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Original article

Yield Stability and Physiological Parameters of Barley (*Hordeum vulgare* L.) Genotypes under Rainfed Conditions

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Abstract

The development of barley (*Hordeum vulgare*) genotypes over its life cycle depend on a number of environmental abiotic stress factors. Grain losses are often caused by high or low temperatures, drought, and such soil structure. The research was carried out to investigate the yield, stability, some quality, and physiological characteristics of some advanced barley genotypes under rainfed conditions. This research was established with 25 genotypes, in randomized complete blocks design with four replications at 3 locations in 2012-2013 growing years. Grain yield, plant height, days of heading, biomass, canopy temperature, 1000-kernels weight, and test weight was investigated. There were significant differences among the genotypes. Based on location, the highest yield was determined in Tekirdağ location. Cultivar Harman had higher yield potential. The highest biomass was measured for cultivars Harman and Lord and the lowest canopy temperature was measured for the G21 line. Earliness in terms of growing forage crops in the same growing year and short plant height for lodging resistance are very important characters in the Trakya region. G11 and G16 were early, and G6, G7, and G16 were the shortest genotypes. The highest 1000 kernels weight was measured in G3, and test weight in G19 lines. It was determined that cultivar Harman and 5 lines G7, G9, G22, G24, and G25 were well adapted to all environmental conditions. Genotypes Sladoran, G18, G3, and G8 were well adapted to fertile environmental conditions. Canopy temperature negatively affected and reduced grain yield, biomass, test weight, 1000-kernel weight, and protein ratio under rainfed conditions. The result of the study suggested that canopy temperature could be used in a barley breeding program for physiological parameters under rainfed conditions.

Keywords: Algeria, Constraints, Marketing, Rabbit farmers, Rabbit's meat.

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INTRODUCTION

Barley, one of the earliest crops in human history, is grown in over 100 countries. In the West, it is used mainly for animal feed or as malt for producing beverages. Barley can survive low rainfall, cold temperatures, and poor soils better than most other crops. In many areas, it is the only food crop that can provide reliable harvests even in bad years (Anonymous, 2006). Barley (*Hordeum vulgare* L.) is considered one of the most important foods and feed crops are grown worldwide in terms of harvested area, trade value, human and animal nutrition. Furthermore, barley is one of the most adapted plants to marginal environments characterized by terminal drought and heat stresses (Hossain et al., 2012). Crop growth is greatly dependent on climate as plant physiological processes respond directly to changes in air and soil temperature, solar radiation, moisture availability and wind speed (McKenzie and Andrews, 2010). Different stress reactions and mechanisms are known leading from susceptibility to resistance/tolerance. Thus, genetic variability plays a primary role in determining positive adaptation to environmental abiotic stresses and, hence, in supporting the spread of various barley genotypes to extreme climatic conditions (Cattivelli et al., 2017). Plants can experience abiotic stresses resulting from the shortage of an essential resource or from the excess of a toxic substance or form climatic extremes. Occurrence, severity, timing, and duration of stresses vary from location to location and in the same location from year to year. Furthermore, an abiotic stress seldom occurs alone, the plants often face growing conditions characterized by a combination of different physical stresses (Cattivelli *et al.* 2002).

Breeding for stress tolerance/resistance requires assessment of the differential sensibility of relevant genotypes. It is only when the response of a genotype to a given stress is known that more detail analyses of the underlying physiological and/or genetic mechanisms of adaptation to stress can be undertaken (Annicchiarico 2002, Voltas et al. 2002). Improving yield in drought prone environments is by far the most challenging topic in the field of abiotic stress tolerance due to the complexity of the physiological and molecular mechanisms involved. The physiologically relevant integrators of drought effects are the water content and the water potential of plant tissues (Jones 2007). Increases in yield potential achieved by plant breeding during the last Century have been well documented for numerous crops. Frequently, genetic gain has been studied by comparing in the same field trial the yield of cultivars characterized by different years of release. Comparison of the different cultivars then enabled identification of the main morpho-physiological traits modified during selection in association with yield improvement. For instance, studies carried out on barley and wheat genotypes commonly grown in the last Century showed that the increase in grain yield was directly correlated to an increase of the harvest index from about 30 up to 55% (reviewed by Cattivelli *et al.* 1994, Slafer *et al.* 1994). Grain yield of barley, like other crops, is a very complex trait that is a function of genetic and environmental factors. At different environmental conditions, different characteristics have an effect on increasing the seed yield and the effect ratio of these characteristics can be different depending on the barely kind. The correlation between the characteristics and the seed yield in barley indicates that seed yield has a significant and positive correlation with the agronomical characteristics (Tomer et al., 1999).

Canopy temperature effected by biological and environmental factors like water status of soil, wind, evapotranspiration, cloudiness, conduction systems, plant metabolism, air temperature, relative humidity, and continuous radiation (Reynolds et al., 2001). Phenotypic correlations of CT with grain yield were occasionally positive (Reynolds et al., 1994). The Normalized Difference Vegetation Index (NDVI) has commonly been used to evaluate the status of the crop and to associate it with growth traits and grain yield (Morgounov et al., 2014). NDVI has also been shown to have a positive relationship with grain yield and biomass under well-irrigated conditions and a stronger association with yield under drought conditions (Gutierrez-Rodriguez et al., 2004). Barley is an economically important growing crop in the Trakya region and earliness is favorable characters in barley due to early maturating cultivars less affected by the diseases and other environmental factors, followed after harvesting farmers produce second crops in the same growing season (Öztürk et al., 2014).

Almost all breeding programs in the world aim to improve varieties with stable yields. The yield stability is generally grouped as static or dynamic stability (Pfeiffer and Braun, 1989). Several methods have been developed to analyze and interpret genotype (G) x environment (E) interaction (Lin et al., 1986; Piepho, 1998). G × E interactions are of major importance, because they provide information about the effect of different environments on cultivar performance and have a key role for assessment of performance stability of the breeding materials (Moldovan et al., 2000). Environmental factors play a main role in the expression of genotype characteristics (Peterson et al., 1998). The development of varieties, which can be adapted to a wide range of diversified environments, is the ultimate goal of the plant breeders in barley improvement program (Vulchev et al., 2013; Valcheva et al., 2009).

Barley is an annual cereal crop and grown in environments ranging from many of the areas. The objective of the study is to investigate yield and some quality components, and physiological characters of barley genotypes under rainfed conditions and, also was to determined stability parameters of the bread barley genotypes.

MATERIALS and METHODS

The research carried out at three locations in Edirne, Kırklareli, and Tekirdağ in the 2012-2013 crop cycles. In the experiment, 20 advanced lines, and 5 local checks (Sladoran, Bolayır, Martı, Harman, Lord) was used. The experiment was set up in a randomized complete block design (RCBD) with four replications, and plots were 6 rows of 6.0 mx1m. Sowing was performed by using a plot drill and 500 seeds per square meter were used. Data recorded on grain yield (GY), days of heading (DH), plant height (PH), 1000-kernel weight (TKW), test weight (TW), and protein ratio (PRT) were compared. In the study some quality parameters, 1000-kernel weights, test weight (Blakeney et al., 2009), and protein ratio (Köksel et al., 2000; Anonymous, 2002; Anonymous, 1990) were investigated. A handheld infrared thermometer, with a field view of 2.5°C, was used to measure CT (°C). The data were taken from the same side of each plot at 1m distance from the edge and approximately 50cm above the canopy at an angle of 30° to the horizontal. Readings were made between 13.00 and 15.00h on sunny days. To avoid the effect of soil temperature on the CT, the data were taken when the infrared thermometer viewed no soil because of high leaf coverage areas (Babar et al., 2006; Reynolds et al., 2012; Pask et al., 2012). Biomass (NDVI) was taken at GS55, and GS69 growth stage (Gutierrez-Rodriguez et al, 2004; Pask et al., 2012).

Days to 50% heading**:** The number of days from the date of 1 October up to the date when the tips of the spike first emerged from the main shoots on 50% of the plants in a plot.

Plant height**:** The height of ten randomly taken plants was measured at harvest maturity from the ground level to the tip of the tallest spike in centimeter and averaged.

The average yield (x), regression coefficient (b), deviation from regression (S2d), and determination coefficients of the regression equations (R2) were used and calculated to determine the stability of varieties in this study (Finlay and Wilkinson, 1963; Eberhart and Russel, 1966). The most widely used method in breeding programs has been the regression on the mean analysis made popular by Finlay and Wilkinson (1963) (FW). A regression analysis was carried out to determine the analyzed characteristics. Correlations between grain yield and other traits were calculated using Microsoft Excel software.

Table 1. The rainfall, humidity, and temperature values recorded in Edirne location in the 2012-2013 growing cycle

Months	**Rainfall (mm)**	**Humidity (%)**	**Temperature (ºC)**		
			Min.	**Max.**	**Mean**
October 2012	46.1	73.3	5.7	34.0	18.9
November 2012	12.4	83.4	-0.9	24.0	12.2
December 2012	165.8	88.3	-6.2	17.6	3.6
January 2013	134.6	90.2	-7.7	18.2	4.2
February 2013	104.5	88.3	-0.7	18.8	6.8
March 2013	62.9	77.0	-1.7	23.6	9.8
April 2013	51.0	71.3	4.0	32.0	14.5
May 2013	11.0	66.7	4.9	32.9	20.8
June 2013	26.6	70.1	11.4	36.2	23.3
Total/Mean	614.9	78.7	-7.7	36.2	12.7

To evaluate significant differences between genotypes, the analysis of variance was performed. The differences between genotype means of parameters were tested by the L.S.D test. Letter groupings were generated by using a 5% level of significance. Data were analyzed statistically for analysis of variance the method described by Gomez and Gomez (1984). The significance of differences among means was compared by using L.S.D (%5) test (Kalaycı, 2005). Some climatic values such as rainfall, humidity, and temperature recorded at Edirne location are given in Table 1.

RESULTS and DISCUSSION

Grain yield is a complex characteristic depending upon a large number of environmental, agronomical, and physiological factors. Grain yields also depend on some other yield components. All the genotypes were evaluated under the rainfed environmental conditions and depending upon the location x genotypes interaction. So, significant differences among genotypes and locations based on yield and other investigated traits were found (Table 2).

Table 2. Sum of the square and mean square for yield physiological and quality traits measured in 25 barley genotypes grown under rainfed conditions

Characters	Sum of squares	Mean squares	F Ratio
Grain yield	556969.0	23207.0	9.175**
Plant height	1769.813	73.742	4.106**
Days of heading	789.413	32.892	24.939**
1000-kernel weight	2786.618	116.109	24.255**
Test weight	303.400	12.642	10.922**
Protein ratio	58.987	2.458	21.932**
Biomass (NDVI)	0.052	0.002	3.479**
Canopy temperature	31.090	1.295	1.649ns

* and ** indicate significances, ns: non-significant at $P<0.05$ and $P<0.01$, respectively.

The mean yield of the genotypes was 6048 kg ha^{-1}. Based on the location, the highest average yield of 7265 kg ha^{-1} was obtained in Tekirdağ, while the lowest mean yield was recorded in Kırklareli location with 4357 kg ha^{-1}. Across the three locations, Harman was the highest yielding cultivar with a yield of 6901 kg ha-1 (Tables 3 and 4). Thousand-grain weight was very variable among the genotypes and ranged between 27.5 g and 47.3 g. The highest 1000-kernels weight was measured in genotypes G3, G9, and Harman. The test weight one of the other examined traits and ranged between 67.5 kg and 76.1 kg and the highest test weight was measured for G19 and G21 lines (Table 4).

Table 3. The average value of the investigated characters based upon locations

Locations	GY	PH	DH	TKW	TW	PRT
Edirne	6521 b	94.8 b	104.3 c	38.2 b	72.8 b	9.2 c
Kırklareli	4357 c	89.9 c	115.9 b	37.0 b	71.0 c	9.6 a
Tekirdağ	7265 a	102.4 a	117.2 a	42.0 a	74.8 a	9.4 b
Mean	6048	95.8	112.5	39.1	72.9	9.4
LSD (0.05)	40.5**	2.3**	0.6**	1.2**	0.6**	0.2*

* and ** indicate significances, ns: non-significant at $P<0.05$ and $P<0.01$, respectively.

GY: Grain yield, PH: Plant height (cm), DH: days of heading, TKW: 1000 kernels weight (g), TW: Test weight (kg), PRT: Protein ratio (%)

There was a significant difference in total protein and its protein fractions among the 25 barley genotypes. The protein component was changeable over the different growing conditions, and the extent of change varied with protein fraction and genotype. Protein content was very variable among the genotypes. The mean protein was 9.4 g, the highest protein content was measured in genotypes Sladoran, Bolayır, G3, and G17.

Biomass and canopy temperatures were measured at the heading stage of the plant. Mean biomass was found to be 0.69 (NDVI) and the highest biomass was measured in Harman and Lord cultivars. Canopy temperature ranged between 21.1 and 23.4 ^{of} degree and the lowest canopy temperature was measured for the G21 line. For lodging resistance plant height is a highly considerable trait in the growing program and short plant height was measured in G6, G7, and G16 lines. Earliness is a very important trait in the Trakya region to grow forage crops in the same growing year. For earliness, G11 and G16 were outstanding genotypes (Table 4).

Table 4. The mean yield and standard deviation of the genotypes and quality, physiological parameters in the 2012-2013 growing cycle

No	Genotypes	GY	TKW	TW	PRT	NDVI	CT	PH	DH
1	Sladoran	6544±1853^{ab}	43.1^{d-g}	72.8^{def}	10.4^{a}	0.71^{b-f}	21.5^{def}	94.0^{e-k}	111.0^{def}
2	G2	5950±1694^{fg}	41.7^{fg}	74.8^{abc}	10.3^{ab}	0.68$^{e-ı}$	22.1^{b-f}	95.0^{d-j}	112.0^{de}
3	G3	6374±1759^{bcd}	47.2^{ab}	73.7^{cde}	10.4^{a}	0.69^{c-h}	22.0^{b-f}	90.7^{h-k}	112.7^{d}
4	G4	5442±1359^{hı}	31.0^{lm}	71.4^{fgh}	8.8^{fg}	0.69^{d-h}	21.9^{b-f}	108.3^{a}	112.3^{de}
5	Bolayır	5949±1677^{fg}	44.4^{b-g}	75.0^{abc}	10.4^{a}	0.71^{a-d}	21.9^{b-f}	102.0^{abc}	112.0^{de}
6	G6	5863±1313^{fg}	31.0^{lm}	68.3^{j}	8.1^{hı}	0.71^{b-f}	22.4^{a-e}	88.0^{k}	116.0^{bc}
7	G7	6432±1533^{bc}	30.2^{m}	70.2^{hı}	7.8^{ı}	0.70^{b-f}	22.2^{a-f}	89.3^{ıjk}	115.0^{bc}
8	G8	6397±1779^{bcd}	45.3^{a-e}	74.1^{a-d}	10.2^{ab}	0.70^{c-g}	21.6^{def}	94.3^{e-k}	111.7^{de}
9	G9	6357±1476^{b-e}	48.2^{a}	75.7^{a}	10.1^{ab}	0.69^{d-h}	21.9^{b-f}	100.7^{b-e}	111.3^{de}
10	Martı	5275±1432^{ıj}	34.8^{ıjk}	69.5^{ıj}	9.3^{def}	0.68^{d-h}	23.4^{a}	99.0^{b-g}	111.0^{def}
11	G11	5959±1047^{efg}	32.2^{klm}	71.9^{fgh}	8.8^{fg}	0.66^{hı}	22.9^{abc}	94.0^{e-k}	109.0^{g}
12	G12	5997±1560^{d-g}	30.0^{m}	70.6^{ghı}	7.8^{ı}	0.70^{c-g}	22.7^{a-d}	88.3^{jk}	116.7^{b}
13	G13	5898±1399^{fg}	34.0^{jkl}	71.2$^{f-ı}$	8.8^{fg}	0.68$^{e-ı}$	22.1^{b-f}	101.3^{bcd}	109.0^{g}
14	G14	5830±1683^{fgh}	35.9^{ıj}	71.7^{fgh}	8.5^{gh}	0.66^{ghı}	23.0^{ab}	95.3$^{c-ı}$	109.3^{fg}
15	Harman	6901±1662^{a}	46.9^{abc}	74.2^{a-d}	10.2^{ab}	0.74^{ab}	21.6^{def}	99.0^{b-g}	110.7^{efg}
16	G16	5662±1620^{ghı}	32.6^{j-m}	72.0^{efg}	8.9^{efg}	0.65^{ı}	22.6^{a-e}	93.0^{f-k}	109.3^{fg}
17	G17	5968±1773^{efg}	43.5^{c-g}	75.2^{abc}	10.4^{a}	0.70^{c-g}	21.7^{c-f}	103.0^{ab}	111.3^{de}
18	G18	6482±1681^{bc}	41.4^{g}	74.4^{a-d}	9.5^{cde}	0.69^{d-h}	21.6^{def}	94.7^{d-k}	112.0^{de}
19	G19	5749±1090^{fgh}	45.1^{a-f}	75.6^{ab}	10.3^{ab}	0.73^{abc}	22.1^{b-f}	93.7^{f-k}	112.3^{de}
20	Lord	4986±1155^{j}	37.6^{hı}	71.8^{fgh}	9.3^{def}	0.74^{a}	21.7^{def}	99.7^{b-f}	125.3^{a}
21	G21	6082±1790^{c-f}	42.2^{efg}	74.9^{abc}	9.8^{bcd}	0.67$^{f-ı}$	21.1^{f}	92.3^{g-k}	112.0^{de}
22	G22	6444±1555^{bc}	41.0^{gh}	73.9^{bcd}	9.9^{abc}	0.69^{c-h}	21.2^{f}	91.0^{h-k}	111.7^{de}
23	G23	5778±1470^{fgh}	41.2^{g}	74.1^{a-d}	10.2^{ab}	0.71^{a-d}	21.7^{c-f}	97.3^{b-h}	112.3^{de}
24	G24	6468±1572^{bc}	46.2^{a-d}	74.4^{a-d}	9.9^{abc}	0.70^{c-g}	22.0^{b-f}	97.0^{b-h}	112.0^{de}
25	G25	6406±1489^{bc}	31.4^{klm}	71.2$^{f-ı}$	7.9ı	0.71^{a-e}	21.5^{ef}	93.3^{f-k}	114.7^{c}
Mean		6048	39.1	72.9	9.4	0.69	22.0	95.8	112.5
LSD (0.05)		40.5	3.5	1.7	0.5	0.04	1.25	6.9	1.8

* and ** indicate significances, ns: non-significant at $P<0.05$ and $P<0.01$, respectively.

GY: Grain yield, TKW: 1000 kernels weight (g), TW: Test weight (kg), PRT: Protein ratio (%), NDVI: Biomass, CT: Canopy temperature (ºC), PH: Plant height (cm), DH: days of heading,

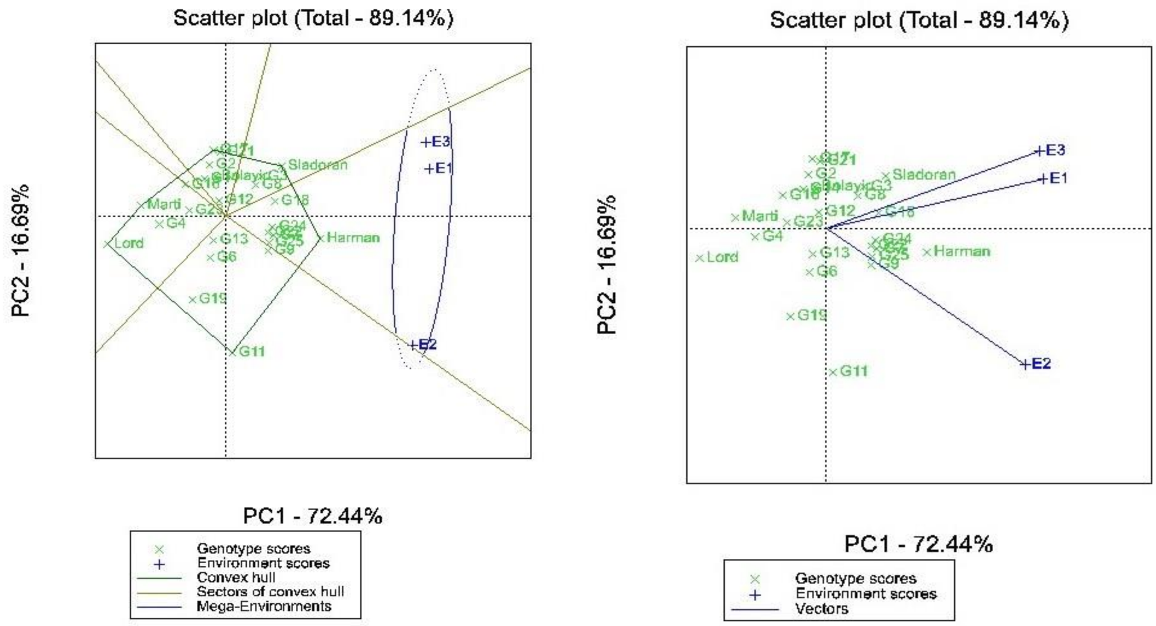
The success of the breeding program depends on the regional adaptability of the cultivars. This study was carried out so as to determine the main three target environments to determine the biotic and abiotic stresses of the genotypes. Several methods have been developed to analyse and interpret genotype x environment interaction (Lin et al., 1986; Piepho, 1998). It was determined that Harman variety and G7, G9, G22, G24, and G25 lines were well adapted to all environmental conditions. Sladoran and G18, G3, and G8 lines were well adapted to well environmental conditions. A genotype having stabile grain yield across the environment condition is very important in wheat breeding. Stability parameters based on grain yield of the genotypes showed that all stability parameters were significantly different. Sladoran and seven genotypes were very stable for grain yield due to their optimum coefficient of determinations (R2=1.00). The lowest value for deviation from regression (S2d) was obtained in Sladoran (S2d=0.38), G12 (S2d=0.65), and G3 (S2d=0.91), followed by G7, G17, and G25. Cultivars Harman and Lord besides G11, G19, G6, and G9 genotypes had the highest positive intercept values (a). The highest intercept value indicated that these cultivars were higher grain quality both fertile and less fertile environment conditions. There were high variation in regression coefficients (b) values and Table 5 shows that the regression coefficients (b) values ranged between 0.82 and 1.00. G12 had an optimum regression coefficient (b), and also genotypes G7, G12, G24, and G16 had value close to the optimum (b=1) regression coefficient. According to the result of the stability parameters, G7 was the best performing genotype and was very stable than other genotypes due to higher mean yield (6432.0 kg ha-1), optimum coefficient of determination (R2=1.00), the lowest value for deviation from regression (S2d=1.89), positive and highest intercept value (a=29.57), and almost very close to the optimum regression coefficient (b=1.01) (Table 5).

Table 5. The mean yield and stability parameters of the barley genotypes

Cv. No	**Genotypes**	**X**	**R^2**	**S^2d**	**a**	**b**
1	Sladoran	6543.7	1.00	0.38	-87.39	1.23
2	G2	5949.7	1.00	11.44	-81.53	1.12
3	G3	6374.3	1.00	0.91	-66.81	1.16
4	G4	5441.7	0.97	48.67	8.56	0.89
5	Bolayır	5949.0	0.99	27.52	-72.43	1.10
6	G6	5863.0	0.98	24.50	65.23	0.86
7	G7	6432.0	1.00	1.89	29.57	1.01
8	G8	6396.7	0.89	282.21	-33.51	1.11
9	G9	6357.3	0.98	31.63	49.93	0.97
10	Martı	5275.0	0.93	114.64	-26.39	0.92
11	G11	5959.0	0.82	162.34	215.47	0.63
12	G12	5996.7	1.00	0.65	-24.76	1.03
13	G13	5898.0	0.98	30.32	34.93	0.92
14	G14	5830.0	0.95	113.10	-74.72	1.09
15	Harman	6901.0	0.92	177.44	50.68	1.06
16	G16	5661.7	0.94	124.45	-63.94	1.04
17	G17	5967.7	1.00	2.81	-112.58	1.17
18	G18	6481.7	1.00	6.69	-23.98	1.11
19	G19	5749.0	0.94	60.83	152.08	0.70
20	Lord	4985.7	0.96	43.91	45.38	0.75
21	G21	6081.7	0.96	96.42	-95.35	1.16
22	G22	6444.0	0.95	103.44	37.86	1.00
23	G23	5778.0	0.95	86.92	3.69	0.95
24	G24	6468.3	0.98	50.40	25.06	1.03
25	G25	6405.7	1.00	3.16	44.98	0.98

X: mean yield, R^2: coefficient of determination, S^2d: deviation from regression, a: intercept value, b: regression coefficient

Almost all breeding programs in the world aim to improve varieties with stable yields. The yield stability is generally grouped as static or dynamic stability. The static stability is defined as the lack of response to environmental variations while the dynamic stability is defined as the average response (Pfeiffer and Braun, 1989). Several methods have been developed to analyze and interpret the genotype (G) x environment (E) interaction (Lin et al., 1986; Piepho, 1998). G × E interactions are of major importance because they provide information about the effect of different environments on cultivar performance and have a key role for the assessment of performance stability of the breeding materials (Moldovan et al., 2000). Environmental factors play a main role in the expression of genotype characteristics (Peterson et al., 1998). Analysis of genotype by environment data is often limited to genotype evaluation based on genotype main effect (G) while genotype-by-environment interactions (GE) are treated or a confounding factor (Yan and Tinker, 2006).

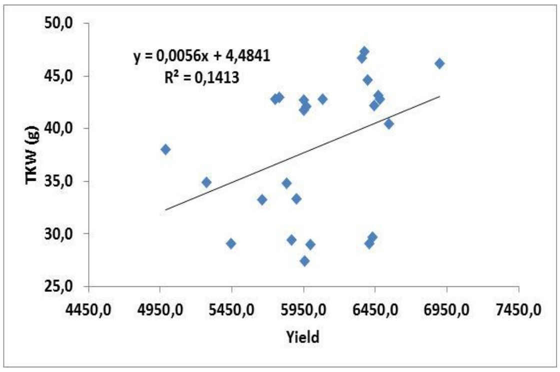


1a 1b

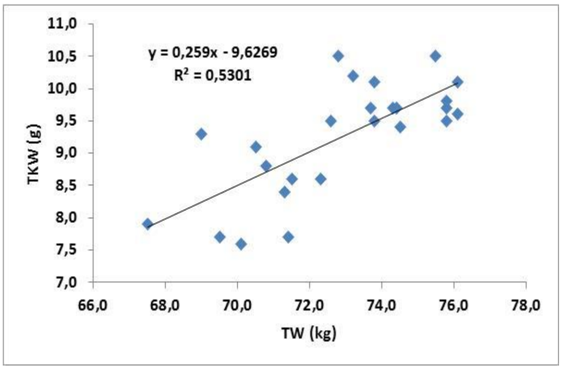
Figure 1. The environment-vector view of the GGE biplot to show similarities among the test environments in discriminating the genotypes (Figure 1a), and Polygon view of GGE biplot for the “which-won-where” pattern of genotypes and environments (Figure 1b).

Figure 1a showed a “what-won-where” biplot for the 25 genotypes across three environments. It is clear that cultivar Harman gives the highest expected yields in the majority of environments. In Figure 1a, the vertex genotypes that form the polygon are Harman, Sladoran, G17, Martı, Lord, and G11. Cultivar Harman is the vertex cultivar in the sector where E1, E2, and E3 are placed in these three environments. Based on the GGE analysis the first two principal components explained about 89.14% of the total interaction variation. The GGE biplot analysis was used for the estimation of discriminating power and representativeness of an environment as a test one for assessing genotypes. GGE biplot allows visualizing environment vectors lengths, which are proportional to standard deviations of genotype yields in a corresponding environment (Figure 1b). The cosine of the angle between environment vectors is used for assessment of approximation between them and the smaller the angle between environment vectors is the larger correlation between them is (Yan, Holland, 2010). Hence the pair of testers, which were positively correlated had an angle between their vectors less than 90^o, so E3 and E1 were highly positively correlated.

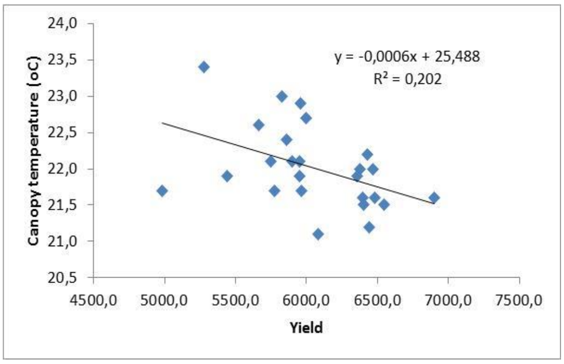
Some relations between the studied characters were examined in the study. Canopy temperature negatively affected and reduced grain yield, biomass, 1000-kernel weight, and test weight. So, it was found a negative relation between canopy temperature with grain yield, biomass, test weight, and 1000-kernel weight. There was a positive relationship between grain yield and thousand kernels weight and test weight (Figure 2). Linear regression was used to determine the grain yield and other examined traits. There was a moderate positive relationship between grain yield and 1000-kernel weight. There was also a negative relationship between canopy temperature with biomass (R2=0.180), grain yield (R2=0.202), 1000-kernels weight (R2=0.277), and test weight (R2=0.346). Grain yield positively correlated with test weight (R2=0.141). It was a moderate negative relationship between grain yield and canopy temperature and (R2=0.202). Canopy temperature also negatively affected and reduced test weight and 1000-kernel weight, so there was a negative correlation between CT with TW (R2=0.346) and TKW (R2=0.277) (Figure 2). The overall evaluation yield of genotypes and location indicated that the grain yield of barley was affected by genetic and environmental factors. Change in yield varied depending on different environmental conditions and agronomic traits of the genotypes.



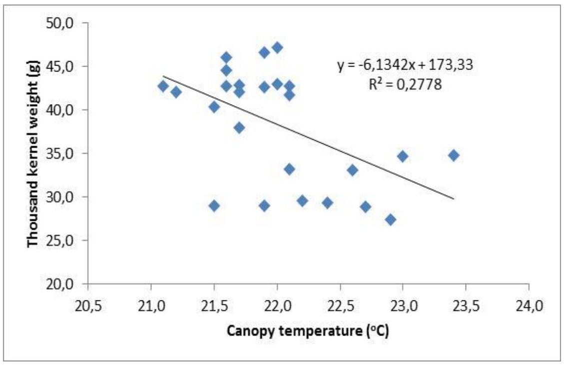
1000-kernels weight and grain yield



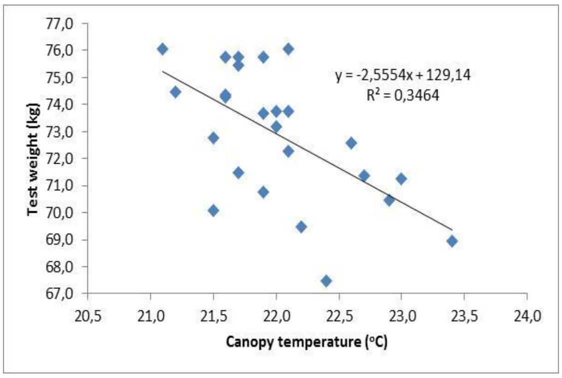
1000-kernel weight and test weight



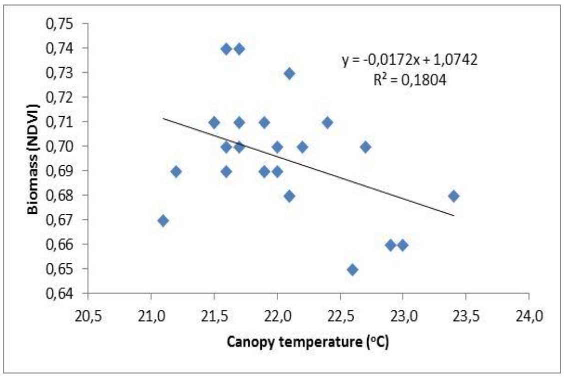
Canopy temperature and grain yield



1000-kernels weight and canopy temperature



Test weight and canopy temperature



Biomass and canopy temperature

Figure 2. The comparison of the some characters examined in this research

Correlation coefficients presented in Table 6 among the tested characters showed that there were significant relations between some traits. A strong negative correlation was observed between grain yield and canopy temperature (r= -0.450*), and moderate positive correlation between grain yield and 1000-kernels weight (r= 0.376), and test weight (r= 0.315). These results indicated that higher test weight and 1000-kernel weight increased grain yield and higher grain yield was obtained under low canopy temperature. It was determined that there was a negative correlation between biomass (NDVI) with canopy temperature (r= -0.425*), and a positive relation between biomass and days of heading (r=

0.548**). Earliness affected the yield potential and the early maturating genotypes had higher yield potential. Canopy temperature was highly and negatively correlated with 1000-kernel weight (r= -0.527**) and test weight (r= -0.589**). Grain protein content was significantly and positively correlated with TKW (r= 0.785**), and TW (r= 0.728**) but was not correlated with biomass (NDVI). These results are in agreement with the earlier finding (Gutierrez-Rodriguez et al., 2004; Babar et al, 2006; Reynolds et al., 2001).

Table 6. Coefficient of correlation of the parameters studied in this research

Traits	GY	NDVI	CT	TKW	TW	PRT	PH
NDVI	0.117						
CT	-0.450*	-0.425*					
TKW	0.376	0.277	-0.527**				
TW	0.315	0.118	-0.589**	0.832**			
PRT	0.170	0.018	-0.320	0.785**	0.728**		
PH	-0.133	0.323	-0.188	0.298	0.246	0.337	
DH	-0.309	0.548**	-0.171	-0.163	-0.322	-0.411*	-0.042

Significance at *: P<0.05 and **: P<0.01, GY: Grain yield, NDVI: Biomass, CT: Canopy temperature, TKW: 1000-kernels weight, TW: Test weight, PH: Plant height, DH: Days of heading

Conclusion

Because of the various environmental conditions, considerable variations were observed among genotypes and locations based on the yield and other studied traits. Cultivar Harman had higher yield potential. Harman variety and G7, G9, G22, G24, and G25 were well adapted to all environmental conditions. Sladoran and G18, G3, and G8 genotypes were well adapted to fertile environmental conditions. Canopy temperature negatively affected and reduced grain yield, biomass, test weight, 1000-kernel weight, and protein ratio under rainfed conditions. There was a positive relationship between grain yield and 1000-kernel weight and test weight. According to the result of the stability parameters, G7 was the best performing genotype and was very stable than other genotypes due to higher mean yield, optimum coefficient of determination, the lowest value for deviation from regression, positive and highest intercept value, and almost very close to the optimum regression coefficient. The result of the study suggested that canopy temperature could be used in a barley breeding program for physiological parameters under rainfed conditions.

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