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Effects of Different Improvement Methods on Some Soil Properties in a Secondary Succession Rangeland

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ABSTRACT

This study was conducted between 2005 and 2008 in a native pasture which was ploughed 30 years ago and abandoned, located in Ondokuz Mayis University Campus in order to investigate the effects of different improvement treatments on chemical characters of pasture soil. Treatment application started in 2006; i) control, ii) aeration, iii) early cutting, iv) commercial fertilization, v) sheep manure application, vi) reseeding, and their combinations. The effects of applied pasture improvement treatments showed differences both in the same year and among the years. There was an outstanding increase in the plots where manure alone was applied; however the increase was not so distinctive in the plots where manure was applied with other treatments (manure and its combinations). Soil physical properties were improved with extra organic matter. Electrical conductivity values of the soil samples of the experimental area were 0.568 – 0.793 dS/m in 2006, 0.459 – 0.675 dS/m in 2007 and 0.289 – 0.698 dS/m in 2008. Potassium, calcium and magnesium contents of the soil samples were very high and changed between 0.261 and 0.798; 28.333 and 37.417; 7.958 and 15.083 cmol kg^{-1}, respectively. In the 3-year study, it was concluded that native pastures should definitely be improved by implementing appropriate improvement methods considering climatic conditions, soil characters, plant species and their botanical compositions.

Key Words: Soil minerals, improvement methods, secondary succession rangeland.

INTRODUCTION

Native pastures occupy 27.9% (21.7 million ha) of Turkey's lands and only 30.12% of ruminant demand as roughage can be met from the pastures (Babalik 2008). Native pastures in many parts of Turkey exposure heavy grazing pressure. These kinds of natural feed sources have become less productive in terms of quantity and quality depending on environmental and utilization factors. This situation negatively affects animal husbandry and indirectly Turkish economy. As result of various socioeconomic changes, large amount of native pasture areas have been cultivated and abandoned in Turkey. Especially, native pastures were intensively ploughed between 1950 and 1960 for agricultural crops and then abandoned. Native pasture areas decreased from 37.9 million ha to 21 million ha (Buyukburc and Arkac 2000). Large amount of these lands are real native pastures and generally slope, dry and they have very limited water amount. After being ploughed, soil erosion occurs in the pastures whose plant vegetation was lost and whose soils were loosened until dense plant formation (Gokkus and Koc 1996). Especially after 1980, these lands were left because of increasing immigration from the country to urban areas (Gokkus et al. 2001). At the beginning of plant succession in the cultivated and abandoned pastures, annual pasture plants or annual and perennial weeds are dominant plant species depending on soil texture, rainfall and other factors. After that, perennial vegetative species with high feed values start to grow in that pastures (Gokkus 1994). By the time, native pastures may regain the botanical composition just like before cultivated. Even bushy plants and a couple of trees can grow in further succession. Knowing the succession in botanical composition is extremely important for pasture management and improvement. In the lights of above mentioned situations, it is necessary to determine the most effective and economic improvement methods to get result in short term so as to increase the yield and quality of the native pastures previously cultivated and abandoned. The number of studies on improvement methods of these pastures is very limited and there is no this kind of study conducted in Black Sea Region.

One of the most significant factors affecting pasture productivity and botanical composition is soil structure. The pasture improvement methods do not only change the botanical composition but also cause structural variations on pasture soils. For this reason, it is extremely important to investigate the soil structure and botanical composition. The study was conducted to figure out the effects of different improvement methods on some soil character of the pasture previously cultivated and abandoned.

MATERIALS AND METHODS

This study was conducted between 2005 and 2008 in a native pasture, which was ploughed 30 years ago and abandoned in the campus of Agriculture Faculty of Ondokuz Mayis University. The side slopes of the experimental area were 18% with 178 m altitude facing south – east. Soil depth was between 23 and 45 cm.

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Before starting the study, the experimental area was fenced with net wire in 2005 and grazing was taken under control.

Soil was slightly acidic (pH 6.35) and clay. It had low lime content (0.33) and very low salt (0.086). Phosphorous content of the experimental soil was also very low (23.7 kg/ha) but it had high potassium (850 kg/ha) and average organic matter content (2.80%). Average long term temperature values of Samsun province was 14.2 ^{0}C. The temperature values during the experiment were 15.0, 14.5, 15.4, 15.6 ^{0}C, in 2005, 2006, 2007 and 2008, respectively.

Total long term average rainfall of Samsun province was 670.2 mm. During the experiment, the average rainfall values in 2005, 2006, 2007 and 2008 were 788.1, 714.7, 677.5 and 605.9 mm, respectively. Average long term air humidity rate of Samsun province was 73.8%. The air humidity rates in 2005, 2006, 2007 and 2008 were 75.4, 74.3, 71.9 and 73.1%, respectively (Figure 3.2).

A randomized complete block design with four replicates was used. 16 treatment plots, each 4mx2.5m in size with a distance of 1m between each plot were established. All treatments were applied in the spring of 2006. Applied improvement treatments were presented Table 1. Aeration treatment was applied by spring-tine harrow. Aeration was made only first year of experiment and surface of vegetation was ripped at 6 cm depth. According to the results of soil analysis, commercial fertilizer was applied as ammonium nitrate with rates of 50 kg N ha^{-1} and as triple super phosphate with rates of 80 kg P ha^{-1}. Half of the N and all of P were applied at the end of November. The remaining N was applied at the beginning of rapid growth period of vegetation in spring. Manure samples were taken from the barn and analyzed for nutrition content (especially N content) 2 week prior to application. Sheep manure was applied on November with rates of 50 kg N ha^{-1}. All of the fertilizers were broadcasted by hand on vegetation. Over-seeding was made at the end of October with rates of 40% legumes (20% sainfoin, 10% birdsfoot trefoil, and 10% white clover) and 60% grasses (20% smooth brome grass, 20% orchard grass, and 20% ryegrass).

Table 1. Investigated improvement methods

1	Control (C)	9	CF + EC
2	Aeration (A)	10	CF + RS
3	Early Cutting (EC)	11	SM + EC
4	Commercial Fertilizer (CF)	12	SM + RS
5	Sheep Manure (SM)	13	A + CF + EC
6	Reseeding (RS)	14	A + SM + EC
7	A+CF	15	CF + RS + EC
8	A+SM	16	SM + RS + EC

In 2006, 2007 and 2008, texture, organic matter, P, K, Ca, Mg contents, pH and EC values were determined for each plot. The texture analysis of the plots was determined by using '*Bouyoucos Hidrometre*' method (Demiralay 1993). The pH values of the soils taken from the each plot were found using the pH meter with glass electrode in the rate of 1:1 soil-water (Bayrakli 1987). Electrical conductivity values were figured out using the electrical conductivity machine in 1:1 soil-water rate (Richards, 1954). Soil organic matter was analyzed according to 'Walkley-Black' method. Phosphorous contents were determined considering 'Bray and Kurtz' or "Olsen" methods depending on the pH values of the soil samples (Kacar 1994). To determine the variable cations, 5g soil sample was leached from the filter paper by extracting 25 ml 1N ammonium acetate ($CHCOONH_4$) with 7.00 pH. The potassium in the leached extract was determined by flame photometer. Calcium and magnesium contents were found by titrating with 0.01M EDTA (Saglam 1997).

RESULTS AND DISCUSSION

Pasture improvement treatments could affect both vegetation and some characters of the soil (Oztas et al. 2003; Bayram 2009). In the study to determine the effects of 16 different improvement methods in a pasture previously cultivated and abandoned, some characters of the experimental area soil was presented in Table 2. According to analysis, it was found out that the soils of the experimental area have been clay structure.

Table 2. Some chemical properties of soil according to improvement treatments

Treatments		Year	O.M. (%)	EC (dS/m)	pH	P (ppm)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)
1	Control (C)	2006	5.20	0.736	5.77	4.299	0.261	32.583	11.167
		2007	5.72	0.460	5.67	5.384	0.343	31.833	13.833
		2008	5.73	0.419	5.89	2.583	0.340	33.042	11.625
2	Aeration (A)	2006	5.96	0.600	6.05	4.663	0.343	32.750	12.000
		2007	3.40	0.659	6.00	4.912	0.447	34.250	10.667
		2008	3.13	0.607	5.98	1.680	0.442	37.417	9.000
3	Early Cutting (EC)	2006	3.70	0.612	6.08	4.833	0.535	33.250	11.250
		2007	4.02	0.565	5.93	5.051	0.664	32.500	10.917
		2008	4.30	0.514	5.97	4.571	0.798	33.167	11.417
4	Commercial Fertilizer (CF)	2006	3.50	0.665	5.83	4.279	0.521	32.917	11.417
		2007	4.60	0.564	5.92	6.629	0.560	31.000	13.917
		2008	4.32	0.450	6.12	3.430	0.420	33.708	9.708
5	Sheep Manure (SM)	2006	2.90	0.580	6.05	7.217	0.345	32.083	11.417
		2007	4.72	0.548	6.20	6.317	0.434	32.417	10.167
		2008	4.68	0.698	6.10	3.147	0.302	32.917	9.500
6	Reseeding (RS)	2006	4.00	0.663	6.38	2.965	0.550	36.458	10.208
		2007	4.93	0.653	6.02	5.714	0.500	30.500	15.083
		2008	4.72	0.504	6.02	3.581	0.358	37.167	8.333
7	A+CF	2006	3.30	0.590	6.01	6.664	0.380	35.750	9.250
		2007	3.09	0.459	6.19	6.334	0.382	33.000	11.083
		2008	3.06	0.494	6.00	2.587	0.385	34.333	11.083
8	A+SM	2006	2.50	0.568	6.41	5.456	0.626	33.250	10.500
		2007	3.15	0.559	6.36	4.842	0.472	35.792	8.875
		2008	3.33	0.558	6.37	2.351	0.376	36.333	9.333
9	CF+EC	2006	4.10	0.793	5.87	6.527	0.489	33.500	11.333
		2007	4.16	0.578	6.05	6.978	0.680	34.583	10.333
		2008	3.17	0.515	5.92	3.013	0.627	33.250	10.083
10	CF+RS	2006	3.30	0.705	6.03	4.538	0.365	31.583	13.167
		2007	3.00	0.653	6.31	4.953	0.434	34.917	11.583
		2008	3.99	0.423	6.16	2.957	0.322	34.708	7.958
11	SM+EC	2006	3.50	0.631	6.36	9.020	0.627	32.875	10.958
		2007	3.82	0.565	6.17	6.676	0.508	28.333	15.000
		2008	4.67	0.291	6.28	1.974	0.407	32.583	8.792
12	AM+RS	2006	4.70	0.635	5.95	5.591	0.550	32.167	11.167
		2007	4.67	0.624	6.12	7.704	0.437	31.250	12.083
		2008	5.86	0.534	6.35	7.645	0.601	33.250	9.917
13	A+CF+EC	2006	3.60	0.631	6.05	7.271	0.325	30.000	11.250
		2007	5.32	0.579	5.90	2.625	0.668	31.250	8.583
		2008	5.07	0.490	6.20	1.190	0.568	31.958	8.708
14	A+SM+EC	2006	4.70	0.661	6.10	5.182	0.448	28.708	12.958
		2007	4.85	0.499	5.96	9.505	0.540	29.667	14.000
		2008	5.46	0.289	6.06	6.332	0.450	31.875	11.125
15	CF+RS+EC	2006	4.20	0.623	5.88	6.392	0.431	31.417	13.167
		2007	3.99	0.504	5.80	5.941	0.495	29.625	13.042
		2008	4.92	0.494	6.15	5.543	0.524	32.625	10.625
16	SM+RS+EC	2006	4.00	0.578	6.12	7.232	0.515	33.917	10.917
		2007	4.16	0.675	6.58	5.807	0.499	34.500	9.917
		2008	4.52	0.590	6.05	5.333	0.390	34.417	9.833

At the beginning of the study, the organic matter of the soil samples was average (2.80%). It was stated that the organic matter of the ploughed and abandoned native pastures in the first 25 years ranged from 1.29 to 2.20%. It was also noted that organic matter of this kind of pasture soils increased and reached at 3.95% in 35th year (Gokkus 1994). In a research conducted by Oner (2006), the organic matter content was low in the soils of the pastures previously cultivated and left. However, the organic matter of the soil samples relatively showed large variation; 2.50 – 5.96% in 2006, 3.00 – 5.72% in 2007 and 3.06 – 5.86% in 2008 (Table 2). The effects of the pasture improvement methods on organic matter content of the soil showed variation both in

the same year and among the years (Figure 1). The pasture improvement treatments and present plant vegetation might affect the organic matter content of the soil.

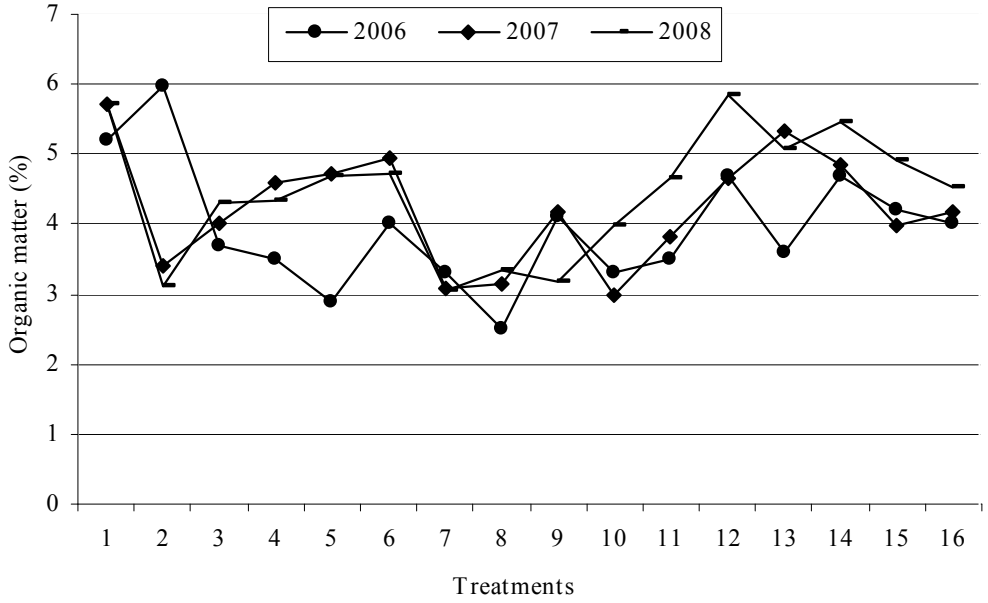

Figure 1. Changing in soil organic matter according to improvement treatments

When treatments were applied alone, the organic matter of the soil samples, taken from the all plots, increased except aeration treatment. Depending on the plant vegetation growth during long time, accumulation of organic matter in the soil might increase as well (Gokkus 1994). Weight and White (1974) stated that availability of the nitrogen and other nutritional element contents of the soil could increase as a result of accelerating decomposition of organic matter depending on the microorganism activities in well aerated soils, but it might conclude with decreasing organic matter content. Furthermore, Shepherd et al. (2002) reported that soils with rough texture and with high aeration capacity could keep the organic matter shorter. It means organic matter of these kinds of soils mineralizes in short period.

A clear increase in organic matter of the soil samples was determined in the plots where manure fertilizer was applied alone. Combination of manure fertilizer treatments slightly increased the organic matter content of the soil as well. Similarly Johnston (1986) stated that the organic matter which was added to soil later could have the greatest impact on organic matter content of the soil. Approximately 5 kg N, 1.5 kg P_2O_5, 4 kg K_2O and 240 kg organic matter could be transferred to soil by implementing 1 metric ton manure fertilizer (Altın et al. 2005).

The organic matter contents find out in the study were higher than the values reported by Oztas et al. (2003), Babalık (2008). It is a natural result because of organic matter content of the soil is depended on soil structure, added extra organic matter, climate, environmental conditions and treatments. In the research, a significant relation ($r^2 = 0,586$) was figured out between organic matter content of soil and legume content of botanical composition which was found by transect method in 2006 (Figure 2). Increasing organic matter content might increase the microorganism activity in the soil (Bakır 1985; Ergene 1993), and consequently legume content could increase with higher germination rates of hard seeded legumes owing to increasing microbial activity.

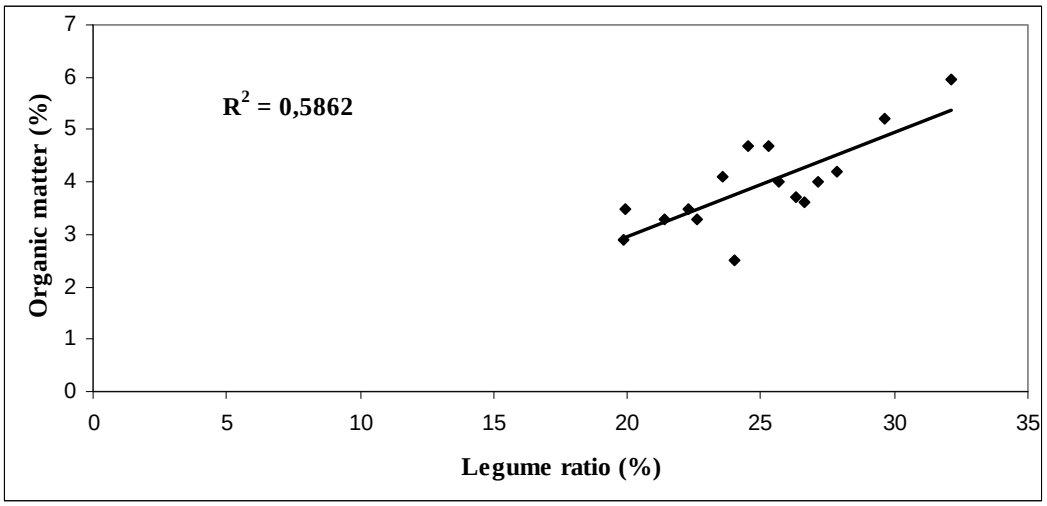

Figure 2. Relationship between soil organic matter and legume ratios determined by transect method in 2006.

Electrical conductivity of the experimental area soils were found as follows 0.568 – 0.793 dS/m in 2006, 0.459 – 0.675 dS/m in 2007, 0.289 – 0.698 dS/m in 2008 (Table 2). Smith and Doran (1996) revealed that critical level for EC values of soils were between 0.8 – 1.0 dS/m and the values over these reported levels could significantly affect the plant growth and microbial activity. The EC values found in the study were lower than the mentioned levels. The implemented treatments decreased the EC values of the soil except manure application. As a matter of fact that Obi and Ebo (2005), Satavast et al. (2005) stated that manure could increase the soil salinity.

The soils of the experimental area were slightly acidic. Soil pH values were found between 5.77 – 6.38, 5.67 – 6.58 and 5.89 – 6.37 in 2006, 2007 and 2008, respectively. The lowest pH values were determined in the soil samples taken from the control plots in 3 years (Table 2). These values were close to those of Kryzic et al. (2000), but lower than the data of Babalık (2008). The relation between pH values of the soils and dry matter yields were found statistically insignificant in the research.

At the beginning of the experiment, phosphorous content (23.66 kg ha^{-1}) of the soil were very low since the experimental area had previously been ploughed, cultivated and then abandoned. Gokkus (1994) reported that the soils, showing high erosive character in the pastures previously cultivated and abandoned, had lower phosphorous content than the soils of native pastures. Phosphorus content of the soils in 2006, 2007 and 2008 were measured between 2.965 – 9.020 ppm, 2.625 – 9.505 ppm and 1.190 – 7.645 ppm, respectively. In general, average phosphorous content of the soils increased during the experiment (Table 2).

Potassium, calcium and magnesium contents of the soil samples taken from the experimental area in 2006, 2007 and 2008 were as follows: 0.261 – 0.627 cmol/kg, 0.343 – 0.680 cmol/kg, 0.302 – 0.798 cmol/kg; 28.708 – 36.458 cmol/kg, 28.333 – 35.792 cmol/kg, 31.875 – 37.417 cmol/kg; 9.250 – 13.167 cmol/kg, 8.583 – 15.083 cmol/kg, 7.958 – 11.625 cmol/kg, respectively. Calcium and magnesium values determined in the study were higher than the Ca ang Mg values reported by Kryzic et al. (2000) but potassium value was lower than researchers' finding. Whalen et al. (2000) stated that manure application could increase the available P, K, Ca and Mg contents of soil. It was also noted that available phosphorous and potassium contents increased in 75% compared to control plots. The researchers reported that increase of Ca and Mg contents were clear in the implementation of high dose applications.

CONCLUSIONS

In this 3 year study, it was concluded that pastures should definitely be improved by appropriate improvement methods considering plant species and their botanical compositions, climatic conditions and soil characters. In the Black Sea Region, as a result of grazing done when soil was wet, a compaction occurs in the plant root region as soil gets toughs by time. Filtration rate also decreases in consequence of compaction in the plant root area because of the clay soil in the pasture. Therefore, soil aeration to give the less damage to natural flora of the native pastures should be provided. In the study, significant increases were

observed owing to the implemented treatments in both plant density and organic matter contents of the soil. Furthermore, fertilization should certainly be supplied to physiologically strengthen the plant species which are desired to be in the native pastures and to increase the productivity. Regarding this situation, aeration and artificial fertilization could be recommended. However, manure + aeration could be better solution in long term considering higher legume content in the botanical composition, higher pasture quality, climatic risks and soil and pasture sustainability.

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