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Full Length Research Paper

The effects of sheep manure application time and rates on yield and botanical composition of secondary succession rangeland

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This experimental study was conducted in Samsun/Turkey on a secondary succession rangeland during 2006 - 2008. Botanical composition of the experimental area consists of 28% legumes, 64% grasses, and 8% of other species. Target rates of sheep manure were 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 sheep manure). The sheep manure was applied at two different times. Means of 3 years of experimental period and total dry matter yield was obtained from the manure treatment of 75.0 kg N ha^{-1} and 50 + 50 kg N ha^{-1} (4153 kg ha^{-1}, and 3813 kg ha^{-1}, respectively). With respect to the three-year average, ratios of legumes, grasses, and other plants ranged from 20.8 to 40.7%, 41.6 to 66.9%, and 10.7 to 20.7%, respectively. Although ratios of legumes, and other plants increased in the all of the treatments, grass ratios decreased. The crude protein content of obtained rangeland hay ranged between 107.0 and 143.0 g kg^{-1} in 2006, 93.0 and 123.4 g kg^{-1} in 2007, 116.3 and 166.4 g kg^{-1} in 2008. The maximum benefit was provided from the application of 75.0 kg N ha^{-1} with a sum of € 971.2 ha^{-1}.

Key words: Dry matter yield, crude protein, manure, application and time, rangeland, botanical composition.

INTRODUCTION

In Turkey, including Samsun, there are about 14 million hectares of rangelands (Anon, 2008a). Greatly different landforms and climates are the characteristics of this large area. Within these landforms, there are remarkable rangeland ecosystem diversities; one of them is the secondary succession rangeland of Samsun. These types of areas in Samsun province are available in Kavak, Ladik, and Vezirköprü towns, and over 200 m height in coastline (Mut, 2009).

The rangeland degradation process is a complex process and brings about the changes in the physical, chemical, and biological properties of soils, as well as changes in plant vigor, species composition, seed germination, seedling recruitment, total biomass production, and other ecological functions (NRC, 1994).

Tueller (1973), who was investigated the process of rangeland degradation, suggested 16 factors that were occurred different stages of the degradation process. The process of rangeland improvement is also complex. Succession starts immediately after the abandonment (Gokkus, 1994; Gokkus and Koc, 1996). Depending on altitude, succession process at different speeds and at some stages and therefore the type of vegetation indicates the time passed since applied abandonment (Matus et al., 2003). The development of semi-natural vegetation has recently been a primary concern of restoration efforts (Csecserits and Rédei, 2001). Milton (1994) reported that recovery of both forage and non-forage species, seemed to be inhibited by competition and seedlings seldom survived near adult plants of the same growth form.

The application of animal manure on land area is an effective alternative form of utilization because of usually lower costs compared with manure treatment and the nutrient benefits derived by crops from manure. It is well

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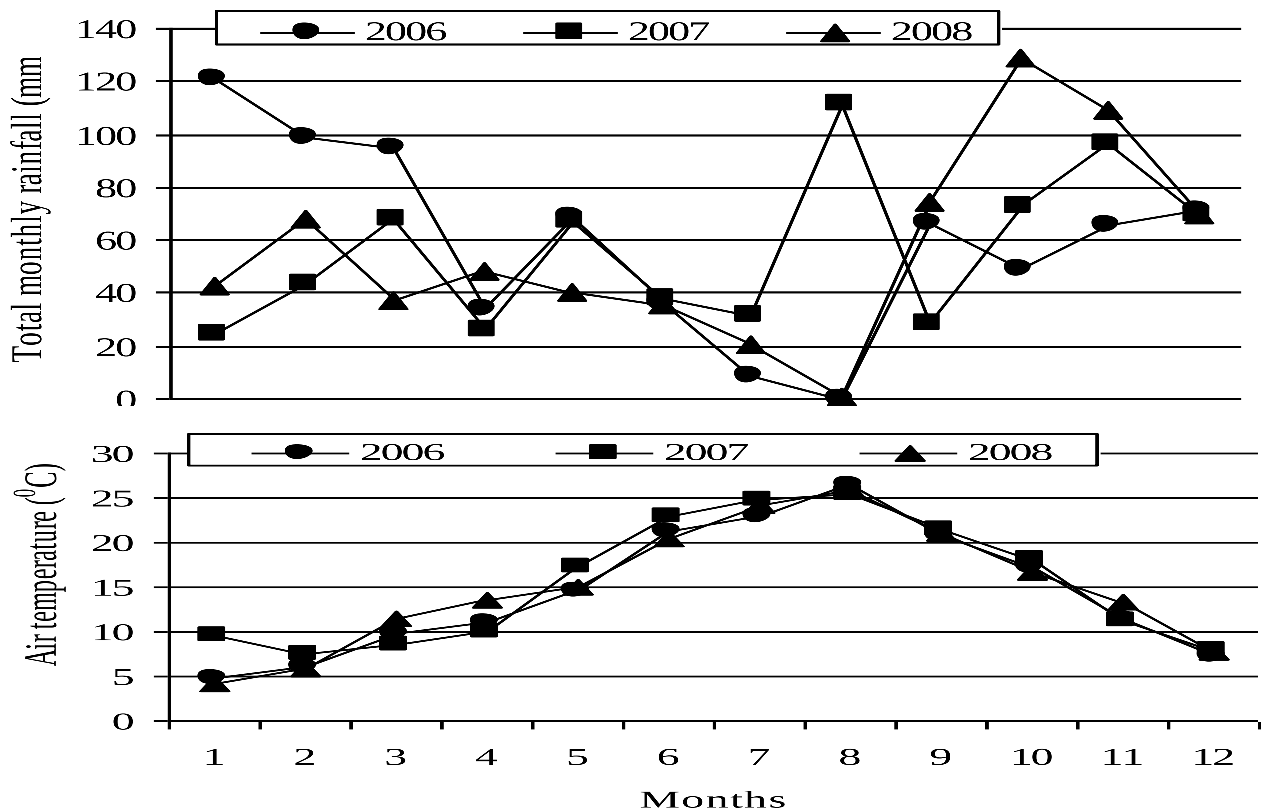

Figure 1. Total amount of rainfall and air temperature during 2006 - 2008.

known that manure nutrients are effective in building and maintaining soil fertility. Manure can also improve soil tilth, increase water-holding capacity, decline wind and water erosion, improves aeration, and promotes beneficial organisms. There are two principal objectives in applying animal manure to land: 1) To ensure the maximum utilization of the manure nutrients by crops and 2) to minimize water pollution hazard (Johnson and Eckert, 1995).

Mugerwa et al. (2008) reported that manured plots showed higher dry matter production, species wealth, percentage cover, and drastic changes in botanical composition than that of non-manure plots.The principle objective of the present research was to identify manure management systems which minimize environmental pollution and result in good agronomic rangeland yields.

MATERIALS AND METHODS

This study was carried out on a secondary succession rangeland in Samsun/Turkey (altitude of 190 m; 41°21' N, 36°15' E) during 2006, 2007 and 2008. The experimental area was plowed about 30 years ago and then abandoned. The growing season of the herbaceous vegetation in Samsun begins in mid-February and ends in June (Aydın and Uzun, 2005). A climatic diagram of the study area in Samsun is presented in Figure 1. While the 50-year mean total rainfall was 670.2 mm, the annual total rainfall was 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 means (14.2°C in long term, 15.0, 14.5, 15.4 and 15.6°C, respectively) (Figure 1). The soil texture was clay with an approximately 2.80% organic matter content, phosphorus content of 2.37 kg da^{-1}, potassium content of 85 kg da^{-1}, pH of 6.35, and soil depth of 23 cm.

Before the application of sheep manure, the botanical composition of experimental area was determined using transects method. Botanical composition of the experimental area consisted of 28% legumes, 64% grasses, and 8% of other species, and plant covering area percentages was 41.01%. Legumes in the botanical composition were haresfoot clover (*Trifolium arvense* L.), burclover (*Medicago polymorpha* L.), little burr medic (*Medicago minima* (L.) Bart.), disc trefoil (*Hymenocarpus circinnatus* (L.) Savi), persian clover (*Trifolium resupinatum* L.), slender bird's-foot trefoil (*Lotus angustissimus* L.), small hop clover (*Trifolium dubium* Sibth.), spotted medick (*Medicago arabica* L.); grasses were wild oat (*Avena fatua* L.), cheatgrass (*Bromus tectorum* L.), bulbous barley (*Hordeum bulbosum* L.), fringed fescue (*Vulpia ciliata* Dumort), perennial ryegrass (*Lolium perene* L.), orchardgrass (*Dactylis glomerata* L.); and other plants were 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.), viper's bugloss (*Echium vulgare* L.).

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

Table 1. Manure treatments used in the rate and time of application experiments.

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

plots can be seen in Table 1.

Manure treatments were applied in a randomized complete block design with 3 replicates during three consecutive growing periods. Manure was applied to 5 × 6 m plots with a distance of 2 m between each plot on November 25, 2005 and on March 14, 2006 and applied only first year. Twenty square meter area of herbaceous vegetation was annually harvested when dominant grass + legume plants reached 50% flowering stage. Harvesting was done by hand on May 23, 2006, on May 22, 2007 and on May 14, 2008. Harvested samples within 1 m^2 quadrate in each plot were separated 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 for each group were oven-dried at 60°C. Dry matter production was calculated through the values of green forage production and dry-weight percentage for each crop family for the plots. After cooling and weighing, the samples were ground to pass through a 1 mm screen. Crude protein contents of samples were determined using near infrared reflectance spectroscopy (NIRS) 13 - 15. NIRS was calibrated using software program coded IC - 0904FE. Crude protein yield was calculated by multiplying dry matter yield with crude protein content of each plot. An over all economic analysis was carried out considering December 2006, 2007 and 2008 prices (€ 0.06 kg^{-1} sheep manure, € 3.38 kg^{-1}in 2006, € 3.62 kg^{-1} in 2007, € 3.663 kg^{-1} in 2008 meat on the hoof and other expenditures were accepted as 20% of manure prices) (Aydın and Uzun, 2005). A conversion rate of 1.8 kg of consumable crude protein per kg of meat on the hoof in cow–calf was assumed (NRC, 1996).

The data were analysed using the statistical package program statistical package for the social sciences (SPSS) 11.0 V and probabilities less than 0.05 were considered significant. The Duncan comparison test was performed to separate the treatment means. All significant main affects were considered.

RESULTS

The effects of manure applications on dry matter production were found to be significant (Table 2). Legume dry matter yield in control plots ranged from 333 to 820 kg ha^{-1} over data of 3-years. In the plots treated with manure, their ratios changed from 128 to 946 kg ha^{-1} in 2006, from 293 to 1370 kg ha^{-1} in 2007, and from 1333 to 3315 kg ha^{-1} in 2008. Over the mean of the years, while the highest legume dry matter yields were obtained from 75, 50+50, and 50 kg N ha^{-1} treatments (1767, 1602, 1476 kg ha^{-1}, respectively), the lowest yield was obtained from control plot (560 kg ha^{-1}) and manure treatment consist of 25.0 kg N ha^{-1} (585 kg ha^{-1}). Dry matter production belonging to the grasses ranged from 688 to 1997 kg ha^{-1} in 2006, from 721 to 1824 kg ha^{-1} in 2007, and 1149 to 1937 kg ha^{-1} in 2008. Based on the results of three years, the other plants yield ranged from 285 (consist of 25.0 kg N ha^{-1}) to 740 kg ha^{-1} (consist of 75.0 kg N ha^{-1}) (Table 2). Total dry matter yield, highest in every year (2006, 2007, and 2008) and over means of 3 years of the experimental period in the manure treatment was obtained from applied 75.0 kg N ha^{-1} (2630, 3258, 6571 and 4153 kg ha^{-1}, respectively) (Figure 2).

The effects of manure applications on ratios of legume, grass, and other plants in botanical composition were found to be significant. Based on 3 years average, ratios of legumes, grasses, and other plants ranged from 20.8 to 40.7%, 41.6 to 66.9%, and 10.7 to 20.7%, respectively. While ratios of legumes, and other plants increased in whole treatments, grass ratios decreased (Table 3).

Crude protein content was calculated in the legume, grass and other plant species were analyzed separately. After that, crude protein content of the plots were calculated concerning legume, grass and other species percentage in samples and botanical composition. As an average of 3 years, the crude protein content of legumes, grasses and other plants are presented in Figure 3. The crude protein ratios of legumes, grass and other families was found to be between 15.5 and 17.4, 8.9 and 12.2, and 13.8 and 16.3%, respectively, depending on manure application (Figure 3). The crude protein content of rangeland hay was ranged between 107.0 and 143.0 g kg^{-1} in 2006, 93.0 and 123.4 g kg^{-1} in 2007, 116.3 and 166.4 g kg^{-1}, depending on sheep manure application. The combined averages of crude protein content varied from 110.7 to 136.9 g kg^{-1}. The application of manure had a significant effect on crude protein production except for control plots. Crude protein yield ranged from 119.5 (37.5 kg N ha^{-1}) to 349.0 (50.0 kg N ha^{-1}) in 2006, from 224.7 (25.0 kg N ha^{-1}) to 390.3 (75.0 kg N ha^{-1}) in 2007, from 394.4 (25.0 kg N ha^{-1}) to 991.3 kg ha^{-1} (75.0 kg N ha^{-1}) in 2008. According to the results of three years, while the highest crude protein yield was obtained from manure

Table 2. Dry matter yield of legumes, grasses, others, and total with different manure application ratios (kg ha $^{-1}$).

Treatments (kg N ha $^{-1}$)	Legumes				Grasses				Others				Total			
	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
0	333 cd	528 de	820 d	560 d	1159 cd	1211 bcd	1149 c	1173 de	397 b	294 de	189 g	293 b	1889 c	2033 b	2157 f	2026 f
25.0	128 e	293 e	1333 c	585 d	1472 bc	1824 a	1467 bc	1588 ab	287 c	300 de	267 g	285 b	1887 c	2417 b	3067 e	2457 ef
50.0	725 b	593 d	3111 a	1476 ab	1997 a	1513 ab	1280 bc	1597 ab	210 d	287 de	604 f	367 b	2932 a	2393 b	4995 bc	3440 bc
75.0	615 b	1370 a	3315 a	1767 a	1520 bc	1482 ab	1937 a	1646 a	496 a	406 cd	131 8 c	740 a	2630 ab	3258 a	6571 a	4153 a
100.0	456 c	633 d	2542 b	1210 bc	1137 cd	982 cde	1446 bc	1188 de	28 f	663 a	866 e	519 ab	1621 c	2279 b	4853 c	2918 cde
12.5 + 12.5	136 e	1003 c	1406 c	848 cd	1767 ab	827 de	1459 bc	1351 abc	70 ef	224 e	1109 d	467 ab	1973 c	2054 b	3974 d	2667 def
25.0 + 25.0	347 cd	1321 ab	2318 b	1329 b	1012 de	1271 bc	1579 b	1287 cde	266 cd	452 bc	937 de	552 ab	1626 c	3043 a	4833 c	3167 bcd
37.5 + 37.5	239 de	1076 bc	2391 b	1235 bc	688 e	721 e	1542 b	984 e	107 e	551 ab	1518 b	725 a	1035 d	2349 b	5450 b	2944 cde
50.0 + 50.0	946 a	1284 ab	2576 b	1602 ab	1425 bc	1736 a	1271 bc	1477 abc	64 ef	450 bc	1686 a	733 a	2435 b	3470 a	5534 b	3813 ab
Mean	436 c	900 b	2201 a		1353	1285	1459		214 c	403 b	944 a		2003 c	2588 b	4604 a	

Values with different letters for the columns indicate different significant groups ($P<0.05$).

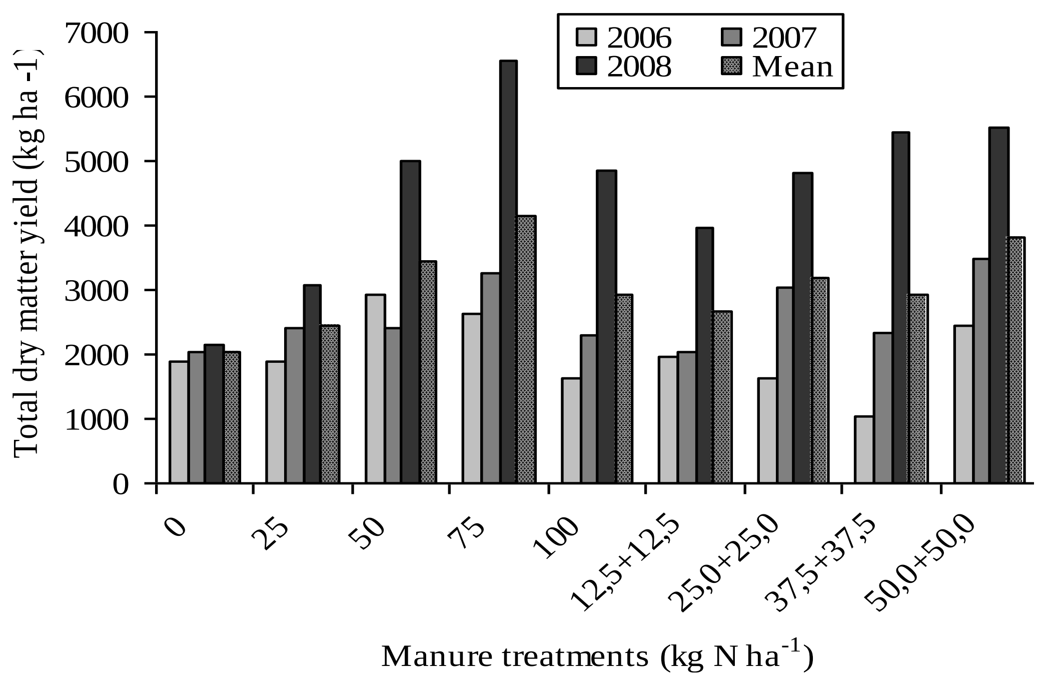

Figure 2. Total dry matter yield with different manure application ratios.

Table 3. Ratios of legume, grass, and other plants in botanical composition for different manure application ratios (%).

Treatments (kg N ha $^{-1}$)	Legumes				Grasses				Others			
	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
0	17.5 d	26.0 d	38.1 de	27.2 cd	61.4 de	59.7 b	53.1 a	58.1 b	21.1 a	14.3 b	8.8 d	14.7
25.0	6.8 e	12.1 e	43.5 cd	20.8 d	77.4 b	75.4 a	47.7 b	66.9 a	15.7 b	12.4 b	8.7 d	12.3
50.0	24.8 bc	24.6 d	62.3 a	37.2 ab	68.0 cd	62.7 b	25.6 ef	52.1 bcd	7.2 c	12.7 b	12.1 c	10.7
75.0	23.4 c	41.7 bc	50.5 b	38.5 ab	57.7 e	45.4 cd	29.4 de	44.2 de	18.9 ab	13.0 b	20.0 b	17.3
100.0	28.1 b	27.8 d	52.5 b	36.1 ab	70.1 c	43.1 cd	29.7 de	47.6 cde	1.7 d	29.1 a	17.8 b	16.2
12.5+12.5	7.0 e	48.6 a	35.1 e	30.2 bc	89.6 a	40.4 d	36.9 c	55.6 bc	3.5 d	11.0 b	28.0 a	14.2
25.0+25.0	21.5 cd	43.4 ab	48.1 bc	37.7 ab	62.2 de	41.7 d	32.6 cd	45.5 de	16.3 b	14.9 b	19.2 b	16.8
37.5+37.5	23.2 c	46.2 ab	43.9 cd	37.7 ab	66.4 cd	30.2 e	28.3 def	41.6 e	10.5 c	23.6 a	27.8 a	20.7
50.0+50.0	38.7 a	37.0 c	46.4 bc	40.7 a	58.6 e	50.0 c	23.1 f	43.9 de	2.6 d	13.0 b	30.5 a	15.4
Mean	21.2 c	34.2 b	46.7 a		67.9 a	49.8 b	34.1 c		10.8 b	16.0 a	19.2 a	

Values with different letters for the columns indicate different significant groups (P<0.05).

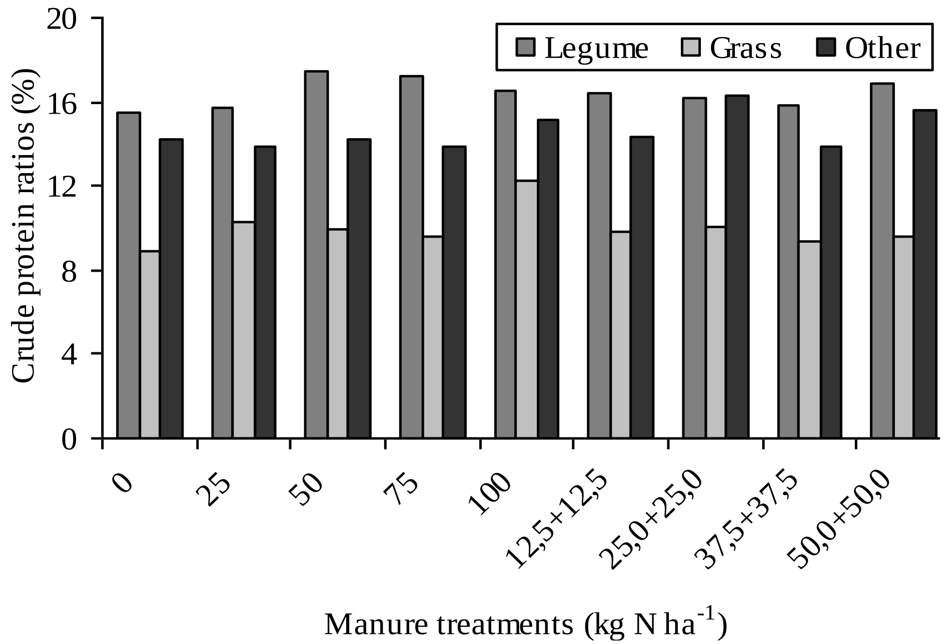

Figure 3. Crude protein ratios of legumes, grass, and other with different manure application ratios as mean of the three experimental years.

Table 4. Crude protein content and crude protein yield on a rangeland with different manure application ratios as mean of the three experimental years.

Treatments (kg N ha $^{-1}$)	Crude protein content (g kg^{-1})				Crude protein yield (kg ha^{-1})			
	2006	2007	2008	Mean	2006	2007	2008	Mean
0	110.7 b	123.4 a	116.3 d	116.8 cd	209.2 b	250.8 c	251.3 e	237.1 f
25.0	110.8 b	93.0 d	128.3 cd	110.7 d	209.4 b	224.7 c	394.4 d	276.2 ef
50.0	118.8 b	101.0 cd	160.7 a	126.8 abc	349.0 a	239.4 c	803.1 b	463.8 abc
75.0	122.7 ab	119.3 ab	150.4 ab	130.8 ab	321.5 a	390.3 a	991.3 a	567.7 a
100.0	143.0 a	117.0 ab	150.9 ab	136.9 a	232.3 b	266.4 c	730.8 b	409.8 cd
12.5+12.5	107.0 b	118.3 ab	134.0 bc	119.8 bcd	209.0 b	243.7 c	530.1 c	327.6 def
25.0+25.0	124.5 ab	113.2 abc	154.8 a	130.8 ab	205.5 b	344.3 ab	746.5 b	432.1 bcd
37.5+37.5	114.3 b	120.8 ab	135.9 bc	123.7 a-d	119.5 c	282.2 bc	740.6 b	380.8 cde
50.0+50.0	127.0 ab	106.2 bcd	166.4 a	133.2 ab	310.9 a	368.8 a	922.8 a	534.1 ab
Mean	119.9 b	112.5 c	144.2 a		240.7 b	290.1 b	679.0 a	

Values with different letters for the columns indicate different significant groups (P<0.05).

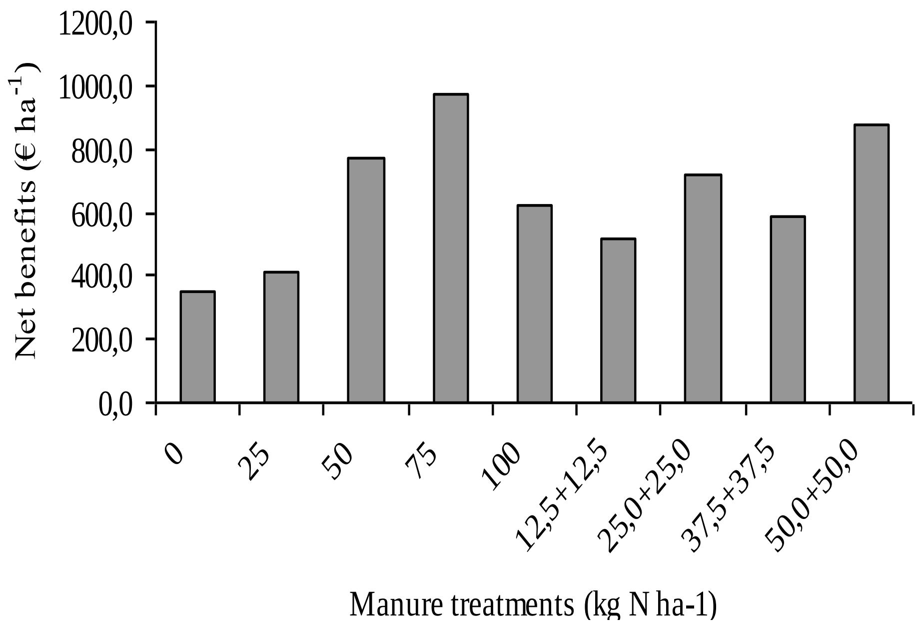

Figure 4. Net benefits for the manure application ratios of rangeland.

application consisting of 75.0 kg N ha^{-1} (567.7 kg ha^{-1}), the lowest yield was obtained from control plots (237.1 kg ha^{-1}) (Table 4).

Averaged of the 3 years, economic analysis results showed that fertilization with sheep manure was found to be beneficial in all the treatments. But, the maximum benefit was provided from the application of 75.0 kg N ha^{-1} with a sum of € 971.2 ha^{-1} (Figure 4).

DISCUSSION

The results of the study indicate that total dry matter production was improved by the application of manure. All of the manure in autumn or in a combination of one half in the autumn and one half in the spring was applied to the experimental area. Time of manure application had significant effect on dry matter yield in secondary succession rangeland. In the present study, the highest yield was obtained with the application of 75.0 kg N ha^{-1} (all of N applied in autumn), however, the botanical composition of the dry matter yield of legumes, grasses, and the others differed significantly between the years. In all application, dry matter increased from 2006 up to 2008. Besides the effect of sheep manure, the distribution of rainfall and temperature during the year was encouraging (Figure 1). Blonski and Bork (2002) reported that in the year following application, above normal precipitation aided in producing significant increases in grass biomass. The increasing of forage yield following nutrient addition was described by earlier studies (Black, 1968; Blonski et al., 2004). Mut (2009) reported that total dry matter yield ranged from 3575 to 6393 kg ha^{-1} in the same ecological conditions.

The effects of manure applications on ratios of legume, grass, and other plants in the botanical composition were found to be significant, and botanical composition was changed in every year in this study. Manure application reduced grass proportion which was less productive annual grasses while legume proportion increased in the vegetation. On the other hand, manure applications altered plant species composition. In ungrazed range-land, study has shown the reducing effect on the abundance of ground cover species (McKenzie et al., 2003). In most areas, grasses are the dominant species in the climax plant community of rangelands with good quality (Holechek et al., 1998). However, in our study, except the control plots, the frequency of annual grasses in botanical composition was lower than 50% in 2008. Like many other authors (Csecserits and Redei, 2001; Bartha et al., 2003; Ruprecht, 2005), we noticed that plant species in abandoned fields showed high hetero-geneity especially consecutive to the abandonment. In this manner, the species diversity plays a more important role in early succession than the spatial heterogeneity (Arsene, 2008). Additionally, Aydın and Uzun (2008) reported that the effects of fertilizer applications on ratios of legume and grass in botanical composition were found to be significant. Bayram et al. (2009) reported that poultry manure had no effect on legume and grass proportions.Crude protein is one of the most limiting factors for livestock productivity. In this study, manure application generally increased crude protein content. As dry weight ratio of legumes which have high crude protein content, were also increased by manure application, botanical composition of forage may directly affect the forage quality (Aydın and Uzun, 2008). Applying hog manure to pasture grass increased crude protein by 80% and brought a three-fold increase in yield (Anon, 2008b). Crude protein production depends on dry matter yield in plots and crude protein content of plants, which changed between plant species. In fact, manure applications affected not only crude protein production but also botanical composition in rangelands (Aydın and Uzun, 2005). In the present study, a net benefit in control plotwas € 352.6 ha^{-1}, and manure application increased the net benefit for all the plots. The ratios of the net benefits ranged between 16.9 and 175.4%.

Conclusion

This study showed that autumn manure applications (all of manure applied in autumn) provided high yield, quality, and net benefit, and conserve the fertility value of manure. It was suggested that no more than 3 t ha^{-1} (75 kg N ha^{-1}) manure per year should be applied according to environmental conditions especially rainfall. Sheep manure should be applied either of 75.0 kg N ha^{-1} all of N in autumn or 50+50 kg N ha^{-1} (half of N applied in autumn, remaining N applied in spring). The crude protein content and yield rose with increasing application rates. In case of suitable conditions at similar climates and vegetations, the application of sheep manure on rangelands will be able to increase dry matter yield.

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