Dicle Üniversitesi Fen Bilimleri Enstitüsü Dergisi

dergi anasayfa: http://www.dufed.org

Evaluation of relationships between yield and yield components with physiological parameters in barley (*Hordeum vulgare* L.) genotypes

Arpa (Hordeum vulgare l.) genotiplerinde verim ve verim unsurları ile fizyolojik parametreler arasındaki ilişkilerin değerlendirilmesi

Ferhat KIZILGECI[1], Mehmet YILDIRIM[2], Cuma AKINCI[2], OnderALBAYRAK[2], Ugur SESIZ[1], Nihan TAZEBAY[1]

[1]*Department of Field Crops, Faculty of Agriculture, Sirnak University 73300 Sirnak, Turkey*

[2]*Department of Field Crops, Faculty of Agriculture, Dicle University,21280 Diyarbakir, Turkey*

M A K A L E B İ L G İ S İ

Geliş Tarihi: 24.07.2018
Revizyon Tarihi: 30.07.2018
Kabul Tarihi: 02.08.2018
Elektronik Yayın Tarihi: 30.08.2018
Basım: 15.09.2018

ABSTRACT

This research was carried out to assess the relationships between yield and yield components with physiological traits which measured at the heading stage of some barley cultivars. The field experiment was arranged as the complete block design with four replications during the 2015-2016 growing seasons under Sirnak ecological conditions. Six-rowed (Altikat, Kendal, Akhisar 98, DZ12-1) and two-rowed (Baris, Pandora) barley cultivars were used as a material. Leaf area index (LAI), SPAD, Normalized Differences Vegetative Index (NDVI), Canopy Temperature (CT), Protein Content, text weight, thousand kernel weight, starch content and grain yield were evaluated. According to the findings of research, differences between genotypes were found significant for protein content, starch content, yield, thousand kernel weight and test weight. The investigated traits ranged between 30.85-35.43 in SPAD, 1.70-2.30 in LAI, 0.505-0.533 in NDVI, 15.45°C-17.85 °C in CT, 1958-3093 kg ha^{-1} in grain yield, 32.55-46.27 g in thousand kernel weight, 66.35-73.40 kg hL^{-1} test weight, 8.1-9.1% in protein content, 63.13-66.49% in starch. Grain yield showed significant (r=0.989**) relationships with canopy temperature.

Keywords: Barley, canopy temperature, Leaf area index, SPAD, grain yield

ÖZET

Bu araştırma, bazı arpa çeşitlerinde başaklanma döneminde ölçülen fizyolojik özellikleri ile verim ve verim unsurları arasındaki ilişkileri değerlendirmek amacıyla yapılmıştır. Arazi çalışması, Şırnak ekolojik koşullarında 2015-2016 yetiştirme döneminde tesadüf blokları deneme desenine göre dört tekrarlamalı olarak yürütülmüştür. Materyal olarak iki sıralı (Barış, Pandora) ve altı sıralı (Altıkat, Kendal, Akhisar 98, DZ12-1) arpa çeşitleri kullanılmıştır. Çalışmada, yaprak alanı indeksi (YAI), SPAD, normalize edilmiş vejetasyon indeksi (NDVI), bitki örtüsü sıcaklığı (BÖS), protein içeriği, hektolitre ağırlığı, bin dane ağırlığı, nişasta içeriği ve tane verimi özellikleri değerlendirilmiştir. Araştırma bulgularına göre genotipler arasındaki farklar protein içeriği, nişasta içeriği, verim, bin tane ağırlığı ve hektolitre ağırlığı açısından önemli bulunmuştur. Arpa çeşitlerinde incelenen özelliklere göre SPAD değeri 30.85-35.43, YAI değeri 1.70-2.30, NDVI değeri 0.505-0.533, BÖS değeri 15.45 °C -17.85 °C, tane verimini 1958-3093 kg ha^{-1}, bin dane ağırlığı 32.55-46.27 g, hektolitre ağırlığı 66.35-73.40 kg hL^{-1}, protein içeriği% 8.1-9.1, nişasta içeriği % 63.13-66.49 arasında bulunmuştur. Tane verimi ile bitki örtüsü sıcaklığı arasında önemli(r = 0.989 **) ilişki bulunmuştur.

Keywords: Arpa, bitki örtüsü sıcaklığı, yaprak alan indeksi, SPAD, dane verimi

Yazışma adresi: *Ferhat Kızılgeçi: ferhat_kizilgeci@hotmail*

1. Introduction

Barley (*Hordeum vulgare* L.) is among the most ancient of the cereal crops. Archeological studies have revealed that barley was cultivated by about 8000 B.C. in Iran. However, other evidence shows that barley in essentially the form that exists today was used at least 17,000 years ago in the Nile River Valley of Egypt. The original area of cultivation has been reported to be in the Fertile Crescent of the Middle East, in present day Lebanon, Iran, Iraq and Turkey. This is also the most likely area of barley origin [1].Barley is grown worldwide in many countries and regions with temperate and subtropical climates. Barley in recent years has been the fourth most- produced cereal after maize, rice and wheat in the world. In Turkey, it occupies around 2.7 million hectares with annual production of 6.7 million tones and average yield of 2481 kg/ha. [2]. Barley is commonly used in breads, soups, stews, and health products, though it is primarily grown as animal fodder and as a source of malt for alcoholic beverages, especially beer. The agriculture in Turkey very important because of it has a suitable culture, rain, weather, soil, source of water and fertile land. In Turkey, many farmers are still following traditional methods to agricultural works. That was the reason new technological tools (SPAD 502 meter, Thermal Infrared, Greenseeker and LAI) were used in this study because of increase yield and quality of agricultural crop. NDVI is one of the most commonly utilized vegetation indexes and its' utility in satellite estimation and monitoring of global vegetation cover has been well indicated over the quarter of a century [3,4]. Leaf chlorophyll concentration is an important parameter that is frequently measured as an indicator of chloroplast development, photosynthetic capacity, leaf N content or general plant health [5].

In this study, yield, quality traits and some physiological parameters of barley and relationships of these traits have been evaluated.

2. Materials and Methods

2.1. Experimental Site, Design Treatments and Experimental Procedure

The present study was conducted at research area of Field Crops Department, Agriculture Faculty of Sirnak University, Turkey during 2015-2016 growing season. Five commercial barley cultivars (Kendal, Altikat, Baris, Pandora and Akhisar 98) and one barley advanced line which developed by University of Dicle, Faculty of Agriculture were used as material. Climate data of the 2015-2016 and long-term averages are given in Figure 1. In total, 642.8 mm precipitation during the growth season was recorded. Rainfall over the growing period in 2015-2016 was higher than the long-term average. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The plot size was 1.2 width, 4 m long (4.8 m^2 plot areas), each plot contained six rows at 20 cm apart and the seeding rates were adjusted for a density of 450 seeds m^{-2} according to standard practice. The plots were fertilized with 60 kg ha^{-1} P_2O_5 at the planting. The nitrogen fertilizers were added in two equal doses. The first application was added at planting time (60 kg ha^{-1} N), whereas the second one was applied in tillering stage (60 kg ha^{-1} N).Weed and pest control was monitored and chemicals were applied when required during the crop season. The traits of grain yield, thousand kernel weight(TKW), protein content, starch content, test weight, SPAD value, leaf area index (LAI), normalized difference vegetation index (NDVI) and plant canopy temperature (CT) were investigated in study.

2.2. Measurements

SPAD reading was measured using the SPAD 502 meter (Minolta Japan) which is a hand-held device that is widely used for rapid, accurate and non-destructive measurement of leaf chlorophyll concentration. Leaf area index was measured using a leaf meter (LI-2000, Li-Cor. Lincoln, Nebraska, USA). Normalized difference vegetative index (NDVI) was measured at heading stage for each plot by using TrimpleGreenseeker hand held. The Measurements were taken around midday on sunny days by passing the sensor over the plots at a height of approximately 50–60 cm above the canopy. Canopy temperature was measured using handheld infrared thermometer (model: Rothenbenger) at sunny days. At least two readings were collected for each replicates. Thousand kernel weight:seed counter was used to count five hundred grains which were then weighed (g) and the result multiplied by 2 to determine TKW. Care was taken to avoid broken seeds. Protein content, starch content, and test weight were analyzed using a NIT System Infratec 1241 Grain Analyzer (Foss, Hillerod, Denmark).

2.3. Statistical Analysis:

The data was analyzed by SAS 98 software and the means were compared by LSD Test at 5% significany level.

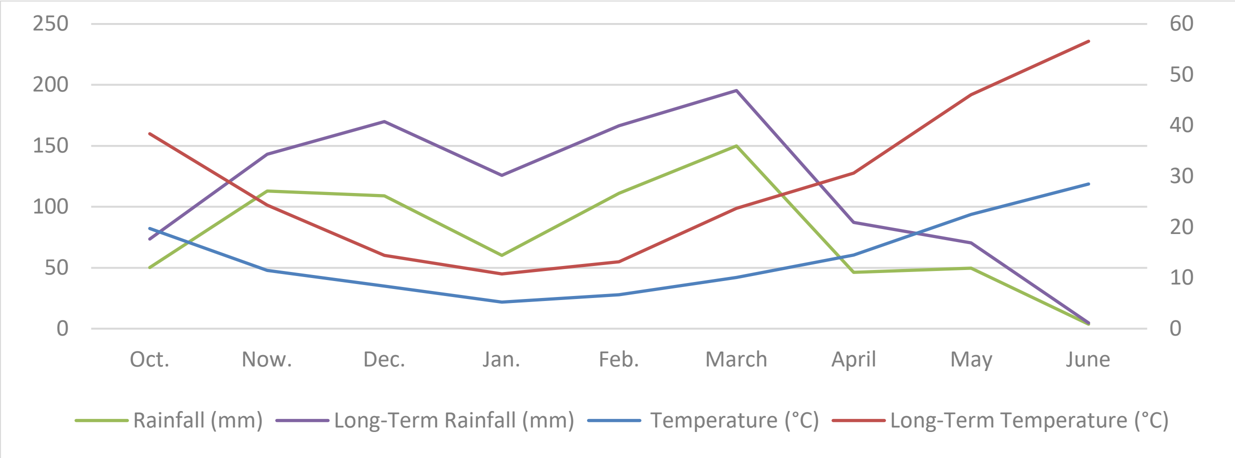

Figure 1. Monthly and long-term averages of the climatic data in the experimental area

3. Results and Discussion

3.1. SPAD Reading

The soil plant analysis development (SPAD) meter was used to measure chlorophyll content of flag leaves. SPAD reading varied between 30.85 (Pandora) and 35.43 (Altikat) (Table 1). [6] observed SPAD reading as the range of 45.33 to 53.12 in Mardin ecological conditions. But, in our study, SPAD reading of all the genotypes were very low. Leaf chlorophyll content is one of the important indicators of the health and potential physiological performance of a plant [7]. The chlorophyll concentration in the leaf is essential for crop growth and development [8] hence quantifying it makes available vital information about the effects of environment on plant growth [9].

3.2. Leaf Area Index (LAI)

The lowest LAI value was found in Pandora variety (1.70), and the highest in Kendal variety (2.30) (Table 1). However, differences were not significant for LAI. Kizilgeci et al.[6] reported that leaf area index at heading stage of barley varied within the range of 1.44-6.00 in Barley; whereas 3.63 to 5.25 cm in triticale [10], 1.2 to 5.2 in wheat [11].

Table 1. Analysis of variance (ANOVA) and Mean data of investigated traits for six barley genotypes grown in Sirnak at 2015/2016

Genotype	SPAD	LAI	NDVI	CT (°C)	PC (%)	SC(%)	TW (kg hL^{-1})	TKW(g)	GY (kg ha^{-1})
Kendal	31.98	2.30	0.518	17.50	8.22b	66.4a	73.4a	46.28a	2804.2a
Baris	32.07	2.09	0.508	17.85	8.41b	66.5a	73.3a	43.08ab	3093.0a
DZ12-1	35.43	2.00	0.508	17.43	8.73ab	63.1b	66.7b	41.83ab	2804.2a
Altikat	37.28	1.86	0.500	17.20	8.11b	63.4b	67.8b	40.68ab	2769.8a
Akhisar 98	31.20	1.77	0.533	16.63	9.12a	63.5b	66.4b	39.43b	2441.0ab
Pandora	30.85	1.70	0.505	15.45	8.78ab	65.7a	68.9b	32.55c	1958.3b
Mean	33.14	1.95	0.512	17.01	8.56	64.76	69.42	40.64	2645.1
Mean Square	27.054	0.217	0.0005	2.988	0.583*	9.762***	40.406**	84.833**	6151.33*
LSD	n.s.	n.s	n.s	n.s.	0.705	1.300	3.58	6.11	736.9
CV(%)	12.08	23.9	8.18	11.98	5.46	1.33	3.44	9.98	18.53

*, **, *** Significant at P < 0.05, P < 0.01, P < 0.001 respectively.LAI, leaf area index; NDVI, normalized differences vegetative index; CT, canopy temperature, PC, protein content; SC, starch content; TW, test weight; TKW, thousand kernel weight; GY grain yield.

3.3. Normalized Difference Vegetative Index

NDVI is a good indicator of crop growth rate, vigor, stay-green, radiation use efficiency and biomass production. The highest NDVI value in this study was found in Akhisar 98 (0.533), while the lowest NDVI value registered in Pandora (0.505) (Table1). The healthy vegetation gives high NDVI values, while the unhealthy plant gives low values [12]. The determined NDVI values is lower compared to the results obtained by [6] in Diyarbakir conditions.

3.4. Canopy Temperature (CT)

The value of canopy temperature was the highest at Baris variety (17.85 °C) and the lowest CT was recorded in Pandora (15.45°C).Heat tolerant genotypes tend to have greater stomatal conductance and higher photosynthesis to keep canopies cool [13]. Genotypes with cooler canopies are presumed to have better root systems and superior yield under high temperature [14-21]There are many reports of the successful selection of temperature tolerant crop genotypes using canopy temperature [9],[22-28].

3.5. Protein Content (%)

Significant differences (P<0.05) in the mean of protein content were observed among barley genotypes (Table 1). The highest value of protein content was found in Akhisar 98 (9.12%), while the lowest protein content was observed in Altikat variety (8.11%). However, low variation for this trait was showed among genotypes. Studies. Barley typically ranges in protein content from 8 to 15%. These values are significantly lower than the previously study.Kendal and Doğan [29] found higher values of protein in their studies. Some researchers indicated that protein content was affected by genotypes and nitrogen fertilizer.

3.6. Starch Content (%)

The major constituent of barley kernels is starch, which is present in the endosperm in the form of discrete granules and represents, on average, 60-64% of the weight of the kernel. The analysis of variance of the starch content value is showing that in Table 1. Highly significant (P<0.001) differences were identified among the genotypes for starch content. The maximum (66.5%) starch content was recorded for Baris variety and minimum value was recorded for DZ12-1 (63.1%). The results were in accordance with those reported by [30].

3.7. Test Weight (kg hl^{-1})

The test weight of barley grain depends on the grain size, shape and density. The analysis of variance of the hectoliter weight is given in Table 1. Significant (P<0.01) differences were identified among the genotypes for test weight. Test weight ranged from 66.4 kg hl^{-1} (Akhisar 98) to 73.4 kg hl^{-1} (Kendal). Shakya and Yamaguchi [12] reported that test weight of the barley genotypes changed between 61.57 and 73.44 kg hl^{-1}.

3.8. Thousand Kernel Weight (g)

TKW is an important yield component and is varying from genotype to genotype. Significant (P<0.01) differences were identified among the genotypes for thousand kernel weight (Table 1). Thousand kernel weight varied from 32.55 g (Pandora) to 46.28 g (Kendal). TKW showed large variation (Table 1). Results are comparable with the earlier findings of [31]. Kizilgeci et al. [30], who reported thousand kernelweight ranges from 38-41 g; 32.22-44.46 g, respectively, for different wheat varieties grown in Diyarbakir, Turkey.

Table 2. Correlation coefficients between all evaluated traits of barley genotypes.

	LAI	NDVI	SPAD	CT	PC	SC	TW	TKW	GY
LAI	1								
NDVI	0.011	1							
SPAD	0.040	-0.561	1						
CT	0.779	-0.044	0.408	1					
PC	-0.583	0.601	-0.509	-0.527	1				
SC	0.483	-0.109	-0.591	0.063	-0.352	1			
TW	0.744	-0.125	-0.349	0.421	-0.575	**0.925****	1		
TKW	-0.069	0.704	-0.717	-0.091	**0.801***	0.081	-0.041	1	
GY	0.734	-0.112	0.411	**0.990****	-0.566	0.107	0.455	-0.126	1

*, ** Significant at P < 0.05, P < 0.01, respectively. LAI, leaf area index; NDVI, normalized differences vegetative index; CT, canopy temperature, PC, protein content; SC, starch content; TW, test weight; TKW, thousand kernel weight; GY grain yield.

3.9. Grain Yield (kg ha^{-1})

The lowest grain yield was recorded by Pandora (1958.3 kg da^{-1}) and the highest grain yield was recorded by Baris (3093.0 kg ha^{-1}) (Table 1). Our results are lower than those of values obtained by [12]. Kizilgeci et al.[30] who stated that the grain yield of barley cultivars ranged from 3667.3kg ha^{-1} to 4889.7kg ha^{-1}. Many researchers reported that grain yield varied according to genotype and environmental conditions [12], [30-32].

3.10. Correlation Analysis

Correlation coefficients between all traits were given on Table 2. Results show that there was strongly positive (r=0.989**) correlation between the CT and grain yield. Significant and positive correlations was found between protein content and TKW (r=0.801**). A very strong positive (r=0.925**) correlation appeared between starch content with test weight, from the results of the present study, related to significant and positive correlation between grain yield and other traits also confirmed by [9]and [12], who reported that LAI, CT, NDVI, SPAD, protein content, starch content, test weight and 1000-grain weight had significant and positive correlation. Similarly, Fenstermaker-Shaulis et al. [33] reported a negative correlation between NDVI and canopy temperature.

4. Conclusions

The experiment year was a stress-free season in which rainfall was high for the demand for barley needed and the average daily temperature was relatively low compared to long years. These climatic conditions caused lodging in barley, resulting in lower average yields. It is understand that the barley cultivar of Kendal, Baris, DZ12-1 and Altikat can be successfully grown under Sirnak conditions in which the suitable genotypes is not determined until now.

The amount of protein content which is a critical quality criterion in the barley as feed, has been found to be low but it significantly associated with grain yield. Physiological measurement of LAI, NDVI and SPAD which are important as selection criterion were not related grain yield.

5. References

[1] R. A. Nilan and S.E. Ullrich, Barley: Chemistry and Technology. In: A.W. MacGregor & R.S. Bhatty (Eds.), Barley: Taxonomy, origin, distribution, production, genetics and breeding. pp. 1-30. St. Paul, Minnesota, USA: AACC Inc. (1993).

[2] FAO. http://www.fao.org/faostat/en/#data/QC (2016) (20.07.2018)

[3] A. R. Huete and H.Q. Liu, An error and sensitivity analysis of the atmospheric-and soil-correcting variants of the NDVI for the MODIS-EOS. IEEE Transactions on Geoscience and Remote Sensing, 32(4): 897-905 (1994)

[4] C. Leprieur, Y. H. Kerr, S. Mastorchio and J. C.Meunier, Monitoring vegetation cover across semi-arid regions: comparison of remote observations from various scales. International Journal of Remote Sensing, 21(2): 281-300 (2000).

[5] Q. Ling, W. Huang and P. Jarvis, Use of a SPAD-502 meter to measure leaf chlorophyll concentration in Arabidopsis thaliana. Photosynthesis research, 107(2): 209-214 (2011).

[6] F. Kizilgeci, C. Akinci, O. Albayrak and M. Yıldırım, Investigation of Yield and Quality Parameters of Barley Genotypes in Diyarbakır and Mardin Conditions Iğdır Univ. J. Inst. Sci. & Tech. 6(3): 161-169 (2016).

[7] R. Raj Kumar, S. Marimuthu, D. Jayakumar and P. R. Jeyaramraja, In situestimation of leaf chlorophyll and its relationship with photosynthesis in tea. Indian journal of plant physiology, 7(4):367-371 (2002).

[8] A. Bannari, K. S. Khurshid, K. Staenz and J. W. Schwarz, A comparison of hyperspectral chlorophyll indices for wheat crop chlorophyll content estimation using laboratory reflectance measurements. IEEE Transactions on Geoscience and Remote Sensing, 45(10): 3063-3074 (2007).

[9] M. R. Schlemmer, D. D. Francis, J. F. Shanahan, and J. S. Schepers, Remotely measuring chlorophyll content in corn leaves with differing nitrogen levels and relative water content. Agronomy journal, 97(1), 106-112 (2005).

[10] F. Kizilgeci, M. Yıldırım, O. Albayrak and C. Akinci, Relationships of Grain Yield and Some Quality Parameters with Physiological Parameters in Some Triticale Advanced Lines Iğdır Univ. J. Inst. Sci. & Tech. 7(1): 337-345 (2017).

[11] H. V. Singh, S. N. Kumar, N. Ramawat and R. C. Harit, Response of wheat varieties to heat stress under elevated temperature environments. Journal of Agrometeorology, 19(1), 17. (2017).

[12] N. Shakya and Y. Yamaguchi, Drought monitoring using vegetation and LST indices in Nepal and northeastern India. In: Proc. 28th Asian Conference on Remote Sensing. (2007).

[13] M. Reynolds and R. Trethowan, Physiological interventions in breeding for adaptation to abiotic stress. Frontis 21: 127-144 (2007).

[14] B. Bahar, M. Yildirim, C. Barutcular and I. Genc, Effect of canopy temperature depression on grain yield and yield components in bread and durum wheat. NotulaeBotanicaeHortiAgrobotaniciClujNapoca 36(1): 34 (2008).

[15] J. L. Araus, G. A. Slafer, C. Royo, and M. D. Serret, Breeding for Yield Potential and Stress Adaptation

in Cereals. Critical Reviews in Plant Sciences 27(6): 377-412 (2008).

[16] M. Farooq, A. Wahid, N. Kobayashi, D. Fujita and S. Basra, Plant drought stress: effects, mechanisms and management. In Sustainable Agriculture, 153-188 (2009).

[17] M. S. Lopes and M. P. Reynolds, Partitioning of assimilates to deeper roots is associated with cooler canopies and increased yield under drought in wheat. Functional Plant Biology 37(2): 147-156 (2010).

[18] C. Saint Pierre, J. Crossa, Y. Manes and M. P. Reynolds, Gene action of canopy temperature in bread wheat under diverse environments. Theoretical and Applied Genetics 120(6): 1107-1117 (2010).

[19] C. M. Cossani and M. P. Reynolds, Physiological traits for improving heat tolerance in wheat. Plant physiology 160(4): 1710-1718 (2012).

[20] G. J. Rebetzke, A. R.Rattey, G. D. Farquhar, R. A. Richards and A. T. G. Condon, Genomic regions for canopy temperature and their genetic association with stomatal conductance and grain yield in wheat. Functional Plant Biology 40(1): 14-33 (2013).

[21] S. Mondal, R. E. Mason, T. Huggins and D. B. Hays, QTL on wheat (Triticumaestivum L.) chromosomes 1B, 3D and 5A are associated with constitutive production of leaf cuticular wax and may contribute to lower leaf temperatures under heat stress. Euphytica 201(1): 123-130 (2015).

[22] D. Saxena, S. S. Prasad, R. Chatrath, S. Mishra, M. Watt, R. Prashar, A. Wason, A. Gautam and P. Malviya, Evaluation of root characteristics, canopy temperature depression and stay green trait in relation to grain yield in wheat under early and late sown conditions. Indian Journal of Plant Physiology 19(1): 43-47 (2014).

[23] V. Ginkel, M. Reynolds, M. Trethowan, R. & Hernandez, E. Complementing the breeders eye with canopy temperature measurements. In International Symposium on Wheat Yield Potential, 134. (2008).

[24] M. P. Reynolds, C. S. Pierre, A. S. Saad, M. Vargas and A. G. Condon, Evaluating potential genetic gains in wheat associated with stress-adaptive trait expression in elite genetic resources under drought and heat stress. Crop Science 47(3): 172-189 (2007).

[25] P. Gupta, H. Balyan, V. Gahlaut and P. Kulwal, Phenotyping, genetic dissection, and breeding for drought and heat tolerance in common wheat: status and prospects. Plant Breeding Reviews, Volume 36: 85-168 (2012).

[26] R. S. Pinto, M. P. Reynolds, K. L. Mathews, C. L. McIntyre, J. J. Olivares-Villegas and S. C. Chapman, Heat and drought adaptive QTL in a wheat population designed to minimize confounding agronomic effects. Theoretical and Applied Genetics 121(6): 1001-1021 (2010).

[27] R. S. Pinto and M. P. Reynolds, Common genetic basis for canopy temperature depression under heat and drought stress associated with optimized root distribution in bread wheat. Theoretical and Applied Genetics 128(4): 575-585 (2015).

[28] M. Kumari, V. Singh, R. Tripathi and A. Joshi, Variation for staygreen trait and its association with canopy temperature depression and yield traits under terminal heat stress in wheat. In Wheat Production in Stressed Environments, 357-363 (2007).

[29] E. Kendal and H. Dogan, Impact of Row Number in Barley Head on Yield, Some Quality and Morphological Parameters in Barley Turkish Journal of Agricultural and Natural Sciences 1(2): 132–142 (2014)

[30] F. Kizilgeci, C. Akinci, O. Albayrak, B. T. Biçer, F. Başdemir and M. Yıldırım, Investigation of Yield and Quality Parameters of Barley Genotypes in Diyarbakır and Şanlıurfa Conditions Journal of Field Crops Central Research Institute, 2016, 25 (Special issue): 146-150 (2016)

[31] H. Aktas, Evaluation of Some Barley (*Hordeum vulgare* L.) Cultivars Commonly Cultivated in Turkey Under Supplemented İrrigation and Rainfall Conditions Journal of Tekirdag Agricultural Faculty14 (03) 86-97 (2017).

[32] E. Kendal and Y. Dogan, Evaluation of Some Spring Barley Genotypes In Terms of Yield and Quality YYU J. AGR. SCI. 2012, 22(2): 77-84 (2014).

[33] L. K., Fenstermaker-Shaulis, A. Leskys and D. A. Devitt, Utilization of Remotely Sensed Data to Map and Evaluate Turfgrass Stress Associated with Drought. Journal of Turfgrass Management. 2:65-81(1997).