Turkish Journal of Field Crops, 2010, 15(2): 198-203

THE EFFECT OF DIFFERENT IMPROVEMENT METHODS ON PASTURE YIELD AND QUALITY OF HAY OBTAINED FROM THE ABANDONED RANGELAND

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ABSTRACT

Rangelands are the most important feed sources for animal husbandry in Turkey. The purpose of this study was to determine the effectiveness of different improvement methods on pasture yield and quality obtained from the rangeland harvested at the grazing maturity stage. This study was conducted on a rangeland that cultivated 30 years ago and then abandoned in the Samsun region in Turkey between 2007 and 2008. Treatments were control, aeration, commercial fertilization; sheep manure application, over-seeding, aeration+fertilization, aeration+sheep manure, fertilization+over-seeding, and sheep manure+over-seeding. Harvest was realised when dominant grass+legume plants reached at grazing maturity. According to the results of two-year mean, the highest hay yield was obtained from the aeration+fertilizer treatment with 3720.5 kg ha^{-1} and from fertilization treatment with 3412.4 kg ha^{-1}. In both years, the highest yields were generally obtained from each of the first cuts. Compared to control, all improvement methods generally increased the total yields in both years. In general, the first cut gave higher crude protein and RFV content and lower ADF and NDF content compared to the second or third cuts. According to quality standards of American Forage and Grassland Council, rangeland hay samples were generally classified in the first class. Rangeland improvement methods, especially aeration and its combinations, increased the hay yield and quality.

Key words: Abandoned rangeland, botanical composition, hay yield and quality, improvement methods.

INTRODUCTION

Rangelands are the most important feed sources for animal husbandry in Turkey, especially the high pastures. Koc (2000) reported that the rangelands are generally located in Central Anatolia, Eastern Anatolia and Southeastern Anatolia, and twelve million animal units (500kg=1 unit) are grazing on Turkish rangelands. As a result of mismanagement, climax vegetation of the rangelands became less effective (Avcioglu et al. 2010), and the plant species with high feeding value started to disappear from the rangelands. Plant cover rates decreased and severe erosion problems have been seen at 90% of the rangelands (Koc et al. 1994). Furthermore, significant rangeland areas have been cultivated since 1940. While the total meadow and rangeland area was about 44.2 million ha in 1940, but these lands decreased to 12.3 million ha in recent years (Avcioglu et al. 2010). Important rangeland area was used as agricultural field (Bayram et al. 2009). Urgent improvement methods could help the lands to be grazed and to supply high-quality feed to livestock.

Improvement methods and management practices can support a healthy rangeland ecosystem over time (Manske 2002). This improvement practices, such as fertilization, aeration and timely cutting, may have a very important role in hay yield and quality (Comakli et al. 2005). Commercial fertilizer applications are widely used practices aiming to increase hay production in rangeland. Fertilization, especially with N, increases hay production in rangelands depending on annual rainfall (Elliot and Abbott 2003). Increased N application generally increases hay production and crude protein content (McConnell and Waller 1986; Gokkus and Koc, 1995). Aydin and Uzun (2005) reported that nitrogen fertilizer increased the dry matter yield. N application generally increases grass content and decreases legume content (Aydin and Uzun 2005; Brum et al. 2009). The application of livestock manure to native rangelands has significant effects on the cycling of plant nutrients in soil and can result in artificially raising nutrient levels, occurring a change in dominant plant species (Chang et al. 1991; Stewart et al. 1998; Sharpley et al. 2001). Aeration generally improves soil fertility and root activity due to increase of microbial activity and soil permeability in heavy soils (Bayram et al. 2009). Rangeland degradation by improper management techniques like overgrazing leads to large denuded areas subject to wind and water erosion. These areas usually occur with a poor vegetation cover. Eiswerth and Shonkwiler (2006) indicated that the success of reseeding efforts is sensitive to the timing of techniques used in reseeding, as well as whether grazing is allowed on the land.

The stage of maturity of forage crops has a major influence on forage quality. As maturity advances in plants, their nutritional value decreases (Comakli et al. 2000). When the cutting was delayed, hay yield generally increased, but quality characteristics like crude protein content and digestibility decreased (Reece et al. 1994). Rangeland hay is an important feed source for livestock, because it provides relatively inexpensive supplemental forage and has a high feed value at the beginning of grazing maturity (Bakoglu et al. 1999). These areas require careful management practices for sustainable hay yield and quality. High quality is as important as high yield.

In this study, the effect of different improvement methods on the yield and quality of rangeland hay obtained from at the grazing maturity stage was investigated. By this way, the conditions of rangeland at every grazing stage could be determined, and obtained results could be useful to regional farmers and scientists.

MATERIALS AND METHODS

The Experimental Area

The experimental area was located in Samsun province (altitude of 178 m) in Turkey (41°21' N, 36°15' E). This field was cultivated about 30 years ago and then abandoned. The study area was fenced to exclude domestic ungulates in 2005, and during experimental period between 2007 and 2008, no livestock entered in the experimental field. The soil of experimental area was clay with approximately 3.30% organic matter, phosphorus content 5.075 ppm, potassium content 0.438 cmol kg^{-1}, and pH of 6.10. A climatic diagram of the study area in Samsun is presented in Figure 1 and 2. Before the application of improvement methods, botanical composition of experimental area was 24.84% legumes, 49.12% grasses, and 26.04% of other species, and covering rate was 55.92%. The vegetation was dominated by burclover (*Medicago polymorpha* L.), small hop clover (*Trifolium dubium* Sibth.), spotted medick (*Medicago arabica* L.), gelemen clover (*Trifolium meneghinianum* Clem.); wild oat (*Avena fatua* L.), corn brome (*Bromus squarrosus* L.), cheatgrass (*Bromus tectorum* L.), bulbous barley (*Hordeum bulbosum* L.), fringed fescue (*Vulpia ciliata* Dumort), perennial ryegrass (*Lolium perene* L.), orchardgrass (*Dactylis glomerata* L.); ribwort plantain (*Plantago lanceolata* L.), corkyfruit waterdropwort (*Oenanthe pimpinelloides* L.), field eryngo (*Eryngium campestre* L.), wild mint **(***Mentha longifolia* L.), field sowthistle (*Sonchus arvensis* L.), and viper's bugloss (*Echium vulgare* L.).

Experimental design and treatments

The experiment was established according to the randomized complete block design with four replicates. There were 9 treatment plots in each block. All treatments were implemented in autumn 2006. Treatments were control, aeration, commercial fertilization, sheep manure application, over-seeding, aeration+commercial fertilization, aeration+sheep manure, commercial fertilization+over-seeding, and sheep manure+over-seeding. The aeration treatment was applied by spring-tine harrow. Aeration was done in the first year of the experiment and the surface of vegetation was ripped at 6 cm depth. According to the results of soil analysis, commercial fertilizer was applied as amonium nitrate with a rate of 50 kg N ha^{-1} and as triple super phosphate with a rate of 80 kg P ha^{-1}. Half N and all P were applied at the end of November. The remaining N was applied at the beginning of rapid growth period of vegetation in spring. Sheep manure was obtained from Ondokuz Mayis University, Faculty of Agriculture. Manure samples were taken from the barn and analyzed for their nutrient content (especially N content) 2-week prior to application. Sheep manure consisted of 2.46% N, 1.48% P, and was applied on November with a rate of 50 kg N ha^{-1}. All fertilizers were broadcasted by hand on the plant vegetation. Over-seeding was done at the end of October with rates legumes 40% (sainfoin 20%, birdsfoot trefoil 10%, and white clover 10%) and grasses 60% (smooth brome 20%, orchard grass 20%, and ryegrass 20%).

The herbaceous vegetation was annually harvested by hand within a 20 m^2 quadrate when the dominant grass+legume plants reached at grazing maturity (dominant plant species were about 10–15 cm height). In this experiment, two cuts in 2007, and three cuts in 2008 were done. The first cut was done on April 19 and second cut on May 22 in 2007; and the first, second, and third cuts were done on April 14, on May 16, and on June 18, respectively, in 2008. Harvested samples (1m^2 quadrate in each plot) were sorted as legumes, grasses and the other species. Samples taken from 1m^2 area of each plot within each group were oven-dried at 60 °C. Dry matter production of each plot was calculated through the values of green forage production and dry-weight percentage for each crop family. After cooling and weighing, the samples were ground to pass through a 1 mm screen. Crude protein, acid detergent fibre (ADF), and neutral detergent fibre (NDF) contents of samples were determined using near infrared reflectance spectroscopy (NIRS) 13-15. NIRS was calibrated using software program coded IC-0904FE. The protein, ADF, and NDF contents of samples separated as legume, grass and other plant species were determined separately. Further the quality characters of rangeland hay obtained from the plots were calculated concerning legume, grass and other species percentages in the botanical composition. As follows; protein content of rangeland hay=[((protein content of legumes x %ratio of legumes in botanical composition)+(protein content of grasses x %ratio of grasses in botanical composition)+(protein content of other species x %ratio of other species in botanical composition))/100]. Relative feed value (RFV) was estimated according to the following equations adapted from Horrocks and Vallentine (1999):

DMI = (120/%NDF dry matter basis),

DDM = 88.9 – (0.779 x %ADF dry matter basis),

RFV = %DDM x %DMI x 0.775.

The data were analyzed using the statistical package programmer SPSS version 11.0. A level of probability of less than 0.05 was considered significant. Duncan's multiple range test was used to compare treatments.

RESULTS

Hay Yield

The annual yield during the experimental period is summarized in Table 1. According to first year’s results, there were statistically significant ($P<0.05$) differences between the improvement methods. The highest total hay yield was obtained from the aeration+fertilization treatment with 3675.8 kg ha^{-1}. Hay yield ranged from 605.0 to 2390.5 kg ha^{-1} in the first cut, from 793.3 to 1441.8 kg ha^{-1} in the second cut in 2007. Hay yields obtained from the plots with implemented treatments were higher than control except for aeration plots in the first cut and except for aeration + manure plots in the second cut in 2007.

Table 1. Hay yield obtained from different improvement methods (kg ha^{-1})

Improvement methods	2007 1st Cut.	2007 2nd Cut.	2007 Total	2008 1st Cut.	2008 2nd Cut.	2008 3rd Cut.	2008 Total	*Mean of two years*
Control	826.3 cd	975.5 bc	1801.8 c	1595.5 bc	1425.0	535.3	3555.8 ab	*2678.8 d*
Aeration	605.0 d	1133.0 ab	1738.0 c	1990.5 a	1594.5	476.5	4061.5 a	*2899.8 cd*
Fertilization	1503.8 b	1403.5 a	2907.3 b	1841.3 ab	1458.3	618.0	3917.5 a	*3412.4 ab*
Manure	1188.5 bc	1192.5 ab	2381.0 b	2121.3 a	1353.8	369.0	3844.0 a	*3112.5 bc*
Over-seeding	1635.3 b	1287.5 ab	2922.8 b	1766.8 ab	1133.0	610.3	3510.0 ab	*3216.4 bc*
Aer.+Fert.	2390.5 a	1285.3 ab	3675.8 a	2101.0 a	1310.3	354.0	3765.3 a	*3720.5 a*
Aer.+Manure	1572.5 b	793.3 c	2365.8 b	1358.3 c	1246.0	411.8	3016.0 b	*2690.9 d*
Fert.+Over-seed.	1475.5 b	1441.8 a	2917.3 b	1977.5 a	1306.5	408.5	3692.5 a	*3304.9 b*
Man.+Over-seed.	1746.8 b	1009.8 bc	2756.5 b	1906.5 ab	1337.3	526.5	3770.3 a	*3263.4 bc*

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

The effects of improvement methods on hay yield obtained from the first cut and total cuts were significant, however, yield differences on second and third cuts were insignificant. The highest hay yields were found in sheep manure treatments in the first cut, in aeration treatments in the second cuts, and in commercial fertilization treatments in the third cut in 2008. Regarding total cuts, the highest hay yield was obtained from the aeration treatment in 2008 (Table 1). According to the results of two-year means, the highest hay yield was obtained from the aeration+fertilizer treatment with 3720.5 kg ha^{-1} and from fertilization treatment with 3412.4 kg ha^{-1} (Table 1).

Botanical Composition

Botanical composition was determined regarding dry weights of the samples. The results of botanical composition analysis in the first and second year were presented in Table 2 and 3, respectively. There were statistically significant ($P<0.05$) differences among the improvement methods except the legumes from first cut in 2007 (Table 2), and grasses in the first cut in 2008 (Table 3). The highest legume rates in the first and second cuts were determined in the control and the aeration plots. In both cuts, the highest grass rates were obtained from the aeration+commercial fertilization plots (96.37, 96.19%, respectively). The highest rate of other plants was found in sheep manure plots in the first cut, but it was determined in the over-seeding plots in the second cut (Table 2). The legume rate in the botanical composition increased to 43.95% with the aeration treatment at the end of third cut in 2008. The highest grass rate was determined in the commercial fertilization+aeration treatment in the first and second cuts. Rates of the others plant species, neither legume nor grass, varied between 11.83 and 51.18% in all cutting (Table 3).

Protein, ADF, NDF, and RFV Content

The protein, ADF, NDF, and RFV content of rangeland hay during the experimental period are summarized in Table 4 and 5. The effects of improvement methods on protein, ADF, NDF, and RFV content were found to be significant in all cuts except protein content in the first cut in 2008, NDF content in the first cut in 2007, and ADF and RFV content in the first cut in both years. Protein content of rangeland hay was generally higher in both years. The highest protein content was generally determined in first cuts, and decreased in the other cuts (Table 4).

Table 2. Ratios of legumes, grasses, and other plants in botanical composition with different improvement methods in 2007 (%)

Improvement methods	Legumes 1st Cut.	Legumes 2nd Cut.	Grasses 1st Cut.	Grasses 2nd Cut.	Others 1st Cut.	Others 2nd Cut.
Control	10.94	16.36 bc	62.52 cd	62.92 d	26.48 bc	20.72 a
Aeration	4.99	30.43 a	76.81 bc	52.82 d	18.20 c	16.76 ab
Fertilization	7.01	4.92 cd	59.26 cd	79.42 bc	33.72 ab	15.67 ab
Manure	5.25	18.17 abc	52.14 d	65.55 cd	42.61 a	16.29 ab
Over-seeding	5.84	22.12 ab	68.43 bcd	56.79 d	25.73 bc	21.09 a
Aer.+Fert.	0.77	0.51 d	96.37 a	96.19 a	2.99 e	3.30 c
Aer.+Manure	9.71	25.52 ab	73.99 bc	62.65 d	16.31 de	11.83 abc
Fert.+ Over-seed.	6.76	4.56 cd	80.48 b	86.84 ab	12.78 de	8.60 bc
Man.+ Over-seed.	10.90	16.96 abc	70.21 bc	62.09 d	18.57 c	20.96 a

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

Table 3. Ratios of legumes. grasses. and other plants in botanical composition with different improvement methods in 2008 (%)

Improvement methods	Legumes			Grasses			Others		
	1st Cut.	2nd Cut.	3rd Cut.	1st Cut.	2nd Cut.	3rd Cut.	1st Cut.	2nd Cut.	3rd Cut.
Control	21.49 ab	27.89 b	27.19 ab	46.15	36.39 c	21.68 d	32.38 bc	35.87 ab	51.18 a
Aeration	22.13 ab	44.06 a	43.95 a	32.21	31.80 c	35.97 bcd	45.66 a	24.15 bcd	20.05 bc
Fertilization	6.71 c	20.30 c	29.57 ab	51.50	41.50 bc	34.11 cd	44.73 a	38.22 a	36.39 ab
Manure	22.33 ab	23.41 bc	23.60 bc	43.71	35.99 c	44.84 a-d	33.99 b	40.60 a	31.44 abc
Over-seeding	17.85 b	29.22 b	31.39 ab	45.43	36.61 c	32.85 cd	37.28 ab	34.17 abc	35.57 ab
Aer.+Fert.	2.97 c	10.67 d	7.78 cd	65.49	58.46 a	58.95 ab	31.62 bc	30.87 a-d	33.38 abc
Aer.+Manure	25.21 a	27.85 b	27.54 ab	50.21	51.50 ab	43.16 a-d	25.03 bc	20.65 d	36.72 ab
Fert.+ Over-seed.	7.99 c	20.96 c	6.32 d	66.17	56.11 a	59.70 a	25.85 bc	22.93 cd	33.43 abc
Man.+ Over-seed.	26.88 a	24.15 bc	38.54 ab	50.68	42.21 bc	49.63 abc	21.75 c	33.65 abc	11.83 c

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

Table 4. Protein content and Relative Feed Value of rangeland hay obtained from different improvement methods

Improvement methods	Protein content (g kg^{-1})					Relative Feed Value				
	2007		2008			2007		2008		
	1st Cut.	2nd Cut.	1st Cut.	2nd Cut.	3rd Cut.	1st Cut.	2nd Cut.	1st Cut.	2nd Cut.	3rd Cut.
Control	161.1 ab	166.6 a	194.2	175.3 cd	141.3 a	108.6	102.0 ab	132.4	128.8 cd	107.6 bc
Aeration	147.3 abc	149.5 ab	190.6	197.1 a	139.2 ab	106.7	105.1 ab	135.0	129.3 cd	110.0 abc
Fertilization	151.9 ab	133.3 b	217.4	169.9 de	153.4 a	114.6	90.9 bcd	133.3	131.3 bcd	117.8 ab
Manure	159.0 ab	130.8 b	196.3	182.9 bc	149.1 a	117.6	104.5 ab	144.6	138.7 ab	120.3 ab
Over-seeding	162.0 a	133.2 b	182.6	194.9 ab	141.9 a	105.1	93.5 bc	123.2	137.1 abc	122.2 a
Aer.+Fert.	126.5 d	101.2 c	176.4	154.2 f	123.7 bcd	113.0	74.6 d	126.5	123.9 d	99.6 cd
Aer.+Manure	146.6 bc	145.7 b	209.3	161.3 ef	121.9 cd	107.5	112.3 a	135.5	115.1 e	97.1 cd
Fert.+ Over-seed.	136.4 cd	110.5 c	191.9	163.5 def	116.8 d	112.3	83.8 cd	138.3	127.0 d	92.4 d
Man.+Over-seed.	151.6 ab	138.5 b	190.6	194.8 ab	136.1 abc	114.9	111.7 a	138.0	142.3 a	102.0 cd

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

The lowest ADF content in the first cut was obtained from the aeration+fertilization plot with 308.2 g kg^{-1}, but in the second cut it was obtained from the control plots with 362.2 g kg^{-1} in 2007 (Table 5). NDF content increased in all treatment in the second cuts compared to the first cut except for manure plots in 2007 (Table 5). Both ADF and NDF contents of rangeland hay obtained from the second or third cuts were higher than first cuts in all improvement methods in 2007 and 2008 (Table 5). The highest RFV content was generally obtained from the manure treatment and its combinations in both years. RFV content in first and second cuts in 2007 was determined between 105.1 and 114.9 g kg^{-1}, 74.6 and 112.3 g kg^{-1}, respectively (Table 4).

Table 5. ADF and NDF content of hay obtained from different improvement methods (g kg^{-1})

Improvement methods	ADF content					NDF content				
	2007		2008			2007		2008		
	1st Cut.	2nd Cut.	1st Cut.	2nd Cut.	3rd Cut.	1st Cut.	2nd Cut.	1st Cut.	2nd Cut.	3rd Cut.
Control	338.1	362.2 b	292.1	301.9 bc	370.6 abc	551.5	569.5 c	470.0 b	478.4 bc	524.9 bc
Aeration	343.3	366.8 b	289.1	315.6 ab	344.7 b-e	545.2	571.2 c	461.1 b	469.0 bc	532.5 bc
Fertilization	330.8	373.8 b	297.5	302.9 b	339.3 cde	533.5	625.5 bc	495.6 b	481.6 bc	509.9 c
Manure	326.2	364.8 b	278.8	298.9 bc	320.3 e	528.9	601.2 c	450.0 b	461.0 c	517.2 c
Over-seeding	343.3	395.0 ab	274.7	283.8 c	335.8 de	571.2	602.7 c	443.3 b	466.4 bc	500.2 c
Aer.+Fert.	308.2	416.4 a	262.8	307.7 ab	362.8 a-d	537.8	710.1 a	431.5 b	492.8 b	590.9 a
Aer.+Manure	318.0	363.0 b	308.3	323.1 a	377.0 ab	563.1	563.9 c	597.9 a	535.1 a	583.3 a
Fert.+ Over-seed.	326.5	413.5 a	276.9	299.3 bc	384.4 a	538.4	667.2 ab	457.2 b	491.5 b	610.4 a
Man.+Over-seed.	333.1	371.8 b	281.1	302.1 bc	358.8 a-d	518.3	572.1 c	462.8 b	468.8 bc	572.3 ab

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

DISCUSSION

Increasing cut numbers positively affected the total yield in the second year (in 2008), and total hay yield in 2008 was higher than in 2007. In both years, the highest yield was generally obtained from first cuts. Compared to the control, all improvement methods generally increased the total yield in both years. According to two-year mean, the highest yield was obtained from the fertilization and aeration+fertilization treatments (Table 1). Similarly, the experiments, conducted in Turkey, showed that hay yields of ranges increased with the chemical fertilizer applications (Andic et al. 2001; Koc et al. 2003; Hatipoglu et al. 2005; Cinar et al. 2005; Ayan and Acar, 2008). Guevara et al. (2000) reported that forage production increased by N+P fertilization. Concerning the botanical composition, grasses whose contents were more than legume and the other plant species in the first year used the given chemical fertilizer faster than other plants from, and they showed more rapid and aggressive growth. Thus, it increased the efficiency of fertilizer on yield. Furthermore, total hay yield in second year increased by sheep manure application. A previous study showed that the application of livestock manure could improve the native rangeland production (Mut, 2009). The aeration treatment and its combinations had significant effect on yield. Over-seeding treatment in this experiment was unsuccessful, because seedlings could not compete against present vegetation. Bayram et al. (2009) reported that aeration treatments had significant effects on dry matter yield.

Legumes in the first cut were very low in 2007. This situation could be explained by that slow growth rates of legumes have rapid growth period of vegetation in spring. Legume rate increased in the second cut and second year. Aeration and manure treatments and their combinations increased this rate. However, a decrease was observed in the grass content in 2008. It could be explained that grass species in the experimental field were annual plant species with shallow root systems and they probably were negatively affected by the treatments aeration and early cuts. The annual grass species were not able to set their seeds due to the treatments aeration and early cut. As a matter of the fact that, Altın et al. (2005) reported that yield loses were seen in the pastures dominated by annual grass species because of pasture ripping.

In both years, chemical fertilization reduced the legume content and increased the grass content and total yield. Similar results were reported by Griffin et al. (2002). Grass content increased by aeration+commercial fertilization treatments in 2007 (Table 2) because of the more intensive and faster growth of grasses. Knezevic et al. (2007) stated the similar results. Content of the plant species belonging to neither legumes nor grasses increased in all cuts in 2008 since cuts increased the competitiveness of rosette forming plants such as ribwort plantain and common daisy etc. Vegetation became more balanced concerning the legume, grass, and other plant contents by the improvement methods.

In general, forage samples from the first cut had higher crude protein content and lower ADF and NDF content compared to the second or third cuts. Higher CP content and lower ADF and NDF contents in first cuts were highly related to early growing stage of plants. Young leaves, and flowers provide the higher feed-quality forage. Additionally, the most rapid plant growth generally occurs during the hottest season. In fast growing plants or more mature plants, leaf ratio is less than stem ratio, so, nutritive value of this plant is lower (Caddel and Allen, 2010).

Air temperature in the growing period of the second and the third cuts were higher than the growing period of the first cut (Figure 1 and 2). Therefore, plant growth was faster in the second and third cuts.

In this experiment, CP, ADF and NDF values of forage samples obtained from the different improvement methods were close to each others. The growth stages of the plots were similar at harvest stage, and that improvement methods affected the CP, ADF, and NDF contents of forage as well. The difference between ADF and NDF values was statistically insignificant. It could be explained that plant species were harvested at early stage (grazing maturity) and cellulose accumulation of the plants at this stage were close to each others.

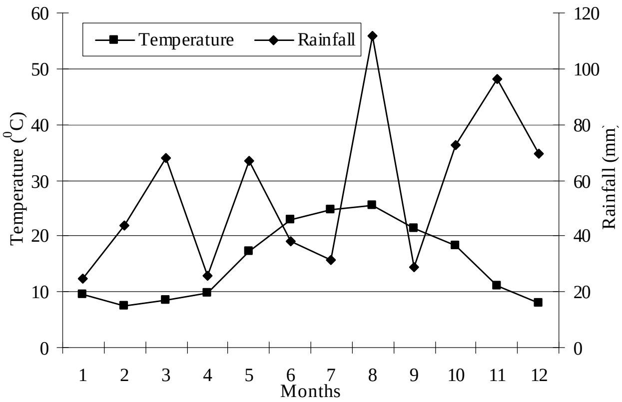

Figure 1. Climatic diagram belong to Samsun Province in 2007.

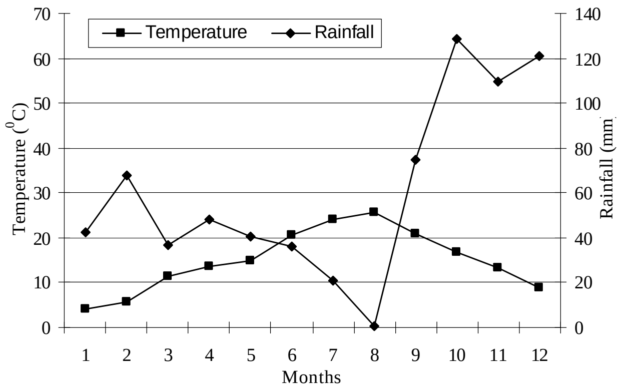

Figure 2. Climatic diagram belong to Samsun Province in 2008.

Caddel and Allen (2010) reported that the most important factor affecting forage quality was stage of growth at harvest. Some researchers reported similar findings (Aydın and Uzun, 2000; Mut, 2009). Crude protein content of forages was generally high, especially in 2008 (Table 4). This situation can be explained by that those legumes with high protein content increased in botanical composition in 2008 (Table 3).

Relative feed value is an important quality character and measures the overall feed value of forages. RFV is used to compare quality of forage based on the maturity of the plant when harvested. The higher the RFV in all forages is the more digestible and palatable. The RFV values in 2007 in the second cut compared to the first cut were lower. Relative feed value of pasture increased in 2008, and according to quality standards of American Forage and Grassland Council (Anon, 2010), rangeland hay was determined as premium in first and second cuts.

CONCLUSION

This study showed that the rangeland improvement methods especially aeration and its combinations increased the hay yield and quality. When the commercial fertilization was applied with aeration, hay yield increased more, but forage quality decreased. Whereas, sheep manure application increased the both yield and quality. The cuts at the grazing maturity stage positively affected the yield and quality of forages.

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