Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.8, No.24, 2018

Status of Selected Soil Chemical Attributes Under the Canopy of Acacia seyal Del in Semiarid Area of Eastern Amhara

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Abstract
In Sirinka catchment, North Wollo, Acacia seyal (Del) is an important component of the agroforestry practices. The aim of the study was to investigate the status of soil chemical attributes under the canopy of Acacia seyal Del in-parkland agroforestry system of semi-arid area of Amhara region. Effects of A. seyal on selected soil chemical attributes were examined on six selected comparable A. seyal trees on croplands. Composite soil samples were collected at three distances from the tree base (1, 2.5, and 9 m) and two soil depths (0-15 and 15-30 cm) in four radial directions. Soil analysis results indicated that the soil organic carbon (SOC), total nitrogen (TN) and electrical conductivity (EC) were significantly influenced by distance from the tree base and available P (Av. P) were significantly affected both by distance from the tree base and soil depths. EC, SOC, TN, and Av. P were higher under the canopy of A. seyal than that of beyond the canopy. However, cation exchange capacity (CEC), exchangeable cations (Ca^{2+}, Mg^{2+} and K^{+}) and pH were not influenced by A. seyal. Soil under A. seyal canopy had higher organic carbon than outside canopy because of litter input and fine roots turnover close to the tree. Higher amount of TN, and Av. P under canopy could be related with high organic matter. Therefore, retaining of A. seyal tree on crop lands for its multiple benefits could contribute to the enhancement of agricultural productivity through improving soil nutrients, if the tree managed in proper way.
Keywords: crop lands, semiarid, Parkland, soil organic carbon, total nitrogen, available phosphorus

1. Introduction

Ethiopia is one of sub-Saharan Africa countries where land degradation and depletion of soil fertility are the major threats to agricultural productivity (Sanchez, 2002; Schroth and Sinclair, 2003). Degradation of soil in the form of loss and deterioration in soil fertility, moisture storage capacity, and structure of the soils is thus the most immediate environmental and human induced problem that impairs agricultural productivity of Ethiopia (Bishaw, 2001; Tesfaye, 2005; Demel, 1999). This is mainly due to, the clearance of forest, soil exposure and poor agricultural activities including cultivation on steep slopes, removal of crop residues and the burning of dung (Wales and Le Breton, 1998).

Particularly, in semiarid area of north eastern Ethiopia; where the study was carried out crop productivity is low partly due to very low soil fertility (Beyene et al, 2016; Kiros Gebretsadikan, 2016) which derived from poor organic residue management, fast rate of organic matter decomposition and low organic-matter content (Bayu et al,. 2006). Therefore, maintenance of soil fertility is very vital and it is the first priority to optimize and sustain the productivity in the area (Alemu and Bayu, 2005; Bayu et al,. 2006).

Intensification of crop production using inorganic fertilizer is one of the interventions implemented in the country in general in the study area in particular. The use of inorganic fertilizer can improve the nutrient balance of soils, which may lead to increases crop production but the costs and other constraints frequently discourage smallholder farmers from using it (Dudal, 2002; Michael et al., 2007)). In addition, inorganic fertilizers alone cannot achieve sustainable agricultural production on many types of soil (Tesfay et al, 2006).

Consequently, agroforestry systems have a potential solution to the problem of declining rural agricultural production in the tropics. Agroforestry which is the integration of trees with annual crops and/or either simultaneously or sequentially on the same unit of land (Young, 1997;) has sustainable alternative for soil reclamation and agricultural productivity enhancement. There are several types of traditional agroforestry practices in different part of our country. Enset- coffee based agroforestry practice of Sidama (Zebene, 2003; Mesele, 2002), integrating agricultural crops with number of tree species (Yeshanew, 1997; Abebe, et al., 2009) and dispersed trees on-farms and/or farm boundaries or 'parklands'(Tesfay, 2005) for example are, some of the best known examples of a successful traditional agroforestry practices.

The potential of tree to rehabilitate land from further degradation is reported by various studies (Young, 1997; Kohili et al., 2008) mainly through the addition of litter fall which is the main source of soil organic matter and the reduction of soil erosion by dissipating the erosive power of rain. Furthermore, different reports revealed that trees on-farms help to maintain soil nutrient status through protection against leaching, translocation of nutrient from deeper soil layers to the surface and accumulation of plant litter which create a temporary nutrient pool at the soil surface below the canopy (Hailu et al., 2000; Jiregna et al., 2005; Kohili et al., 2008; Abebe et al., 2009; Kindu et al., 2009 and Kindu et al., 2011).

In eastern Amhara, especially the dry area, farmers have left different shrubs and tree species on their croplands since long time for multiple uses and benefits *Acacia seyal* (hereafter termed as *A. seyal*) variety seyal which is the common and economical tree species in the study area. There is also an information gap on the effect of scattered *A. seyal* tree on soil fertility and crop productivity. However, the biomass of on farm tree species and their composition were studied by Yigardu (2002). Her findings indicated that *A. seyal* (Del) was the dominant tree on farmlands followed by *Acacia lahai and Ziziphus spinach*risty which accounts 51%, 21% and 9% dominancy respectively.

Therefore, the aim of this study was examining status of soil chemical attributes under the canopy of *A. seyal* Del in-parkland agroforestry system of semiarid area of Amhara region.

2. Material and Methods

2.1. Description of the Study Site

The study was conducted in Sirinka catchment which is found in Habru district (Wereda), North Wollo zone, Amhara region. It is geographically located in between 11°41.2'- 11°47.7' N and 39°31.4' - 39°37.6' E. The catchment comprises three adjacent kebeles namely: Gerado, Sirinka and Goshuweha. The research was conducted at Sirinka and Goshu weha kebeles based on the presence of good distribution of the tree. The district is intermediate lowland agro ecologies that range from 1000 to 2400 m above sea level. The climate of the study area is generally characterized by arid and semiarid climate. The mean minimum and maximum daily temperature falls between 13 °C to 26 °C and the mean annual rain fall varies from 750 to 1000 mm with bimodal distribution, the main rainy season lies between June to September and the short rainy season occurring from March to April but the amount and distribution of the rain is fluctuated. The district characterized by rugged and undulated topography. The western part makes a chain of hill that border the high land escarpment of the country from rift valley low lands.

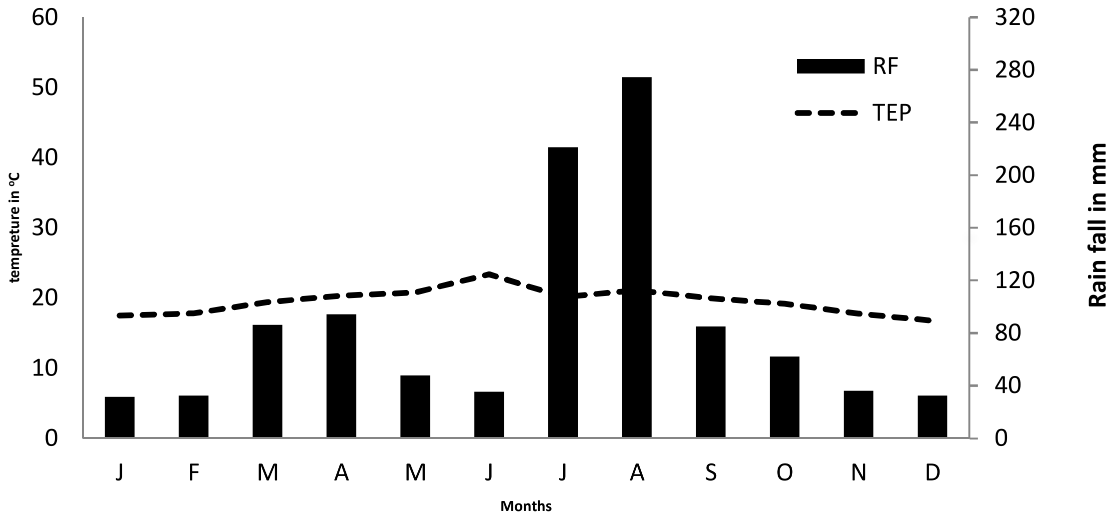

Figure6: The mean monthly temperature and rain fall of the study area (1992-2012, Sirinka station)

2.2. Tree Selection and Soil Sampling

By adopting of the Yeshanew's method (1997) single/isolated *A. seyal* trees were systematically selected from farmers' fields which have similar topography, cropping history, management practice and distribution of trees. And also, trees with approximately the same size and age were used for the study purpose (Table 1).

Table 1. Description of the sampled *A. seyal* trees considered for the study

Sampled Tree	*Height (m)*	*DBH (cm)*	*Average CD(m)*	*Crown area (m^2)*	*Estimated Age (year)*	*Cropping history (5 years)*
1	9.45	39.15	6.25	30.66	14-16	T, S, S, T, T
2	9.15	36.92	6.00	28.26	12-14	T, T, S, S, T
3	8.65	35.96	5.40	22.89	10-12	T, T, S, T, T
4	8.50	39.78	6.00	28.26	12-14	T, S, T, T, T
5	9.00	35.96	5.00	19.63	12-14	T, TS, S, T, T
6	9.20	36.60	5.50	23.75	10-14	T, T, T, S, T

Descriptions: *T= teff, S= sorghum, TS= intercrop of teff with sorghum, the previous 5 years CD= crown diameter and DBH= diameter at breast height,*

There are two factors in this study. The first one is distance from the tree base, and the second one is soil depth from the ground level. Factor one encompasses three levels: 1 m, 2.5 m, and 9 m (considered as control) and factor two also include two levels: 0-15 cm (surface soil) and 15-30 cm (subsurface soil) depth. Representative soil samples were taken at three different distances from the tree base and at each distance from two different depths in four different directions, from each of the six trees. Soil samples for the same distance and depth were bulked to form a composite soil sample. So, totally 36 composite soil samples were collected from under six trees.

2.3. Soil Analysis and Laboratory Methods

Soil samples were air dried, ground, and sieved through 2-mm sieve; and selected chemical properties of the samples were tested at Sirinka Agricultural Research Center (SARC) soil and plant analysis laboratory. The soil organic carbon (SOC) was analyzed by Walkley and Black method (1934) and converted to SOM by multiplying the SOC with 1.724, total nitrogen (TN) by the Kjeldahl method (Bremner and Mulvancy, 1982), available phosphorus was determined by Olsen method (Olsen et al, 1954), exchangeable cations (Ca^{2+}, K+ and Mg^{2+}) and CEC were determined after the soil was extracted using 1 M of ammonium acetate buffered at pH 7. Ca^{2+} and Mg^{2+} were determined by atomic absorption spectrophotometer (AAS) and exchangeable potassium (K^{+}) was also determined by using flame photometer (Black, 1965a). Cation exchange capacity was also determined after extraction with 1 M of ammonium acetate buffered at pH 7 titrametrically by distillation of ammonium (Black, 1965a). Soil pH and EC were determined in a 1:2.5 water soil suspension.

2.4. Data Analysis and Interpretation

All statistical comparison is used SAS software window version 9 (SAS institute, 1999). The quantitative data (chemical parameters) that were obtained from laboratory were analyzed by two-way analysis of variance (ANOVA) to test variations between distances, depths and their interaction. Least significant different test (LSD) was used for mean comparison when differences were significant at 5% of probability level. Simple correlation analysis was also carried out by SAS to examine magnitudes and direction of relationships between selected soil physicochemical properties.

3. Results

3.1. Soil pH and Electrical Conductivity (EC) and Cation Exchange Capacity (CEC)

Soil pH and Cation Exchange Capacity under A. seyal tree canopy was not significantly (P >0.05) different as compared to the soil farther away from the tree base. Similarly, the soil pH at 0-15 cm soil depth was not significantly different from that at 15-30 cm soil depth (Table 4). However, electrical conductivity (EC) of the soil did show significant difference (p<0.05) among distances from the tree base and but not significant in soil depths (Table 2).

3.2. Exchangeable Cations (Ca2+, Mg2+ and K+)

Exchangeable Ca^{2+}, exchangeable Mg^{2+} and exchangeable K^{+} were not significantly influenced by *A. seyal* on crop lands both in terms of distance from the tree base and soil depths (Table 4).

Table 2. The result of two-way analysis of variance (ANOVA) of selected soil chemical attributes in relation to distance from the tree base and soil depth

	Distances from the tree base(Factor A)			***Soil depths(Factor B)***		
Variables	*MS*	*F*	*P*	*MS*	*F*	*P*
pH	0.0002	0.09	0.9181^{ns}	0.0002	0.12	0.7300^{ns}
CEC cmol+/kg	23.37	0.50	0.6147^{ns}	19.06	0.40	0.5304^{ns}
EC dSm^{-}	0.02	3.35	0.0440*	0.0005	0.09	0.7609^{ns}
SOC%	1.01	7.79	0.0027***	0.083	0.66	0.4244^{ns}
TN %	0.005	9.95	0.0007***	0.0007	1.42	0.2451^{ns}
AP mg/ kg	36.07	7.39	0.004**	75.21	15.4	0.0008***
Ex.Ca cmol+/kg	4.26	0.47	0.6282^{ns}	2.40	0.27	0.6098^{na}
Ex. Mg cmol+/kg	0.02	0.03	0.8594^{ns}	0.03	0.03	0.8594^{ns}
Ex. K cmol+/kg	0.011	0.65	0.5308^{ns}	0.001	0.09	0.7624^{ns}

Descriptions: CEC= Cation exchange capacity, EC=electrical conductivity, SOC= soil organic matter, TN= total nitrogen, Av.P= available phosphorus, and Ex. cation (exchangeable Ca^{2+}, Mg^{2+} and K^{+}), ***= significant at p<0.001, **= significant at P≤ 0.01, *= significant at P<0.05, and ns= not significant at P<0.05

3.3. Soil Organic Carbon (SOC)

Soil organic carbon was significantly different among the distances from the tree base (Table 6) and the surface soil (0-15 cm) has slightly higher soil organic carbon than that of the subsurface (15-30 cm) soil (Table 4). The soils under canopy of the tree have shown higher soil organic carbon as compared to the soil outside the canopy

(Table 4).

Table 6: Soil pH, CEC, and EC influenced by distance from the tree base and soil depths

Treatments	Soil parameters		
	pH	CEC (cmol+/kg)	EC dSm^{-1}
Horizontal Distances (m)			
1	6.29±0.02[a]	47.23±2.52[a]	0.49±0.03[a]
2.9	6.28±0.02[a]	49.49±2.78[a]	0.46±0.01[ab]
9	6.28±0.02[a]	46.93±1.63[a]	0.41±0.02[b]
Soil Depths (cm)			
0-15	6.29±0.02[a]	47.16±2.12a	0.46±0.02a
15-30	6.28±0.02[a]	48.62±1.68a	0.45±0.02a

3.4. Total Nitrogen (TN)

Total nitrogen (TN) content of the soil was significantly ($p<0.001$) influenced by distance from the tree base, but it was not significantly affected by soil depth. As shown from table 5, the soils under the tree canopy have shown higher total nitrogen (TN) as compared to the soil outside the canopy. The mean value changes in decreasing trend from canopy zone to outside the canopy. The surface soil (0 – 15cm) has shown higher nitrogen content as compared to subsurface soil (15-30 cm, Table 4).

3.5. Available Phosphorus (P)

As shown in Table 4, the soil available P was significantly affected by the two main effects of distance from the tree base and soil depths (P< 0.004 and P<0.0008 respectively. As shown from Table 4, the soils under the tree canopy have shown higher available P as compared to the soil outside the canopy. Whereas the surface soil (0-15 cm) has shown higher available P as compared to subsurface soil (15-30 cm, Table 4) i.e. the amount of available P of surface soil has 65.2% higher as compared to subsurface soil (Table 4).

Table 7. SOC, TN, Av. P and Exchangeable Cations (Ca2+, Mg2+ and K+) influenced by distance from the tree base and soil depths

Treatments	Soil parameters					
	SOC %	TN %	Av.P (mg kg-1)	Ex.Ca (cmol+/kg)	Ex.Mg (cmol+/kg)	Ex. K (cmol+/kg)
Horizontal Distances (m)						
1	2.00±0.13[a]	0.13±0.01[ab]	9.09±1.82[a]	14.49±0.65[a]	5.62±0.19[a]	0.69±0.04[a]
2.9	1.81±0.12[ab]	0.15±0.01[a]	8.03±1.84[a]	14.65±0.81[a]	5.63±0.25[a]	0.75±0.03[a]
9	1.43±0.10[b]	0.11±0.01[b]	5.40±1.37[b]	13.55±1.03[a]	5.70±0.28[a]	0.74±0.04[a]
Soil Depths (cm)						
0-15	1.77±0.15[a]	0.14±0.01[a]	9.09±1.40 [a]	13.97±0.70[a]	5.67±0.18[a]	0.74±0.03[a]
15-30	1.72±0.10[a]	0.13±0.01[a]	5.93±1.30 [b]	14.49±0.67[a]	5.62±0.21[a]	0.72±0.03[a]

Descriptions: The mean value under each columns with the same superscript letter are not significantly different at P<0.05, SOC= soil organic Carbon, TN= total nitrogen, Av.P= available phosphorus, and Ex. cation (exchangeable Ca, Mg and K) values are mean ±SE , SE= standard error

4. Discussions

4.1. Soil pH, CEC and EC

The result of the present study revealed that soil pH and CEC were not significantly influenced by the presence of *A. seyal* tree both along the distance from the tree base and soil depths. However, the mean value of pH of surface and subsurface soil under the tree canopy was approximately similar with the corresponding surface and subsurface soil outside the canopy. This shows that the presence of scattered *A. seyal* on croplands did not alter the soil pH. This result is supported by Hailu et al., (2000), who observed that the soil pH beneath the canopy of *Militia ferruginea* tree have not shown significant variation to the soil beyond the canopy of the tree. Enideg, (2008) also showed that the occurrence of *F. thonnigii* tree did not influence the soil pH along distances from the tree base and soil depths in Northern Ethiopia. Jiregna et al., (2005), Kindu et al., (2009), and Hailemariam et al., (2010) elsewhere in Ethiopia and Camargo-Ricalde et al., (2010) in Mexico found that the occurrence of tree species on croplands had no significant influence on soil pH.

In contrast Abebe et al., (2009) obtained that the soil under the canopy of scattered *Cordia africana* were less acidic than those of the adjacent open area. He explained that the increasing of soil pH under the canopy might be attributable to higher litter deposition which upon decomposition and subsequent mineralization release cations to the soil system than open land. Similarly, Hailemariam et al., (2010) under *Balantis aegyptiaca* in northern Ethiopia, Mordelet et al., (1993) under savanna tree clump in West Africa, Yadav et al., (2008) under

Prosopis cineraria, *Dalbergia sissoo*, *Acacia nilotica* and *Acacia leucophloea* in India and Kahi et al., (2009) under *P. juliflora* and *A. tortilis* canopy in Kenya, found that soil pH is influenced by tree canopy when compared to the open canopy either negatively or positively.

In the present study, the cation exchange capacity (CEC) has not shown difference among distance from the tree base and soil depths. In contrast to the present study Hailu et al (2000) observed that the higher-level cation exchange capacity (CEC) of soil under the canopy of *M. ferrugniea* as compared to the soil beyond the canopy in southern Ethiopia. Cation exchange capacity (CEC) of the soil was significantly different along distances and soil depths under *C. macrostachyus* in north-western Ethiopia (Yeshanew, 1997).

Electrical conductivity (EC) of the soil was influenced only by distance from the tree. The mean value of electrical conductivity (EC) have shown decreasing trend with distance from the tree base and soil depths. The overall value of soil electrical conductivity (EC) in the present study was ranged from 0.31- 0.72 dSm^{-1}, is low.The salinity level of the soil having EC less than 2 dSm^{-1}had No effect on plant growth (Hazelton and Murphy, 2007). In contrast soil EC did not vary with respect to distance from the tree base (Hailemariam et al., 2010).

4.2. Soil Organic Carbon (SOC)

Soil organic carbon (SOC) has been affected by distance from the tree base. The soil under *A. seyal* canopy had higher level of SOC than open canopy. The highest value of SOC was observed under the canopy and the surface soil this might be due to the accumulation of litter fall and fine root decay. In agreement with the present study higher SOC under the canopy of the tree was reported by different studies elsewhere in Ethiopia (Hailu et al., 2000; Jiregna et al., 2005; Abebe et al., 2009; Kindu et al., 2009; Kindu et al., 2011) and in other countries (Teklehaimanot and Kwapong, 1996; Gallardo, 2003; Akpo et al., 2005; Pandey et al., 2005; Yadav et al., 2008; Kahi et al., 2009; Camargo- Rcalde et al., 2010). They reported higher SOC under different tree canopy than the corresponding open area of that on crop and pasture. In Ethiopia, Abebe et al., (2009) reported that the SOC was higher under the canopy of *C. africana* than in the open area. SOC was about two to three times higher under the shade than that of in the open for all the rangeland (Akpo et al., 2005). In contrast to the present study Hailemariam et al., (2010) showed that the SOC was not significantly influenced by horizontal distances from the *B. agyptiaca*base both at Goble, Korbebit and Limat site because of low litter fall and the existed organic matter might have readily decomposed due to high temperature coupled with available moisture of the area during the period of his experiment.

4.3. Total Nitrogen (TN)

In the present study, we observed that TN have shown decreasing trend as distance increases from the tree base towards open canopy. In general, the soil under *A. seyal* canopy had higher level of TN as compared to that of soil beyond the canopy. SOM is positively correlated to TN in the present study and other study (Enideg, 2008; Kindu, 2011). Therefore, this difference could be due to the higher SOM accumulation under the canopy from litter fall and root turnover. Hailu et al., (2000) observed that TN under influence of *Millettia* was higher than that of the open area. Total nitrogen was higher under the canopy of *P. juliflora* and *A. tortilis*than outside the canopy (Kahi et al., 2009) in Kenya. Similar results were reported by Jiregna et al., (2005) in eastern Ethiopia, Yeshanew, (1997) in north-western Ethiopia, Enideg, (2008) in North eastern Ethiopia, and Pandey et al., (2005) in central India. In addition, in degraded cocoa farms Teklehaimanot and Kwapong, (1996) reported that the soil TN under the canopy of *Albizzia zygia* was higher as compared with the adjacent distance of open lands likely due to nutrient input by tree litter. Because nutrients taken up by trees from deep soil become an input when transferred to surface soil in the form of leaf litter, roots and pruning of tree leaves and branches (Schroth, 1995). In contrast to the present study, Hailemariam et al, (2010) in northern Ethiopia, found that TN content did not differ among distances from the tree base.

4.4. Available P

The result of the present study showed that the soil available P was influenced by both distance from the tree base and vertically by soil depths. In general the soil under the canopy of *A. seyal* have shown greater amount of available P than beyond the canopy and surface soil had substantial amount of available P than the corresponding subsurface soil. In similar study, the soil available P in the surface soil was significantly higher under the canopy of *Millettia* tree than beyond the canopy; and the surface soil available P was higher than the subsurface one which is attributed to organic matter accumulation (Hailu et al., 2000). Abebe et al., (2009) also reported higher available P under the canopy of *C. africana* than in the open area because of higher amount of organic matter and also biological activities under the tree canopy which may facilitate the release of P from organic matter and inorganic sources. Soil available P under the canopy of *C. africana* and *C. macrostachyus* tree were significantly higher as compared to the soil beyond the canopy; the surface soil also have higher available P than the corresponding subsurface soil (Jiregna et al., 2005) and he explained that the higher amount of available Punder the canopy of *C. macrostachyus* than *C. Africana* is possibly due to higher foliar P in the former than the later species. Similar results were found from other several studies (Mordelet et al, 1993; Teklehaimanot and Kwapong, 1996; Gallardo, 2003; Kindu et al., 2009; Noumi et al., 2011). They all found higher available P under the canopy than open land. In contrast to present study, Hailemariam et al., (2010) found similar concentration of available P between the soils under the canopy of tree than the soil outside the canopy, in northern Ethiopia. The soils outside the canopy of *P. joliflora*and *A. toritilis* have higher concentration of available P than the soil under the canopy of the two trees in Kenya (Kahi et al., 2009).

4.5. Exchangeable Cations (Ca2+, Mg2+ and K+)

Exchangeable cations (Ca^{2+}, Mg^{2+} and K^{+}) were not influenced by the presence of *A. seyal* in terms of distance from the tree base and soil depths. In general, exchangeable $Ca^{2+}$of the soil under *A. seyal*canopy found to be similar as compared to the soil beyond the canopy. Similar report presented by Abebe et al (2009) who observed no difference in exchangeable Ca^{2+} among distances from the tree base. Exchangeable Ca^{2+} among the distance from the tree base was similar, but it was slightly higher under the canopy of *F. thonnigi*than open field (Enideg, 2008). In contrast to the present study exchangeable Ca^{2+} decreased with soil depth at different distances from tree base in central highlands of Ethiopia (Kindu et al., 2009). In south Ethiopia (Hailu et al., 2000) and in south Tunisia (Noumi et al., 2011) findings indicated that the value of exchangeable Ca^{2+} was higher under *Millettia* and *A. tortilis* than in the open field and higher in surface soil than the corresponding subsurface soil.

In the present study, exchangeable Mg^{2+} was not affected by distance from the tree and soil depth. The finding of Enideg, (2008) agrees with the result of the present study. However, the result obtained from other studies showed that the exchangeable Mg^{2+} under the canopy of tree were higher as compared to the soil beyond the canopy (Hailu et al., 2000; Abebe, et al., 2009; Kindu et al., 2009; Noumi et al., 2011).

Exchangeable K+ in the present study also showed no difference among distance from the base of the tree and soil depths. In agreement with the present study, other studies reported that soil exchangeable K+ was not different among distances (Endeg, 2008; Hailemariam et al., 2010). However, higher exchangeable K+ under canopy of the tree than that of open area were reported by other studies elsewhere in Ethiopia (Hailu et al., 2000; Jiregna, et al., 2005; Abebe et al., 2009; Kindu et al., 2009; Noumi et al., 2011).

5. Conclusions

Generally, the farmers in the study area deliberately leave and manage the naturally regenerated tree seedlings on farm boundaries, marginal areas, and inside croplands to fulfill their wood requirements and to generate extra income; A. seyal tree is one of multipurpose tree species commonly found on croplands of the Sirinka catchment. The study demonstrates some information about the effectiveness of the tree on the traditional agroforestry practices, as scattered tree species on crop land ecosystem so as to improving soil fertility and productivity of agricultural lands. Therefore, the study concludes, the presence of scattered A. seyal tree on croplands has positive effects on selected soil chemical properties through its leaf and root litter addition on the ground. That improves soil organic matter (SOM), total nitrogen (TN), and available P in its area of influence. Therefore, the the present study was restricted to generating information about the impact of scattered A. seyal tree on selected soil chemical attributes. Therefore, further research should be conducted on: Appropriate silvicultural management of the tree on croplands; fine root production and distribution of the tree; litter production, chemical compositions and decomposition rate of the tree litter.

ACKNOWLEDGEMENT

I would also like to express my deepest gratitude to Amhara Region Agricultural Research Institute (ARARI) for giving me the chance to pursue this study and financially supporting my study expenses and field research. I am also grateful to Sirinka Agricultural Research Center (SARC) for granting me a study leave and allowed me laboratory facilities and transportation during field work.

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