



Research Article

Yield and quality characteristics of pastures with different plant densities

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Abstract

This study was carried out to determine the yield and quality characteristics of Aciyurt pastures with different plant densities in Ulaş district of Sivas province in the Central Anatolia Region of Türkiye. For this purpose, to determine the vegetation's plant density, 10 m resolution Sentinel 2A satellite images of April and May 2021 were used, NDVI data were created and 4 different vegetation densities (very high, high, medium and very low) were determined. Hay yield, botanical composition, and forage quality characteristics differed significantly among pastures with different plant densities, with hay yield ranging from 1.662 to 4.292 tons/ha and the highest overall performance was observed in pastures with very high plant density. The findings indicate that the very high plant density pastures were best for hay yield and quality within the borders of Ulaş and Altinyayla districts of Sivas province.

Keywords: ADF, Hay yield, NDF, Pasture, Plant densities.

Introduction

Meadows and pastures, which have influenced human destiny throughout history, are significant not only in agricultural frameworks but also in the economic resources of nations worldwide today (Genckan, 1992). The sustainable utilization of natural resources has emerged as a critical issue owing to the finite nature of these resources, the burgeoning global population, and climate change. Meadow pasture lands, characterized by their extensive biodiversity, are among the most significant natural resources, providing inexpensive and high-quality roughage for cattle (Surmen and Koc, 2016; Bhutia *et al.*, 2024).

The Turkish Statistical Institute reports that Türkiye has 13.2 million hectares of pastureland, with a total meadow-pasture area of 14.6 million hectares. Eastern, Central, and Southeastern Anatolia, including approximately 78% (10.3 million ha) of Türkiye's total pasture land, mostly experiences prolonged or intermittent droughts throughout the year. The majority of Türkiye's natural pastures are situated in dry and semi-arid climatic regions (Gokkus, 2014; Seydosoglu *et al.*, 2019; Yildiz and Cacan, 2023). The studies conducted across Türkiye indicate that pastures are overgrazed and that the number

of animals exceeds their carrying capacity, resulting in insufficient roughage to meet the needs of the existing livestock given the current productivity levels (Yavuz *et al.*, 2008; Aydin, 2014; Dixit *et al.*, 2015; Cacan *et al.*, 2016; Sahinoglu and Uzun, 2016).

The nutritional value of feed derived from meadow pasture and forage crop cultivation is contingent upon grass quality; factors such as palatability, consumption, digestibility, presence of harmful compounds (toxins, etc.), chemical and morphological composition, as well as energy and protein content, influence feed quality. Furthermore, environmental climatic factors (including temperature and precipitation), season, grass-legume ratio in vegetation, elevation, and orientation are determinants of the quality of the obtained feed (Theunissen, 1995; Ball *et al.*, 2001; Ganskopp and Bohnert, 2001; Kirilov, 2001; Kaya, 2008; Singh *et al.*, 2023; Mir *et al.*, 2024). Recent research has also emphasized that pasture plant density is closely associated with botanical composition and pasture performance (Saygin *et al.*, 2025). This study was carried out to determine the yield and quality characteristics of pastures with different plant densities located within the borders of Ulaş and Altinyayla districts of Sivas province.

Materials and Methods

Study area and climate conditions: The study area, located within the borders of Ulaş and Altinyayla districts of Sivas province, mainly covers the pastures of Aciyurt village in Ulaş district. The area extends approximately between 39.35°-39.41° N latitudes and 37.00°-37.17° E longitudes, covering about 1,849.21 ha. The elevation of the study area ranges from 1635 m to 1938 m above sea level (Fig 1). Although most of Sivas Province lies in Central Anatolia, it does extend into Eastern Anatolia and the Black Sea regions. Its Kizilirmak, Yesilirmak, and Firat basins make up a significant portion of its overall area. When compared to other Turkish cities, its area ranks second, behind only Konya. Over a thousand meters is the average elevation of Sivas province. Mountains, valleys, plains, and plateaus make up the city's landscape. The plains and valleys are spread between the mountains, while the plateaus and high areas are naturally produced. The majority of Sivas province is composed of plateaus. Out of the total land area, 47.6% is plateau, 46.2% is mountain, and 6.2% is plain. Sivas experiences severe, hard winters with heavy snowfall. Hot and dry spells characterize the summer months, while spring and fall are prime times for rainstorms. Looking at climatic data over longer periods of time, January is the coldest month with -34.6°C. July had the highest temperature of 38.3°C. The average monthly rainfall was also highest in May and lowest in August. Annual temperatures range from 8 to 12°C, while rainfall averages 460 to 470 millimeters (Anonymous, 2024).

Hay yield and botanical composition: Before grazing began in the spring, 2x2 m wire cages were placed at 3 randomly selected locations in each area with different plant densities. After the plants under the cage completed their vegetative growth and development, the cages were removed and 3 pieces of 33 x 33 cm squares were placed under each cage and the herbage were harvested from the ground level. The herbage samples cut from the cages in the pastures with different plant densities and separated into groups (grasses, legumes and other plant families) were weighed separately after being dried for 24 hours in a drying cabinet set at 78°C. The total dry weights of the herbage samples belonging to the three plant groups (grasses, legumes and other plant families) were recorded as the dry herbage yield. This value was then converted to dry herbage yield per hectare. Dry herbage values of plant groups determined in each cage were proportioned to the total dry herbage yield determined in the cage in question, the contribution rates of different plant groups to dry herbage yields were determined as a percentage (%), and the botanical composition value was determined according to the average weight.

Crude protein rate and yield: Dried herbage samples from each set were ground and the nitrogen content in the samples was determined with a semi-automatic Kjeldahl device. The determined nitrogen rates were multiplied by a coefficient of 6.25 to determine the crude protein rate in the dry herbage (Anonymous, 1995). The crude protein content in the dry herbage was multiplied by the dry herbage yields per hectare to calculate the crude protein yields per hectare.

The other quality parameters: The NDF (neutral detergent fiber) contents of the hay samples were analyzed according to Van Soest and Wine (1967), and the ADF (acid detergent fiber) content was analyzed according to Van Soest (1963) using the ANKOM 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA). The digestible dry matter (DDM) ratio was calculated using the ADF ratio, and the dry matter intake (DMI) ratio was calculated using the NDF ratio and RFV was calculated as follows (Morrison, 2003).

$$\text{Digestible Dry Matter (DDM)} = 88.9 - (0.779 \times \text{ADF})$$

$$\text{Dry Matter Intake (DMI)} = 120 / (\text{NDF})$$

$$\text{Relative Feed Value} = (\text{DDM} \times \text{DMI}) / 1.29.$$

Data analysis: The trial data were analyzed using a randomized complete block design and the JMP statistical package program (JMP, 2005). The

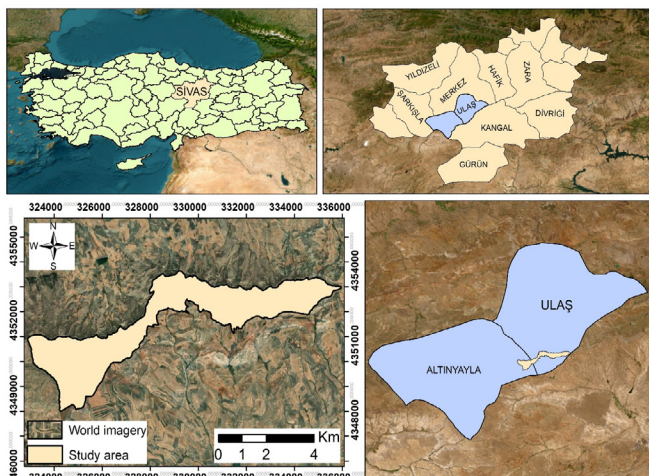


Fig 1. Study area location map

LSD test was used to evaluate the significance of differences among the averages.

Results and Discussion

Hay yield, ratio of grasses, legumes and other family plants in hay in the pastures: The pastures with different plant densities examined were found to be statistically significant at the 1% level in terms of hay yield, the ratio of grasses, legumes and other family plants in hay.

The highest hay yield (4.292 tons/ha) was found in pastures with very high plant density, while the lowest hay yield (1.662 tons/ha) was found in pastures with very low plant density. The average hay yield of pastures was 2.760 tons/ha (Table 1). In our previous studies on the yields of pastures in different provinces of Türkiye, it was reported that the pasture yields were 2.806-7.727 tons/ha in Mustafabeyli pasture, Ceyhan-Adana (Hatipoglu *et al.*, 2001), 1.141–4.741 tons/ha in Adana (Kokten *et al.*, 2003), 2.70–8.73-tons/ha in the upland site of rangeland (Cinar *et al.*, 2005), 1.181–5.254 tons/ha in the bottomland site of rangeland (Hatipoglu *et al.*, 2005) of Hanyeri village, Tufanbeyli-Adana, 2.580–3.253 tons/ha in Karapolat Village, Yedisu-Bingol (Agin and Kokten, 2013), 4.65 tons/ha in Cicekyayla village, Bingol (Cacan and Kokten, 2014), 1.413–2.823 tons/ha in Bahcecik Village, Karakocan-Elazig (Tasdemir and Kokten, 2015), 1.293-2.320 tons/ha in Ormanardi village, Bingol (Tutar *et al.*, 2018), 6.94–5.274

tons/ha in Agricultural Research and Practice Center, Bingol (Cacan and Kokten, 2019), and 3.04–5.60 tons/ha in Kiyibasi village, Mus (Kokten and Tanriverdi, 2020). As seen in Table 1, the highest ratio of grasses in hay was found in pastures with very high (61.9%) and high (62.7%) plant densities, while the lowest ratio of grasses in hay was found in pastures with medium (52.3%) and very low (51.3%) plant densities. The average ratio of grasses in hay of the examined pastures was 57.1%. On the other hand, the highest ratio of legumes in the hay was found in pastures with very high plant density (21.4%), while the lowest ratio of legumes in the hay was found in pastures with very low plant density (5.2%). It was vice versa in terms of other family plants. The averages of the ratio of legumes and other family plants in the hay of the examined pastures were obtained as 12.1 and 30.8%, respectively. In dry herbage of the Bingol-Ormanardi village pasture, it was reported that the grasses, legumes and other family plants were 67.5, 0.5 and 32.0%, respectively (Tutar *et al.*, 2018), while in the study of botanical composition in dry herbage of the Bingol-Cicekyayla village pasture, it was reported to be 29.61, 4.08 and 66.31%, respectively (Cacan and Kokten, 2014). On the other hand, the botanical composition in dry herbage of the Elazig/Karakocan-Bahcecik village pasture was reported that the grasses, legumes and other family plants were 72.5, 0.3 and 27.2%, respectively (Tasdemir and Kokten, 2015), while botanical composition in dry herbage of the Bingol/Yedisu-Karapolat village pasture was reported to be 35.7, 17.5 and 46.8%, respectively (Agin and Kokten, 2013).

Table 1. Averages of the hay yield, the ratio of grasses, legumes and other family plants in hay of pastures with different plant densities

Plant densities	Hay yield (tons/ha)	Grasses in hay (%)	Legumes in hay (%)	Other family plants in hay (%)
Very high	4.292 A**	61.9 A**	21.4 A**	16.7 D**
High	2.708 B	62.7 A	11.8 B	25.5 C
Medium	2.377 C	52.3 B	9.9 C	38.8 B
Very low	1.662 D	51.3 B	5.2 D	42.5 A
Average	2.760	57.1	12.1	30.8

** ($p \leq 0.01$)

Table 2. Averages of crude protein yield, crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), dry digestible matter (DDM), dry matter intake rates (DMI), and relative feed value (RFV) of pastures with different plant densities

Plant densities	Crude protein yield (tons/ha)	Crude protein (%)	ADF	NDF	DDM	DMI	RFV
Very high	0.592 A**	13.8 A**	34.7 B**	57.2	61.9 A**	2.10	100.5 A*
High	0.313 B	11.6 B	34.1 B	58.5	62.3 A	2.05	99.1 A
Medium	0.253 C	10.7 C	39.3 A	58.5	58.3 B	2.05	92.8 B
Very low	0.158 D	9.5 D	35.3 B	57.6	61.4 A	2.09	99.3 A
Average	0.329	11.4	35.9	58.0	61.0	2.07	97.9

* ($p \leq 0.05$); ** ($p \leq 0.01$)

Quality characteristics of the hay of the pastures examined: Crude protein yields, crude protein, ADF and DDM ratios of the pastures with different plant densities were found to be statistically significant at the 1% level, the RFV value was found to be statistically significant at the 5% level, and the NDF and DMI ratios were found to be statistically insignificant. The averages of the quality characteristics determined in the hay of pastures with different plant densities are given in Table 2.

Looking at Table 2, it was seen that the highest crude protein yield and rate were obtained from the pasture with very high plant densities, at 0.592 tons/ha and 13.8%, respectively, while the lowest crude protein yield and ratio were obtained from pastures with very low plant density, with 0.158 tons/ha and 9.5%, respectively. In our previous studies conducted in different pastures of Türkiye, it was reported that the crude protein yield and rates were 0.167–2.3 tons/ha and 9.9–12.9%, respectively, in Bingöl/Ormanardı village pasture (Tutar *et al.*, 2018), 0.0733 tons/ha and 16.08%, respectively, in Bingöl/Cicekyayla village pasture (Cacan and Kokten, 2014), 0.154–0.265 tons/ha and 9.4–12.2%, respectively, in Elazığ/Karakocan-Bahcecik village pasture (Tasdemir and Kokten, 2015), 0.0331–0.0768 tons/ha and 10.93–14.37%, respectively, in Mus-Kiyibasi village pasture (Kokten and Tanriverdi, 2020), and 0.198–0.330 tons/ha and 7.6–10.1%, respectively, in Bingöl/Yedisu-Karapolat village pasture (Agin and Kokten, 2013). On the other hand, in a study conducted in natural pastures in different provinces of Türkiye, it was reported that crude protein values varied between 0.97–3.18 g/kg (Karadavut *et al.*, 2015).

As seen in the table, the highest ADF rate was found in pastures with medium plant density (39.3%), while the lowest ADF rates were found in pastures with very high (34.7%), high (34.1%) and very low (35.3%) plant density. On the other hand, NDF and DMI ratios of the hay of pastures with different plant densities varied between 57.2–58.5% and 2.05–2.10%, respectively (Table 2). In our previous studies on the yields of pastures in different provinces of Türkiye, it was reported that the ADF and NDF rates were 34.8–37.4 and 52.5–62.7%, respectively, in Bingöl-Ormanardı village pasture (Tutar *et al.*, 2018), 34.0–37.0 and 49.0–56.0%, respectively, in Elazığ/Karakocan-Bahcecik village pasture (Tasdemir and Kokten, 2015), 21.2–34.0 and 57.0–59.8%, respectively, Mus-Kiyibasi village pasture (Kokten and Tanriverdi, 2020), and 38.2–47.9 and 51.4–66.9%, respectively, in Adana/Ceyhan-Mustafabeyli pasture (Hatipoglu *et al.*, 2001).

As seen in Table 2, the highest DDM ratios and RFV values were found in pastures with very high, high and very low plant densities, while the lowest DDM ratios and RFV values were found in pastures with medium plant density. In the study on the quality of the Bingöl-

Ormanardı village pasture, it was reported that the DDM, DMI rates and RFV in dry herbage were 59.7–61.7%, 1.92–2.08% and 91.8–109.4, respectively (Tutar *et al.*, 2018), while in the study where the quality in dry herbage of the Elazığ/Karakocan-Bahcecik was determined, it was reported to be 60.1–62.4%, 2.17–2.52% and 103.0–118.4, respectively (Tasdemir and Kokten, 2015). On the other hand, in the study where the quality in dry herbage of the Mus-Kiyibasi village pasture was determined, it was reported that the DDM, DMI rates and RFV were 62.4–72.3%, 2.0–2.1% and 102.0–112.5, respectively (Kokten and Tanriverdi, 2020).

Conclusion

Hay yields, botanical composition in the hay and quality characteristics of the hay were investigated in pastures with different plant densities within the borders of Ulas and Altinyayla districts of Sivas province. The averages of hay yield and botanical composition (grasses, legumes and other family plants) ratios in the hay were found to be 2.760 tons/ha, 57.1, 12.1 and 30.8%, respectively, while the quality values of the hay were obtained as crude protein yield, crude protein, ADF, NDF, DDM and DMI rates and RFV values as 0.329 tons/ha, 11.4, 35.9, 58.0, 61.0 and 2.07%, and 97.9, respectively. When all these data were examined, it was concluded that the best pasture in terms of hay yield and quality was the pasture with very high plant density.

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