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Determination of grain yield and some yield components of some two and six row barley (*Hordeum vulgare* L.) genotypes in Eskisehir ecological terms

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Abstract

This study was carried out to investigate yield and some yield characteristics of two and six row barley genotypes (5 hybrids and 5 standard varieties) in 2012/13 and 2013/14 growing seasons. The study, which was carried out in the experimental and research fields of Eskisehir Osmangazi University Faculty of Agriculture, was established according to the randomized blocks experimental design with 3 replications. In the research; plant height, spike length, grain number spike^{-1}, grain weight per spike^{-1}, spike number per M^{-2}, harvest index and grain yield characteristics were investigated. Genotypes were found to be statistically significant at the level of 1 % in all the traits examined. When the differences between the years were examined, the years were significant in all characteristics except the ear length. The effect of year x genotype interaction was found to be significant in all traits except for the harvest index value. Grain yield values varied between 347.9 kg/da-1 and 537.76 kg/da-1. The highest grain yield and grain weight per spike were obtained from the CLR x PLS (6) six-row hybrid, followed by PLS x KLC (6) with 468.44 kg/da-1 and PLS x CLR (6) (467.03 kg/da-1). These hybrids have been identified as promising.

Keywords: Barley, genotype, grain yield, yield components, hybrid

Introduction

Barley (*Hordeum vulgare L.*), which has the oldest history among cultivated plants, was used as human food together with settled agriculture. Barley, which is the most produced in the world after wheat, rice and corn, is mostly used in animal nutrition and malt production. (Kün, 1996). The yield value of barley, which has 51 731000 Hectares of cultivation area and 159 738 000 tons of production in the world, is 310 Kg/da. In Turkey, barley production area in 2020 is 28 690 715 decares, production amount is 7 600 000 tons and yield value is 268 kg/da (Anonymous, 2021a). In Eskişehir Province, the production amount was realized with 1 019 278 decares of cultivation area and 272 512 tons (Anonymous, 2021b). In addition to being the most selective among the cool climate cereals in terms of climate and soil requirements, it is produced both in dry farming areas and in areas with sufficient precipitation. Most of the barley production in our country takes place in the Central Anatolian Region (Kınacı and Kınacı, 1992). It is the most preferred cereal in terms of animal nutrition due to its high crude protein and digestible nutrient content in its grain (Akkaya and Atken, 1986).

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The aim of breeding studies is to create varieties with high yield and quality, resistant to diseases and pests. Yield performances of the developed cultivars vary according to environmental conditions. In order to obtain high yield per unit area, varieties that adapt to the ecological conditions of the region should be obtained and production should be made with appropriate cultivation techniques. Changes can be made in terms of cultural practices, but no changes can be made regarding cultivar or genotype characteristics. Considering this factor, it is focused on increasing or improving the yield potential of the genotypes considered in breeding studies. Therefore, the characters that can affect the yield should be well known and the mutual effects on each other should be revealed (Yağdı, 2002). The annual precipitation in the Central Anatolia region shows an irregular distribution according to the months. It is necessary to develop stable varieties that can withstand the irregular precipitation and winter conditions of the region (Yüksel et al., 2017). The study was carried out with the aim of determining the morphological characteristics of the two-row and six-row barley cultivar candidates developed as a result of breeding work and the cultivars adapted to the region and cultivated in large areas. For producers, high yield is very important in barley cultivation.

Material and Methods

The research was carried out in Eskişehir Osmangazi University Faculty of Agriculture Application and Research fields in the 2012/13 and 2013/14 production periods in Eskisehir conditions, and was carried out with a total of 10 barley genotypes consisting of five cultivar candidates (hybrids) and five cultivars. The experiment, which was carried out according to the randomized blocks trial design, was carried out in dry conditions with 3 replications. As the material in the study; PLS x CLR (6) (6-row), PLS x CLR (2) (2-row), PLS x KLC (6) (6-row), CLR x PLS (2) (2-row), CLR x PLS (6) (6-row), Kalaycı 97 (2-row), Plaisant (6-row), Cumhuriyet 50 (2-row), İnce-04 (2-row) and Özdemir-05 (2-row) genotypes were used. The soil in which the research was carried out was prepared for sowing by ploughing with a plow with a plow and plow with a combination of crowbar and rake. The plots were 4 m long, 14.5 cm row spacing and 6 rows in the planting made with the parcel seeder on 15.10.2012 and 25.10.2013. In the experiment, the seed amount was applied as 22 kg/da-1 and the fertilizer amount was 6 kg/da-1 P_2O_5 and 6 kg/da-1 N. Weed control was done by mechanical means. In order to eliminate the edge effects, observations, measurements and harvests were made 0.5 m from the beginning and end of the rows and from the remaining parts by removing the side rows. Eskisehir province is under the influence of terrestrial climate. The meteorological data of the production years (2012-2013-2014) and the long-term averages in which the research was conducted are given in Table 1.

Table.1. Meteorological data for many years (1975-2014) and 2012-2013 and 2013-2014 years in the vegetation period in Eskişehir province

	Year	October	November	December	January	February	March	April	May	June	July	Avarege/Tot.
Avarege Temperature (ºC)	2012/13	14,2	7,3	2,2	1,7	4,3	7,1	10,8	17,7	20,0	21,6	10,7
	2013/14	9,8	6,7	1,7	3,6	6,0	6,2	11,3	16,4	19,9	23,7	10,5
	Long-Term (1975-2014)	12,4	6,5	3,2	0,5	2,9	6,0	10,6	15,4	19,8	22,7	10,0
Total Precipitation (mm)	2012/13	16,1	14,5	73,2	18,5	36,5	33,2	37,8	9,5	14	0,8	254,1
	2013/14	65,0	15,0	1,5	21,0	7,0	27,1	23,2	53,8	70,5	20,4	304,5
	Long-Term (1975-2014)	26,1	29,8	46,1	38,2	32,5	33,4	35,2	43,3	28,6	13,5	326,7

In the application and research fields of Eskisehir Osmangazi University Faculty of Agriculture, where the experiment was carried out, the soils of the trial area contain 1.68 % organic matter and 4.38 % lime. It is loamy and slightly alkaline (pH 7.6–8.2). Some physical properties of the trial site are given in Table 2.

Table 2. Some physical and chemical characteristics of soil for research area

Soil depth (cm)	Total salt (%)	Organic Matter (%)	Lime (%)	Phosphorus P_2O_5 (kg/da)	Potassium K_2O (kg/da)	Structure	pH
0-30	0,050	1,68	4,35	3,84	215,2	Loamy	7,98

For each genotype in the experiment, plant height, spike length, number of grains per spike, grain weight per spike, number of plants per square meter, harvest index and grain yield measurements were made. Statistical analyzes were held trough SAS and and Jump 7 package program. Comparisons between mean values are given using the LSD Test.

Results and Discussion

Plant height, spike length, number of grains per spike, grain weight per spike, number of spikes per m2, harvest index and grain yield parameters were investigated in our study to reveal the performance and yield values of some cultivars and cultivar candidates in Eskisehir conditions. The combined variance analysis results of the genotypes used in the experiment are given in Table 3.

Table 3. Variance Analysis Results of the Parameters Evaluated in the Experiment

		Mean Square						
Source of Variation	**D.F.**	**Plant Height**	**Spike Length**	**Grain Number Spike^{-1}**	**Grain Weight per Spike^{-1}**	**Spike numbers M^{-2}**	**Harvest Index**	**Grain Yield**
Replication	2	1,007 ns	0,077 ns	1,433 ns	0,00*	17,617 ns	4,046 ns	49,822 ns
Year	1	812.544**	0.028	232.460**	0.490**	43578.150**	73.549*	10965.531**
Error	2	1.897	0.210	0.769	0.000	18.650	2.936	5.498
Genotype	9	14.346**	2.201**	808.376**	0.371**	4179.831**	18.365ns	18643.649**
Year x Genotype	9	45.872**	1.915**	29.802**	0.097**	1796.780**	5.031ns	3609.078**
Error	36	0.486	0.076	0.322	0.000	46.244	10.151	43.599
General	59	23.353	0.684	132.069	0.080	1679.745	11.246	3608.818
CV %		5.23	10.85	35.83	20.92	10.03	9.14	14.24

*P≤ 0.05,** P≤ 0.01 ns: Not significant.

The mean values of the genotypes and the classification according to the LSD test are given in Table 4. In terms of plant height, the interaction of year, genotype and year x genotype was found to be statistically significant at the 1% level. Average plant height values among genotypes varied between 91.05 cm and 95.33 cm. Kalaycı 97 (95.33 cm) variety got the highest value, while 2-row PLS x CLR (2) (91.05 cm) hybrid, 6-row CLR x PLS (6) (91.05 cm) hybrid and Cumhuriyet 50 (91. 07 cm) cultivar and took place in the same group statistically.

Table 4. Two-year average values of the parameters examined in barley cultivars and cultivar candidates

Genotypes	**Plant Height**	**Spike Length**	**Grain Number Spike^{-1}**	**Grain Weight per Spike^{-1}**	**Spike numbers M^{-2}**	**Harvest Index**	**Grain Yield**
PLS x CLR (6)	93,93b	6,94f	46,10b	1,67b	439,67a	36,07bc	467,03b
PLS x CLR (2)	91,05e	8,52a	23,15ef	1,26d	423,00b	35,73bc	383,86ef
PLS x KLC (6)	92,27cd	7,53cd	47,83a	1,52c	348,67h	35,92bc	468,44b
CLR x PLS (2)	94,35ab	7,95bc	22,85ef	1,21e	405,50ef	35,50bc	430,73c
CLR x PLS (6)	91,05e	7,01ef	45,35b	1,79a	409,33ef	34,69c	537,76a
Kalaycı 97	95,33a	7,42de	22,58ef	1,11h	420,50cd	38,79ab	347,94h
Plaisant	92,22cd	7,03ef	42,55c	1,50c	390,00g	37,19abc	410,84d
Cumhuriyet 50	91,07e	7,96b	24,65d	1,19f	410,83de	37,50abc	378,62f
İnce-04	91,23de	8,59a	23,32e	1,15g	438,67a	40,31a	390,87e
Özdemir-05	92,37c	7,31def	22,33f	1,10h	398,67fg	35,32bc	402,29d
Mean	92,49	7,62	32,07	1,35	408,48	36,70	421,84
LSD Year	3,53	0,51	2,25	0,01	11,07	1,90	6,01
LSD Genotype	1,10	0	0,89	0,02	10,68	3,73	10,37
LSD Year x Genotype	1,55	0,61	1,26	0,03	15,10	5,28	14,66

The average plant height values of the years are given in Table 5. The plant height value was higher in the 2013-2014 production season (96.17 cm). The high amount of precipitation in April and May, when the vegetative growth of the plants is high, was effective in the high plant height.

Table 5. Average values of parameters examined in barley cultivars and cultivar candidates by years

Years	**Plant Height**	**Spike Length**	**Grain Number Spike^{-1}**	**Grain Weight per Spike^{-1}**	**Spike numbers M^{-2}**	**Harvest Index**	**Grain Yield**
2012/2013	88.81b	7,60a	30,10b	1,26b	381,53b	35,59b	408,32b
2013/2014	96.17a	7,65a	34,04a	1,44a	435,43a	37,81a	435,36a
Mean	92,49	7,62	32,07	1,35	408,48	36,70	421,84

Plant height is a feature that changes according to the effect of genotype and environment and is mostly affected by genotype (Whitman et al., 1985; Yılmaz and Dokuyucu, 1994; Kendal et al. 2010; Sirat and Sezer, 2017a). While some researchers emphasized that shorter varieties should be developed in order to increase lodging resistance and yield (Anderson and Reinbergs, 1985), some researchers (Şener et al., 2020) emphasized the development of tall varieties in order to close the roughage deficit. In the study conducted by Sönmez and Yüksel (2019) in Eskisehir conditions, the plant height values were found to be between 70 cm and 101.3 cm in dry conditions, and Yüksel et al. (2017) reported that it varies between 92.5 cm and 129.5 cm. The findings obtained in the study are similar to the findings of other researchers.

The interaction of genotype and genotype x years in terms of spike length was found to be significant at the level of 1% (Table 3). The highest spike length among the cultivars was the Ince 04 (8.59 cm) cultivar, the PLS x CLR (2) (8.52 cm) two-row hybrid was found in the same group statistically. PLS x CLR (6) (6.94 cm), a six-row hybrid, had the lowest spike length value (Table

4). According to the average spike length values; the 2012-2013 production season had a lower value (Table 5). It is stated that the length of the spike is mostly affected by genetic factors as well as by the time of earing, sowing frequency, precipitation and other environmental factors (Puri et al., 1982; Çölkesen et al. 2002; Kaydan and Yağmur, 2007). In studies conducted by some researchers in similar and different ecologies, the spike length values are 5.8-9.4 (Çölkesen et al. 2002; Sirat and Sezer, 2016; Yüksel et al., 2017; Şener et al., 2020; Çelik, 2020) detected among them.

The difference between year, genotype and year x genotype interaction in terms of grain number spike^{-1} was found to be significant at the level of 1% (Table 3). When the average values of the number of grains per spike of the plants were examined, the six-row PLSxKLC (6) and PLS x CLR (6) hybrids (47.83; 46.10 units) had the highest values. Özdemir-05 variety and Kalaycı-97 variety had the lowest grain count values with 22.33 pieces per spike (Table 4). According to the averages of the years, the 2013-14 production season has a higher value than the 2012-13 production season with 34.04 grains per spike (Table 5). The number of grains per spike is among the yield elements. The number of grains per spike is among the yield elements. It varies depending on the number of flowers in the spikelet and the grain setting ratio of the flowers, and it is also under the influence of environmental factors (Sirat and Sezer, 2013; Kaydan and Yağmur, 2007). The high amount of precipitation in April and May of the 2013/2014 production season affected this feature positively and caused it to have a higher value compared to the first year. The values obtained as a result of this study with six-row and two-row barley genotypes Yüksel et al. (2017) is similar to the obtained values. The number of grains per spike of six-row barley is higher than that of two-row barley. In studies conducted by many researchers in different ecologies in two- and six-row genotypes, the grain count values per spike were reported to be between 19 and 83 (Sirat and Sezer, 2013; Çöken and Akman, 2016; Sirat and Sezer, 2016; Şener et al., 2020).

In the two-row and six-row barley genotypes included in the experiment, the interaction of year, genotype and year x genotype was found to be significant at the level of 1% in terms of grain weight per ear (Table 3).The average of the grain weight values per ear of the two years was determined as 1.35 g. In the 2013/14 production season, the average grain weight per ear was 1.44 g, which was higher than the first year and was consistent with the grain number and yield values per ear (Table 5). CLR x PLS (6) and 1.67 g, PLS x CLR (6) hybrids had the highest values with 1.79 g and Özdemir-05 and 1, respectively, the lowest values with 1.10 g, according to the number of grains per spike in which the two years were evaluated together. Kalaycı 97 cultivars were obtained with .11 g (Table 4). Sirat and Sezer (2013), in their study, average grain weight per ear is 1.25 g in the first year and 1.29 g in the second year, Yüksel et al. (2017) reported that they found it to be 0.86 g in two years. Grain weight per spike is one of the most important features affecting grain yield per unit area (Akdamar et. al., 2002, Sirat and Sezer, 2017a). Spike length is affected by the number of grains per spike, the number of rows of the genotype and other genotypic effects. In addition, the planting frequency is very important in the precipitation it receives during the grain filling period in the growing season (Kenar and Şehirali, 2001; Kaydan and Yağmur, 2007). In the study, it is estimated that the high amount of precipitation in the second year caused the weight to be higher.

The differences between year, genotype and year x genotype interaction in terms of the number of spike number M^{-2} were found to be statistically significant (Table 3). According to the average of two years, the number of spikes per square meter of genotypes varied between 348.67 and 439.67. While PLS x CLR (6) six-row hybrid showed the highest value with 439.67 units, İnci-04 variety was in the second place with 438.67 units and were included in the same group. The lowest value was PLS x KLC (6) six-row hybrid (348.67 units). Sirat and Sezer (2013); while stating that the amount of precipitation after planting takes place and the amount of precipitation during the vegetation period affects the number of ears per square meter, Walker and Matthews (1991) stated that the number of fertile ears may be lower in years with harsh winters. In the first year of our study, precipitation amounts in October and November, and in April and May were lower than in the second year, and it is estimated that this may be the reason for the lower value compared to the second year. In some studies conducted in different ecologies, the number of spikes per square meter varied between 397.57 - 516.73 (Sönmez et al., 1996; Sirat and Sezer 2013; Sirat and Sezer 2017a). The findings of our study are in agreement with the findings of the researchers.

According to the results of analysis of variance in terms of harvest index, statistically significant ($P \leq 0.05$) differences were found between years, while the interaction of genotype and year x genotype was found to be insignificant (Table 3). While the average of the harvest index values of the genotypes was determined as 36.70% in the experiment, the second year was found to be 37.81% higher than the first year (35.59%) (Table 5). The highest harvest index was the Ince-04 variety with 40.31%, while the lowest harvest index was the CLR x PLS (6) hybrid with 34.69 % (Table 4). Sirat and Sezer (2017a) expressed the harvest index as the efficiency of conversion of dry matter into yield. Harvest index varies according to variety, sowing time and frequency, number and weight of grains per spike, number and weight of stems (Kenar and Şehirali, 2001; Akdamar et. al., 2002). In the study conducted by Sirat and Sezer (2017b) on some barley varieties in the Bafra Plain, the average harvest index values were found to be between 36.11-42.92 % and this is consistent with our study. It was determined as 15.50-30.17 % and did not comply with our study.

According to the variance analysis results in terms of grain yield per decare, the differences between genotypes, year and year x genotype interaction were found to be statistically significant at the $P \leq 0.01$ level (Table 3). According to the average of two years, the highest grain yield was obtained with 537.76 kg/da-1 from CLR x PLS (6) 6-row hybrids. This was followed by PLS x KLC (6) 6-row barley cross with 468.44 kg/da-1 and PLS x CLR (6) 6-row barley cross with 467.03 kg/da-1. The lowest average yield was determined from Kalaycı 97 (347.94 kg/da-1) and Cumhuriyet 50 (378.62 kg/da-1) varieties (Table 4). High precipitation amount received in the second year of the study affected the total yield and higher grain yield was obtained compared to the first year. In the experiment, 408.32 kg da-1 in the first year, 435.36 kg/da-1 in the second year and 421.84

kg/da-1 in the average of two years were determined (Table 5). Grain yield is a parameter that occurs as a result of genotype characteristics reflecting cultivar characteristics and environmental factors (Feil, 1992; Poehlman and Sleper, 1995; Paunovic et al. 2006). Genotypic features are stated as morphological features including tillering, ear length, grain number and size, hectoliter weight (Kandemir N. 2004; Kaydan et al. 2007). Varieties can show different yield values according to the ecological structure of the environment and the cultural processes applied (Kalaycı et al. 1991; Karadoğan et al., 1999; Sirat and Sezer, 2017b). The most effective factors among these are the amount of precipitation and its distribution, and temperature (Kalaycı et al. 1991; Hay and Porter, 2006). In the experiment, the total amount of precipitation in the second year was higher than the first year, which caused the plant height, number of grains and weight, the number of spikes per square meter and the harvest index values to be higher. Some researchers stated with their findings that yield values in grain differ according to years and varieties. Çöken and Akman (2016), who stated that the grain yield changed between 169.67-363 kg/da-1 in Isparta ecological conditions and Zeynelağa and Bolayır cultivars had the highest value, reported that the grain yield of some barley lines and cultivars was 471.4-697 in Eskişehir ecological conditions. Indicating it as kg/da-1, Yüksel et al. (2017)'s findings show parallelism with the findings in our study. Similar results have been obtained in many studies conducted in different climates and locations (Sirat and Sezer 2013; Yüksel et al. 2017; Sönmez and Yüksel, 2019; Şener et al. 2020).

Conclusion

According to the findings obtained from a total of ten genotypes consisting of 5 cultivar candidates (hybrids) and 5 cultivars; yield and yield components of genotypes were investigated. According to the results obtained, the interaction of genotypes, year and year x genotype was found to be statistically significant. According to the results of the research, the highest grain yield is CLR x PLS (6) (537.76 kg/da-1), PLS x KLC (6) (468.44 kg/da-1) and PLS x CLR (6) (467, 03 kg/da-1) were determined from 6-row hybrids. Among the cultivars, Plaisant and Özdemir-05 had the highest grain yield. The highest plant height is from Kalaycı 97 variety and CLR x PLS (6) and PLS x CLR (6) hybrids; highest spike length from the Slim 04 variety and the PLS x CLR (2) hybrid; highest grain number per spike from PLS x KLC (6), PLS x CLR (6) and CLR x PLS (6) hybrids; The highest grain weight per ear was obtained from CLR x PLS (6) and PLS x CLR (6) hybrids, and the highest yield index with the highest number of ears per square meter was obtained from İnce-04 variety. According to the yield results obtained from the study, CLR x PLS (6), PLS x KLC (6) and PLS x CLR (6) hybrids are more promising in Eskisehir conditions compared to other genotypes. Their performance was better than the cultivars used in the study.

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Author Contributions

Nazife Gözde AYTER ARPACIOĞLU: Field work, ,article writing; Zekiye BUDAK BAŞÇİFTÇİ: Field work, ,article writing.

Conflict of Interest

The authors are declared that they have no conflict for this research article.

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