Yuzuncu Yil University Journal of Agricultural Sciences, Volume: 33, Issue: 1, 31.03.2023

Yuzuncu Yil University
Journal of Agricultural Sciences
(Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi)
https://dergipark.org.tr/en/pub/yyutbd

ISSN: 1308-7576 e-ISSN: 1308-7584

Research Article

Exploring Adaptation Abilities of Barley Genotypes in Van Growing Conditions for Biomass and Grain Yield

**Sana SALIH*[1], Bulut ÖNGÜN[2], Burak ÖZDEMİR[3], Erol ORAL[4], Fevzi ALTUNER[5]
Şadiye DEMİR ATMACA[6], Mehmet ÜLKER[7]**

[1,2,3,4,6,7]Van Yuzuncu Yil University, Faculty of Agriculture, Field Crops Department, Van, Türkiye
[5]Van Yuzuncu Yil University, Gevaş MYO, Van, Turkey

[1]https://orcid.org/0000-0001-9937-1001, [2]https://orcid.org/0000-0002-9295-9838, [3]https://orcid.org/0000-0002-7766-4919
[4]https://orcid.org/0000-0001-9413-1092, [5]https://orcid.org/0000-0002-2386-2450, [6]https://orcid.org/0000-0003-4174-3778
[7]https://orcid.org/ 0000-0001-9419-2012

*Corresponding author e-mail: sanajsalih@gmail.com

Article Info

Received: 10.11.2022
Accepted: 28.01.2023
Online published: 15.03.2023
DOI: 10.29133/yyutbd.1199884

Keywords

Advanced lines of barley,
Barley cultivars,
Grain yield

Abstract: Discovering the variation among genotypes is an important criterion for selecting the suitable cultivar for a certain environment. The study aimed to explore the genetic variation among 17 genotypes of barley based on grain yield and some related traits. Plants were grown under field grown conditions in the 2019-2020 and 2020-2021 growing seasons, and plant height (PH), spike per square meter (SSM), spike length (SL), spikelets per spike (NSS), seed per spike (SPS), biological yield (BY), grain yield (GY), and thousand grain weight (TGW) were measured. Results indicated that PH ranged (51.7 to 81.33 cm) and (58.20 to 79.90 cm), SSM (374 to 582) and (418 to 701), SL (7.10 to 9.63 cm) and (6.87 to 9.13 cm), NSS (9 to 15) and (8 to 17), SPS (21 to 49) and (21 to 51), BY (3466.7 to 5905.3 kg h^{-1}) and (3731.7 to 6080 kg h^{-1}), GY (1442 to 2192 kg h^{-1}) and (811.8 to 1763.7 kg h^{-1}), TGW (34 to 55.67 g) and (33.47 to 52.63 g) for the first and second year of experiment respectively. The advanced lines measurement values were higher in the second year of the experiment. It can be concluded that the advanced lines Anka-08 and Anka-11 are promising in most of the parameters. Some of the old and new cultivars still preserve their yield potential.

To Cite: Salih, S, Öngün, B, Özdemir, B, Oral, E, Altuner, F, Demir Atmaca, Ş, Ülker, M, 2023. Exploring Adaptation Abilities of Barley Genotypes in Van Growing Conditions for Biomass and Grain Yield. *Yuzuncu Yil University Journal of Agricultural Sciences*, 33(1): 91-99. DOI: https://doi.org/10.29133/yyutbd.1199884

1. Introduction

Barley is one of the oldest cereal crops still in use today. It is ranked among the important cereal crops around the world, it comes after maize, wheat, and rice in production quantity and cultivation area (FAO, 2022). World barley production was more than 157 million tons in 2020, about 7.73 million tons was produced in Turkey (FAO, 2022). Various morphological variations of the crop, such as two-row or six-row and diverse colours are currently available (black, blue, purple or yellow). Plants can also be different in hulls, with or without, which can be used to distinguish varieties (Biel et al., 2020). As reported by Sullivan et al. 2013, the whole grain of barley contains about 70% starch, protein 10 to 20%, 2 to 3% lipids, about 2.5% minerals, soluble dietary 3 to 20%, and 11 to 34% dietary fibres. Thus, barley come to be an essential ruminant cereal grain feed around the world, directly for meat cattle and after processing to increase milk production (Güney, 2019).

Based on the growth habits of the crops, barley classified into three categories; winter, spring, and alternative (or facultative). Winter barley requires to be vernalized for a period of time to initiate flowering, also sensitive to photoperiod which delays flowering after cold conditions pass (Cuesta-Marcos et al, 2016). Winter barley may be grown in double-cropping or intercropping systems with a summer annual cash crop like soybeans since it is often harvested sooner than winter wheat in some regions. The capacity of winter barley to assist the economy and the environment depends on how well it can withstand the winter and deliver adequate amount of high-quality grain (Zhong et al., 2019). Spring types do not need vernalization to start flowering and sown in spring. Facultative genotypes, on the other hand, do not require vernalization but can still survive under cold temperatures, and can be planted in spring or autumn (Cockram et al., 2015).

Considering climate change, the development of sustainable agriculture and food security still depends on efforts to find suitable barley cultivars carrying yield-improving traits in varied climates. Therefore, it was aimed in this experiment, to evaluate some barley cultivars, and advanced lines of barley under rainfed conditions to explore adaptability to Van climate for biomass and grain yield potential.

2. Material and Methods

2.1. Site, plant material, and experimental design

During the growing season of 2019-2020, 2020-2021, barley genotypes were planted at the experimental field of the Field Crops Department, Van Yuzuncu Yil University (38°33’46.3” N 43°17’54.7” E, 1725 a.s.l). As a plant material, 13 varieties and 4 advanced lines were used, a brief description of the genotypes is presented in Table 1.

Table 1. Description of the genotypes

Genotype		Row type	Growth habit	Producer	Registration year
Akar	G1	2 rows	winter-alternative	CRIFC-2012	CRIFC-2012
Anka-06	G2	2 rows	winter	CRIFC-2019	CRIFC-2019
Anka-08	G3	2 rows	alternative	CRIFC	-
Anka-09	G4	2 rows	winter	CRIFC	-
Anka-10	G5	2 rows	winter	CRIFC	-
Anka-11	G6	2 rows	alternative	CRIFC	-
Asil	G7	2 rows	winter	CRIFC-2019	CRIFC-2019
Avci 2002	G8	6 rows	winter	CRIFC-2002	CRIFC-2002
Aydanhanim	G9	2 rows	winter	CRIFC-2002	CRIFC-2002
Bozlak	G10	2 rows	winter	CRIFC-2018	CRIFC-2018
Burakbey	G11	2 rows	alternative	CRIFC-2013	CRIFC-2013
Cacabey	G12	2 rows	winter	CRIFC-2019	CRIFC-2019
Cetin 2000	G13	6 rows	winter	CRIFC-2000	CRIFC-2000
Larende	G14	2 rows	alternative	BDIARI-2006	BDIARI-2006
Olgun	G15	6 rows	winter	EAARI-2011	EAARI-2011
Tarm-92	G16	2 rows	alternative	CRIFC-1992	CRIFC-1992
Tosunpasa	G17	2 rows	winter	CRIFC-2016	CRIFC-2016

BDIARI: Bahri Dağdaş International Agricultural Research Institute, CRIFC: Central Research Institute of Field Crops, EAARI: Eastern Anatolia Agricultural Research Institute.

The meteorological data of the experiment location is described in Table 2. The trial was established as a randomized complete block design with three replications and plots of 6 m^2 (6 seed rows 5 m long and 1.2 m wide). The sowing rate was adjusted based on thousand grain weight of each genotype to achieve plant population of 500 plants per square meter. Fertilizers were added to each plot at rate of 80 kg h^{-1} P_2O_5 and 100 kg h^{-1} N.

Table 2. Meteorological data of trial site

Month	Average Temperature (°C)		Total Rainfall (mm)		Average Humidity (%)	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
September	18.8	20.1	0.8	5.6	42.7	41.3
October	13.4	13.3	24.1	1.8	32.9	53.0
November	5.2	6.7	22.9	12.8	48.2	65.4
December	3.0	1.4	46.7	30.7	51.3	71.5
January	-1.7	-0.7	31.1	15.7	59.5	67.2
February	-1.5	0.8	21.3	18.0	63.8	73.3
March	2.7	3.7	24.4	53.6	63.4	66.9
April	7.0	11.7	36.2	12.1	56.1	48.8
May	15.2	16.7	15.3	22.7	51.9	46.4
June	21.0	21.6	7.2	18.6	45.4	32.0
Total			229.9	191.6		

2.2. Trait measuring and data analysis

Represented sample of each genotype was taken at maturity from the plots' middle rows. The measured traits were Plant height (PH cm), Number of spikes per square meter (SSM), Spike length (SL cm), Number of spikelets per spike (NSS), Number of seeds per spike (SPS), Biological yield (BY t h^{-1}), Grain yield (GY t h^{-1}), and Thousand grain weight (TGW g). Separate (Table 3) and combined (Table 4) statistical analyses of the years were performed with COSTAT. Analysis of Variance and significance of mean values were tested by least significant difference test (LSD) using at significance level of $p < 0.05$.

3. Results and Discussion

Analysis of main effects of genotypes (G), year (Y), and two-way interactions of genotype x year (G x Y) showed significant differences in some parameter (Table 3, 4). A wide variation in the examined genotypes was detected for most of the studied traits, PH, SL, NSS, SPS, BY, GY, and TGW were significant in both experiment years, only SSM was significant in the second year of experiment. Furthermore, across year combined analysis of variance for studied traits across years indicates significant G x Y interaction on the SL, NSS, and BY.

Table 3. First and second year mean squares for studied traits

Source of variance	df	Mean squares							
		PH		SSM		SL		NSS	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Blocks	2	1226.57***	33.04 ns	5870.13 ns	536.01 ns	0.29 ns	0.11 ns	1.58 ns	2.33 ns
Genotypes	16	179.23***	140.73***	7037.14 ns	17605.54***	1.59***	1.86 ***	7.96***	21.54***
Error	32	44.59	35.67	5183.65	3876.29	0.31	0.42	0.7	1.67
CV (%)		9.71	8.31	15.03	11.77	6.74	7.71	6.67	11.57

Source of variance	df	Mean squares							
		SPS		BY		GY		TGW	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Blocks	2	16.34 ns	23.91 ns	34655.21***	9984.37 ns	11778.60***	933.55 ns	237.80***	2.26 ns
Genotypes	16	237.80***	176.09***	9999.88***	21286.37**	1728.84*	2712.35***	103.91***	92.91***
Error	32	21.13	11.43	2491.42	5930.81	832.99	499.36	4.75	5.82
CV (%)		16.11	11.16	11.36	15.98	15.69	17.47	4.67	5.48

PH: plant height, SSM: number of spike per square meter, SL: spike length, NSS: number of spikelets per spike, SPS: number of seeds per spike, BY: biological yield, GY: grain yield, TGW: thousand grain weight (g), CV (%): coefficient of variation.

Table 4. Mean square combined analysis data for variance of studied traits in barley genotypes

Source of Variance	Mean squares								
	df	PH	SSM	SL	NSS	SPS	BY	GY	TGW
Genotypes	**16**	267.54***	19112.65***	2.56***	23.40***	406.06***	19287.68***	2934.38**	176.64***
Year	**1**	251.16 ns	63450.35***	0.43 ns	55.07***	78.88*	46408.53**	80161.31***	184.27***
G x Y	**16**	52.42 ns	5530.04 ns	0.89 **	6.09***	7.82 ns	11998.58*	1506.81 ns	20.18 ns
Error	**68**	74.82	4451.92	0.35	1.23	16.51	5276.3362	1000.8766	12.03
CV (%)		12.3	13.24	7.15	8.34	13.81	15.77	20.29	7.65

PH: plant height, SSM: number of spike per square meter, SL: spike length, NSS: number of spikelets per spike, SPS: number of seeds per spike, BY: biological yield, GY: grain yield, TGW: thousand grain weight (g), CV (%): coefficient of variation.

3.1. Plant height (PH)-cm

Genotypes had a significant effect on PH in both years of experiment, while the G x Y interaction was non-significant (Table 3). The average value of PH ranged 54.63 cm (Anka-09) to 79.78 cm (Olgun) for both years (Table 7). Plants of the varieties Olgun and Tosunpasa were the tallest (81.33 cm) in the first year, whereas the advanced line Anka-08 (79.90 cm), the varieties Akar (79.40 cm) and Aydanhanim (78.37 cm) produced the tallest plant in the second year. Anka-09 had the lowest value of plant height in both years (51.07 cm and 58.20 cm) (Table 6). Most of the varieties had tall plants in the second year compare to the first year. The mean value of the parameter's variation of both years was 3.14 cm (Table 7). The highest variation was detected in Anka-08 (12.57 cm) whereas the lowest variation was in Cetin 2000 (1.03 cm). Variation among barely genotypes in PH was reported by a number of previous studies. The genotypes showed variation in PH. Ahmadi et al. (2016) mentioned a significant effect of genotypes and G x Y interaction on PH, and the barley advanced lines were superior.

3.2. Number of spike per square meter (SSM)

Genotypes had a significant effect on SSM only in the second year, whereas the G x Y interaction was non-significant (Table 3). The advanced line Anka-08 and the variety Asil had the highest mean value of SSM (593 and 592 spikes), respectively, Anka-06 had the lowest mean value of SSM (396 spikes) (Table 7). The variety Asil had the highest SSM in the first year (582 spikes) and Anka-08 had 701 spikes in the second year. The lowest SSM was from the advance line Anka-06 (374 and 418 spike) in both years, respectively. SSM value was higher in the second year compare to the first year for all the genotypes except Akar and Calabey (Table 5). The yearly variation for genotypes was 49.88 spikes. The highest variation was observed in Anka-08 (215 spikes) and the lowest variation in SSM was 6 spikes form Calabey (Table 7). Mirosavljević et al. (2020) found a significant effect of G, Y, and G x Y interaction. The highest value they obtained range from 406-442. Lower values of SSM were gained by Dorostkar et al. (2015), 95.25 to 233.00.

3.3. Spike length (SL)-cm

A significant effect of genotypes and G x Y interaction on SL was detected in both years of experiment (Table 3). The yearly SL mean value of the variety Asil was the highest (9.38 cm) and the highest value among the advanced lines was from Anka-06 (9.00 cm), whereas the lowest yearly SL mean value was 7.10 cm from Avci 2002(Table 7). The tallest spikes were produced by Asil (9.63 cm) in the first year, and in the second year most of the genotypes were within the same statistical group at the range of 8.53 cm (Anka-08 and Anka-10) to 9.17 cm (Tosunpasa). The minimum SL value was 7.10 cm from Olgun in the first year and 6.87 cm from Avci 2002 in the second year (Table 5). The variation in SL for both years was 0.31 cm. Experiment year had the most effect on the genotype Anka-08 (0.84 cm) and the lowest effect was 0.01 cm from the genotype Akar (Table 7). Our results were similar to Güngör et al. (2022) who obtained a significant effect of G, Y, and G x Y interaction on SL. Moreover, the SL value recorded in Mirosavljevıć et al. (2016) experiment was close to our findings, 9.9 cm. The range of SL reported by Ahmadi et al. (2016) was 5 to 12.30 cm with a mean value of 8.14 cm, which is lower than the SL in our experiments.

3.4. Number of spikelets per spike (NSS)

NSS was affected significantly by genotypes and the G x Y interaction in both years of the experiment (Table 3). The mean value for both years and it was in the range of 9 (Avci 2002) to 15 (Akar, Anka-06, Asil, Aydanhanim, Bozlak, and Burakbey) (Table 7). The heights NSS value was 15 for Asil and Burakbey in the first year and 17 for Aydanhanim in the second year. The lowest NSS value was from the genotype Avci 2002 (9 and 8 spikelets) for both years, respectively (Table 5). Differences among the genotypes in both years for NSS was 1.53, the genotypes Calabey, Catin 2000 and Tusunpasa were most affected genotypes by years (4 spikelets), whereas the genotype Burakbey was not affected by years (Table 7). Güngör et al. (2022) stated a significant effect of G, Y, and their interaction. The value of NSS they obtained was higher than our result, ranged from 16.4 to 20.3.

3.5. Number of seed per spike (SPS)

SPS was affected by genotypes in both years, whereas the G x Y interaction was non-significant (Table 3). The SPS was in the range of 21 (Anka-9) to 50 (Olgun) SPS (Table 7). In the first year, the genotype Olgun had the highest SPS (49 seeds) and it was in the same statistical group with Avci 2002 (46 seeds) and Catin 2000 (44 seeds), the genotype Olgun had the highest value of the parameter in the second year (51 seeds). The minimum obtained SPS was 21 seeds from Anka-09 and Tarim-92 in the first year, and 21 seeds obtained from Anka-09 in the second year (Table 5). The yearly variation was 1.88 seeds, the genotypes Avci 2002, Aydanhanim, Calabey, and Larende were the most affected (4 seeds), whereas Anka-09 and Burakbey showed no variation (Table 7). Mirosavljević et al. (2020) found a significant effect genotypes on SPS, with a range value of 48.3-53.1 to 49.8-54.5. However, their research indicated a significant effect of year and G x Y interaction on SPS. Ahmadi et al. (2016) obtained a mean value of 36.79 and Güngör et al. (2022) obtained 34.2 to 59.6 SPS, which are close to our findings.

Table 5. Year 1 and year 2 values of Plant height (cm), Spikes per square meter, Spike length (cm), Number of spikelets per spike, and Number of seeds per spike of barely genotypes

Genotypes	PH (cm)		SSM		SL (cm)		NSS		SPS	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
AKAR	74.73 ab	79.40 a	486	452 fgh	8.96 abcd	8.97 a	14 ab	16 ab	27 bc	28 c
ANKA-06	62.23 cd	71.77 abcde	374	418 h	9.07 abc	8.93 a	14 ab	16 a	27 bc	29 c
ANKA-08	67.33 bcd	79.90 a	486	701 a	7.69 efgh	8.53 a	12 cdef	14 bc	22 bc	25 cd
ANKA-09	51.07 e	58.20 g	466	513 cdefgh	7.41 fgh	7.10 c	11 efg	12 c	21 c	21 d
ANKA-10	59.93 de	64.70 efg	497	592 bcd	8.17 cdefg	8.53 a	12 efg	15 ab	22 bc	25 cd
ANKA-11	67.33 bcd	73.20 abcde	509	532 cdefg	8.37 cde	8.33 ab	13 abc	15 ab	25 bc	27 cd
ASIL	72.23 abc	75.73 abcd	582	602 abc	9.63 a	9.13 a	15 a	16 ab	29 b	30 c
AVCI 2002	67.13 bcd	59.07 fg	422	465 efgh	7.34 gh	6.87 c	9 h	8 d	46 a	42 b
AYDANHANIM	74.47 ab	78.37 a	459	513 cdefgh	8.39 cde	8.87 a	14 ab	17 a	26 bc	30 c
BOZLAK	74.60 ab	68.37 bcdef	448	460 efgh	8.31 cdef	8.73 a	14 ab	16 ab	26 bc	28 c
BURAKBEY	69.87 bcd	71.57 abcde	538	562 bcde	9.33 ab	8.37 ab	15 a	15 ab	27 bc	27 cd
CALABEY	68.80 bcd	75.03 abcd	501	495 defgh	8.07 defg	8.73 a	12 defg	16 ab	24 bc	28 c
CETIN 2000	67.13 bcd	66.10 defg	433	443 gh	8.91 abcd	7.33 bc	13 bcd	9 d	44 a	44 b
LARENDE	59.75 de	67.60 cdefg	452	503 cdefgh	7.72 efgh	9.10 a	12 defg	15 ab	22 bc	26 cd
OLGUN	81.33 a	78.23 ab	460	553 cdef	7.10 h	7.15 c	11 g	10 d	49 a	51 a
TARM-92	68.67 bcd	77.57 ab	508	658 ab	7.77 efgh	9.10 a	11 fg	14 bc	21 c	26 cd
TOSUNPASA	81.33 a	76.50 abc	520	527 cdefg	8.49 bcde	9.17 a	12 cde	16 a	26 bc	29 c
%CV	9.70	8.30	15.00	11.70	6.70	7.70	6.69	9.20	16.10	11.10

PH: plant height, SSM: number of spike per square meter, SL: spike length, NSS: number of spikelets per spike, SPS: number of seeds per spike. Numbers with no letter indicated non-significant differences. The same letter means non-significant differences between groups, whereas different letters indicate significant differences between groups.

3.6. Biological yield (BY)-t h^{-1}

The effect of genotypes and the G x Y interaction on BY was significant in the first and second year (Table 3). The maximum yearly BY value was obtained from Olgun (5.91 t h^{-1}), whereas the minimum value was form Anka-09 (3.47 t h^{-1}) (Table 8). In the first year, Olgun produced the highest

BY (5.91 t h^{-1}), while in the second year Asil (6.08 t h^{-1}), Anka-11 (6.00 t h^{-1}), Olgun (5.86 t h^{-1}) and Calabey (5.73 t h^{-1}) gave the highest BY value (Table 6). The lowest BY was 3.47 t h^{-1} obtained from Anka-09 and 3.73 t h^{-1} obtained from Avci 2002, for year one and two, respectively. BY was varied between years (0.43 t h^{-1}), Ails was the most affected by years with a value of 2.44 t h^{-1} variation in BY, while the variation was 0.05 t h^{-1} in Olgun (Table 8). Dorostkar et al. (2015) found variation among the tested genotypes, the values of BY ranged 523.3 to 770 g m^2. In addition, Saroei et al. (2017) results were 0.40 to 2.10 t h^{-1} BY from 42 different barley varieties.

3.7. Grain yield (GY)-t h^{-1}

GY was significantly affected by genotypes, while the G x Y interaction was non-significant (Table 3). GY average of years was in the range of 1.21 t h^{-1} (Anka-09) to 1.97 t h^{-1} (Akar) (Table 8). In the first year, Akar (2.19 t h^{-1}) and Tarim-92 (2.17 t h^{-1}), produced the highest grain, and Anka-06 (1.76 t h^{-1}), Akar (1.76 t h^{-1}), and Olgun (1.71 t h^{-1}) in the second experiment year. The lowest GY was 1.44 t h^{-1} produced from the genotype Catin 2000, and 0.81 t h^{-1} from Anka-09 in the first and second year, respectively (Table 6). Variation in GY for both years was 0.56 t h^{-1}, the genotype Tarim 92 was the most affected (1.22 t h^{-1}), and Asil GY had the lowest reduction (0.08 t h^{-1}) (Table 8). Our results suggested that GY of the varieties were higher than the advanced lines. In contrast, Beşer et al. (2019) mentioned that the GY of the advanced lines they studied were higher than the standard varieties. Furthermore, Erol et al. (2017) concluded that some barely lines obtained from CIMMYT were promising in terms of grain yield compare to varieties. The yield of Tarim-92 was higher than other varieties as Ertuş (2021) indicated when comparing barley varieties. The values ranged from 1.82 to 2.43 t h^{-1}. In contrast, Kılıç et al. (2010) reported higher GY obtained from Aydanhanim (4.56 t ha^{-1}).

Table 6. Year 1 and year 2 values of Biological yield (t h^{-1}), Grain yield (t h^{-1}), and Thousand grain weight (g) of barely genotypes

Genotypes	BY (t h^{-1})		GY (t h^{-1})		TGW (g)	
	Y1	Y2	Y1	Y2	Y1	Y2
AKAR	5.21 ab	5.42 ab	2.19 a	1.76 a	49.67 bcde	46.93 bcde
ANKA-06	4.55 bcd	5.19 abc	1.89 abcde	1.76 a	48.00 de	50.10 ab
ANKA-08	4.43 bcde	4.87 abcd	2.10 ab	1.24 bcde	50.17 bcd	52.63 a
ANKA-09	3.47 f	3.80 d	1.61 cde	0.81 f	47.17 de	42.57 fg
ANKA-10	4.50 bcd	3.96 cd	1.72 abcde	0.87 ef	48.17 cde	48.07 bcd
ANKA-11	4.11 cdef	6.00 a	1.75 abcde	1.23 cde	55.67 a	44.07 def
ASIL	3.64 ef	6.08 a	1.46 de	1.53 abc	42.50 f	36.23 hi
AVCI 2002	4.47 bcd	3.73 d	1.60 cde	1.30 bcd	35.50 gh	39.43 gh
AYDANHANIM	3.80 def	5.09 abc	1.68 bcde	1.25 bcd	47.00 de	44.23 def
BOZLAK	4.58 bcd	3.97 cd	1.78 abcde	1.12 def	48.33 cde	45.30 cdef
BURAKBEY	4.15 cdef	3.99 cd	1.82 abcde	1.07 def	46.33 e	42.37 fg
CALABEY	4.47 bcd	5.73 a	1.97 abc	1.31 bcd	51.67 bc	49.67 ab
CETIN 2000	4.15 cdef	4.36 bcd	1.44 e	1.14 def	38.33 g	34.10 i
LARENDE	4.08 cdef	3.76 d	1.93 abcd	1.07 def	52.50 ab	48.63 abc
OLGUN	5.91 a	5.86 a	2.14 ab	1.71 a	34.00 h	33.47 i
TARM-92	4.86 bc	4.80 abcd	2.17 a	0.96 def	49.67 bcde	46.80 bcde
TOSUNPASA	4.30 cde	5.31 ab	2.01 abc	1.61 ab	48.83 cde	43.20 efg
%CV	1.10	1.60	1.60	1.70	4.60	5.40

BY: biological yield, GY: grain yield, TGW: thousand grain weight (g). Numbers with no letter indicated non-significant differences. The same letter means non-significant differences between groups, whereas different letters indicate significant differences between groups.

3.8. Thousand grain weight (TGW)-g

The effect of genotypes was significant on TGW, whereas the G x Y interaction was non-significant (Table 3). The mean TGW was in the range of 33.73 (Olgun) to 51.40 g (Anka08) for both years (Table 8). The maximum TGW in the first year was from Anka-11 (55.67 g) and Anka-08 (52.63 g) in the second year. The minimum value was 34 g from Olgun in the first year, and 33.47 g from Olgun and 34.10 g from Cetin 2000 in the second year (Table 6). TGW was affected by years, 2.69 g, the Anka-

11 showed reduction in TGW by 11.6 g, while the reduction was 0.1 g in Anka-10. These indicates that TGW of modern varieties was higher in the new varieties compare to old varieties of barley (Table 8). Kılıç et al. (2010) stated that only genotypes had an effect on TGW, and Y and G x Y effect is non-significant. Vasilescu et al. 2022 examined varieties of three periods starting from 1952 until 2019. They reported that TGW mean value of the new varieties was higher, 44.14 g, compared to the old varieties, 42.01 g. Moreover, Ay et al. (2018) stated a genotypic, environment and their interaction effect TGW, and the highest value was 65.75 g which is higher than our TGW values.

Table 7. Year 1 and year 2 mean values and year variation of Plant height (cm), Spikes per square meter, Spike length (cm), Number of spikelets per spike, and Number of seeds per spike of barely genotypes

Genotypes	PH		SSM		SL		NSS		SPS	
	Y1-Y2 average	Year variation	Y1-Y2 average	Year variation	Y1-Y2 average	Year variation	Y1-Y2 average	Year variation	Y1-Y2 average	Year variation
AKAR	77.07	4.67	469.00	-34.00	8.96	0.01	15	2	28	1
ANKA-06	67.00	9.54	396.00	44.00	9.00	-0.14	15	2	28	2
ANKA-08	73.62	12.57	593.00	215.00	8.11	0.84	13	2	23	3
ANKA-09	54.63	7.13	490.00	47.00	7.25	-0.31	12	1	21	0
ANKA-10	62.32	4.77	544.00	95.00	8.35	0.36	13	3	24	3
ANKA-11	70.27	5.87	520.00	23.00	8.35	-0.04	14	2	26	2
ASIL	73.98	3.50	592.00	20.00	9.38	-0.50	15	1	29	1
AVCI 2002	63.10	-8.06	444.00	43.00	7.10	-0.47	9	-1	44	-4
AYDANHANIM	76.42	3.90	486.00	54.00	8.63	0.48	15	3	28	4
BOZLAK	71.48	-6.23	454.00	12.00	8.52	0.42	15	2	28	2
BURAKBEY	70.72	1.70	550.00	24.00	8.85	-0.96	15	0	27	0
CALABEY	71.92	6.23	498.00	-6.00	8.40	0.66	14	4	26	4
CETIN 2000	66.62	-1.03	438.00	10.00	8.12	-1.58	11	-4	44	0
LARENDE	63.67	7.85	478.00	51.00	8.41	1.38	13	3	24	4
OLGUN	79.78	-3.10	507.00	93.00	7.13	0.05	10	-1	50	2
TARM 92	73.12	8.90	583.00	150.00	8.44	1.33	12	3	23	5
TOSUN PASA	78.92	-4.83	523.00	7.00	8.83	0.68	14	4	27	3
Mean		3.14		49.88		0.13		1.53		1.88

* The (-) indicates a reduction in the parameter value.

Table 8. Year 1 and year 2 mean values and year variation of Biological yield (t h^{-1}), Grain yield (t h^{-1}), and Thousand grain weight (g) of barely genotypes

Genotypes	BY		GY		TGW	
	Y1-Y2 average	Year variation	Y1-Y2 average	Year variation	Y1-Y2 average	Year variation
AKAR	5.31	0.21	1.97	-0.44	48.30	-2.74
ANKA-06	4.87	0.64	1.83	-0.13	49.05	2.10
ANKA-08	4.65	0.43	1.67	-0.86	51.40	2.46
ANKA-09	3.64	0.34	1.21	-0.79	44.87	-4.60
ANKA-10	4.23	-0.54	1.30	-0.85	48.12	-0.10
ANKA-11	5.05	1.88	1.49	-0.52	49.87	-11.60
ASIL	4.86	2.44	1.49	0.08	39.37	-6.27
AVCI 2002	4.10	-0.74	1.45	-0.30	37.47	3.93
AYDANHANIM	4.44	1.29	1.46	-0.43	45.62	-2.77
BOZLAK	4.28	-0.61	1.45	-0.66	46.82	-3.03
BURAKBEY	4.07	-0.15	1.45	-0.75	44.35	-3.96
CALABEY	5.10	1.26	1.64	-0.66	50.67	-2.00
CETIN 2000	4.26	0.21	1.29	-0.30	36.22	-4.23
LARENDE	3.92	-0.31	1.50	-0.86	50.57	-3.87
OLGUN	5.88	-0.05	1.92	-0.43	33.73	-0.53
TARM 92	4.83	-0.06	1.56	-1.22	48.23	-2.87
TOSUN PASA	4.81	1.01	1.81	-0.41	46.02	-5.63
Mean		0.43		-0.56		-2.69

* The (-) indicates a reduction in the parameter value.

4. Conclusion

Analysis of variance indicates the existence of variation among the genotypes, and the effect of growing season on the yield. The examined genotypes varied in most of the studied parameters. Some of the advanced lines showed promising data. Anka-11 biological yield was among the highest group with compare to the variety Olgun which had the highest biological yield among the varieties. Thousand grain weight of the advanced line Anka-08 was higher than all other genotypes, and its grain yield was among the highest genotypes. Even though, the total rainfall in the second year was lower by 38.3 mm, the genotypes, especially the advance lines, showed an increase in some of the studied traits; NSS, SPS, BY, GY, and TGW. Thus, further studies on water requirement of the genotypes are necessary.

References

Ahmadi, J., Vaezi, B., & Pour-Aboughadareh, A. (2016). Analysis of variability, heritability, and interrelationships among grain yield and related characters in barley advanced lines. *Genetika*, *48*(1), 73-85. DOI: 10.2298/GENSR1601073A.

Ay, H., Aykanat, S., Anay, A., Akkaya, M. R., & Zeybek, A. (2018). Agronomic and Quality Evaluation of Rainfed Barley (Hordeum Vulgare L.) in Eastern Mediterranean Condition.

Beşer, N., Kaya, Y., Civi, G., & GumusS, T. (2019). *The evaluation of yield performances of some barley cultivars in Trakya region.* Paper presented at the International Bioogical, Agricultural and Life Science Congress.

Biel, W., Kazimierska, K., & Bashutska, U. (2020). Nutritional value of wheat, triticale, barley and oat grains. *Acta Scientiarum Polonorum Zootechnica, 19* (2), 19-28. doi:10.21005/asp.2020.19.2.03

Cockram, J., Horsnell, R., Soh, E. H., Norris, C., & O'Sullivan, D. M. (2015). Molecular and phenotypic characterization of the alternative seasonal growth habit and flowering time in barley (Hordeum vulgare ssp. vulgare L.). *Molecular Breeding*, *35*(8), 1-11. DOI: 10.1007/s11032-015-0359-5.

Cuesta-Marcos, A., Kling, J.G., Belcher, A.R., Filichkin, T., Fisk, P., Graebner, R., Helgerson, L., Herb, D., Meints, B., Ross, A.S., Hayes, P.M., & Ulrich, S.E. (2016). Barley: Genetics and Breeding. In C. Wrigley, H. Corke, K. Seetharaman & J. Faubion (Eds), *Encyclopedia of Food Grains* (pp. 287-295). Academic Press.

Dorostkar, S., Pakniyat, H., Kordshooli, M. A., Aliakbari, M., Sobhanian, N., Ghorbani, R., & Eskandari, M. (2015). Study of relationship between grain yield and yield components using multivariate analysis in barley cultivars (Hordeum vulgare L.). *International Journal of Agronomy and Agriculture Research*, *6*, 240-250.

Erol, Oral, Kendal, E., & Dogan, Y. (2017). Investigation of yield and some quality criteria of summer barley genotypes in Adıyaman and Şanlıurfa-Hilvan conditions. *Journal of Uludag University Faculty of Agriculture*, *31* (2), 23-36.

Ertuş, M. M. (2021). A Research on the Determination of Grain Yield of Some Barley (Hordeum vulgare L.) Varieties in Late Autumn Sowing in The High-Altitude Agricultural Area of Anatolia. *ISPEC Journal of Agricultural Sciences*, *5*(1), 210-215. https://doi.org/10.46291/ISPECJASvol5iss1pp210-215

FAO, (2022). *Crops and livestock products*. https://www.fao.org/faostat/en/#data/QCL/visualize. Access date: 03.11.2020.

Güngör, H., Cakir, M. F., & Dumlupinar, Z. (2022). Evaluation of wheat genotypes: genotype× environment interaction and gge biplot analysis. *Turkish Journal of Field Crops*, *27*(1), 149-157. DOI: 10.17557/tjfc.1081513

Güney, M. (2019). Effect of grain processing at different barley varieties on nutrient compositions, starch contents and in vitro digestion parameters. *Progress in nutrition*, *21*(3). https://doi.org/10.23751/pn.v21i3.8571

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.

Mirosavljević, M., Momčilović, V., Mikić, S., Abicić, I., & Pržulj, N. (2020). Breeding progress in grain filling and grain yield components of six-rowed winter barley. *Zemdirbyste-Agriculture*, *107*(3), 271-278. DOI 10.13080/z-a.2020.107.035.

Mirosavljević, M., Momčilović, V., Pržulj, N., Ristov, N., Aćin, V., Čanak, P., & Denčić, S. (2016). The variation of agronomic traits associated with breeding progress in winter barley cultivars. *Zemdirbyste-Agriculture*, *103*(3), 267-272. DOI 10.13080/z-a.2016.103.034.

Saroei, E., Cheghamirza, K., & Zarei, L. (2017). Genetic diversity of characteristics in barley cultivars. *Genetika*, *49*(2), 495-510. Doi.org/10.2298/GENSR1702495S.

Sullivan, P., Arendt, E., & Gallagher, E. (2013). The increasing use of barley and barley by-products in the production of healthier baked goods. *Trends in Food Science & Technology*, *29*(2), 124-134. doi.org/10.1016/j.tifs.2012.10.005.

Vasilescu, L., PetcuE, S. A., Petcu, E., & Lazăr, C. (2022). Grain morphometry analysis of Romanian winter barley cultivars registered during 1959-2019 period. *Romanian Agricultural Research*, *39*, 165-173. DOI 2067-5720 RAR 2022-155

Zhong, B. H., Wiersma, J. J., Sheaffer, C. C., Steffenson, B. J., & Smith, K. P. (2019). Assessment of winter barley in Minnesota: relationships among cultivar, fall seeding date, winter survival, and grain yield. *Crop, Forage & Turfgrass Management*, *5*(1), 1-8. doi:10.2134/cftm2019.07.005.