Black Sea Journal of Agriculture
doi: 10.47115/bsagriculture.1256346

Open Access J
e-ISSN: 2618 – 6578

Research Article
Volume 6 - Issue 4: 350-355 / July 2023

# DETERMINATION OF GRAIN YIELD AND AGRICULTURAL TRAITS OF SOME OAT CULTIVARS AT DIFFERENT LOCATIONS

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**Abstract:** This research was carried out during the 2016-2017 and 2017-2018 growing seasons at Edirne, Kırklareli, and Tekirdağ locations with the aim of determining some agricultural and quality traits of nine registered oat cultivars. The experiments were arranged in a randomized complete block design with four replications. According to the results of the examined traits, plant height ranged from 101.5 to 132.4 cm, vegetative period from 125.1 to 138.9 days, thousand kernel weight from 26.6 to 40.0 g, test weight from 46.2 to 53.2 kg $hl^{-1}$, protein content from 12.5% to 15.1%, and grain yield from 4011 to 5321 kg $ha^{-1}$. According to the biplot analysis, PC1 and PC2 (accounting for 69.3% and 18.3% of the total variation, respectively) constituted 87.6% of the total variation. The angle value between the vectors of grain yield and protein content, thousand kernel weight, and test weight was narrow, indicating a high positive relationship between these traits, whereas the angle between the vectors of grain yield and plant height and vegetative period was wide, indicating a negative relationship between these traits. According to the correlation analysis, grain yield had a positive and significant relationship with test weight (r=0.594**), protein content (r=0.431**), and thousand kernel weight (r=0.350**), and a negative and significant relationship with a vegetative period (r=-0.360**) and plant height (r=-0.047**). According to the biplot analysis, cultivars Kahraman, Kırklar, Kehlibar and Somun Yıldızı were found outstanding genotypes in terms of grain yield.

**Keywords:** Oat, Grain yield, Yield components, Principal Component Analysis, Correlation Analysis

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**Received:** February 25, 2023
**Accepted:** May 05, 2023
**Published:** July 01, 2023

**Cite as:** Güngör H, Çakır MF, Dumlupınar Z. 2023. Determination of grain yield and agricultural traits of some oat cultivars at different locations. BSJ Agri, 6(4): 350-355.

## 1. Introduction

Oat (*Avena sativa* L.) is an important crop used mainly as animal feed but also utilized in the human food, pharmaceutical and cosmetic industries. There are three species of oats cultivated worldwide: *Avena sativa* L., *Avena byzantina* Koch. and *Avena nuda* L. (Hoffmann, 1995; Batalova et al., 2016). In 2021, oat cultivation area was 9.4 million ha, with a production of 23.5 million tons and an average yield of 2360 kg $ha^{-1}$ worldwide, while in Türkiye, oat cultivation area was 136 thousand ha, with a production of 276 tons and an average yield of 2080 kg $ha^{-1}$ (FAO, 2023; TUIK, 2023). In recent years, there has been an increasing demand for oat cultivation in Türkiye. One of the factors that hinder the desired level of oat production in the country is the lack of sufficient commercial varieties. Therefore, it is crucial to develop appropriate varieties for each region to achieve the desired level of oat cultivation (Halil and Uzun, 2019). Oat is rich in β-glucan, protein, vitamins, minerals, dietary fiber, fat, fatty acids, and some antioxidants. With the recent studies demonstrating the benefits of oats in the food and health sectors, oat has gained more importance in human nutrition (Butt et al., 2008; Jing and Hu, 2012; Finnan et al., 2019). The goal of plant breeders is to develop superior varieties that are adaptable to different ecological conditions and have desired traits. GGE Biplot is a combined analysis method that visually evaluates the two basic components, genotype (G) and G×E (interaction), on the same graph, thus providing plant breeders with a two-way evaluation of the data. The GGE Biplot analysis method is considered an innovative approach in plant breeding because it allows for the simultaneous visualization of many traits and influences success in selection (Yan and Tinker, 2006). Correlation analysis is significant in developing high-yielding and quality varieties by determining the level of binary relationships between the examined traits and is used by many researchers (Albayrak and Ekiz, 2004; Erol and Carpici, 2020).

The aim of this study was to investigate some agronomic and quality traits of nine registered oat cultivars at Edirne, Kırklareli, and Tekirdağ locations and determine the relationships between these traits to identify oat cultivars that hopeful for grain yield and quality.

## 2. Materials and Methods

The study was carried out with nine registered oat cultivars (Table 1) at Edirne, Kırklareli, and Tekirdağ locations in the 2016-2017 and 2017-2018 growing seasons according to the randomized complete blocks experimental design with four replications. The seeds were sown between the end of October and the first week of November in both growing seasons, with 500 seeds per square meter density in 6 m$^2$ plots. Weed control was done manually in the trials, and no application was made for pests. 50 kg ha$^{-1}$ of nitrogen and 50 kg ha$^{-1}$ of phosphorus (20-20-0) were applied at sowing, and the top dressing was split into two with 90 kg ha$^{-1}$ (46% Urea) of nitrogen applied during the tillering stage and 60 kg ha$^{-1}$ (26% Ammonium Nitrat) of nitrogen applied during the heading stage. Harvest was done in the first week of July in both growing seasons.

In the study, plant height (PH), vegetative period (VP), thousand kernel weight (TKW - Williams et al., 1988), test weight (TW – Vasiljevic and Banasic, 1980), protein content (PR-NIR), and grain yield (GY) were evaluated. According to the results of the homogeneity test, there was no significant difference between the years ($p>0.05$), and therefore, the analysis of variance was conducted by combining the years (Levene, 1960). Principal component analysis was performed using JMP software (JMP 15.1 SAS Institute Inc., 2020).

**Table 1.** The oat cultivars used in the experiment, owner company/institute and registration years and amounts of precipitation of environments

| Cultivars | Owner Companies / Institutes | Registration Year | Environments | Precipitation (mm) 2016-2017 | Precipitation (mm) 2017-2018 |
|---|---|---|---|---|---|
| Kehlibar | SM | 2018 | Edirne | 408.0 | 799.6 |
| Somun Yıldızı | SM | 2020 | Kırklareli | 366.3 | 699.3 |
| Kahraman | TARI | 2014 | Tekirdağ | 451.7 | 633.0 |
| Kırklar | TARI | 2014 | | | |
| Yeniçeri | BDIARI | 2013 | | | |
| Faikbey | BDIARI | 2004 | | | |
| Seydişehir | BDIARI | 2004 | | | |
| Checota | TZARI | 1986 | | | |
| Sebat | TASC | 2011 | | | |

SM= Som Un Seed company, TARI= Trakya Agricultural Research Institute, BDIARI= Bahri Dagdas International Agrıcultural Research Institute, TZARI= Transitional Zone Agricultural Research Institute, TASC= Trakya Agriculture Seed company

## 3. Results and Discussion

According to the statistical analysis made for plant height, years were found to be insignificant, while genotypes and locations were found significant at the level of 5%. The plant height of the examined oat cultivars varied between 101.5-132.4 cm. The longest plant height was measured in the cultivar Seydişehir (132.4 cm), and the shortest plant height was in the cultivar Somun Yıldızı (101.5 cm). Plant height was measured as 113.9 cm in the first year of the experiment and 114.8 cm in the second year. As for the locations, plant height was determined as 115.8 cm at Kırklareli, 114.2 cm at Tekirdağ, and 113.0 cm at Edirne (Table 2). In other studies, plant height was found to vary between 82.5-172.5 cm (Sari and Imamoglu, 2011; Naneli and Sakin, 2017; Kahraman et al., 2021). Plant height is influenced by cultivation techniques, environmental conditions, and genetic structure. Researchers focused on short and non-lodging genotypes in oat breeding studies (Kara et al., 2007; Dumlupinar et al., 2016; Kahraman et al., 2022).

In terms of vegetative period, years were statistically insignificant, while genotypes and locations were found to be significant at the level of 1%. The average vegetative period of oat cultivars ranged from 125.1 to 138.9 days. The cultivar Faikbey had the longest vegetative period, while cultivars Kahraman and Kırklar had the shortest vegetative period. Tekirdağ had the longest vegetative period (136.3 days), while Edirne had the shortest (132.0 days) among the trial locations (Table 2). In studies conducted in different ecologies, the vegetative period was reported to vary between 141-183 days (Dumlupinar et al., 2016; Dumlupinar et al., 2017; Naneli and Sakin, 2017). Although the duration of the vegetative period in oats is largely influenced by genetic structure (Locatelli et al., 2008; Dumlupinar et al., 2016; Naneli and Sakin, 2017), it is also affected by environmental conditions (Gautam et al., 2006).

As for thousand kernel weight, years, genotypes, and locations were found to be statistically significant at the level of 1%. Thousand kernel weight was determined as 34.7 g in the first year and 34.3 g in the second year of the experiment. The thousand kernel weight of the cultivars included in the trial varied between 26.0-40.0 g, and the lowest thousand kernel weight was obtained from the cultivar Sebat (26.6 g), while the highest thousand kernel weight was from the cultivar Kahraman (40.0 g). As for the locations, thousand kernel weight was determined as 35.1 g at Edirne, 34.0 g at Kırklareli, and 34.4 g at Tekirdağ (Table 2). In similar studies, thousand kernel weight was found to vary between 13.5-51.0 g (Sari and Imamoglu, 2011; Dumlupinar et al., 2016; Naneli and Sakin, 2017; Sahin et al., 2019).

The years, genotypes, and locations were found statistically significant in terms of test weight. The lowest test weight was observed in the cultivar Seydişehir (42.1 kg $hl^{-1}$), while the highest was in the cultivar Kahraman. The test weight was 45.3 kg $hl^{-1}$ in the first year and 49.0 kg $hl^{-1}$ in the second year. Previous studies have reported test weights ranging from 36.6 to 59.8 kg $hl^{-1}$ (Naneli and Sakin, 2017; Sahin et al., 2019; Kahraman et al., 2021; Hocaoglu et al., 2022). The shape and size of oat grains can affect test weight, along with genetic and environmental factors (Dumlupinar et al., 2016; Sahin et al., 2019).

In terms of protein content, genotypes and locations were statistically significant, while years were not. The protein content was 13.77% in the first year and 13.79% in the second year. The study found that protein content ranged from 12.56% to 15.10%, with the highest protein content observed in the cultivar Kahraman and the lowest in the cultivar Sebat. The Kırklareli (13.83%) and Edirne (13.81%) locations had statistically similar protein content, while the Tekirdağ location (13.70%) had the lowest protein content (Table 2). Previous studies have reported protein content ranging from 11.71% to 13.34% (Naneli and Sakin, 2017), 10.59% to 20.85% (Sahin et al., 2019), and 12.40% to 13.47% (Kececioglu et al., 2021). Protein content is an important quality factor in oats, and high protein content is desirable. Oat grains typically have protein content ranging from 11% to 15% (Dumlupinar et al., 2011; Rodehutscord et al., 2016).

In terms of grain yield, years were not significant, while genotypes and locations were statistically significant. The highest grain yield was obtained from the cultivars Somun Yıldızı (5321 kg $ha^{-1}$), Kahraman (5222 kg $ha^{-1}$), and Kehlibar (5065 kg $ha^{-1}$), while the lowest grain yield was obtained from the cultivars Sebat (4011 kg $ha^{-1}$) and Checota (4037 kg $ha^{-1}$). When locations were examined, the highest grain yield was obtained from the Tekirdağ (4744 kg $ha^{-1}$) location, while the lowest grain yield was obtained from the Edirne (4514 kg $ha^{-1}$) location (Table 2). Previous studies have reported grain yields ranging from 2336 to 4481 kg $ha^{-1}$ (Naneli and Sakin, 2017), 2150 to 5810 kg $ha^{-1}$ (Mut et al., 2018), 5696 to 8127 kg $ha^{-1}$ (Hocaoglu et al., 2022), and 4136 to 8104 kg $ha^{-1}$ (Kahraman et al., 2021). Oat grain yield can vary significantly depending on the variety's genetic potential, cultural practices, and climatic and soil conditions (Dumlupinar et al., 2016; Gungor et al., 2017).

**Table 2.** Average data belong to plant height (PH), vegetative period (VP), and thousand kernel weight (TKW), test weight (TW) protein ratio (PR) and grain yield (GY)

| | | PH (cm) | VP (days) | TKW (g) | TW (kg $hl^{-1}$) | PR (%) | GY (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| | | ns | ns | ** | ** | ns | ns |
| Years | 2016-2017 | 113.9 | 133.8 | 34.7 a | 45.3 b | 13.77 | 4658 |
| | 2017-2018 | 114.8 | 133.7 | 34.3 b | 49.0 a | 13.79 | 4608 |
| | | * | ** | ** | ** | ** | ** |
| Cultivars | Kehlibar | 105.6 d | 133.3 d | 34.6 d | 49.6 c | 14.18 c | 5065 a |
| | Somun Yıldızı | 101.5 e | 136.3 c | 34.0 e | 48.6 d | 14.17 c | 5321 a |
| | Kahraman | 105.5 d | 125.1 e | 40.0 a | 53.2 a | 15.10 a | 5222 a |
| | Kırklar | 108.6 d | 125.3 e | 38.3 b | 50.8 b | 14.43 b | 4743 b |
| | Yeniçeri | 120.5 c | 132.9 d | 33.0 f | 45.4 f | 13.60 d | 4612 bc |
| | Faikbey | 128.1 b | 138.9 a | 37.5 c | 43.2 g | 12.97 f | 4335 d |
| | Checota | 120.3 c | 136.2 c | 34.2 e | 45.1 f | 13.25 e | 4037 e |
| | Seydişehir | 132.4 a | 138.3 ab | 32.4 g | 42.1 h | 13.76 d | 4353 cd |
| | Sebat | 106.5 d | 137.6 b | 26.6 h | 46.2 e | 12.56 g | 4011 e |
| | | * | ** | ** | ** | ** | * |
| Locations | Kırklareli | 115.8 a | 133.0 b | 34.0 c | 48.0 a | 13.83 a | 4636 ab |
| | Tekirdağ | 114.2 ab | 136.3 a | 34.4 b | 46.1 c | 13.70 b | 4744 a |
| | Edirne | 113.0 b | 132.0 c | 35.1 a | 47.2 b | 13.81 a | 4514 b |
| | Mean | 114.3 | 133.8 | 34.5 | 47.1 | 13.7 | 4633 |
| | CV (%) | 3.7 | 0.6 | 1.2 | 1.5 | 1.3 | 10.0 |
| Year x Genotype | | * | ** | ** | ** | ** | * |
| Year x Location | | * | ** | ** | ** | ** | ** |
| Genotype x Location | | * | ** | ** | ** | ** | ** |
| Year x Genotype x Location | | * | ** | ** | ** | ** | ns |

** Significant at 1%, * Significant at 5% and ns: not significant

### 3.1. Principal Components (PCA) and Correlation Analysis

The biplot analysis of the principal components allows for a visual representation of the relationships among the genotypes and the studied traits, providing ease in evaluating the relationships among both the genotypes and the traits (Yan and Kang, 2003). According to the biplot analysis, PC 1 (69.3%) and PC 2 (18.3%) explained 87.6% of the total variation (Figure 1). Grain yield, thousand kernel weight, test weight, and protein content had a positive correlation, while plant height and vegetative period had a negative correlation. A positive correlation was found between plant height and vegetative period. The cultivars Somun Yıldızı, Kahraman, Kehlibar, and Kırklar stood out in terms of grain yield, protein content, and test weight, while cultivars Seydişehir and Faikbey were determined to be the leading cultivars in terms of plant height and vegetative period. Hocaoglu et al. (2022) reported a positive relationship between grain yield and thousand kernel weight. The correlation coefficients for the studied traits are provided in Figure 2. Grain yield had a positive and significant correlation with test weight (r=0.594**), protein content (r=0.431**), and thousand kernel weight (r=0.350**), and a negative and significant correlation with vegetative period (r=-0.360**) and plant height (r=-0.047**). A positive and significant correlation (r=0.410**) was found between plant height and vegetative period. Dumlupinar et al. (2012) reported a positive correlation between grain yield and thousand kernel weight but a negative correlation between grain yield and plant height. Sari and Unay (2015) found a positive and significant relationship between grain yield and test weight and thousand kernel weight. Gungor et al. (2017) reported a positive but insignificant relationship between grain yield and vegetative period and a negative and significant relationship between grain yield and plant height.

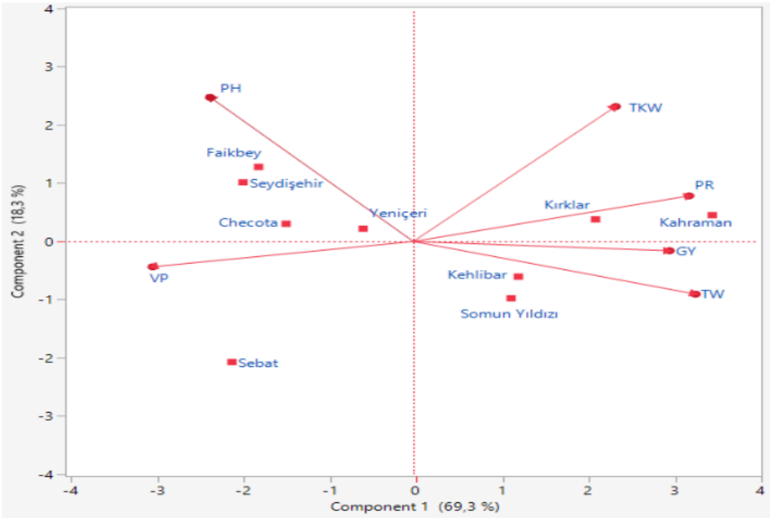


**Figure 1.** Relationships among cultivars and traits according to principal components biplot analysis.

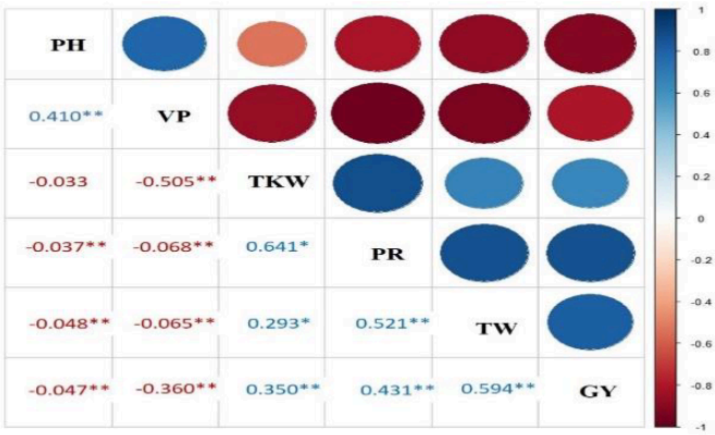


**Figure 2.** Relationships among investigated traits.

## 4. Conclusion

The study was conducted out for two years at Edirne, Kırklareli, and Tekirdağ locations to examine the agronomic and quality characteristics of nine different oat cultivars. The results of the principal component biplot analysis and correlation analysis showed that there was a positive relationship between grain yield and thousand kernel weight, test weight, and protein content. Tekirdağ location had a higher grain yield compared to Edirne and Kırklareli locations. According to biplot graph, cultivars Kahraman, Kırklar, Kehlibar, and Somun Yıldızı were found prominent for grain yield.

**Author Contributions**

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

| | H.G. | M.F.C. | Z.D. |
|---|---|---|---|
| C | 40 | 30 | 30 |
| D | 40 | 30 | 30 |
| S | 40 | 30 | 30 |
| DCP | 40 | 30 | 30 |
| DAI | 40 | 30 | 30 |
| L | 40 | 30 | 30 |
| W | 40 | 30 | 30 |
| CR | 40 | 30 | 30 |
| SR | 40 | 30 | 30 |
| PM | 40 | 30 | 30 |
| FA | 40 | 30 | 30 |

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

**Conflict of Interest**

The authors declared that there is no conflict of interest.

**Ethical Consideration**

Ethics committee approval was not required for this study because of there was no study on animals or humans

## References


Albayrak S, Ekiz H. 2004. Determination of characters regarding to hay yield using correlation and path analysis in some perennial forage crops. J Agri Sci, 10(3): 250-257.

Batalova GA, Shevchenko SN, Tulyakova MV, Rusakova II, Zheleznikova VA, Lisitsyn EM. 2016. Breeding of naked oats having high-quality grain. Russian Agri Sci, 42(6):407-410.

Butt MS, Tahir-Nadeem M, Khan MKI, Shabir R, Butt MS. 2008. Oat: unique among the cereals. European J nutrition, 47(2): 68-79. DOI: 10.1007/s00394-008-0698-7

Dumlupinar Z, Dokuyucu T, Akkaya A. 2011. Identification of Turkish oat landraces (*Avena sativa* L.) based on avenin proteins by SDS-PAGE technique. Turkish J Field Crops, 16(1): 76-83.

Dumlupinar Z, Kara R, Dokuyucu T, Akkaya A. 2012. Correlation and path analysis of grain and yield components of some Turkish oat genotypes. Pak J Bot, 44 (1): 321-325.

Dumlupinar Z, Ercan K, Tekin A, Herek S, Kurt A, Kekec E, Olgun MF, Dokuyucu T, Akkaya A. 2016. Performance of local oat lines in Kahramanmaraş. KSU J Nat Sci, 19(4): 438-444.

Dumlupinar Z, Tekin A, Herek S, Tanrıkulu A, Dokuyucu T, Akkaya A. 2017. Evaluating some Turkish originated oat genotypes for some agronomic traits. TURJAF, 5(7): 763-772.

Erol S, Carpici EB. 2020. Determination with correlation and path analysis of relationships between yield and yield components in Alfalfa (*Medicago sativa* L.) genotypes collected from the Bursa. J Agri Fac Bursa Uludag Univ, 35(1): 75-84.

FAO 2023. Food and Agriculture Organization of the United Nations. URL:http://www.fao.org/faostat/en/#data (accessed date: 30 January 2023).

Finnan J, Burke B, Spink J. 2019. The effect of nitrogen timing and rate on radiation interception, grain yield and grain quality in autumn sown oats. Field Crops Res, 231: 130–140.

Gautam SK, Verma AK, Vishwakarma SR. 2006. Genetic variability and association of morpho-physiological characters in oat (*Avena sativa* L.). Farm Sci J, 15(1): 82-83.

Gungor H, Dokuyucu T, Dumlupinar Z, Akkaya A. 2017. Determination of relationships between grain yield and some agronomic traits by correlation and path analysis in oat (*Avena* spp.). J Tekirdag Agri Fac, 14(01): 61-68.

Halil SD, Uzun A. 2019. Seed yield and some quality characteristics of oat (*Avena sativa* L.) genotypes growing at Bursa ecological conditions. J Agri Fac Bursa Uludag Univ, 33(2): 293-305.

Hocaoglu O, Akcura M, Ceri S. 2022. Evaluating grain yields and agronomic traits of selected oat cultivars and naked oat genotypes in Marmara region. Turkish J Agri Nat Sci, 9(3): 771-778.

Hoffmann LA. 1995. World production and use of oats. In: Welch RW, editor. The oat crop production and utilization. Chapman and Hall, London, UK, pp: 34-61.

Jing P, Hu X. 2012. Nutraceutical properties and health benefits of oats. Cereals and pulses: Nutra Proper Health Benef, 21-36.

JMP®. 2020. Version 15.1. SAS Institute Inc., Cary, NC, 1989–2020.

Kara R, Dumlupinar Z, Hısır Y, Dokuyucu T, Akkaya A. 2007. Evaluation of oat varieties in terms of grain yield and yield components in Kahramanmaraş conditions. VII. Field Crops Congress, 25-27 June 2007, Erzurum, Türkiye, pp: 121-125.

Kahraman T, Avci R, Yildirim M. 2021. Determination of grain yield, yield components and quality traits of oat genotypes (*Avena sativa* L.). KSU J Agric Nat, 24(5): 1003-1010.

Kahraman T, Orhun E, Baytekin, H. 2022. Evaluation of Oat (*Avena sativa* L.) Genotypes for green forage, hay yield and some quality parameters in Trakya-Marmara region. KSU J Agric Nat, 25(Suppl 2): 462-470.

Kececioglu Y, Kara R, Dokuyucu T. 2021. Determination of genetic differences and improvements of some oat genotypes in terms of morphological and Agri characteristics. Turkish J Agri Nat Sci, 8(1): 103-115. DOI:10.30910/turkjans.816927.

Levene H. 1960. Robust tests for equality of variances. In: Olkin I, editor. Contributions to Probability and Statistics. Stanford University Press, Palo Alto, California, USA, pp: 278–292.

Locatelli AB, Federizzi LC, Milach SCK, McElroy AR. 2008. Flowering time in oat: genotype characterization for photoperiod and vernelization response. Field Crops Res, 106: 242-247.

Mut Z, Akay H, Erbas Köse, ÖD. 2018. Grain yield, quality traits and grain yield stability of local oat cultivars. J Soil Sci Plant Nutri, 18(1): 269-281.

Naneli I, Sakin MA. 2017. Determination of yield and quality parameters of some oat varieties (*Avena sativa* L.) in different locations. J Central Res Instit Field Crops, 26(Special Issue): 37-44.

Rodehutscord M, Ruckert C, Maurer HP, Schenkel H, Schipprack W, Knudsen KEB, Schollenberger M, Laux M, Eklund M, Siegert W, Mosenthin R. 2016. Variation in chemical composition and physical characteristics of cereal grains from different genotypes. Archiv Anim Nutri, 70(2): 87–107.

Sari N, Imamoglu A. 2011. Determination of improved oat lines suitable for Menemen ecologial conditions. J AARI, 21(1): 16-25.

Sari N, Unay A. 2015. Determining characteristic affecting grain yield of oats (*Avena sativa* L.). J Central Res Instit Fields Crops, 24(2): 115-123.

Sahin M, Ceri S, Gocmen AA, Aydogan S, Hamzaoglu S, Demir B. 2019. Investigation of relationships between yield and technological properties of winter oat (*Avena sativa* spp.) Genotypes. J Bahri Dagdas Crop Res, 8 (1): 34-42.

TUIK 2023. Turkish Statistical Institute. URL:https://www.tuik.gov.tr (accessed date: January 30, 2023).

Vasiljevic S, Banasik OJ. 1980. Quality testing methods for durum wheat and its products. Department of Cereal Chemistry and Technology, Fargo, North Dakota: North Dakota State University, pp: 134.

Williams P, El-Haramein JF, Nakkoul H, Rihawi S. 1988. Crop quality evaluation methods and guidelines. Syria: International Center for Agricultural Research in The Dry Areas (ICARDA), Syria, Sam, pp: 145.

Yan W, Kang M. 2003. GGE biplot analysis: A graphical tool breeders. Geneticists and Agronomists. CRC Press, Boca Raton, UK, pp: 286.

Yan W, Tinker NA. 2006. Biplot analysis of multi-environment trial data: principles and applications. Can J Plant Sci, 86: 623-645.