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Botanical composition, forage yield and quality under different improved Mediterranean rangeland

Farklı yöntemlerle ıslah edilen Akdeniz merasının botanik kompozisyonu, ot verimi ve kalitesi

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ABSTRACT

Proliferation of invasive of annual plant species and thorny shrubs such as Christ's thorn (*Paliurus spina-christi*) is common in Mediterranean rangelands due to climatic shifts and heavy grazing. Improved practices are needed to manage such invasive species. This study assessed how improved rangeland practices affected herbage yield and quality, botanical composition in the Canakkale in western Turkey. The rangeland practices were: 1. control (no improvement practices (C), 2. removal of Christ's thorns followed by forage crop planting (R), 3. use of herbicides to treat Christ's thorn shrubs (H), 4. removal of Christ's thorn shrubs by grubbing with dozers and rippers (M), and 5. the shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then, it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops (F). The seeding practice has been done into bare parts of the rangelands that were occurred due to the removal of Christ's thorn. The treatment plots were seeded with perennial ryegrass, orchardgrass and alfalfa. Control had the greatest number of species (45 species) whereas mechanically-treated plot had the least (28 species). All treatments increased herbage yield and grazed herbage quantities of the rangelands. The mechanically-treated rangeland increased yield by 2.5 folds compared with control. Treatments did not affect herbage quality of the rangelands. Results indicate that improvement practices improved rangelands invaded with Christ's thorn shrubs.

MAKALE BİLGİSİ

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ÖZ

Akdeniz meralarında iklim ve aşırı otlatma sonucunda tek yıllık bitki türleri ile karaçalı (*Paliurus spina-christi*), gibi dikenli çalılarda artış olmaktadır. Bu çalışma ile Batı Türkiye'de (Çanakkale) mera iyileştirme çalışmalarının meranın botanik kompozisyonu, ot verimi ve kalitesine nasıl etki ettiği belirlenmiştir. İyileştirme uygulamalarında 1. kontrol (hiçbir işlem uygulanmayan (C)), 2. karaçalıların uzaklaştırılarak, yem bitkileri ekilen mera (R), 3. herbisitlerle çalıları yok edildiği mera (H), 4. dozer ve riper ile çalıları kökünden sökülerek uzaklaştırılmış alan (M), 5. uzun yıllar tarla olarak kullanıldıktan sonra tohumlanarak oluşturulan mera (F). Bütün uygulama alanlarında tohumlama yapılmıştır. Tohumlamada çok yıllık çim, domuz ayrığı ve yonca kullanılmıştır. Araştırma bulgularına göre; en fazla tür (45 adet) kontrol merasında, en az ise mekanik olarak karaçalının yok edildiği (28 tür) merada belirlenmiştir. Yapılan tüm ıslah çalışmaları meraların kuru ot verimi ile yenen ot miktarını önemli derecede artırmıştır. Kuru ot verimi en fazla mekanik olarak çalıların yok edildiği merada olmuş ve verim 2.5 kat artmıştır. Islah çalışmaları meraların ot kalitesini değiştirmemiştir. Bu durum ülkemizdeki karaçalı ile kaplı meralarda ıslahın kaçınılmaz olduğu sonucunu doğurmaktadır.

1. Introduction

Rangelands cover about 26% of land surfaces in the world (FAO 2015) and 18.8% of land surfaces in Turkey (TUIK 2017). Rangelands are the greatest sites used for animal feed production mostly through grazing. They are also feeding, sheltering and reproduction sites for wild species. Intense uses may destroy the normal conditions and plant cover of these sites

(Heady 1973). Especially in rangelands with dominant Mediterranean climate, heavy grazing activities resulted in significant increases in populations of annual species (*Aegilops, Bromus, Hordeum, Cynosurus, Taeniatherum,* vb.), thorny shrubs like Christ's thorn (*Paliurus spina-christi*) and prickly burnet (*Sarcopoterium spinosum*) and thorny-leaved junipers (*Juniperus oxycedrus*) (Montalvo et al. 1993; Seligman 1996; Lavorel et al. 1999; Sternberg et al. 2000; Özaslan Parlak et al. 2011a). Some of these shrubs are ever-green species and may supply year-long quality feed source for goats (Özaslan Parlak et al. 2011b). Christ's thorn is common over the rangelands without goat grazing. It is a defoliate species and provides high quality feed source in spring, summer and autumn. However, it is grazed only by goats because of thorny nature of the shrub. Thorns may create injuries in mouths and udders of the other animals. Regional people usually deal with livestock activities and they never use the rangelands with Christ's thorn cover. Such a case then results in ever-increasing Christ's thorn population over these rangelands.

Besides heavy grazing over regional rangelands, some fertile rangelands are converted into agricultural lands. The lands converted from rangelands and used for agriculture for long time then left for rangelands again with 4243-numbered Rangeland Law. The rangelands exposed to heavy grazing, transformations to agricultural lands and grazed with the same animals all the time seriously destroyed vegetative cover of those rangelands and now improvement is evident for such sites. There are several methods and approaches used for improvement of rangeland vegetative covers. Mechanic or chemical methods are common to remove shrubs from the rangelands. Especially the mechanical approach is both a cheap and environment-friendly method. However, removal of shrubs with dozers and rippers may destroy soil structure and thus alter vegetative cover and soil structure significantly (Vallentine 1989). With foliar chemicals on the other hand, there is not intervention to soil, but serious alterations are evident in vegetative cover (Thilenius et al. 1974; Murray et al. 1991). Following the mechanical and chemical control practices, seeding is preferred to replace old vegetation with forages (Link et al. 2017). It was reported that mechanical shrub control and subsequent seeding practices reduced shrub population and improved herbage yield of rangelands (Adema et al. 2004).

The Ministry of Food Agriculture and Livestock of Turkey have been implementing comprehensive rangeland improvement and management projects in accordance with 4243-numbered and 02.28.1998-dated Rangeland Law in almost every province of Turkey. Remarkable success was achieved in some of these works, but desired outcomes were not achieved in some others. However, success of reclamation or improvement works have usually assessed visually, scientific approaches haven't been used to assess the success of such practices. The present study was conducted to scientifically assess the improvement practices implemented by Çanakkale Provincial Directorate of Agriculture over the rangelands of Hacıpehlivan village of Biga town. For this purpose, two-year data on herbage yield and quality and botanical composition of rangeland plots with five different improvement processes were assessed.

2. Materials and Methods

2.1. Description of Research Site

The research was conducted in Hacıpehlivan village with 113.2 decare rangeland area. The village is 17 km far from Biga town and 120 km from Canakkale province. Canakkale located in northwest part of Turkey. Rangeland site is adjacent to village settlement area and lies along East-West direction. Rangeland boundaries are surrounded with 40˚ 15′ 09″ N / 27˚ 24′ 24″ E - 40˚ 15′ 16″ N/ 27˚ 24′ 58″ E coordinates from the North and with 40˚ 14′ 20″ N / 27˚ 25′ 27″ E - 40˚ 14′ 25″ N / 27˚ 25′ 36″ E coordinates from the South (Figure 1). Coordinates were measured with "Magellan 310" portable Global Positioning System (GPS) device.

Animals of the village (400 cattle, 55 goats and 40 sheep) are grazed over the rangelands. The region has a typical Mediterranean climate (Türkeş et al. 2002). Canakkale exhibits Mediterranean precipitation regime with the greatest precipitation in winter and the least precipitation in summer.

Average temperature in Biga was above the long-term averages in both years. Precipitations were quite low in 2008 and were almost half of long-term averages. But the precipitations of 2009 were above the long-term averages (Figure 2).

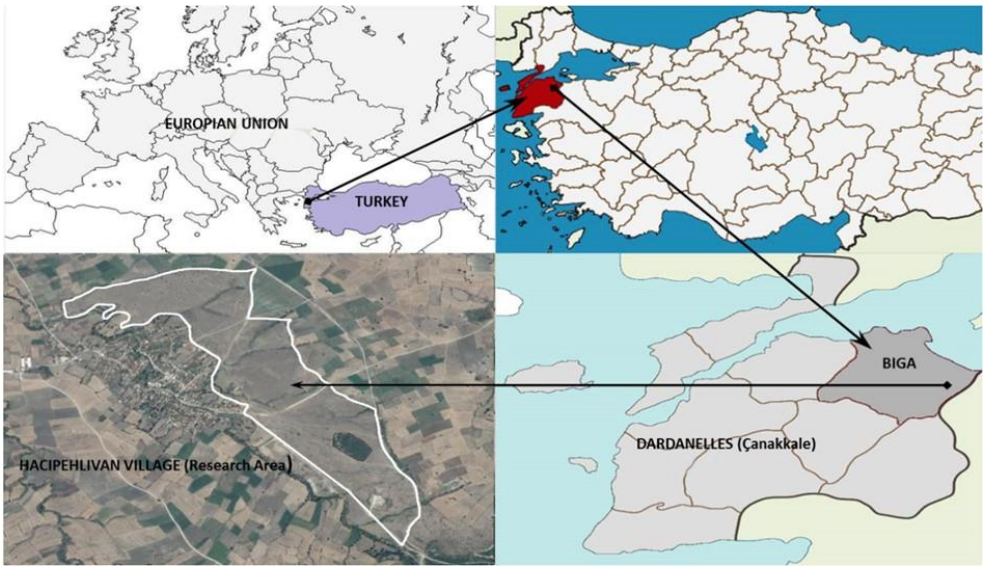

Figure 1. Map showing the Canakkale-Biga Hacıpehlivan vilage rangeland and study area.

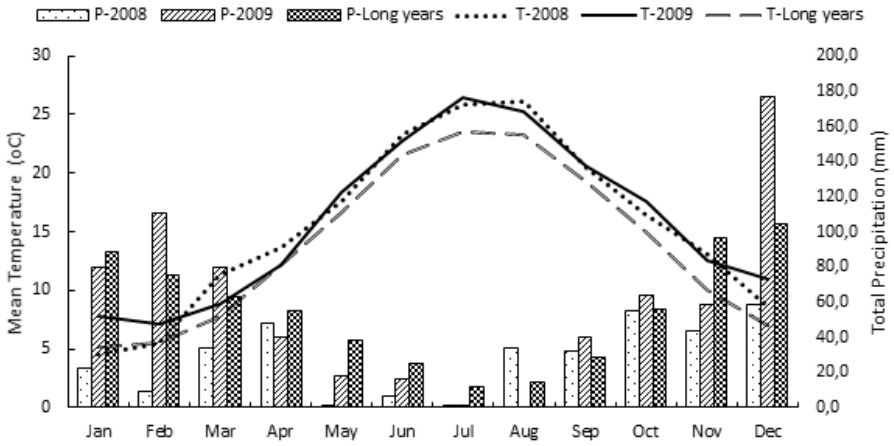

Figure 2. Avarage climatic data of experimental period and long years of Biga distict (Canakkale/Turkey).

2.2. Experimental Design

Experiments were conducted over five different sites with different previous improvement practices. The rangeland practices were: 1) Control (no improvement practices, (C) these rangelands are dominated Christ's thorn (*Paliurus spina-christi* Mill.); 2) Removal of Christ's thorns followed by forage crop planting (E), 3) Use of herbicides (glyphosate-containing) to treat Christ's thorn shrubs (H), 4) removal of Christ's thorn shrubs by grubbing with dozers and rippers (25-30 cm depth) (M), and 5) The shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then, it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops (F).

The spaces created through removal of shrubs with mechanical and chemical methods were seeded with forage crops on 12.01.2016. In seeding treatments, 40% legumes and 60% grasses quadruple mixture (Plato alfalfa - *Medicago sativa* L., G.S. Gabriele bird's foot trefoil - *Lotus corniculatus* L., Verdi perennial ryegrass - *Lolium perenne* L. and orchardgrass - *Dactylis glomerata* L.) were used. In mixtures, 15% alfalfa, 25% bird's foot trefoil, 30% perennial ryegrass and 30% orchardgrass were used. Grazing did not performed for a year for better rooting of seeded species. During the sowing and after sowing, 40 kg ha^{-1} nitrogen (N), 40 kg ha^{-1} phosphorus (P) and 20 kg ha^{-1} potassium (K) were applied with 15-15-15 and 20-20-0 composed fertilizers. Fertilization was not performed in subsequent years.

2.3. Investigated Traits

Nutritional composition of the herbage: Samples were ground and total nitrogen content of 1 g ground sample was determined with Kjeldahl method. Then total nitrogen content was multiplied by 6.25 to get crude protein content (AOAC 1990). NDF, ADF and ADL ratios were determined in accordance with Van Soest et al. (1991) and crude ash was determined in accordance with AOAC (1990).

Botanical Composition: During flowering of herbaceous vegetation, samples taken from the fences were separated and weighed according to the species and the botanical composition was assessed depending on their weight.

Herbage yield: From the entrance to the end of each rangeland, eight wire fences (1 x 1x 1 m) were placed in each 30 m with 20 cm grid spacing. Herbage within the fences was cut from the ground on 12 May 2008 and 15 May 2009. Harvested herbage was then dried in an oven at 60 °C for 48 hours. Resultant values were converted into decare to get dry herbage yields per decare.

Herbage consumption: Rangeland herbage samples were taken through cutting 1 m^2 sections from inside and outside the fences. Then quantities of different grazed herbages were determined for inside and outside the fences.

2.4. Data Analysis

Resultant data were subjected to one-way ANOVA and means were compared with Duncan's multiple range test. Statistical analyses were performed with SPSS software.

3. Results and Discussion

3.1. Botanical Composition

The greatest number of species (45 species) was identified in control (C) plot. It was followed by E-plots with 36 species. H-plots with 34 species, F-plots with 33 species and M-plots with 28 species (Table 1, 2).

Table 1. Number of species and botanical composition (%) of rangeland plots improved with different methods

Plant Species	Rangelands (species / %)									
	C*		E		H		M		F	
Legumes	14	18.0	9	16.2	11	16.0	9	22.3	10	19.0
Grasses	13	52.3	13	41.4	12	55.7	8	51.3	7	36.4
Forbs	18	29.7	14	42.4	11	28.3	11	26.4	16	44.6
Total	45	100	36	100	34	100	28	100	33	100

*: (C): Control (no improvement practices; (E): Removal of Christ's thorns followed by forage crop planting; (H): Christ's thorn shrubs were treated with herbicides; (M): Removal of Christ's thorn shrubs by grubbing with dozers and rippers; (F): The shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then, it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops.

Natural rangelands are significant sites for preservation and sustainability of genetic and ecological resources (Richards et al. 1997). In present study, since the animals were not able to graze over shrub covered control plot. Species were preserved in this plot. Özaslan Parlak et al. (2011c) identified more number of species in seed bank for shrubland rangelands.

Table 2. Botanical composition (%) of rangeland plots improved with different methods (C): Control (no improvement practices; (E): Removal of Christ's thorns followed by forage crop planting; (H): Christ's thorn shrubs were treated with herbicides; (M): Removal of Christ's thorn shrubs by grubbing with dozers and rippers; (F): The shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops.

No	Plant Species	C 2008	C 2009	E 2008	E 2009	H 2008	H 2009	M 2008	M 2009	F 2008	F 2009
	Legumes										
1	*Hymenocarpus circinnatus*	0.21	0.18	0.33	0.28	0.90	1.02	0.31	1.05		
2	*Lathryrus cicerum*	1.15	0.95			0.17	1.20	1.81	2.01	0.15	0.80
3	*Lathyrus salifolia*	0.59	1.47	0.91	1.42	0.98	1.91				
4	*Lotus corniculatus*							2.16	2.85	1.98	3.01
4	*Medicago lupulina*	1.91	2.49	4.38	5.16	2.17	1.32	0.01	0.85		
5	*Medicago minima*	0.59	3.96	1.29	1.85	1.10	1.62	0.31	0.86	0.98	3.38
6	*Medicago sativa*							3.45	4.05	1.61	2.45
7	*Medicago setiro*	0.02	0.68			4.03	2.15				
8	*Onobrychis caput-galli*	0.26	0.36	0.48	1.07	0.37	0.95				
9	*Onobrychis aequidentata*	1.26	1.17								
10	*Scorpiurus muricatus*									0.65	2.13
11	*Trifolium arvense*	0.27	2.28	1.96	2.15	0.69	0.98	1.61	1.66	3.20	1.68
12	*Trifolium campestre*	1.00	0.83	0.48	0.98	0.55	0.72			1.00	2.52
13	*Trifolium echinatum*	0.03	0.30								
14	*Trifolium repens*	2.16	0.82	3.91	4.05						
15	*Trifolium resupinatum*	0.52	3.83	0.66	1.15	2.72	3.13	3.19	3.75	1.03	2.15
16	*Vicia grandiflora*	3.72	2.96			1.97	1.16	7.99	6.65	3.09	3.02
	Total	**13.69**	**22.28**	**14.07**	**18.11**	**15.65**	**16.16**	**20.84**	**23.73**	**14.86**	**23.29**
	Total species	**14**	**14**	**9**	**9**	**11**	**11**	**9**	**9**	**10**	**10**
	Grasses										
17	*Aegilops sp.*	0.27	0.37	1.02	0.96	0.09	0.85	0.95	0.85		
18	*Avena barbata*	6.68	4.95	2.15	3.05	3.15	2.18	2.74	2.05		
19	*Bromus arvensis*	2.07	1.57	0.15	0.10	4.52	2.87				
20	*Bromus hordaceus*			1.18	0.85						
21	*Bromus squarrosus*			0.23	0.15						
22	*Bromus tectorum*	0.55	0.33	0.88	0.58	1.05	1.17			1.64	1.65
23	*Carex sp.*	0	0.80								
24	*Dactylis glomerata*	7.09	5.68	7.08	7.15	9.51	10.52	1.64	1.65		
25	*Echinaria capitata*	0.09	0.1								
26	*Festuca valesiaca*	0.13	0.55	0.42	0.52	2.15	1.98	1.13	1.85	0.20	1.20
27	*Hordeum spotaneum*	5.07	4.72	7.75	5.15	6.87	4.95	10.01	8.15	4.85	4.18
28	*Lolium perenne*	0.35	0			14.85	15.15	5.50	7.50	16.36	20.55
29	*Lolium rigidum*	18.09	13.55	18.42	16.15	9.38	8.96			8.55	6.81
30	*Phalaris paradoxa*	6.55	8.54	3.77	2.15	3.18	4.18	6.37	6.85		
31	*Phleum pratense*	10.55	4.00			1.15	0.95	3.75	2.15		
32	*Poa bulbosa*			0.04	0.01						
33	*Poa trivialis*	1.03	0.98			0.96	0.82			0.82	1.03
34	*Vulpia muralis*			1.73	1.13					2.91	1.98
	Total	**58.52**	**46.14**	**44.82**	**37.95**	**56.86**	**54.58**	**52.81**	**49.75**	**35.33**	**37.40**
	Total species	**13**	**13**	**13**	**13**	**12**	**12**	**8**	**8**	**7**	**7**
	Forbs										
35	*Anagallis arvensis*	0.89	1.00	1.50	2.01	1.05	1.15	3.31	2.15	0.63	0.67
36	*Anthemis arvensis*	1.09	1.17	1.77	2.15	2.15	2.98			3.17	3.15
37	*Asphodelus aestivus*			0.36	0.98						
38	*Ballota nigra*			0.36	0.63						
39	*Campanula lyrata*							1.49	1.99		
40	*Capsella bursa-pastoris*									0.06	1.15
41	*Centaurea solstitialis*	3.63	2.17	7.06	6.95	3.15	3.05	3.18	3.85	7.97	8.05
42	*Chenopodium glaucum*	2.64	3.95								
43	*Conium maculatum*	2.05	4.53	2.84	4.97	4.85	4.06	3.15	3.65	6.13	3.17
44	*Convolvus arvense*			0.39	0.65						
45	*Conyza canadensis*	0.32	0.37								
46	*Crepis sp.*	1.06	1.25	2.83	2.65	1.48	2.03	3.37	2.95	6.01	2.17
47	*Erodium cicutorium*	1.57	1.75	4.71	4.15	3.14	2.85	2.71	3.45	4.04	2.15
48	*Eryngium campestre*	7.00	4.52	4.36	4.72	4.00	3.65	3.88	3.05	5.07	1.11
49	*Euphorbia pubescens*	0.07	0							0.68	0.87
50	*Galium heldreichii*	1.50	0.71	0.89	1.05	1.35	0.96	0.81	0.95	4.95	2.13
51	*Geranium dissectum*	0	1.27			2.15	3.36				
52	*Lactuca saligna*							1.55	1.26		
53	*Linum nodiflorum*	0.01	0								
54	*Onosma sp.*									0.68	1.05
55	*Plantago lanceolata*					2.15	3.16				
56	*Poterium sanguisorba*	2.32	4.70								
57	*Ranunculus repens*	0.78	1.25	5.79	5.12					1.39	0.97
58	*Salvia sp.*	0.06	0.07								
59	*Scolymus hispanicus*	0.16	0.10	7.20	6.89			0.75	1.06	3.18	3.68
60	*Sherardia arvensis*									0.16	1.17
61	*Sinapis alba*	2.40	2.40	0.72	1.02					5.08	6.80
62	*Sonchus asper*	0.24	0.37							0.55	1.02
63	*Taraxacum serotinum*					1.92	2.01	2.15	2.16		
	Total	**27.79**	**31.58**	**40.78**	**43.94**	**27.39**	**29.26**	**26.35**	**26.52**	**49.75**	**39.31**
	Total species	**18**	**18**	**14**	**14**	**11**	**11**	**11**	**11**	**16**	**16**

Number of species is usually high in rangelands with a less grazing pressure (Renzhong and Ripley 1997). The rangeland plot transformed and seeded 15 years ago (F) had the second place in number of species. Number of species in improved rangelands years ago decreased because of grazing pressure, but then increased with the plant seeds coming from the surrounding sites. The rangeland seeded after herbicide treatments followed these sites. In that plots, only the shrubs were removed without creating any hazard on natural vegetation. Then these sites were seeded with forage crops. The least number of species were observed in totally-plowed plots (M and F-plots). Low number of species in those plots was because of partial removal of vegetation cover through ploughing. Seeds were buried deeper with ploughing and emergence was partially hindered.

3.2. Herbage Yield and Herbage Consumption

Following the improvement practices significant increases were observed in herbage yields of rangeland plots in 2008 and 2009 (Figure 3). The least yields in both years (145.9 kg da^{-1} in the first year and 224.3 kg da^{-1} in the second year) were obtained from the control (C) plot and the greatest yields (3870.8 kg ha^{-1} in the first year and 5340.6 kg ha^{-1} in the second year) were obtained from M-plots. It was followed respectively by E, H and F-plots. The same order of herbage yield of the first year was also observed in the second year, but yields were higher in the second year because of higher precipitations of the year.

There were significant differences in grazed herbage quantities of the rangeland plots. The M-plots with the highest yields had also the greatest grazed herbage quantities in both years (respectively with 2910.1 and 366.8 kg ha^{-1}). However, there were not significant differences in grazed herbage quantities of H, E and F-plots. The least grazed herbage quantity was observed in control (C) plot respectively with 1100.16 and 1380.0 kg ha^{-1} in the first and the second year of experiments.

Dozers grubbed the shrubs from 20-30 cm depths and then the rangeland was leveled and seeded afterwards. Since high-yield seeds were used, herbage yield of the plot was also high. Plowing and seeding may be successful in places without any problems with regard to soil moisture contents (Vallentine 1990). Weeds do not emerge in the first year because of deep plough and turnover of the soil. With this practice, a kind of artificial pasture is created (Özaslan 2005). Yield is usually higher in rangelands seeded with multiple mixtures (Rumbaugh et al. 1982; Ta and Faris 1987; Heichel and Henjum 1991). Legumes had the greatest ratio and broad-leaf species had the least ratio in botanical composition of mechanical shrub control plot (Table 2). Such a case indicated high ratios of well rangeland crops in botanical composition. The rangeland plot from which Christ's thorn shrubs were removed 15 years ago and seeded with forage crops had the second greatest yield. This plot is also an artificial pasture, but the plot lost high-yield forage crops since management practices were not obeyed for years. Such a case then reduced the yield levels of the plot. With regard to yields, this plot was followed by herbicide treated and seeded plot. In this plot, natural vegetation was not destroyed. Only total herbicide was used to control the shrubs over the rangeland and weeds around the shrubs also died. Therefore, a decrease was observed in yields as compared to the other plots. Similar findings were also reported by Laycock and Phillips (1968), Altın and Tuna (1991) and Özaslan (1996). An artificial pasture was also created through transformation from

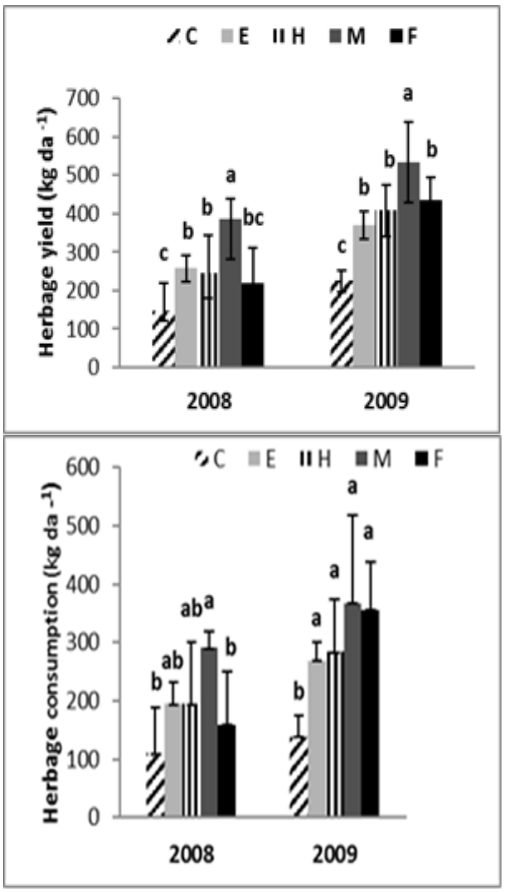

Figure 3. Herbage yield and herbage consumption of rangeland plots improved with different methods (C): Control (no improvement practices; (E): Removal of Christ's thorns followed by forage crop planting; (H): Christ's thorn shrubs were treated with herbicides; (M): Removal of Christ's thorn shrubs by grubbing with dozers and rippers; (F): The shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then, it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops. The differences in means indicated with different letters are significant. (a > b > c > d). Duncan test, $P < 0.05$).

agricultural field and reseeding two years ago. This plot was exposed to heavy grazing since it is quite close to the village. Therefore, yields decreased also in this plot as compared to the others. Almost half of control plot is covered with Christ's thorn shrubs; therefore yield of herbaceous species was quite low because of shrub competition.

Herbage yields were higher in the second year than in the first year in all improvement plots. The precipitations of the first year were quite below the long-term averages and the precipitations of the second year were twice as much the first year. Therefore, higher yields were observed in the second year since precipitation is the greatest factor designating the herbage yields of rangelands (Vallentine 1990).

3.3. Nutritional Composition of Rangeland Herbage

Significant changes were not observed in herbage quality (crude protein, crude ash, NDF and ADL) of rangeland plots in both years. Only the differences in crude ash of treatment plots in 2009 were found to be significant (Figure 4). Crude protein

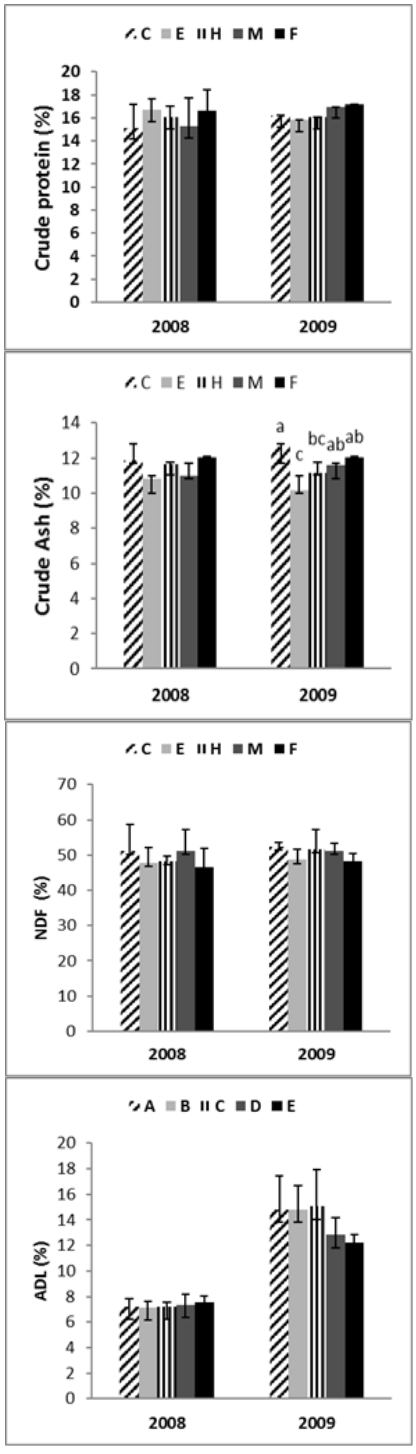

Figure 4. Crude protein (%), crude ash (%), NDF (%), ADL (%) of rangeland plots improved with different methods (C): Control (no improvement practices; (E): Removal of Christ's thorns followed by forage crop planting; (H): Christ's thorn shrubs were treated with herbicides; (M): Removal of Christ's thorn shrubs by grubbing with dozers and rippers; (F): The shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then, it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops. The differences in means indicated with different letters are significant. (a > b > c > d). Duncan test. $P < 0.05$).

ratios of improved rangelands were lower than the control plot. Contrarily, control plot had higher crude ash ratios. In 2009, the lowest crude ash ratio (10.16%) was observed in E-plots. There was a significant correlation between crude ash ratio of the herbage and soil K content. Crude ash ratios increased with increasing soil K contents. NDF and ADL ratios, indicating total fibrous compounds of plants, were similar in all improvement plots and the differences were not significant.

Forage quality is influenced by soil type, climate regime, plant composition, improvement practices and environmental factors (Perez-Corona et al. 1998; George et al. 2001). Herbage nutritional composition was quite similar in all plots. With regard to botanical compositions, legumes, grasses and forbs species had closer ratios. Therefore, herbage quality was also similar. Quite similar herbage quality parameters were reported in study carried out over the rangelands of Russia (Mikhailova et al. 2000).

4. Conclusions

The present study was conducted to assess plant characteristics of rangelands improved with different practices. Improvement practices were primarily implemented to eliminate the invasive Christ's thorn shrub from the rangelands of Mediterranean region in Turkey. These practices were (C): control treatment without any improvement practices, these rangelands are intensely covered with Christ's thorn (*Paliurus spina-christi* Mill.); (E): Removal of Christ's thorns followed by forage crop planting (H): Christ's thorn shrubs were treated with glyphosate-containing herbicides (Roundup) and rangelands were seeded with forage crops (perennial ryegrass, orchardgrass, alfalfa, bird's foot trefoil); (M): Christ's thorn shrubs were removed through grubbing from 25-30 cm depth with dozer + rippers and rangelands were seeded with the same forage crops and (F): The shrubs were cut out in the rangelands dominated with Christ's thorn. The field has been plowed deep by a tractor. Then, it had been used as field for 10 years (sown with wheat). At the end, it has been turned back in the form of rangelands by sowing forage crops. There were 45 species identified in control plot. Number of species decreased with improvement practices and the least number of species (28 species) was observed in plot from which shrubs were grubbed with dozers. The greatest herbage yield and grazed herbage quantities were observed in the plot from which shrubs were mechanically eliminated and seeded with forage crops. Improvement practices increased herbage yields and grazed herbage quantities of the rangeland plots. Experimental plots had quite similar herbage quality parameters. It was concluded that mechanical control and herbicide treatments were successful in sites intensely covered with Christ's thorn. However, heavy grazing should definitely be prevented to sustain this success in shrub control.

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