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Original Research

METHODS FOR IMPROVING RANGELANDS IN THE BLACKSEA REGION OF TURKEY

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ABSTRACT: The objective of this study was to determine the most suitable method (or methods) to improve in the rangelands around Samsun-Turkey rangelands between 1993 and 1999. The 12 management treatments in this study included: control, aeration, burning, herbicide application, fertilization, over-sowing, ploughing + resowing and a combination of all the treatments. A mixture of seeds consisting of alfalfa, sainfoin, smooth bromegrass, orchardgrass and blue wheatgrass was used for oversowing and in the ploughing + resowing plots. The trial was established in a randomized block design and four replications. Lime and no lime were applied as split plot treatments.
The highest yield and crude protein ratio were obtained from the ploughing + resowing plots. Although most seeds in the resowing and over-sowing plots germinated, all young seedlings died due to competition with existing vegetation. The results obtained from this research showed that satisfactory results could not be obtained with the treatments without sufficient aeration in soils. It was determined that aeration using the rake had not been adequate. High yield and hay protein ratio were obtained from the ploughing + resowing plots as the ploughing provided adequate air to soil before resowing. Liming increased the soil pH from 6.0 to 6.5 and also increased hay yield and crude protein ratio.
Key Words: Range improvement methods, Liming, yield, Crude protein-ash and fiber, Turkey

TÜRKİYE – KARADENİZ BÖLGESİ MERALARININ ISLAHI İÇİN YÖNTEMLER

ÖZET: Bu çalışma Samsun yöresindeki doğal meralarda en iyi ıslah yöntemini belirlemek amacıyla 1993-1999 yılları arasında yürütülmüştür. Bu çalışmada havalandırma, havalandırma + üstten tohumlama, yakma, yakma + üstten tohumlama, herbisit uygulaması, herbisit uygulaması + üstten tohumlama, gübreleme, gübrele + üstten tohumlama, kontrol, kontrol + üstten tohumlama, havalandırma + yakma + herbisit uygulaması +gübreleme + üstten tohumlama, sürüm + yeniden ekim olmak üzere 12 mera ıslah işlemi uygulanmıştır. Üstten tohumlama işleminde ve sürüm + ekim yapılan tüm parsellerde baklagil yembitkisi olarak yonca, korunga, buğdaygil yembitkisi olarak kılçıksız brom, domuz ayrığı ve mavi ayrık türleri kullanılmıştır. Deneme Tesadüf Blokları Deneme Deseninde dört tekerrürlü olarak kurulmuştur. Ayrıca tüm işlemlerde parsellerin yarısına kireç verilmiş, yarısına verilmemiştir.
En yüksek kuru ot verimi ve ham protein oranı sürüm + yeniden ekim parsellerinden elde edilmiştir. Üstten tohumlama ve yeniden ekim parsellerinde ekilen tohumların çoğu çimlenmesine rağmen, genç fidecikler mevcut vejetasyon ile rekabet edemediklerinden dolayı ölmüşlerdir. Bu araştırmada, toprakta yeterli havalandırma yapılmadığı taktirde uygulanan işlemlerin etkilerinin tam olarak görülemeyeceği sonucuna varılmıştır. Tırmık kullanılarak yapılan havalandırma yeterli olmamıştır. Sürüm + yeniden ekim parsellerinde en yüksek kuru ot verimi ve protein oranının belirlenmesi, bu parsellerde sürüm işleminin toprakta yeterli havalandırmayı sağlanması ile açıklanabilir. Kireçleme toprak pH'sını 6.0'dan 6.5'e yükseltmiştir. Kireçleme ile kuru ot verimi ve otun protein oranı artmıştır.
Anahtar Kelimeler: Mera ıslah yöntemleri, Kireçleme, Verim, Ham protein, Kül ve selüloz, Türkiye

1. INTRODUCTION

Natural rangeland ecosystems provide ecologically important functions such as the genesis, fertility and stability of soils; cycling of nutrients; maintenance of biological diversity; and the preservation of natural beauty (West, 1993; Newman and Redente, 2001). At the same time, meadow-range ecosystems provide economically important benefits such as forage, water, minerals, building materials and numerous recreational opportunities (NRC, 1994). Turkey's rangelands are very rich in species, ecotypes, genetic diversity and gene sources of plants. For long periods, different civilizations have existed in Anatolia, locating between Asia and Europe as a bridge. Agriculture and livestock production has been to region for years and years. As a consequence of intensive grazing systems applied by many civilizations, many species were depressed by overgrazing. Therefore, improvement treatments must be applied for the rangelands in Anatolia. Forage yield and quality may not be dependent on only a single treatment. Many interactions of different sort of treatments may affect the yield and quality. (Bakır, 1971, 1985; Stillman, 1980; Tosun and Altın, 1986; Tükel, 1989; Kituku et al., 1992; Masters et al., 1992; Acar et al., 1995).

Fertilization, especially using N and P, may be significant treatment for rangelands to increase forage yield and nutrition content of forage crops (Büyükburç, 1983; Altın and Tuna, 1991; Erden et al., 1994; Rubio et al., 1996; Jacobsen et al., 1996; Gillen and Berg, 1998; Marilyn and Hart, 1998; Guevara et al., 2000; Newman and Redente, 2001). Yet, fertilizer may not be so effective to increase forage yield and quality without sufficient soil moisture. So, forages quality and quantity obtained from rangelands are mostly related to sufficient precipitation in spring

period. Fertilizer increases water use efficiency as well (Jacobsen et al., 1996; Guevara et al., 2000).

A critical treatment on acidic soils may be lime application to increase soil pH. It is one of the main factors that can affect the solubility and availability of trace elements such as Ca, Mg, Mo, P and S (Jones, 1974; Martin et al., 1976; Quin and Richard, 1981; Tham and Kerridge, 1982). Molybdenum directly influences nodule formation and biological N fixation, (Jackson, 1967; Martin *et al*., 1976). Forage yield and quality could be increased with lime application on acidic soils, and then it may result in increasing microbial activity and root and stem growth of plants (Mahoney et al., 1981; Scott and Lowther, 1981; Tham and Kerridge, 1982; Murphy et al., 1986; Haland, 1986; Romero and Rejas, 1993).

Aeration may be a suitable improvement method on over-grazed rangelands when soil is wet in springs. On these tight soils or soil compacts which are possibly caused by heavier grazing severity, aeration may help increase microbial activity, water and nutrient content (Stillman, 1980; Gokkus 1984; Choi et al., 1996).

Although over-sowing is a hard and expensive sowing system, it may be the fastest improving method for rangelands if they have lost their high quality forage species and vegetative cover. However, seedlings growing from over-sowing are not able to compete with undesirable species on these areas (Tosun et al., 1975, 1977; Olea and Paredes, 1980; Tung et al., 1991).

Annual and fast growing broad-leaved weeds may be reduced by herbicide application on rangelands, and herbicide application may facilitate growing of high quality plants. Ultimately it may cause increasing yield, forage quality and digestibility (Rice and Stritzke, 1989; Kituku et al., 1992; Jacobs and Sheley, 1999; Sheley et al., 2000).

The research results on firing are variable because of pre-burn vegetative composition, soil moisture and fertility, relative humidity, wind speed, fire intensity, precipitation and grazing following firing (Robert et al., 1992; Cook et al., 1994; McDaniel *et al*., 1997; Engle *et al*., 1998). Firing temporarily increases yield and nutritional content of forage (Kituku et al., 1992; Cook et al., 1994). It is known that shrub (maquis) areas and other rangelands, on which sheep and goats have been grazed, used to be fired by shepherds once few years in Anatolia (Tosun and Altin, 1986).

Ploughing and reestablishing new pastures may be an important way to have high forage quality when rangeland productivity has been substantially reduced (Tosun et al., 1975).

Concerning all treatments mentioned above, this study aimed to determine the most suitable method (or methods) to improve forage quality and yield of rangelands in the Black Sea Region in Turkey.

2. MATERIALS AND METHODS

2.1. The Experimental Area

This research was conducted in a pasture on Mollisol soils with 15-17% slope at approximately 150 meters above sea level in Samsun-Turkey (41º 21' N, 36º 15' E) between 1993 and 1999. Some major soil characters were determined by the method described by Rowell (1996). P_2O_5, K_2O and organic matter of the soil are sufficient for pasture growth. The soil contained no lime and no-salt. Soil pH was 6.00.

The climate in the experimental area was temperate. Mean annual temperature was 14 ºC. The coldest months were January and February (6.5 and 6.6 ºC), and the hottest months were July and August (22.7 and 22.6 ºC). Mean annual precipitation was 790 mm. Distribution of the precipitation during the year was uniform. The highest rainfall occurred in October and November (83 and 88 mm); the lowest rainfall was in July and August (30 and 28 mm). Mean annual relative humidity was 75 %.

2.2. Methods

The field study was established as a randomized block design using strip plots, with two lime levels (lime and no-lime) and twelve management treatments with four replications (Little and Hills, 1978). Table 1 shows the management treatments.

Table 1. Improvement treatments

Treatment Number	Treatments
1	Aeration (Aer.)
2	Aeration + over-sowing (A + S)
3	Burning (Bur.)
4	Burning + over-sowing (B + S)
5	Herbicide application (Herb.)
6	Herbicide application + over-sowing (H + S)
7	Fertilization (Fert.)
8	Fertilization + over-sowing (F + S)
9	Control (Cont.)
10	Over sowing (C + S)
11	Combination of all the treatments (Comb.)
12	Ploughing + resowing (Ploug + RS)

The plot area per treatment was 80 m^2. Lime was applied to half of the plot (8m x 5m = 40 m^2). The area of one block (replicate) for all treatments was 80m x 12m = 960 m^2. The whole experimental area covered 3840 m^2. The spaces between replicates were 2 m and 1 m buffers between lime treatment strips.

Agricultural lime was applied at the rate of 6300 kg per ha in autumn 1993 to the soil which had 6 pH value. The rate was calculated according to Atesalp (1976), to adjust the pH to 6.5, concerning 20 cm of the soil profile.

Aeration treatment was applied using a weighted rake to a depth of 5-8 cm in early October 1993. Diesel oil, Glyphosate Isopropylamine (Roundup®) and ammonium sulphate containing 21% Nitrogen were used for burning, herbicide and fertilizer applications, respectively. In early September 1993

when the vegetation was dry, 1 liter of diesel oil was sprayed out per 40 m² and the firing treatment was realized. Weeds were treated with Roundup® (500 cm^3 per 100 L of water) in October 1993. Nitrogen was applied at 50 kg per ha in autumn; a further 100 kg per ha was applied in spring after the plants started to grow (Tosun and Aydin, 1990; Erden et al., 1994).

A seed mixture consisting of 10% alfalfa (*Medicago sativa* L.), 20% sainfoin (*Onobrychis sativa* Lam.), 25% smooth bromegrass (*Bromus inermis* Leyss.), 25% orchardgrass (*Dactylis glomerata* L.), and 20% blue wheatgrass (*Agropyron intermedium* (Host) Beauv.) was used on the over-sowing and ploughing + resowing plots. Seed mixture with 500 g was sown into each plot (80 m²) in early October 1993. For the over-sowing plots, 62.5 g of seed from the prepared mixture was sown into rows, which had been cultivated by a weighted rake.

To assess the biomass, each plot (1 m² areas) was harvested. After the samples had been sorted according to botanical families, they were air dried before being oven dried at 70 ºC until the weight stabilized and then samples were dried and ground, crude protein content was figured out according to the Kjeldahl method. The crude ash ratio and crude cellulose ratios were also found out (AOAC, 1990).

Yields were measured once per year over 6 years, though only the overall mean was analyzed.

The means of treatments were evaluated and ranged according to the Duncan Test. MSTAT-C program was used for all statistic analysis (MSTAT-C, 1989).

3. RESULTS

3.1. Hay yield

The mean results for all treatments are resented in Fig. 1. Raw data is presented in Table 2.

Lime application plots had 888 kg ha^{-1} higher hay yield than the plots that had no lime over the average of six years. Lime application increased the soil pH from 6.00 to 6.50 on all plots. Although, pH increased to 6.5 in the limed plots in the second year but it then started to decrease again. During the experiment, organic matter of the soil increased, and the lime applied plots had a greater increase than the other plots. At beginning of the experiment soil organic matter content was 4.43% in 1993. After the liming application, OM content increased to 4.67% in 1996, and then it decreased to 4.47% in 1999.

From the mean yields of the lime plots over six years, the ploughing + resowing treatment showed the highest yield followed by the combination of all treatments, aeration + over-sowing and fertilization + over-sowing (7009, 5582, 5448 and 5340 kg per ha, respectively). Lime was ineffective on hay yield with combination treatment (11) and fertilizer-lime treatments (7 + 8), but had a substantial effect on some of the other treatments.

Most of the seed germinated on the ploughing + resowing plots, but only a few seedlings were survived because they were not able to compete with native vegetation. Pasture area was also covered with dense vegetative thatch. In spite of this, the highest dry matter yield was obtained from ploughing + resowing plots, (Table 2, Figure 1).

The experimental area for aeration + over-sowing was raked before sowing. This application resulted in some seedlings dying, however higher hay yield was obtained rather than over-sowing alone. Consequently, in comparing single treatments, over-sowing treatments gave higher yield (Table 2, Figure 1). This shows that these types of pastures may require aeration treatment.

Because of favorable climatic conditions, the highest yields were obtained in the second year

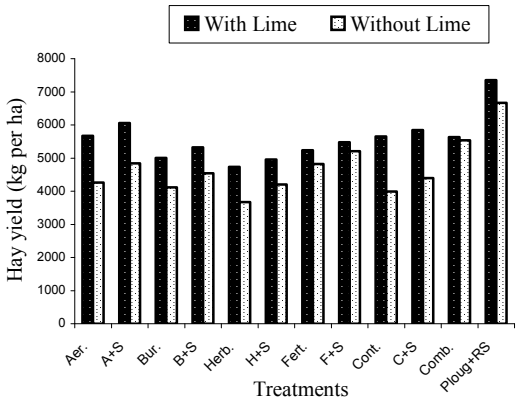

Fig 1: Mean hay yields for all treatments

(1995). As a mean of all applications, 6,159 kg per ha hay yield was obtained in 1995. The mean yields obtained from the first three years were significantly higher than the yields for the final three years.

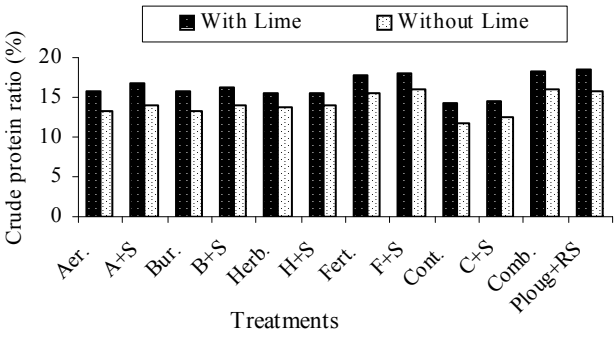

Fig 2. Crude protein ratio for all treatments

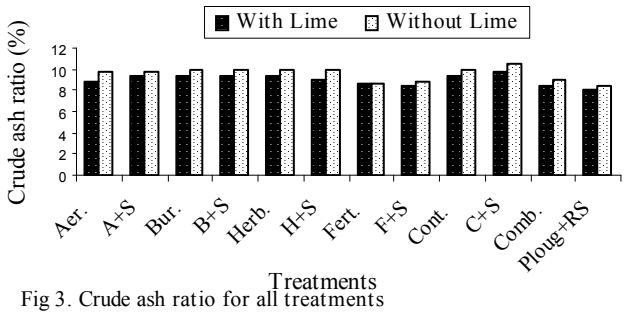

Fig 3. Crude ash ratio for all treatments

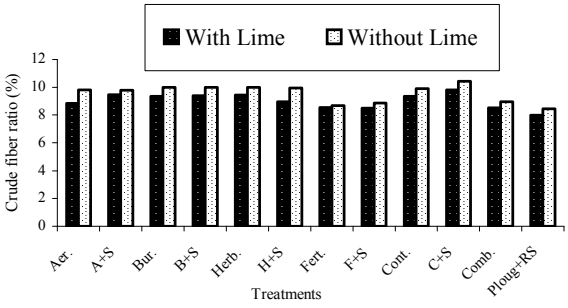

Fig 4. Crude fiber ratio for all treatments

3.2. Crude Protein, Ash and Cellulose

The mean results for all treatments are presented in Figures 2, 3 and 4. It was determined that there were significant differences among the treatments in crude protein, ash and cellulose contents ($P \leq 0.01$). The highest crude protein ratios were obtained from the ploughing + resowing plots, combination of all treatments plots and fertilization + over-sowing plots (Figure 2, 3, 4).

The highest crude ash and cellulose ratios were obtained from control + over-sowing plots. The lowest crude ash and cellulose ratios were obtained from ploughing + resowing plots which also provided the highest hay yield (Figure 3 and 4).

4. DISCUSSION AND CONCLUSION

Lime application increased the soil pH on all plots in the second year however it started to decrease again. During the experiment, organic matter of the soil increased, and the lime applied plots had a greater increase than the other plots. The results are in agreement with that of Mahoney et al. (1981), Scott and Lowther (1981), Haland (1986), Romero and Rojas (1993). They also indicated that lime application on acidic soils increased soil pH, microbial activity, stem and root growth and plant quality.

From the mean yield of the lime plots over six years, the ploughing + resowing management treatment showed the highest yield. Lime was in effective on hay yield with combination treatment (11) and fertilizer lime treatments (7 and 8) (Table 2, Figure 1). This can be explained with nutritional effect of liming. Liming and fertilization are suggested to be a remedy for Ca deficiency in acidic soils and are effective practices to improve crop performance on the soils (Demhich and Sharpe, 2001). Tisdale and Nelson (1975) reported that Ca is related to protein synthesis by enhancement of the nitrate nitrogen uptake and is associated with the certain enzyme activities.

Ploughing + resowing gave the highest yield it may be caused by excellent aeration. Stillman (1980), Gokkus (1984) and Choi et al. (1996) conducted experiments in different ecosystems and found the similar results.

Higher hay yield was obtained from aeration + over – sowing plots rather than over-sowing alone. Aeration + over-sowing increased the yield. Aeration might supply better conditions for new seedlings germinated from over-sowing application. The studies of Sevilla et al. (1996), Olea et al. (1980) and Tung et al. (1991) support our findings. These researchers determined that of similar seeds used in over – sowing plots, firstly germinated, however the seedlings could not compete with native vegetation and they subsequently died.

As a mean of all applications, hay yield decreased after from second year (Table 2). These results may indicate that the effects of treatments decreased rapidly. Because of the strong thatch of vegetation, results indicated that beneficial response cannot be obtained from soils which have not been aerated sufficiently.

According to Stillman (1980), Gokkuş (1984) and Choi et al. (1996) aeration could presumably increase the microbial activity, water and nutrient uptake and botanical composition of perennial forage plants (especially legumes). This might increase in crude protein ratio of the hay obtained from ploughing + resowding plots. Lime applied on acidic soils increases the availability of many elements, such as Ca, Mg, Mo and P (Quin and Richard, 1981; Tham and Kerridge, 1982). Molybdenum affects nitrogen fixation and nodulation directly (Martin et al., 1976). So, the crude protein content obtained from lime plots was greater than non-limed plots.

Good aeration was very important on pasture areas having strong thatch. The remaining treatments were ineffective without aeration. Superficial aeration by disturbing the thatch with a rake was insufficient. As a result of effective aeration (i.e. ploughing + resowing), hay yield and crude protein ratio increased. Seeds germinated on the over-sowing and ploughing + resowing treatments, but all the new seedlings died as they were not able to compete with the established vegetation. Even though the thatch was ploughed, other plant tissues and seeds in the soil grew rapidly and they dominated and killed the germinated seedlings. Liming also increased hay yield and crude protein content, significantly.

It was concluded that, without aeration, all other treatments were ineffective. For improvement of rangelands in the Blacksea region of Turkey it is suggested that the most important and potentially efficacious treatments are effective aeration with fertilization. It is recommended that further research be carried out in relation to time, method and efficiency of aeration.

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Table 2. Average hay yields obtained from plots according to years, liming and other treatments (kg per ha)*

Treatment No	Liming application	Years							
		1994	1995	1996	1997	1998	1999	Mean**	Difference to control (%)
1	+	5826	6509	5759	5342	5328	5240	5668	+ 0.4
	-	4280	5149	4401	3973	3928	3833	4260	+ 6.8
(Aer.)	Mean	5504	5829	5080	4657	4628	4537	4964 d,e,f	
2	+	5981	6975	5557	6012	5943	5856	6054	+ 7.2
	-	4857	5715	4964	4552	4529	4433	4841	+ 21.4
(A + S)	Mean	5419	6344	5260	5282	5236	5145	5448 b,c	
3	+	5191	5867	5117	4693	4622	4534	5004	- 11.4
	-	4219	4961	4212	3799	3814	3716	4120	+ 3.3
(Bur.)	Mean	4705	5414	4664	4246	4218	4126	4562 g	
4	+	5462	6036	5388	5164	4980	4892	5320	- 5.8
	-	4587	5412	4663	4242	4218	4123	4541	+ 13.9
(B + S)	Mean	5024	5724	5025	4703	4599	4508	4931 e,f	
5	+	4918	5992	4840	4423	4371	4250	4732	- 16.2
	-	3475	4847	3763	3345	3360	3265	3676	- 7.8
(Herb.)	Mean	4197	5220	4302	3884	3866	3757	4204 h	
6	+	5166	5829	5066	4625	4572	4450	4952	- 12.3
	-	4194	5090	4342	3920	3875	3820	4207	+ 5.5
(H + S)	Mean	4680	5460	4704	4273	4223	4135	4579 g	
7	+	6070	6411	5131	4627	4610	4555	5234	- 7.3
	-	5517	6281	4680	4180	4172	4074	4817	+ 20.8
(Fert.)	Mean	5794	6346	4906	4404	4391	4315	5026 d,e	
8	+	6450	6705	5450	4588	4871	4780	5474	- 3.1
	-	5974	6281	5084	4582	4499	4400	5206	+ 30.6
(F + S)	Mean	6212	6700	5267	4585	4685	4590	5340 c	
9	+	5816	6493	5745	5332	5278	5223	5648	0.0
	-	3945	4862	4111	3689	3707	3608	3987	0.0
(Cont.)	Mean	4881	5678	4928	4511	4492	4416	4817 f	
10	+	6008	6671	5972	5567	5485	5398	5850	+ 3.6
	-	4322	5321	4556	4136	4070	3971	4396	+ 10.3
(C + S)	Mean	5165	5996	5264	4852	4777	4685	5123 d	
11	+	6490	7074	5463	4968	4940	4850	5631	- 0.3
	-	6326	7038	5428	4917	4797	4698	5534	+ 38.8
(Comb.)	Mean	6409	7056	5446	4943	4868	4774	5582 b	
12	+	7745	8222	7381	6961	6916	6860	7348	+ 30.1
(Ploug + RS)	-	6892	8052	6775	5712	6356	6234	6670	+ 67.3
	Mean	7318	8137	7078	6336	6636	6574	7009 a	
Mean**		5405 b	6159 a	60 c	4723 d	4719 d	4628 e	5132	
Liming		5927	6532	5572	5192	5160	5047	5576 **a**	
Nonliming		4882	5785	4748	4254	4277	4182	4688 **b**	

** sx data; for applications: 4.421; for years: 1.893; for liming: 1.546

* Data with same letter are not significantly different ($P \leq 0.01$)

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