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Aims and Scope

Turkish Journal of Range and Forage Science is the official publication of Society of Rangeland and Forage Science. The Journal is dedicated to publishing quality original material that advances rangeland management and forage crops production.

Turkish Journal of Range and Forage Science is a peer-reviewed, international, electronic journal covering all aspects of range, forage crops and turfgrass management, including the ecophysiology and biogeochemistry of rangelands and pastures, terrestrial plant–herbivore interactions, rangeland assessment and monitoring, effects of climate change on rangelands and forage crops, rangeland rehabilitation, rangeland improvement strategies, conservation and biodiversity goals. The journal serves the professions related to the management of crops, forages and grazinglands, and turfgrass by publishing research, briefs, reviews, perspectives, and diagnostic and management guides that are beneficial to researchers, practitioners, educators, and industry representatives.

Publication Date and Subscription Information

Turkish Journal of Range and Forage Science is published twice a year (June and December) as online.

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TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE

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When a revision is required by the reviewer or reviewers, the author(s) are to consider the criticism and suggestions offered by the reviewers, and they should be sent back the revised version of manuscript in twenty days. If revised manuscript is not sent in twenty days, the manuscript is removed from reviewer evaluation process. Reviewers may request more than one revision of a manuscript. Manuscripts which are not accepted for publication are not re-sent to their authors.

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The author(s) that submit an article to the Turkish Journal of Range and Forage Science consider accepting of these peer review conditions and procedures.

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Research

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Silage Quality of Corn Grown at Different Weed Densities

Onur İLERİ[1] Emre KARA[2] Şule ERKOVAN[1] Mustafa SÜRMEN[2]
Halil İbrahim ERKOVAN[1*] Ali KOÇ[1]

[1]Eskişehir Osmangazi University, Faculty of Agriculture, Department of Field Crops, Eskişehir, Türkiye

[2]Aydın Adnan Menderes University, Faculty of Agriculture, Department of Field Crops, Aydın, Türkiye

A R T I C L E I N F O

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A B S T R A C T

Quality of silage corn is assessed over dry matter ratio, dry matter intake, crude protein, energy, and mineral contents. In this study, the effects of different weed densities on the silage quality of corn were investigated in the 2019 and 2020 years. Silage pH, Fleig score, dry matter ratio, crude protein, NDF, and ADF contents were assumed as silage quality parameters. The experiment was established in randomized block design. Silage pH, Fleig score, dry matter ratio did not present significant variations between the years but crude protein, NDF, and ADF contents significantly varied. Weed density significantly affected NDF content only. Although weed density did not have a significant effect on the silage quality of corn, cultivation should be carried out weed-free for high yielding.

1. Introduction

Silage corn is an important roughage source and cultivated for its high energy, fiber, crude protein, and mineral content. Silage feeding could reduce feeding costs and increase nutritive value without affecting the performance and physiology of the animals. But silage quality is affected by many factors as plant density, maturity, moisture, silage conditions, etc. (Satter and Reisi, 2012). Besides the genetic factors, the growing environment and some physical characteristics as to leaf, stem, and cob ratios also could have significant effects on the nutritive value of the silage (Khan et al., 2012; Ileri et al., 2018). Some physical factors as particle size and cob ratio could affect the aerobic stability of the silage, and thereby the nutritive value because particle size could raise silage pH by increasing the consumption of soluble carbohydrates (Silva et al., 2015). High-quality silage could not be expected from the plants, which exposed a strong competition for nutrition, light, and water in earlier development stages, because silage corn could not reach silage maturity under these conditions.

Weeds strongly compete with silage corn for nutrition, light, and water, especially in the early stages of the corn. This competition causes a significant decrease in the silage yield of corn. Besides, cobs, which are significant carbohydrate sources, could not develop, and consequently carbohydrate content of silage material decreases. Under low carbohydrate conditions, silage fermentation is delayed and quality is decreased. Heuze et al (2017) also indicated that any decrement in dry matter ratio might increase silage quality proportionally, but decrease totaly. For example, crude protein and digestibility ratios decrease when the dry matter ratio increase (Heuze et al., 2017). Weed competition decreases silage yield, dry matter ratio, and cob ratio of the corn, and thereby decreases the nutritive value of the silage. In addition to poor nutritive value, the

*Correspondence author: erkovan@ogu.edu.tr

fermentation period is prolonged and silage might be spoiled. Inoculants could be useful to avoid the spoilage of silage but they increase the costs. Yield loss, a decrease in silage quality, and additional costs due to weed competition might reach intolerable levels for growers. Shresta et al (2019) recorded a yield loss between 20-80% due to weed competition. Low yield, carbohydrate, nutritive value, and losses during ensilage limit silage production.

In this study, silage corn grown under different weed densities were ensilaged separately and silage pH, Fleig score, dry matter ratio, crude protein, NDF, and ADF contents were investigated. It was aimed to determine the effect of weed density on the silage quality of corn.

2. Materials and Methods

The research was carried out in the experimental station of Eskişehir Osmangazi University, Faculty of Agriculture during the main crop season of 2019 and 2020 years. Simpatico was used as the corn cultivar and ensilaged after growing in different weed densities as 0, 2, 4, 6, 8, 10, 12, 14 weeds m^{-2}. Weed numbers for per meter square were controlled by hand remowing. Weed species were identified as *Chenopodium album*, *Amaranthus blitoides*, *Amaranthus hybridus*, *Solanum nigrum*, and *Xanthium strumarium* in the plots. In every plot, 70 kg ha^{-1} N and 180 kg ha^{-1} P_2O_5 were applied while sowing. Additional fertilization was carried out using 70 kg ha^{-1} N both during the 4-6 leaf stages and 6-8 stages. Plants were irrigated once a week for 15 hours using drip irrigation that has a 1.9 l h^{-1} flow rate. Harvest was carried out when corns reached to dough stage in weed-free plots for both years. Harvested plants were mechanically processed and ensilaged. All samples were subjected to the same mechanical process to interrupt the effect of particle size and any inoculant was not used. After filling, silage bags were vacuumed and strapped to avoid air intake of the bags. The experiment was conducted due to a randomized complete blocks design with 6 replications.

Silage bags were opened and investigated after 8 weeks of the fermentation period. Silage pH was determined using a digital pH meter from the extracts of 25 g of samples, which were kept in 250 ml of distilled water for 30 minutes and filtered. Another 500 g samples from each bag were oven-dried at 70 ºC until reached constant weight and the dry matter ratio was calculated by dividing dry and fresh samples. Fleig score was calculated using the formula suggested by Kilic (1986), which was given below;

$$\text{Fleig Score} = 220 + (2 \times \%\ DM - 15) - 40 \times pH$$

Dry samples were grounded to pass through a 2 mm sieve and CP, NDF, ADF contents were determined using FT-NIR (Fourier Transform Near-Infrared, Bruker MPA) spectroscopy. To validate the results of FT-NIR spectroscopy, randomly selected 20 samples were analyzed using the Dumas method for CP content, and using Ankom Fiber Analyzer for NDF and ADF contents. Dumas and Ankom Fiber Analyzer results had a significant correlation ($r \geq 0.9$, $P \leq 0.01$) with FT-NIR results. Therefore, FT-NIR results were used in the statistical analyses.

All data were subjected to analysis of variance using SAS statistical software (SAS Institute, 2011). Means were compared using Bonferroni/Dunn multiple comparison test.

3. Results and Discussion

Silage pH of corns, which were grown at different weed densities, did not vary significantly between years and among weed densities but year × weed density interaction was significant ($p<0.001$) (Table 1). The mean silage pH was 4.32 and it was measured as 4.32 in 2019, and 4.33 in 2020 (Table 1). Silage pH of weed densities varied between 4.15-4.66 (Table 1). In 2019, pH was similar among weed densities but it was significantly higher in the second year at 14 weeds m^{-2} density (Figure 1). This difference caused a significant year × weed density interaction.

The mean Fleig score was 92.6 and the variation between years and among weed densities, and year × weed density interaction was not statically significant (Table 1). Fleig score was 93.44 in the first year and 91.94 in the second year of the study (Table 1). Even the variation among the weed densities was statically not significant, it was numerically higher in weed-free plots (Table 1).

The dry matter ratio was 30.51% in 2019 and 30.03% in 2020 and this variation between the years was not statically significant (Table 1). The dry matter ratio changed between 34.4 – 26.31% depend on weed density and it was numerically higher in weed-free plots but the effect of weed densities on the dry matter ratio was not statistically significant (Table 1).

Crude protein content significantly varied (p<0.001) between years but weed densities and year × weed density interaction were not statically significant (Table 1). Crude protein content was 7.25% in 2019 but it significantly increased to 10.23% in 2020 (Table 1). A slight increment was observed in crude protein content as the weed densities increased but this variation was not significant (Table 1).

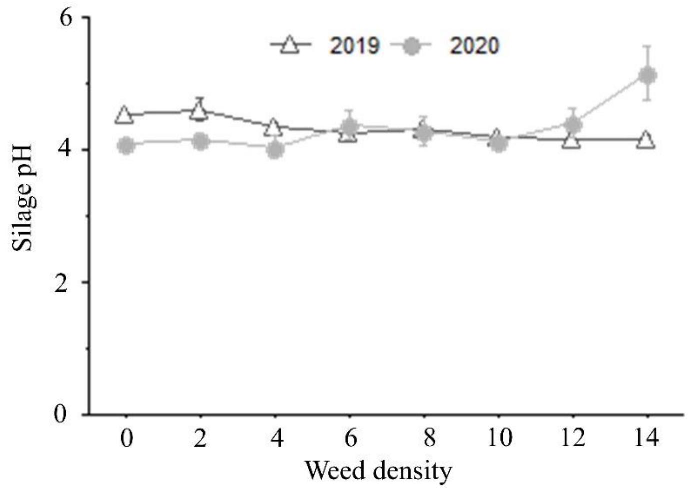

Figure 1. Silage pH at different weed densities and years

Table 1. Means and ANOVA results of the examined silage characteristics

	pH	Fleig Score	Dry Matter (%)	Crude Protein (%)	NDF (%)	ADF(%)
Year (Y)						
2019	4.32	93.44	30.51	7.25 B	31.85 A	17.36 A
2020	4.33	91.94	30.03	10.23 A	27.59 B	15.39 B
Weed Density (W)						
0	4.32	101.21	34.44	8.54	30.71 b	17.08
2	4.37	94.12	31.99	8.47	30.02 b	16.88
4	4.19	94.77	28.62	8.71	29.81 b	15.22
6	4.31	100.60	34.00	8.71	25.42 d	16.31
8	4.30	91.06	29.06	8.45	28.99 b	14.99
10	4.15	91.68	26.31	8.66	28.27 c	16.57
12	4.28	93.67	29.87	9.06	32.71 a	17.35
14	4.66	74.40	27.87	9.29	31.81 a	16.60
Average	4.32	92.69	30.27	8.74	29.72	16.38
Y	ns	ns	ns	**	**	**
W	ns	ns	ns	ns	*	ns
YxW	**	ns	ns	ns	ns	ns

ns: non significant, *: P≤0,05, **: P≤0,01

NDF content, which is an indicator of dry matter intake, significantly varied between years (p<0.001) and among the weed densities (p<0.05) but year × weed density interaction was not statically significant (Table 1). It was determined as 31.85 % in the first year and in decreased to 27.59 % in the second year (Table 1). NDF content decreased as the weed density increased up to 6 weeds m^{-2} but then, an unstable increase was recorded (Table 1).

Mean ADF content was 16.38% and it varied significantly (p<0.001) between the years (Table 1). In the first year, ADF content was 17.36 % and it decreased to 15.39 % in the second year. Variation among the weed densities and year × weed density interaction was not statically significant. (Table 1).

Silage pH is important for avoiding silage spoilage and thereby, it has significant effects on silage quality. Silage pH ranged between 4.15-4.66 in our study and it did not significantly change between years and among weed densities. Other researchers also recorded similar pH values for the silage corn that have 25-35% dry matter ratio (Carvalho et al., 2006; Geren, 2001; Abdelqader et al., 2009; Azevedo et al., 2011; Silva et al., 2015; Heuze et al., 2017). Cob ratio of the corns decreased evidently as the weed density increased (unpresented data) and the higher pH values were expected based on the decreased carbohydrate content of the silage material due to decreased cob ratios. This pH increment was recorded only in the second year of the study, which might be the reason for the significant year × weed density interaction.

Fleig score is a quality parameter for silage and calculated using silage pH and dry matter content. In the study, the Fleig score of the silage did not present a significant variation between years and among weed densities but Fleig score for 14 weeds m^{-2} density was in good class while the others were in very good class (McDonald et al., 1991).

A higher dry matter ratio is expected for the silage, which is prepared using the silage material grown in weed-free conditions considering other weed densities. In the study, the dry matter ratio did not cause a significant variation on the dry matter content of the silage but a numerical increment was recorded as the weed density decreased. Other researchers also determined similar results (Nedunzhiyan et al., 1997; Özer ve ark., 2001; Vazin, 2012; Tursun ve ark., 2016).

Silage crude protein content was significantly affected by yearly variations and it was higher in the second year. This is possibly due to the higher leaf ratio of the silage material in the second year (unpresented data) because researchers stated that leaf ratio has a significant impact on the crude protein ratio of the silage (Turgut et al., 2005; Ileri et al., 2018; İleri et al., 2020). Weed density did not have a significant effect on the crude protein content of the silage. Other research findings showed that crude protein content of the silage corn, which contains 25-30 % dry matter, could range between 4.9 – 9.8 % (Carvalho et al., 2006; Geren, 2001; Abdelqader et al., 2009; Azevedo et al., 2011; Silva et al., 2015; Heuze et al., 2017) and out findings of crude protein content (8.45 – 9.29 %) were consistent with the literature.

NDF and ADF contents of the silage showed a significant variation between years. Yearly variations are very common for agricultural production due to climatic differences, especially in recent years. This variation in NDF and ADF contents of the silage is possibly affected by the NDF and ADF contents of the silage material grown at field conditions in 2019 and 2020. Other researchers revealed the significant relations between silage and silage material in terms of NDF and ADF contents (Turgut et al., 2005; Ileri et al., 2018; İleri et al., 2020). Our findings of NDF and ADF contents were lower than other results (Carvalho et al., 2006; Geren, 2001; Abdelqader et al., 2009; Azevedo et al., 2011; Silva et al., 2015; Heuze et al., 2017).

4. Conclusion

Plant materials and their growth conditions significantly affect the physical and quality characteristics of corn silage. In this study, silage pH, Fleig score, and dry matter ratio are not affected from years but crude protein content was higher in the second year, while NDF and ADF contents were lower. Weed density had a significant effect only on silage NDF content. Although weed density did not significantly affect the silage characteristics in this study, it is important for high silage yield.

In conclusion, the result of present study showed that silage quality is also affected negatively by weed invasion. Hence, weed control practices positively contribute to silage quality as is in yield.

Conflict of Interest

There is no conflict of interest among the authors.

Credit authorship contribution statement

All authors equally contributed to the manuscript.

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Research

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Determination of Some Characteristics of Tall Fescue (*Festuca arundinaceae* Schreb.) Populations Collected from Natural Flora and Selection of Grass Type Genotypes

Fatih ALAY[1*] **İlknur AYAN[2]**

[1]Field Crops, Black Sea Agricultural Research Institute, Samsun, Türkiye

[2]Department of Field Crops, Faculty of Agriculture, 19 Mayıs University, Samsun, Türkiye

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A B S T R A C T

The aim of this study was to determine the identification criteria (phenological, morphological and some agricultural) and select the ones suitable for turfgrass. Agricultural studies in Black Sea Agricultural Research Institute Ambarköprü Station were carried out. Identification studies was done according to IBPGR with 900 genotypes in 2015 and 2016. Some parameters determined in the study as follows. Average plant height 65–177 cm, main stem thickness 2.0–6.1 mm, internode length 11–53 cm, flag leaf length 10–42 cm, flag leaf width 3–14 mm, days to heading 208–246, lodging ratio 1.5–5.0 (1=erect; 5= prostrate), tillering potential 9–330, spring growth 1.5–5.0 (1- early; 5- late), herbage forage yield 101–2330 g/plant. End of the morphological and technological measuring and observations, 49 genotypes were selected for turfgrass with using relative rating method. According to the analysis, the genotypes were first divided into two main groups. It was determined that the genotypes FA 06-07, FA 31-02, FA 09-08 and FA 05-13 in the first group were collected from Samsun and Tokat locations, and all of the genotypes in the second group were collected from the Tokat location.

1. Introduction

Today, while the population is decreasing due to migration from rural areas to cities, it is increasing in cities. As cities grow geographically and humanly, natural areas disappear and people's need and longing for green spaces increases. Rapid population growth, migration and unplanned urbanization, social, economic, political and cultural conditions cause the deterioration of the physical environment of the people living in the city and a decrease in the quality of life (Kır et al., 2010; Özköse, 2012; Alay, 2020).

In cities where green areas are sufficient, the quality of life and productivity of individuals are also high. Therefore, a great deal of importance is given to green areas in the establishment of cities. Today, green areas are needed in many sports and playgrounds such as parks, gardens, football-golf fields, horse races, as well as on railway sides, airports, around buildings, hospitals and schools. (Kuşvuran, 2009; Özköse, 2012).

Turfgrass areas, in addition to their aesthetic contribution to urban spaces, create a green cover that allows them to play and rest. They absorb sunlight during the day and affect the environment positively by not giving back the

*Correspondence author: fatih.alay@tarimorman.gov.tr

radiation they collect during the night. By absorbing the dust in the air, they eliminate the dust problem. They also consume carbon dioxide in the atmosphere as they are a natural oxygen producer. Green areas also remove other atmospheric pollutants such as ozone, sulfur dioxide, nitrogen dioxide, ammonia, carbon monoxide, volatile organic compounds and lead (Stier et al., 2013). They ensure that rain and snow waters are transformed into groundwater on a regular basis. They lose water by transpiration, thereby reducing the ambient temperature up to 5 ˚C. By forming approximately 4000 shoots in an area of 1 m^2, they function like an air conditioner due to their energy absorption properties (Uzun, 1992; Avcıoğlu, 1997; Oral and Açıkgöz, 1998, Nick et al., 2016).

Although our country has a great genetic potential in terms of grass breeding, all purchased grass species are varieties obtained from breeding studies of foreign countries. These varieties cannot show the desired characteristics in our country's conditions (such as climate, soil, resistance to diseases and pests) and the plant life is short. This situation necessitates more fertilization, irrigation and other maintenance works in lawn areas and requires the facility to be renewed in a short time (Özköse, 2012; Alay, 2020). Thus, the construction and maintenance costs of lawn fields increase significantly. We need to breed new varieties by using the grass plants found in our natural flora and use our potential to produce grass seeds. Developing a domestic grass variety will not only contribute to meeting the seed needs of our country, but also contribute to meeting the grass needs of countries with similar ecologies and improving export opportunities. Scientific studies on this subject will gain momentum and the number of trained people, information and resources will increase.

This study was carried out to determine the morphological and agricultural characteristics of tall fescue (*Festuca arundinaceae* Schreb.) populations collected from the natural flora of the Central Black Sea Region and to select genotypes that could be turf type.

2. Materials and Methods

2.1. General characteristics of the research area

The research was carried out in Samsun Black Sea Agricultural Research Institute, Çarşamba Ambarköprü trial station (41°29' 11 N - 36° 401 06 E) between 2014-2016. Its height above sea level is 17 meters.

2.2. Soil and climate characteristics of the research area

The pH value of the soil of the research area is 7.35, and it is slightly alkaline, clay loam, organic matter is medium, phosphorus is very low, lime is medium, salt free and potassium is insufficient.

The average temperature of the province of Samsun 1980-2016 for many years is 15.0 °C and the total precipitation is 992.4 mm. According to the long-term average, the highest temperature value was 24.9 °C in August, and the lowest temperature value was 6.5 °C in January. The highest total precipitation was in January with 154.4 mm and the lowest precipitation was in July with 22.8 mm. When the average temperature and total precipitation values for many years are examined, it is seen that the dry period begins in late June and continues until mid-October (Table 1).

When the climate data of the years of the experiment were compared, the lowest monthly total precipitation was in April with 16.8 mm in the first year of the experiment, in November with 18.5 mm in the second year and in July with 31.5 mm in the third year. In March 2014, the total precipitation amount in March, April and May, when the seedlings were planted and the cool season plants made a significant part of their development, was lower than the average of 2015-2016 and many years. While the average relative humidity for many years was 77.2%, this value was 78.5% in 2014, 79.0% in 2015 and 78.1% in 2016 (Table 1).

Within the scope of TAGEM /TA/00/11/01/009 and "Black Sea Region Forage Crops Research Project", seeds of a total of 64 populations, 9 from Samsun, 53 from Tokat and 2 from Sinop, were collected. While collecting, features such as collection place, latitude, longitude, altitude were recorded, and the seeds were taken from different places at a distance of at least 1 km.

Table 1. The average temperature, average relative humidity and total precipitation values of the county of Çarşamba, 2014, 2015 and 2016 and the long-term average (U.Y.O.) (1980-2016) (Anon., 2018)

Location	**Çarşamba**											
	Total Precipitation (mm)				**Average Temperature (°C)**				**Average Relative Humidity (%)**			
Months	**Long-Term Average**	**2014**	**2015**	**2016**	**Long-Term Average**	**2014**	**2015**	**2016**	**Long-Term Average**	**2014**	**2015**	**2016**
January	154.4	-	128.5	199.9	6.5	-	6.9	6.3	69.8	-	68.8	100.0
February	52.2	-	103.0	37.4	8.7	-	8.0	10.9	71.9	-	76.0	70.3
March	81.5	41.5	112.9	103.8	9.6	9.8	8.6	10.3	77.1	77.3	81.4	73.2
April	68.5	16.8	106.0	50.6	12.1	12.2	10.7	14.4	76.8	75.2	74.8	75.6
May	100.2	48.6	20.4	267.7	16.6	16.8	16.7	16.7	80.2	79.5	79.3	79.6
June	103.7	115.4	106.8	33.6	21.2	20.5	20.7	22.2	78.4	79.6	82.2	77.0
July	22.8	46.4	29.5	31.5	23.8	23.9	23.0	23.9	76.5	78.4	80.4	76.3
August	69.7	95.8	179.6	37.4	24.9	24.7	24.6	25.2	79.9	79.8	80.7	78.9
September	59.1	101.2	42.5	108.1	21.1	20.4	22.4	20.0	80.5	81.6	86.8	76.4
October	69.6	103.9	76.0	38.9	15.6	15.8	16.6	14.9	84.7	86.9	90.3	83.4
November	73.1	116.2	18.5	79.6	11.8	10.4	13.0	11.2	75.0	71.6	72.0	71.2
December	137.7	93.8	125.6	162.8	8.2	10.0	7.4	4.9	75.3	75.3	74.8	75.7
Mean	**82.7**	**77.9**	**87.4**	**95.9**	**15.0**	**16.4**	**14.9**	**15.1**	**77.2**	**78.5**	**79.0**	**78.1**
Total	**992.4**	**779.6**	**1049.3**	**1151.3**	–	--	–	–	–	--	–	–

Seeds belonging to the populations were sown in one row on the land of the Black Sea Agricultural Research Institute, Ambarköprü trial station in October 2013. Sowing was done manually in rows of 5 m in length. From these rows, 20 randomly selected genotypes (per plant) for each population were planted in the observation garden with 20 plants (genotypes) from each population in March 2014. Considering the soil analysis results, fertilization was made at the stage of planting the seedlings in the field at 5 kg N (nitrogen) and 8 kg P (phosphorus) per decare. In the years of 2015 and 2016 of the experiment, a total of 10 kg of nitrogen fertilization, 5 kg per decare in the early spring and 5 kg after the first cutting, was applied. In general, irrigation was not done in the experiment. It has been sprayed twice a year against Melolontha ssp. with the drug whose active ingredient is Lambda-cyhalothrin. Weed control was done when necessary. The total number of plants in the experiment was 1280, and later on, some genotypes were damaged by (*Melolontha* ssp.) and lost during mechanization studies. For this reason, observations and measurements were made in 900 genotypes. In 2015, the cutting was done on May 6, and in 2016, on May 15. In both years, the second cutting was not done because the plants showed little development after cutting. Cleaning was carried out at the end of October in the establishment year, 2015 and 2016 years.

In this study, turf type genotypes were determined according to the weighted scaling method among 900 genotypes, with agricultural and morphological identification lasting two years, excluding the establishment year. The averages of two-year data were used to determine the superior tall fescue genotypes, which are candidates for turf type. The minimum (by subtracting the extreme ones) and the maximum (by subtracting the extreme ones) values were obtained from the values obtained. The difference between the maximum and minimum values is divided by 3, and the result is added to the minimum value and added to the maximum values to form 3 groups. Average values were obtained by multiplying the scale score of the genotypes with the feature of being a turf type and the % importance level. Genotypes above the mean were selected (Gebeyahou et al, 1982; Yazgan, 1989; İslam and Deligöz, 2012). Descriptive statistics of the data of each feature obtained from this study were made. At the end of the calculations, the minimum and maximum value, mean, standard deviation and coefficient of variation results were obtained. Since the data obtained will only show the characteristics of the group to which it is related, "mean±standard deviation" is given together (Özbek and Keskin, 2007).

3. Results and Discussion

3.1. Spring growth (1-5)

When the average of 2015 and 2016 in terms of spring growth is examined, the lowest group value was 1 (early), the highest group value was 5 (late), and the average group value was 3 (medium). It was determined that 140 of the genotypes were early, 697 of them were medium and 63 of them were late. The standard deviation value determined between genotypes was calculated as 3±0.84. Looking at the average of both years, it is seen that the standard deviation is low. This shows that the variation between the observation values given to the genotypes in terms of spring growth is close. The coefficient of variation was calculated as 30.7% on average (Table 2). This shows that the variability between genotypes is high. This is an expected result since the studied populations were collected from nature.

If tall fescue is grown for forage grass, it gives more green grass and comes to grazing maturity early, if it is grown for turf grass, it stays green for a longer time and provides the expected benefits as green area. Late maturing genotypes were selected for turf type.

Arslan and Orak (2011) reported the spring growth rate of of tall fescue with turf type grass characteristics and some species as 3 (1-5) in Tekirdağ coastal belt. Also, Alagöz and Türk (2017) reported the spring growth rate of 1.7-4.3 (1-5) in five turf grass crops (*Lolium perenne* L., *Poa pratensis*, *Festuca arundinacea*, Festuca rubra var. rubra, Festuca rubra var. commutata) in Isparta ecological conditions. Moreover, Varoğlu (2010) reported the spring growth of *Festuca arundinacea* as 3.5 (1-5) in its mixtures with pure stand and *Lolium perenne* in İzmir conditions, while Varoğlu et al. (2015) reported that the spring growth of tall fescue (*Festuca arundinaceae*) and red fescue (*Festuca rubra*) varieties in Bornova conditions between 2-4 (1-5). In another study, Erdoğan and Sürmen (2019), spring growth of *Festuca rubra var. rubra* in Aydın conditions was measured as 4.5 (1-5) while *Festuca rubra var. commutata*'s was 2.0 (1-5) and *Festuca arundinacea*'s spring growth was 2.5 (1-5). In addition, Özkan and Avcıoğlu (2013) determined the spring growth rate in Mediterranean conditions between 1.38-3.32 (1-5) in the mixtures of *Festuca arundinacea* with pure stand and *Lolium perenne*, while Eraşık and Soya (2014) were reported as 2.57 (1-5), and Balekoğlu (2015) reported as 6.52 (1-9) in Mediterranean conditions.

These results are in general agreement with our study. Spring growth is closely related to the climate. How long the winter season lasts, the severity and duration of the cold, the snow cover, the number of days when the temperature is below zero, the number of hot days, etc. factors directly affect spring growth. In addition, the genetic diversity of tall fescue turf type genotypes is also important.

Table 2. Frequency distribution and descriptive statistics values of spring growth of tall fescue genotypes

Observation Value		**Mean**	
	Group Value (1-5)	**Number**	**%**
1-2*	1 (early)	140	15.56
3*	3 (medium)	697	77.44
4-5*	5 (late)	63	7.00
Minimum		1	
Maximum		5	
Average		3	
Standard Deviation		3±0.84	
Coefficient of Variation (CV) (%)		30.7	

*1-Too fast growth *2-Fast growth *3-Moderate growth * 4-Slow growth *5-Too slow growth DK- Coefficient of Variatio

3.2. Tillering potential (number/genotype)

When the average of the years 2015 and 2016 was analyzed in terms of tilling potential, the minimum number of tillering was 9 (less-infrequent), the maximum number of tillering was 330 (frequent-high), the mean of genotypes was 84.87 (near medium), and the standard deviation value was 84.87±51.6. Looking at the average of both years, it is seen that the standard deviation is high. This shows that genotypes have wide variation in terms of tillering potential. It was determined that 551 genotypes were in the 1st (less-rare) group, 276 were in the moderate and 73 were in the 5th (frequent-high) group. The coefficient of variation was calculated as 60.7% on average (Table 3). This shows that the variability between genotypes is high. Grass density can be measured by counting the amount of stems or leaves per unit area. However, it can be determined more easily and accurately by stem counting.

It is desirable that the density (tillering potential) value, which expresses the number of shoots per unit area, is high in grass areas. Therefore, over tillering is important in terms of suppressing foreign plants, completely covering the area and creating a good green plant (Beart, 1973; Avcıoğlu, 1997). Genotypes that have over tillering potential were selected for turf purposes.

Varoğlu (2010) found tillering potential of some species (*Festuca rubra* (Engina, Franklin, Pernille), *Festuca arundunaceae* (Eldorado, Finelawn, Apache), *Poa pratensis* (Enprima, Geronimo, Connni)) used in green areas and to be 4.3 (1=seldom, 5=dense), while Özkan and Avcıoğlu (2013) reported between 3.67-4.56 (1-5) for *Festuca arundinacea*, *Lolium perenne*, *Festuca rubra var. rubra*, *Festuca rubra var. commutata*, *Festuca ovina* and *Poa pratensis* in Mediterranean conditions. Also, Eraşık and Soya (2014), reported as 4.61 (1-5) in Mediterranean conditions. On the other hand, Balekoğlu (2015) investigated the tillering potential of some *Festuca arundinacea* cultivars (Eldorado, Millenium, Rebel Pro, Regiment-2, Tahoe, Tomat, Turbo RZ) in Mediterranean conditions on a scale of 1-9 (1=rare, 9=frequent), and reported it as 7.36. Whihe Erdoğan ve Sürmen (2019), stated the tillering potential in tall fescue as 3.25 (1-5) in Aydın province conditions, Varoğlu et al., (2015), found it between 2.8-4.8 (1= sparse, 5= dense) of *Lolium* sp., *Poa* sp., *Festuca* sp. turf type grass crops, in Bornova conditions. Saygın and Ayan (2019) found that the number of tillering varies between 3.5-5 (1-5) in pure stand tall fescue sowing, in which a total of 6 cuttings were made and 4 sowing rates were applied (30, 40, 50 and 60 g/m^2) in Samsun – Çarşamba conditions. Okkaoğlu (2006), who measures tillering condition as a number instead of a scale, reported 104.60 in İzmir conditions, while Ayan et al. (2011) reported it as 17-220 in Samsun-Çarşamba conditions.

There is a general similarity between the results of this study and the results of other researchers. In tall fescue turf type genotypes, besides the genetic differences of plants in terms of tillering number, environmental factors (climate, soil moisture, etc.) such as cutting tool type, cutting height, cutting frequency, amount of nutrients in the soil, light exposure of the bottom parts of the plant, plant age and development also are factors affecting.

Table 3. Frequency distribution and descriptive statistics values of tillering potential of tall fescue genotypes

Observation/Measurement Value (number/genotype)		Mean	
	Group Value (1-5)	Number	%
[5-85]	1 (seldom)	551	61.22
[86-165]	3 (moderate)	276	30.67
165<	5 (dense)	73	8.11
Minimum		9	
Maximum		330	
Average		84.87	
Standard Deviation		84.87±51.6	
Coefficient of Variation (CV) (%)		60.7	

3.3. Lodging ratio (1-5)

When the average of the years 2015 and 2016 is examined in terms of lodging ratio, the lowest group value was 1 (erect), the highest group value was 5 (prostrate) and the average group value was 2.23 (semi-erect). It was determined that 448 genotypes were in the 1st (erect) group, 403 were in the 3rd (moderate) group and 49 were in the 5th (prostrate) group. The standard deviation value determined between genotypes was calculated as 2.23±0.89. Looking at the average of both years, it is seen that the standard deviation is very high. This shows that the genotypes have high variation. The coefficient of variation was calculated as an average of 52% (Table 4). As a result of the scoring, 49 genotypes can be evaluated as turf type, which develops erect, semi-erect, covers the soil surface better and gets 50 score (highest) in terms of lodging ratio.

Lodging ratio in tall fescue and some species in some species, while Ayan et al. (2011) were determined as 1-3 in *Festuca arundinacea* Schreb., *Festuca ovina* L., *Festuca pratensis* Huds., *Festuca rubra* L., *Festuca drymeja* Koch., *Festuca amethystina* L., *Festuca woronowii* Hackel. and *Festuca lazistanica subsp. giresunica* Alex. in Samsun conditions, Özköse (2012) was determined that it varies between 1-8 (1=erect, 9=prostrate) in Ankara conditions.

In our study, the growth pattern of genotypes varied between 1 and 5. There is a general similarity between the study and the results of the researchers. The differences may be caused by many factors such as the type of plants, genetic structure, temperature, soil and air humidity, nitrogen fertilization.

Table 4 Frequency distribution and descriptive statistical values of tall fescue genotypes of lodging ratio

Observation Value	Group Value (1-5)	Mean: Number	Mean: %
1*	1 (erect)	448	49.78
2-3*	3 (semi-erect)	403	44.78
4-5*	5 (prostrate)	49	5.44
Minimum		1	
Maximum		5	
Average		2.23	
Standard Deviation		2.23±0.89	
Coefficient of Variation (CV) (%)		52	
*1- Erect *2- Semi-erect *3- Moderate *4- Semi-prostrate *5- Prostrate			

3.4. Days to heading

When the average of the years 2015 and 2016 in terms of days to heading is examined, the lowest number of days was 207, the highest number of days was 242 and the average number of days was 232. 163 genotypes were in the 1st (early) group, 672 were in the 3rd (medium) group and 65 were in the 5th (late) group. The standard deviation value determined between genotypes was calculated as 232±11.2. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the genotypes are somewhat far from each other in terms of days to heading. The coefficient of variation was calculated as an average of 5.6% (Table 5). This shows that the variability between genotypes is high. This result is an expected result since the studied populations are collected from nature.

Early stem elongation and flowering are undesirable in turf grass (Açıkgöz, 1994). Controlling the entry of turf type grasses into the booting stage means controlling the quality of the grass. Because when the turf grass enter the seed creation period, the desired continuous uniform green cover is disrupted due to the stem elongation (Avcıoğlu, 1997). As stated by the researchers, 65 genotypes, which were determined grass having late maturity in terms of the number of days of stem elongation, can be considered as grass type.

The number of days of stem elongation in tall fescue genotypes varied between 207 and 242, as the average of two years. Since the reactions of plants to the common effects of photoperiod and temperature factors are different, there are significant differences in terms of maturation time between genotypes in the species (Tosun, 1973). Grass plants are generally long day plants and can flowering in very wide photoperiods (Açıkgöz, 1994; Avcıoğlu, 1997).

Oliveira and Charmet (1989) found the between 6 May and 7 June in 50 perennial ryegrass population collected from North West Spain, while while Romani et al (2002) found 52 genotypes of perennial ryegrass (*Lolium perenne*) collected from different regions of Italy reported the heading date between 5 and 25 May. Also, Mirjalili and Bennet (2006), in their study in Iran, reported the average heading date of 11 perennial ryegrass lines to be 6 May. Shipway et al (2010) reported that in the UK conditions, when there is 50% stem elongation in grass species or varieties, it is determined as the stem elongation date; for example, if it happened after 20 days from 1 May, it expressed as REE20 (Relative Ear Emergence). They are divided into three groups as early, medium and late, since the duration of stem elongation differs in tall fescue, and they report that each group covers a period of 12 days or more. They report that the heading dates of the perennial ryegrass varieties they are working on vary between 18 May and 29 June. Sokolovic et al. (2011) recorded the heading dates of populations collected from different parts of the country between 13-20 May for perennial ryegrass breeding suitable for Serbian conditions.

The number of days of stem elongation or dates values obtained from this study are generally in agreement with the results of other researchers. Differences may be caused by many environmental factors such as climate and soil characteristics, as well as genetic and variety differences in the materials used.

Table 5. Frequency distribution and descriptive statistics values for the number of days to heading of tall fescue genotypes

Observation/Measurement Value (day)		**Mean**	
	Group Value (1-5)	**Number**	**%**
[206-220]	1 (early)	163	18.11
[221-232]	3 (medium)	672	74.67
232<	5 (late)	65	7.22
Minimum		207	
Maximum		242	
Average		232	
Standard Deviation		232±11.2	
Coefficient of Variation (CV) (%)		5.6	

3.5. Plant height (cm)

When the average plant height of 2015 and 2016 is examined, the lowest plant height was 65 cm, the highest plant height was 184 cm and the average plant height was 129.5 cm. It was determined that 114 of the genotypes were in the 1st (long) group, 703 in the 3rd (medium) group and 83 in the 5th (short) group. The standard deviation value determined between genotypes was calculated as 129.5±17.42. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the variation between genotypes in terms of plant height is high. The coefficient of variation was calculated as 18.5% on average (Table 6). This shows that the variability between genotypes is high. Since the studied populations are populations collected from nature, this result is expected. 83 short-grown genotypes can be evaluated with 50 points (the highest) as turf type grass in terms of plant height.

Table 6. Frequency distribution and descriptive statistics values of plant height of tall fescue genotypes

Observation/Measurement Value (cm)		**Mean**	
	Group Value (1-5)	**Number**	**%**
136<	1 (long)	114	12.67
[95-136]	3 (medium)	703	78.11
[51-94]	5 (short)	83	9.22
Minimum		65	
Maximum		184	
Average		129.5	
Standard Deviation		129.5±17.42	
Coefficient of Variation (CV) (%)		18.5	

Desired plant height varies according to the purpose of growing in tall fescue. Tall fescue plants to be used as turf grass should be short in length, slowly developing after the cutting, narrower leaf blade width, etc. features are required. In this study, the average plant height of two years varied between 65-184 cm.

Watkins and Meyer (2004) measured the plant height of *Festuca arundinaceae* between 71.7-104 cm in American conditions, while Edward (1993) reported it as 122 cm. Also, Dzyubenko and Dzyubenko (2011), stated it between 100-160 cm in Russian conditions. While Gençkan (1983) found the plant height of Festuca arundinaceae between 30-200 cm in İzmir conditions, Davis (1985) reported that he measured the plant height between 30-150 cm in Turkey conditions, just two years later. Öztan and Okatan (1985) found the plant height of *Festuca arundinaceae* to be between 100-150 cm in the climatic conditions of Trabzon province located in the humid Black Sea Region, while Ayan and Acar (2009) measured it between 120-150 cm in Samsun conditions, and again Ayan et al., (2011) reported that they found it between 63-170 cm in Samsun conditions. Moreover, Serin and Tan (1998) reported that the plant height of tall fescue varies between 100-150 cm in Erzurum cold climate conditions. Başer and Kaplan (2015) reported that the plant height of tall fescue varies between 69.1-97.3 cm Kayseri conditions, while Kaya and Avcı (2019) reported that they determined it as 20-95 cm Konya conditions in the continental climate.

Although there is a general similarity in terms of plant height, there are some differences as well. These differences may be caused by environmental and genetic factors.

3.6. Main stem thickness

When the average of the years 2015 and 2016 is analyzed in terms of main stem thickness, the lowest main stem thickness was 1.9 mm, the highest main stem thickness was 6.1 mm and the average main stem thickness was 3.1 mm. It was determined that 235 of the genotypes were in the 1st (thick) group, 538 in the 3rd (medium) group and 127 in the 5th (thin) group. The standard deviation value determined between genotypes was calculated as 3.1±0.64. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the variation between genotypes is high in terms of main stem thickness. The coefficient of variation was calculated as an average of 23.7% (Table 7). This shows that the variability between genotypes is high. Since the studied populations are populations collected from nature, this result is expected. 127 genotypes with 50 points (highest) in terms of main stem thickness can be evaluated.

Desired main stem thickness varies according to the purpose of cultivation. There is a close relationship between main stem thickness and yield-yield components in tall fescue. There is a very important relationship between plant height and main stem thickness in tall fescue plant. As the main stem thickness increases, the plant height also increases (Ayan et al., 2011). It is desirable that the main stem of tall fescue plant to be used as turf type is thin, the herbage yield is low and it develops slowly.

Table 7. Frequency distribution and descriptive statistics values of main stem thickness of tall fescue genotypes

Observation/Measurement Value (mm)		**Mean**	
	Group Value (1-5)	**Number**	**%**
3.8<	1 (thick)	235	26.11
[2.8-3.8]	3 (medium)	538	59.78
[1.7-2.7]	5 (thin)	127	14.11
Minimum		1.9	
Maximum		6.1	
Average		3.1	
Standard Deviation		3.1±0.64	
Coefficient of Variation (CV) (%)		23.7	

In this study, main stem thickness in tall fescue genotypes varied between 1.9–6.1 mm. The main stem thickness was found as 2.29 mm by Yazgan et al. (1992), while it was reported as 2.66 mm by Ekiz et al. (1995) in Ankara conditions. While Arslan and Orak (2011) were stated as 2.10 mm of stem thickness in Tekirdağ coastal belt, Ayan et al. (2011) were reported between 2.22-6.77 mm in Samsun conditions.

Although there is a general similarity between the main stem thickness determined in the research and the results of the researchers mentioned above, there are also differences with some of them. Among the reasons for this; It may also be caused by the genetic structure of the studied genotypes, such as the different climate and soil conditions of the research location.

3.7. Internode length

In terms of internode length, the lowest internode length was 11 cm, the highest internode length was 53 cm, and the average internode length was 25.25 cm, according to the average of 2015 and 2016. It was determined that 154 of the genotypes were in the 1st (long) group, 720 in the 3rd (middle) group and 26 in the 5th (short) group. The standard deviation value determined between genotypes was calculated as 25.25±4.81. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the variation between genotypes is high in terms of internode length. The coefficient of variation was calculated as 19.9% on average (Table 8). This shows that the variability between genotypes is high. Since the studied populations are populations collected from nature, this result is expected. The above 26 genotypes with 50 points (the highest) in terms of internode length were selected. Internode length plays an important role in determining the height of the plant in tall fescue. It is not a desirable situation because turf type tall fescue plant to be used in the green area is tall in height, has a high herbage yield and grows rapidly, as it will require more care (irrigation, mowing, fertilization) both in terms of aesthetics. The large number of genotypes (900 genotypes) used in this study and the fact that these genotypes were collected from different ecological regions and altitudes may cause a wide variation in internode length.

In this study, it was determined that the internode length varies between 11 and 53 cm in tall fescue genotypes. While Watkins and Meyer (2004) found the internode length between 13.1-20.9 cm in American conditions, Okkaoğlu (2006) stated as 13.3 cm in İzmir conditions, and Ayan et al. (2011) reported between 3.2-37 cm in Samsun conditions.

Although there is a general similarity between the research conducted and the results of the researchers mentioned above, there are differences. These differences are due to the differences in the research location, climate and soil conditions, and the genotypes studied.

Table 8. Frequency distribution and descriptive statistics values of internode length of tall fescue genotypes

Observation/Measurement Value (cm)		**Mean**	
	Group Value (1-5)	**Number**	**%**
36<	1 (long)	154	17.11
[22-36]	3 (medium)	720	80.00
[6-21]	5 (short)	26	2.89
Minimum		11	
Maximum		53	
Average		25.25	
Standard Deviation		25.25±4.81	
Coefficient of Variation (CV) (%)		19.9	

3.8. Flag leaf length (cm)

When the average of the years 2015 and 2016 is examined in terms of flag leaf length, the lowest flag leaf length is 10 cm, the highest flag leaf length is 42 cm, and the average flag leaf length is 19.94 cm. It was determined that 443 genotypes were in the 1st (long) group, 383 in the 3rd (middle) group and 74 in the 5th (short) group. The standard deviation value determined between genotypes was calculated as 19.94±5.06. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the variation between genotypes is high in terms of flag leaf length. The coefficient of variation was calculated as an average of 25.5% (Table 9). This shows that the variability between genotypes is high. Since the studied populations are populations collected from nature, this result is expected.

Many researchers have reported that flag leaf length of tall fescue (*Festuca arundinacea* Schreb.) varies between 4-61 cm in different ecologies (Gençkan, 1983; Davis, 1965-1985; Öztan and Okatan, 1985; Edward, 1993; Serin and Tan, 1998; Hannaway et al., 1999; Okkaoğlu, 2006; Salman et al., 2008; Ayan and Acar, 2009; Dzyubenko and Dzyubenko, 2011; Kaya and Avcı, 2019). The flag leaf length values (10-42 cm) determined in this study are among the values obtained in the studies.

Although there is a general similarity between the research conducted and the results of the researchers mentioned above, it also differs with some others. The reasons for this may be due to the different research location, climate, soil conditions and genotypes.

Table 9. Frequency distribution and descriptive statistics values of flag leaf length of tall fescue genotypes

Observation/Measurement Value (cm)	Group Vlaue (1-5)	Mean	
		Number	**%**
29<	1 (long)	443	49.22
[18-29]	3 (medium)	383	42.56
[6-17]	5 (short)	74	8.22
Minimum		10	
Maximum		42	
Average		19.94	
Standard Deviation		19.94±5.06	
Coefficient of Variation (CV) (%)		25.5	

3.9. Flag leaf width (mm)

When the average of the years 2015 and 2016 in terms of flag leaf width is examined, the lowest flag leaf width was 3 mm, the highest flag leaf width was 14 mm and the average flag leaf width was 8.06 mm. It was determined that 764 of the genotypes were in the 1st (very rough) group, 86 in the 3rd (rough) group and 50 in the 5th (moderate) group. The standard deviation value determined between genotypes was calculated as 8.06±2.89. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the variation between genotypes is high in terms of flag leaf width. The coefficient of variation was calculated as 35.5% on average (Table 10). This shows that the variability between genotypes is high. Since the studied populations are populations collected from nature, this result is expected.

If the leaf width is less than 1 mm, it is described as very fine, between 1-2 mm as fine, between 2-3 mm as moderate, between 3-4 mm as rough and if larger than 4 mm as very rough. It is ideal for grass plants to have a flag leaf width between 1.5-3 mm (Beard 1973; Avcıoğlu 1997).

In order to determine the turf type grass characteristics in tall fescue, Edward (1993) reported that the flag leaf width changed between 0.3-1.27 mm in American conditions, while Hannaway et al. (1999) reported that it changed between 3-12 mm in American conditions. Also, Davis (1985) calculated the width of the flag leaf in tall fescue as 5-10 mm in the natural flora of Turkey. While Okkaoğlu (2006) reported the flag leaf width as 6.75 mm in tall fescue in İzmir conditions, Varoğlu (2010) reported it as 3.6 mm in the same conditions. Again in the same province, Salman and Avcıoğlu (2008) reported that they calculated the flag leaf width between 2-6 mm in Lolium perenne and *Festuca arundinacea*. While Avcıoğlu (1997) reported the flag leaf width between 5.2-6.2 mm (very rough) in Bornova conditions, Uyaroğlu (1999) reported it as 4.77 mm (very rough) in the same conditions. While Alagöz and Türk (2017) found the flag leaf width in tall fescue to be 3.28 mm in Isparta conditions, it was reported by Kılıç and Türk (2017) that it changed between 3.1-3.4 mm, Starlet, Debussy and Rebel cultivars in the same province in the same year. On the other hand, Karaca and Akgün (2005) measured it in LoliumxFestuca hybrids between 5-8.5 mm in the same conditions. While Erdoğan and Sürmen (2019) found it in tall fescue to be 4.08 mm in humid Aydın climatic conditions, Arslan and Acar (2019) reported that it was 3.3 mm (rough) in humid Samsun conditions. In the continental climate conditions, while Ekiz et al. (1995) measured it in tall fescue as 6.58 mm in Ankara, Kaya and Avcı (2019) measured it between 0.6-10 mm in Konya, and Yılmaz and Avcıoğlu (2000) measured it as 4.71 mm (very rough) in Tokat and Demiroğlu et al (2011) reported that 2.9-4.4 mm in İzmir conditions.

Edward (1993) reported the flag leaf width between 0.3-1.27 mm in order to determine the grass area characteristics in tall fescue, while Hannaway et al. (1999) reported that they found it between 3-12 mm in American conditions. Davis (1985), in the natural flora of Turkey, measured the flag leaf width between 5-10 mm in tall fescue. While Avcıoğlu (1997) measured the flag leaf width between 5.2-6.2 mm in Bornova conditions as very rough, Uyaroğlu (1999) found it as 4.77 mm in Bornova conditions as very rough. In continental climate, Yılmaz and Avcıoğlu (2000) reported the flag leaf width as 4.71 mm (very rough) in Tokat conditions, Kaya and Avcı (2019) reported it as 0.6-10 mm in Konya conditions, and Ekiz et al. (1995) stated it as 6.58 mm in Ankara conditions. Moreover, Alagöz and Türk (2017) calculated the flag leaf width of tall fescue as 3.28 mm in Isparta conditions. While Karaca and Akgün (2005) found the flag leaf width of 5-8.5 mm in LoliumxFestuca hybrids in Isparta conditions, Kılıç and Türk (2017) reported it as 3.1-3.4 mm in Starlet, Debussy and Rebel cultivars in same conditions. In Izmir climate conditions, Okkaoğlu (2006) reported the flag leaf width of tall fescue to be 6.75 mm, while Salman and Avcıoğlu (2008) calculated it to be 2–6 mm in Lolium perenne and *Festuca arundinacea*, and Varoğlu (2010) found it 3.6 mm in same climatic conditions. While Erdoğan and Sürmen (2019) calculated it to be 4.08 mm in Aydın conditions, Arslan and Acar (2019) found it to be 3.3 mm (rough texture) in Samsun conditions.

In this study, it was determined that flag leaf width varies between 3-14 mm or between 1-5 group values in tall fescue genotypes. Although there is a general similarity between the flag leaf width found in the study and the results of the researchers mentioned above, there are also differences with some of them. The reasons for the differences may be due to the different genotypes in terms of research location, climate and soil conditions, cultural practices, cutting height, fertilization, variety and species.

Table 10. Frequency distribution and descriptive statistics values of flag leaf width of tall fescue genotypes

Observation/Measurement Value (mm)		**Mean**	
	Group Value (1-5)	**Number**	**%**
4<	1 (very rough)	764	84.89
4	3 (rough)	86	9.44
3	5 (moderate)	50	5.67
Mimimum		3	
Maximum		14	
Average		8.06	
Standard Deviation		8.06±2.89	
Coefficient of Variation (CV) (%)		35.5	

3.10. Herbage yield (g/genotype)

When the average of the years 2015 and 2016 in terms of herbage yield is examined, the lowest herbage yield was 101 g, the highest herbage yield was 2330 g and the average herbage yield was 629.1 g. In terms of herbage yield it was determined that 267 of the genotypes were in the 1st (high) group, 337 in the 3rd (medium) group and 296 in the 5th (low) group. The standard deviation between genotypes was calculated as 629.1±370.7. Looking at the average of both years, it is seen that the standard deviation is high. This shows that the variation between genotypes in terms of herbage yield is very high. The coefficient of variation was calculated as 57.8% on average (Table 11). As can be seen from the variation limits, the variability between genotypes is very high. Since the studied populations are populations collected from nature, this result is expected. It is important for the turf type grass to stay green as long as possible, to be short, to have low herbage yield and to grow slowly, both in terms of aesthetics and the sustainability of the grass. In the study, herbage yield in tall fescue genotypes varied between 101-2330 g/genotype.

Many factors such as genotype, climate, season, soil moisture, cutting tool, cutting height, cutting frequency affect the herbage yield (Beart, 1973; Avcıoğlu, 1997).

Avcıoğlu et al. (1999) calculated the herbage yield per plant as 24.6 g in Kentucky bluegrass in İzmir conditions. Yılmaz and Avcıoğlu (2000), found the average herbage yield values as 1932.6-2486.5 kg/da, 2277.1 kg/da, 4107.6-4410.7 kg/da, 1684.1-2054.6 kg/da, 2148.4-2326.8 kg/da, 1859.5-2196.6 kg/da and 5053.5 kg/da of creeping bentgrass (*Agrostis stolonifera* L.), bent grass (*Agrostis capillaris*), perennial ryegrass (*Lolium perenne*), kentucky bluegrass (*Poa pratensis*), creeping red fescue (*Festuca rubra var. rubra*), chewings fescue (*Festuca rubra var. commutata*) and tall fescue (*Festuca arundinaceae* Schreb.) in Tokat conditions, respectively. Moreover, Okkaoğlu (2006) reported that herbage yields per plant were found as 953 g for smooth brome (*Bromus inermis*), as 925 g for intermediate wheatgrass (*Elymus hispidus*), as 617 g for reed canary grass (*Phalaris arundinacea*), as 585 g for tall fescue (*Festuca arundinacea* Schreb.), as 453.50 g for orchard grass (*Dactylis glomerata*), as 379.5 g for tall meadow oat (*Arrhenatherum elatius*), and as 197 g for perennial ryegrass (*Lolium perenne*) in İzmir conditions. Also, Kuşvuran (2009) reported that he measured herbage yield values between 153.2-651.4 g/m^2 in tall fescue and bent grass species in Çukurova conditions. Saygın and Ayan (2019), in their study conducted in Samsun – Çarşamba conditions (in pure stand tall fescue), determined the herbage yield between 281-460 g at 30 g/m^2 sowing rate, between 218-670 g at 40 g/m^2 sowing rate, between 248-525 g 50 g/m^2 sowing rate, and between 258-1071 g 60 g/m^2.

While the data obtained from the study and the results reported by some researchers overlap, there are differences with some of them. The herbage yield values obtained from some non-overlapping researchers are yield values per decare, m^2. There is a general similarity with the others, although the plant variety and species are different.

Table 3.11. Frequency distribution and descriptive statistical values of herbage yield of tall fescue genotypes

Observation/Measurement Value (g/genotip)		**Mean**	
	Group Value (1-5)	**Number**	**%**
[100-400]	5 (low)	296	32.89
[401-800]	3 (medium)	337	37.44
800<	1 (high)	267	29.67
Minimum		101	
Maximum		2330	
Average		629.1	
Standard Deviation		629.1±370.7	
Coefficient of Variation (CV) (%)		57.8	

3.11. Genotypes selected as turf type and their characteristics

Among 900 genotypes, 49 turf type genotypes were selected by weighted scaling method and 49 selected genotypes were subjected to cluster analysis. According to the results of the analysis, 5 groups were formed.

1. GROUP (FA 26-10, FA 29-07, FA 49-02, FA 23-17, FA33-12, FA26-02, FA28-08, FA21-07, FA11-12, FA24-03, FA25-03, FA27-01, FA28-20,

FA22-01, FA36-09, FA20-02, FA20-07, FA23-02, FA07-03, FA28-13, FA34-14, FA44-17)

2. GROUP (FA06-07, FA31-02, FA09-08, FA05-13)

3. GROUP (FA43-14, FA37-15, FA09-13, FA25-15, FA36-12, FA58-10)

4. GROUP (FA11-15)

5. GROUP (FA22-18, FA24-08, FA49-16, FA09-19, FA23-16, FA28-03, FA32-06, FA37-02, FA31-19, FA36-13, FA32-14, FA32-17, FA37-12, FA35-19, FA07-13, FA24-18) it has been found. Only FA11-15 genotype was included in the fourth group. According to the analysis, it was determined that FA 26-10 in the 1st group and FA 06-07 in the 2nd group had the farthest degree of relationship in terms of relationship level. FA 26-10 in group 1 and FA 43-14 in group 3, FA 26-10 in group 1 and FA 11-15 in group 4, FA 26-10 in group 1 and FA 22-18 in group 5, respectively are first four genotypes far from each other, as can be seen from the dendogram in Figure 1. It was determined that FA 32-06 in the 3rd group and FA 37-02 in the 5th group had the closest relationship degree in terms of relationship level. FA 32-14 in group 5, FA 32-17 in group 5, FA 20-07 in group 1, FA23-02 in group 1, FA 25-03 in group 1 and FA 27-01 in group 1, respectively are the first four genotypes close to each other, as can be seen from the dendogram in Figure 1. Looking at Figure 1, we can see that the genotypes were first divided into two main groups (1 and 2). Group 1 includes FA 06-07, FA 31-02, FA 09-08 and FA 05-13. These genotypes have the same lodging ratio, spring growth and internode length (except FA 05-13) while also having similar number of days to heading, herbage yield, main stem thickness and flag leaf length (except FA 05-13). These genotypes were collected from Samsun and Tokat locations. The large group 2 is the group with the most differentiation and is clearly divided into two groups as 2a and 2b. Group 2a is less than group 2b in terms of genotype number and includes FA 43-14, FA 37-15, FA 09-13, FA 25-15, FA 36-12, FA 58-10 genotypes. All of these genotypes were collected from Tokat location. These genotypes have the same lodging ratio and spring growth. Group 2b is the group with the most sub-branching and all genotypes were collected from the Tokat location (except FA 07-13 and FA 07-03). Of these genotypes, FA11-15 alone differed from other groups in terms of lodging ratio.

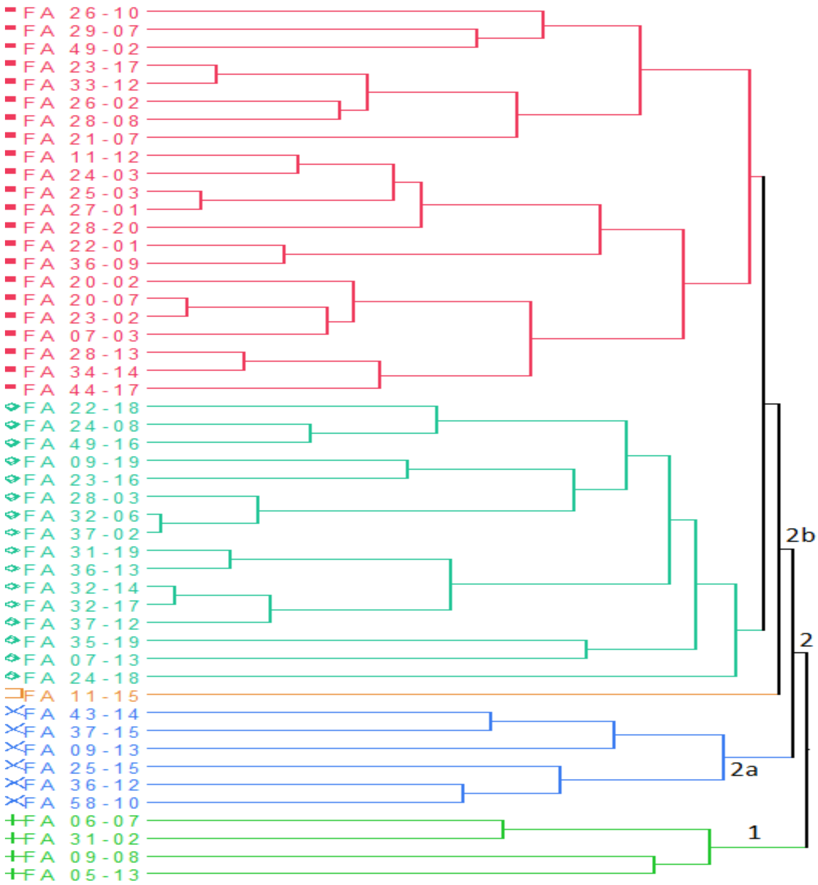

Figure 1. Grouped version of 49 selected grass genotypes

4. Conclusion

According to the analysis, it was determined that FA 26-10 in the 1st group and FA 06-07 in the 2nd group had the farthest relationship degree in terms of relationship level. FA 26-10 in group 1 and FA 43-14 in group 3, FA 26-10 in group 1 and FA 11-15 in group 4, FA 26-10 in group 1 and FA 22-18 in group 5, respectively are the first four genotypes far from each other. It was determined that FA 32-06 in the 3th group and FA 37-02 in the 5th group had the closest relationship degree in terms of relationship level. FA 32-14 in group 5, FA 32-17 in group 5, FA 20-07 in group 1, FA23-02 in group 1, FA 25-03 in group 1 and FA 27-01 in group 1, respectively are the first four genotypes close to each other, as can be seen from the dendogram in Figure 1.

Among 900 genotypes collected from Samsun, Sinop and Tokat provinces, 49 turf type genotypes with broad genetic pool were selected according to their morphological and agricultural characteristics. This genetic material, whose basic data are known, will make a significant contribution to the breeding studies that will be carried out later.

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Research of the Effect of Ni (Nickel) Treatment at Different Concentrations on Morphological Features of Some Grain Sorghum Varieties

Hava Şeyma İNCİ[1*] **Kağan KÖKTEN**[2]

[1]Department of Crop and Animal Production, Vocational School of Food, Agriculture and Livestock, University of Bingol, Bingol, Türkiye

[2]Sivas University of Science and Technology, Faculty of Agriculture and Technology, Department of Herbal Production and Technologies, Sivas, Türkiye

A R T I C L E I N F O

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A B S T R A C T

There is no doubt that agricultural production is one of the most affected parts of environmental pollution, which is increasing day by day. Among these pollution factors, heavy metals are the most common. Ni element is used in many fields, especially in industry, and it contaminates the soil and water where agricultural production is made. In this study, it was aimed to determine the changes in the morphological features of the plants by treatmenting different concentrations of Ni to some sorghum varieties (Akdarı, Beydarı and Öğretmenoğlu) registered in our country and obtained from the Batı Akdeniz Agricultural Research Institute (BATEM). The research was carried out in the greenhouses of Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, during the summer crop growing season in 2017. 0, 100, 200, 300, 400 and 500 mg kg^{-1} nickel (Ni) was treatmented to grain sorghum varieties. The features examined at the end of the 130-day growing period; grain weight, cluster length, plant height, plant stem diameter, stem ratio, leaf ratio and cluster ratio. Although the morphological features of the plants generally show a neutral or positive effect up to 200-300 mg kg^{-1} levels at different Ni concentrations applied, it has been observed that the morphological features of the plants were adversely affected at Ni levels above these doses. In this study, it is thought that depending on the concentration of the Ni element, in some cases it has a nutrient effect, and in some cases it causes heavy metal stress.

1. Introduction

Sorghum bicolor, which is included in the Poaceae family, is an annual and warm season plant. It is cultivated for different purposes such as grain, feed, sugar and bioenergy (Smith and Frederiksen 2000). While 50% of the universally grown sorghum plant is used in human nutrition, 90% of it is used in animal nutrition in the USA (Hamman et al. 2001). Sorghum has a yield potential comparable to rice, wheat and maize under favorable conditions (House 1985). In regions with a semi-tropical climate, sorghum double crops can be grown (Banks and Duncan 1983).

*Correspondence author: hsyilmaz@bingol.edu.tr

The term we call heavy metal is actually used for metals with a density higher than 5 g cm^3 in terms of physical properties. There are more than 60 metals including lead, cadmium, chromium, iron, cobalt, copper, nickel, mercury and zinc (Kahvecioğlu et al. 2007).

Nickel (Ni), one of the 23 polluting metals, seriously threatens the ecosystem and human health (Duda-Chodak and Baszczyk 2008). It is predicted that the global nickel production will be 1,614 Mt in 2008 (USDI 2009). Reck et al. (2008) reported that the element nickel is used in the stainless steel industry (68%). Ni-alloys are widely used in the production of magnetic-electrical devices, and they are also used in medicine and food technology. Ni compounds are used in paints, ceramics and glass production, and batteries in the form of Ni-Cd compounds. Nickel is considered an extremely serious pollutant from metal processing plants and originating from coal-oil burning. In addition, some sewers and phosphate fertilizers can be important contamination points of nickel in agricultural production soils (Kabata-Pendias 2011).

Previously, there was no evidence that nickel plays an important role in plant metabolism, but some researchers (Mishra and Kar 1974; Mengel and Kirkby 1978) stated that the element nickel may be necessary for plants and proved that nickel is necessary in a number of bacterial biosynthesis. The role of nickel in the nodulation of legumes and its effects on the mineralization and nitrification of some organic matter are described. Therefore, the element nickel is considered essential for urease metabolism for some legumes (Eskew et al. 1983).

The mechanism of Ni toxicity and the biological effects of nickel are related to the forms of the element nickel. Ni^{2+} in the cation form is more easily absorbed and more toxic than its complex forms. The Ni content of the plants is a parameter controlled by the soil in which the plants are grown, and the most prominent factor is the soil pH. The mechanism of plants against Ni toxicity is not fully understood, but it has been observed for a long time that the growth of plants is limited due to the excess of the element nickel (Kabata-Pendias 2011).

This study was carried out to investigate the effect of nickel element, which spreads easily to the environment and can easily contaminate soil and water, which is the most important point of agricultural production, on the morphological characteristics of sorghum, which has an important feed value and is tolerant to many stress factors.

2. Materials and Methods

2.1. Plant cultivation, nickel treatment and harvesting

This research was carried out in the greenhouses of Kahramanmaraş Sütçü İmam University Faculty of Agriculture between April 28 and September 10, 2017. The soil used for the experiment was obtained from Kahramanmaraş Sütçü İmam University Campus and the soil analysis results are as in Table 1.

Table 1. Some properties of the soil used in this study

Saturation (%)	pH	Salinity (%)	$CaCO_3$ (%)
58.3	7.33	0.1	0.71
Organic matter (%)		**K (mg kg^{-1})**	**P (mg kg^{-1})**
0.6		275.2	8.12

The grain sorghum varieties used in the study are Akdarı, Beydarı and Öğretmenoğlu and were obtained from the Batı Akdeniz Agricultural Research Institute. The element nickel is commercially supplied in the form of NiSO4 6H2O. The study was designed according to a split-plot experimental design (3 varieties x 6 doses x 1 element x 3 replications). The soil was sieved with a 4 mm sieve. Then it was waited in the greenhouse to reach its dry weight. Then they were weighed 10 kg and placed in pots. 5 seeds (per pot) were planted in pots. After germination, the weak seedlings were diluted and the only strong sorghum seedling was left. Fertilization; (20 kg N $da^{-1}$and 10 kg P2O5 da^{-1}) were calculated according to the amount of soil used, weighed and applied. Until the plants were 20-25 cm tall, only irrigation (tap water) was made according to the field capacity. Ni element was given to pots at concentrations of 0, 100, 200, 300, 400 and 500 mg kg^{-1}. After the application, all irrigations until the harvest time were made with tap water according to the field capacity and nickel washing/leakage was tried to be prevented.

At the end of the 130-day growth period, the plants were harvested manually. Morphological characteristics such as plant height, plant stem diameter, cluster length, thousand-grain weight, leaf ratio, stem ratio and cluster ratio were measured.

Statistical analysis of the data belonging to the parameters examined was carried out according to the split plot design (analysis of variance). The results were compared with the LSD test (SAS, 1999).

3. Results and Discussion

3.1. Plant height (cm)

Means of doses, varieties, dose x variety interactions and LSD test groups were given in Table 2 and the graph of change is given in Figure 1. According to the results of the variance analysis of the Ni doses of plant heights, variety, dose and the interaksiyon of variety x dose was found to be very significant ($p<0.01$). When the effect on plant heights of grain sorghum varieties under Ni stress was examined, it was seen that the plant heights varied between 73.35-92.99 cm in the average of the varieties, the highest plant height was found in Akdarı and Beydarı varieties and the lowest plant height was on Öğretmenoğlu variety. In the averages of the doses, it was observed that increasing Ni doses caused an increase in plant height up to 400 mg kg^{-1} treatment, and it started to decrease plant height in 400 mg kg^{-1} and above treatments. The smallest plant height (73.12 cm) was obtained from 500 mg kg^{-1} Ni treatment, while the highest plant height (95.02 cm) was obtained from the control group plants. In the variety x dose interaction, it was observed that the highest plant height was obtained from 0 mg kg^{-1} Ni (control) dose of Beydarı variety in Ni treatment, while the smallest plant height was obtained from 500 mg kg^{-1} treatment, which is the highest Ni dose of Öğretmenoğlu variety.

The treatment of plants with different concentrations of nickel caused an increase in plant height at some doses and a decrease at some doses in all varieties. While this situation was generally positive up to 300 mg kg^{-1} Ni treatment, it had a negative effect at higher doses. Al Chami et al. (2015) cultivated sorghum plant under Ni stress at 6 different doses in hydroponic culture and stated that the plant failed to grow after the 3rd level dose. Ahmad et al. (2007) reported that the growth of mung bean regressed after a certain dose (40 mg L^{-1}) of increasing Ni level in the nutrient solution in their study with mung beans. In cases where the plant perceives the Ni element as stress, the fact that the plant height does not increase is similar to the studies carried out.

Table 2. Averages of the Effect of Different Ni Doses on Plant Height (cm) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	94.86±4.02 C**	106.11±2.52 A	84.07±3.74 EF	**95.02 a****
100	93.50±3.91 CD	86.33±4.04 DE	76.33±8.33 FG	**85.39 bc**
200	95.00±5.96 C	97.00±2.65 BC	76.67±5.51 FG	**89.56 ab**
300	95.67±0.58 C	104.33±4.04 AB	78±8.72 FG	**92.67 a**
400	92.20±3.70 CD	81.5±2.50 EF	65.00±70 HI	**79.57 c**
500	86.70±3.20 DE	72.67±2.52 GH	60.00±50 I	**73.12 d**
Mean	**92.99 a****	**91.33 a**	**73.35 b**	

**: 1%, level of significance; capital letters show significant differences between the interactions of varieties and doses; small letters show significant differences between the averages of varieties and doses.

3.2. Plant stem diameter (mm)

Means of doses, varieties, dose-variety interactions and LSD test groups were given in Table 3 and the graph of change was given in Figure 1. According to the variance analysis results of the plant stem diameters of the Ni doses, the variety and dose were very important ($p<0.01$), while the variety x dose interaction was found to be insignificant.

It was observed that the plant stem diameters of the grain sorghum varieties varied between 9.46 mm and 11.30 mm on average against Ni treatment, and the thickest stem diameter was observed in Beydarı variety and the thinnest stem diameter in Akdarı variety.

Although the increase in Ni doses caused an increase in stem diameter at doses other than control treatments (up to 400 mg kg^{-1} treatment), 400 mg kg^{-1} and subsequent treatments decreased the plant stem diameter. On the average of the doses, the thinnest stem diameter (9.14 mm) was obtained from 500 mg kg^{-1} Ni treatment, while the thickest stem diameter (11.58 mm) was obtained from the control group plants. The cultivar x dose interaction, on the other hand, plant stem diameter varied between 8.44-13.00 mm.

Like other plant growth factors, plant stem diameter also varied depending on whether plants perceive Ni as stress or perceive it as a nutrient element. While it showed improvement in plant morphological properties at certain doses, it was observed that it was adversely affected at certain doses. Tsui (1955) in his study to investigate the effects of nickel (Ni) on wheat seeds reported that when 100 mg kg^{-1} Ni treatment is applied, the root and stem of the plant show the best growth compared to other concentrations, but when 250 mg kg^{-1} and above Ni treatment the growth is inhibited. Similar situations are present in our study as in this study.

Table 3. Averages of the Effect of Different Ni Doses on Plant Stem Diameters (mm) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	9.84±0.58	11.91±0.8	13.00±4.33	**11.58 a****
100	9.10±0.96	11.67±0.49	10.57±0.73	**10.45 ab**
200	9.91±0.03	11.88±0.92	10.61±1.32	**10.80 a**
300	10.09±1.01	12.6±0.26	10.85±0.56	**11.18 a**
400	8.96±0.62	11.3±0.67	10.29±0.79	**10.19 ab**
500	8.85±0.18	8.44±1.06	10.14±1.22	**9.14 b**
Mean	**9.46 b****	**11.30 a**	**10.91 ab**	

**: 1%, level of significance; small letters show significant differences between the averages of varieties and doses.

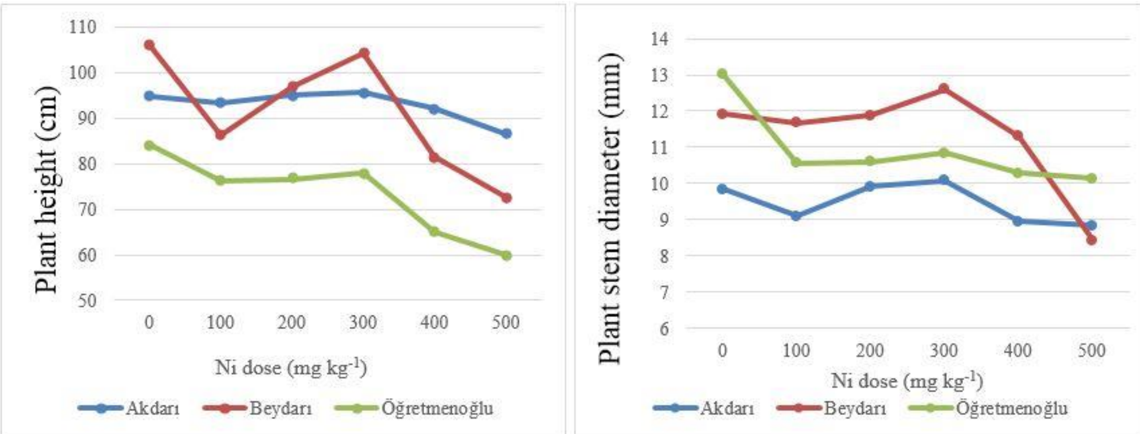

Figure 1. Change Graph of the Effect of Different Ni Doses on Plant Height and Plant Stem Diameter in Grain Sorghum Varieties

The graph on the left shows the change in plant height at different concentrations of Ni doses. The graph on the right shows the change in plant stem diameter with different concentrations of Ni doses.

3.3. Cluster length (cm)

Means of doses, varieties, dose-variety interactions and LSD test groups were given in Table 4 and the graph of change was given in Figure 2. According to the results of cluster length variance analysis of Ni doses, the interaction of variety, dose and variety x dose was found to be very significant ($p<0.01$). The cluster length of the varieties varied between 15.25 cm and 17.36 cm, and the longest cluster length was found in the Beydarı variety, while the shortest cluster length was found in the Akdarı and Öğretmenoğlu varieties. Increasing Ni doses caused an increase in cluster length up to 400 mg kg^{-1} Ni treatment at doses other than control plants, but decreased cluster length in 400 mg kg^{-1} and subsequent treatments. On average, the lowest cluster length (13.82 cm) was obtained from 500 mg kg^{-1} Ni treatment, while the longest cluster (18.25 cm) was obtained from the control group plants. In the variety x dose interaction, while the longest cluster was obtained from 0 mg kg^{-1} Ni/control plants of Beydarı variety, the shortest cluster was obtained from 500 mg kg^{-1} Ni treatment of Öğretmenoğlu variety.

The effects of nickel on the cluster lengths of the grain sorghum varieties used varied depending on the doses. In nickel treatment, while some doses had a positive effect on the cluster length, at some doses the cluster length was negatively affected. Wyszkowska et al. (2007), in their study, treated two different soils of loamy sandy and slightly silty loam with Ni at a concentration of 200 mg kg^{-1} and examined the yield of the oat plant. They reported that the yield decreased by 65% and 40%, respectively. In this study, similar to the situation in which the yield of the oat plant was affected, the development status of the generative organs/cluster length in sorghum was also negatively affected after certain doses.

Table 4. Averages of the Effect of Different Ni Doses on cluster length (cm) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	15.57±1.09 E-G**	21.16±0.49 A	18.03±0.73 BC	**18.25 a****
100	14.8±0.80 F-I	16.63±1.18 C-E	15.23±0.4 E-H	**15.56 b**
200	15.83±1.61 E-G	16.8±1.32 C-E	15.27±1.25	**15.97 b**
300	17.8±1.06 B-D	18.65±0.95 B	15.87±1.03 E-G	**17.44 a**
400	13.83±0.47 HI	16.27±0.59 D-F	15.2±1.31 E-H	**15.10 b**
500	13.67±0.35 HI	14.63±0.35 G-I	13.15±0.85 I	**13.82 c**
Mean	**15.25 b****	**17.36 a**	**15.45 b**	

**: 1%, level of significance; capital letters show significant differences between the interactions of varieties and doses; small letters show significant differences between the averages of varieties and doses.

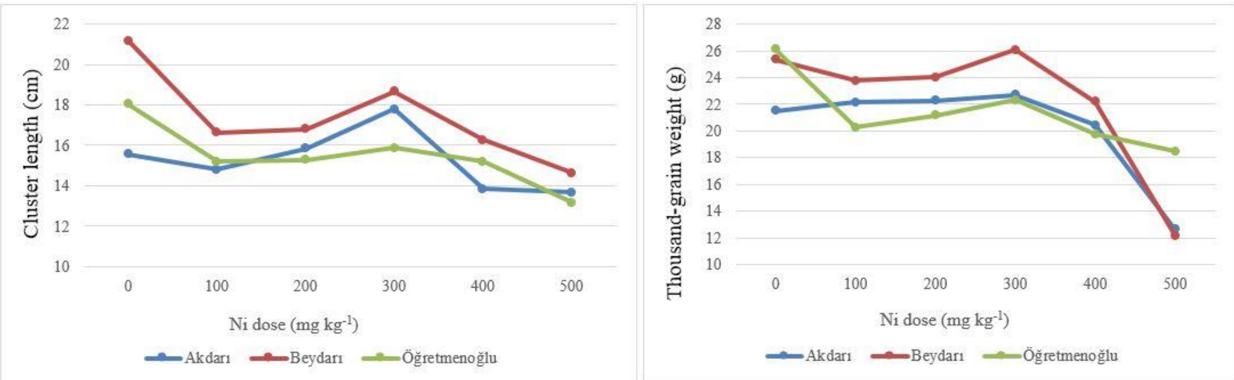

Figure 2. Change Graph of the Effect of Different Ni Doses on Cluster Length (cm) and Thousand-Grain Weight (g) in Grain Sorghum Varieties

The graph on the left shows the change in Cluster Length (cm) of Ni doses at different concentrations. The graph on the right shows the change in the thousand-grain weight of Ni doses at different concentrations.

3.4. Thousand-grain weight (g)

Means of doses, varieties, dose x variety interactions and LSD test groups were given in Table 5 and the graph of change was given in Figure 2. According to the thousand grain weight variance analysis results of Ni doses, the interaction of variety, dose and variety x dose was found to be very significant (p<0.01).

The thousand-grain weights of the varieties varied between 20.28 g and 22.26 g. While the highest thousand grain weight was in Beydarı and Öğretmenoğlu varieties, the lowest thousand grain weight was in Akdarı variety. The increase in Ni doses caused an increase up to 400 mg kg^{-1} treatment in the doses other than the control plants, but decreased the thousand grain weight in 400 mg kg^{-1} and subsequent treatments. On average, the lowest thousand grain weight (14.42 g) was obtained from 500 mg kg^{-1} Ni treatment, while the highest thousand grain weight (24.32 g) was obtained from the control group plants. In the variety x dose interaction, the highest thousand grain weight was obtained from 0 mg kg^{-1} Ni/control treatment of Öğretmenoğlu variety, while the lowest thousand grain weight was obtained from 500 mg kg^{-1} Ni treatment of Akdarı and Beydarı variety.

Although there were some changes in the form of increase and decrease in the thousand-grain weight of all sorghum varieties used in the study, decreases were observed in all three varieties at doses above 400 mg kg^{-1}. Zengin and Munzuroğlu (2005) stated that chlorophyll production affects negatively in cases where nickel is at the toxicity level, and thus the roots cannot get the macro and micro elements they need as much as they need, and as a result, the plant suffers from a lack of nutrients. The grains of the plant, which suffers from nutrient deficiency, may have remained weak and this may have adversely affected the weight of a thousand grains.

Table 5. Averages of the Effect of Different Ni Doses on thousand-grain weights (g) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	21.49±1.8 D-F**	25.36±0.95 AB	26.11±0.11 A	**24.32 a****
100	22.15±1.35 C-E	23.78±2.28 BC	20.27±1.68 E-G	**22.07 bc**
200	22.25±2.22 C-E	24.03±1.34 A-C	21.14±0.9 D-F	**22.47 bc**
300	22.71±0.69 CD	26.06±1.20 AB	22.3±0.75 C-E	**23.69 ab**
400	20.44±0.71 D-G	22.2±1.40 C-E	19.76±0.49 FG	**20.80 c**
500	12.63±0.97 H	12.13±1.91 H	18.48±2.18 G	**14.42 d**
Mean	**20.28 b****	**22.26 a**	**21.34 a**	

**: 1%, level of significance; capital letters show significant differences between the interactions of varieties and doses; small letters show significant differences between the averages of varieties and doses.

3.5. Stem ratio (%)

Means of doses, varieties, dose-variety interactions and LSD test groups were given in Table 6 and the graph of change was given in Figure 3. According to the variance analysis results of the stem ratios of Ni doses, the variety, dose and the interaction of variety x dose was found to be very significant (p<0.01). The stem ratios of the varieties varied between 50.36% and 53.26%. While the highest stem rate was in Beydarı variety, the lowest stem rate was determined in Akdarı and Öğretmenoğlu varieties. As a result of the increase in Ni doses, 100, 400 and 500 mg kg^{-1} Ni treatments were included in the same mean group, while the control group plants and 200, 300 mg kg^{-1} Ni treatments formed a different mean group. The highest stem rate (54.66%) was obtained from 500 mg kg^{-1} Ni treatment, while the lowest stem rate (47.94%) was obtained from 0 mg kg^{-1}. In the varietiy x dose interaction, the highest stem rate (56.33%) was obtained from the 500 mg kg^{-1} Ni treatment of Beydarı, while the lowest stem rate (42.36%) was obtained from the Öğretmenoğlu variety at 0 mg kg^{-1} Ni/control

In this study, the stem ratio; It was determined by the ratio that the leaves and clusters of the plant were also taken into account. In this case, when the varieties were examined, it was observed that the leaf ratio did not change much, and the change was in parallel with the increase or decrease in the cluster ratio and the increase and decrease in the stem ratio. In other morphological parameters, nickel element caused us to observe an increase in some doses, while it caused us to observe a decrease in some doses. In cases where the plants were adversely affected by nickel, the generative parts were adversely affected, which caused a decrease in the cluster ratio and an increase in the stem ratio. Phytotoxic Ni concentrations vary widely with plant species and varieties and have been reported to range from 40 to 246 mg kg^{-1} for various plants (Gough et al. 1979). The mechanism of Ni toxicity to plants is not fully understood, but limited growth of plants due to excess of this metal has been observed for quite some time (Kabata-Pendias 2011). The situations that the researchers stated may have caused this situation in a similar way.

Table 6. Averages of the Effect of Different Ni Doses on Stem Ratio (%) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	49.29±0.45 FG**	52.19±0.83 A-F	42.36±0.92 H	**47.94 c****
100	52.12±1.49 B-F	53.61±3.49 A-E	55.59±4.12 A-C	**53.77 a**
200	50.51±3.84 D-G	51.71±1.10 C-F	54.17±1.86 A-D	**52.12 ab**
300	47.44±0.51 G	49.68±3.18 E-G	53.34±0.97 A-F	**50.15 bc**
400	50.81±0.92 D-G	56.07±3.98 AB	54.14±0.92 A-D	**53.67 a**
500	52.00±4.07 B-F	56.33±2.11 A	55.67±2.58 A-C	**54.66 a**
Mean	**50.36 b****	**53.26 a**	**50.54 b**	

**: 1%, level of significance; capital letters show significant differences between the interactions of varieties and doses; small letters show significant differences between the averages of varieties and doses.

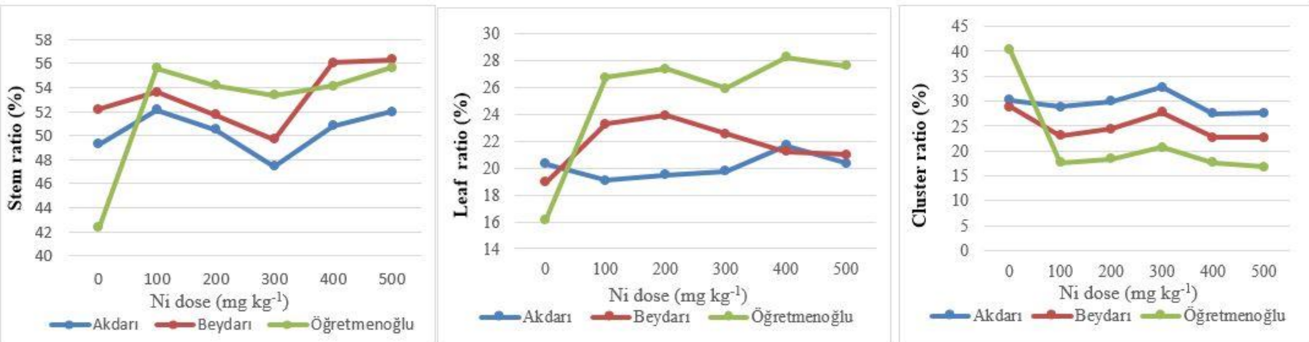

Figure 3. Change Graph of the Effect of Different Ni Doses on in Grain Sorghum Varieties

The graph on the left shows the change in the stem ratio of Ni doses at different concentrations. The graph in the middle section shows the change in leaf ratio of Ni doses at different concentrations. The graph on the far right shows the change in the cluster ratio of Ni doses at different concentrations.

3.6. Leaf ratio (%)

Means of doses, varieties, dose-variety interactions and LSD test groups were given in Table 7 and the graph of change was given in Figure 3. According to the variance analysis results of Ni doses and leaf ratios, the interaction of variety, dose and dose x variety was very significant ($p<0.01$). The average leaf ratios of the varieties varied between 20.12% and 25.35%. While the highest leaf rate was observed in Öğretmenoğlu variety, the lowest leaf rate was observed in Akdarı and Beydarı varieties. As a result of the increase in Ni doses, leaf ratios increased in all doses except 0 mg kg^{-1} Ni /control treatment and included in the same mean group. In the variety x dose interaction, the highest leaf rate (28.25%) was obtained from the 400 mg kg^{-1} dose of Öğretmenoğlu variety. In this group, 200 and 500 mg kg^{-1} treatments of Öğretmenoğlu variety were also included, and the lowest leaf rate (16.14%) was obtained from 0 mg kg^{-1} Ni/control treatment of Öğretmenoğlu variety.

With the increase in doses, all doses were in the same mean group, except for the control plants; that is, the plants did not show a significant change in leaf ratio with the increase of Ni level. The changes in the ratios were generally determined by the cluster and stem parts. Tiffin (1972) reported that Ni is bound to anionic and organic complexes in the xylem and that Ni is mobile in plants, although Ni transport and storage seem to be metabolically controlled. The fact that the leaf ratio did not experience great changes in our study is perhaps due to this mobility of the Ni element in the plant. Also, there was previously no evidence that nickel plays an important role in plant metabolism, but some researchers (Mishra and Kar 1974; Mengel and Kirkby 1982) have suggested that nickel may be important to plants. In plants under Ni stress, the absorption of nutrients, root development and metabolism are adversely affected. It is known that high concentrations of this metal in plant tissues inhibit photosynthesis and transpiration, usually before symptoms of Ni toxicity become evident (Bazzaz et al. 1974). These studies show that nickel can cause both positive and negative physiological changes in plant metabolism.

Table 7. Averages of the Effect of Different Ni Doses on Leaf Ratio (%) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	20.33±0.15 E-G**	18.93±0.33 GH	16.14±0.07 H**	**18.47 b****
100	19.09±2.19 GH	23.3±4.40 C-E	26.76±2.55 AB	**23.05 a**
200	19.48±2.29 F-H	23.9±0.97 B-D	27.39±2.61 A	**23.59 a**
300	19.78±0.84 FG	22.55±3.37 C-F	25.94±0.34 A-C	**22.76 a**
400	21.69±1.65 D-G	21.22±2.84 D-G	28.25±1.13 A	**23.72 a**
500	20.34±0.51 E-G	21.01±1.91 D-G	27.6±1.74 A	**22.98 a**
Mean	**20.12 b****	**21.82 b**	**25.35 a**	

**: 1%, level of significance; capital letters show significant differences between the interactions of varieties and doses; small letters show significant differences between the averages of varieties and doses.

3.7. Cluster ratio (%)

Means of doses, varieties, dose-variety interactions and LSD test groups were given in Table 8 and the graph of change was given in Figure 3. According to the variance analysis results of the effect of Ni doses on the cluster ratio of the varieties, the interaction of dose, variety and dose x variety was very significant ($p<0.01$). The cluster ratios of the varieties varied between 21.92% and 29.48% and the highest cluster ratio was obtained from the Akdarı variety, and the lowest cluster ratio was obtained from the Öğretmenoğle variety. All varieties were included in the different mean group.

When the effect of Ni doses on the cluster ratios of the plants was examined, the control group had the highest cluster ratio (33.12%) and formed the first mean group. 300 mg kg^{-1} Ni treatment created the second highest cluster ratio and formed the second mean group. 500 mg kg^{-1} Ni treatment formed the lowest cluster rate (22.35%) and took place in the same mean group as 100, 200 and 400 mg kg-1 treatments. When we look at the variety x dose interaction, the highest cluster rate (40.31%) was obtained in 0 mg kg^{-1} Ni/control treatment of Öğretmenoğlu variety, and the lowest cluster rate (16.74%) was obtained in 500 mg kg^{-1} Ni treatment of the same variety.

Among the sorghum varieties used, the cluster ratios of Beydarı and Öğretmenoğlu varieties were determined the highest in the control plant, that is, even the lowest Ni treatment caused a decrease in the cluster rate in these two varieties. The highest cluster rate was observed in the Akdarı variety at a dose of 300 mg kg^{-1}. When certain concentrations of Ni are applied to *Capsicum frutescens* L. (paprika) and *Lycopersicon esculentum* L. (tomato) plants, plant growth and development progress positively at levels up to 1 µg L^{-1}, but higher doses applied after 1 µg L^{-1} stress and doses higher than 1 µg L^{-1} have been reported to be toxic (Pais et al. 1969). It is also believed that an excess of Ni causes a true Fe deficiency by preventing the transport of Fe from the roots to the tops (Wyszkowska et al. 2007). Rombolà and Tagliavini (2006) stated that iron element significantly affects fruit/grain yield and quality. It is thought that the possibility of a deficiency of Fe element at doses where the nickel element is perceived as stress and this negativity may cause a decrease in the seed/cluster ratio.

Table 8. Averages of the Effect of Different Ni Doses on Cluster Ratio (%) of Grain Sorghum Varieties

	Varieties			
Ni dose (mg kg^{-1})	**Akdarı**	**Beydarı**	**Öğretmenoğlu**	**Mean**
0	30.15±0.25 BC**	28.89±0.34 C	40.31±0.53 A	**33.12 a****
100	28.79±2.11 C	23.09±1.95 DE	17.65±2.04 FG	**23.18 c**
200	30.01±1.56 BC	24.4±2 D	18.44±2.44 FG	**24.28 c**
300	32.78±1.01 B	27.77±1.16 C	20.72±1.3 EF	**27.09 b**
400	27.5±2.47 C	22.71±1.16 DE	17.61±0.63 FG	**22.61 c**
500	27.66±3.57 C	22.66±3.06 DE	16.74±0.85 G	**22.35 c**
Mean	**29.48 a****	**24.92 b**	**21.92 c**	

**: 1%, level of significance; capital letters show significant differences between the interactions of varieties and doses; small letters show significant differences between the averages of varieties and doses.

4. Conclusion

The effects of different Ni doses on some sorghum cultivars (Akdarı, Beydarı and Öğretmenoğlu) were investigated in terms of morphological characteristics. It was determined in 1987 as a result of researches that nickel is a plant nutrient that is needed for plants and also necessary for growth and development (Brown et al. 1987; Brown et al. 1990; Fageria 2009; Bolat and Kara 2017). However, whether the plants use such metals instead of plant nutrients or not, the intense accumulation of heavy metals in plant tissues adversely affects the vegetative and generative development of plants (Gür et al. 2004). In addition, this accumulation has a negative effect on product and yield values (Long et al. 2002). In this study, morphological properties of plants under Ni treatment were generally positively affected up to 200-300 mg kg^{-1} levels, but were negatively affected at higher doses. Considering the soil pH and the availability of other macro and micro elements in the soil, it has been observed that plants take Ni element as a plant nutrient element up to some concentrations and the element has a toxic effect after certain concentrations. It has been predicted that the morphological characteristics of the plants are therefore negatively affected. According to the soil analyzes to be made in the Ni-contaminated areas and the plant type, the doses that will be accepted by the plants as a heavy metal or plant nutrient element should be determined and a decision should be made to make cultivation in this direction.

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Short-Term and Topographic Variations in Ecological Site Description of a Semi-Arid Mountain Rangeland

Onur İLERİ[1*]

[1]Eskisehir Osmangazi University, Department of Field Crops, Eskişehir, Türkiye

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A B S T R A C T

Deficiencies in the rangeland assessment methods prompted researchers to seek new methodologies. Rangeland Ecological Site Description (RESD), is a method suggested to produce information about the sustainability of the ecological services of the rangelands. Improvability for various ecologies is an advantage of the method. In this study, the short-term variation and the effect of the topographical differences on the RESD method were determined. Suggested ecological indicators were scored at the 60 different locations (20 north, 20 south, 20 summits) of the Bozdağ Rangeland for two years (2019-2020), and the ecological indicator scores were compared using non-parametric tests. Results showed that the RESD did not change in two years but it was lower at the south face considering the north face and summit. The RESD class of the south faces was "fair", while they were "good" for north faces and summit positions. Variations in slope gradient, light exposure, and grazing practices might be responsible for this difference. RESD method provides wider information about the ecological services of the rangelands. However, this method should be improved to give information that could be used in short-term rangeland management plans, including grazing capacity.

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1. Introduction

Rangeland management practices have a significant impact on sustainable ecosystem services of these wide natural areas by protecting them from deterioration, desertification, and depletion. Management practices could change related to the number of livestock, forage resources, vegetation characteristics, climate, socio-economic status of the ranchers, etc. (DiTomaso et al., 2010; Altın et al., 2011; Garnick et al., 2018; Kamrani et al., 2019) but the condition of the rangelands is the most important factor to decide proper management practice. Several methods have been used to assess rangelands as Rangeland Condition, Rangeland Health, Rangeland Quality Degree, etc., but all of the methods are focused on vegetation characteristics, mostly the climax theory of Clements (1916) and could not be used in different ecologies (Pyke et al., 2002; Briske et al., 2005; Koç et al., 2013).

Researchers suggested the importance of other characteristics such as soil, hydrology, and wildlife for the assessment of rangeland conditions and their sustainability (USDI/USDA, 1994; Adams et al., 1995; Pyke et al., 2002). Firstly, Adams et al (1995) described a new method by using soil, hydrology, and vegetation characteristics. Subsequently, this method was developed for Rangeland Ecological Site Description that uses ecological indicators to assess

*Correspondence author: oileri@ogu.edu.tr

the rangeland and has been used by many researchers (Pyke et al., 2002; Bestelmeyer and Brown, 2010; Williams et al., 2016; Aoyama et al., 2020). The RESD method investigates the ecological characteristics of the soil, hydrology, and vegetation of the rangelands that could be used to determine the proper rangeland management method. Koç et al (2013) stated that the ecological indicators could change in different ecosystems and therefore, they adjusted the method by considering the ecological differences in Türkiye and determined 17 different ecological characteristics for rangeland assessment. Erkovan et al., (2016) and Güllap et al. (2020) used this method in East Anatolia rangelands and suggested it for the other natural rangelands in Türkiye.

Rangelands mostly have a rugged topography in Türkiye and therefore, topography-related great variations could be observed in soil, hydrology, and vegetation characteristics (Oztas et al., 2003; Ünal et al., 2014; Sürmen and Kara, 2018). It is known that these environmental factors are closely related to each other (Gökkuş, 2020) and rangeland management plans should be prepared by considering these differences. In this study, the differences in Ecological Site characteristics were investigated among the different topographical positions of Bozdağ Rangeland for two years. It was aimed to determine if ecological site characteristics change related to topography in short term.

2. Materials and Methods

The study was conducted during the 2019-2020 years on the Bozdağ Rangeland of the Sündiken Mountain Range, which is located in Eskişehir Province of Türkiye (Figure 1). Bozdağ Rangeland is located at an altitude between 1200-1400 meters and has quite rough topography. Semi-arid climate condition prevails in the region. Long-term annual total precipitation was 336.7 mm and it was 351.7 and 299.2 mm in the 2019 and 2020 years, respectively. Long-term annual average temperature was 10.8 °C, and it was 12.3 °C and 13.0 °C in the experimental years, respectively. Perennial grasses and legume shrubs are common in the vegetation and are mostly grazed by small ruminants.

Figure 1. Location of the Bozdağ Rangeland and sampling points

The Ecological Site Descriptions are recorded at the beginning of autumn in both years by using the suggested method and the ecological indicators (Koç et al 2013), which were given in Table 1. In this method, every indicator indicates soil (S), hydrology (H), and vegetation (V) characteristic (one, two and/or all of them, see Table 1) and they are evaluated by 1-5 scoring (1: very poor, 5: very good). In the study, scores are firstly separated considering their soil, hydrology, and vegetation indication and then, averaged for north, south, and summit in 2019 and 2020 years respectively. Totally 60 locations (20 north, 20 south, and 20 summits) were selected for evaluation and the ecological indicators were scored in every location.

The score-based data used in this study was not homogenous and did not distribute normally. Therefore, the data were analyzed using Kruskal Wallis and Man Whitney U tests, which are non-parametric and suggested for unevenly distributed data (Zar, 2013). These tests assign ranks to the categorical data and then compare the means over the assigned ranks. Man Whitney U test was used to compare the years because the year had only two levels as a factor and the Kruskal Wallis test was used to compare the topographical positions because the positions were independent (Zar, 2013).

Table 1. Indicators used to determine Ecological Site Description

No	Ecological Indicators
1	Numbers and width of dry rills (S, H)
2	Runoff path (S, H)
3	Foot track presence (V, S, H)
4	Bare ground (S, H)
5	The presence of soil carved and transported by wind or water on rangelands (S, H)
6	Death plant material transport (H)
7	Erosion resistance of the soil surface (V, S, H)
8	Soil loss and degradation (V, S, H,)
9	Relation of composition and species distribution with surface runoff and infiltration (H)
10	Soil compaction (V, S, H,)
11	Functional plant groups (V)
12	Plant death (V)
13	Dead material (V, H)
14	Production (V)
15	Invasive plants (V)
16	Reproductive ability of perennial plants (V)
17	Stubble height (V)

S: Soil, H: Hydrology, V: Vegetation

3. Results and Discussion

Results showed that the scores of the ecological indicators did not vary between the years (Table 2). It is known that soil characteristics could change temporally but this change occurs very slowly (Huggett, 1998). Vegetation and hydrologic conditions of the environment are also effective in the acceleration of the change. In arid and semi-arid regions, soil characteristics generally do not change in a short period, or annually as long as any intense human interference does not occur. Hydrologic characteristics are mostly dependent on the variations of precipitation. There was nearly a 50 mm difference in precipitation between the 2019 and 2020 years, which could not be assumed as great, and this variation did not affect the score of the hydrologic indicators in Bozdağ (Table 2). Variations belonging to the indicators of vegetative characteristics could be high between different ecologies, but local variations of vegetation are mostly caused by grazing differences, and climate events such as drought, flood, etc. In Bozdağ Rangeland, there was not any significant difference in climate or grazing management practices between 2019 and 2020 years. Therefore, scores of the vegetation indicators might be similar between these years

Table 2. Descriptive statistics belong to the yearly variation of ecological indicator scores at different topographical positions and the results of Mann Whitney U test

Aspect	Variable	Year	N	Mean± SE	StDev	Q1	Median	Q3	Rank mean	Indicator scores[is]	P Value
North	Soil	2019	20	3.850±0.167	0.745	3.00	4.000	4.00	18.90	4	0.398[ns]
		2020	20	4.050±0.135	0.605	4.00	4.000	4.00	22.10	4	
	Hydrology	2019	20	3.850±0.150	0.671	3.00	4.000	4.00	20.08	4	0.820[ns]
		2020	20	3.850±0.131	0.587	4.00	4.000	4.00	20.93	4	
	Vegetation	2019	20	3.750±0.099	0.444	3.25	4.000	4.00	19.50	4	0.602[ns]
		2020	20	3.850±0.082	0.366	4.00	4.000	4.00	21.50	4	
South	Soil	2019	20	3.050±0.135	0.605	3.00	3.000	3.00	17.55	3	0.114[ns]
		2020	20	3.400±0.152	0.681	3.00	3.500	4.00	23.45	3	
	Hydrology	2019	20	3.100±0.124	0.553	3.00	3.000	3.00	17.40	3	0.096[ns]
		2020	20	3.450±0.135	0.605	3.00	3.500	4.00	23.60	3	
	Vegetation	2019	20	2.950±0.170	0.759	2.00	3.000	3.75	18.00	3	0.183[ns]
		2020	20	3.300±0.179	0.801	3.00	3.500	4.00	23.00	3	
Summit	Soil	2019	20	3.950±0.153	0.686	4.00	4.000	4.00	21.60	4	0.565[ns]
		2020	20	3.850±0.167	0.745	3.00	4.000	4.00	19.40	4	
	Hydrology	2019	20	3.900±0.143	0.641	4.00	4.000	4.00	21.70	4	0.529[ns]
		2020	20	3.800±0.138	0.616	3.00	4.000	4.00	19.30	4	
	Vegetation	2019	20	3.650±0.131	0.587	3.00	4.000	4.00	21.45	3	0.620[ns]
		2020	20	3.550±0.135	0.605	3.00	4.000	4.00	19.55	3	

ns; non-significant, is; 5: Very good, 4: Good, 3: Fair, 2: Poor, 1: Very poor

Variations in topography caused significant differences ($p<0.01$) in the scores of soil, hydrology, and vegetation indicators (Table 3). Soil score was lower (fair) at the south positions of the Bozdağ Rangeland, while it was higher in the north and summit but it was similar between them (good). Soil indicator mostly consists of erosion-based parameters to evaluate (Table 1). Therefore, it should be stated that erosion risk was higher in the southern aspect. Increasing gradients of the slope could be responsible for a higher erosion rate (Fox and Bryan, 2000). In semi-arid conditions, drought cause more damage on vegetation, especially at south aspect due to higher evaporation rate (Koç, 1995). Besides, higher freezing-thawing event increases the erosion-sensibility by decreasing the soil aggregate stability (Fuss et al., 2016. Therefore, lower soil characteristics are common at south faces in arid and semi-arid regions. On the other hand, light exposure is higher at the south faces (Moeslund et al., 2013), and therefore, vegetation growth begins earlier at the south considering the north and summit. Ranchers commonly drive herds to these south face in early spring and cause an overgrazing effect (Oztas et al., 2003). Overgrazing challenges the vegetation in the south, which in turn decreases the coverage at the south faces of Bozdağ Rangeland. The erosion rate significantly increases as the soil coverage decreases in rangelands (Altın et al., 2021) and this might be the reason for the lower soil score in the south.

The score of the hydrology indicators was the lowest at the south faces, which was fair, and it was ‘‘good’’ at the north and summit (Table 3). Hydrology indicators are closely related to soil indicators naturally (Koç et al., 2013) because water erosion is the most common erosion type in Türkiye (Koç et al., 1994; Altın et al., 2021) and consequently, variation of the scores among the topographical positions was similar in terms of hydrology and soil indicators in Bozdağ Rangeland. Moreover, moisture-related characteristics might have lower quality at south faces because higher light exposure increases the evaporation at south faces (Moeslund et al., 2013). These reasons might be responsible for the lower score of hydrology indicators at the south faces of Bozdağ Rangeland.

The vegetation indicator score class was “fair” at the south faces while it was “good” at the north and summit (Table 3). Vegetative characteristics are shaped by many factors including soil, climate, grazing practices, and topography in rangelands (Altın et al., 2011; Holechek et al., 2011). Topography has a significant impact on soil and hydrologic cycle (Biswas, 2019), and consequently on vegetation (Koç, 1995; Oztas et al., 2003; Stephenson et al., 2013). This might be explaining the similar results among vegetation, soil, and hydrology indicators in Bozdağ Rangeland. Additionally, early grazing practices at south faces could also be responsible for lower vegetation scores, because heavy grazing in early spring could damage the plants, especially desirable species (Gökkuş, 2020), and therefore, the condition of the vegetation indicators may deteriorate.

Table 3. Descriptive statistics and the result of the Kruskal Wallis test belong to indicator scores among different topographical positions of Bozdag Rangeland

Variable	Aspect	N	Mean± SE	StDev.	Q1	Median	Q3	Rank mean	Indicator scores^{is}	P Value
Soil	North	40	3.950±0.107	0.677	3.25	4.000	4.00	71.03^{A}	4	<0.000**
	South	40	3.225±0.104	0.660	3.00	3.000	4.00	40.95^{B}	3	
	Summit	40	3.900±0.112	0.709	3.25	4.000	4.00	69.53^{A}	4	
Hydrology	North	40	3.850±0.098	0.622	4.00	4.000	4.00	69.71^{A}	4	<0.000**
	South	40	3.275±0.095	0.599	3.00	3.000	4.00	42.08^{B}	3	
	Summit	40	3.850±0.098	0.622	4.00	4.000	4.00	69.71^{A}	4	
Vegetation	North	40	3.800±0.064	0.405	4.00	4.000	4.00	73.20^{A}	4	<0.000**
	South	40	3.125±0.125	0.791	2.25	3.000	4.00	44.38^{B}	3	
	Summit	40	3.600±0.093	0.591	3.00	4.000	4.00	63.93^{A}	4	

(**P<0.01;A.B., is; 5: Very good, 4: Good, 3: Fair, 2: Poor, 1: Very poor)

4. Conclusion

Extreme climate events or human effect (grazing, etc.) may change the condition of the rangeland ecological indicators but results showed that the condition of these indicators do not change in consecutive two years as long as no extreme climate events or human impact occurred. However, topographical differences could significantly change the scores of the rangeland ecological indicators. South face had a lower indicator score considering the north face and summit, and were in the class of "fair" in terms of ecological site description. A higher slope gradient, higher evaporation, and early grazing practices might be responsible for the lower ecological site description class at the south face. North face and summit had similar indicator scores and the ecological site descriptions of these two positions were in the class of "good". Ecological site description could provide site-specific information about the recent condition of the rangelands and this method might be improved to include information about grazing capacity also. Results also indicated that degradation is higher at south aspects and this risk may increase during the global warming process. Consequently, rangeland management plans should also aim to increase the soil quality at south faces of Bozdağ Rangeland. Although there was not any difference between the years, a significant variation is expected on the long-term. Therefore, RESD should be monitored between 5-10 years of period. Monitoring is essential for a sustainable rangeland management.

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Investigation of the Morphological Characteristics of Chickpea (*Cicer arietinum* L.) Cultivars Cultivated under Irrigated and Non-Irrigated Conditions Sown in Winter and Early Spring

Dürdane MART[1*]

Eastern Mediterranean Agricultural Research Institute, Adana, Türkiye

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A B S T R A C T

This research was carried out to determine the yield and physiological characteristics of İnci, Hasanbey, Seçkin and Aydın chickpea (*Cicer arietinum* L.) cultivars at different sowing times and under irrigated and non-irrigated conditions in Çukurova climate conditions. Experiments were carried out in a divided plot design with four replications for two years, in 2012 and 2013 growing years. In the study, two different planting times (winter-early spring) and two different water applications (irrigated and non-irrigated) were applied and some properties related to yield and morphology were examined. The trials were conducted at the Doğankent location in the Eastern Mediterranean Agricultural Research Institute research area. In the experiments, the main plots were arranged according to sowing time, and the sub-plots consisted of cultivars, and irrigated and non-irrigated plots. As a result of the research, it was determined that sowing time and water applications affected agronomic and morphological characteristics. These changes were observed according to planting times and varieties.
In terms of morphological characteristics, it was determined that there were decreases in summer plantings and non-irrigated conditions in which planting time and irrigation were significantly effective in all four cultivars. Increases were determined in winter plantings compared to summer plantings. Increases in yield and hundred-seed weights under irrigated conditions, increases in yield values, flowering and pod binding values were observed in winter plantings. In terms of two-year average values, a yield of 196.29 kg da^{-1} was obtained in irrigated conditions and 158.11 kg da^{-1} in non-irrigated conditions in winter plantings. In terms of two-year average values, 139.67 kg da^{-1} yield was obtained in irrigated conditions and 121.14 kg da^{-1} yield was obtained in summer plantings.

1. Introduction

Chickpea (*Cicer arietinum* L.) is a genus of Cicer, which has 2n=16 chromosomes, highly self-fertile, and is in the Leguminosae team, *Papilionacea* (butterfly-flowered) family, *Viceae* subfamily. Proteins are of great importance in human nutrition because they are highly digestible and close to animal-derived proteins in terms of amino acids they contain (Thudi et al., 2011). Edible legumes are an important food source for human nutrition with their cheap and high-quality vegetable protein content, mineral, vitamin and

*Correspondence author: durdanemart@yahoo.com

fiber ratio (Şehirali, 1988; Friedman, 1996). Chickpea is an important food source and contains high amounts of protein, fiber and carbohydrates. In terms of protein richness, it has an important position in human nutrition as a source of carbohydrates and is one of the basic nutrients. Chickpeas are rich in nutritional values and have positive contributions to the soil where they are grown. Chickpea is generally grown in arid and irrigated regions in our country. Chickpea is the second plant that is the second most resistant to heat and drought after the lentil plant, and suitable for cultivation in poor soils, it is an important plant in increasing the yield obtained from the unit area by entering the crop rotation in arid regions and narrowing our fallow areas (Eser, 1978). In Turkey, the cultivation area is 487,885 ha, the production is 475,000 tons, and the yield per unit area is 97 kg da^{-1} (TUIK, 2022). The fact that the chickpea plant can benefit from elemental nitrogen in the air through Rhizobium bacteria, which maintains a symbiosis in its roots, that it fixes the nitrogen in the air to the soil, that its cultivation is easy and that the vegetation period is short (Azkan 1989; Sepetoğlu 1994) increases the importance of the chickpea plant (Yorgancılar et al., 2008; Muehlbauer et al., 1987). Growing season can be postponed from winter to early spring to avoid anthracnose blight disease. However, in these regions, spring precipitation shows an insufficient and uneven distribution; The yield of chickpeas planted in summer is adversely affected by high temperature and drought stresses (Slim et al. 1993).

There are genetic and environmental variables that affect yield and yield elements in chickpea cultivation. It has been emphasized that the most important factor affecting the yield among the cultivation techniques applications is the sowing time, and that the flowering, pod filling and yield can vary depending on the climatic factors at different sowing times (Kayan et al., 2014). In previous studies, chickpea cultivars planted on different dates showed differences in terms of yield and yield components (Karasu et al., 1999; Partigöç et al., 2007; Ray et al., 2017), and late sowing dates affected yield and quality (Ali et al., 2018; Varoğlu and Abak, 2018). In addition, plant height and first pod height decrease (Akdağ, 1995; Erman and Tüfekçi, 2004), grain yield per decare decreased (Akdağ, 1995; Erman and Tüfekçi, 2004), 100 seed weight and alteration in protein content (Topalak and Ceyan, 2015).

The most important problem in chickpeas is anthracnose tolerance and suitability for mechanized agriculture. Since the production purpose is a high grain product, the development of varieties suitable for the region where chickpea will be grown is an important factor in increasing production and quality. This research was carried out to investigate and evaluate the yield and yield elements of chickpea plant, grown in irrigated and non-irrigated conditions in winter and summer plantings for the Çukurova region, and present it to the service of the farmer.

2. Materials and Methods

In this study, İnci, Hasanbey, Seçkin and Aydın chickpea cultivars were used. Experiments were carried out at Doğankent location in Çukurova region Agricultural Research Institute experimental area in 2012 and 2013 growing years, by planting in winter (December) and early spring (February) for two years. Sowing was done in 6 rows (13.5 m^2) of 5 m length with 45 cm row spacing and 8 cm row elevation. Before planting, fertilization was done with 3.0 kg N and 6 kg P_2O_5 per decare. Trials were 4 replications in split plots trial design in both years; It was made as 4 cultivars, 2 planting time and 2 applications (irrigated and non-irrigated).

2.1. Climatic characteristics of the experimental area

When Table 1 is examined, monthly precipitation, temperature and relative humidity rates in the production periods of chickpea are seen. Especially in 2012-2013, when precipitation did not show a balanced and regular distribution during the growing periods, heavy precipitation pressure and uneven precipitation compared to long years had a negative effect on the development of plants. It is seen that it receives low precipitation compared to the average of many years during the development periods. In both years, uneven precipitation distribution had a negative effect on the growth of plants.

Table 1. Climate data of Adana province for 2011-2012 and 2012-2013 growing years

Months	Precipitation (mm)			Average Temperature ℃			Relative humidity (%)		
	Long Year	2012-2013	2013-2014	Long Year	2012-2013	2013-2014	Long Year	2012-2013	2013-2014
November	67.2	187	1.0	15.3	17.4	17.7	63	52.3	57.5
December	118.1	154.4	12.2	11.1	11.4	10.4	66	73.7	42.7
January	111.7	25.9	28.2	9.7	9.5	11.5	66	66.8	69.6
February	92.8	49.0	18.5	10.4	12.1	10.8	66	73.9	56.9
March	67.9	70.1	56.1	13.3	13.9	15.1	66	61.1	65.6
April	51.4	43.2	18.6	17.5	18.1	17.7	69	72	66.9
May	46.7	57.4	22.4	21.7	22.7	21.3	67	72.3	70.4
June	22,4	0.3	50.0	25.6	25.3	24.0	66	65.7	68.2
July	5.4	0.0	0.3	27.7	28.2	28.2	68	65.2	72.6

3. Results and Discussion

Chickpea plant needs water like all plants, but the amount of water it needs is lower than for other crops. It is reported by many researchers that the yield components of this plant, which is generally fed with rain water, differ under different irrigation regimes (Özgun et al., 2004; Silim and Saxena, 1993; Toğay et al., 2005). In this context, agronomic parameters were examined in the prominent lines in the region where summer and winter cultivation were made under Mediterranean agro-ecological conditions, using irrigated and non-irrigated farming systems.

In 2012 and 2013, 50% flowering days, number of pod tying days, plant height, first pod height, hundred-seed weight and yield values in İnci, Hasanbey, Seçkin and Aydın chickpea cultivars in winter plantings with irrigation and without irrigation applied as four repetitions. analyzed and evaluated statistically (Table 2).

In 2012, the average number of days until flowering was 152.9 days, the number of days until pod tying 166.0 days, average plant height 64.5 cm, average first pod height 29.3 cm, average 100 seed weight 35.1 g and the average grain yield 183.7 kg da^{-1} was observed in irrigated plots sown in winter. In chickpea plots without irrigation, the average number of days until flowering was 152.3 days, the number of days until pod tying 165.31 days, average plant height 64.0 cm, average first pod height 27.9 cm, average 100 seed weight 35.9 g and the average grain yield 123.8 kg da^{-1} was observed (Table 2).

In 2013, the average number of days until flowering was 86.69 days, the number of days until pod tying 103.81 days, average plant height 70.0 cm, average first pod height 35.3 cm, average 100 seed weight 40,97 g and the average grain yield 208,9 kg da^{-1} was observed in irrigated plots sown in winter. In chickpea plots without irrigation, the average number of days until flowering was 88,50 days, the number of days until pod tying 102,4 days, average plant height 54,54 cm, average first pod height 28,74 cm, average 100 seed weight 40,5 g and the average grain yield 192,4 kg da^{-1} was observed (Table 2).

Two-year average for agronomic characters were 121,3 days until flowering, the 134,9 days until pod tying, 67,3 cm plant height, 32,3 first pod height, average 100 seed weight 38,1 g and the average grain yield was 196,3 kg da^{-1} in irrigated plots sown in winter. In chickpea plots without irrigation, the average number of days until flowering was 120,05 days, the number of days until pod tying 133,9 days, average plant height 59,28 cm, average first pod height 28,30 cm, average 100 seed weight 38,2 g and the average grain yield 158,1 kg da^{-1} was observed (Table 2).

All agronomic parameters varied between cultivars, years and irrigation practices, and the differences were found to be statistically significant. This difference stands out especially in yield and 100 grain weight parameters.

Togay et al. (2005) emphasized that the yield and agronomic characters in dry farming areas were lower than those in irrigated farming areas in their study using 2 cultivars in Van conditions. Özgun et al. (2004) in the result of a similar study carried out in Diyarbakır agro-ecological conditions, determined that 100 grain weight and yield per decare decreased in dry farming areas. In Adana conditions, 100 grain weight was found to be higher in dry agriculture than in irrigated agriculture, while yield per unit of area was determined to be higher in irrigated agriculture. Uzun et al. (2012) emphasized that the number of pods per plant and the amount of yield per area showed a high positive correlation. Özgun et al. (2004) stated that the number of minor, major and pods per plant in chickpea cultivated without water is quite low. In our study, although the weight of 100 grains was low in non-irrigated agriculture, the reason why the yield per unit area was determined lower than in irrigated agriculture is thought occur due to the higher number of main branches and pods that highly affects the yield per plant.

Table 2. Agronomic Characteristics of Chickpea Varieties in Winter Sowing

Year	Application	Cultivars	Days Until Flowering (days)	Days Until Pod Tying (days)	Plant Height (cm)	First Pod Height (cm)	100 Seed Weight (g)	Yield (kg da^{-1})
2012	Irrigated	INCI	154a	166,0ab	63,9bc	29,4b-c	32,9 h	205,1 ab
		HASANBEY	152ab	165,8ab	64,4bc	30,3bc	39,0c-f	183,7 b-d
		SECKIN	153,3ab	166,8a	69,7ab	30,2bc	36,4fg	197,3 b
		AYDIN	152,5ab	165,5ab	60,1bcd	27,2c	32,2 h	148,8 c-e
	Average		152,9	166,0	64,5	29,3	35,1	183,7
	Non - Irrigated	INCI	153,3ab	167a	67,9ab	30,8bc	32,3 h	139,2 de
		HASANBEY	151,3b	163,5b	61,8bc	27,3c	37,7fg	114,7 e
		SECKIN	152,3ab	165,5ab	63,1bc	26,7c	37,9e-g	122,2 e
		AYDIN	152,5ab	165,3ab	63,3bc	26,6c	35,9g	119,2 e
	Average		152,3	165,3	64,0	27,9	35,9	123,8
2013	Irrigated	INCI	92,0c	106,5c	64,9bc	34,2ab	37,9 e-g	252,4 a
		HASANBEY	87,8de	102de	69,1ab	37,1a	42,9 ab	194,8bc
		SECKIN	89,8d	103de	69,6ab	36,2a	41,8 a-c	200,7 b
		AYDIN	89,3d	103,8d	76,5a	33,8ab	41,2 b-d	187,6 bc
	Average		89,7	103,8	70,0	35,3	40,9	208,8
	Non - Irrigated	INCI	89,8d	103,5de	56,3cd	29,2bc	37,9 e-g	214,37ab
		HASANBEY	87,0e	101e	56,2cd	27,9c	44,6 a	188,11 bc
		SECKIN	88,5de	102,5de	54,9cd	30,4bc	40,6b-e	195,11 bc
		AYDIN	88,8de	102,5de	50,8d	27,5c	38,7d-g	172,07 b-d
	Average		88,50	102,38	54,5	28,7	40,5	192,4
	LSD		2,06	2,67	10,3	5,2	2,8	47,49
2012 2013	Irrigated	INCI	123a	136,25a	64,4a-c	31,8ab	35,5de	228,8a
		HASANBEY	119,8cd	133,9bc	66,8ab	33,7a	41,0ab	189,2bc
		SECKIN	121,5b	134,9ab	69,6a	33,2a	39,1bc	198,9ab
		AYDIN	120,9bc	134,6ab	68,3ab	30,5a-c	36,7de	168,2b-d
	Average		121,3	134,9	67,3	32,3	38,1	196,3
	Non - Irrigated	INCI	121.5b	135,3ab	62,2b-d	30,0a-c	35,1e	176,7b-d
		HASANBEY	119,1d	132,3c	58,9cd	27,6c	41,1a	151,4d
		SECKIN	120,4b-d	134bc	58,9cd	28,5bc	39,3a-c	158,7cd
		AYDIN	120,6bc	133,9bc	57,0d	27,0c	37,3cd	145,6d
	Average		120,1	133,9	59,3	28,3	38,2	158,1
	LSD		1,5	1,9	7,3	3,7	2,0	33,6
	CV		1,2	1,4	11,5	12,0	5,2	18,8

In 2012 and 2013, the number of 50% flowering days, number of pod tying days, plant height, first pod height, hundred-seed weight and yield values in İnci, Hasanbey, Seçkin and Aydın chickpea cultivars in summer plantings with irrigation and non – irrigated areas applied as four repetitions analyzed and evaluated statistically (Table 3).

Table 3. Agronomic Characteristics of Chickpea Varieties in Summer Planting

Year	Application	Cultivars	Days Until Flowering (days)	Days Until Pod Tying (days)	Plant Height (cm)	First pod Height (cm)	100 Seed weight (g)	Yield (kg da^{-1})
2012	Irrigated	İNCİ	62,56a	72,90a	55,95b-d	24,74fg	31,07ıj	113,68bc
		HASANBEY	61,25a-c	70,25b	54,16 b-e	27,58c-g	37,67b-d	132,78bc
		SEÇKİN	60,0cd	70,50b	46,08f	26,58e-g	35,16d-g	120bc
		AYDIN	61,75ab	71,50ab	60,41b	28,41b-g	31,75h-j	102,89c
	Average		61,4	71,3	54,2	26,8	33,9	117,3
	Non - Irrigated	İNCİ	61,50a-c	71,25ab	56,50b-d	27,33d-g	29,92j	123,37bc
		HASANBEY	60,25b-d	71,0b	55,66b-e	25,58fg	34,67d-h	118,22bc
		SEÇKİN	59,50d	69,75b	51,17c-f	23,74g	33,33f-ı	124,96bc
		AYDIN	60,75b-d	71,25ab	68,08a	33,07ab	32,41g-j	110,44c
	Average		60,5	70,81	57,85	27,43	32,58	119,25
2013	Irrigated	İNCİ	48,75e	66,50c	57,48bc	33,70a	32,95f-j	148,74b
		HASANBEY	43,0h	65,25cd	56,65b-d	34,58a	37,30b-e	189,70a
		SEÇKİN	46,25g	62,00e	54,55 b-e	32,08a-d	38,63bc	189,59a
		AYDIN	47,75e-g	66,50c	57,45bc	32,45a-c	33,63f-ı	120bc
	Average		46,44	65,06	56,53	33,20	35,63	162,01
	Non - Irrigated	İNCİ	49,0e	64,75cd	51,13c-f	31,80a-d	33,98e-ı	128,74bc
		HASANBEY	42,75h	65,50c	49,87d-f	30,75a-e	42,48a	123,11bc
		SEÇKİN	46,50fg	63,50de	48,73ef	28,70b-f	39,80ab	125,26bc
		AYDIN	48,0ef	65,25cd	52,38 c-f	31,23a-e	36,15c-f	114,96bc
	Average		46,56	64,75	50,53	30,62	38,10	123,02
	LSD		1,63	1,90	7,08	4,93	3,44	25,95
2012 2013	Irrigated	İNCİ	55,63a	69,70a	56,71ab	29,22a-c	32,01c	131,21bc
		HASANBEY	52,13cd	67,75bc	55,41ab	31,08ab	37,48a	161,24a
		SEÇKİN	53,13c	66,25d	50,32c	29,33a-c	36,89a	154,80ab
		AYDIN	54,75ab	69,00ab	58,93a	30,43ab	32,69c	111,44c
	Average		53,91	68,18	55,34	30,02	34,77	139,67
	Non - Irrigated	İNCİ	55,25ab	68,00b	53,81bc	29,57a-c	31,95c	126,06c
		HASANBEY	51,50d	68,25b	52,77bc	28,17bc	38,57a	120,67c
		SEÇKİN	53,0c	66,63cd	49,95c	26,22c	36,57ab	125,11c
		AYDIN	54,38b	68,25b	60,23a	32,15a	34,28bc	112,70c
	Average		53,53	67,78	54,19	29,03	35,34	121,14
	LSD		1,14	1,34	4,99	3,47	2,42	25,95
	CV		2,11	1,95	9,01	11,62	6,83	19,63

In 2012, the average number of days until flowering was 61.4 days, the number of days until pod tying 71.3 days, average plant height 54.2 cm, average first pod height 26.8 cm, average 100 seed weight 33.90 g and the average grain yield 117.3 kg da^{-1} was observed in irrigated plots sown in early spring. In chickpea plots without irrigation, the average number of days until flowering was 60.5 days, the number of days until pod tying 70.81 days, average plant height 57.85 cm, average first pod height 27.43 cm, average 100 seed weight 32.58 g and the average grain yield 119.25 kg da^{-1} was observed (Table: 3).

In 2013, the average number of days until flowering was 46.44 days, the number of days until pod tying 65.06 days, average plant height 56.53 cm, average first pod height 33.2 cm, average 100 seed weight 35.63 gr and the average grain yield 162.01 kg da^{-1} was observed in irrigated plots sown in early spring. In chickpea plots without irrigation, the average number of days until flowering was 46.56 days, the number of days until pod tying 64.75 days, average plant height 50.53 cm, average first pod height 30.62 cm, average 100 seed weight 38.1 gr and the average grain yield 123.02 kg da^{-1} was observed (Table 3).

Two-year average for agronomic characters were 53.91 days until flowering, the 68.18 days until pod tying, 55.34 cm plant height, 30.02cm first pod height, average 100 seed weight 34.77 g and the average grain yield was 139.67 kg da^{-1} in irrigated plots sown in early spring. In chickpea plots without irrigation, the average number of days until flowering was 53.53 days, the number of days until pod tying 67.78 days, average plant height 54.19 cm, average first pod height 29.03 cm, average 100 seed weight 29.03 g and the average grain yield 121.14 kg da^{-1} was observed (Table 3).

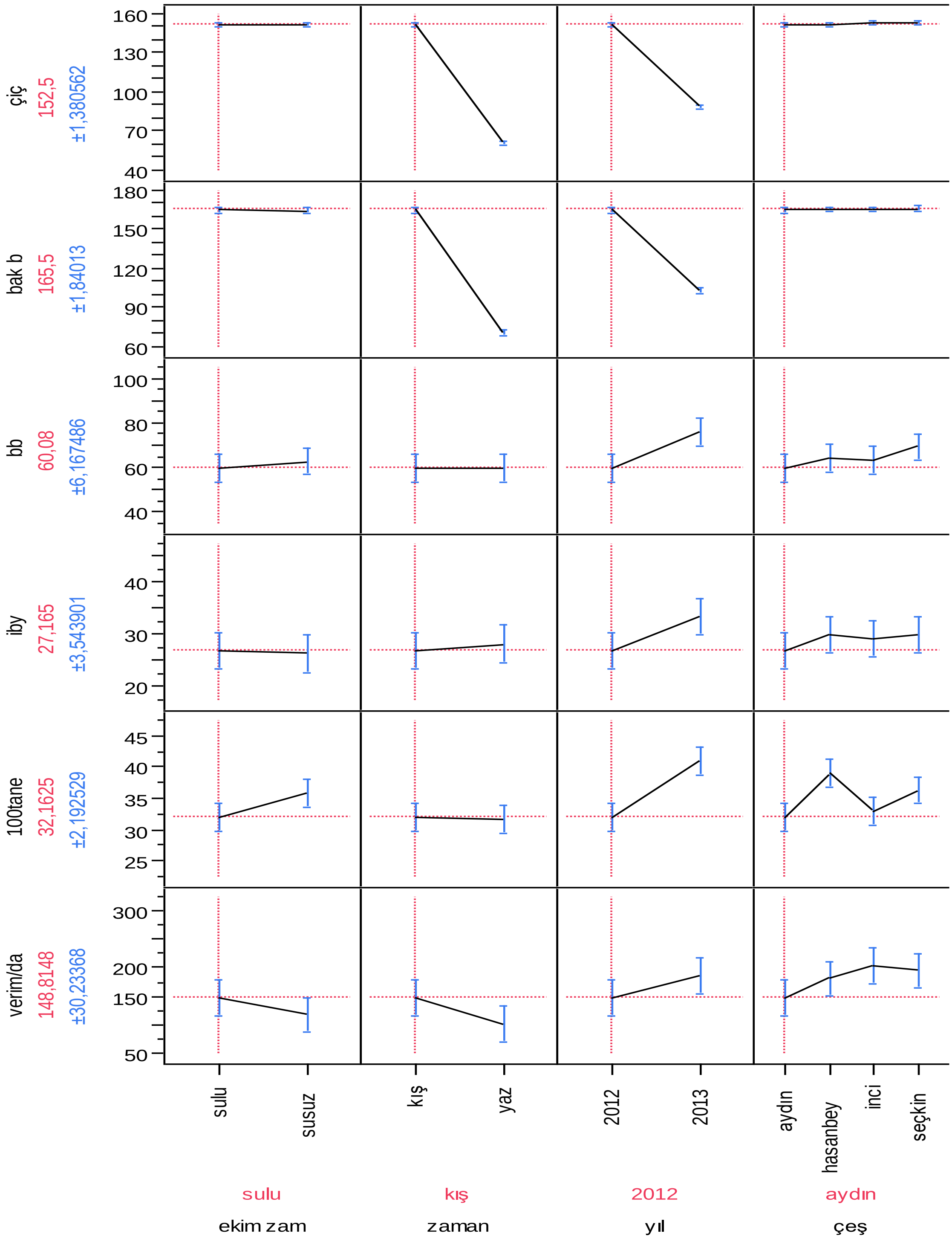

Figure 1. Agronomic characteristics in irrigated and non-irrigated conditions of chickpea cultivars in winter, summer sowing

While 4 chickpea cultivars subjected to different irrigation regimes in 2012 and 2013 in summer planting did not show any significant difference in terms of agronomic characters according to years and irrigation systems, it was determined as a result of statistical analysis that the observed differences were caused by cultivars. Silim and Saxena (1993) found in their study that the parameters most affected by the irrigation regime are yield and biomass. It has been determined that some agronomic characters of İnci, Aydın, Seçkin and Hasanbey cultivars are not significantly affected in irrigated and non-irrigated agriculture, but it has been determined that yield elements are affected more by the irrigation regime than other parameters, and at the same time, the degree of impact of the irrigation regime varies depending on the cultivar (Table 2 – 3; Figure 1). In addition, Şanlı and Kaya (2008) reported in their study that the amount of yield per unit area from the areas where summer planting is made is quite low compared to winter planting. Karadavut and Sözen (2020) emphasized that with the delay of sowing time, there is a decrease in the quality of the agronomic characters of the chickpea plant. The difference between chickpeas cultivated in winter and summer is supported by the literature.

When the agronomic characteristics of the cultivars were evaluated regardless of irrigated and non-irrigated agriculture, the highest yield was observed in İnci cultivar, while the highest 100 grain weight was observed in Hasanbey cultivar (Figure 1).

Mart et al. (2021), in their study, determined that the yield elements of İnci, Seçkin, Hasanbey cultivars were the highest under Adana Agro – ecological conditions.

The number of flowering days and pod-fixing days are vegetation characteristics and are highly affected by planting time and ecological conditions (Gregersen et al., 2013). The number of flowering days and pod-fixing days were observed to differ between years and depending on the planting time, which is thought to be related to ecological and planting time.

4. Conclusion

The importance of irrigated and non-irrigated agriculture in winter chickpea planting in 2012-2013 and 2013-2014 was investigated and evaluated in terms of different agronomic characters. At the same time, the response of standard cultivars to irrigated and non-irrigated farming in the region was studied. As a result of the study, agronomic characters differed depending on irrigation, variety and year. It has been determined that the yield per decare in the irrigated areas is high, and the 100-grain weight is higher in non - irrigated agriculture.

In the same years, the effects of summer chickpea planting on the development and yield of cultivars in irrigated and non-irrigated agriculture were investigated, and it was determined that the yield elements were 50% higher in irrigated agriculture compared to non-irrigated agriculture in summer planting conditions. Winter sowing is recommended to obtain high yields; at the same time, if the conditions are suitable, it is appropriate to make irrigated farming irrigated farming with tolerant cultivars.

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Effect of Irrigation on the Content of Cellulose in Proso Millet Stalk (*Panicum miliaceum* L.) in Aydın/Turkey Conditions

Ersel YILMAZ[1*]

[1]Aydın Adnan Menderes University, Faculty of Agriculture, Department of Biosystems Engineering, Aydın, Türkiye

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A B S T R A C T

Proso millet stalks are an under-utilized material that remains after the harvest. Given the share of large proso millet stalks in total production in Turkey, more than 8% of stalks could be easily available as a raw material in the fabrication of fuels. Unlike corn, proso millet stalks are not used as green fodder or silage due to the higher cellulose content and smaller green leaves for animal feeding. In this study, the usability of proso millet plant as a biofuel material due to this feature was tested in terms of the chemical parameters such as cellulose, lignin and some other nutritional elements. The impact on the plants grown and harvested materials parameters by applying control (non-irrigated) and four irrigation levels (50%, 75%, 100% and 125%) was investigated. Results of the study show that the highest values were obtained for 125% irrigation level.

1. Introduction

About 20 different millet species have been cultivated worldwide and occupy over 30 million hectares in 30 countries located in Asia, Africa, the Americas and Australia (FAO 2020). Millet is one of the important cereal grains in the world and sustaining more than one-third of the world's population (FAO 2020) and is an important cereal crop for arid and semi-arid climate areas where rainfall is low and erratic (Habiyaremye et al., 2016; Taylor, 2019).

Commonly cultivated millet species (*Panicum miliaceum* L.) are characterized by high tolerance to abiotic stresses such as drought, salinity, high temperatures and nutrient deficiency in the soil (Saleem et al., 2021).

Millet is an annual summer grass and can complete its life cycle within 60–100 days (Habiyaremye et al., 2016). It is a highly nutritious cereal grain used mainly for human consumption (Meena et al., 2021). However, most millet crop in Turkey is used primarily for bird feed and cattle-fattening rations. In 2020, 5.7 million proso millet was produced in Turkey (TUIK, 2021).

Millet grains, as was mentioned before, are used as food or feed for animals, but there are also, after harvesting remained, stalks, which are often considered residue discarded as agricultural waste which can be used for energy purposes.

Using agricultural residue material for the energy holding sector, like biofuels and biogas, has many benefits for farmers and the environment, such as reducing the need for waste disposal, which currently increases farming entry costs and reducing environmental pollution such as fires or pesticides. On the other side, the increasing cost of energy and finite oil and gas reserves has created a need to develop alternative fuels from renewable sources. The need to generate an ample and sustainable supply of biomass to make biofuels generation from lignocellulose profitable will

*Correspondence author: eyilmaz@adu.edu.tr

require the development of crops grown specifically for bioenergy production as well as the application of agricultural residues (Arevalo-Gallegos et al., 2017; Wzorek et al., 2021).

Lignocellulosic residues (agricultural wastes, forestry residues, grasses and woody materials) are complex carbohydrate polymers built from sugar monomers (xylose and glucose) and lignin – a highly aromatic material. They comprise cellulose, hemicellulose, lignin, extractives and several inorganic materials (Anwar et al., 2014).

It was stated that the composition of lignocelluloses materials/residues varies with species and variety, but also because of the type of soil, weather conditions and the age of the plant (Yadav et al., 2019; Guimarães et al., 2009).

The possibility of using the stalk as a local source of cellulose has not been studied systematically. For example, Packiam et al. (2018) determined that pearl millet corn was rich in cellulose (41.60%), hemicellulose (23.32%), and lignin (21.81%). In contrast, pear millet stalks contain 52.49% cellulose, 25.42% hemicellulose and a relatively low level of lignin, 10.54% (Yadav et al., 2019). Therefore, it looks like millet stalks are a promising feedstock for the energy sector.

While the producing reason of bioenergy feedstock is to produce renewable fuel, one of the critical components in their production will be water. According to one of the new types of irrigation strategies, deficit irrigation scheduling is a valuable and sustainable production strategy which can be applied to dry regions (Yilmaz et al., 2021).

Specially millet varieties need relatively less water than the other crops because they have short growing seasons and show exceptional tolerance to various abiotic and biotic stresses (Taylor, 2019).

Some studies explained this impact of water stress; for example, Seghatoleslami et al. (2008) observed that deficit irrigation for three species of millet (*Panicum miliaceum*, *Setaria italica* and *Pennisetum americanum*) declined yield by reduction of seed number per panicle and panicle number per plant and caused reduction in the number of tiller, as well as peduncle and panicle length and plant height. Yadav et al. (1999) demonstrated that water stress after pollination in pearl millet reduces seed yield by reducing the number of tillers per m^2, number of seeds per panicle and seed weight. Bartwal et al. (2016) obtained a 200% increase in ascorbate content, limiting ROS accumulation (Reactive Oxygen Species) for finger millet. Golombek & Al-Ramamneh (2002) indicated that drought reduces CO_2 assimilation area by reducing leaf number and area.

The water-use efficiency is critical as one of the factors for plant production where rainfalls and water reserves are limited.

There is little data on how irrigation affects stalk lignocellulose concentrations. Hence, the main idea of this study is to analyze the effects of irrigation on stalk lignocellulose concentrations in proso millet stalks. Also, this study can provide valuable information for proso millet stalk potential as a biofuel feedstock.

2. Materials and Methods

In this study, a local variety of proso millet (*Panicum miliaceum* L.) was used as plant material.

2.1. Local and climatic descriptions of the experimental area

The experiment was conducted between the end of May and the beginning of September 2020 at the Department of Biosystems Engineering research center and application on the field of Faculty of Agriculture Farm, which is located on the south campus of Aydın Adnan Menderes University (N:37º 45’ 39”; E:27º 45’ 37”), in town Koçarlı of city Aydın in Turkey (Figure 1.)

Table 1 presents the long-term averages of the selected meteorological data study area.

Figure 1. Location of Biosystems Engineering research area.

Table 1. shows that in 2020 during sowing time (May), the temperature of the air was 1.1 ºC higher than in the period of 1970-2019, the humidity was 2% less, as well as rainfall, but the level of evaporation was higher compared to

previous years. All parameters were higher than normal except for the temperature ratio in June and July. In August, temperature and evaporation ratios were higher than normal, and rainfall and humidity were less than normal. Generally, it can be stated that the climatic conditions were changing, which is not suitable for plant growth.

Table 1. Long-term averages selected meteorological data comparing to the year of study.

1970-2019				
Month	**Temperature (ºC)**	**Humidity (%)**	**Rainfall (mm)**	**Evaporation (mm)**
May	21	56.9	35.6	161.3
June	26	49.2	16.6	222.1
July	28.6	48.6	7.5	257.5
August	27.6	52.9	5.3	231.6
September	23.3	55.9	15.1	161.9
2020				
Month	**Temperature (ºC)**	**Humidity (%)**	**Rainfall (mm)**	**Evaporation (mm)**
May	22.1	54.9	33.3	175.2
June	25.2	54.4	20.3	200.2
July	29.9	47.8	0	272.6
August	29.2	46.9	0	247.1
September	26.9	54.7	0	182.8

2.2. Soil Description

Soil profiles of the study area are presented in Table 2. Classification of soils of the research area is sandy-loam type in effective root zone sandy-loam. Moreover, the volume weight of the soil profile by irrigation norms is in sequence 1.35, 1.45, and 1.52 g cm^{-3}. The available water capacity of soil by irrigation norms was changing by deep of soil in 300 mm in sequence 52.7, 58.7, 50.6 mm.

Table 2. Soil profiles of the study area

Soil Profile deep (cm)	Structure of soil (%)			Classification	Volume weight (g cm^{-3})	* Field capacity		* wilting point		Available water capacity	
	Sand	Clay	Loam			(%)	(mm)	(%)	(mm	(%)	(mm)
0-30	58.4	13.6	28.0	Sandy loam	1.35	23.1	93.6	10.1	40.9	13.0	52.7
30-60	56.4	13.6	30.0	Sandy loam	1.45	22.9	99.6	9.4	40.9	13.5	58.7
60-90	68.2	13.6	19.2	Sandy loam	1.52	18.4	83.9	7.3	33.3	11.1	50.6

2.3. Methods

Experimental layout, design and treatments

This study was carried out in three replications in a randomized block design with 5 different doses of water (50%, 75%, 100% and 125% and control (non-treatment)). The soils of the trial area were plowed with a plow after the first spring rains, and the formed clods were fragmented with a discarrow, and the seedbed was prepared by passing a rake and a slide. Afterwards, the seeds were sown with a pneumatic seeder to a depth of 5 cm, with 4 rows which contains as distance 70 cm from each other and at 10 cm above the row. The plot lengths were marked as 5 m after vegetative growth started and while plants were 15-20 cm high the proso millet plants were ejected with a discarrow between the blocks as 3 m and between plots 2.1 m spaces.

Irrigation water

Irrigation water doses were calculated using Cropwatt version 8.0 software by 7 days intervals.

Irrigation topics were designed for deficit irrigation conditions, which topics were informed before, and the pipelines were designed as main lines with 75 mm diameter surface (PVC), which transport irrigation water from the control unit to 3 manifolds which are controlled by valves as 63 mm diameter (PVC) and from manifolds for control the flow by manual PVC valves to the 16 mm diameter drip irrigation lateral lines (PE), which contains inline drippers with included pressure controller membrane and 2 l/h flow and above the row 20 cm. Evapotranspiration ET0 ratios were calculated by equation 1 (Walker and Skogerboe 1987).

$$ET = I + P + Cp - Dp \mp Rf \mp \Delta S \qquad (1)$$

where: ET - plant water consumption (mm), I - over the period amount of irrigation water applied (mm), P - rainfall over the period precipitation (mm), Cp - the amount of water entering the root zone by the capillary rise (mm), Dp - penetration losses (mm), Rf - the trial amount of runoff (mm) entering and leaving plots of land, DS - root changes in soil moisture in the region (mm), values shows. Since there is no groundwater problem in the study area, there is no capillary water entry into the plant's root zone. Assuming the Cp value is not taken into account. Also, the surface flow amounts were not included in the accounts because the pressurized irrigation system was used (Kanber, 1997). Penetration losses of a substrate were observed for defemination of the level of penetrating deep.

Harvesting procedure and data collection

The harvesting of samples of plants was collected at the end of August and the beginning of September. The plant rows located on the border of parcels were separated and samples were measured and taken randomly into two rows which were in the middle of parcels and biomasses were calculated by using parcels size for per decare (1.40 m x 4.80m = 6.72 m^2).

Sample preparation for chemical analysis

Raw materials were cut into 3–5 cm segments and prepared to be dried. The moisture content was determined according to ASTM D 2216. The percentage difference between the initial weight (1 g) and the final weight of the sample was calculated after three days drying them at 60 °C to a constant weight. The sample was allowed to cool in a desiccator and reweighed to record the final weight. Samples were tested in triplicate, and the average of three values was recorded. The moisture content of the material was calculated using the following equation 2.

$$\text{Moisture content} = W1 - W2/W1*100 \qquad (2)$$

where: W1 is the weight of the moist sample, and W2 is the weight of the dry sample.

After drying, samples were milled and sieved to obtain 1 mm particles.

NIR spectroscopy

After completion of the treatments, all samples were analyzed using near-infrared spectroscopy (NIRS) which is a rapid analysis method that is expanding the application field. The applications of NIRS in forage have long been investigated by, i.e. Ono et al. (2003) Chen et al. (2006), Huang et al. (2010) and Guo et al. (2021) and shows successful results for the analysis of the composition of plant materials.

Absorbance measurements were made using a near-infrared reflectance spectrophotometer (Bruker MPA analysis) which was connected to a personal computer. The computer was equipped with software (OPUS Lab). This device covered a spectral range of 400–2500nm in 2nm intervals.

All samples were analyzed to determine chemical composition. Parameters such as NDF (neutral detergent fiber), ADF (acid detergent fiber), and ADL (acid detergent lignin).

Each sample was analyzed in triplicate, and the results were expressed as weight percent on a dry basis. The cellulose, hemicellulose, and lignin of each sample are related to NDF, ADF, and ADL by the relation (Van Soest and Robertson, 1985):

ADL = lignin and cutin
ADF = lignin and cutin + cellulose
NDF = lignin and cutin + cellulose + hemicellulose

Hemicellulose was calculated as NDF -ADF.

2.4. Statistical analyses

The descriptive statistics, including the minimum, maximum, mean, SD, ANOVA and LSD tests, were calculated by SPSS and TARİST software.

3. Results and Discussion

3.1. Water Use Efficiency (WUE)

Ullah et al. (2017) argue that the optimal water requirements for pearl millet precipitation range from 300 to 350 mm. His experiments with pearl millet showed that growth and development respond to good soil moisture conditions (irrigation) and even function reasonably under unpredictable weather conditions due to deep and rapid root penetration. Pearl millet requires less water than other crops; for example, sorghum, wheat, corn, cotton, rice and sugarcane require 14, 28, 42, 71, 57 and 500% more water than pearl millet, respectively.

Some field studies compare water stress for millet and other crops to determine the water use efficiency (WUE) and yield response (Hulse et al., (1980); Maman et al., (2003); Murthy (2007). For example, Maman et al. (2003) compared pearl millet and soybean in the western Nebraska region in two seasons, 2000 and 2001 and for both crops were used a similar amount of water (was 336 and 330 mm in 2000 and 370 and 374 mm in 2001 for pearl millet and grain sorghum, respectively). Both crops responded to irrigation with a linear increase in grain yield as water use increased. Pearl millet grain yields were 60 to 80% that of grain sorghum.

Singh and Singh (1995) have reported that the plot level and water use efficiency (WUE) values of 300–400 kg biomass ha^{-1} cm^{-1}, assuming a full ground cover (LAI > 3–4). However, under low planting density, the WUE usually drops to the range 50–150 kg ha^{-1} cm^{-1}, primarily because of an increased evaporation component (Payne, 1990), itself high because of the fertility-related low sowing density. Therefore, it seems that fertility may be the number one factor to improve the WUE at the plot level.

In most of the cases, high yield and WUE were noted under full irrigation, indicating the high potential of pearl millet crop (Nagaz et al. 2009)

The impact of water on the transpiration rate is also observed (Tr). Vadez et al. (2012) observed that it sets the maximum amount of carbon dioxide with water availability. Furthermore, the very availability of water forces the stomata in such a way that the transpiration efficiency (TE) can be kept at the highest possible level. Physiologically, plants show low photosynthetic and stomatal conductance rates and root respiration which help them to escape from water stress (Taylor 2019).

Table 3 presents parameters such as biomass, irrigation, seasonal evapotranspiration, irrigation water use (IWEU) and water use efficiency (WUE).

Irrigation water ratios were between 235 mm to 587.5 mm, and seasonal evapotranspiration levels were changed between 215.6 mm and 641.1 mm. The ratios of IWUE were calculated as 2.24 kg m^{-3} to 6.14 kg m^{-3}, and WUE was calculated in sequence between 2.05 kg m^{-3} and 5.7 kg m^{-3}.

Calculated data shows how much mm water will applicate by drip irrigation for full irrigation topics; the other research topics were used as the ratio in raw 1.25, 1.0, 0.75, 0.50 and 0 (control). The yield ratio of proso millet stalks was changed between 1233.33 and 1853. 33 kg da^{-1}.

As shown in Table 3, the biomass ratios were changed parallel by the level of irrigation water. Moreover, the biomass ratio was less on level 1.25 irrigation coefficient when compared with a parallel decrease of irrigation levels. It can be stated that the cellulose content of stalks was negatively affected by higher irrigation levels of water. Fibrous construction, which was determined in proso millet stalks, can influence on less irrigation levels more than the full one. It also explains that biomass on each tested irrigation level was less obtained than the full irrigated level.

3.2. Chemical components

From the point of view of energy use of biomass, three substances are the carrier of most of the energy accumulated in biomass: cellulose, hemicellulose and lignin. Some research also indicated a high correlation between calorific value and the content of cellulose, hemicellulose, and lignin (Demirbaş, 2005). Ultimately, the heat of combustion of biomass depends mainly on the percentage share of cellulose, hemicellulose and lignin in its structure, but the decisive factor for the high value of the heat of combustion is, therefore, the share of lignin in relation to holocellulose.

Table 3. Biomass, irrigation, seasonal evapotranspiration, irrigation water use and water use efficiency

Treatments	Biomass (kg da^{-1})	Irrigation (mm)	SET Seasonal ET_o (mm)	IWUE (kg m^{-3})	WUE (kg m^{-3})
125%	1316.67	587.5	641.1	2.24	2.054
100%	1853.33	470.0	523.6	3.94	3.540
75%	1730.00	352.5	406.1	4.91	4.260
50%	1443.33	235.0	288.6	6.14	5.000
Control (non-treatment)	1233.33	0	215.6	0	5.700

In Table 4 are presented the average values of cellulosic components as cellulose, hemicellulose, and lignin and also NDF, ADF, and ADL after subjecting to different water stress.

Table 4. Chemical characteristics of proso millet stalk (in dry base)

Average %					
Level of irrigation	**125%**	**100%**	**75%**	**50%**	**0**
Nb of samples	**1**	**2**	**3**	**4**	**5**
Cellulose, %	37,40	37,35	36,64	35,97	34,20
Hemicellulose, %	30,28	25,90	19,72	19,23	17,85
Lignin, %	12,24	11,68	11,56	10,34	8,90
NDF %	67,30	62,18	58,87	58,22	55,09
ADF, %	37,02	36,28	39,15	38,99	37,24
Dry mass, %	94,24	92,90	94,73	93,86	95,09
Moisture, %	5,76	7,10	5,27	6,14	4,91

The cellulose content in millet stalks raged from 34% to above 37% and was similar content as was observed by Harinarayana et al. (2005) - 39.4%. Regarding the level of irrigation, it can be seen that the cellulose content decreases as the amount of irrigation water fed decreases as the plant grows.

Compared to other non-woods, millet has similar cellulose content of corn stalks 32.4% (Siriwattana, 2002), tobacco stalks (Burley) 34 % (Kulic and Radojc, 2011), rice husks 36% and cotton stalks 38% (Singh and Chouhan, 2014).

Hemicellulose content in millet stalks raged from 17% to 30%, whereas lignin content is in the range 8-12%. Huang et al. (2010) and Wzorek and Troniewski (2007) clam the average content of lignin in stalk-type biomass is 15-16 wt%.

Lignin content in grasses depends mainly on the degree of lignification, which is related to the maturity of the shoots. Growing shoots contain less lignin, while mature, dying shoots contain more of it, because the lignification process reaches its maximum just before cell death.

Yadav et al. (2019) claim that the lignin component (acid soluble and insoluble) is maximum (29%) in the sheath and lower (9–10%) in the core and outer leaves. It is because the lignin present in the cellular wall (sheath) provides structural support, impermeability and resistance against microbial attack and oxidative stress.

Also, there were no statistically significant relations on the Anova test between water level and cellulose ratios as linear (Table 5). However, results showed that there are exponential relations between the cellulose content of proso millet stalks and irrigation levels.

Figure 2 are presented samples obtained from different irrigation levels.

Proso millet is one of the low-water consumption crops. Research has shown that prolonged periods of warm and dry weather can be detrimental to it and can reduce yields.

Figure 2. Full irrigated and no-irrigated stalk of proso millet

Table 5. Results of the content of chemical and Anova LSD analysis

	Source of Variation	Degrees of freedom	Sum of squares	Mean Sum square	Calculated F	Sequence LSD results
PROTEIN	Repetition	2	0.348	0.174	0.932ns	4,5,1,3,2
	Factor A	4	0.623	0.104	0.556ns	10.237-10.233 10.070-9.917 9.847
	Error	8	0.241	0.187		
	General	14	3.212	0.161		
FAT	Repetition	2	0.804	402.175	1.018	1,3,3,2,4,5
	Factor A	4	2202.8	367.133	0.930ns	32.817-7.350 6.560-3.667 2.793
	Error	8	4738.628	394.886		
	General	14	7745.777	387.289		
Starch	Repetition	2	0.186	0.093	0.105ns	3,2,5,1,4
	Factor A	4	2.817	0.469	0.530ns	10.37-9,860 9.633-9.510 8.993
	Error	8	10.629	0.0886		
	General	14	13.631	0.682		
Ca	Repetition	2	0.330	0.165	0.235	5,4,3,1,2
	Factor A	4	2.046	0.341	0.485	1.630-1.080 0.927-0.897 0.767
	Error	8	8.441	0.703		
	General	14	10.818	0.541		
Mg	Repetition	2	0.001	0.001	0.143ns	2,3,1,4,5
	Factor A	4	0.010	0.002	0.411ns	0.240-0.237 0.207-0.197 0.197
	Error	8	0.048	0.004		
	General	14	0.059	0.003		
Biomass	Repetition	2	21.532	10.766	1.692ns	1,4,2,5,3
	Factor A	4	29.699	4.950	0.778ns	94.920-94.733 94.240-93.857 92.897
	Error	8	76.379	6.364		
	General	14	127.600	6.380		
Cellulose	Repetition	2	1.688	0.844	0.670ns	1,2,4,5,3
	Factor A	4	4.446	0.741	0.589ns	37.867-37.293 36.687-36.653 36.587
	Error	8	15.106	1.259		
	General	14	21.239	1.062		
ADF	Repetition	2	66.285	33.143	0.462ns	5,3,4,1,2
	Factor A	4	900.237	150.040	2.090ns	45.160-39.573 35.100-29.383 24.093
	Error	8	861.459	71.788		
	General	14	1827.982	91.399		
ADL	Repetition	2	3.177	1.589	0.368ns	5,2,1,3,4
	Factor A	4	8.563	1.427	0.330ns	12.400-10.953 10.740-10.730 10.623
	Error	8	51.858	4.321		
	General	14	63.598	3.180		
NDF	Repetition	2	75.807	0.535ns		5,3,4,1,2
	Factor A	4	1023.351	2.409ns		57.607-50.350 45.770-40.153 35.093
	Error	8	849.581			
	General	14	1948.740			

ns: non-significant

4. Conclusions

Proso millet stalks can be an attractive biomass source for energy applications. However, due to problems with water resources, the amount of water introduced into the soil during its growth phase should be optimized.

Tests show that the influence of irrigation on the content of cellulose, hemicellulose and lignin in the samples of proso millets stalks increased at different water content; it can be concluded that there was a tendency of the increase of these parameters along with the amount of water administered during their growth. The highest values were obtained for the 125% irrigation level. In this study, irrigation water was changed between 235 – 587.5 mm in Aydin condition, and seasonal evapotranspiration was determined to the topics between 215.6 mm and 641.1 mm.

IWUE were determined in these conditions from 2.24 V to 6.14 kg m^{-3} and WUE were determined as between 2.05 kg m^{-3} and 5.7 kg m^{-3}.

In this study, there were no statistically significant relations on the ANOVA test between water level and cellulose ratios as linear; however, results show that there are exponential relations between cellulose content of proso millet stalks and irrigation levels.

It can be stated that the cellulose content of stalks was negatively affected by higher irrigation levels of water.

Fibrous construction determined in proso millet stalks was more influenced by less irrigation levels compared to higher irrigation levels. Results also explain that biomass on each tested irrigation level was less obtained than full irrigated.

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