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Investigation of Dry Herbage Yield and Some Quality Characteristics of Sorghum x Sudan Grass Hybrid Varieties Grown Under Semi-Humid Ecological Conditions

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Abstract
This research was conducted in the 2019 and 2020 growing seasons to determine the most suitable sorghum x sudan grass hybrid variety or varieties in terms of dry herbage yield and quality characteristics in Bingöl, which has a semi-humid climate. Dry herbage yield (DHY), crude protein ratio (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), dry matter digestibility (DMD), dry matter intake (DMI) and relative feed value (RFV) were determined for ten sorghum x sudan grass hybrid varieties grown in Bingöl University Faculty of Agriculture, Agricultural Application and Research Center according to coincidence blocks experimental design with 3 replications. In the varieties examined in the research, DHY varied between 12216-16397 kg ha^{-1}, CP 5.15-8.15 %, ADF 39.43-45.85 %, NDF 51.45-62.89 %, ADL 9.20-13.15 %, DMD 53.18-58.18 %, DMI 1.91-2.33 % and RFV 78.68-104.30. According to the two-year combined averages, the Master BMR variety produced a higher dry herbage yield than the other varieties. Among the varieties, the highest CP, DMI, RFV, and the lowest NDF were obtained in the Master BMR variety. It was concluded that the Master BMR variety gave high values in terms of dry herbage yield and quality characteristics in Bingöl province's ecological conditions.

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1. Introduction

Türkiye ranks first in the world in terms of the number of animals, it has not reached the desired level in the yield, production, and quality of animal products. It should be in an important place due to its location, potential, and natural ecology. However, feed, which constitutes 60-75 % of the majority of production inputs, cannot be obtained easily and cheaply. The solution to livestock feed problems is not only concentrated feed resources. In addition, the production of quality forage resources should be increased. Forage crops, which have a very important share in agricultural production, are the most important way of roughage production (Açıkgöz et al., 2005). One of the main reasons for the high forage deficit in Türkiye is the insufficiency of forage crop cultivation areas in arable agriculture. In Türkiye, 55.4 million tons of quality roughage, including grass and silage corn, is produced on 2.1 million hectares annually. The production of forage crops is approximately 13.1 million tons and 10.3 million tons from meadow-pasture areas, while the total amount of quality dry herbage produced is 23.4 million tons per year (Tuik, 2022).

The low cost of roughages such as dry grass, green feeds, and silo feeds reduces production inputs (Bilgen et al., 1996). For this reason, to meet the quality roughage requirement of animal husbandry, in addition to the improvement of meadow pastures, it is necessary to expand forage plant agriculture and increase the production of cheap and alternative roughage resources (Serin and Tan, 2001; Yolcu and Tan, 2008). Sorghum x sudangrass hybrid, which is the result of sorghum crossing with sudangrass, is a plant species with high biomass yield, wide adaptability, drought tolerant, close to maize in terms of nutritional value, and more resistant to diseases and pests (Bean et al., 2002). Sorghum x sudan grass hybrid can be grown in marginal areas due to its low water and fertilizer demand. Therefore, it is seen that it can be a very important source in closing the roughage deficit. It is one of the alternative plants that can be cultivated as a second crop. It can also be used to reduce diseases and pests in areas where sugar beet is grown (Akdoğan 2004; Avcıoğlu et al., 2009; Erdurmus et al., 2018).

Many studies have been carried out on dry herbage yield and quality characteristics of sorghum x sudangrass hybrids cultivated for energy and forage crops under different ecological conditions (Kara et al., 2019; Ateş and Atalay, 2020; Bilen and Türk, 2021; Kardeş et al., 2023). However, studies on dry herbage yield and quality characteristics of sorghum x sudan grass hybrid varieties under Bingöl ecological conditions are insufficient. Therefore, this study aimed to determine the dry herbage yield and quality characteristics of ten different sorghum x sudan grass hybrid varieties under the ecological conditions of Bingöl province.

2. Materials and Methods

The research was conducted in Bingöl, which has a semi-humid climate, in the Bingöl University Agricultural Application and Research Centre experiment area for two years in 2019 and 2020. The climatic data of Bingöl province, where the research was carried out, for the long years and the years in which the experiment was carried out were given in Table 1 (GDM, 2021). In 2019 and 2020, the average temperature of June-September, which is the vegetation period, was 24.9 ºC in both years and the long-term average temperature was 24.0 ºC. An increase of approximately 1 ºC was observed between the years in which the experiment was carried out and the long-term average temperature. Total precipitation during the vegetation period was 8.7 mm in 2019, 17.5 mm in 2020, and 46.9 mm for long years. It is seen that the rainfall was very low in the periods when the experiment was carried out compared to long years, especially in 2019. The average relative humidity is 33.6 % in 2019, 34.5 % in 2020, and 39.6 % for long years. There was no significant difference in relative humidity between the period in which the experiment was conducted and long years (Table 1).

Table 1. Climatic data of the research area for long years (1961-2018), 2019 and 2020

Years/Months	June	July	August	September	Total/Average
Average Temperature Values (^{0}C)					
Long Years (1961-2018)	21.9	26.6	26.4	21.2	24.0
2019	24.6	26.2	27.3	21.6	24.9
2020	22.4	27.0	26.5	24.0	24.9
Total Precipitation (mm)					
Long Years (1961-2018)	22.1	7.5	4.7	12.6	46.9
2019	3.6	0.5	4.6	0.0	8.7
2020	10.0	5.7	0.6	1.2	17.5
Average Relative Humidity (%)					
Long Years (1961-2018)	44.3	36.4	36.0	41.7	39.6
2019	37.8	31.8	30.5	34.3	33.6
2020	40.6	35.3	29.9	32.3	34.5

With the irregular distribution of rainfall throughout the year, the decrease in the amount of precipitation during vegetation periods, and the increase in temperature, the symptoms of drought began to be seen.

Table 2. Soil properties of the study area

Soil Texture	**Water Saturation (%)**	**EC (%)**	**pH**	**Lime (%)**	**Organic Matter (%)**	**P_2O_5 (kg da^{-1})**	**K_2O (kg da^{-1})**
Clayey-loamy	54	0.02	6.1	-	1.89	3.60	37.0

As a result of the analyses performed on the soil samples taken from 0-30 cm depth from the research area, the soil has a clayey-loamy texture. The soil was determined as slightly acidic, salt-free, and lime-free. It was found to be 'low' in terms of organic matter and poor in terms of phosphorus (P) and potassium (K) content (Table 2).

In the study, 10 sorghum x sudan grass hybrid varieties (Aneto, Greengo, Jumbo, Master BMR, Nutri Honey, Nutrima, Sugar Graze II, Supergraze 1000, Super Su 22 and Tonka) obtained from private sector companies were used. The study was established according to the randomized block design with three replications. The plot area was determined as 5 x 1.8 = 9 m^2 and four rows were placed at 45 cm row spacing. Sowing was done by hand and the seed rate was set at 4 kg da^{-1}. Fertilization was done with 10 kg da^{-1} NPK compound fertilizer at sowing and 22 kg da^{-1} Urea (46 % N) as the upper fertilizer when the plants were 40-50 cm. For aphids, 50 g l^{-1} Lambda-cyhalothrin insecticide was used once. Irrigation was carried out by sprinkler system until the emergence of the plants and then by drip irrigation. Hand hoeing was done once to control weeds. Harvesting was carried out at the dough stage of the grains.

Fresh herbage samples taken from the harvested plants were dried at 70 ºC, weighed and dry herbage yield was determined. The plant material was then ground in a 0.5-1 mm sieve and prepared for analysis. Nitrogen ratios determined by the Kjeldahl device (Kacar and Inal, 2008) were multiplied by a coefficient of 6.25 to determine the crude protein ratio. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) ratios were determined according to the method described by Van Soest (1963) and, Van Soest and Wine (1967). DMD, DMI, and RFV are determined by the following equations (Morrison, 2003).

DMD (%): 88.9 - (0.779 * % ADF)

DMI (%): 120 / (% NDF)

RFV: (DMD * DMI) / 1.29

The data obtained from the experiment were analyzed by using JMP statistical software according to the random blocks experimental design. According to the results of variance analysis, the differences between the means were determined by the LSD multiple comparison test.

3. Results and Discussion

The mean values of DHY, CP, ADF, NDF, ADL, DMD, DMI, and RFV of sorghum x sudangrass hybrid varieties were given in Table 3,4,5,6.

Table 3. Mean values of DHY and CP parameters of sorghum x sudangrass hybrid varieties

	DHY (kg ha^{-1}) **			CP (%) **		
	2019	2020	Mean	2019	2020	Mean
Aneto	14071	15971	15021 b	6.93	7.57	7.25 de
Greengo	14691	16108	15399 b	7.47	6.52	7.00 e
Jumbo	14847	16247	15547 b	8.23	7.40	7.82 bc
Master BMR	15896	16898	16397 a	8.43	7.87	8.15 a
Nutri Honey	12762	11706	12234 e	8.17	7.37	7.77 bc
Nutrima	14172	16039	15106 b	8.33	7.95	8.14 a
Sugar Graze II	13869	12810	13339 d	5.76	4.53	5.15 f
Supergraze 1000	13424	12700	13062 d	7.50	8.33	7.92 ab
Super Su 22	11519	12914	12216 e	7.33	7.97	7.65 bc
Tonka	13882	14542	14212 c	7.57	7.47	7.52 cd
Mean	13913 b	14593 a		7.57 a	7.29 b	
CV (%)		3.89			3.46	

[a, b, c.] Differences between means indicated by different letters in the same row ; **:p< 0.01 significant. DHY: dry herbage yield, CP: crude protein

It was determined that there was significant ($p<0.01$) variation in terms of dry herbage yield in terms of years, varieties, and year x variety interaction. The average dry herbage yield was 13913 kg ha^{-1} in the first year and 14593 kg ha^{-1} in the second year. Dry herbage yield among the varieties varied between 12216-16397 kg ha^{-1}, the lowest yield was obtained from Super Su 22 (12216 kg ha^{-1}) and Nutri Honey (12234 kg ha^{-1}), which were statistically in the same group, and the highest yield was obtained from Master BMR variety with 16397 kg ha^{-1}. In terms of dry herbage yield of sorghum x sudangrass hybrid varieties, Master BMR variety stood out. This shows that the variety is better adapted to environmental conditions. In many studies conducted with sorghum x sudangrass hybrid varieties, significant differences were recorded between dry herbage yields. For example, dry herbage yield was determined as Çoban and Acar 2018 (1794-2581 kg da^{-1}), Kara et al., 2019 (1003-1701 kg da^{-1}), Ateş and Atalay 2020 (528-4542 kg da^{-1}), Bilen and Türk 2021 (1177-1314 kg da^{-1}) ve Erecek et al., 2023 (1814-2004 kg da^{-1}). The genotype differences, location, slope, orientation, altitude, climatic factors during the vegetation period, and soil structure affect the yield and some quality characteristics of the plant. It was found that the variations were significant ($p<0.01$) among years, varieties, and year x variety interactions in terms of crude protein ratio. The average CP rate was 7.57 % in the first year and 7.29 % in the second year. The CP ratio between the varieties varied between 5.15-8.15 %. In terms of this parameter, Sugar Graze II (5.25 %) had the lowest CP rate, Master BMR (8.15 %), and Nutrima (8.14 %), which were statistically in the same group, had the highest CP rate. According to Adesogan (2006), the crude protein content of sorghum should be more than 8 %. In this case, Master BMR and Nutrima varieties had a rate higher than 8 %. In previous studies, some researchers, Nazlı et al., 2013, Karadağ and Özkurt 2014, Dursun Sahan 2017, Canyigit and Okant 2018, Budak and Kır 2019, Yıldırım and Bengisu 2019 determined the crude protein ratio as 10.0-10.5 %, 9.5-11.0 %, 7.8-10.5 %, 9.1-13.1 %, 12.0-12.9 %, 14.1-16.2 % respectively. The difference in crude protein ratio may be because the ecologies in which the trials were conducted, the genotypes used and the plant growth stages in the harvest periods were not the same.

Table 4. Mean values of ADF and NDF parameters of sorghum x sudan grass hybrid varieties

	ADF (%) **			NDF (%) **		
	2019	2020	Mean	2019	2020	Mean
Aneto	40.63	39.43	40.03 def	56.77	55.80	56.28 ef
Greengo	42.26	38.77	40.52 cd	59.47	58.25	58.86 c
Jumbo	45.26	43.24	44.25 b	60.40	59.39	59.90 b
Master BMR	40.35	39.83	40.09 def	51.90	51.00	51.45 g
Nutri Honey	42.70	39.31	41.01 c	57.70	54.13	55.92 f
Nutrima	42.72	38.17	40.45 cd	58.97	56.40	57.69 d
Sugar Graze II	44.90	46.80	45.85 a	62.36	63.42	62.89 a
Supergraze 1000	40.13	38.77	39.45 ef	58.69	55.40	57.05 de
Super Su 22	40.57	39.83	40.20 de	59.60	55.50	57.55 d
Tonka	40.13	38.73	39.43 f	57.38	55.10	56.24 ef
Mean	41.96 a	40.28 b		58.32 a	56.43 b	
CV (%)		1.56			1.35	

[a, b, c.] Differences between means indicated by different letters in the same row ; **:p< 0.01 significant. ADF: acid detergent fiber, NDF: neutral detergent fiber

The ADF ratio was found to be statistically significant at the level of p<0.01 for years, varieties, and year x variety interactions. In this respect, ADF, which was 41.96 % in the first year of the experiment and 40.28 % in the second year, varied between varieties as 39.43-45.85 %. The lowest ADF rate was obtained from Tonka (39.43 %) and the highest was obtained from Sugar Graze II (45.85 %). As a result of the analysis of variance, it was found that there were significant differences between years, varieties, and year x variety interactions in terms of NDF ratio (p<0.01). The mean values were 58.32 % in the first year and 56.43 % in the second year of the study, and this trait varied between 51.45-62.89 % among the varieties. The lowest NDF rate was determined in the Master BMR (51.45 %) variety, while the highest NDF rate was determined in the Sugar Graze II (62.89 %) variety. ADF value gives an idea about the digestibility of feed. NDF ratio, which is composed of cell wall components, is also desired to be low as in ADF. The ADF, NDF and ADL ratios obtained in the studies conducted by some researchers and the data obtained in this study are compatible with each other (Güven, 2017; Kır and Dursun Sahan, 2019; Bilen and Türk, 2021; Erecek et al., 2023).

Table 5. Mean values of ADL and DMD parameters of sorghum x sudangrass hybrid varieties

	ADL (%) **			DMD (%) **		
	2019	2020	Mean	2019	2020	Mean
Aneto	9.83	8.56	9.20 e	57.25	58.18	57.72 abc
Greengo	10.60	8.43	9.52 de	55.98	58.70	57.34 cd
Jumbo	12.10	11.78	11.94 b	53.65	55.21	54.43 e
Master BMR	9.87	8.73	9.30 e	57.47	57.87	57.67 abc
Nutri Honey	11.17	10.07	10.62 c	55.63	58.28	56.96 d
Nutrima	11.43	10.57	11.00 bc	55.62	59.17	57.39 cd
Sugar Graze II	12.63	13.67	13.15 a	53.92	52.44	53.18 f
Supergraze 1000	10.63	10.25	10.44 cd	57.64	58.70	58.17 ab
Super Su 22	11.63	11.11	11.37 bc	57.30	57.87	57.58 bc
Tonka	11.66	10.36	11.01 bc	57.64	58.73	58.18 a
Mean	11.15 a	10.35 b		56.20 b	57.51 a	
CV (%)		8.16			0.88	

[a, b, c.] Differences between means indicated by different letters in the same row ; **:p< 0.01 significant. ADL: acid detergent lignin, DMD: dry matter digestibility

Significant differences were found between years and varieties in terms of ADL ratio (p<0.01), while year x variety interaction was not significant. The average ADL was 11.15% in the first year and 10.35 % in the second year; this value varied between varieties as 9.20-13.15 %. The lowest ADL rate was obtained from Aneto (9.20 %) and Master BMR (9.30 %) varieties and the highest ADL rate was obtained from Sugar Graze II (13.15 %) varieties. As a result of statistical analysis, significant differences were found between

years, varieties, and year x variety interactions at p<0.01 level for DMD. DMD average was 56.20 % in the first year and 57.51 % in the second year. DMD rate varied between varieties as 53.18-58.18 %. The lowest DMD rate was found in Sugar Graze II (53.18 %) and the highest DMD rate was found in Tonka (58.18 %).

Table 6. Mean values of DMI and RFV parameters of sorghum x sudangrass hybrid varieties

	DMI (%) **			RFV **		
	2019	2020	Mean	2019	2020	Mean
Aneto	2.11	2.15	2.13 bc	93.82	97.02	95.42 b
Greengo	2.02	2.06	2.04 e	87.59	93.74	90.67 e
Jumbo	1.99	2.02	2.00 f	82.64	86.48	84.56 f
Master BMR	2.31	2.35	2.33 a	103.03	105.57	104.30 a
Nutri Honey	2.08	2.22	2.15 b	89.70	100.15	94.93 bc
Nutrima	2.03	2.13	2.08 d	87.74	97.59	92.66 d
Sugar Graze II	1.92	1.89	1.91 g	80.44	76.92	78.68 g
Supergraze 1000	2.05	2.17	2.11 cd	91.38	98.57	94.98 bc
Super Su 22	2.01	2.16	2.09 d	89.47	97.00	93.24 cd
Tonka	2.09	2.18	2.13 bc	93.44	99.16	96.30 b
Mean	2.06 b	2.13 a		89.92 b	95.22 a	
CV (%)		1.34			1.61	

[a, b, c.] Differences between means indicated by different letters in the same row; **:p< 0.01 significant. DMI: dry matter intake, RFV: relative feed value

Statistically years, varieties, and year x variety interactions were found statistically significant at p<0.01 level in terms of DMI ratio. The average DMI ratio was 2.06 % in the first year and 2.13 % in the second year. This value was determined as 1.91-2.33 % among the varieties. The highest DMI rate was obtained from Master BMR (2.33 %) and the lowest DMI rate was obtained from Sugar Graze II (1.91 %). Significant differences (p<0.01) were found in terms of RFV according to years, varieties, and year x variety interactions. The average RFV was 89.92 in the first year and 95.22 in the second year. RFV between varieties was determined as 78.68-104.30. The highest RFV was found in Master BMR (104.30) and the lowest RFV was found in Sugar Graze II (78.68). According to the classification of Linn and Martin (1989), sorghum x sudangrass hybrid varieties were classified as medium quality in terms of DMD, DMI ratios, and RFV. The values obtained in the studies conducted by Özmen (2017) and, Bilen and Türk (2021) are similar to the values obtained in this study.

4. Conclusion

Dry herbage yield and quality characteristics of ten sorghum x sudan grass hybrid varieties were determined under ecological conditions of Bingöl Province. It was observed that there were statistically significant differences between the varieties in terms of dry herbage yield and all quality parameters (CP, ADF, NDF, ADL, DMD, DMI, and RFV). The highest dry herbage yield, CP, DMI ratio, and RFV were obtained from the Master BMR variety. The lowest ADF rate was obtained from the Tonka variety and the lowest NDF rate was obtained from the Master BMR variety. Therefore, it was concluded that the Master BMR variety gave the highest values in terms of dry herbage yield and quality characteristics of sorghum x sudan grass hybrid varieties examined in Bingöl province ecological conditions. It is recommended that this variety should be prioritized in terms of cultivation in Bingöl and regions with similar ecological conditions.

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