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Effect of Manure Application on the Chemical Composition and Nutritive Value of Rangeland Hay

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Abstract: This study was conducted on a secondary succession rangeland at the Samsun region in Turkey. The area which was plowed about 30 years ago and then abandoned. In the study was used sheep manure. Target rates of sheep manure was 0, 25.0, 50.0, 75.0 and 100 kg total N ha^{-1} based on the manure analyses results (according to N rates in manure). Ca, P, K, Mg content of rangeland hay ranged from 7.54-10.64 g kg^{-1}, from 3.08-3.37 g kg^{-1} from 25.66-36.07 g kg^{-1}, from 2.11-2.57 g kg^{-1}, respectively over 3 years. ADF content of rangeland hay ranged from 376.2-397.3 g kg^{-1} in 2006, from 391.9-410.5 g kg^{-1} in 2007, from 361.0-385.0 g kg^{-1} in over the 3 years. NDF content was determined between 547.5 (in 37.5+37.5 kg N ha^{-1} treatment) and 619.9 g kg^{-1} (25.0 kg N ha^{-1} treatments) in the mean of 3 years. The effect of manure on rangeland hay quality and chemical properties generally affected positive as application rates increased.

Key words: Chemical composition, nutritive value, manure aplication rates and time, Rangeland, Turkey

INTRODUCTION

In the Turkiye including Samsun, there are about 14 million hectares of rangelands (Anonymous, 2008). This large area has vastly different landforms and climates. Within these landforms are a remarkable diversity of rangeland ecosystems, one of them the secondary succession rangeland of Samsun. A great portion of the rangeland in Turkey that legally belong to Turkish State and villagers have rights to graze their animals on these areas freely (Aydin and Uzun, 2008) is in poor condition due to insufficient precipitation and improper range management practices (Tetik *et al*., 2001).

For this reason, ranges are not up to the high standards of developed countries (Cakmakci *et al*., 2004). Firincioglu *et al*. (1996) reported that the increasing pressure due to over-grazing on the rangelands made it almost impossible to implement range improvement techniques. Therefore, it has paramount importance to increase dry matter production and forage quality by improving rangelands in order to meet forage requirements of ruminants which is in shortage in Turkey (Aydin and Uzun, 2005). The most practical and effective method to increase dry matter production in rangelands is an appropriate and adequate fertilization of these areas (Frame, 1992). Fertilization, especially with manure can also increase forage yield and quality, improve soil fertility, increase water-holding capacity, lessen wind and water erosion improve aeration and promote beneficial organisms (Johnson and Eckert, 1995). Mugerwa *et al*. (2008) reported that manured plots showed high dry matter production, species richness, percentage cover and drastic changes in botanical composition compared to nonmanured plots. Land application of animal manure is an efficient utilization alternative because of usually lower costs compared to treatment and the nutrient benefits derived by crops from the manure.

In most parts of the world animal production is dependent on the pasture and rangeland areas and the subsequent forage availability throughout the year (Ocak *et al*., 2006). Indeed, a great majority of feed for livestock is provided by rangelands in many countries of the Mediterranean region. Several problems such as heavy grazing and grazing out of season, limited grassland and local climatic conditions that cause insufficient quantity and quality of forage are prevalent in many countries (Uzun, 2010). Moreover, some rangeland areas are deprived of plant flora to prevent soil erosion. In

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such areas it is very important to increase hay production and quality for ruminant forage requirements by improving rangelands. The basic goal of many grazing programs is to provide high quality forage over the years to reduce the costs of storing and purchasing concentrate feeds (Mut *et al*., 2006).

The objective of the present research was to investigate chemical composition and nutritive value of rangeland hay in relation to sheep manure application rates and time on rangeland.

MATERIALS AND METHODS

This study was carried out on a secondary succession rangeland at the Samsun region (altitude of 190 m) in Turkey (41°21'N, 36°15'E) between 2006 and 2008. The area which was plowed about 30 years ago and then abandoned. The growing season of the herbaceous vegetation begins in mid-February and ends in June in Samsun.

While the 50 year mean total rainfall was 670.2 mm, the annual total rainfall were 778.1, 714.7, 677.5 and 675.9 mm for 2005, 2006, 2007 and 2008, respectively. Air temperatures during the experiment were close to the long term mean (14.2°C in long term, 15.0, 14.5, 15.4 and 15.6°C, respectively). Total monthly rainfall and air temperature are shown in Fig. 1. The soil texture is shown in Table 1.

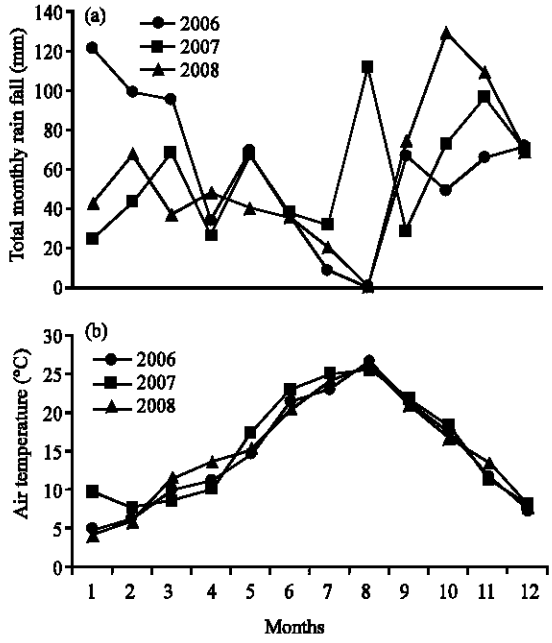

Fig. 1: Total monthly rainfall and air temperature during the 2006-2008

In the study, sheep manure was used. Sheep manure was obtained from Ondokuz Mayis University, Faculty of Agriculture. Manure samples were taken from the barn and analyzed for nutritient content (especially N content) 2 weeks prior to each application period (autumn and spring). Target rates of sheep manure was 0, 25.0, 50.0, 75.0 and 100 kg total N ha^{-1} based on the manure analyses results (according to N rates in manure). Manure treatments in plots have been shown in Table 2.

Manure treatments were conducted using a randomized complete block design with 3 replicates during three consecutive years. Manure was surface applied to 5×6 m plots with a distance of 2 m between each plot. Treatments were applied November 25 in 2005 and March 14 in 2006 and applied only 1st year. Herbaceous vegetation was annually harvested within 20 m^2 area when grass plants reached full flowering stage at the beginning of May. Harvesting was done by hand on May 23 in 2006, on May 22 in 2007 and on May 14 in 2008. Harvested samples within 1 m^2 quadrate in each plot were seperated as legumes, grasses and the others as well as determining the dry weight ratio of each group for every year.

Samples taken from 1 m^2 area of each plot within each group were oven-dried at 60°C. After cooling and weighing, the samples were ground to pass through a 1 mm screen. Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF), Ca, K, Mg and P contents of samples were determined using Near Infrared Reflectance Spectroscopy (NIRS) 13-15. NIRS was calibrated using software program coded IC-0904FE. Total Digestible Nutrients (TDN), Digestible Dry Matter (DDM), Dry Matter Intake (DMI) and Relative

Table 1: Physical and chemical characteristic of the soil at the experimental site

Soil parameters	Value	Content
Soil texture		Clay
Organic matter (%)	2.88	Moderate
pH	6.10	Slightly acid
EC (dS m^{-1})	0.57	Low (saltless)
Available P (ppm)	6.39	Moderate
Exchangeable K (cmol kg^{-1})	0.38	Low
Exchangeable Ca (cmol kg^{-1})	32.19	High
Exchangeable Mg (cmol kg^{-1})	10.18	High

Table 2: Manure treatments used in the rate and time of application experiments

Treatments (kg N ha^{-1})	Aplication of treatments
0	No treatment applied
25.0	All of N was applied in autumn
50.0	
75.0	
100.0	
12.5+12.5	Half of N was applied in autumn, remaining
25.0+25.0	N was applied at the beginning of rapid
37.5+37.5	growth period of vegetation (mid-March)
50.0+50.0	

Feed Value (RFV) were estimated according to the following equations adapted from Horrocks and Vallentine (1999):

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

$$DMI = (120/\text{Percentage of NDF dry matter basis}),$$

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

$$RFV = \text{Percentage of DDM} \times \text{Percentage of DMI} \times 0.775,$$

The data were analysed using a computerised statistical package SPSS 11.0 V. probabilities <0.05 were considered significant. Duncan test was used to separate the treatment means. All significant main affects were considered.

RESULTS AND DISCUSSION

Chemical composition: The results of this research indicate that forage quality significantly varied with sheep manure application rates and time. Quality characters were calculated in the forage that legume, grass and other plant species were analyzed separately. After that quality characters of the plots were calculated concerning legume, grass and other species percentage in samples. This results have been shown Table 3-6. Additionally, Ca, P, K and Mg concentrations of legumes, grasses and other plants are shown in Fig. 2. Legumes and other plants had richest than grasses in terms of Ca and Mg content. While the highest P content was obtained from grasses, it was followed by legumes and other plants. The highest K content was determined other plants in this research (Fig. 2). While the effects of manure application rates and time on Ca, K, Mg content and Ca:P, K:(Ca+Mg) ratios of rangeland hay were significant, P contents were insignificant as a mean of 3 years.

Ca, P, K, Mg content of rangeland hay ranged from 7.54-10.64 g kg^{-1}, from 3.08-3.37 g kg^{-1}, from 25.66-36.07 g kg^{-1}, from 2.11-2.57 g kg^{-1}, respectively over 3 years. Tajeda *et al.* (1985) reported that forages should contain at least 0.30% Ca for ruminant. Ca content of rangeland hay in this study was high to this value. This situation could be explained that the high level of available Ca content of the soil (Table 1) might have increased Ca content of hay. It is reported that forages for cattle and sheep should contain P between 0.17 and 0.39% (National Research Council, 1996), 0.16 and 0.38% (National Research Council, 1985), respectively. P content of hay in this research was similar to recommended value. K content was high in 2006. Potasium content generally high in grass species (Minson, 1990). The ratio of grass species was high in the first year of this study. This situation was expected because this experimental area was former ploughed and abondoned area. K content of hay was high because of the high ratio of grass in rangeland hay.

Table 3: Ca, P contents and Ca/P ratios in rangeland with different sheep manure application ratios

Treatments	Calcium (Ca) (g kg^{-1})				Phosphor (P) (g kg^{-1})				Ca/P			
(kg N ha^{-1})	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
0	8.53^{a}	8.63^{cde}	8.33^{d}	8.50^{cd}	3.17	3.13	3.27	3.19	2.69^{abc}	2.77^{cd}	2.57^{c}	2.68^{bc}
25.0	6.90^{bc}	5.37^{f}	10.37^{c}	7.54^{d}	3.17	3.13	3.17	3.16	2.18^{c}	1.71^{e}	3.28^{b}	2.39^{c}
50.0	7.63^{ab}	7.47^{e}	11.70^{b}	8.93^{bc}	3.40	3.03	3.67	3.37	2.25^{bc}	2.45^{d}	3.19^{b}	2.63^{bc}
75.0	8.93^{a}	9.47^{bcd}	11.30^{bc}	9.90^{ab}	3.27	3.03	3.57	3.29	2.72^{abc}	3.10^{bc}	3.20^{b}	3.01^{ab}
100.0	9.17^{a}	9.73^{bc}	11.50^{bc}	10.13^{ab}	3.27	3.00	3.50	3.26	2.79^{ab}	3.26^{bc}	3.28^{b}	3.11^{ab}
12.5+12.5	5.40^{c}	10.43^{b}	10.37^{c}	8.73^{bcd}	3.53	2.90	3.27	3.23	1.54^{d}	3.59^{b}	3.17^{b}	2.77^{bc}
25.0+25.0	8.63^{a}	9.87^{bc}	11.50^{bc}	10.00^{ab}	3.20	2.97	3.57	3.24	2.68^{abc}	3.35^{bc}	3.22^{b}	3.09^{ab}
37.5+37.5	9.30^{a}	8.27^{de}	10.60^{bc}	10.64^{a}	3.10	2.73	3.40	3.08	2.98^{a}	4.47^{a}	3.14^{b}	3.53^{a}
50.0+50.0	9.03^{a}	12.03^{a}	12.90^{a}	10.07^{ab}	3.37	2.97	3.47	3.27	2.69^{abc}	2.79^{cd}	3.76^{a}	3.08^{ab}
Mean	8.17^{c}	9.03^{b}	10.95^{a}	-	3.27^{b}	2.99^{c}	3.43^{a}	-	2.50^{b}	3.06^{a}	3.20^{a}	-

Values within columns with different letters differ significantly ($p<0.05$)

Table 4: K, Mg contents and K/Ca+Mg ratios in rangeland with different sheep manure application ratios

Treatments	Potassium (K) (g kg^{-1})				Magnesium (Mg) (g kg^{-1})				K/Ca+Mg			
(kg N ha^{-1})	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
0	44.57	25.70	22.90	29.68^{bc}	2.23^{ab}	2.47^{cd}	2.40	2.37^{ab}	4.13^{cd}	1.96^{bcd}	2.41	2.74^{b}
25.0	33.03	20.43	23.50	25.66^{c}	1.97^{b}	1.90^{f}	2.47	2.11^{b}	3.73^{d}	2.82^{a}	1.83	2.79^{b}
50.0	60.57	22.17	25.83	36.19^{a}	1.93^{b}	2.10^{ef}	2.50	2.18^{b}	6.37^{a}	2.31^{b}	1.82	3.50^{a}
75.0	59.07	20.63	25.27	34.99^{ab}	2.10^{ab}	2.40^{cde}	2.53	2.34^{ab}	5.35^{b}	1.74^{cde}	1.83	2.97^{ab}
100.0	60.93	23.30	23.97	36.07^{a}	2.07^{ab}	2.90^{ab}	2.67	2.54^{a}	5.44^{b}	1.85^{cd}	1.70	3.00^{ab}
12.5+12.5	32.27	20.73	22.13	25.04^{c}	1.30^{c}	2.63^{bc}	2.43	2.12^{b}	4.80^{bc}	1.60^{de}	1.73	2.71^{b}
25.0+25.0	52.83	21.07	24.03	32.64^{ab}	2.20^{ab}	2.50^{f}	2.90	2.53^{a}	4.89^{bc}	1.70^{de}	1.67	2.75^{b}
37.5+37.5	53.60	21.03	22.53	32.39^{ab}	2.33^{a}	3.07^{a}	2.30	2.57^{a}	4.67^{bc}	1.39^{e}	1.75	2.60^{b}
50.0+50.0	51.63	22.00	26.73	33.46^{ab}	2.10^{ab}	2.13^{def}	2.90	2.38^{ab}	4.72^{bc}	2.11^{bc}	1.69	2.84^{b}
Mean	49.83^{a}	21.44^{b}	24.10^{b}	-	2.03^{b}	2.46^{a}	2.57^{a}	-	4.90^{a}	1.94^{b}	1.83^{b}	-

Values within columns with different letters differ significantly ($p<0.05$)

Table 5: ADF, NDF and RFV values in rangeland with different sheep manure application ratios

Treatments	ADF (g kg^{-1})				NDF (g kg^{-1})				RFV			
(kg N ha^{-1})	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
0	384.2	402.5	343.0^{b}	376.6	594.6^{bc}	612.8^{b}	550.5^{a}	586.0^{bc}	92.3^{abc}	87.5^{b}	105.2^{d}	95.0^{bc}
25.0	389.8	399.2	366.1^{a}	385.0	621.5^{ab}	689.9^{a}	548.3^{a}	619.9^{a}	87.8^{bc}	77.9^{c}	102.5^{d}	89.4^{c}
50.0	387.0	404.8	314.9^{c}	368.9	594.8^{bc}	644.4^{b}	464.6^{cd}	568.0^{bcd}	91.9^{abc}	83.1^{bc}	129.3^{ab}	101.4^{ab}
75.0	392.3	391.9	332.0^{bc}	372.1	595.1^{bc}	611.6^{b}	498.1^{bc}	568.2^{bcd}	91.3^{abc}	88.8^{ab}	117.8^{bc}	99.3^{ab}
100.0	387.8	402.5	325.7^{bc}	372.0	565.2^{c}	616.0^{b}	483.6^{bcd}	554.9^{cd}	96.6^{ab}	86.9^{b}	122.2^{bc}	101.9^{ab}
12.5+12.5	397.3	399.1	333.6^{bc}	376.7	644.3^{a}	605.2^{b}	521.2^{ab}	590.2^{b}	83.9^{c}	88.9^{ab}	112.4^{cd}	95.1^{bc}
25.0+25.0	377.7	404.0	333.4^{bc}	371.7	579.9^{bc}	612.5^{b}	497.5^{bc}	563.3^{bcd}	95.5^{ab}	87.4^{b}	117.9^{bc}	100.3^{ab}
37.5+37.5	376.2	392.4	334.7^{bc}	367.8	558.1^{c}	567.5^{c}	516.9^{ab}	547.5^{d}	99.5^{a}	95.7^{a}	113.1^{cd}	102.8^{ab}
50.0+50.0	378.7	410.5	293.8^{d}	361.0	566.1^{c}	641.5^{b}	449.5^{d}	552.3^{d}	98.0^{ab}	82.7^{bc}	136.9^{a}	105.9^{a}
Mean	386.0^{b}	401.0^{a}	331.0^{c}	-	591.0^{b}	622.0^{a}	503.0^{c}	-	92.9^{b}	86.6^{c}	117.5^{a}	-

Values within columns with different letters differ significantly ($p<0.05$)

Table 6: TDN, DDM and DMI values in rangeland with different sheep manure application ratios

Treatments	TDN (g kg^{-1})				DDM (g kg^{-1})				DMI (g kg^{-1})			
(kg N ha^{-1})	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
0	517.5	493.9	570.7^{c}	527.4	589.7	575.5	621.8^{c}	595.7	20.2^{abc}	19.6^{b}	21.8^{d}	20.5^{bc}
25.0	510.2	498.2	540.9^{d}	516.5	585.3	578.1	603.8^{d}	589.1	19.3^{bc}	17.4^{c}	21.9^{d}	19.5^{c}
50.0	513.9	490.9	607.0^{b}	537.3	587.6	573.7	643.7^{b}	601.6	20.2^{abc}	18.7^{b}	25.9^{ab}	21.6^{ab}
75.0	507.0	507.5	584.8^{bc}	533.1	583.4	583.7	630.4^{bc}	599.1	20.2^{abc}	19.6^{b}	24.1^{bc}	21.3^{ab}
100.0	512.8	493.8	593.0^{bc}	533.2	586.9	575.4	635.2^{bc}	599.2	21.2^{a}	19.5^{b}	24.8^{bc}	21.8^{ab}
12.5+12.5	500.6	498.3	582.7^{bc}	527.2	579.5	578.1	629.1^{bc}	595.6	18.7^{c}	19.8^{b}	23.1^{cd}	20.5^{bc}
25.0+25.0	525.8	491.9	583.0^{bc}	533.6	594.7	574.3	629.3^{bc}	599.4	20.7^{ab}	19.6^{b}	24.2^{bc}	21.5^{ab}
37.5+37.5	527.8	507.0	581.5^{bc}	538.8	595.9	583.4	628.3^{bc}	602.5	21.5^{a}	21.1^{b}	23.2^{cd}	22.0^{a}
50.0+50.0	524.6	483.5	634.2^{a}	547.4	594.0	569.2	660.1^{a}	607.8	21.3^{a}	18.7^{b}	26.7^{a}	22.2^{a}
Mean	515.59^{b}	496.13^{c}	586.42^{a}	-	588.6^{b}	576.8^{c}	631.3^{a}	20.4^{b}	19.4^{c}	24.0^{a}	-	-

Values within columns with different letters differ significantly ($p<0.05$)

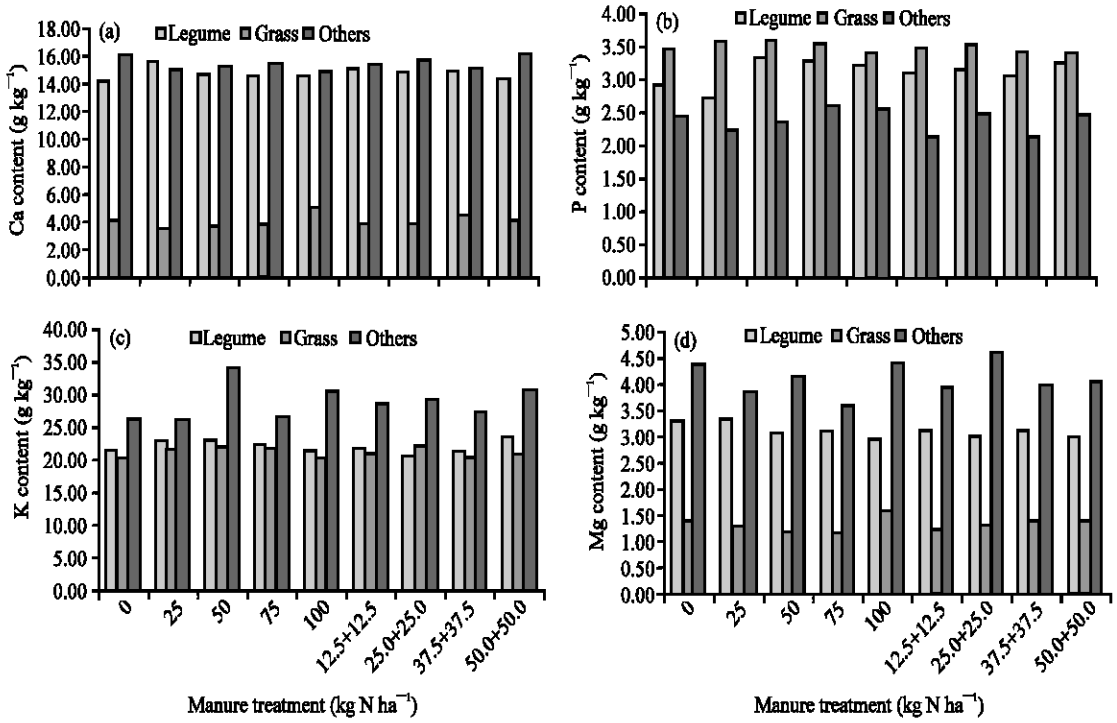

Fig. 2: Ca (a), P (b), K (c) and Mg (d) content in rangeland with different sheep manure application ratios as a mean of three experimental year

Mg contents of hay were similar the recommended value (0.2%) by Tajeda *et al.* (1985) whereas Mg contents of some treatments were higher than the value (0.1%) recommended by National Research Council (1996).

Ayan *et al*. (2006) found that Mg contents of natural rangeland plants ranged from 0.01-1.19% in the same ecological conditions. Ca:P ratios were determined between 2.18 and 2.98 in 2006, 1.71 and 4.47 in 2007, 3.76 and 2.57 in 2008. Ca:P ratio is over 2.00, milk fewer may be observed in animals and effectiveness in forage-animal product transformation may decrease (Jacobsen *et al*., 1972; Reid and Jung, 1974). In this study Ca:P ratio of rangeland hay in each years and mean of 3 years were higher than reported values (Table 3).

Maximum productivity and good health of sheep depend on both the actual amounts of Ca and P supplied and the ratio of Ca:P. K:(Ca+Mg) ratio should not exceed 2.2. While all of K:(Ca+Mg) values are high in 2006, this value is low in 2007 and 2008 except for 25.0 and 50.0 kg N ha^{-1} treatments in 2007, control plots in 2008 (Table 4). The risk of grass tetany dramatically increases when the K:(Ca+Mg) ratio of forage exceeds 2.2 (Georgievskii, 1982; Jefferson *et al*., 2001). In this experiment, K:(Ca+Mg) ratio was higher than stated value in 2006. This situation could be explained that K content was high in 2006. Sheep manure treatments generally decreased K:(Ca+Mg) ratio in 2007 and 2008 (Table 4). Mut (2009) found that K:(Ca+Mg) ratio ranged from 1.26-3.58 in the same ecological conditions and same rangeland. Feed estimation as a set of parameters of the chemical composition is a important information for feed quality evaluation.

Nutritive value: Content of ADF and NDF are important quality characteristics for forages. Acid Detergent Fiber (ADF) content were no significant differences between all of the treatments in 2006, 2007 and over the 3 years; the only significant differences were determined in 2008. ADF content of rangeland hay ranged from 376.2-397.3 g kg^{-1} in 2006, from 391.9-410.5 g kg^{-1} in 2007, from 361.0-385.0 g kg^{-1} in over the 3 years. The highest ADF value in 2008 was determined 366.1 g kg^{-1} with 25.0 kg N ha^{-1} treatment.

The effects of sheep manure application rates and time on Neutral Detergent Fiber (NDF) content were significant. NDF content was determined between 547.5 (37.5+37.5 kg N ha^{-1} treatment) and 619.9 g kg^{-1} (25.0 kg N ha^{-1} treatment) in mean of 3 year (Table 5). ADF and NDF are important quality characteristic for forages (Caballero *et al*., 1995; Assefa and Ledin, 2001). Over the mean of the years, ADF content of rangeland hay was found good quality in all manure treatments but NDF content was fair quality. Generally, as ADF increases in hay, digestibility and nutrient availability decreases. Relative Feed Value (RFV) was significantly affected by the sheep manure aplication rates and time (Table 5). According to mean of 3 years, RFV value in this study ranged from 89.4-105.9. The highest RFV value was obtained in 2008. The RFV is an index that is used to predict the intake and energy value of the forages and it is derived from the DDM and DMI. Forage with an RFV value >151 is considered prime (Horrocks and Vallentine, 1999). Nutritional quality of plants directly affects the performances of the livestock (Uzun *et al*., 2002). In the experiment, RFV was increased with manure applications.

While the effects of sheep manure application rates and time on Total Digestible Nutrient (TDN) and Digestible Dry Matter (DDM) in 2006, 2007 and over the mean of the years were insignificant, it was significant in 2008. Digestible Dry Matter Intake (DMI) was significant all of the years. Averaged of the 3 years, TDN, DDM and DMI content ranged from 516.5-547.4 g kg^{-1}, from 589.1-607.8 g kg^{-1}, from 19.5-22.2 g kg^{-1}, respectively (Table 6). The TDN refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage. 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 (Lithourgidis *et al*., 2006). The NDF is used to predict DMI and is negatively correlated with DMI which means that when NDF is high the quality and the DMI are low (Horrocks and Vallentine, 1999).

CONCLUSION

The application of sheep manure has generally an positive effect on rangeland hay quality as application rates increased. A amount of 50.0 and 75.0 kg N ha^{-1} as sheep manure can be given to rangeland with similar features considering their the soil characteristics. This apllication will further have an possitive affect on rangeland vegetation and some soil characteristics. The evaluation of nutritive value of rangeland hay is important for rangeland conservation and cultivation and interactions between plant/animal productions.

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