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Research Article

Selection of Barley (*Hordeum vulgare* L.) Lines for Grain Yield and Some Quality Traits under Rainfed Conditions

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Abstract

This research was conducted to select barley lines with high grain yield and quality traits, adaptable to dryland environments by evaluating grain yield and quality traits of some barley lines in Konya Province of Turkey. In this study, 19 advanced lines which were improved in barley breeding program in Bahri Dagdas International Agricultural Research Institute (BDIARI) and 5 standard varieties (Karatay 94, Tarm 92, Ince 04, Tokak 157/37 and Larende) were used. The trials were setup in randomized complete block design with 3 replicates during growing season in 2011-12 and 2012-13. During the study, the grain yield (GY), thousand kernel weight (TKW), kernel size (KS), test weight (TW), crude protein content (CP), and crude fiber content (CF) of barley lines were determined. The differences among the genotypes were found statistically significant with respect to the studied traits. According to the results obtained for both years, the GYs of barley lines ranged between 3.18 and 4.33 t ha^{-1}. The highest GY was obtained from advanced line 17. Karatay 94 had the highest yield with 4.05 t ha^{-1} among control cultivars. The values ranged in genotypes between 33.7-43.2 g in TKWs, 57.2-86.6 % in KSs, 58.5-65.0 kg hl^{-1} in TWs, 10.91-12.65 % in CP, and 6.11-7.36 % in CF. To conclude 4, 14 and 17 numbered lines were promising with higher GYs and better-quality properties in the rainfed conditions. Therefore, these lines were selected as new cultivar candidates for use by dry farming farmers and to use as parent in the development of new varieties by barley breeders.

Key words: Barley, breeding, cultivar, crude fiber, crude protein.

Yağmura Dayalı İklim Koşullarında Tane Verimi ve Bazı Kalite Özellikleri İçin Arpa (*Hordeum vulgare* L.) Hatlarının Seçimi

Özet

Bu araştırma Türkiye'nin Konya ilinde bazı arpa hatlarının tane verimi ve kalite özelliklerini değerlendirerek, kurak alanlara uyumlu yüksek tane verimi ve kalite özelliklerine sahip arpa hatlarını seçmek amacıyla yürütülmüştür. Bu çalışmada Bahri Dağdaş Uluslararası Tarımsal Araştırma Enstitüsünde (BDUTAE) arpa ıslah programında geliştirilen 19 ileri hat ve 5 standart çeşit (Karatay 94, Tarm 92, İnce 04, Tokak 157/37 ve Larende) genetik materyal olarak kullanılmıştır. Denemeler 2011-12 ve 2012-13 yetiştirme dönemlerinde tesadüf blokları deneme deseninde 3 tekerrürlü olarak kurulmuştur. Çalışma esnasında, arpa genotiplerinde tane verimi (TV), bin tane ağırlığı (BTA), tane iriliği (Tİ), hektolitre ağırlığı (HL), ham protein oranı (HP) ve ham lif içeriği (HLİ) belirlenmiştir. İncelenen tüm özelliklerde genotipler arasındaki farklılıklar istatistiki olarak önemli bulunmuştur. İki yıllık elde edilen sonuçlara göre, arpa genotiplerinin TV 3.18 ve 4.33 T ha^{-1} arasında değişmiştir. En yüksek TV 17 numaralı hattan elde edilmiştir. Karatay 94, kontrol çeşitleri arasında 4.05 T ha^{-1} ile en yüksek TV sahip olmuştur. İncelenen hatlarda BTA 33.7-43.2 g, Tİ % 57.2-86.6, HL 58.5-65.0 kg hl^{-1}, HP % 10.91-12.65 ve HLİ % 6.11-7.36 arasında değişmiştir. Sonuç olarak 4, 14 ve 17 numaralı hatlar, yağmura dayalı iklim koşullarında yüksek TV ve yüksek kalite özellikleri ile ümitvar bulunmuştur. Bu nedenle, bu hatlar kuru tarım çiftçileri tarafından kullanılması ve arpa ıslahçılarının yeni çeşit geliştirmelerinde ebeveyn olarak kullanmaları için yeni çeşit adayları olarak seçilmiştir.

Anahtar kelimeler: Arpa, ıslah, çeşit, ham lif, ham protein.

Introduction

Barley has been placed in the second rank after wheat with respect to total cultivated area and production among winter cereals in the world and Turkey. It was cultivated over a total area of 2.8 million hectares in Turkey, and this area covered about 25% of the total cereal area (Anonymous, 2016). Barley has been mainly cultivated for the animal feed, food and beer production industries. It is a major cereal crop for animal feed, especially in low-rainfall areas. In Konya, barley has been grown mostly in monoculture under rainfed conditions between October and June over an area of 307 088 ha (Anonymous, 2016). One of the most important environmental stress factors limiting crop production in the region is drought. The drought in this region can be characterized by the annual rainfall deficiency and irregular distribution of rainfall during growing period. In this region, April and May rainfalls are very important for barley production. Usually, this region is cold and snowy in winters and warm in summers. This fluctuation in the climate causes to the significant yield losses in the region. In order to get higher yield, a barley cultivar must possess resistance to stress factors that occur in the cultivated environment. One of the measures to be taken against to the agricultural drought is to develop the winter barley varieties having high-yielding and quality, to answer the needs of the region.

Development of high-yielding cultivars is the primary objective of most barley breeding programs. Up to now, the most meaningful selection criterion for drought resistance is GY under rainfed conditions. As drought simulation in controlled environment facilities was not found as practical for use in breeding programs, it was suggested that GY must be tested in the field under natural arid conditions (Hurd, 1971; Weltzien and Srivastava, 1981).

The nutritional quality of barley is influenced by the physical characteristics of grain such as grain weight and size, hull content, TKW and TW as well as its nutrient composition such as starch, CF, CP, crude fat, minerals and vitamins (Bleidere and Gaile, 2012). For cost-effectiveness of feed barley cultivation, it is essential for the variety to have high yield potential sufficiently. Therefore, breeders carrying out genetic improvement of feed barley should concurrently keep in mind the balanced position of quantitative and qualitative traits of grain (Bileidere and Gaile, 2012). The higher proportion of hulls increase the CF of grain, resulting decrease in its metabolizable energy content, especially for poultry (Bell et al, 1983). For this reason, it can be said that the feed value of barley varies according to its CF. Since it is too difficult or impossible to digest CF which is the main constructive structure of the barley hull, it is not desired the high CF of barley grain. It was reported by Ayyıldız (1986) that the CF in barley ranged between 5.1 and 9.5 %. Grain weight and size are important quality indicators both for malting and feed industry. The grain weight closely depends on the concentration of specific nutrients in the grain. Therefore, cereal breeders study on the targeted selection to increase the weight and size of grain to improve productivity and other required commercial traits of the variety (Rodomiro et al, 2002; Pasarella et al, 2005). TW is a measure of the density of grain. It measures the grain weights for specific volume. TW is considered to be one of the important measures of grain quality and is directly related to the density and soundness of the grain. High TW values indicating grain being of good soundness are desirable (Troccoli and Di Fonzo, 1999) and indicate an acceptable visual appearance with high grain density. Low TW values can occur as a result of various adverse events such as intolerance to different climate conditions (Czarnecki and Evans 1986; Saadalla et al 1990), insect damage (Buntin et al 1992), defoliation (Blum et al 1991), lodging (Laude and Paul 1956; Weibel and Pendleton 1964) or delayed harvesting (Pool et al 1958). CP of barley has an utmost importance for both feed and malt industry. The CP of barley, identical to that of other cereals with its essential amino acids plays basic physiological roles in the metabolism in animals and people consumed it in any way (Newman and Newman 1992; Evers et al 1999). Protein makes up the second largest fraction of the grain endosperm. Dry matter of the barley grain consists of 8–20 % CP depending on its genetic make-up (Evers et al 1999). Barley protein has a complex interaction with quality. It is well known that the high protein is undesirable for malt because of the strong correlation with low carbohydrate (starch) levels and thus low extract values (Bishop, 1930). But, it is desirable the high protein for feeding livestock. The previous breeding programs in Turkey achieved a significant progress in GY and quality features as evidenced by the studies of Topal (1997), Karadogan et al. (1999), Ozturk et al. (2001), Ayranci et al. (2004), Soylu et al. (2009).

The aim of the present study was to select advanced barley lines, originating from BDIARI barley breeding program under rainfed climate conditions, for high GY and better-quality characteristics.

Materials and Methods

The research was conducted in the experimental field of BDIARI under rainfed conditions of Konya Province for two years in 2011-12 and 2012-13. Konya Province is located on the Central Anatolia and situated at 36°51′−39°29′ Northern latitudes and 31°36′−34°52′ Eastern longitudes at 1030 meters above sea level.

The detailed characteristics of weather in 2011-12 to 2012-13 for each period were presented in Table 1.

Table 1. Some climatic data for 2011-12 and 2012-13 in Konya

Months	Rainfall (mm)			Temperature (°C)			Relative Humidity (%)		
	LT*	2011-12	2012-13	LT	2011-12	2012-13	LT	2011-12	2012-13
Sept.	11.6	0.8	1.0	18.7	16.8	20.4	46.0	38.8	34.0
Oct.	32.2	45.0	31.5	12.6	14.3	12.0	58.0	54.7	59.7
Nov.	37.6	8.7	39.1	5.9	5.6	8.9	69.0	62.6	78.0
Dec.	41.9	23.5	60.8	1.5	4.3	4.6	77.0	74.8	82.1
Jan.	34.4	86.1	42.0	-0.3	2.5	1.1	76.0	85.9	80.6
Feb.	24.4	39.5	42.9	1.0	5.4	1.7	70.0	83.4	70.6
Mar.	26.2	15.1	29.8	5.7	7.9	4.6	62.0	63.2	55.4
Apr.	38.8	10.2	67.1	11.1	10.4	8.8	58.0	46.9	58.1
May.	41.7	56.8	95.4	15.8	16.3	13.2	55.0	58.3	45.9
Jun	20.1	19.8	14.2	20.4	19.7	18.4	47.0	39.6	36.3
July	7.5	1.4	1.3	23.6	24.7	24.3	42.0	31.8	34.0
Aug.	5.0	13.6	0.1	23.2	25.9	22.3	42.0	36.4	32.3
Annual	321	321	425						
Average				11.6	12.8	11.7	58.5	56.4	55.6

*LT: Long Term Averages

In the growing season, the years in 2011-12 and 2012-13 when the trials were carried out, the rainfall and relative humidity were more favorable according to the average for the long-term period. The precipitation was 321 mm in average for long-term in the region and it was 321 and 425 mm in 2011-12 and 2012-13, respectively (Table 1). In addition, the lowest temperature in the region was -20 and -12.9 °C during winter season in 2011-12 and 2012-13, respectively. The soil pH of the trial land ranged from 7.6 to 8.2, and it had a clay or clay loam texture. The content of organic matter in the soil was less than 1%, and the contents of phosphorus (P_2O_5) and potassium (K_2O) were 11.06-6.99 kg da^{-1} and 88.89-62.17 kg da^{-1}, respectively.

19 advanced lines in barley breeding program at BDIARI and named as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19 and 5 control varieties (Karatay 94, Tarm 92, Ince 04, Tokak 157/37 and Larende) were used. The information showing the hybrid and pedigree of the barley lines and control varieties were given in Table 2.

The experimental design was a randomized complete block with three replications. Trials were established in crop rotation system "fallow-cereal". Plots were 7 m long with 6 rows spaced 20 cm apart. Seeds were drilled at a rate of 550 grain for each square meter. During the sowing, DAP fertilizer was applied to each plot as 23 kg pure N per ha and 60 kg P_2O_5 per ha. In the start of stem elongation, AN fertilizer was used meeting 47 kg pure N per ha. Weed control was performed by chemical application as 2,4-D Ester. At maturity, each plot which was reduced to 5 m length was harvested by using a combine harvester. The same trial procedure was applied for each year. Planting in the first year of the experiment was held on 10th October in 2011 and the second year was on 14th October in 2012. The harvesting dates for trials were on 15th July in 2012 and the second year on 20th July in 2013.

The methodology for measurement and observation of GY and other properties of the genotypic material tested in the study was established according to Akkaya and Akten (1990) and Kun et al (1992). TKW was determined using grain counter Contador (Pfeuffer GmbH, Kitzingen, Germany).

Table 2. Advanced barley lines (1-19) used in the study and control cultivars (20-24)

Entry No	Variety, Cross, Pedigree
1	KHARKOVSKIY-112/KARATAY-94
2	4875/ÇATALHÖYÜK (14 F6)
3	4875/ÇATALHÖYÜK (27 F6)
4	ERG//364TH/TOK/3/ERG/4/KALAYCI (11 F6)
5	ERG//364TH/TOK/3/ERG/4/KALAYCI (39 F6)
6	TOK/ANGORA (7 F6)
7	TOK/ANGORA (24 F6)
8	PLAISENT/TORRENT
9	KALAYCI/ST5807
10	AIVA-1/ANADOLU-98
11	KT 2169/AYDANHANIM (13 F6)
12	KT 2169/AYDANHANIM (18 F6)
13	STE/ANTARES//VİRİNGA'S/3/KRTY-94/4/KRTY-94/5/7351 ELVAS CE 9704/BÜLBÜL-89
14	YEA389-3/YEA475-4/5/CUM-50/3/3896/GZK//TOK/4/P26-5/132TH
15	11TH/P15-B27281//ST4652/TOK/5/CUM-50/3/3896/GZK//TOK/4/P26-5/132TH
16	TOKAK/97-98DH9
17	OBSOR/ORZA-96
18	CERRAJA/3/AVAGE/BERMEJO//HIGO/4/DC-B/SEN/5/TARM-92/6/TARM-92/7/AYDNHNM
19	YUG. MALT TEK BAŞ. 2A-0A/ÇUMRA-2001
20	Karatay 94
21	Tarm 92
22	Ince 04
23	Tokak 157/37
24	Larende

KS given as percentage, the proportional rate of kernels sized above 2.8 and 2.5 mm was measured by using Sortimat screening machine (Pfeuffer GmbH, Kitzingen, Germany). TW was determined by using a Dickey-John GAC2100 (Fox et al 2007). Kernel samples for each genotype were individually ground to pass through 0.5 mm screen using a Udy-Cyclone Mill (Ft.Collins). The ground samples were then used for analyzing CP (N x 6.26) with elemental analyzer Leco (LECO, St. Joseph, USA). CF was determined by using John 660-Near Infrared Reflectance (NIR) spectroscopy (AACC, 1990).

The obtained data were analyzed by using variance analyze method according to experimental designs with JMP.7 software (Anonymous, 2007). LSD multiple range test was used to compare the averages of parameters in studied genotypes.

Results and Discussion

In this study, the data regarding the studied parameters for 2011-12 and 2012-13 growing seasons were analyzed as combining by variance analyze. The results of statistical analysis were given in Table 3. As seen in Table 3, when considered the variance within the belonging to year, genotypes, genotype x year interactions in all characteristics were found significant at the 0.01 level, the variance of the genotype x year interaction in GY was significant at the 0.05 level. After that, the LSD test was applied to determine the differences among the groups. The GY and quality properties results were given in Table 4 and 5.

Grain yield

The effect of the years on the GY and the differences among the genotypes in terms of GYs were found statistically significant at 0.01 level. As a result of the response of genotypes to environmental factors, GY ranking over the years was different, and genotype x year interactions were found statistically significant at 0.05 level. The average yield of genotypes over year was ranked between 4.33 t ha^{-1} (No. 17 line) - 3.18 t ha^{-1} (No. 7 line), and trial average yield realized as 3.74 t ha^{-1} (Table 4). The average yield (3.56 t ha^{-1}) obtained in the first year of the study was lower than that (3.92 t ha^{-1}) of the second year. On this result, the insufficient rainfall and the average high temperature in March and April have had a significant effect in the 2011-12 growing period (Table 1). On the average of years, the highest GY performance (4.05 t ha-1) in control varieties was obtained from Karatay 94, while the GY performance of Tokak 157/37 was the lowest with 3.51 t ha-1. The average GY of control cultivars used in this trial was obtained as 3.86 t ha^{-1}.

Table 3. Analysis of variance for GY and quality parameters of barley genotypes

Source	DF	Mean Squares					
		GY	TKW	KS	TW	PC	CF
Year	1	47742.25**	653.527**	1325.567**	408.680**	1.930**	0.839**
Replicate[Year]	4	6607.735	3.498	1.450	0.750	0.113	0.002
Genotype	23	3913.882**	18.0637**	436.404**	10.573**	1.226**	0.491**
Genotype*Year	23	2618.921*	5.928**	109.233**	4.201**	0.456**	0.596**
Error	92	1471.020	0.600	1.360	0.359	0.050	0.003
C. Total	143						
CV (%)		10.25	1.87	1.66	0.97	1.92	0.81

,*significant at P< 0.05 and P<0.01, respectively.
GY, Grain yield (t ha^{-1}); **TKW**, Thousand kernel weight (g); **KS**, Kernel size (> 2.5 mm sieve fraction); **TW**, Test weight (kg hl^{-1}); **CP**, Crudeprotein content (%); **CF**, Crude fibre content (%).

During the 2011-12 growing period, lines 14, 17, 16, 18, 4 and 15 performed above the average of control cultivars (3.61 t ha-1) with yields of 4.23, 4.07, 3.95, 3.93, 3.90 and 3.75 t ha^{-1}, respectively. In the 2012-13, lines 17, 6 and 19, which can exceed the average of control cultivars (4.11 t ha^{-1}), had the yield values of 4.60, 4.17 and 4.14 t ha^{-1}, respectively. When the yield results of the two years were evaluated together, line 17, which was successful in both years of the experiment, was alone in "a" group with the yield value 4.33 t ha^{-1}. The 14 and 4 lines, which were successful in the first year of the experiment in which drought was more effective, came to the fore with the "ac" group in the combined evaluation with the yield values of 4.01 and 3.98 t ha^{-1}, respectively. In this study, it was found that lines 6 and 19 were genotypes that showed high performance when conditions improved. Lines 18, 15 and 16 were determined as genotypes which can maintain their yield levels at a level close to the average of control varieties (Table 4). As a result of the two-year assessment under rainfed conditions in Konya, 17, 14 and 4 genotypes showed higher GY and quality performances compared to control cultivars and other lines determined as promising lines.

The GY which is a combination of different yield components, is emerging function of genetic structure and its environment. In this study, the average grain yield (3.74 t ha^{-1}) of 19 advenced barley lines and 5 control cultivars tested under rainfed conditions in Konya was higher than those of Aydogan et al (2011), Ayranci et al (2004) in the studies conducted with different genotypes in the same conditions. In addition, the grain yield results obtained in this study were also higher than those of Akkaya and Akten (1990), Ozturk et al. (2001), Kaydan and Yagmur (2007), Akdeniz et al (2004) and Ulker et al (2001) in the studies conducted in different ecological regions. In these results, there had a significant share of high yield potentials of newly developed genotypes in rainfed conditions.

Thousand-kernel weight

The TKW of genotypes ranged between 37.7 to 43.8 g. for this parameter, the average of years was 41.3 g, and the average of control varieties was 42.9 g. Karatay-94 control cultivar showed the highest performance in "a" group with 43.8 g TKW, followed by Larende (43.2 g), 16, and 11 lines (43.1 g) in "ab" group (Table 4).

In Konya ecological conditions, 16 numbered line had higher performance than the average of control cultivars only regarding GY and TKW. The 15, 4 and 14 numbered lines' TKW values were as 42.4, 42.1 and 41.7 g, respectively. While number 16 line was determined as a promising malting line with respect to TKW 15, 4 and 14 numbered lines were also acceptable for this trait in order to use in malting or feed industry. Our results were similar with those of some researchers (Ozturk et al 2007, Karahan and Sabancı 2010, Aydogan et al 2011). On the other hand, while those had higher values than those of some researchers (Tas and Yurur 2002), were less values than those of some research (Sirat and Sezer 2005). That TKW is a varietal feature and can vary according to years and climatic factors, was reported by some researchers (Akkaya and Akten, 1990; Turgut et al., 1997).

Kernel size

Size analysis provides information about the homogeneity and grain size. This is very important, especially for softening and germination circuit in the malt industry. The large sized grains are desired for the synchronization of malting barley germination. It was determined that the proportion of barley grain whose sieve sizes was over the 2.8 and 2.5 mm in the present study ranged between 57.2 % to 86.6 %, as percentage.

Table 4. The mean GY, TKW and KS values of barley genotypes cultivated under rainfed climate conditions

Entry	GY (t ha^{-1})			TKW (g)			KS (%)		
	2012	**2013**	**Avr.**	**2012**	**2013**	**Avr.**	**2012**	**2013**	**Avr.**
1	3.48 b-g*	3.54 e-h	3.51 d-h	39.5 l	38.4 fg	38.9 ıj	60.9 lm	65.7 fg	63.3 m
2	3.20 e-g	4.04 a-f	3.62 b-g	43.0 f-h	37.3 gh	40.2 gh	68.0 k	59.7 j-l	63.9 m
3	3.38 c-g	4.05 a-e	3.71 b-g	41.1 jk	35.6 ı	38.3 jk	72.6 gh	61.1 ıj	66.9 ı-k
4	3.90 a-d	4.06 a-e	3.98 a-c	42.6 h-ı	41.5 bc	42.1 c-e	59.9 m	63.0 hı	61.4 n
5	3.55 b-g	3.72 d-e	3.64 b-g	45.2 a-c	39.8 de	42.5 b-d	71.0 h-j	64.1 gh	67.5 ıj
6	3.01 fg	4.17 a-d	3.59 c-h	44.3 c-f	40.6 cd	42.5 b-d	83.3 a	81.0 c	82.2 cd
7	2.93 g	3.43 gh	3.18 h	43.4 e-g	37.3 gh	40.3 gh	78.3 de	75.4 d	76.9 e
8	3.25 d-g	3.70 d-h	3.47 e-h	41.7 h-j	37.4 gh	39.5 hı	80.9 bc	81.8 c	81.3 d
9	3.35 c-g	4.01 a-g	3.68 b-g	43.0 gh	39.6 d-f	41.3 ef	76.3 f	66.9 f	71.6 fg
10	3.41 b-g	4.06 a-e	3.74 b-g	40.1 kl	35.3 ı	37.7 k	60.4 lm	55.3 n	57.8 o
11	3.45 b-g	3.40 h	3.42 f-h	43.4 e-g	42.9 a	43.1 ab	81.4 b	91.8 a	86.6 a
12	3.38 c-g	3.45 f-h	3.42 gh	43.6 d-g	42.0 ab	42.8 bc	79.6 cd	90.3 a	85.0 b
13	3.54 b-g	3.80 d-h	3.67 b-g	41.5 ıj	39.6 d-f	40.5 fg	80.6 bc	86.2 b	83.4 c
14	4.23 a	3.79 d-h	4.01 a-c	46.0 a	37.4 gh	41.7 de	72.3 g-ı	69.0 e	70.7 gh
15	3.75 a-e	3.99 b-h	3.87 b-e	45.8 ab	38.9 ef	42.4 b-d	62.1 l	52.2 o	57.2 o
16	3.95 a-c	3.82 c-h	3.89 b-e	45.8 ab	40.5 cd	43.1 ab	78.5 de	61.6 ıj	70.1 h
17	4.07 ab	4.60 a	4.33 a	42.9 gh	37.6 gh	40.3 gh	70.7 ıj	60.3 jk	65.5 l
18	3.93 a-c	3.81 d-h	3.87 b-e	41.5 ıj	37.0 h	39.2 ı	69.3 jk	53.1 o	61.2 n
19	3.58 a-g	4.14 a-e	3.86 b-f	41.8 h-j	37.4 gh	39.6 hı	76.8 ef	56.2 mn	66.5 j-l
Karatay 94	3.57 a-g	4.53 ab	4.05 ab	46.0 a	41.5 bc	43.8 a	76.5 f	65.0 g-h	70.7 gh
Tarm 92	3.81 a-e	4.09 a-e	3.95 a-c	45.4 a-c	39.5 d-f	42.5 b-d	73.3 g	58.4 kl	65.9 kl
İnce 04	3.73 a-e	4.12 a-e	3.92 a-d	44.7 a-d	40.7 cd	42.7 bc	79.9 b-d	65.3 fg	72.6 f
Tokak 157/37	3.61 a-f	3.41 h	3.51 d-h	44.7 a-e	39.9 de	42.3 b-d	71.4 hı	64.7 gh	68.1 ı
Larende	3.33 c-g	4.41 a-c	3.87 b-e	44.5 b-e	41.9 ab	43.2 ab	68.2 k	58.2 lm	63.2 m
Exp. Avr.	**3.56**	**3.92**	**3.74**	**43.4**	**39.1**	**41.3**	**73.0**	**66.9**	**70.0**
Check. Avr.	**3.61**	**4.11**	**3.86**	**45.1**	**40.7**	**42.9**	**73.9**	**62.3**	**68.1**
LSD (0.05)	**0.66**	**0.59**	**0.43**	**1.36**	**1.17**	**0.89**	**1.73**	**2.09**	**1.34**

*Significant at 0.05 level of probability

GY, Grain yield (t ha^{-1}); **TKW**, Thousand kernel weight (g); **KS**, Kernel size (> 2.5 mm sieve fraction).

As the trial average over the years, KS was determined as 70 %, and the average of the control cultivars was 68.1 %. The highest KS with 86.6% belonged to the11 numbered line in the group "a". The KS values of lines 12, 13, 6 and 8 following line 11 were 85%, 83.4%, 82.2% and 81.3% respectively. The 7, 9, 14 and 16 numbered lines had higher KS values compared to the control varieties (Table 4). 14 and 16 lines were found as the promising lines to use as malting with higher GY performance and KS values in comparison to control varieties in the current experiment. The results of the KS variation obtained in the study agreed with those of Colkesen et al (2002), Ayranci and Aydogan (2013).However, the range of change reported by Ozturk et al (2007) on KS was higher than our findings. KS values of genotypes 14 and 16 with high TKW were also found to be high,as reported by some researchers (Colkesen et al 2002, Ozturk et al 2007).

Test weight

The barley genotypes containing higher TW have rich extracts to be used in malting (Atli et al, 1989). The TWs of barley genotypes in the experiment ranged between 58.5 to 65 kg hl^{-1}. While the average TW over the years was obtained as 61.7 kg hl^{-1}, the average TW of control varieties was determined as 62.1 kg hl^{-1}. The 10 numbered line which located in the group "a" had the highest TW (65 kg hl^{-1}), followed by the 11, 1 and 14 lines with 63.7, 63.3 and 62.9 kg hl^{-1}, in order. Like 12 and 13 lines, Tarm 92, Tokak 157/37, Ince 04 varieties took place over the average TW of control varieties (62.1 kg hl^{-1}) (Table 5).

The line 14 was found as a promising line for malting quality due to its GY and TW in the present trial. The TW varies according to genotypes depending on the homogeneity, the husk ratio and endosperm structure of the grains (Kun et al 1992). While the TW obtained in this study was higher than those of 52.18-61.51 kg ha^{-1} reported by Tas and Yurur (2002), it was less than those of 65.6-75.3 kg hl^{-1} reported by Ozturk et al (2001), 63.4-68.1 kg hl^{-1} reported by Sirat and Sezer (2005), 65.9-70.5 kg hl^{-1} reported by Ozturk et al (2007), 60.0-69.7 kg hl^{-1} reported by Karahan and Sabancı (2010). On these results were influential the genotypic and environmental differences, as indicated by some researchers (Tas and Yurur 2002, Karahan and Sabancı 2010).

Crude protein content

The CP contents of barley genotypes in the current study ranged from 10.91 % to 12.65 %. Due to less rainfall in 2011-12, while the GY of genotypes was lower, their CP ratio was higher according to 2012-13. GY in cereals is generally negatively related to protein content (Simmonds 1995, Ozturk et al 1999). Similar to our results, researchers such as Colkesen and Kaynak (1992) and Ozturk et al. (1997) also obtained less GY and higher CP ratio in the year of low rainfall. While the average CP content in the trial years was 11.65 %, the mean CP of control varieties was almost similar to the average of test years, with 11.63 %. While the highest CP was obtained in the line numbered 10 in "a" group (12.65 %) as seen in Table 5. The 5, 12, 11 and 4 numbered lines had CP values as 12.24, 12.21, 12.17 by 12.03 %, respectively. The mean CP of control cultivars Ince 04, Tarm 92, Tokak 157/37, and lines 1, 17, 14, 13 was above 11.63 % (Table 5). When the CP values of lines compared to the mean of their GYs, lines 4, 14 and 17 were higher than the averages of control cultivars in terms of both GY and CP, suggesting that these lines can be considered as promising lines for fodder quality. The rest of them were below the average of cultivars in terms of CP and had higher GY values than critical value (3.86 t ha^{-1}). The numbers of 15 (11.53 %), 18 (11.44 %), 16 (11.07 %) and 6 (10.91%) lines came to the forefront for malting quality features. Our results were similar with those of some researchers (Aydogan et al 2011) in same ecological conditions, but those were higher than values (9.96 % to 10.92 %) reported by Soylu et al (2009), and (10.46 % to 11.65 %) reported by Akdeniz et al (2004). These differences may be explained by the interaction of genotypes and environmental factors since the CP is a quantitative character.

Crude fiber content

Because it is difficult to digest the crude fibre having a negative effect on the nutritive value of barley and, which forms the main structure of a husk, high crude fibre contained grains are undesirable for poultry and baby ruminants. The CFs of barley genotypes were determined as ranged from 6.11% to 7.36%. While the lowest CF (6.11%) was obtained from line13, followed by lines 7 (6.21%), 12 (6.29%), 10 (6.29%), 2 (6.32%), 8 (6.33%) and 15 (6.49%) (Table 5). Having lower CFs, the lines 15 (6.49%), 14 (6.52%) and 16 (6.52%) produced higher GY than that of the control varieties (3.86 t ha^{-1}). These lines should be considered promising lines in terms of malting or feed quality features. Some researchers (Soylu et al 2009; Aydogan et al 2011) reported that CF in barley varieties was between 6.78% to 5.22%, supporting our findings.

Table 5. The mean TW, CP and CF values of barley genotypes cultivated under rainfed climate conditions

Entry	TW (kg hl^{-1})			CP (%)			CF (%)		
	2012	**2013**	**Avr.**	**2012**	**2013**	**Avr.**	**2012**	**2013**	**Avr.**
1	60.5 c-g*	66.1 ab	63.3 bc	12.03 b-f	11.75 cd	11.89 d-f	6.80 de	6.50 ı	6.65 e
2	59.7 g-ı	63.1 ef	61.4 ef	11.58 fg	11.46 e-ı	11.52 h-j	6.30 jk	6.33 l	6.32 ı
3	58.8 ıj	63.5 de	61.2 e-h	11.22 g-ı	11.47 e-h	11.35 ı-k	8.43 a	6.30 lm	7.36 a
4	55.4 l	61.6 g	58.5 j	12.06 b-e	12.01 b	12.03 b-d	7.03 c	6.22 op	6.62 e
5	58.7 ı-k	61.6 g	60.2 ı	12.20 c-d	12.28 a	12.24 b	6.91 cd	6.63 f-h	6.77 d
6	60.0 e-h	62.1 g	61.1 e-h	10.85 h-j	10.96 lm	10.91 m	6.40 ı-k	6.68 de	6.54 g
7	60.8 c-f	61.9 g	61.3 e-g	11.22 g-ı	11.22 ı-k	11.22 kl	6.18 l	6.24 no	6.21 j
8	60.3 d-g	62.1 g	61.2 e-h	12.20 b-d	11.00 kl	11.60 g-ı	5.91 n	6.75 c	6.33 ı
9	61.0 b-e	61.8 g	61.4 ef	11.89 c-f	10.74 m	11.31 j-l	6.39 ı-k	6.69 d	6.54 fg
10	63.2 a	66.8 a	65.0 a	13.23 a	12.07 ab	12.65 a	6.46 l	6.16 q	6.31 ı
11	61.3 b-d	66.1 a	63.7 b	12.38 b	11.95 bc	12.17 bc	6.73 ef	6.91 b	6.82 cd
12	61.3 b-d	63.5 de	62.4 d	12.30 bc	12.12 ab	12.21 bc	6.31 jk	6.27 mn	6.29 ı
13	59.5 g-ı	65.2 bc	62.4 d	11.90 c-f	11.52 d-g	11.71 f-h	6.05 m	6.16 q	6.11 k
14	61.5 bc	64.3 d	62.9 cd	12.16 b-d	11.35 g-j	11.76 e-h	6.77 e	6.26 mn	6.52 gh
15	59.7 g-ı	62.5 fg	61.1 e-h	11.84 d-f	11.22 ı-k	11.53 h-j	6.36 ı-k	6.61 h	6.49 gh
16	58.4 jk	63.7 de	61.0 e-h	10.90 h-j	11.23 h-k	11.07 lm	6.62 fg	6.41 k	6.52 g
17	57.6 k	63.6 de	60.6 hı	12.00 b-f	11.63 de	11.81 d-g	6.58 gh	6.62 gh	6.60 ef
18	58.4 jk	63.2 ef	60.8 f-ı	11.22 g-ı	11.65 de	11.44 ı-k	6.70 ef	7.06 a	6.88 c
19	59.2 h-j	62.1 g	60.7 g-ı	10.66 j	11.19 j-l	10.93 m	7.90 b	6.31 l	7.11 b
Karatay 94	60.0 f-g	63.2 ef	61.6 e	11.28 gh	11.43 e-j	11.36 ı-k	6.90 d	6.66 d-f	6.78 d
Tarm 92	61.1 b-d	64.4 cd	62.7 cd	12.36 b	11.43 e-j	11.90 d-f	6.42 ıj	6.65 e-g	6.54 g
İnce 04	61.4 bc	63.6 de	62.5 d	12.34 bc	11.62 d-f	11.98 c-e	6.46 ı	6.19 pq	6.33 ı
Tokak 157/37	62.0 b	63.2 ef	62.6 d	11.66 e-g	12.02 b	11.84 d-g	6.28 kl	6.63 f-h	6.46 h
Larende	60.5 c-g	61.6 g	61.0 e-h	10.78 ıj	11.37 f-j	11.08 lm	6.46 hı	6.45 j	6.46 h
Exp. Avr.	**60.0**	**63.4**	**61.7**	**11.76**	**11.53**	**11.65**	**6.64**	**6.49**	**6.56**
CheckAvr.	**61.0**	**63.2**	**62.1**	**11.68**	**11.57**	**11.63**	**6.50**	**6.52**	**6.51**
LSD (0.05)	**1.07**	**0.89**	**0.69**	**0.45**	**0.25**	**1.92**	**0.12**	**0.03**	**0.06**

*Significant at 0.05 level of probability

TW, Test weight (kg hl^{-1}); **CP**, Crude protein content (%); **CF**, Crude Fibre content (%).

Conclusion

When evaluated the collected research findings in the present study collectively, lines 17 and 4, which was selected for feed quality characteristics such as high GY and CPC, are suggested as a new cultivar candidate for farmers who grow feed barley in dry agricultural areas.On the other hand, line 14, which was selected as malt barley genotype for its success in GY and TW, TKW, KS parameters, may be a new cultivar candidate for cultivation in dry farming conditions. Lines 6 and 16, which have some desirable properties in malt barley such as high GY, TKW, KS and low CPC, are recommended to be used as genetic material in malt barley development programs, since they can contribute significantly to the genotypic variation in barley breeding.

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