DIVERSITY OF SOIL MACROFAUNA AND SOIL PHYSICO-CHEMICAL PROPERTIES UNDER THE CANOPES OF ACACIA SALIGNA STAND IN TIGRAY, ETHIOPIA

Kahsu Gebretsion1, Emiru Birhane2, Abbadi Girmay3


Acacia saligna is an introduced tree species for the purpose of restoring degraded drylands in Ethiopia. The study was conducted to assess the effect of Acacia saligna tree species on soil macro fauna diversity and soil physico-chemical properties in Barka Adi Sebha kebele, Atsibi Wemberta district, Tigray, Ethiopia. Soil macro fauna and soil samples were collected under the canopy, edge of the canopy, 3 m far from the edge and 50 m outside the canopy. Soil macro fauna were collected using a wood frame having a dimension of 25 cm width by 25 cm length at 20 cm soil depth while soil samples were taken using auger at 20 cm soil depth. A total of 7548 soil macro fauna were recorded. Termites, millipede, centipede, earthworms, ants, beetles, spider and earwig were the encountered soil macro fauna. The abundance of macro fauna was higher under the canopy compared to the edge of the canopy, 3 m away from the edge and 50 m outside the canopy. Shannon diversity, dominance and richness decrease as the distance from the canopy increases. Soil bulk density, exchangeable calcium and sand content were increase as the distance from the tree trunk increases. However, soil total nitrogen, available phosphorus, soil organic carbon, moisture content, silt and clay percentages, soil electrical conductivity, cation exchange capacity and exchangeable bases (potassium, sodium and magnesium) were larger under the canopy compared to a distance from the canopy. Thus, enrichment of Acacia saligna tree is important to enhance the soil macro fauna diversity and soil physico-chemical properties.

Keywords: Acacia saligna, exclusures, soil macro fauna, soil properties

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INTRODUCTION

Soil macro fauna are organisms that comprise the invertebrate soil that has body length >1cm (Wallwork 1970) and weight >2mm (George and Rupert 2002). Worldwide, soil fauna (macro fauna, mesofauna and microfauna) constitutes 23 percent of the whole living animals’ diversity and most of them are concentrated in the top 30cm soil depth (Iradi and Habashi 2016). The taxonomic groups of the soil macro fauna include; ants, beetles, arachnida, centipede, millipede, millipoda, isopods, Insects, mollusks and oligochaeta (Bardgett and Putten 2014). They play an important role in ecosystem functioning processes (Gholami et al 2016, Menta 2012) such as decomposition of organic matter and nutrient cycling processes (Karanja et al 2006).

Soil macro fauna are dynamic (Decaëns et al 1994) or sensitive biological indicators (Martínez-Salgado et al 2010). Their diversity, density and distribution could be altered by different land use practices and disturbances such as overgrazing, fire, deforestation, pollution, soil erosion, depletion of soil fertility, climate change and soil type (Bignell et al 2 008, Menta 2012). Also, the type of tree species especially the nitrogen-fixing trees can significantly influence the abundance of the soil macro fauna in comparison with the non-nitrogen-fixing trees (Sayad et al 2012). In addition, soil fauna includes microfauna, mesofauna and macro fauna which are more abundant inside the canopy compared to outside the canopy of trees (Tripathi et al 2010).

The physio-chemical properties of the soil changed considerably as a result of tree planting (Raison & Retta 1982). Trees improve soil chemical, physical and biological properties in terms of improved soil organic carbon, percent clay, available phosphorus, total nitrogen, soil pH, soil organic carbon, cation exchangeable capacity, soil electrical conductivity, moisture content, exchangeable K, Na, Ca and Mg, available water capacity, declined sand particles and increased clay particles (Berhe et al 2015). Many studies revealed that the soil physicochemical properties such as soil moisture content (Berhe et al 2013), organic carbon (Berhe et al 2013, Mamo and Asfaw 2017), available phosphorus (Berhe et al 2013, Mamo and Asfaw 2017), available potassium (Berhe et al 2013), soil total nitrogen (Berhe et al 2013, Mamo and Asfaw 2017), soil electrical conductivity (Berhe et al 2013, Agena et al 2014) and Cation exchange capacity (Berhe et al 2013, Mamo and Asfaw 2017, Mugunga and Mugumo 2013) decrease as the distance from the tree trunk increases while the soil bulk density and soil pH increases as the distance from the tree trunk increases (Berhe et al 2013, Manjur et al 2014, Mamo and Asfaw 2017).

Acacia saligna (A. saligna) is fast growing and has the potential to grow under adverse environmental conditions such as drought-prone area, waterlogged, alkaline and saline soil dominated areas (Orwa et al 2009). A. saligna is a multi-purpose tree species e.g., the leaves are important sources of feed for small ruminants (Boufennara et al 2013). In addition, they are important for ornamental purposes and nitrogen fixation (Orwa et al 2009). The tree also promotes the arbuscular mycorrhizal symbiosis and it is considered as an important source of inoculum in semi-arid ecosystems (Bouazza et al 2015). It also has the potential to reduce the amount of sunlight reaching in the soil through the shading effect and consequently enhance the soil moisture (Abd El-Gawad and El–Amier 2015). This higher soil moisture content in A. saligna plantation creates a sustainable environment for the soil macro fauna population (Sayad et al 2012).

Planting of A. saligna tree was practiced into Tigray in 1972 to restore degraded areas of the region (Rinaudo 2010). It is widely distributed to different agro-ecological zones of the region. Although A. saligna is commonly grown in different parts of the region, its role in contributing towards soil macro fauna development, restoration of degraded soils and enhancing the soil physiochemical properties, including soil macro fauna distribution, abundance, diversity and soil carbon sequestration has been less studied for the semi-arid degraded ecosystem. Therefore, the present study was conducted to assess the effect of A. saligna tree species on the soil macro fauna diversity and selected soil physio-chemical properties under the canopy of the tree compared to the location outside the canopy.

MATERIALS AND METHODS

Study area

The study was conducted in Barka Adi Sebha peasant association, Atsibi Wemberta district Eastern zone of Tigray, northern Ethiopia (Figure 1). Geographically, the study area is located at 39° 39'30"-39°47"00 East longitude and 13° 45' 0"- 13° 51' 0" North. The elevation of the study area ranges from 2171 to 2718 m a.s.l (meter above sea level) and consists of areas in the midland (5.5%) and the remaining 94.5% is highland agro-ecological zones (Extracted using Arc Map 10.3).
The district is characterized as an arid, semi-arid agro-ecological zone with erratic rainfall and rugged terrain (Taha et al. 2006). The consecutive eleven years (2006-2016) of the mean annual rainfall of the district ranges between 332-972 mm per year while the mean annual minimum and maximum air temperatures are 9.40 and 20.40°C respectively.
The geological formation of the study area is characterized by sandstones, Paleozoic sedimentary rocks, Edaga Arbi Tillite, and recent alluvial sediments (Nata and Bheemalingeswara 2010). The dominant soil types are Leptosols, Regosols, Cambisols and Fluvisols (Gessesse 2017).

The district has 89,880 hectares (ha) of state forest, 96,861 ha of exclosures, 6,946 ha of communal land and 13,059.45 ha cultivated land (OoARD 2018). The major annual crops grown in the district includes wheat, barley, teff, maize and sorghum whereas the dominant pulses are beans and field pea. Also in irrigated lands, different vegetables and fruits such as tomato, pepper, lettuce, onion, banana and psidium guajava are cultivated. The vegetation resource of the study site is characterized by mixed A. saligna exclosures and exclosures free of A. saligna enrichment plantation. The exclosures in the study area are areas protected from any human as well as livestock use to rehabilitate degraded lands through natural regeneration of vegetation and soils (source: local communities). The existing tree species are Acacia schemperi, Olea europea var. africana, Acacia abyssinica, Maytenus senegalensis, Dodonaea angustifolia, Milletia ferruginea, Rhus natalensis, Eucalyptus commadulensis and A. saligna (personal observation during the survey).

Soil macro fauna and soil sample collection

For the sampling of soil macro fauna and soil sample, twelve A. saligna trees with almost having a similar crown diameter, diameter at breast height (DBH) and tree height were selected in the exclosures. To minimize the topographic variation the trees were assigned four at the bottom, four at middle and four at top of the study site (Figure 3) and each tree was considered as a replication. Then, to assess the effect of the canopy distance on soil macro fauna diversity, soil monoliths (25 cm width by 25 cm length by 20 cm soil depth) were excavated using the method recommended by the Tropical Soil Biology and Fertility Programme (Anderson and Ingram 1993) with modification of soil depth from 30 cm to 20 cm since the study area is sloppy which is difficult to obtain soil to 30 cm depth (Figure 3).

Figure 3: soil macro fauna and soil samples collected area

Soil macro fauna were collected under the canopy, at the edge of the canopy, 3 m far from the edge and 50 m outside the canopy following four transects at a right angle from each other (Figure 4). The soil macro fauna were preserved in seal vials using 70% denatured alcohol following (Ayuke et al 2009) (Appendix 1). Soil samples were taken under the canopy, at the edge of the canopy, 3 m far from the edge and 50 m outside the canopy (Figure 4) at 20 cm depth using soil auger. The soil samples collected from those canopy distances were thoroughly mixed as per the canopy distance to get a single composite sample and a total of 48 composite soil samples were collected. The samples were air-dried at room temperature of 19-21°C, crushed, homogenized and passed through 2 mm sieve and subjected to analysis for soil texture, gravimetric moisture content, soil pH, soil organic carbon, available phosphorus, total nitrogen, exchangeable base (sodium, calcium, potassium and Magnesium), available potassium, electrical conductivity, and cation exchange capacity and further sieved through 0.5 mm size for analysis of soil total nitrogen. In addition, 20 soil samples were taken for analysis of soil bulk density using a core sampler of 5 cm height and 3 cm in
diameter at soil depth 0-10 cm. The collected soil samples were analyzed in Tigray Agricultural Research Institute (TARI), Mekelle Soil Research Center. The soil macro fauna and soil samples were collected starting from late September up to the beginning of December 2017.

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Figure 4: Soil macro fauna and soil sampling layout

The bulk density of the undisturbed soil sample was determined by the core method (Grossman and Reinsch 2002) and determining the mass of solids and the water content of the core, by weighing the wet core, drying it to constant weight in an oven at 105°C. Soil texture was determined using the hydrometer method as described by (Dewis and Freitas 1985).

Soil pH was measured by using a pH meter in a 1:2.5 soil: water suspension method (Houba et al 1989). Electrical conductivity was measured using the water suspension method (Reeuwijk 1992). The soil organic carbon was determined using methods proposed by Walkley-Black oxidation method with potassium dichromate (K2Cr2O7) in a sulfuric acid medium using moisture correction factor (Jackson 1970, Dewan and Neguse 1987), total nitrogen by Kjeldahl method (Bremner and Mulvaney 1982). Besides, available phosphorus was determined by sodium bicarbonate (NaHCO3) extraction procedures (Olsen et al 1954). Cation exchange capacity was analyzed by the Ammonium acetate method (Houba et al 1989). Exchangeable potassium, sodium and available potassium were extracted by sodium acetate method and measured by a flame photometer while exchangeable calcium and magnesium was measured by ammonium acetate (Reeuwijk 1992, Houba et al 1989).

Soil macro fauna identification

Soil macro fauna identification process was performed at field level and laboratory level. At the field level, soil macro fauna were identified using guidelines proposed for field identification of macro fauna (e.g. Brown et al 2001, Menta 2012) (Appendix 2): Soil macro fauna difficult to identify at field level were identified at laboratory level in soil ecology laboratory at Mekelle University visually with expert support.

Data analysis

Shannon diversity, Margalef (Richness), Simpson (dominance) and Equitability (evenness) were calculated using PAleontological STatistics (PAST) version 1.93. The soil macro fauna diversity indices and selected soil parameters were checked for normal distribution by the Shapiro-Wilk test (P<0.05) and the data’s fail to normality were log-transformed prior to conducting analysis. Then, the mean significance difference of the soil macro fauna diversity indices and soil physicochemical properties among the canopy distances were analyzed by one way analysis of
variance in SPSS (Statistical Package for Social Science) software version 20.

RESULTS AND DISCUSSION

Soil macro fauna abundance

A total of 7548 soil macro fauna individuals were collected from under the canopy (3690), the edge of the canopy (1573), 3 m far from the edge (1179) and 50 m outside the canopy (1106) (Appendix 3). Termites, millipede, centipede, earthworms, ants, beetles, spider and earwig are the encountered soil macro fauna. The abundance of the soil macro fauna were calculated as a number of individuals per square meter (individual m⁻²). The individual abundance of the encountered soil macro fauna were decreased as the distance from the tree trunk increases (Table 1). The highest individual abundance of soil macro fauna under the canopy of A. saligna which is attributed to the higher moisture and organic matter continent under the canopy of the tree. Ivask et al (2006) noted that soil moisture content is the most influential factor to enhance the abundance of the soil macro fauna than the soil types. The finding is in agreement with the studies conducted for other tree species such as the southernmost boreal forest (Bayartogtokh et al 2016) and Hardwickia binata tree (Tripathi et al 2010).

**Table 1**: Soil macro fauna abundance (m⁻²) under and outside the canopy of A. saligna tree

<table>
<thead>
<tr>
<th>List of soil</th>
<th>Canopy distance</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± Std. Error</td>
<td>Mean ± Std. Error</td>
<td>Mean ± Std. Error</td>
<td>Mean ± Std. Error</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Termites</td>
<td>101 ± 24.3</td>
<td>56 ± 32.5</td>
<td>31 ± 8.3</td>
<td>40 ± 13.3</td>
<td>0.121</td>
<td></td>
</tr>
<tr>
<td>Millipede</td>
<td>33 ± 6.4</td>
<td>12 ± 4.4</td>
<td>4 ± 1.5</td>
<td>6 ± 2.4</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Centipede</td>
<td>18 ± 5.4</td>
<td>6 ± 2.0</td>
<td>2 ± 1.1</td>
<td>1 ± 0.93</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Earthworms</td>
<td>40 ± 8.6</td>
<td>11 ± 5.1</td>
<td>24 ± 13.2</td>
<td>10 ± 5.4</td>
<td>0.031</td>
<td></td>
</tr>
<tr>
<td>Ants</td>
<td>90 ± 25.5</td>
<td>32 ± 8.3</td>
<td>33 ± 14.5</td>
<td>31 ± 10.4</td>
<td>0.068</td>
<td></td>
</tr>
<tr>
<td>Beetles</td>
<td>14 ± 5.65</td>
<td>6 ± 4.1</td>
<td>1± 0.86</td>
<td>1 ± 0.54</td>
<td>0.041</td>
<td></td>
</tr>
<tr>
<td>Spider</td>
<td>7 ± 2.89</td>
<td>5 ± 2.2</td>
<td>2 ± 0.84</td>
<td>2 ± 0.85</td>
<td>0.187</td>
<td></td>
</tr>
<tr>
<td>Earwig</td>
<td>4 ± 2.5</td>
<td>2±1.7</td>
<td>1 ± 0.93</td>
<td>1 ± 0.85</td>
<td>0.467</td>
<td></td>
</tr>
</tbody>
</table>

T1=under the canopy, T2=Edge of the canopy, T3=3 m far from the edge, T4=50 m outside the canopy. Means in a row with similar lowercase letters are not significantly different at P<0.05.

Soil macro fauna diversity

The Shannon diversity index and Simpson (dominance) of the soil macro fauna were significantly (P<0.05) higher under the canopy than 3 m far from the edge of the canopy and 50 m outside the canopy of A. saligna stand. In addition, there was a significant difference in species Margalef (richness) of the macro fauna under the canopy and 50 m outside the canopy which is higher under the canopy of A. saligna. However, the species Equitability (evenness) of the soil macro fauna was not significantly different under the canopy and outside the canopy of the A. saligna tree (Table 2). The higher soil macro fauna diversity under the canopy of the A. saligna tree could be due to the presence of higher availability of the soil organic carbon under the canopy of the tree and shading effect of the tree which protects the soil macro fauna from direct light penetration. Many studies have shown that the diversity of the soil macro fauna increases close to the canopy compared to the outside canopy of trees (Bayartogtokh et al 2016, Carpenter et al 2012, Perińka et al 2012).
Soil physical properties

In the present study slight lower soil bulk density was recorded under the canopy of A. saligna compared to the edge of the canopy, 3 m far from the edge of the canopy and 50 m from the canopy but not statistically different (Table 3). This lower soil bulk density under the canopy could be due to the higher accumulation of soil organic matter under the canopy of A. saligna stands as soil bulk density is strongly correlated with soil organic matter content, constituent minerals, porosity and soil texture (Mugunga and Mugumo 2013, Tanveera et al 2016). Similar to the present finding, Mamo and Asfaw (2017) reported that no significant difference of soil bulk density values for soil samples collected under the canopy and outside the canopy of Croton macrostachyus.

The results presented in Table 3 indicated that a significantly (P<0.05) higher soil moisture content was observed under the canopy compared to the edge of the canopy, 3 m far from the edge of the canopy and 50 m outside the canopy of A. saligna tree (Table 3). Higher moisture content under the canopy of the A. saligna tree is attributed to the shading effects that protect soil moisture from excessive evaporation and increased accumulation soil organic matter which enhances infiltration of rainwater and water holding capacity of the soil. The present result was consistent with study on Ficus thonningii (Berhe et al 2013), Croton macrostachyus (Mamo and Asfaw 2017) and Faidherbia albida (Desta et al 2018) where soil moisture content decreased significantly with increasing distance from the tree trunks.

The current study result showed that lower sand and higher silt and clay contents were recorded under the canopy compared to the edge of the canopy, 3 m far from the edge of the canopy and 50 m outside the canopy of A. saligna stands but statistically not significantly different. The textural classification of the soils in the study was sandy loam (Table 3). Similar to this investigation, El Atta et al (2013) reported more clay and silt content but lower sand particle content under the canopy than away for A. ebaica, A. tortilis and A. asak, Mamo and Asfaw (2017) on Croton Macrostachyus tree species. Furthermore, Mohammad (2016) reported that the soil particle size compositions (clay, silt and sand) were not significantly different under the canopy and far from the canopy of Salsola arbusculiformis Drob.

Table 3: Soil physical properties under the canopy and outside the canopy of A. saligna tree

<table>
<thead>
<tr>
<th>Soil parameters</th>
<th>Canopy distance</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density g/cm$^3$</td>
<td>Mean ± Std.</td>
<td>1.67±0.24$^a$</td>
<td>1.80±0.09$^a$</td>
<td>1.99±0.20$^b$</td>
<td>2.04±0.17$^a$</td>
<td>0.474</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>Mean ± Std.</td>
<td>3.46±0.45$^a$</td>
<td>2.95±0.25$^{ab}$</td>
<td>2.74±0.30$^{ab}$</td>
<td>2.01±0.34$^b$</td>
<td>0.040</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>Mean ± Std.</td>
<td>62.50±1.67$^a$</td>
<td>64.50±1.81$^b$</td>
<td>63.33±1.6$^a$</td>
<td>64.67±2.30$^a$</td>
<td>0.825</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>Mean ± Std.</td>
<td>25.00±1.09$^a$</td>
<td>23.50±1.39$^a$</td>
<td>24.00±1.30$^b$</td>
<td>23.00±1.62$^a$</td>
<td>0.760</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>Mean ± Std.</td>
<td>12.50±0.82$^a$</td>
<td>12.00±0.82$^a$</td>
<td>12.37±0.62$^a$</td>
<td>12.33±0.95$^b$</td>
<td>0.946</td>
</tr>
</tbody>
</table>

T1=under the canopy, T2=edge of the canopy, T3=3 m far from the edge of the canopy, T4=50 m outside the canopy. Means within the row followed by the same letters in superscripts are not significantly different at $P=0.05$. 

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Soil chemical properties

The common soil pH ranges are very strongly acid (pH < 4.5), strongly acid (pH 4.5-5.2), moderate acid (pH 5.3-5.9), slightly acid (pH 6.0-6.6), neutral (pH 6.7-7.3), moderately alkaline (7.4-8.0) and strongly alkaline (pH >8.0) (Tadesse et al 1991). According to Tadesse et al (1991) soil pH rates, the current results of the soil pH values either under the canopy or outside the canopy of the A. saligna tree was qualified as moderate alkaline. The result showed that there were no significant differences in mean values of soil pH under the canopy compared to the sampling location at increasing distance from the tree trunk (P>0.05) (Table 4). Yasin et al (2016) for Capparis decidua forsk tree species reported that soil pH decreased with the increasing distance from the tree trunk, but statistically not different. In addition, Manjur et al (2014) found lower soil pH under the canopies of Faidherbia albida and Croton macrostachyus in Southern Ethiopia compared to the corresponding soil pH outside the canopies of these trees but not significantly different. Available phosphorous did not show any significant difference between the canopy distances of A. saligna tree (under the canopy, the edge of the canopy, 3 m far from the edge of the canopy and 50 m outside the canopy) (Table 4). The same trend was reported for other tree species by Mohammad (2016) and Yao et al (2017). The mean value of the total nitrogen was not significantly different between the sampling under the canopy and at a distance from the canopy (Table 4). In line with this result, the studies conducted by different authors for other tree species showed that soil total nitrogen was not significantly different as the distance increases from the canopy of Capparis decidua Forsk (Yasin et al 2016, Yao et al 2017).

The results presented in Table 4 showed that soil organic carbon was significantly higher under the canopy compared to the soil organic carbon content at a sampling distance of 50 m outside the canopy of A. saligna stand. Similar to this finding, the study conducted on scattered Faidherbia albida and Croton macrostachyus (Manjur et al 2014) and Faidherbia albida and Acacia tortilis (Desta et al 2018) revealed that soil organic carbon was decreasing significantly as the distance from canopies increases. Furthermore, Tripathi et al (2010) added that soil organic carbon was higher under the canopy compared to sampling location outside the canopy of the Hardwickia binate tree. Soil electrical conductivity of the soil sample collected under the canopy was significantly higher (P<0.05) compared to the corresponding soil electrical conductivity at the edge of the canopy, 3 m far from the edge of the canopy and 50 m outside the canopy. The result conducted by Berhe et al (2013) for Ficus thonningii and Mohammad (2016) under Salsola arbusculiformis tree species showed that soil electrical conductivity decreases significantly as the distance from the base of the tree increases. Cation exchange capacity was higher under the canopy (41.73 meq/100g soil) compared to the edge of the canopy (35.37 meq/100g soil), 3 m far from the edge of the canopy (38.29 meq/100g soil) and 50 m outside the canopy (31.50 meq/100g soil) of A. saligna tree but not statistically different (Table 4). The relatively higher cation exchange capacity under the canopy of A. saligna tree might be due to the slightly higher accumulation of soil organic matter and clay content under the canopy as cation exchange capacity of the soil is strongly related with the organic matter content of soil (Werku 2009). In support of this finding, the study conducted by Mugunga and Mugumo (2013) showed that the mean value of cation exchange capacity under the canopy of Acacia sieberiana decreases as the distance from the canopy increases, but not statistically different.

Available potassium was higher under the canopy than at the edge of the canopy, 3 m far from the edge of the canopy and 50 m outside the canopy of A. saligna tree but the difference was not statistically significant (Table 4). In line with this result, Yasin et al (2016) also found non-significant differences in soil available potassium under Capparis decidua Forsk tree species among soil sampling locations relative to the tree i.e. under the canopy and outside the canopy of the tree. The exchangeable bases of Ca, Na, Mg and K were not varied under the canopy, the edge of the canopy, 3 m far from the edge of the canopy and 50 m outside the canopy of A. saligna tree. The study conducted by Kamara and Haque (1992) under Faidherbia albida tree species in the highlands of Ethiopia showed that exchangeable bases such as sodium, calcium and magnesium were not significantly affected by tree canopy distances. In addition, Molla and Linger (2017) under Acacia decurrens and Desta et al (2018) under Acacia tortilis (Forsk) found that except the soil exchangeable calcium, the other exchangeable bases of sodium, magnesium and potassium were not statistically different as the distance increase from the tree trunks.
further study is recommended to conduct, besides, higher available phosphorus, soil moisture content, silt and clay percentage, soil total nitrogen, exchangeable bases (Na, K and Mg), available potassium and soil electrical conductivity but lower soil bulk density, soil pH, sand content and exchangeable calcium were observed within the canopy of *A. saligna* tree compared to outside the canopy. The result revealed that restoration practices of degraded areas using exotic or natives’ tree species on to soil fertility and it is essential to enrich the tree in different area exclosures. As our study was conducted in one season, further study is recommended to conduct the effect of seasonal variation on soil macro fauna diversity and selected soil physico-chemical properties.

<table>
<thead>
<tr>
<th>Soil Parameters</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH (1:2.5 H2O)</td>
<td>7.37±0.076&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.52±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.50±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.49±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.338</td>
</tr>
<tr>
<td>Ave.P (ppm)</td>
<td>6.91±0.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.18±0.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.05±0.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.67±0.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.777</td>
</tr>
<tr>
<td>TN (%)</td>
<td>0.016±0.002&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.015±0.002&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.015±0.002&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.016±0.002&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.910</td>
</tr>
<tr>
<td>SOC (%)</td>
<td>3.52±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.90±0.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.05±0.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.88±0.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.211</td>
</tr>
<tr>
<td>EC (dsm&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>0.088±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.054±0.005&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.046±0.002&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.049±0.003&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.00</td>
</tr>
<tr>
<td>CEC(meq/100 g soil)</td>
<td>41.73±10.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>35.37±9.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38.29±10.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.50±6.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.880</td>
</tr>
<tr>
<td>Ave.K (ppm)</td>
<td>78.36±10.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>70.60±9.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>68.52±8.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.12±9.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.857</td>
</tr>
<tr>
<td>Ex.Ca (meq/100 g soil)</td>
<td>7.72±1.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.13±1.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.97±1.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.30±1.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.804</td>
</tr>
<tr>
<td>Ex.Mg (meq/100 g soil)</td>
<td>3.73±0.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.85±0.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.57±0.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.68±0.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.364</td>
</tr>
<tr>
<td>Ex.K (meq/100 g soil)</td>
<td>70.83±5.97&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.50±4.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>66.33±5.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.58±4.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.733</td>
</tr>
<tr>
<td>Ex.Na (meq/100 g soil)</td>
<td>31.00±4.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.29±6.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.48±4.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.90±4.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.585</td>
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</tbody>
</table>

**Table 4: Results of soil chemical properties under *A. saligna* tree canopy and outside the canopy**

**Conclusion and Recommendation**

Understanding the contributions of different either exotics or natives’ tree species on to soil fertility and soil organisms is important for economic, environmental and ecological sustainability of the dryland system. Higher abundance and diversity of the soil macro fauna were recorded under the canopy of *A. saligna* tree than outside the canopy.

Besides, higher available phosphorus, soil moisture content, silt and clay percentage, soil total nitrogen, exchangeable bases (Na, K and Mg), available potassium and soil electrical conductivity but lower soil bulk density, soil pH, sand content and exchangeable calcium were observed within the canopy of *A. saligna* tree compared to outside the canopy. The result revealed that restoration practices of degraded areas using exotic *A. saligna* tree improve the soil macro fauna diversity and selected soil physio-chemical properties and it is essential to enrich the tree in different area exclosures. As our study was conducted in one season, further study is recommended to conduct the effect of seasonal variation on soil macro fauna diversity and selected soil physico-chemical properties.

**Acknowledgments**

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Yasin G, Nawaz MF, Rasool F, Yousuf MTB, Nazir MQ and Javed A (2016): Effect of
Canopy Cover of Capparis decidua Forsk. On Soil Conditions in the Thal Desert.
Journal of Bioresource Management 3(2): 3
Appendix 1: Preserved soil macro fauna at Mekelle University, Forestry Laboratory

<table>
<thead>
<tr>
<th>Soil Macro fauna</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>Proportion (%)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termites</td>
<td>1213</td>
<td>669</td>
<td>375</td>
<td>476</td>
<td>36.21</td>
<td>1</td>
</tr>
<tr>
<td>Millipede</td>
<td>397</td>
<td>147</td>
<td>50</td>
<td>73</td>
<td>8.84</td>
<td>4</td>
</tr>
<tr>
<td>Centipede</td>
<td>214</td>
<td>74</td>
<td>21</td>
<td>14</td>
<td>4.28</td>
<td>5</td>
</tr>
<tr>
<td>Earthworms</td>
<td>482</td>
<td>136</td>
<td>288</td>
<td>124</td>
<td>13.65</td>
<td>3</td>
</tr>
<tr>
<td>Ants</td>
<td>1079</td>
<td>389</td>
<td>391</td>
<td>373</td>
<td>29.56</td>
<td>2</td>
</tr>
<tr>
<td>Beetles</td>
<td>167</td>
<td>76</td>
<td>15</td>
<td>9</td>
<td>3.54</td>
<td>6</td>
</tr>
<tr>
<td>Spider</td>
<td>86</td>
<td>58</td>
<td>25</td>
<td>24</td>
<td>2.56</td>
<td>7</td>
</tr>
<tr>
<td>Earwig</td>
<td>52</td>
<td>24</td>
<td>14</td>
<td>13</td>
<td>1.36</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>7548</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

T1=under canopy, T2=edge of the canopy, T3=3m far from the edge, T4=50m outside the canopy.

Appendix 2: Guideline used for soil macro fauna identification at field level (source: Brown et al 2001, Menta 2012)