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Plant and Soil Characteristics of Rangelands Improved with Different Methods

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Abstract: Annual plant species and thorny shrubs like Christ's thorn (*Paliurus spina-cristi*) are common in Mediterranean rangelands because of climate and heavy grazing. Mediterranean rangelands (Biga-Çanakkale/Turkey) with invasive Christ's thorn (CT) populations improved with various practices through removing shrubs from the rangelands and seeding the places with forage crops. Improvement practices were as follows; (C): Control treatment, (E): CT's were removed 15 years ago, rangelands were seeded with forage crops; (H): CT's shrubs were treated with herbicides; (M): CT's shrubs were removed through grubbing with dozers and rippers; (F): The rangelands were used as agricultural field and reseeded to create a rangeland. All treatment plots were seeded with perennial ryegrass, orchard grass and alfalfa. Effects of these improvement practices on soil and plant nutrients and some soil characteristics were investigated. Soil pH; decreased in herbicide-treated rangelands. The electrical conductivity of the soil did not change in the first year but changes have been occurred among the applications in second year of the study work. The amount of soil nitrogen varied with the applications, while there was no change in the amount of plant nitrogen. Treatments resulted in significant changes in soil and plant macro (K, Ca, Mg) and micro (Fe, Cu, Zn) nutrients and only the phosphorus (P) contents were not significant. The applied improvement methods in rangelands have brought certain changes the nutrients of soil and plant, but these variations did not mean to any negativity. It was concluded based on present findings that any methods used in this study could be used to eleminate Christ's thorn from the rangelands, but the method which is more economical and sustainable for the relavent rangeland should be preferred in reclamation works.

Keywords: *Paliurus spina-cristi*, rangeland improvement, soil, herbage

Farklı Yöntemlerle Islah Edilen Meraların Bitki ve Toprak Özellikleri

Özet: Akdeniz tipi meralarda iklim ve ağır otlatmadan dolayı tek yıllık türler ve karaçalı (*Paliurus spina-crist)* gibi dikenli çalılar oldukça yaygındır. Akdeniz tipi mera özelliğinde olan Türkiye'nin Çanakkale ilinin Biga ilçesinde karaçalı (CT) çalılarını yok etmek ve merayı ıslah etmek için çeşitli uygulamalar yapılmış ve yem bitkileri ekilmiştir. Merayı ıslah etme uygulamaları (C): Kontrol, (E): karaçalı çalıları 15 yıl önce yok edilmiş ve mera yem bitkileri ile tohumlanmıştır, (H): karaçalı çalısına herbisit uygulanmıştır, (M): karaçalı çalısı dozer ve ripel ile sökülmüştür, (F): mera uzun yıllar tarla alanı olarak kullanılmış daha sonra yem bitkileri ekilerek mera oluşturulmuştur. Yapılan bütün uygulamalarda çok yıllık çim, domuz ayrığı ve yonca bitkileri ile tohumlama yapılmıştır. Yapılan bu uygulamaların toprak ve bitkilerin besin elementi içeriğine ve toprağın bazı özelliklerine etkisi ortaya konulmuştur. Toprak pH'sı herbisit uygulanan parsellerde azalmıştır. Toprağın elektiriksel iletkenliği ilk yıl değişmemiş fakat ikinci yıl önemli bir değişim belirlenmiştir. Meraya yapılan iyileştirme çalışmaları ile topraktaki azot miktarında da değişim meydana gelmiştir. Yapılan uygulamalarla toprak ve bitkideki makro (K, Ca, Mg) ve mikro (Fe, Cu, Zn) besin elementlerinde önemli değişim olurken fosfor miktarında herhengi bir değişim meydana gelmemiştir. Meranın ıslahı için yapılan çalışmalar toprak ve bitki besin elementlerinde değişim meydana getirmiştir, fakat bu değişim olumsuz olmamıştır. Bu çalışma sonucunda meralarda bulunan karaçalının yok edilmesinde bu merada kullanılan yöntemlerin hepsi uygulanabilir fakat ıslah çalışması yapılacak mera için hangi uygulama daha ekonomik ve sürdürülebilirse o yöntem tercih edilmelidir.

Anahtar kelimeler: *Paliurus spina-cristi*, mera ıslahı, toprak, ot

Introduction

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. Year-long average protein content of Christ's thorn is 114,6 g/kg, NDF is 474,8 g/kg and digestibility value (DMD) is around 62,54% (Özaslan-Parlak 2011). 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. In the erodication of invasive species in rangeland mechanical, chemical methods are used. In addition, the rangeland is completely removed from the vegetation. Rangeland is being processed and artificial pastures are established (Link et al. 2017). The plant of Christ's thorn has been harvested at bottom with mechanic methods or adopted the way of keeping away the bush using ripel like tools. During the removal of top soil is lower stem stolen. The herbicide is also applied by chemical methods. The seeds of forage are sown in the gaps formed by the destruction of the invasive species, leading to the improvement of the rangelands (Endress et al. 2012).

The Ministry of Food Agriculture and Livestock of Turkey have been implementing comprehensive rangeland improvement and management projects in accordance with 4243-numbered and 28.02.1998-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 plant and soil macro and micro nutrients of rangeland plots with five different improvement processes were assessed. Soil reaction (pH) and salinity (EC) were also determined to assess changes in soil chemical composition.

Materials and Methods

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 Çanakkale province. Çanakkale 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. 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). Çanakkale have Mediterranean precipitation regime with the highest 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 1).

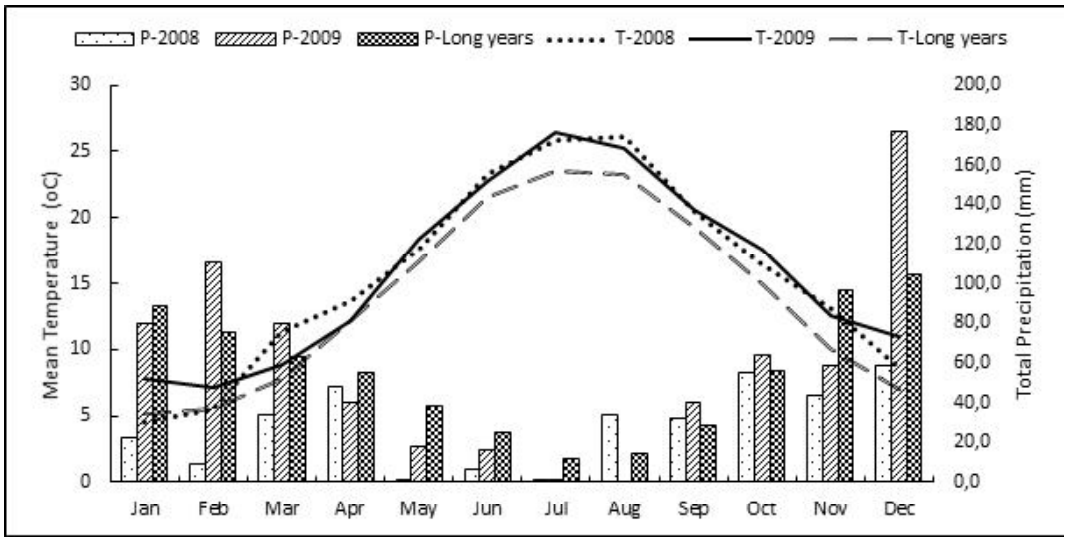


Figure 1. Avarage climatic data of experimental period and long years of Biga distict (Canakkale/Turkey)

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-cristi* 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 ased 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 01.12.2016. 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, 4 kg/da nitrogen (N), 4 kg/da phosphorus (P) and 2 kg/da potassium (K) were applied with 15-15-15 and 20-20-0 composed fertilizers. Fertilization was not performed in subsequent years.

Investigated Traits

Soil analyses: Soil samples were taken from 8 different locations (0-30 cm soil profile) of each rangeland plot. Coordinates of each sampling location were taken with a GPS device and sampling was performed from the same locations in subsequent years. Samples were transported to laboratory in polyethylene bags and air-dried in the laboratory. Then they were sieved through 2 mm sieves and made ready for analyses (Jackson 1958; Müftüoğlu et al. 2014). Soil samples were subjected to following analyses with the methods specified in Table 1.

Table 1. Soil Analyses and methods

Analyses	***Explanation***	***Methods***
Soil reaction (pH)	In soil-water suspension (1:2.5) with a glass-electrode pH meter	Jackson (1958)
Soil salinity (EC)	In soil-water suspension (1:2.5) with an EC meter	Richards (1954)
Total N	In LECO C-N elemental analysis device with dry-ashing method	Kirsten (1983)
Lime ($CaCO_3$)	In Scheibler calcimeter through volumetric measurement of CO_2 released by HCl acid	Allison and Moodie (1965)
Fe, Cu, Zn	In AAS-OES device after DTPA extraction	Lindsay and Norvell (1978)
Available P	In a spectrophotometer through readings from colored P with 0.5 M $NaHCO_3$ (pH=8.5) solution	Olsen et al (1954)

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). Ground herbage samples were subjected to microwave (Velp Scientifica DK 6 Heating Digester) digestion to get P, K, Ca, Mg, Na, Fe, Cu and Zn contents (Jones et al. 2001) and readings were performed in an ICP-OES (Perkin Elmer Optima 7000 DV) device (Isaac and Kerber 1971). Phosphorus readings were performed with a spectrophotometer (Shimadzu UV-1201V) as specified by Kitson and Mellon (1944) from the wet-digested and yellow-colored samples (Barton 1948).

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 (Winer et al. 1991). The relationships among rangeland yield, soil parameters and macro and micro nutrients were analyzed with Pearson's correlation tests.

Results and Discussion

Soil Chemistry

Soil pH levels were lower in H-plots (herbicide-treated and seeded) than the others in both years (Figure 2). Because of these low values, H-plots were classified as "slightly acidic" and the other plots were classified as "neutral" and "slightly alkaline". (Richards 1954; Grewelling and Peech 1960). In a previous study carried out over the same rangelands, Türkmen et al. (2013) reported the lime content of H-plots as 0,66% and such a value was lower than the other plots. Thus, low pH levels might have resulted from those lower lime contents of H-plots. Soil pH is directly related to lime content (Richard 1954). Such soils are not considered as problematic soils with regard to nutrient uptake of plants (Kacar 2009).

Soil salinity (EC) did not change significantly with the treatments in the first year, but significant changes were observed in F and M-plots in the second year (Figure 1). Despite the significant differences in soil salinity of the second year, values did not reach to harmful levels neither in different treatment nor in control treatment. All soils of improved plots were classified as "unsaline" (Maas 1986; Müftüoğlu et al. 2014).

The changes in Ca and K contents of rangeland soils in different years were found to be significant. Ca and K had similar characteristics also based on improvement practices (Figure 2). The highest values were observed in control plot and the lowest values were seen in H-plots. Such findings may be explained with low lime levels of H-plots as indicated by Türkmen et al., (2013). Low lime-originated carbonates may also reduce especially potassium and alkaline cation levels as carbonates ($CaCO_3$ and KCO_3) (Jones et al. 1998; Tan 2011).

The highest soil Mg content was observed in F-plot and the lowest value was seen in control plot (C). Such a case may be resulted from different soil characteristics of improved plots (Türkmen et al. 2013) and differences in herbage yields and diversity. Different plants uptake different amount of nutrients from the soil (Jones et al. 1998), thus nutrient composition of soils may greatly vary (Kacar 2009; Tan 2011; Kabata-Pendias 2011).

Similarly, significant differences were observed in N contents of the years. In the first year, the highest N content was observed in H-plots and the lowest value has been seen in E-plots. In the second year; E, H and M-plots had similar nitrogen contents and the lowest value was found in F-plots. Low pH levels of H-plots treated with herbicides might have resulted in excessive exhaustion or leaching of alkali cations (Kacar 2009; Tan 2011). On the other hand, positive and/or negative influences of herbicides on soil microorganisms were also reported by Buscot and Varma (2005). It has also been reported in another study carried out in the USA that glyphosate treatments reduced the microbial activity in soilless cultivation, but such treatments had insignificantly affected the microbial respiration with soil cultivation. It was also reported in another study that long-term high-dose glyphosate treatments increased microbial respiration in forest soils since microorganisms used this compound as carbon source (Busse et al. 2001).

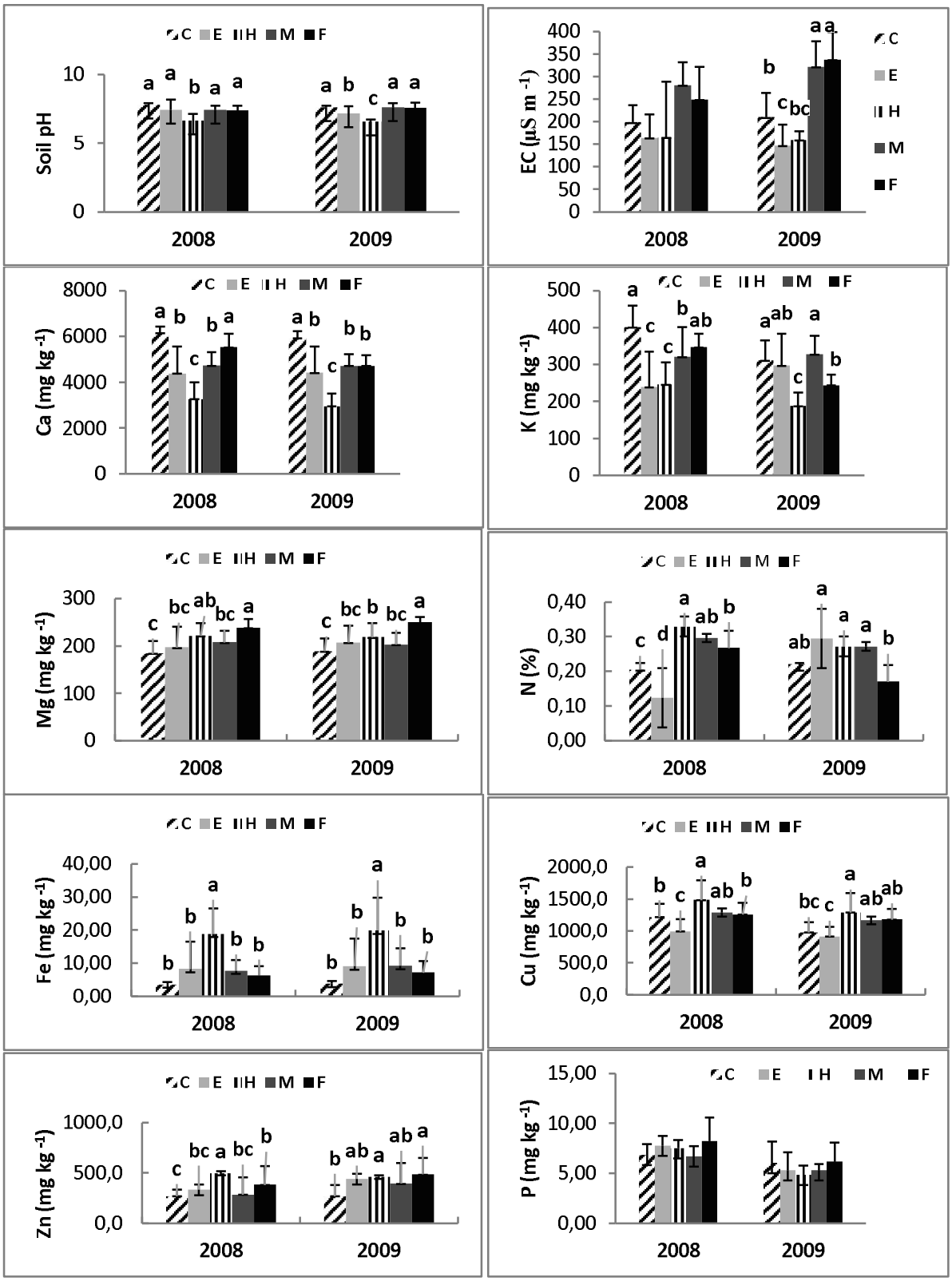


Figure 2. Soil macro and micro nutrients of rangeland plots improved with different methods (C): Control (no improvement practices; (E): Removal of Christ's thorns followed by forage crop planting; (H): Christ's thorn shrubs were treated with herbicides; (M): Removal of Christ's thorn shrubs by grubbing 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 ased 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).

Significant differences were not observed in phosphorus contents of improved plots. Available forms of micro nutrients (Fe, Cu and Zn) were also investigated in this study and significant differences were observed in micro nutrient contents of treatments in both years. The highest Fe, Cu and Zn contents were observed in H-plots in both years. Again low pH and the least lime levels of that plot increased micro element extraction of the soils and bioavailability of these elements (Hinsinger 2001; Jones 2012). Fe levels of the experimental plots were similar to each other. The lowest Cu content was observed in E-plots and the lowest Zn content was observed in control plot (Figure 2). Current findings comply with the results of Jones (2001) reporting different micro and macro nutrient uptakes of different high plants; with the results of indicating high variations in soil nutrient contents of different sites and with the findings of Kabata-Pendias (2011), Lindsay and Norvell (1978) and Jones (2012) indicating changing nutrient uptakes with soil characteristics.

Chemical Composition of Rangelands

Chemical composition of rangeland herbages significantly changed with improvement practices. Only the phosphorus did not have significant changes with improvement practices showed in Figure 2. The rangeland plot (F) has been used as agricultural filed for a long time and reseeded in 2006 had the highest Ca, Mg and Zn contents. The lowest herbage Ca, Mg, Fe, Cu and Zn contents were observed in control plot. While there were non-significant changes in K and Na contents in the first year, the changes in the second year were found to be significant. Correlations of soil nutrients with plant nutrients and yields were also investigated in this study. There was a significant positive correlation between soil EC ($P<0,05$) and yield ($r = 0,44$) in 2008 and 2009. Since the experimental soils were unsaline and increased salinity levels enriched salt-forming nutrients, except for sodium, such increases positively reflected on yields (Kabata-Pendias, 2011, Jones, 2012).

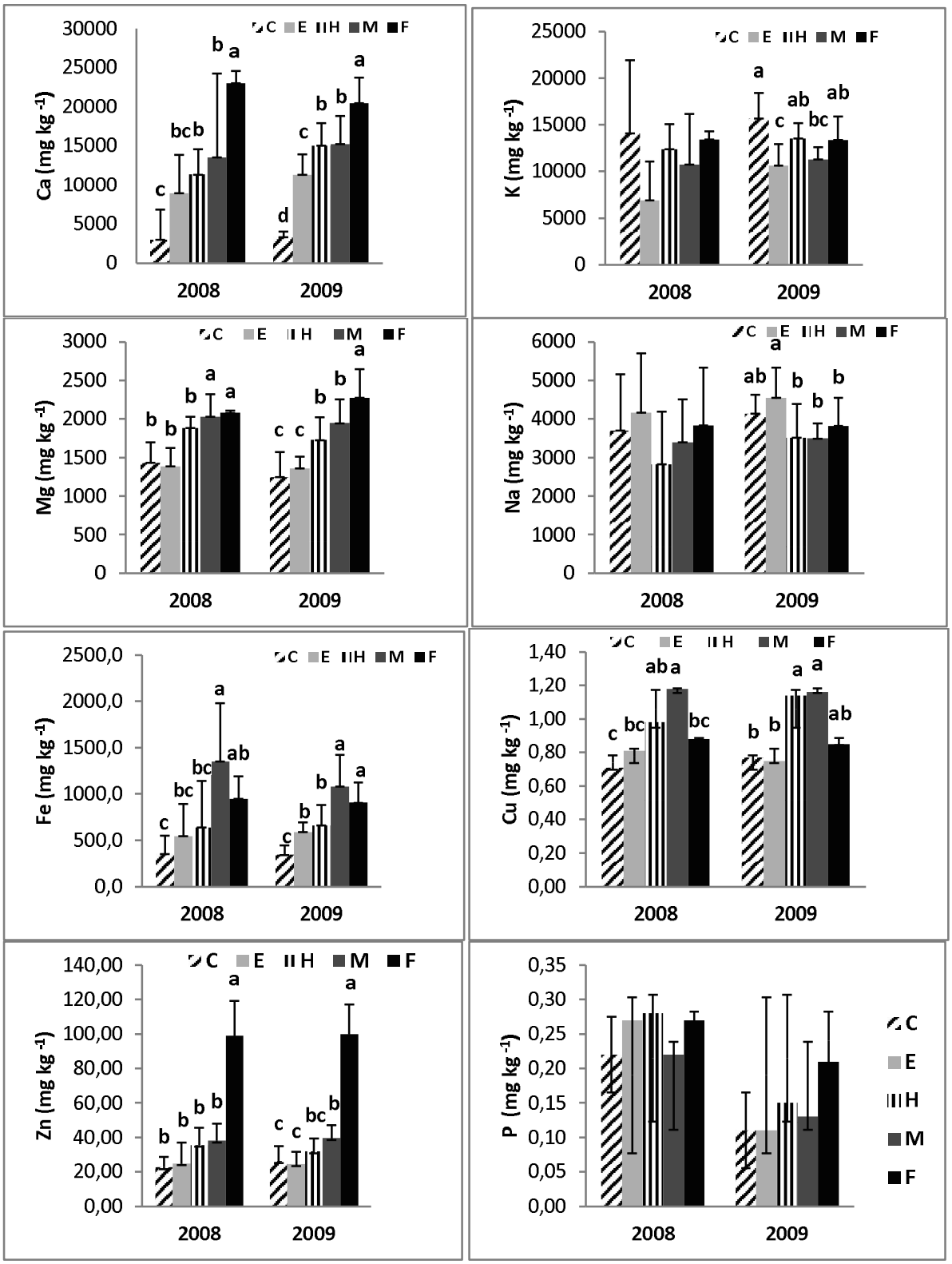


Figure 3. Herbage macro and micro nutrient contents of rangeland plots improved with different methods (C): Control (no improvement practices; (E): Removal of Christ's thorns followed by forage crop planting; (H): Christ's thorn shrubs were treated with herbicides; (M): Removal of Christ's thorn shrubs 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 ased 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). Soil Mg content positively correlated with plant Mg (r = 0,47), Ca (r = 038), Fe (r = 0,39) and Zn (0,52) contents. There was also positive correlations between soil K

content and plant ash content (r = 0,34); between soil Cu content and plant Cu content Cu (r = 0,41); between soil P content and herbage crude protein content (r = 0,38).

Conclusions

The present study was conducted to assess soil and plant characteristics of rangelands improved with the application of 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-cristi* 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 ased 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. Significant differences were observed in soil macro and micro nutrients of treatment plots. Different treatments had similar pH levels, but the plot with herbicide treatments had lower pH and lime levels as compared to the other plots. Different treatments did not create any significant changes in both soil and plant P contents. There were significant differences in some plant macro and micro nutrients (Ca, Mg, Fe, Cu and Zn). While the differences in K and Na contents were not significant in the first year, they were found to be significant in the second year. In both years, soil Mg content positively correlated with plant Mg, Ca, Fe and Zn contents. There were also positive correlations between soil K content and plant crude ash, between soil Cu content and plant Cu content. 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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