2). On the other hand, genotypes were differed significantly in both interaction and basic effect and majority of the genotypes (particularly G7, G8, and G22, Kendal G12, G19) located above the x-axis. The GY of these genotypes was high for mean of both growing season. Some other genotypes (particularly G3 and G6 and Şahin) demonstrated low performance, because they located under the x-axis. On the other hand, the GY of 2012/13(normal season) was very high than 2013/14(late spring frost and draught affect). The genotypes G7, G8, G12 and G22 had high GY potential and were stable across years,

whereas G1, G3, and G6 had low GY potential and were unstable (Figure 2, Table 5). In the AMMI analysis, it offers us very useful opportunities in selection, since we can see both the efficiency performances of genotypes and environments as well as the stability of genotypes at the same time. Therefore, it is very useful to be used for selection breeding programs. On the other hand; the relationship between genotype and growing season, and grouping of the season showed by sector analysis (Figure 3). In the analysis total seven sectors were occurred and the growing season took places in different group and sector. The biplot showed that G12, G17 and G7 genotypes were the best for 2013/14 season (late spring frost and drought was happened), and G19, Kendal variety, G14 and Dara variety were the best for normal season (2012/13). The genotype G22 was the best for two growing season and some other genotypes which separated by sector from growing season (G3, G6 and Şahin variety) were not suitable for any growing season. We can say that the genotype 22, G7 and G8 are stable and favorable genotypes for both growing seasons (Table 3, Figure 1 and Figure 2). More researcher advised AMMI analysis to evaluate genotypes and some of them found same results and reported that AMMI analysis can be used to selection candidate in breeding programs [22, 23, 24, 25].

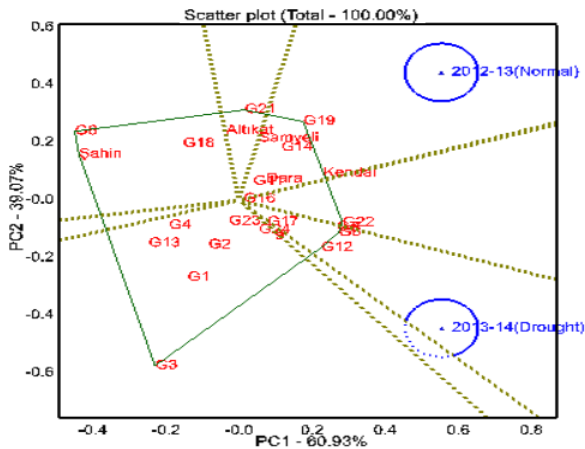


Figure 3. Relation of genotype-years and grouping of growing seasons based on grain yield.

GGE Biplot Analysis

GGE biplot analysis accounted for 55.72% (37.15% and 18.58%) in 2012/13, and 62.98% (33.06% and 29.92%) in 2013/14 for principal components [PCs] 1 and 2, respectively) of the total variation of the means over years. The relationships among traits based on genotypes (Figure 4), the relationship between genotype-traits and trait groupings (Figure 5), and ranking of genotypes based on trait means (Figure 6) were showed over mean of traits(2012/2013 season) in the biplot. The relationships among traits based on genotypes (Figure 6), the relationship between genotype-traits and trait groups (Figure 7), and ranking of genotypes on trait means (Figure 8) were showed over mean of traits (2013/2014 season) in the biplot. The total variation of 2013/14 was high than 2012/13 growing season.

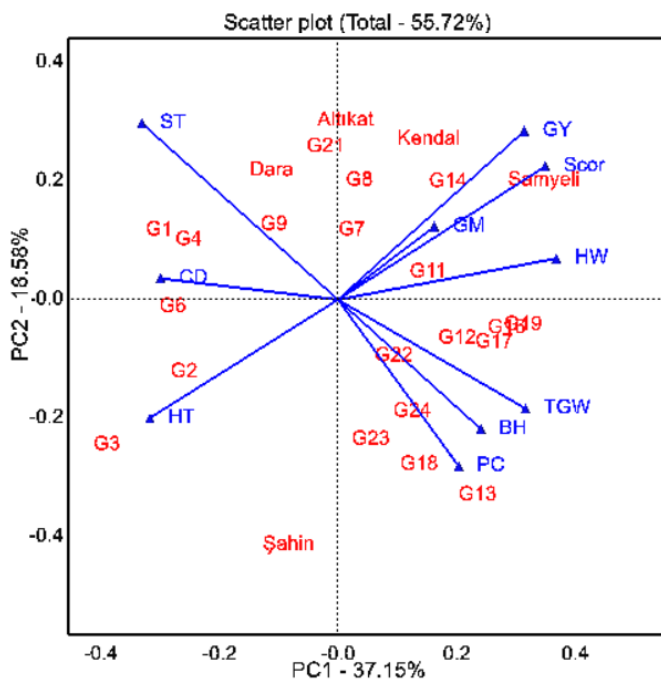


Figure 4. The relation among traits in 2012/13.

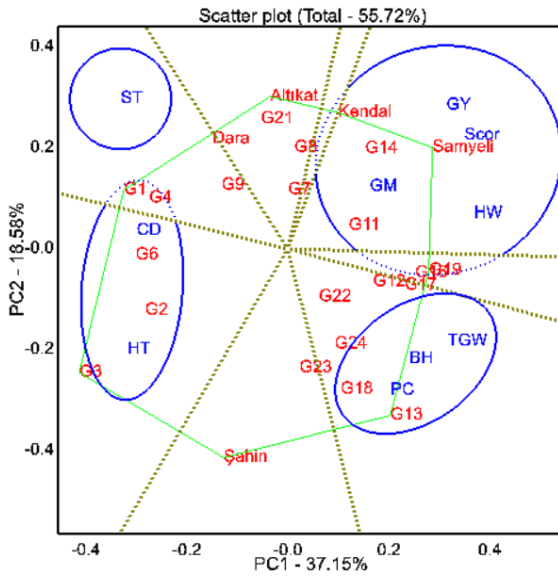


Figure 5. Relation of genotype-traits and grouping of traits in 2012/13.

The Relationship between Genotypes-Traits and Grouping of Traits

The angles of the vectors of the traits give information about the state of the relationship between the traits (Figure 4 and Figure 7). The biplot showed that there were high correlation among PC, PH, TGW and HW, GM, Score, GY, and CD, HT in 2012/13 (Figure 4), while among ST, GM, CD, PH and Score, GY and TGW, HW in 2013/14 (Figures 7). In both cultivation seasons, high and positive correlation between grain yield and scoring based on morphological observations in the field showed that scoring was very healthy. On the other hand, there were negative correlation among GY and HT, PC and showed that GY yield was decreased depend on high PC and late heading. In the 2012/13 normal growing season, there was a high positive correlation between grain yield and moisture content in the grain, whereas in the 2013/14 growing season when drought was effective, no relationship was detected. Because in this season, with the effect of drought, the moisture rates in the grain decreased and accordingly the grain yield decreased (Figure 4, Figure 7). An understanding of the relationship between genotypes and traits can aid in better understanding breeding objectives and in identifying traits that are

positively or negatively correlated with genotypes. This helps to visualize the strengths and weaknesses of genotypes, which is important for both parental and cultivar selection [26, 27, 28].

The sector analysis gives information about the relationship between the traits and genotypes-traits (Figure 5 and Figure 8). The biplot showed that it was occurred 8 sector based on genotype- traits, and 4 group among traits first group (PC, PH, TGW), second group (HW, GM, Scor, GY), and third group (CD, HT), and fourth group (only ST) in 2012/13 (Figure 4), while it was occurred eight sector and five group in the second season and first group (among ST, GM, CD, PH), and second group (Scor, GY), and third group (TGW, HW), and HT and PC independently formed fourth 4th and 5th. groups in 2013/14 which there were late frost and drought affect season (Figures 7). Moreover, the G11, G14 Kendal and Samyeli genotypes and HW, GM, Score, GY traits took placed in same sector in 2012/13 growing season (Figure 5), while only G3 and GY and score took placed in same sector in 2013/14 growing season (Figure 8). In both cultivation seasons, there was high and positive correlation between grain yield and scoring based on morphological observations in the field, and it was showed that scoring was very healthy observed. On the other hand, there were negative correlation among GY and HT, PC and showed that GY yield was decreased depend on high PC and late heading. In the 2012/13 normal growing season, there was a high positive correlation between grain yield and moisture content in the grain, whereas in the 2013/14 growing season when drought was effective, no relationship was detected. Because in this season, with the effect of drought, the moisture rates in the grain decreased and accordingly the grain yield decreased (Figure 5, Figure 8). Thus, the biplot showed excellent discriminating ability in selecting specific genotypes with particular traits and in recommending genotypes for their traits [1, 29].

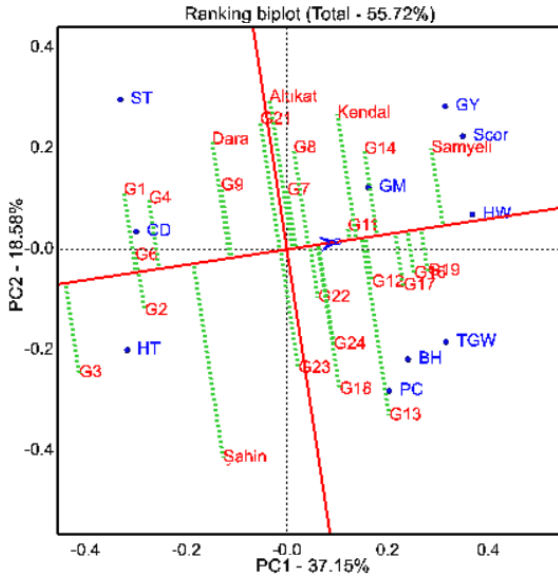


Figure 6. Ranking of genotypes based on means of traits in 2012/13.

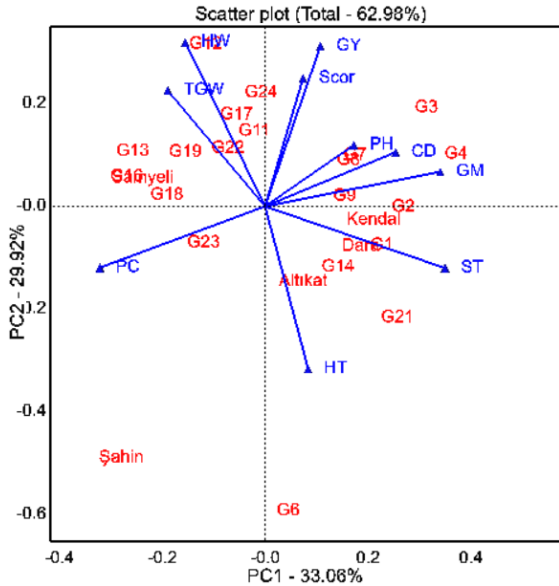


Figure 7. The relation among traits in 2013/14.

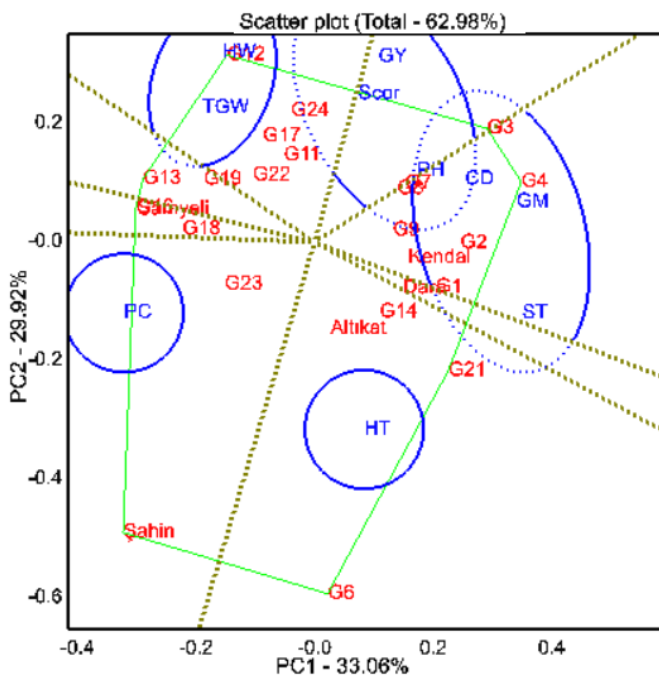


Figure 8. Relation of genotype-traits and grouping of traits in 2013/14.

Ranking and Comparison of Genotypes–Traits

The ranking analysis give information about the stability, ideal and undesirable genotypes based on mean of traits values by occurring a stability and mean line. The genotype with both high mean and stability for traits is called an ideal genotype, and should have both high mean performance and high stability for all traits (Figures 6, Figure 9). The ranking of genotypes based on trait means in the 2012/2013 season (Figure 6) showed that G11 and G19 and Samyeli were ideal genotypes, some other genotypes (G12, G7, G8, and G24) were favorable, as they were above the mean of trait axis. Other genotypes (G2, G3, G1, G4 and Şahin) were not desirable, as they were under mean of trait axis. On the other hand; G1 and G6 were stable, because of these two genotypes took places near of the stability line axis. While the ranking of genotypes based on trait means in the 2013/2014 season (Figure 9) showed that G3 and G4 and G2 were ideal genotypes, some genotypes (G1, G17, Kendal, and G24) were

favorable, as they were above the mean of trait axis. Other genotypes (G6, Şahin, G13 and G18) were not desirable, as they were under mean of trait axis. On the other hand; G7 and 23 were stable, because of these two genotypes took places near of the stability line axis. As can be seen from the figures (Figure 6, Figure9), while different genotypes appear stable in terms of stability in both growing seasons, it is possible to say that this situation is entirely due to ecological differences between the growing seasons. It is possible to say the same for ideal genotypes for exam: G14 and Samyeli desirable for 2012/13, while Kendal and G12 for 2013/14 season. When comparing both cultivation seasons, G3 is actually the best example, while it is not preferred, when the conditions are favorable (2012/13 cultivation season) and it is not preferred, when the conditions were stressful (2013/14 cultivation season), and it became the most ideal genotype. Some researchers reported that the genotype with both high mean performance and high stability for all of the traits was called an ideal genotype [28, 30, 31, 32, 33].

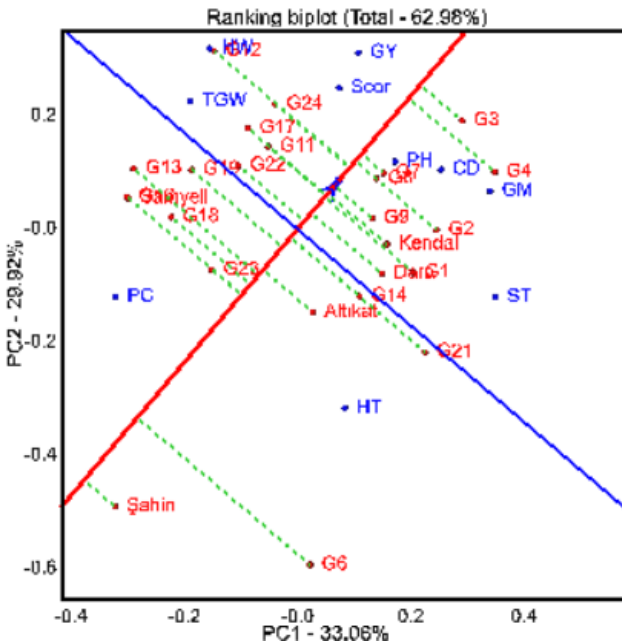


Figure 9. Ranking of genotypes based on means of traits in 2013/14.

CONCLUSION

In the study, the effects of late spring frost and drought were investigated based on grain yield (GY) and quality of spring barley genotypes. Grain yield (GY), test weight (TW), thousand grain weight (TGW) traits were affected negatively from late spring frost and drought, but protein content (CP) was affected positively from late spring frost and drought. Also, the results of the study indicated that late spring frost has adversely affect to early heading genotypes were more from, compared to late maturing genotypes. Moreover; AMMI and GGE biplot analysis showed that the stable and desirable spring genotypes can be definite based on grain yield, quality and other traits, for the Southe-astern Anatolia Region in Turkey. The results showed that G7, G8, G19 and Samyeli variety are the best for normal conditions, whereas G3 and G4 can be recommended for stress conditions. On the other hand, G22 can also be recommended as an ideal genotype across all traits. The AMMI and GGE biplot analysis provided useful results and high image quality to study stress conditions and define both specific and general recommendations for breeders in barley breeding program.

ACKNOWLEDGMENTS

This study was carried within the scope of “Southeastern Anatolia Region Cool Season Cereals Research Project (TAGEM/TBAD/A12/P05/008)”and author want to thanks to director of this Institute. The project was supported financially by General Directorate of Agricultural Research and Policy (TAGEM), Turkish Ministry of Agriculture, Forest and Livestock.

REFERENCES

- [1] Kendal, E; Sayar, MS; Tekdal, S; Aktas, H; Karaman. M. Assessment of the impact of ecological factors on yield and quality parameters in triticale using GGE biplot and AMMI analysis. *Pak. J. Bot.*, 48(5), 1903-1913, 2016.
- [2] Fiust, A; Rapacz, M. Down regulation of three novel candidate genes is important for freezing tolerance of field and laboratory cold acclimated barley. *Journal of plant physiology*, 244, 153049, 2020.
- [3] Frederiks, TM; Christopher, JT; Fletcher, SHE; Borrell, AK. Post head-emergence frost resistance of barley genotypes in the northern grain region of Australia. *Crop and Pasture Science*, 62(9), 736-745, 2011.
- [4] Asadi, A; Askary Kelestanie, AR; Gholi Mirfakhraii, SR; Abasi, AR. Genetic Variation of the 20 Bread Wheat Cultivars under Chilling Stress by Using GGE Biplot Analysis. *Int. J. of Agr. and Plant Prod.*, 4 (4), 696-706, 2013.
- [5] Frederiks, TM; Christopher, JT; Sutherland, MW; Borrell, AK. Post-head-emergence frost in wheat and barley: defining the problem, assessing the damage, and identifying resistance. *Journal of Experimental Botany*, 66(12), 3487-3498, 2015.
- [6] Visioni, A; Tondelli, A; Francia, E; Pswarayi, A; Malosetti, M; Russell, J; Comadran, J. Genome-wide association mapping of frost tolerance in barley (*Hordeum vulgare* L.). *BMC genomics*, 14(1), 424, 2013.
- [7] Martino, DL; Abbate, PE. Frost damage on grain number in wheat at different spike developmental stages and its modelling. *European Journal of Agronomy*, 103, 13-23, 2019.
- [8] Fitzgerald, GJ; Perry, EM; Flower, KC; Callow, JN; Boruff, B; Delahunty, A; Nuttall, J. Frost damage assessment in wheat using spectral mixture analysis. *Remote Sensing*, 11(21), 2476, 2019.
- [9] SAS, Institute. *JMP Statistics*. Cary, NC, USA: SAS Institute, Inc., 707 p. 2002.
- [10] GenStat 12 release Edition, 2014.

- [11] Yan, W; Frégeau-Reid, J. Genotype by Yield*Trait (GYT) Biplot: a Novel Approach for Genotype Selection based on Multiple Traits. *Sci Rep.*, 8(1), 1-10, 2018.
- [12] Yan, W; Frégeau-Reid, J; Mountain, N; Kobler, J. Genotype and management evaluation based on genotype by yield* trait (GYT) analysis. *Crop Breeding, Genetics and Genomics*, 1(2), 2019.
- [13] GRDC. Tips and Tactics, Managing Frost Risk, GRDC, www.grdc.com.au/ManagingFrostRisk, 2016.
- [14] Kouchaki, AR; Sorkhilaleloo, B; & Hesari, ME. Yield stability of barley elite genotypes in cold regions of Iran using GGE biplot. *Seed and Plant Improvement Journal*, 28(4), 2012.
- [15] Hussain, HA; Hussain, S; Khaliq, A; Ashraf, U; Anjum, SA; Men, S; Wang, L. Chilling and drought stresses in crop plants: implications, cross talk, and potential management opportunities. *Frontiers in plant science*, 9, 393, 2018.
- [16] Wu, YF; Zhong, XL; Hu, X; Ren, DC; Lv, GH; Wei, CY; Song, JQ. Frost affects grain yield components in winter wheat. *New Zealand Journal of Crop and Horticultural Science*, 42(3), 194-204, 2014.
- [17] Visioni, A. Barley adaptation to stress prone environments (Doctoral dissertation, Universitat de Lleida), 2012.
- [18] Rebbeck, M; Knell. *Managing Frost Risk: A Guide for Southern Australian Grains*, GRDC, <https://grdc.com.au/Resources/Bookshop/2007/06/Managing-Frost-Risk-a-guide-for-southern-Australian-grains>, 2007.
- [19] Sallam, A; Alqudah, AM; Dawood, MF; Baenziger, PS; Börner, A. Drought stress tolerance in wheat and barley: advances in physiology, breeding and genetics research. *International journal of molecular sciences*, 20(13), 3137, 2019.
- [20] Oral, E; Kendal, E; Kilic, H. Dogan Yusuf. Evolution barley genotypes in multi-environment trials by AMMI model and GGE biplot analysis. *Fresenius Environmental Bulletin*, 28, 3186-3196, 2019.

- [21] Kilic, H; Kendal, E; Aktaş, H. Evaluation of yield and some quality characters of winter barley (*Hordeum vulgare* L.) genotypes using biplot analysis. *Agriculture & Forestry*, 64(3), 101-111, 2018.
- [22] Dessie, A; Zewdu, Z; Berie, A; Atnaf, M. GGE Biplot analysis of genotype x environment interaction of cold tolerant green super rice genotypes in Ethiopia. *International Journal of Research and Review*, 7(1), 300-305, 2020.
- [23] Kendal, E; Tekdal, S. AMMI model to assess durum wheat genotypes in multi-environment trials. *J. Agr. Sci. Tech.*, Vol. 20, 153-166, 2018.
- [24] Oral, E; Kendal, E; Dogan, Y. Selection the best barley genotypes to multi and special environments by AMMI and GGE biplot models. *Fresenius Envir. Bulletin*, 27(7), 5179-5187, 2018.
- [25] Kilic, H. Additive main effect and multiplicative interactions (AMMI) Analysis of grain yield in barley genotypes across environments, *J. Agr. Sc.*, 20, 337-344, 2014.
- [26] Nega, M. Effect of frost hazard on major crops grown in Banja Woreda, Awi Administrative zone, Amhara national regional state, North West Ethiopia (Doctoral dissertation), 2019.
- [27] Angessa, TT; Li, C. Frost tolerance and genetic improvement in barley. In *Exploration, Identification and Utilization of Barley Germplasm* (pp. 209-221). Academic Press., 2016.
- [28] Yan, W; Tinker, NA. Biplot analysis of multi-environment trial data; Principles and applications. *Canadian J. of P. Sci.*, 86, 623-645, 2006.
- [29] Miroslavlievic, M; Przulj, N; Bocanski, J; Stanisavljevic, D; Mitrovic. B. The application of AMMI model for barley cultivars evaluation in multi-year trials. *Genetika*, 46(2), 445-454, 2014.
- [30] Farshadfar, E; Rashidi, M; Jowkar, MM; Zali, H. GGE Biplot analysis of genotype × environment interaction in chickpea genotypes. *European J. of Exper. Biology*, 3(1), 417-423, 2013.
- [31] Kendal, E; Dogan Y. Stability of a candidate and cultivars (*Hordeum vulgare* L) by GGE Biplot analysis of multi-environment yield trials in spring barley. *Agriculture & Forestry*, 61(4), 307-318, 2015.

- [32] Kizilgeci, F; Mokhtari, NEP; Hossain, A. Growth and physiological traits of five bread wheat (*Triticum aestivum* L.) genotypes are influenced by different levels of salinity and drought stress. *Fresenius Environmental Bulletin*, 29, 8592-8599, 2020.
- [33] Kizilgeci, F; Albayrak, O; Yildirim, M. Evaluation of thirteen durum wheat (*Triticum durum* Desf.) genotypes suitable for multiple environments using GGE biplot analysis. *Fresenius Environmental Bulletin*, 28(9), 6873-6882, 2019.