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EFFECTS OF ANIMAL GRAZING ON ALLOWED FORAGE YIELD AND QUALITY OF RANGELANDS WITH DIFFERENT SLOPE

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ABSTRACT

This study conducted between 2016 and 2017 in the Kosk Village of Yakutiye District of Erzurum Province, Turkey on rangeland sites with 4 different slopes (0-10%, 10-30%, 30-60 and 60% and above). In the research, current allowed forage yield and some forage quality characteristics of rangeland sites with different slope degrees were investigated. It was determined that the forage yield of rangeland sites decreased in steep slope rangeland sites and increased in slightly sloping rangeland sites. It was determined that the effect of different sloping degrees on some forage quality was important. Slightly slope rangeland sites, forages had higher crude protein content, while steep slope rangeland sites had higher ADF and NDF ratio. Also, it was calculated that the Relative Feed Value (RFV) in the rangelands decreased due to the increase in slope. According to the obtained results, it reveals the necessity to practice appropriate management such as the proper intensity of grazing, especially in sloping areas to ensure sustainable rangeland use.

Keywords: Allowed forage yield, forage quality, rangelands, slope

INTRODUCTION

The rangeland culture is as old as human history, and have an important place in terms of social, economic, and cultural activities of human beings besides animal production. Approximately 26% of the world's surface area consists of natural rangelands (Anonymous, 1991) and the share of rangeland areas in the surface area of our country is 18.7% and 30% in the Eastern Anatolia region (TUIK, 2018). In the Eastern Anatolia region, rangeland-based animal husbandry is the locomotive of regional agriculture due to its high altitude, rugged topography, and short growing period (Koc et al., 2007).

Grazing is the most economical way to benefit from rangeland ecosystems. Although rangelands have crucial importance for regional agriculture, there is significant deterioration in this region as in the country, due to mismanagement principles. Early spring and late autumn grazing and heavy grazing are the main causes of this degredation (Koc, 1995). Rangeland vegetation is destroyed by the effect of heavy grazing, and as a result, increases the density of low-quality plants, which not be effective in soil conservation, the canopy becomes sparse, as well as the forage production decreases (Holechek et al., 2004; Koc et al., 2005; Severoglu, 2018).

Although the slope has a negative effect on the animal distribution (Lyons and Machen, 2015), the negative effect of grazing increases as the environmental factors are negatively affected by the increasing slope (Sen et al., 2017). Researches conducted in different regions showed that plant cover was sparsed, the species component changed, the rate of undesired species increased, and the feed quality was negatively affected with the increasing slope under inappropriate grazing pressure (Allen-Diaz and Jackson, 2000; Tamartash et al., 2007; Gullap, 2010; Karan and Basbag, 2018).

The forage alowance may be defined as the existing feed in the rangeland during the grazing season. While, during the active plant growth period, the forage allowance in the rangelands increases depending on appropriate grazing management, after the growth period it shows decreasing trends regularly until the end of the grazing season (White et al., 1991; Koc et al., 2000). It is recommended that a certain amount of biomass should be remained in the rangeland to protect the rangeland soil from erosion and to maintain active growth of vegetation (Altin et al., 2005), for example, the amount of biomass to be left in rangelands with short plants should be around 400 kg ha^{-1} (Molinar et al., 2001).

Feed quality is negatively affected as the crude protein content decreases in rangeland and the fiber (NDF, ADF) components increase. In a study conducted in the Palandoken Mountains (Koc et al., 2000; Dasci et al., 2010; Erkovan et al., 2010; Koc, 2013), it was determined that the crude protein content was higher in the bottom and the ridge than the slope and the crude cellulose (fiber)

ratio was lower. Similar results have been reported by Cinar (2001) and Dasci (2008).

Allowed forage amount and quality are important for adequate and balanced nutrition of animals. In this study, it was aimed to reveal the appropriate grazable forage amount and quality in rangelands with different slope in the Kargapazari Mountain rangelands. In this regard, the obtained results from this study will contribute to the effective grazing plans depending on the slope.

MATERIALS AND METHODS

This study was carried out on rangelands with different slopes that used for cattle grazing, in 2016 and 2017, in Kosk Village of Yakutiye District of Erzurum Province. The rangeland area was separated into four different sloping groups. All rangeland sites were located in the north aspect. Accordingly, the general characteristics of determined rangeland sites were as follows: First rangeland site (I.) 0 - 10%, second one (II.) 10 - 30%, the third one (III.) has a slope of 30 - 60% and the fourth one (IV.) had a slope of 60% and above.

In study sites, a total of 78 plant species was determined. Dominant plant species were sheep fescue (*Festuca ovina*), intermediate wheatgrass (*Agropyron intermedium*) and mountain timothy (*Phleum montanum*) from grasses, milkvetch species (*Astraglus sp.*) from legumes and tanacetum (*Tanacetum abrotanifolium*), Lady's bedstraw (*Galium verum*) and felty germander (*Teucrium polium*) from other families. In pasture sites with 0-10%, 10-30%, 30-60% and 60% and above slopes, canopy coverage ratios were determined as 62.44%, 50.45%, 32.18% and 13.16%, respectively.

According to the long-term average, the average temperature and average relative humidity and total precipitation values were presented in Figure 1. In the first study year, while more rainfall was recorded compared to the long-term average, the second year was lower (Figure 1).

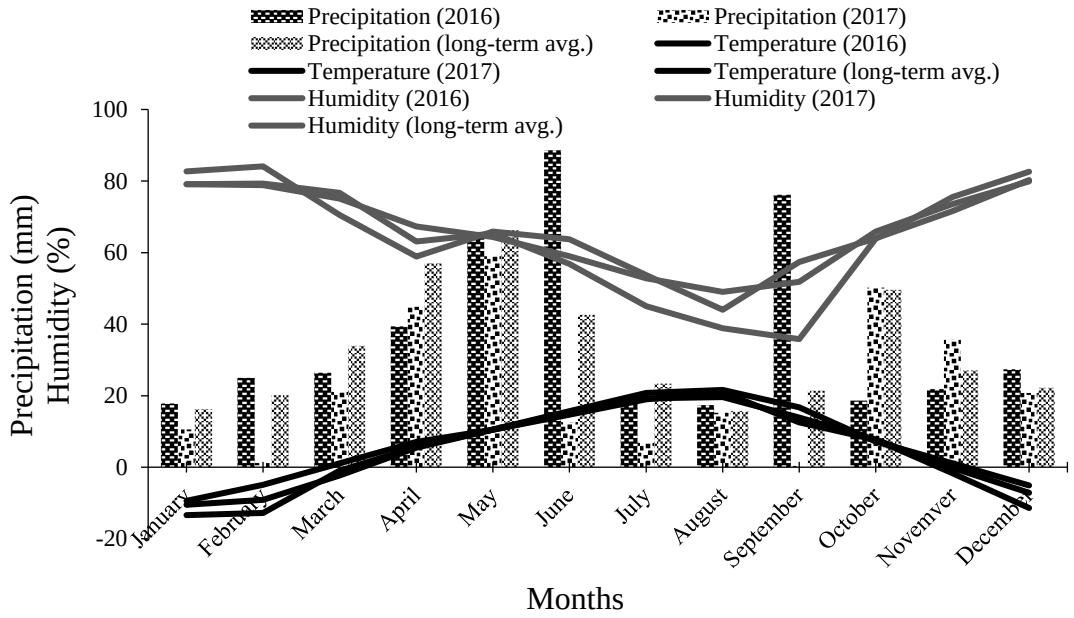

Figure 1. Some climate data of Yakutiye district of Erzurum Province in 2016, 2017, and long-term average (LTA).

Soil samples were taken from the rangeland sites with different slope of the research area (0-10%, 10-30%, 30-60%, and 60% and above), and soil texture and structure were determined using the Bouyoucos hydrometer method, aggregate stability (AS) values were determined using Yoder type, a wet-sieving tool (Demiralay, 1993), soil pH values were measured with a pH meter with a glass electrode (Saglam, 1994). The electrical conductivity (EC) was determined using an EC meter device in a soil-pure water solution (Gulcur, 1974), organic matter (OM) contents of soil samples were determined according to the method specified by Aydin and Sezen 1995, the available phosphorus (P_2O_5) was determined according to the method of molyphosphosphoric blue color (Olsen and Summer, 1982) and potassium (K), sodium (Na), and calcium (Ca) contents were determined using the solution made by ammonium acetate method in lame photometry (Saglam, 1994).Analysis results of some soil physical and chemical properties of the study areas were presented in Table 1.

In each rangeland sites, slopes were determined by the clinometer, forage samplings were taken at the flowering period of dominant species. 10 sampling areas, with a size of 0.5 x 0.5 m, were harvested and dried at 70 ^{0}C until reaching a constant weight (Sleugh et al., 2000), and then for each rangeland site samples were weighed and the remaining forage amount, after grazing, was calculated.

Table 1. Some physical and chemical properties of soil in the study areas

Rangeland Sites	%0 – 10	%10 – 30	%30 – 60	%60 - above
% Clay	15.3	15.4	14.8	15.2
% Silty	24.7	24.6	25.9	23.9
% Sand	60.0	60.0	59.3	60.9
Texture	Sandy-loamy	Sandy-loamy	Sandy-loamy	Sandy-loamy
% Agr. Stabl.	71.47	61.44	29.06	22.95
pH (1:2,5)	6.58	6.56	6.19	6.28
EC (dS/m)	0.255	0.193	0.179	0.176
OM (%)	5.46	4.45	2.70	1.30
P2O5 (kg/da)	12.2	4.6	3.5	3.4
K (me/100 g)	1.87	1.27	1.33	0.97
Na (me/100 g)	0.17	0.14	0.11	0.10
Ca (me/100 g)	4.25	3.64	3.56	3.23

Nitrogen content in forage samples was determined according to the Kjeldahl method (Kacar, 1972), and the crude protein contents were calculated by multiplying the values by the coefficient of 6.25 (Adesogan et al., 2000). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios were determined based on the method specified by Van Soest et al. (1991), while RFV was determined based on the method specified by Rohweder et al. (1978).

All data were subjected to analysis of variance based on general linear models for repeated measurements using the SPSS statistical package program (SPSS, 1999). Means were separated using Duncan's Multiple Range Test.

RESULTS

According to the results of this study due to the increase in the slope, it was determined that there was a significant decrease in the amound of allowed forage, crude protein ratios, and RFV, while an increase in ADF and NDF values.

According to the variance analysis results, the interactions of allowed forage amount, crude protein content, ADF, NDF, and RFV were not significant. The average forage allowance of the rangeland sites was 544.6 kg ha^{-1} and varied between 266.1 and 857.9 kg ha^{-1} among the sites (Table 2). The results showed that the forage allowance values decreased regularly with increasing slope and each site was in a different statistical group according to the multiple comparison test results. The allowed forage amount showed a significant difference between study years. In the first study year (564.3 kg ha^{-1}), allowed forage amount was higher than the second year (524.8 kg ha^{-1}).

Table 2. Allowed forage yield and some forage quality properties of different sloping rangeland sites, based on two years average.

Rangeland Sites	Allowed Forage yield (kg ha^{-1})	Crude Protein Content (%)	NDF (%)	ADF (%)	RFV (%)
0-10	857.9 A	12.79 A	58.61 D	41.79 D	89.48 A
10-30	587.3 B	10.88 B	65.84 C	44.57 C	76.62 B
30-60	466.9 C	9.98 BC	68.52 B	48.75 B	69.28 C
60-above	266.1 D	9.70 C	70.72 A	51.00 A	64.81 D
Mean	**544.6**	**10.84**	**65.92**	**46.53**	**75.05**
2016	564.3 a	11.31 a	64.29 B	45.11 B	78.36 A
2017	524.8 b	10.36 b	67.55 A	47.94 A	71.74 B
Mean	**544.6**	**10.84**	**65.92**	**46.53**	**75.05**
Slope	**	**	**	**	**
Year	*	*	**	**	**
Slope x Year	ns	ns	ns	ns	ns

[1]Values followed by small and capital in a column shows significantly differences at P<0.05 and P< 0.01 levels, respectively, using Duncan's multiple range test.
[ns]No statistical difference at P<0.05 and P<0.01, *Statistical difference at P< 0.05, **Statistical difference at P< 0.01.

The effect of the slope on crude protein contents was very significant statistically (P <0.01). While the rangeland site I (0-10% slope) had the highest crude protein content (12.79%), the lowest crude protein content was determined in site IV (slope of 60% and above) with a rate of 9.70%. The crude protein content was higher in the first study year (11.31%) than in the second year (10.36%) (Table 2).

According to the results of two years study, NDF ratio of allowed forage increased with increasing slope. The average NDF ratio was 65.92% and the highest NDF ratio was determined in the site with a slope of 60% and above

(70.72%), while the lowest NDF ratio (58.61) was determined in the rangeland site with a 0-10% slope (Table 2). NDF ratio in rangeland sites with different slopes showed a significant difference by study years, and in the first year, NDF ratio was higher than in the second year.

In forage samples taken from rangeland sites with different slopes, the ADF ratio varied between 41.79 to 51.00% and increased depending on the increased slope. In the first study year, ADF ratio was 45.11% and it was significantly higher (47.94%) in the second study year.

According to the average of the study years, relative feed value (RFV) was determined as 75.05% and varied between 64.81% and 89.48% among the rangeland sites with different slope. As the slope increase, RFV showed a decreasing trend ($p < 0.01$). In the first study year, it was determined as 78.36%, and decreased to 71.74% in the second year (Table 2).

DISCUSSION

The obtained results showed that, with increasing slope in the study area under uncontrolled grazing conditions, the allowed forage amount regularly decreased. This is a consequence of the negative impact of grazing on plants in addition to the low water and nutrient contents of soil as a result of reduced field availability due to increased slope. Because the plants grown in the insufficient environment are more negativity affected by grazing and as a result, the frequency and species composition changes negatively as well as the decrease in aboveground production (Gullap, 2010; Dasci and Comakli, 2011; Ispirli et al., 2016; Amiri et al., 2018). Since this change will result in sparse vegetation and a decrease in biomass production, it is expected that forage allowance will decrease (Skomik et al., 2010; Surmen and Kara, 2018). The fact that the increased surface flow due to the increasing slope negatively affects the moisture balance and the transportation of the nutrients by erosion can be effective in reducing the forage allowance. The preceding statements explain the obtained results from this study.

It is suggested that the amount of biomass to be left in the rangelands with short plants should be around 400 kg ha^{-1} (Molinar et al., 2001). However, even in the sampling period that was at the first half of the grazing season, forage allowance (and covering) in sloping areas over 60% was quite below this value and it is inevitable to decrease further in the following period. The results, dealing with the allowed forage amount reveal higher slope rangelands should be closed to grazing especially over 60% sloping, as Altin et al. (2005) suggested. In other sloping sites, the amount of forage allowance was lower than in the low sloping site (0-10% slope). For this reason, reducing the grazing intensity with the increasing slope, and close to the grazing of over 60% sloping sites is essential for the sustainable use of rangeland ecosystems in the study area and around.

In the second study year, lower forage allowance was determined compared to the first year. It is expected to produce higher biomass production in rainy years (Enright et al., 2005; Miao et al., 2015). However, there was no significant difference in the precipitation amount between the years, too much precipitation was recorded in the fall of the first year, especially in September, this situation may be closely related to the precipitation amount in fall. Because, in the rangelands dominated by cool climate plants, the autumn precipitation in the first year is the most important determining factor for biomass production (Koc, 2001). In such rangelands, the dry autumn decreases the water use efficiency of the plants in the following year.

In this study, it was found that increasing slope was caused significantly decreased in the crude protein content ($P < 0.01$). The crude protein content difference seen in forage samples between sites can be attributed to the species composition difference of vegetation, and different soil moisture content, because, changes in botanical composition affect the crude protein ratio (Dovel, 1996). Also, available water in the soil is consumed earlier in the sloping areas since they are not able to hold enough rain and snow water (Koc, 1995) and the crude protein content of forages may rapidly decrease (Koc et al., 2000; Andrae, 2003; Koc et al., 2005). It was an expected result that as the moisture content decrease in the sloping site soil, the crude protein ratio decreases due to the early maturing of the plants. The lower crude protein content in the forage samples can be attributed to low precipitation amount, recorded in the second year during the growing season.

The ADF and NDF contents are indicators of the digestibility of the forage (Ball et al., 2001; Rayburn, 2004) and may vary depending on the plant species (Ball et al., 2001) and plant growth periods (Lacefield et al., 1999). The differences in botanical composition in the rangeland sites may have caused the ADF and NDF ratios to be different. The higher ADF and NDF ratio in sloping sites can be attributed to the changes in botanical composition and early maturing of the plants in sloping sites due to low soil moisture content. Indeed, similar situations have been emphasized by researchers such as Taiz and Zieger (2008) and Alaturk (2012). The higher ADF and NDF ratio in the second study year compared to the first year may have resulted from the fact that climate differences during the study years and different effects of grazing on vegetation. While the total precipitation amount was lower, the average temperature was higher in the second study year compared to the first year, and this caused to the plants early mature than the first year. Some researchers also reported this situation affects the feed quality negatively (Kamstra et al., 1968; Pieper et al., 1974).

Relative feed value is an important indicator for feed quality, and the estimation of the energy value to be obtained from the feed by the animals that consumption of these feeds (Gursoy and Macit, 2017). The RFV ratio can decrease depending on the high ADF and NDF ratio of forages. The increase of sloping in rangeland sites caused

an increase in the ADF and NDF ratios in forage and as a resut of this, RFV decrease. This situation may have resulted from many factors such as climate, soil, plant species and variety and differences in the vegetation period of the feed (Gursoy and Macit, 2017). The significant difference between study years in terms of relative feed value may have caused by a negative relationship between NDF and ADF values.

CONCLUSION

In this study, it was determined that the increase in slope significantly affects the allowed forage amount, crude protein, ADF, NDF, and RFV ratios. This situation has shown that rugged rangelands were more negatively affected by grazing compared to the flat rangelands under uncontrolled grazing conditions. Therefore, reducing the grazing intensity on rugged rangelands is important for the sustainable use of rangeland ecosystems. The results showed that it was important closed to animal grazing more than 60% sloping rangeland sites. Because these areas do not have adequate soil protective cover.

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