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The Determination of Forage Yield and Quality of Some Sorghum and Sorghum Sudangrass Cultivars in Ecological Conditions of Uşak Province

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A B S T R A C T

This study was conducted to determinate of yield and some quality characters of sorghum (*Sorghum bicolor* (L.) Moench) and sorghum-sudangrass (*Sorghum sudanense* L.) hybrid cultivars in Usak province in 2014. In the study was used four sorghum sudangrass hybrid (Aneto, Sugar Graze II, Greengo, Nutri Honey) and two sorghum cultivars (Teide and Rox). The experiment was carried out in completely randomized block design with three replications. In the study, plant height, herbage yield, hay yield, crude protein (CP) ratio, crude protein yields, acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrient (TDN) and relative feed value (RFV) were determined. There were significant differences in all the properties examined among sorghum and sorghum-sudangrass hybrid cultivars. According to the results of the research, plant heights of cultivars ranged from 200.1 to 229.7 cm, herbage yields ranged from 57.40 to 77.73 t ha-1, hay yields ranged from 14.11 to 18.95 t ha-1, crude protein ratios ranged from 9.95 to 11.94%, crude protein yields ranged from 1.46 to 2.15 t ha-1, ADF ratios from 36.64 to 42.41%, NDF ratios from 55.79 to 60.12%, total digestible nutrient ratios from 46.60 to 54.05%, relative feed values from 87.14 to 100.56. Greengo cultivar had higher herbage yield, hay yield, total digestible nutrient and relative feed values and lower ADF and NDF ratio than other cultivars. The results revealed that Greengo cultivar can be considered suitable for the Uşak and similar ecological conditions.

1. Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is an important crop that can be grown successfully in summer season in hot and dry environment (Prakash et al. 2017). The cultivation of sorghum is gradually increasing due to the efficient water use, low fertilizer requirement, advantages in erosion and weed control. Sorghum is extensively grown as a forage crops and becoming increasingly important in many regions of the world (Miron et al., 2006; Yosef et al., 2009; Glamoclija et al., 2011). Fodder quality is of great important as well as higher forage yield. The fodder quality of sorghum depends on many factors such as

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fertilization, irrigation, genotype, plant density and harvesting time (Saeed and El-Nadi, 1998; Cakmakci et al., 1999; Zulfiqar and Asim, 2002; Ayub et al., 2003; Miron et al., 2006).

Breeding of sorghum cultivars with high adaptability, yield and quality makes sorghum a source of alternative summery forage crop. In addition, sorghum is the best crop adapted to arid ecologies having irregular seasonal rainfall distribution and high temperatures during the summer period. Determining the regional adaptation capabilities of sorghum and sorghum-sudangrass hybrids in the regions where water is limited and extending the cultivation of varieties with well adapted and desired characteristics will benefit the economy of the region and the country (Tiryaki, 2005). Therefore, determining the quality characteristics is very important in sorghum and sorghum-sudangrass hybrid cultivation besides the selection of appropriate and efficient cultivars in the regions.

The objective of this research was to compare forage yield and forage quality of four sorghum-sudangrass hybrid and two sorghum cultivars.

2. Materials and Methods

The research was performed at Usak province in the Aegean region of Turkey in 2014. Total precipitation was 118.4 mm in 2014 (May-September), long-term average is 118.6 mm. Average temperature was 20.28°C in 2014 (May-September), long-term average (May-September) is 20.78°C. According to the results of the soil analysis, the soil of the trial area is loamy, salt-free, rich in phosphorus and sufficient in terms of potassium, but medium in terms of organic matter.

In the study was used four sorghum sudangrass hybrid (Aneto, Sugar Grase II, Greengo, Nutri Honey) and two sorghum cultivars (Teide and Rox). The experiment was carried out in completely randomized block design with three replications. Each plot consisted of 6 rows, each 5 m in length. The row spacing was 50 cm. At the time of harvest, one row at the edge of each plot and 30 cm edges of the two middle rows were not evaluated due to the side effect. The seeding rates were 20 kg ha–1 for each cultivars. Before seeding, 80 kg ha-1 each of N and P2O5 was applied. Additionally, nitrogen was top dressed at the rate of 70 kg ha-1 when the plants attained 40-50 cm height (Atis et al., 2012). If necessary, weeds were controlled by hand and harrowing. Depending on climatic conditions, plots were irrigated every 10-14 days when consumed nearly half of the available soil water. Sorghum cultivars and sorghum-sudangrass hybrids cultivators harvested at the soft dough stage (Geren and Kavut, 2009).

In the study, plant height, herbage yield, hay yield, crude protein (CP) ratio, crude protein yields, ADF, NDF, total digestible nutrient (TDN) and relative feed value (RFV) were determined. Nitrogen content was calculated by using the Kjeldahl method. Crude protein content (N×6.25) and then crude protein yields were calculated. The ANKOM Fiber Analyzer was used for NDF and ADF analysis. Ankom F57 filter bags were used for ADF and NDF analysis in this study (Anonymous 2010). Total digestible nutrients (TDN) and relative feed values (RFV) were estimated according to the following equations adapted from Horroks and Vallentine (1999).

$$TDN = (-1.291 \times ADF) + 101.35$$

$$DMI = 120/NDF \text{ \% dry matter basis}$$

$$DDM = 88.9-(0.779 \times ADF \text{ \% dry matter basis})$$

$$RFV = DDM\% \times DMI\% \times 0.775$$

The data were analysed using the Proc GLM (SAS 1998). Means were separated by LSD at the 5 % level of significance.

3. Results and Discussion

According to the results of variance analysis, statistically significant differences were found among the cultivars in all the properties examined in the study (Table 1).

Plant heights were varied between 200.0 and 229.7 cm depending on the varieties. The tallest plants were obtained from Greengo and Aneto cultivars, while the shortest plants were determined in Teide and Nutri Honey cultivars (Table 2). In previous studies on different sorghum species, different values were obtained in plant heights. Plant heights in sorghum cultivars were found 183-355 cm in Cukurova (Saglamtimur et al., 1988), 300-360 cm in California (Skerman and Riveros, 1990), 261-285 cm in Karaman (Gunes and Acar, 2005), 174 cm in Diyarbakır (Gul and Basbag, 2005), 178-223 cm in Isparta (Balabanli and Turk, 2005), 148-330 cm in Bornova (Geren and Kavut

2009), 245 cm in Bartın (Basaran, 2011), 245.7-266.1 cm in Hatay (Atis et al., 2012), 137-177 cm in Yozgat (Tosunoglu, 2014), 209 cm in Bingol (Özmen, 2017), 197.1-299.4 cm in Igdır (Keskin et al., 2018).

Table 1. The results of variance analysis

Sources of Variation	df	Plant Height	Herbage Yield	Hay Yield	CP Ratio	CP Yield	ADF	NDF	TDN	RFV
Block	2	286.7	220691*	54062	0.04	866.7	25.58	21.22	128.4	112.1
Cultivars	5	448.6*	1778529*	142772**	47.12**	2720.0*	88.49**	96.14**	88.6**	246.5**
Error	10	123.9	51854	43511	0.74	705.7	22.12	19.51	11.2	50.2

Table 2. Mean plant height, herbage yield, hay yield, crude protein (CP) ratio, crude protein yield of some silage sorghum and sorghum-sudangrass hybrid cultivars.

Cultivars	Plant Height (cm)	Herbage Yield (t ha^{-1})	Hay Yield (t ha^{-1})	CP Ratio (%)	CP Yield (t ha^{-1})
Greengo	229.7 a*	77.73 a	18.95 a	9.95 d	1.91 ab
Teide	200.0 b	69.33 b	16.34 b	10.64 c	1.74 ab
Aneto	224.3 a	75.01 ab	18.77 a	11.47 b	2.15 a
Rox	221.3 ab	73.73 ab	18.66 a	10.33 cd	1.90 ab
Nutri Honey	200.0 b	63.66 c	14.53 c	10.03 d	1.46 b
Sugar Graze II	214.0 ab	57.40 d	14.11 c	11.94 a	1.69 ab

*There is no significant difference between the averages indicated by the same letters (P<0.05). CP:Crude protein

The differences among the herbage yields of the cultivars were found to be statistically significant. The highest herbage yields were obtained from Greengo (77.73 t ha-1), Aneto (75.01 t ha-1) and Rox (73.73 t ha-1) cultivars (Table 2). Sugar Graze II cultivar had the lowest herbage yield (57.40 t ha-1). In previous studies on different sorghum species, different values were obtained in herbage yields. Herbage yields in sorghum cultivars were found 45.5-68.3 t ha-1 in Isparta (Balabanli and Turk, 2005), 62.96-76.13 t ha-1 in Konya (Karadas 2008), 44.53 t ha-1 in Bartın (Basaran, 2011), 75-152 t ha-1 in Çanakkale (Yolcu, 2015), 73.23 t ha-1 in Bingol (Ozmen, 2017). The differences between the reported results may be due to the differences in harvest times and ecological conditions of research areas, status of the first and the second crop cultivations, and the genetic characteristics of the cultivars used in studies.

The highest hay yields were obtained from Greengo (18.95 t ha-1), Aneto (18.77 t ha-1) and Rox (18.66 t ha-1) cultivars. Sugar graze II and Nutri Honey cultivars had the lowest herbage yields (14.11 and 14.53 t ha-1). In studies on sorghum, the hay yields were found to be 48-93 t ha-1 by Tosun and Aydin (1985), 43-50 t ha-1 by Iptaş et al. (1997), 45-57 t ha-1 by Acar et al. (2000), 15-20 t ha-1 by Yilmaz (2000), 21-23 t ha-1 by Gunes and Acar (2005), 19-23 t ha-1 by Karadas (2008), 6-12 t ha-1 by Tosunoglu (2014), 5.5-25.6 t ha-1 by Ozmen (2017). The hay yields obtained in this study were higher than Sevimay et al. (2001), Gul and Basbag, (2005), Tosunoglu (2014), lower than Tosun and Aydin (1987), Iptaş et al. (1997), Acar et al. (2002), Gunes and Acar (2005), Karadas (2008) and similar to Yilmaz (2000), Cecen et al. (2005), Geren and Kavut (2009) and Ozmen (2017).

As seen in Table 2, the highest value of CP ratio (11.94%) was found in Sugar Graze II cultivar. The lowest CP ratios were determined in Greengo (9.95 %) and Nutri Honey (10.03%) cultivars (Table 2). In previous studies on different sorghum species, different values were obtained in CP ratios. Crude protein ratios in sorghum cultivars were found 10.10% in Cuba (Cacares ve Santana, 1987), 8.35% in Samsun (Aydin and Albayrak, 1995), 9.3-15% in Tokat (Iptaş et al., 1997), 7.2-8.7% in Van (Hosaflioglu, 1998), 4.41-5.15% in Karaman (Gunes and Acar, 2005), 9.5-10.2 % in Poland (Kozlowski et al., 2006), 5.60-6.63% in Konya (Karadas, 2008), 7.2% in New Mexico (Marsalis et al., 2010), 7.1-9.7% in Antalya (Arslan and Cakmakci, 2011), 7.2-8.8% in Bursa (Canbolat,

2012), 2.5-7.0% in Bingöl (Ozmen, 2017). The findings obtained in this study are in consistent with the results of Cacares and Santana (1987), Iptaş et al. (1997), Kozlowski et al. (2006), Arslan and Cakmakci (2011).

The CP yields were varied between 1.46 and 2.15 t ha-1 depending on the varieties in this research. The CP yields obtained in this study were higher than Hosaflioglu (1998), Yilmaz and Hosaflioglu (2000), Gunes and Acar (2005), Keskin et al. (2005), Yılmaz and Sağlamtimur (1997), Tosunoğlu (2014), Ozmen (2017), Atis et al. (2012) and similar to Iptaş et al. (1997), Kir and Dursun Sahan (2019). Crude protein yield, which is directly related to dry matter yield and crude protein ratio, is very important in animal nutrition (Keskin et al., 2005). Since protein is one of the most costly supplements for livestock, the total amount of protein produced per unit area is one of the most important quality characteristics as suggested by Assefa and Ledin (2001) and Lithourgidis et al. (2006).

In this research, the lowest ADF ratios were determined Nutri Honey (36.64%) and Greengo (36.68%) cultivars, while the highest ADF ratios were found in Sugar Graze II (42.41%) and Rox (41.81%) cultivars (Table 3). In studies on sorghum, the ADF ratios were found to be 27.3-36.5% by Siefers et al. (1997), 32.5-34.6% by Kozlowski (2006), 24.9-32.6% by Canbolat (2012), 34.1-40.1% by Tosunoglu (2014), 36.4-45.1% by Akdeniz et al. (2003), 36.89-49.65% by Ozmen (2017), 30.1-37.4% by Kır and Dursun Şahan (2019). The difference between the ADF ratios obtained in this study and the ADF ratios in the other studies was probably related to the differences in cultivars used and ecologies of experimental sites. The ADF ratio is inversely proportional to digestibility, thus cultivars with low ADF ratio can be expressed as cultivars of higher quality. The high NDF ratio in forage decreases the forage consumption by animals (Yavuz, 2005; Kır and Dursun Şahan, 2019).

Table 3. Mean ADF, NDF, TDN and RFV values of some silage sorghum and sorghum-sudangrass hybrid cultivars.

Cultivars	ADF (%)	NDF (%)	TDN (%)	RFV
Greengo	36.68 d*	55.79 d	54.00 a	100.56 a
Teide	40.29 b	58.69 b	49.34 c	91.14 c
Aneto	38.71 c	57.78 c	51.38 b	94.55 b
Rox	41.81 a	60.12 a	47.37 d	87.14 d
Nutri Honey	36.64 d	56.51 d	54.05 a	99.33 a
Sugar Graze II	42.41 a	57.54 c	46.60 d	90.29 c

According to the results, Rox cultivar had the highest NDF ratio (60.12%). Nutri Honey (56.51%) and Greengo (55.79%) cultivars had the lowest NDF ratios in this research (Table 3). In studies on sorghum, the NDF ratios were found to be 45.1-58.0% by Siefers et al. (1997), 55.7-59.3% by Kozlowski (2006), 66.2-75.9% by Karadas (2008), 50.3% by Marsalis et al. (2010), 46.6-55.9% by Canbolat (2012), 62.7-72.1% by Tosunoglu (2014), 62.5-74.0% by Akdeniz et al. (2003), 55.81-76.11% by Ozmen (2017), 44.6-57.2% by Kir and Dursun Sahan (2019). The ADF and NDF ratios are the best indications of the energy capacity of a forage. The high NDF ratio in forage decreases the forage consumption by animals (Yavuz, 2005). Delaying the harvest time of sorghum increases the ratio of cellulosic structures, a cell wall component. The differences among the NDF ratios reported by different researchers may be due to the differences in the ecologies of research areas, as well as the harvesting during different maturity periods.

The TDN refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage (Surmen et al., 2011). As ADF increases, there is a decline in TDN which means that animals are not able to utilize the nutrients that are present in the forage (Aydin et al., 2010). The differences among the TDN values of the cultivars were found to be statistically significant in this research. The highest TDN values were obtained from Greengo (54.00%) and Nutri Honey (54.05%) cultivars. Sugar Graze II

(46.60%) and Rox (47.37%) cultivars had the lowest TDN values (Table 3).

The RFV is an index that is used to predict the intake and energy value of forages. This index is derived from the digestible dry matter (DDM) and dry matter intake (DMI). Forages with a RFV value of >151, 150-125, 124-103, 102-87, 86-75, and <75 are categorized as prime, premium, good, fair, poor and rejected, respectively (Lithourgidis et al., 2006). In this research, the highest RFV values were determined Greengo (100.56) and Nutri Honey (99.33) cultivars, while the lowest RFV value was found in Rox cultivar (87.14). The relative feed value is not a direct measure of the nutritional content of forage, but it is important for estimating the value of forage (Van Soest, 1982). Ozmen (2017) reported that RFV values of sorghum varied between 61.39 and 99.87 in Bingöl. Researcher stated that the highest RFV value was obtained from Greengo cultivar (99.87). These results are similar to our results. Canbolat (2012) reported that RFV values of sorghum varied between 105.8 and 138.7 in Bursa. These values are higher than our results.

4. Conclusion

In this study, the yield and quality components of sorghum and sorghum-sudangrass hybrid cultivars were determined in Uşak ecological condition. Greengo cultivar had higher herbage yield, hay yield, total digestible nutrient and relative feed values and lower ADF and NDF ratio than other cultivars. The results revealed that Greengo cultivar can be considered suitable for the Uşak and similar ecological conditions. In addition, the cultivation of sorghum and sorghum-sudangrass hybrid which will be helpful to meet the quality forage need should be increased. This trial should be repeated for at least one more year for the results to be more reliable.

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