RESPONSE OF HERBACEOUS VEGETATION TO WOODY PLANT SPECIES IN THE RANGELANDS OF EASTERN ETHIOPIA†

[RESPUESTA DE LA VEGETACIÓN HERBÁCEA A LAS ESPECIES DE PLANTAS LEÑOSAS EN LOS AGOSTADEROS DE ETIOPÍA ORIENTAL]

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SUMMARY

In the lowlands of arid and semiarid rangelands woody plants plays an important role in soil fertility maintenance, providing food, medicine, cosmetics, fodder, fuel wood and pesticides. A better understanding of the interaction of woody plants on their immediate environment is needed to guide optimum management of native vegetation in the production landscapes. However, the response of herbaceous vegetation to woody plant species remains poorly understood. This study evaluates the impact of two dominant woody plant species (*Acacia senegal* and *Balanite aegyptica*) on herbaceous vegetation in rangelands of eastern Ethiopia. Eighteen trees of relatively the same diameter at breast height were selected to study the effect of the tree on herbaceous vegetation. Vegetation sample data were collected from under canopy and open areas, and analysed for herbaceous vegetation parameters using two ways ANOVA. The herbaceous vegetation parameters under both woody plant species was significantly higher especially with regard to dry matter (101.3±0.97g/m^2), basal cover (65.02±0.7%) and species richness (6.9±0.1211 no. species/m^2) than the open grassland with dry matter (74.2±0.72g/m^2), basal cover (50.53±0.67%) and species richness (5.3±0.11 no. species/m^2). The species composition of herbaceous species also showed significant improvements under woody plant canopy with regard to percentage composition of perennial grasses (0.40%) than the open grassland with percentage composition of perennial grasses (0.27%). The positive effect woody plant presence can be also ascribed to some understory species such as *Cenchrus ciliaris*, *Panicum maximum* and *Eragrostis papposa* which have a good pastoral value, grow better under woody plants. Presence of woody plants facilitates the establishment of more palatable herbaceous vegetation under unfavorable climatic conditions that characterize these environments. Therefore, this tree has a significant effect on herbaceous vegetation improvement in resource poor rangelands and as a result, it is important to retain scattered *A. senegal* and *B. aegyptica* plants in the rangelands of eastern Ethiopia.

Key words: Canopy; eastern Ethiopia; grazing; herbaceous species; woody species.

RESUMEN

En las tierras bajas de los pastizales áridos y semiáridos, las plantas leñosas desempeñan un papel importante en el mantenimiento de la fertilidad del suelo, proporcionando alimentos, medicinas, cosméticos, forraje, leña y pesticidas. Se necesita una mejor comprensión de la interacción de las plantas leñosas en su entorno inmediato para guiar el manejo óptimo de la vegetación nativa en los paisajes de producción. Sin embargo, la respuesta de la vegetación herbácea a las especies de plantas leñosas sigue siendo poco conocida. Este estudio evalúa el impacto de dos especies dominantes de plantas leñosas (*Acacia senegal* y *Balanite aegyptica*) en la vegetación herbácea en los pastizales del este de Etiopía. Dieciocho árboles de relativamente el mismo diámetro a la altura del pecho fueron seleccionados para estudiar el efecto del árbol sobre la vegetación herbácea. Los datos de la muestra de vegetación se obtuvieron de debajo del dosel y las áreas abiertas, y se analizaron los parámetros de la vegetación herbácea utilizando ANOVA de dos vías. Los parámetros de vegetación herbácea en ambas especies de plantas leñosas fueron significativamente mayores, especialmente con respecto a la materia seca (101.3 ± 0.97 g/m^2), la cobertura basal (65.02 ± 0,7%) y la riqueza de especies (6.9 ± 0.1211 especies/m^2) que las praderas abiertas con materia seca (74.2 ± 0.72 g/m^2), cobertura basal (50.53 ± 0.67%) y riqueza de especies (5.3 ± 0.11 especies/m^2). La composición por especies de especies herbáceas también mostró mejoras significativas bajo el dosel de plantas leñosas con respecto al porcentaje

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de composición de pastos perennes (0.40%) que el pastizal abierto con porcentaje de composición de pastos perennes (0.27%). El efecto positivo de la presencia de plantas leñosas también se puede atribuir a algunas especies de sotobosque como *Cenchrus ciliaris, Panicum maximum* y *Eragrostis papposa*, que tienen un buen valor pastoral y crecen mejor bajo plantas leñosas. La presencia de plantas leñosas facilita el establecimiento de una vegetación herbácea más agradable en condiciones climáticas desfavorables que caracterizan estos ambientes. Por lo tanto, estos árboles tienen un efecto significativo sobre la mejora de la vegetación herbácea en los pastizales de escasos recursos y, como resultado, es importante mantener las plantas dispersas de *A. senegal* y *B. aegyptica* en los pastizales del este de Etiopía.

Palabras clave: dosel; Etiopía oriental; pasto; especies herbáceas; especie leñosa

INTRODUCTION

In arid and semi-arid ecosystems, where the nature of rain fall is highly irregular and nutritious grass disappear in dry season; woody plants are essential source of feed for both domestic and wild herbivores (Gemedo *et al.,* 2006). In addition to their crucial role as source of forage for herbivores, woody plants have multiple roles in farming system as fire wood, food, source of medicine, beds and sleeping mats, shade, mulch and soil conservation (Solomon *et al.,* 2006). They also ameliorate environmental stress under their canopies, which in turn stimulate production of the herbaceous layer (Treydte *et al.,* 2007). Furthermore, the herbaceous species which have a good pastoral value is often enhanced underneath tree canopies (Treydte *et al.,* 2007; Abdallah *et al*., 2008).

Dense woody plants may have negative effects on herbaceous vegetation due to competition for available soil nutrients, water (Teshome *et al.,* 2012) and decreased light intensity for under canopy vegetation (Kahi *et al.,* 2009). Scattered woody plants have positive effect on the herbaceous layer by altering resource availability and microclimatic condition. These may occur through improved soil water availability related to hydraulic lift, or through a reduction in the incoming solar irradiation, thus decreasing sub-canopy evapotranspiration, soil temperatures and reducing water stress for the herbaceous community. Increased animal deposits under canopied areas may further increase nutrient availability, contributing to an 'island of fertility' effect (Abdallah *et al.,* 2008). Thus, a grass patch of high nutrient content created beneath tree canopy compared to open grassland (Treydte *et al.,* 2007). In addition, grasses growing under woody canopies had a higher biomass, greener leaf material and stayed green for longer into the dry season than grasses growing further away from woody plants (Treydte *et al.,* 2008).

The result of different study conducted in the lowland rangelands showed the importance of scattered woody plants on their immediate vicinity herbaceous vegetation and soil nutrients. Herbaceous layer under the canopied areas characterized by the domination of perennial grasses and production of high biomass of herbaceous vegetation than corresponding open grasslands (Abule *et al*., 2005; Solamon and Mlambo, 2010). Similarly, the improvements in the soil nutrients have been reported under woody plants from resource poor lowland rangelands (Abule *et al*., 2005; Belay and Kebede, 2010). Therefore, a better understanding of these patterns is needed to guide optimum management of native vegetation in the production landscapes.

Despite the importance assigned to woody plants, they are being cleared from forested rangelands in eastern Africa for charcoal, firewood and timber production and expansion of cultivation (Treydte *et al*., 2007; Zelalem, 2010). In arid and semi-arid ecosystems such as east Africa, where variations in spatial and temporal moisture and nutrients are extreme, clearing of woody plants may result in loss of soil nutrients from already nutrient poor ecosystem which in turn leads to the loss of palatable nutritious grasses (Ludwig *et al.,* 2004). Such loses in species composition has the possibility of affecting negatively the populations of grazing livestock and wildlife that select these sites and livelihood of the people (Treydte *et al.,* 2007). Hence, local communities are faced with the decision of either removing woody plants for immediate charcoal use or preserving them to take the advantage of their potential positive effects on other plants and animals.

In the rangelands of eastern Ethiopian, in spite of the presence of woody plants and herbaceous strata (Zelalem, 2010), there is only a limited understanding of the relationships between individual woody plants with the herbaceous species around them. With this original physiognomy of herbaceous vegetation and presence of *Acacia senegal* and *Balanite aegyptica* woody plants, the dominant and multipurpose woody plants in the study areas, it is fundamental to investigated the potential relationship existing between woody plants with herbaceous strata. Therefore, this study was undertaken with the objective of studying influences of woody plant species on herbaceous vegetation lowlands of eastern Ethiopia.

MATERIALS AND METHODS

Study area

The study was carried out in the Bordade Rangelands of the Oromia Regional State, eastern Ethiopia (40° 12'31.37''to 40°32'12.32'' E and 8° 56'38.75''N to 9°13'58.35'' N), ~ 268 km east of Addis Ababa. The rainfall in the study areas is bimodal with a short rainy season from March to April, and the main rainy season from July to September. The mean minimum rainfall is ~400 mm and means maximum rainfall ~900 mm. The mean annual temperature is 21°C. The natural vegetation of the study area is characterized as Acacia-wooded grasslands (Le Houérou and Corra, 1980). This study was carried out from September to December 2014, immediately after the main rainy season.

Experimental Procedures

Woody plant selection

Widely spaced (isolated), matured tree species with extended canopy cover of *A. senegal* and *B. aegyptica* were selected. These woody plants were chosen based on the fact that previous studies indicated that they are abundant and important in the study area (Zelalem, 2010). At each of the grazing intensity site, six trees of each species were randomly selected. The heights and canopy diameters of the selected trees were measured. A measuring pole of 10 m, graduated at every 100 cm, and measuring tape was used to take the measurements of tree heights and canopy diameters.

Table 1 Heights and canopy diameters (means and SE) of replicated woody species

Woody species	N	Height (m)	Diameter (m)
Acacia senegal	18	5.8±0.25	10.8± 0.465
Balanite aegyptica	18	4.6±0.23	6.7±0.224

Sub-habitat identification

Having identified the sites and the woody plants under investigation, the next step was sub-habitat characterization or identification. Accordingly, two sub-habitats, viz., under-canopy and the corresponding open grassland were considered. This method is considered because trees in the rangeland circumstances are sparse in distribution (Zelalem, 2010). Under tree canopy means it is area located directly beneath the tree crown. On the other hand, open grassland is located beyond the influence of the roots of the woody plants. Absence of tree roots in the open grassland zone was confirmed by digging 1 m deep trenches at various locations around each tree.

Field layouts

Eighteen trees of relatively the same diameter at breast height (DBH) were considered for the study. The grass samples were collected from two sub-habitats, viz., under-canopy and open areas. As a result, measurements of grass and soil parameters were taken on four directions (east, west, South and north) by quadrants from the under canopy outward into the open area. In due course of open area sampling, care was taken so that neighbouring trees, their shade and other influences are avoided.

Sampling of herbaceous vegetation

The field work was carried out during the main growing season (August, 2014) at the time when most of the grasses were at their flowering stages. Sampling of herbaceous vegetation was done by laying a quadrant of 1m x 1m under canopy and outside canopy in four directions (east, west, south and north) for each selected individual trees. A total of 96 quadrants were recorded (2 woody plant species x 6 individual for each woody species x 2 sub-habitat x 4 quadrants). The herbaceous vegetation within each quadrant was clipped at 5 cm above the ground using hand sickles to avoid soil contamination. All herbaceous species rooted within the quadrant were identified and recorded. Species occurring at the edge of the quadrants were included when part of the rooting system was inside the quadrant. Tufted and rhizomatous vegetation were counted as individuals. During sampling, care was taken to avoid the influence of neighbouring trees, their shade and other influences.

The herbaceous vegetation were identified and recorded in the field into different categories of species. Identification of herbaceous species was done in the field with the help of field guides and experienced technician. In case when it was difficult to identify species in the field, the local name were recorded with the help of the community and herbarium specimens were collected, pressed and dried properly using plant presses and transported to the Herbarium of Haramaya University (HU) for proper identification. Nomenclature of the plant species followed the Flora of Ethiopia (Hedberg *et al*., 2003).

In order to measure the species composition, basal cover, species richness and DM yields of herbaceous species were assessed using the quadrants systematically laid out under woody plants and open grasslands. Basal cover (the area occupied at the

intersections of the plant-soil interface) of the living plant parts were estimated in quadrants of $1m^2$ area that is partitioned into two halves, each being further divided into quarters and eighth. All plant basal covers in each quadrate was cut and drawn into the eighth segment to facilitate visual estimation of basal cover of living plant parts. Above ground DM yields were determined by harvesting the whole fresh biomass within each quadrant. The fresh samples were weighed using a simple balance immediately and were transferred into properly labelled paper bags. These were carried to Haramaya University (HU) for dry matter (DM) analysis. The DM of herbaceous species was collectively dried to constant mass in an oven at 105 ^oC for 24 hr to a constant temperature.

Experimental Design and Data Analysis

Variables included for analyses were species composition, basal cover, species richness and dry matter yield of herbaceous vegetation. Two ways ANOVA using the R statistical package (R Development Core Team, 2005), with woody plant species, sub-habitat as categorical predictors or factors and vegetation as dependent variables was performed to test the factors' main and interactive effects on all variables. The model included effect of woody plant species, sub-habitat and their interactions. The values of the probability lower than 0.05 ($P < 0.05$) were regarded as statistically significant. Data were transformed to meet the assumption of normality and homogeneous variances. Significant differences among mean values were done using least significant difference (LSD) method.

RESULTS AND DISCUSSION

Botanical Composition of Herbaceous Species

In the study area, a total of 40 herbaceous species were recorded from the sample quadrants studied, which included 25 grass species, 6 herbaceous legumes and 9 forbs (Table 2). From 25 grass species, 14 were annual grasses whereas 11 were perennial grass species. The annual grass took highest share (35%), followed by perennial grasses (27.5%) and all the remaining percentage formed non-graminoid forbs were contributed for overall of herbaceous species of study sites. In line with the study by Abule *et al.* (2007*)* and Tessema *et al.* (2012), the current study showed the greatest contribution of grass for vegetation of the study areas. In this study, the term non-graminoid is used to include all herbaceous families other than poaceae (grass family).

Table 2. Herbaceous species recorded from sample sites in the study sites

No	Botanical name	Family	Habit	Life form[1]
1	*Amaranthus hypochondriacus(L)*	Amarantaceae	Herb	A
2	*Aristida adscensionis*	Poaceae	Grass	A
3	*Aristida adoensis*	Poaceae	Grass	A
4	*Bothriochloa radicans*	Poaceae	Grass	P
5	*Cenchrus ciliaris*	Poaceae	Grass	P
6	*Chloris gayana Kunth*	Poaceae	Grass	P
7	*Chrysopogon plumulosus*	Poaceae	Grass	P
8	*Commelina benghalensis*	Commelinaceae	Herb	P
9	*Crotalaria albicaulis*	Fabaceae	Legume	P
10	*Cynodon dactylon (L.) Pers.*	Poaceae	Grass	P
11	*Dactyloctenium aegyptium*	Poaceae	Grass	A
12	*Digitaria ternata*	Poaceae	Grass	A
13	*Digitaria velutina (Forskk)*	Poaceae	Grass	A
14	*Eleusine indica*	Poaceae	Grass	A
15	*Eragrostis cilianensis*	Poaceae	Grass	A
16	*Eragrostis papposa (Steud)*	Poaceae	Grass	A
17	*Flaveria trinervia (Spr.) Mohr*	Asteraceae	Herb	A
18	*Euphorbia hirta(L.)*	Euphorbiaceae	Herb	A/P

No	Botanical name	Family	Habit	Life form[1]
19	*Hebiscus aponerus*	Malvaceae	Herb	A
20	*Heteropogon contortus(L.) Beauv*	Poaceae	Grass	P
21	*Hyparrhenia rufa*	Poaceae	Grass	P
22	*Cyperus rotundus (L.)*	Cyperaceae	sedge	P
23	*Indigofera viciodes*	Fabaceae	Legume	P
24	*Ipomoea ochracea Lind(L.) G.Don*	Convulaceae	Herb	P
25	*Ocimum basilicum (L.)*	Lamiaceae	Herb	A
26	*Panicum coloratum(L.)*	Poaceae	Grass	P
27	*Panicum maximum Jacq.*	Poaceae	Grass	P
28	*Parthenium hysterophorus*	Parthenium	Herb	A
29	*Paspalidium desertorum (A.Rich)*	Poaceae	Grass	A
30	*Setaria pumila*	Poaceae	Grass	A
31	*Setaria verticillata*	Poaceae	Grass	A
32	*Solanum incanum (L.)*	Solanaceae	Herb	A
33	*Sporobolus panicoides(A.Rich)*	Poaceae	Grass	A
34	*Tephrosia subtriflora*	Fabaceae	Legume	P
35	*Solanum incanum (L.)*	Solanaceae	Herb	A
36	*Tragus barteronianus*	Poaceae	Grass	P
37	*Tragus racemosus*	Poaceae	Grass	P
38	*Tribulus ternatus*	Zygophylaceae	Herb	A
39	*Urochloa panicoides*	Poaceae	Grass	A
40	Xanthium strumarium	Xanthiaceae	Herb	A

P = Perennial, A = Annual ; P/A = Semi perennial or annual

[1]Source: Hedberg and Edwards (1989), Phillips (1995) and Clayton *et al*. (2002)

Effect of Woody plant Species on Herbaceous Species Composition

Woody plant species did not have a significant effect on species composition of grasses (annual and perennial grasses) and non-grass species (Table 3). The factor woody plant species was unimportant in describing the differences in species composition in the study areas. This observation is in agreement with reports of other studies relating to species composition which reports nearly identical species composition of herbaceous species under different tree species (Belsky *et al*., 1989 and Abule *et al*., 2005). The contrasting results of this study might be due to young age of most experimental tree and to the fact that the response of the herbaceous layer may lag behind an environmental changes (Abdallah and Chaeib, 2013; Ampoorter *et al*., 2015). The expected environmental impacts of woody plants observed further as they grow older, which might lead to the loss of some species and the establishment of others in the longer term.

Table 3. Percentage composition of herbaceous species in canopied and un-canopied sub habitat

Woody plant species	Annual grass	Perennial grass	Non-grass
A. senegal	0.41[a]	0.55[a]	0.14[a]
B. aegyptica	0.37[a]	0.51[a]	0.12[a]

Means within a column with the same letter are not significantly different at $P \leq 0.05$

Effect of Sub-Habitat on Herbaceous Species Composition

There was a significant difference in percentage composition of grass (annual and perennial grass) and non-grass species in the canopy and open grassland (Table 4). The percentage composition of overall

grass and perennial grass species were higher under tree canopy than corresponding open grassland. Similarly, higher percentage composition of non-grass and annual grass species were recorded at open grassland than that of canopied sub habitat.

Table 4. Percentage composition of herbaceous species in canopied and un-canopied sub habitat

Sub habitat	Annual grass	Perennial grass	Non-grass
Canopied	0.30[a]	0.40[a]	0.11[a]
Un-canopied	0.36[b]	0.27[b]	0.16[b]

Means within a column with the same letter are not significantly different at $P \leq 0.05$

Below tree canopy, the positive effect of woody plants was observed by presence of perennial grass species known for their high palatability, such as *Panicum maximum*, *Cenchrus ciliaris*, *Chrysopogon plumolusus*, *Cynodon dactylon*, and *Eragrostis papposa*. This result confirm the observation from Tunisia (Abdallah and Chaieb, 2012), that show a positive interrelationship between the woody plants and grass cover. This result also confirmed the research by Abule *et al.* (2005) in Ethiopia showing that *P. maximum* grows better underneath tree canopy. The change in grass species composition beneath tree canopy has a positive impact on the herbaceous species quality as *P. maximum*, dominant beneath the canopy, is a highly nutritious grass preferred by herbivores (Treydte *et al*., 2006). Similarly, other studies (Abule *et al.*, 2005; Phoebe *et al.*, 2009; Abdallah *et al.*, 2012), showed higher percentage composition of perennial species and weaker percentage composition of annual grasses underneath tree canopy than corresponding open grassland.

According, to Abdallah and Chaieb. (2012), the improvement in herbaceous species under tree canopy can be related to improvement in soil fertility and a more favorable microclimate under tree canopy. The main factor causing differences in species composition was probably nutrient availability in the soil and shade. Nutrients such as nitrate, phosphorus, anions and cations and various trace elements are essential to the nutrition of all plants (Bell, 1982). In the lowland of Ethiopian rangelands are characterized by soils with low levels of these elements, therefore; the increase in concentration of such nutrients can act as a determinant of the composition, structure and productivity of vegetation. In addition, woody plants may protect herbaceous plants from herbivores especially when they have spines (Milchunas and Noy-Meir, 2002) and in windswept arid zones, trees provide a better protection for species growing under their canopy, which probably explains the increase in total plant cover observed under tree canopy compared to the open area (Abdallah *et al*., 2008).

Effect of Woody Species on Dry Matter Yields of Herbaceous Species

The DM yields of herbaceous species showed highly significant ($P < 0.001$) difference due to tree species. DM yields under *A. senegal* were higher than corresponding *B. aegyptica* tree species (Fig. 1).

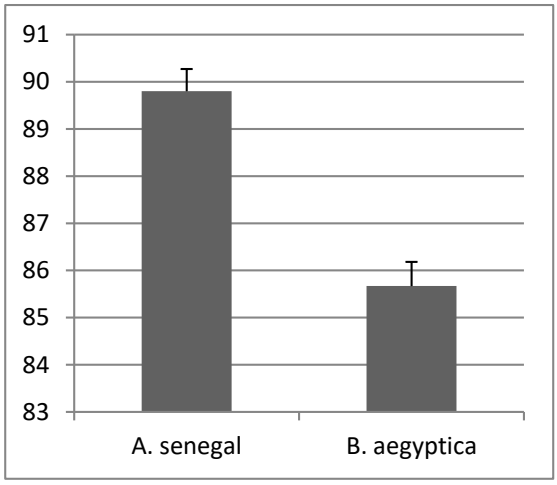

Figure 1 DM yields of herbaceous species under *A.senegal* and *B.aegyptica* tree species

This study confirmed other studies (Jeddi and Chaieb, 2009; Esquivel-Mimenza *et al*., 2013), that revealed the influence of tree species on DM yields. According to Jeddi and Chaieb. (2009), higher DM yields under a leguminous woody (nitrogen fixing tree) species compared to a non-leguminous woody (non- nitrogen fixing tree) species was related to the improvement of soil fertility mainly, total nitrogen and organic matter under leguminous tree species (Pugnaire *et al*., 2004). In this study, the higher DM yield under *A.senegal* compared to *B.aegyptica* could be related to the improvement in soil nutrients especially total nitrogen and organic matter under *A.senegal* than corresponding *B.aegyptica* tree species.

Effect of Sub habitat on Dry Matter Yields of Herbaceous Species

The analysis of variance of the study showed that the DM yields of herbaceous species were significantly different ($P < 0.001$) due to the effect of sub habitat. The DM yields recorded under tree canopy were higher than corresponding open grassland (Fig. 2). This suggests that total grass production and livestock production may be favored by presence of such woody plants to certain density. Therefore, the total

clearing of woody plants in areas dominated by *A. senegal* and *B. aegyptica* may cause an undesirable shift in dry matter yields and desirable grasses.

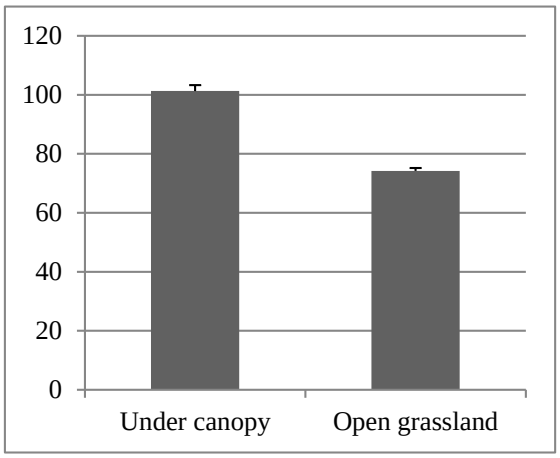

Figure 2 DM yields of herbaceous species under tree canopy and open grassland sub-habitats

The result of this study complements previous finding that canopied sub-habitat yields higher DM compared with adjacent open grassland (Abdallah *et al*., 2008; Solomon and Mblambo, 2010). The higher yields of DM in the sub-canopy sub-habitat can be related to improvement in soil nutrients and water availability (Treydte *et al.*, 2010), high proportion of perennial grasses growing in association with tree crown (Solomon and Mblambo, 2010). Trees often improve the growing conditions for the herbaceous layer by providing shade, reducing evapotranspiration and improving soil physicochemical properties close to their root systems (Ries and Shugart, 2008). Litter fall can also increase soil nutrients and microbial activities thus fertilizing grasses and forbs growing close to tree canopies (Belsky, 1994).

In addition, isolated plants act as obstructions for water, organic matter, nutrients, sediment and seeds carried by runoff water and wind (Belsky *et al*., 1989). These conditions create microhabitats suitable for herbaceous growth and increase plant productivity (Cortina and Maestre, 2005). Far from the tree canopy, ecological constraints were always more intense (more water and nutrient stresses) and the competition for water between plants which was more pronounced due to the fewer levels of resources in the soil (Abdallah *et al.*, 2008) tended to decrease dry matter yields in open grassland sites. The high DM yields recorded under tree canopy in the present study could be explained by improvement in soil physicochemical properties and high percentage of perennial grasses under tree canopy than corresponding open grasslands.

Effect of Woody Species on Basal Cover and Herbaceous Species Richness

There were no significant (P = 0.05) differences between *A. senengal* and *B. aegyptica* with respect to herbaceous species richness and basal cover. This is unlike several previous studies that have shown difference in species richness and basal cover of herbaceous species between tree species (Jeddi and Chaieb, 2009; Kahi *et al*., 2009). The contrasting results of this study might be due to the young age of the most experimental tree and to the fact that the response of the herb layer may lag behind an environmental changes (Abdallah and Chaeib, 2013; Ampoorter *et al*., 2015). The expected environmental impact of the planted trees increase further as they grow older, which might be lead to loss of some species and the establishment of others in the longer term.

Effect of Sub-habitat on Basal Cover and Herbaceous Species Richness

Sub-habitat had highly significant (P<0.001) effect on basal cover and herbaceous species richness species richness. Higher herbaceous species basal cover and species richness in canopied sub-habitat than that of open grass lands (Fig. 3 and 4). This result is in agreement with studies by Abdallah *et al*. (2012), who reported higher basal cover and species richness under canopy of *A. tortilis* (Forssk.) ssp. *raddiana* (Savi) compared to open grassland in southern Tunisia. In addition, study by Abdallah and Chaeib. (2012) also reported higher basal cover in canopied sub-habitat than corresponding open grassland.

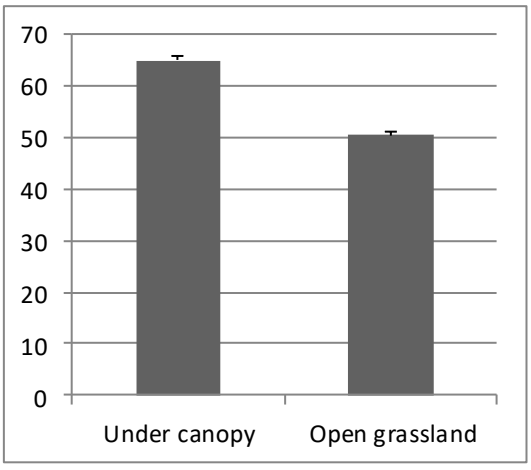

Figure 3. Basal covers of herbaceous species between canopied and open grasslands

According to Abdallah *et al*. (2012), the higher basal cover and species richness related to higher soil fertility, more favorable microclimate under tree canopy as compared to open grassland. Similarly,

lower basal cover and species richness at open grassland could be related to intense ecological constraints (more water and nutrient stresses) far from the areas under tree canopy (Abdallah *et al*., 2012). In current study, higher basal cover and species richness can be related to higher soil fertility under tree canopy than that of open grasslands.

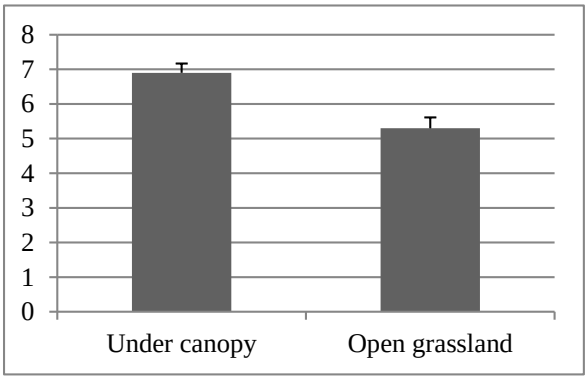

Figure 4. Species richness of herbaceous species under canopied and open grass land sites

Interactive Effect of Tree Species and Sub-habitat on herbaceous vegetation

The study showed that there was no any interactive effects of woody plant species and sub-habitat (P = 0.05) on species composition, dry matter, basal cover and species richness of herbaceous species, which implies that the positive effects of canopy cover on herbaceous vegetation attributes remained constant regardless of the woody plant species.

Further research should be carried out involving larger and more replicated areas with these woody plants at different season and years to obtain more definitive results on regional or national scales. This study recommends that caution be exercised in extrapolating the results to other arid rangelands as this work was conducted at only one site.

CONCLUSIONS

From this finding, it can be concluded that the retaining scattered woody plants in resource poor lowlands of Ethiopia have been effective in improving plant species composition, biomass and cover of herbaceous species and the areas under scattered woody plants were in a better condition than the open grassland areas. The positive effect woody plant presence can be also ascribed to some understory species such as *C. ciliaris*, *P. maximum* and *E. papposa* which have a good pastoral value, grow better under woody plants. Presence of woody plants facilitates the establishment of more palatable herbaceous vegetation under unfavorable climatic conditions that characterize these environments. Similarly, it can be also concluded that the *A. senegal* had higher positive effects on DM yields than that of *B. aegyptica* tree species. The use of *A. senegal* and *B. aegyptica* may induce positive effects on community composition and ecosystem functions. However, the use of *A. senegal* can be important because it can be also used for fodder production, fuel, furniture construction and gum production, apart from its positive effects on herbaceous vegetation.

Conflict of Interests

The authors have not declared any conflict of interests.

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Appendix. Average cover (%) of herbaceous species sampled in the canopied and open grasslands.

Grazing intensity	Light		Moderate		Heavy	
Species	CS	US	CS	US	CS	US
Amaranthus hypochordriacus(L)	0.00	0.00	0.00	0.00	1.07	0.78
Aristida adscensionis	0.00	0.00	0.00	0.00	2.16	2.83
Aristida adoensis	3.14	1.45	0.22	0.00	0.00	0.00
Bothriochloa radicans	0.00	1.01	0.39	3.24	1.23	1.75
Cenchrus ciliaris	7.72	0.00	1.94	0.00	0.00	0.00
Chloris gayana Kunth	5.65	0.57	0.17	0.00	0.00	0.00
Chrysopogon plumulosus	22.48	4.20	0.75	0.00	0.00	0.00
Commelina benghalensis	0.79	0.00	0.00	0.00	0.00	0.00
Crotalaria albicaulis	4.09	2.67	0.55	0.00	0.00	0.00
Cynodon dactylon (L.) Pers.	0.86	4.59	7.89	0.65	0.00	0.00
Cyperus rotundus (L.)	0.00	0.00	1.77	0.00	0.00	0.00
Dactiloctinium aegyptium	3.15	9.12	3.20	0.00	0.00	0.00
Digitaria ternata	0.00	0.00	0.00	0.00	3.76	3.17
Digitaria velutina (Forskk)P.Beauv	0.88	0.70	0.00	0.00	0.00	0.00
Eleusine indica	0.00	0.00	4.11	3.45	0.00	0.00
Eragrostis cilianensis	1.70	11.82	3.59	0.00	0.00	0.00
Eragrostis papposa (Steud)	1.66	9.95	0.34	0.00	0.00	0.00
Euphorbia hirta (L.)	0.00	0.00	2.17	2.61	0.00	0.00
Hebiscus aponerus	0.00	0.00	0.00	2.55	0.00	0.00
Hetropogon contortus (L.) Beauv	0.24	1.07	2.29	0.00	0.00	0.00
Hyperrhenia rufa	2.60	0.00	0.00	0.00	0.00	0.00
Indigofera viciodes	0.70	0.35	0.74	0.00	0.06	0.00
Ipomoea ochracea Lind (L.) G.Don	2.11	2.98	0.00	0.00	0.00	0.00
Lintonia nutans	0.56	0.00	3.70	0.00	0.00	0.00
Ocimum basilicum (L.)	0.00	0.00	0.05	1.80	0.00	0.00
Panicum coloratum (L.)	7.91	1.81	0.00	0.00	0.00	0.00
Panicum maximum Jacq.	7.61	1.30	0.06	0.00	0.00	0.00
Parthenium hysteresis	0.00	0.00	0.00	1.62	4.79	2.81
Paspalidium desertorum (A.Rich) Stapf	19.36	3.97	2.75	0.00	0.00	0.00
Setaria pumila	0.08	0.00	0.00	0.00	0.00	0.00
Setaria verticillata	0.15	0.00	0.00	0.00	0.00	0.26
Sporobolus panicoides(A.Rich)	0.00	0.00	0.00	0.00	0.33	0.31
Tephroisa subtriflora	0.00	0.00	0.00	1.27	0.00	0.00
Solanum incanum (L.)	0.00	0.00	3.83	9.91	0.00	0.00
Tetrapogon cenchriformis (A.Rich)	0.77	13.01	16.56	5.14	0.00	0.00
Tragus barteronianus	0.00	0.00	0.00	0.00	12.27	8.76
Tragus racemosus	0.00	0.00	3.07	12.39	0.00	0.00
Tribulus ternatus	0.00	0.00	0.00	0.00	6.68	5.32
Urochloa panicoides	0.00	0.00	1.14	6.17	0.00	0.00
Xanthium abyssinica	0.00	0.00	0.00	0.00	7.11	5.25