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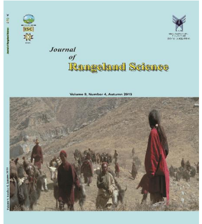

Research and Full Length Article:

Patch Enclosure and Localized Effects of Selected *Acacia* Species on Herbaceous Richness and Soil Properties of Rangelands in Somali Regional State in Ethiopia

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Abstract. Enclosure and *Acacia* shade availability to plants are basic variable in arid and semi-arid rangelands. the aim of this study was investigation the impact of patch enclosure and *Acacia* shade using four treatments which are Inside Enclosure Under Acacia shade (IEUA), Inside Enclosure Without Acacia shade (IEWA), Outside Enclosure Under Acacia shade (OEUA) and Outside Enclosure Without Acacia shade (OEWA) on herbaceous species richness and soil chemical properties of rangelands in Shinile Woreda, Somali regional state. The effects of enclosures and *Acacia* shade were completely different. Herbaceous species richness was significantly high in *Acacia* enclosure. All soil chemical properties showed significance difference under *Acacia* shade compared to areas without it except soil pH. On the other hand, there was no significant difference for soil chemical properties between inside enclosures and the nearby open grazing areas except for soil pH which was significantly higher inside enclosures. The result of study revealed that soil pH, Organic Carbon (OC) and Organic Matter (OM) were positively correlated with species richness in all of treatments. Electro Conductivity (EC) and potassium (K) showed positive correlation with species richness only under *Acacia* shade inside enclosures but they were negatively correlated in other treatments. Phosphorous (P) showed positive correlation with species richness at place without *Acacia* shade inside and outside of enclosure. Determining the relationship between soil and plants is a useful way to better understand the ecosystem condition and can help to manage the rangeland ecosystem. The degraded rangelands can be restored by an increase of an enclosure and *Acacia* shade which will benefit pastoral community from it.

Keywords: *Acacia* shade, Enclosure, Rangeland, Richness, Soil properties

Introduction

The rangelands of Ethiopia are mainly located within the arid and semi-arid agro-ecological zones below 1,500 masl (Coppock, 1994; Alemayehu, 2004) and cover about 62% (682,000 km^2) of total land area of the country (EARO, 2002). These areas support different types of livestock and they are the major browsing and grazing areas of the country. The importance of rangeland is far greater than the appreciation of local community as they are mostly concerned with only one of the function of rangelands; animal production. However, rangelands are also of great ecological importance, because rangeland vegetation type protect often fragile soil profiles, harness large amount of carbon dioxide, are a habitat for wild fauna and flora and acts watersheds for large river system (Friedel *et al.*, 2000). The rangeland improvement and maintenance are necessary for various benefits and ecological balance to determine sustainable, optimal grazing capacity and maximum profitability for livestock production which requires the knowledge of the biological, physical and socio-economical characteristics of the system. In the extensive communal low land grazing areas of Ethiopia, herbaceous and woody plants are the major feed source of livestock (Abule *et al.,* 2005; Abule *et al.,* 2007) which support more than 90% of the domestic ruminants (Alemayehu, 2004).

The Ethiopian Somali region is mostly semi-desert and desert with high temperatures and low precipitation. Different arid and semi-arid rangeland vegetation types, such as grasslands, open bush grassland and closed bush land are found in the regional (SoRPARI, 2005). These rangelands are rich in botanical resources, but at present they are subjected to human and natural influences which reduce biodiversity (Gemedo-Dalle *et al.*, 2006). Loss of plant cover, undesirable change in herbaceous species composition (e.g. annual grasses replacing perennials), soil erosion of various types associated with intensification of grazing and woody encroachment have been dominant features in the rangelands which could have different implications for pastoral productivity and rangelands potentials. Due to this reason, pastoral communities internalize the problems mainly through engagement in land use types that directly compete with their life. One of the resolutions they seek through is a traditional rangeland management activity that focuses mostly on natural forage of rangeland (Sandford, 1983). Proliferation of an enclosures may be cited as examples as the solution (Tache and Oba, 2010; Tache, 2010; Berhanu and Colman, 2007). Reserving a section of the communal rangeland through enclosure for later use has always been an integral part of pastoralist innovation in land use in the arid and semi-arid environments where pastoralist land use strategies are largely influenced by spatial and temporal resource variability.

The establishment of communal enclosures in area followed the critical drought in 1983 which led to massive livestock mortality (Alison and Solomon, 2011). Under ideal common property resource tenure, a decision to make an enclosure is made through consensus. Management of the enclosed pasture is a collective responsibility and utilization is for communal purpose. The main functions of making an enclosure are to rehabilitate degraded rangeland by enhancing recovery in place where soil degradation and overgrazing are common. Nowadays there are many type of enclosure. One is the communal enclosure where a group of villages reserve pasture on communal basis The communal pasture reserves, locally known as *seero*, provided a means for meeting the special need of pastoral community. The second type is the enclosures used by the community but introduced or supported by nongovernment organizations (NGOs). The third category is private enclosure which is not common like others (Talasan, 2009).

Substantial research and development works have been conducted in most of the arid and semi-arid rangelands of Ethiopia. However, in the Somali regional State in general and the Shinile Woreda areas in particular, research and development interventions have been insignificant (Gezu, 2011). Limited studies conducted in the region which were focused on rangeland resources and establishment of enclosure were; the impact of rangeland degradation on the pastoral production systems, livelihoods and perceptions of the Ethiopia Somali pastoralists (Kassahun *et al.,* 2008); Changing pastoralist in the regional (Sugule and Walker, 1998); The impact of enclosures on access to rangelands (Talasan, 2009). Assessment of pastoralists' views on enclosures in Shinille and Dollo (Gezu, 2011) and range and forestry biophysical business process, establishment of area enclosures to rehabilitate and improve degraded rangelands (SoRPARI, 2011). Clearly, there is lack of information on impacts of patch enclosure and *Acacia* shade in plant richness and soil nutrient status across study area that would contribute a lot regarding optimal utilization of the rangeland resources. Moreover, issues of enclosure and acacia shade on the protection of herbaceous and soil properties, which are important for proper rangeland management, were generally ignored in those limited studies. Therefore, the objective of this study was to investigate the impacts of patch enclosure and localized effects of selected *Acacia* shade on herbaceous species richness and soil chemical properties in semi-arid rangeland in Shinile Woreda, Somali regional State in Ethiopia.

Materials and Methods

Study area

Ethiopian Somali Regional State is located between 4-11^{o}N and 40-48^{o}E, within the eastern and southeastern lowlands of Ethiopia. The current study was conducted in Shinile Woreda, Shinile zone, 85000 km^2 in size, which is located in the northern part of the Regional State. Shinile Woreda is bordered by Dire Dawa district in the south, Erer Woreda in the southwest, Dambal Woreda in the south-east and Ayshia in north east.

The area is known for its hot climate and as a result annual plant growth periods are short, ranging between 40 and 65 days, which is inadequate to support crop agriculture without supplementary irrigation (SoRPARI, 2011). The rainfall is bimodal which include the short rainy season from March to April (2 months) and the main rainy season from July to September (3 months). The variation in the precipitation between the driest and wettest months is 108 mm. throughout the year; temperatures vary by 7.1 °C. The average temperature is 27 °C in Shinile. The mean annual rainfall is 554 mm.

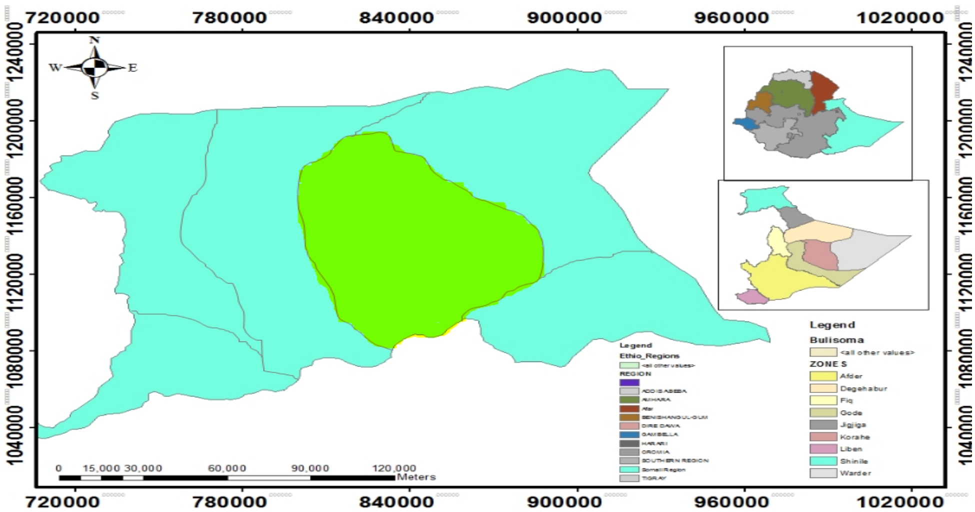

Fig. 1. Map of the study area and sampling sites (the green one is specific study area Shinile Woreda), Somali regional State, Ethiopia

Research Methods

For plant and soil sample collection, a total of 40 sampling plots of 1x1m were randomly located inside and outside of enclosure of study site; 20 from inside enclosure and 20 in open grazing area. As follows:

10 plots Inside Enclosure Under *Acacia* shade (IEUA)

10 plots Inside Enclosure Without *Acacia* shade (IEWA)

10 plots Outside Enclosure Under *Acacia* shade (OEUA)

10 plots Outside Enclosure Without *Acacia* shade (OEWA)

Both herbaceous plants and soil samples were collected from under canopies of *Acacia nilotica, Acacia senegal, Acacia tortilis, Acacia mellifera* and *Acacia nubica* at both inside the enclosure and open communal grazing areas. Plants were collected from late August to mid-September 2016, a time when herbs go to flower and fruit. All plant species were counted and collected in each treatment for further analysis. Plant samples were prepared according to the guidelines of the National Herbarium for Floras and Faunas of Ethiopia (NHFFE, 1987). Herbs were collected by carefully uprooting the plant using a shovel, together with above-ground parts such as stems, leaves, shoots, flowers, pods or seeds. Samples were pressed, dried and then transported to the NHFFE for identification using annotated herbarium specimens and Flora of Ethiopia and Eritrea. Soil was sampled at the four corners and a center of the 1 x 1m plot using 6 cm auger from the top 0 to 10 cm depth. All soils samples from each site was carefully kept in separate paper bags and air dried for following analysis: Soil acidity (pH), Electrical Conductivity (EC), Organic Carbon (OC), Organic Matter (OM) available Phosphorus (P) and exchangeable potassium (K) (Okalebo *et al*., 2002). The analyses were conducted at Soil, Plant and Water analysis laboratory of Haramaya University, Ethiopia.

Statistical analysis

Species frequency for each species was determined based on percentage of occurrence of individual plant species in relation to the total number of observation points. The data of herbaceous plant richness, and soil chemical parameters among different sites were subjected to analysis of variance (ANOVA) using R Software (R version 3.4.1., 2017). Mean comparisons were made between treatments using Tukey tests ($P \leq 0.05$) for herbaceous species richness, soil nutrient such as pH, EC, OC, OM, P, K and plant agronomical traits as: seed weight, seed number, plant height and tiller number of selected species at four treatment (IEUA, IEWA, OEUA and OEWA). Correlation analyses were made between herbaceous species richness and soil chemical properties.

Results

A total of 27 plants species were recorded from the different treatments and one of these, *Parthenium hysterophorus,* is an invasive species that was introduced recently. *Eragrostis cilianensis* is the most frequent species while *Tragus berteronianus* and *Eragrostis ciliaris* are the least frequent in the study area. The study showed that both enclosure and *Acacia* shade affects the presence and absence, abundance and number of grasses and herbs of certain species (Table 1). The effects of *Acacia* shade inside the enclosure and outside it (open grazing area) were different (Table 1).

Table 1. Effect of enclosure and *Acacia* shade on species frequency and the vernacular name of the herbaceous plant

Species name	Species Frequency (%)	Vernacular Name
Grasses		
Andropogon amethystinus	3.15	Terfae
Anthephora pubescens	1.99	Saard
Aristida adscensionis	2.49	Mayeer
Aristida kelleri	3.98	Duur
Aristida mutabilis	2.49	Guurta
Aristida paoliana	4.32	Hadaf
Brachiaria serrata	6.15	Sardi-cah
Brachiaria burrata	1.99	Bael-beleiti
Cenchrus ciliaris	5.64	Baldohoor
Chloris gayana	1.99	Aagaar
Dactyloctenium aegyptium	4.98	Maedahabour
Eragrostis aspera	2.82	Xarfo
Eragrostis cilianensis	9.97	Harfooe
Eragrostis minor	1.82	Saaren
Eragrostis papposa	5.98	Mequalihid
Eragrostis ciliaris	1.16	Nefeer
Eriochloa fatmensis	6.15	Awis-shebel
Eriochloa nubica	1.99	Awis-shebel
Ochthochloa compressa	3.15	Baal-dori
Sporobolus piliferous	6.48	Yer-yerot
Stipagrostis hirtigluma	3.32	Osuguul
Tragus berteronianus	1.16	Merebaabis
Forbs		
Acanthospermum hispidum	1.83	
Aerva javanica	2.32	Rhido
Bergia suffruticosa	1.99	Baareed
Parthenium hysterophorus	4.32	Arema cuba
Senna obtusifolia	2.99	Waan-aad
Tribulus terrestris	2.49	Gooundoo

Effect of enclosure and Acacia shade on species richness and soil properties

The result of one-way ANOVA showed significant differences of soil acidity (pH), soil salinity (EC), organic carbon (OC%), organic matter (OM%), soil phosphorous (P), soil potassium (K), grass and Forb between four treatments including inside enclosure under Acacia (IEUA), inside enclosure without Acacia (IEWA), outside enclosure under Acacia (OEUA) and outside enclosure without Acacia (OEWA) ($p<0.01$) (Table 2).

The higher mean value of grass species was recorded from inside enclosures under *Acacia* shade and followed by a value from enclosures without it (Table 3). On the other hand, there was a decreasing trend in grasses species from under *Acacia* shade to without it in open grazing areas. Furthermore, the mean values of EC, OC, P, K and OM were higher under *Acacia* shade of the enclosures and nearby open grazing areas than without it in both treatments (Table 3).

Table 2. The effects of enclosure and *Acacia* shade on plant species richness and soil chemical properties of the various sites (one-way ANOVA)

Source	DF	MS							
		pH	EC(d Sm-1)	%OC	%OM	P(ppm)	K(ppm)	Grass	Forb
Treatment	3	0.734**	147546**	1.551**	4.601**	1374.2**	38476**	583.16**	5.667**
Error	36	0.090	2417	0.021	0.061	34.0	2984	7.98	1.239
Total	39								

**=significant in 1% probability level

Table 3. Mean values ±SD of the species richness (grasses and forbs) and soil chemical properties of the rangeland at the 40 sampling plots.

Parameter	IEUA (N=10)	IEWA (N=10)	OEUA (N=10)	OEWA (N=10)	Mean (N=40)
Grasses	23.00±2.87 ^{a}	13.30±3.53 ^{b}	9.20±2.62 ^{c}	5.20±2.09 ^{d}	12.67±7.22
Forbs	3.30±1.42 ^{a}	2.20±1.32 ^{b}	2.60±0.84 ^{c}	1.50±0.707 ^{d}	2.40±1.25
pH	7.44±0.081 ^{a}	7.51±0.097 ^{a}	7.06±0.42 ^{b}	6.96±0.42 ^{b}	7.24±0.37
EC(dSm^{-1})	388.1±61.1 ^{a}	226.6±30.9 ^{b}	427.5±67.24 ^{a}	177.7±21.2 ^{b}	304.9±116.5
Organic carbon %	1.95±0.091 ^{a}	1.23±0.18 ^{c}	1.51±0.163 ^{b}	1.04±0.126 ^{d}	1.43±0.372
Organic matter%	3.36±0.15 ^{a}	2.13±0.31 ^{c}	2.60±0.282 ^{b}	1.79±0.213 ^{d}	1.43±0.372
Phosphorous (ppm)	34.57±3.66 ^{a}	13.70±7.27 ^{b}	35.59±4.01 ^{a}	16.00±7.318 ^{b}	24.96±11.71
Potassium (ppm)	394.6±50.09 ^{a}	308.3±57.51 ^{b}	417.1±51.9 ^{a}	292.1±58.52 ^{b}	353. 5±75.59

IEUA=Inside Enclosure under *Acacia*
IEWA=Inside Enclosure without *Acacia*
OEUA=Outside Enclosure under *Acacia*
OEWA=Outside Enclosure without *Acacia*
Means of rows (treatments) followed by similar letters is not significant

Relationship between species richness and Soil properties

The study has revealed that species richness was positively correlated with soil pH and phosphorous (P) in outside enclosure without *Acacia* (OEWA) (Table 4). Indicating that in open grazing area the higher species richness is related with higher soil pH and P.

The soil acidity was negatively correlated with soil EC in outside enclosure without *Acacia* (OEWA) (Table 4) indicating that in open grazing area the increasing of soil salinity led to reduce the soil pH. In contrast, the soil pH was positively correlated with soil organic carbon and organic matter in inside enclosure under Acacia shade (IEUA), indicating that in Acacia protected aria the fertile soils had higher pH. (Table 4). Similarly, the soil pH was positively correlated with soil Potassium (K) in inside enclosure without Acacia (IEWA).

The soil salinity (EC) was positively correlated with phosphorous in all of area except inside enclosure without Acacia (IEWA), similarly soil salinity (EC) was positively correlated with potassium in outside enclosure area under Acacia (OEUA). There was strong positive correlation between soil organic carbon and soil organic matter in all of four area (Table 4). Finally, the relationship between phosphorous and potassium was contradiction. There were positive and significant correlation between two elements in in inside enclosure under Acacia shade (IEUA) and outside enclosure area under Acacia (OEUA) and negative and significant correlation in inside enclosure without Acacia (IEWA) and outside enclosure without Acacia (OEWA) (Table 4).

Table 4. Correlation coefficients between herbaceous species richness and soil chemical properties at four areas of IEUA, IEWA, IEUA and IEWA

sites	Traits	richness	pH	EC	%OC	%OM	P
IEUA	pH	0.30					
IEWA	pH	0.18					
OEUA	pH	0.01					
OEWA	pH	**0.61***					
IEUA	EC (d Sm-1)	0.14	-0.23				
IEWA	EC (d Sm-1)	-0.11	0.43				
OEUA	EC (d Sm-1)	-0.49	0.20				
OEWA	EC (d Sm-1)	-0.45	**-0.62***				
IEUA	Organic carbon %	0.14	**0.63***	-0.07			
IEWA	Organic carbon %	0.07	-0.04	-0.24			
OEUA	Organic carbon %	0.00	-0.11	-0.41			
OEWA	Organic carbon %	0.27	-0.04	-0.11			
IEUA	Organic matter%	0.13	**0.61***	-0.07	**0.99****		
IEWA	Organic matter%	0.07	-0.04	-0.25	**0.99****		
OEUA	Organic matter%	0.01	-0.11	-0.41	**0.99****		
OEWA	Organic matter%	0.26	-0.06	-0.11	**0.99****		
IEUA	Phosphorous (ppm)	-0.05	-0.56	**0.68***	-0.32	-0.30	
IEWA	Phosphorous (ppm)	0.17	-0.29	-0.38	0.25	0.25	
OEUA	Phosphorous (ppm)	-0.42	0.17	**0.70***	-0.45	-0.46	
OEWA	Phosphorous (ppm)	**0.66***	0.43	**0.68***	0.28	0.27	
IEUA	Potassium (ppm)	0.21	-0.40	0.45	-0.32	-0.31	**0.86****
IEWA	Potassium (ppm)	-0.05	**0.68***	0.32	-0.29	-0.29	**-0.85****
OEUA	Potassium (ppm)	-0.56	0.19	**0.90****	-0.43	-0.44	**0.83****
OEWA	Potassium (ppm)	-0.57	-0.39	0.59	-0.14	-0.13	**-0.82****

IEUA=Inside Enclosure under *Acacia*
IEWA=Inside Enclosure without *Acacia*
OEUA=Outside Enclosure under *Acacia*
OEWA=Outside Enclosure without *Acacia*

Discussion

Typically in our result, we recorded that the *Acacia* shade provides biological shelters (local refugia) for most of grasses and forbs by protecting them from biotic factors interaction such as goat, donkey, camel and cattle grazing. Grazing pressure has a significant effect on total vegetation cover, species richness, species composition, diversity and productivity (Angassa, 2014; Gamoun, 2014; Wiebke *et al.*,2014; Hanke *et al.*,2014), and therefore the detailed effect of different grazing pressures on semi-arid rangelands requires careful assessment. Furthermore, these local level refugia ameliorate environmental factor such as soil-water evaporation and wind erosion at enclosures and nearby open grazing areas. *Chloris gayana* was one species recorded under *Acacia* shade at both inside and nearby open grazing area. This could be perhaps attributed to its ability to establish rapidly in degraded areas. This species was reported as persistent and drought resistance (Gohl, 1981). *Chloris gayana* also propagates by stolon in addition to from seeds. The highest grass species richness was recorded at inside enclosures compared to open grazing areas. Nevertheless forbs show highest richness at under *Acacia* shade at both enclosure and open grazing areas. This shows *Acacia* shade is provided high protection for forbs, i.e., it serves as local refugia facilitating the germination of seeds and survivorship. On the other hand, because of a substantial overgrazing at open grazing area, some grass species were found to be susceptible grazing intensity and confined to enclosures under *Acacia* shade and without it, e.g. *Tragus berteronianus.*

Effect of treatments on specie richness

Our study has investigated the effects of enclosures and selected *Acacia* shade on plant richness of study area. Enclosure showed an increase in plant species richness by protecting them from over grazing. Grazing exclusion has been reported to be an effective practice to restore degraded grassland, as vegetation characteristics have been shown to improve under long-term grazing exclusion (Angassa, 2014; Wang *et al.*, 2015; Zhao *et al.*, 2011). In the same way, earlier studies in Afar region also reported that enclosed areas have been effective in restoring plant species composition, and cover of herbaceous species richness than the communal, open grazing areas (Ibrahim, 2016). The shade of *Acacia* species has high contribution in increasing plant species richness in arid and semi-arid (Mahgoub *et al.*, 2016).

The species richness higher in enclosures than open grazing areas could be explained by considering grazing intensity. There is a higher grazing intensity in open grazing areas than enclosures. Therefore, exposure of herbaceous vegetation to the high overgrazing, lack of protection and livestock movements (physical destruction) could be detrimental for variable composition of species between these treatments. The nature of rangelands outside unprotected areas were found to be more degraded than where protected elsewhere (e.g. Bahareh *et al.*, 2016). Furthermore, Angassa, (1999) assessed the traditional grazing management in southern range land of Ethiopia and reported that heavy grazing pressure might have caused a deterioration in plant species composition and diversity over time. Disturbance prejudiced plant species richness and diversity (Cumming, 1982). This could indicate that grasses and forbs growing inside of enclosure are well protected compared to areas outside enclosures. Earlier studies (e.g., Angassa, 2014; Gamoun, 2014), have shown a general decrease in vegetation cover with increasing grazing pressure.

Effect of treatments on soil chemical properties

In our study, pH was not affected by *Acacia* shade. It was nearly the same at both under *Acacia* shade and in areas without it. In contrast to our result, Hagos and Smit (2005) reported significantly low value of soil pH under the shade cover of *Acacia mellifera*. On the other hand, soil pH tends to be slightly more alkaline in under *Acacia* shade compared to without it. More species richness was also observed under *Acacia* shade.

In this study, soil under *Acacia* shade had shown higher soil EC than without it inside enclosures and open grazing areas. The lower species richness under *Acacia* shade in open grazing area could be due to the negative effect of high salinity perhaps coupled with soil degradation. Although high value of EC was recorded for soil under *Acacia* shade in enclosures, the relatively higher species richness could be attributed to reduced intensity of soil degradation. The observed high electrical conductivity (EC) values under tree shade might be due to accumulation of Na^+, Ca^{++} and Mg^{++}. High EC value may not imply high species number. Furthermore, although the positive effects of shade on species number is obvious, there are perhaps other factors which are detrimental for increasing species number. Open grazing areas are usually prone to disturbance which may result in trampling of seedlings limiting recruitment and establishment compared to enclosures. The lower number of species from *Acacia* shade from open grazing area could be due to disturbance although *Acacia* shade in enclosures and open grazing areas provides the same microclimate for plant species.

Abdallah *et al.* (2008) investigated the influence of *Acacia tortilis* trees on the soil nutrient status and that the top soil has higher in OC, pH, EC, available P and exchangeable K underneath as compared to outside the canopy. Similarly our study showed that OC, OM

EC available P and exchangeable K were significantly higher under *Acacia* shade at both inside and outside enclosure. Increased OC and OM content may be due to the accumulation of litters under the canopies at both sites. Other study also shows that OC was increased under *Acacia* (Mahgoub *et al.,* 2016). This also completely in agreement with our result in which Soil OC and OM were significantly high under *Acacia* shade and declined nearby place where the shadow might not rich. Similarly other studies have reported higher soil OC contents in topsoil of arid and semi-arid regions under trees than in open areas (Herrera *et al.,* 2007).

Adequate grazing management may balance provisioning and regulating ecosystem services (Onatibia *et al.,* 2015). The tradeoff between ecosystem conservation and utilization should thus be taken into consideration by local rangeland managers. After a certain number of years of fencing, appropriate management, such as rotational grazing and mowing, should be carried out. On the one hand, moderate grazing can increase the community stability and biodiversity and pastoralists have benefited directly from adding animals. Extensive enclosures and grazing management could improve the grassland utilization efficiency and foster sustainable development of the social-ecological system.

In the study area, soil degradation is linked to overgrazing and this threatens the conservation of soil organic matter and other soil nutrients (Sebastia *et al.,* 2008). This result shows a strong influence of overgrazing on the soil chemical properties affecting species richness. Rangeland management coupled with amelioration of microclimate by *Acacia* shade resulted in a high species richness compared to exposed areas which are prone to soil degradation. Species richness and soil chemical nutrients such as EC, OC, OM and P exhibit significant correlation. This result indicates a significant relationship between species richness and soil chemical properties. Interactions between species richness and soil chemical properties may be attributed to changes in vegetation during the restoration process through enclosure.

Relationship between species richness and Soil properties

The patterns of plant species richness are directly related to resource availability which impact plant growth. Plant establishment and changes in species richness are brought about by environmental factors such as soil properties affecting the growth bed of plants. This suggests that there are a variety of patterns of species richness along with soil nutrient gradients (Pilania and Panchal, 2014 and 2016; Panchal and Pandey, 2002). Also Vegetation plays an essential role in the process of soil formation through breaking rock particles and enriching soil with organic substance from aerial and subterranean layers (Donahue, 1977).

Soil pH was reported as a major factor driving species richness as a fine scale (Palpurina *et al.,* 2017). *Acacia* shade ameliorates moisture, which has a direct impact on soil pH, compared to areas without it. Although the effect of soil pH is confounded with other soil chemical properties, there is a tendency of positive relationships between species richness and increased soil pH. Furthermore, that means *Acacia* shade could be present more favorable soil conditions through decomposition of organic matter from plant detritus which increases soil pH. Numerous studies indicated that the increased soil pH could possibly be due to an increase in organic matter accumulation. Increases in pH after the addition of organic matter are purported to occur due to the decarboxylation of organic anions (Tang and Yu, 1999). EC rises with the quantity of soluble salts and high value of EC negatively affects vegetation (Pilania and Panchal, 2014 and 2016). Similarly; in our study, EC was negatively correlated to species richness at all treatments, except by inside of enclosure with *acacia* shade. This could be due to low grazing and low soil degradation at this place. Soil salinity increases with soil degradation (Panchal and Pandey, 2002).

Organic materials of plants being returned to the soil led to faster soil OC turnover via the accumulation of litter (Steffens *et al.,* 2009) and soil OC improvement was caused by microorganisms' decomposition of organic matter (Tanentzap and Coomes, 2012; Steffens *et al.*, 2009). Furthermore, there is a linear relationship between soil factors such as OC and OM and plant diversity and species richness (Abbasi-kesbi *et al.,* 2017). In this study, the soil OC and OM have shown to be positively correlated with species richness at all treatment. The soil OC can increase plant growth by providing plants with appropriate nutrients (Qiu *et al.,* 2013). In semi-arid grassland ecosystems, the maintenance of heterogeneous vegetation and associated topsoil structures are essential for the accumulation of soil OC and OM (Wiesmeier *et al.,* 2009). The enclosure improves soil organic matter of the rangeland by reducing wind erosion due to increased vegetation cover at inside. Increases in soil OC and OM resulted in decreased soil erosion by wind and water in this region due to increased vegetation cover, which enable nutrients to easily fix to the soil surface after livestock exclusion (Chen and Tang, 2016). Besides, grazing protection enhanced the soil aggregation as the physical protection of soil OC and OM (Wiesmeier *et al.,* 2012). The observed high values of soil factors such as OC, OM, P, Na, Ca and K could be attributed to the local refugia effect of *Acacia* shade and enclosures and such improved soil chemical properties was also previously reported (Nuray-Müftüoğlu and Gokkuş, 2016).

Conclusions

There is considerable evidence that *Acacia* canopy and enclosure strongly affects the plant richness, and composition of herbaceous vegetation in arid and semi-arid rangelands. The results of the study can be vital for the development and sustainable management of rangelands in arid environments. Protection of rangeland by construction of enclosure is widely considered to be a simple and effective method for restoring the herbaceous vegetation and soil chemical properties in degraded arid and semi-arid rangelands. The ecological purposes of work on enclosures are to rehabilitate degraded rangeland by enhancing recovery in place where soil degradation and overgrazing are common. In our study, herbaceous species richness and soil chemical properties were improved by the presence of either *Acacia* shade or enclosure. This indicates, patch enclosure and *Acacia* shade have great advantage for herbaceous species conservation and increase soil chemical properties of rangelands of study area. Determining the relationship between soil and plants is a useful way to better understand the ecosystem condition and can help to manage the rangeland ecosystem.

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بررسی اثر مناطق قرق و قطعه‌بندی شده با گونه‌های انتخابی ***Acacia*** بر غنای علفخواران و ویژگی‌های خاک مراتع ایالت ناحیه سومالی کشور اتیوپی

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چکیده. قرق و سایه‌بان همراه با دسترسی به گیاهان از جمله عناصر اساسی در مراتع خشک و نیمه خشک می‌باشند. هدف از این تحقیق بررسی تاثیر قرق و سایه درختان اقاقیا بر غنای گونه‌های گیاهی و خواص شیمیایی خاک مراتع در Shinile Woreda دولت منطقه‌ای سومالی است. این تحقیق با استفاده از چهار تیمار داخل قرق و زیر سایه درخت اقاقیا، داخل قرق بدون سایه درخت اقاقیا، خارج از قرق و زیر سایه درخت اقاقیا و خارج از قرق و بدون سایه درخت اقاقیا انجام شد. نتایج نشان داد که اثرات قرق و سایه درخت اقاقیا در تنوع گیاهی تاثیر گذار بود به طوری که غنای گونه‌های گیاهی به طور قابل توجهی در قرق با سایه درخت اقاقیا نسبت به سایر تیمارها بالاتر بود. همچنین نتایج نشان داد که خواص شیمیایی خاک تفاوت معنی‌داری در تیمار با سایه درخت اقاقیا نسبت به تیمار بدون وجود سایه درخت اقاقیا به جز در خصوص عامل pH وجود داشت. از سوی دیگر تفاوت معنی‌داری در خواص شیمیایی خاک بین دو تیمار قرق و خارج از قرق به جز pH وجود داشت. نتایج حاصل از این مطالعه نشان داد که pH خاک، کربن آلی(OC) و ماده آلی (OM) با غنای گونه‌ای در تمام تیمارها رابطه مثبت دارد. هدایت الکتریکی (EC) و پتاسیم (K) تنها در زیر سایه اقاقیا و در داخل تیمار قرق با غنای گونه‌ای همبستگی مثبت داشتند، اما در سایر تیمارها همبستگی منفی نشان داد. عنصر فسفر (P) با غنای گونه در تیمار قرق و بدون سایه اقاقیا و نیز در تیمار قرق و خارج از قرق همبستگی مثبت داشت. می‌توان نتیجه گرفت که تعیین رابطه بین خاک و گیاهان راهی مفید برای درک بهتر شرایط اکوسیستم می‌باشد و می‌تواند به مدیریت اکوسیستم مراتع کمک کند. نتایج این تحقیق بیان می‌کند که مراتع تخریب شده را می‌توان با قرق و افزایش سایه گیاهانی نظیر درخت اقاقیا که جوامع روستایی از آنها استفاده می‌کنند، احیا شوند.

کلمات کلیدی: سایه اقاقیا، قرق، مرتع، غنا، ویژگی‌های خاک