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Assessment of Soil Fertility Status of Different Types of Soils in Selected Areas of Southern Ethiopia

Abay Ayalew
Department of Natural Resources Research
Hawassa Agricultural Research Center, Southern Agricultural Research Institute
Hawassa, Southern Nations Nationalities and Peoples' region, Ethiopia

Abstract

A soil fertility assessment study was conducted in Luvic Calcisols (Siltic), Haplic Calcisols (Chromic), Haplic Calcisols (Humic), Haplic Luvisols (Humic), Andic Lixisols (Humic), Andic Cambisols (Humic), Haplic Lixisols (Siltic) and Haplic Lixisols (Humic) in the southern part of Ethiopia to investigate their fertility status. Soil samples were collected randomly from 0-15cm and 15-30cm depths using augur with three replications on farmers' fields representing the above soil types. The samples were air dried, crushed to pass 2 mm sieve and analyzed for pH, OC, $CaCO_3$, CEC, exchangeable bases, total nitrogen, available phosphorus, Zn, Cu, Fe and Mn contents. The results revealed that the above soil properties varied between soil types and depths. The OC and CEC contents were varied between moderate and high, whereas $CaCO_3$ was ranged from low to high increasing with depth. The total nitrogen content was ranged from low (<0.2%) to medium (0.2-0.5%), whereas available phosphorus was medium (8-18 mg kg^{-1} soil). The micronutrients contents were decreased with depth and they were low in most of the soils. Organic carbon was positively correlated with total nitrogen and CEC indicating that application of organic materials can improve soil fertility in these soils. In conclusion, soil fertility management practices that can improve micronutrients and a study on nutrient placement for growth of different crops should be carried out in the study soils.

Keywords: soil depth, soil types, micronutrient, organic carbon, total nitrogen, cation exchange capacity

1. Introduction

The sustainable productivity of a soil mainly depends upon its ability to supply essential nutrients to the growing plants as plants take their nutrients mostly from soil (Kumar and Babel, 2011), which can be considered a box from which nutrients are removed (output) and in which nutrients are entered (input) (Hartemink, 2006).

Soil fertility, which is defined as ''the quality of a soil that enables it to provide nutrients in adequate amounts and in proper balance for the growth of specified plants or crops (Hartemink,2006), is an important factor that determines the growth of plant and is determined by the presence or absence of nutrients (Nazif et al., 2006).

Continuous cropping without adequate restorative practices may cause soil fertility decline or nutrient depletion and endanger the sustainability of agriculture. Since nutrient depletion is a major form of soil degradation, knowledge on the depletion of plant nutrients from soils may be helpful in devising nutrient management strategies (FAO, 2003). Mulugeta and Sheleme (2010) reported that continuous intensive cultivation without appropriate soil management practices has contributed to the degradation of the important soil quality indicators in Kindo Koye Watershed in Southern Ethiopia. Soil fertility decline includes nutrient depletion (larger removal than addition of nutrients), nutrient mining (large removal of nutrients and no inputs), acidification (decline in pH and/or an increase in exchangeable Al), the loss of organic matter, and an increase in toxic elements such as aluminum (Hartemink, 2006). Since physico-chemical properties like: soil texture, organic carbon, calcium carbonate, cation exchange capacity, pH and electrical conductivity of soil control the availability of nutrients on which plant growth and crop yield depend (Kumar and Babel, 2011), these properties need to be known for proper soil fertility management plan.

In agricultural ecosystem nutrients are removed not only through erosion and leaching but also with crop yield and residues. The periodic disturbances of soils including tillage and weeding in agricultural ecosystems can cause removal of nutrients higher than natural ecosystems (Logan, 1990). Soil analytical data by Hertemink (1997b) indicated that soil nutrients were lower in permanent cropping lands than bush vegetation lands of different types of soils. A survey of soil fertility status, which includes soil sampling and analysis, would provide valuable information for diagnosis and prediction of fertilization needs (Maria and Yost, 2006). Therefore, it is very important to periodically assess the status of nutrients in agricultural ecosystems in order to keep good crop production through better nutrient management. This study was, therefore, conducted with the objective of assessing the soil fertility status of Luvic Calcisols (Siltic), Haplic Calcisols (Chromic), Haplic Calcisols (Humic), Haplic Luvisols (Humic), Andic Lixisols (Humic), Andic Cambisols (Humic), Haplic Lixisols (Siltic) and Haplic Lixisols (Humic) at different depths in southern parts of Ethiopia.

2. Materials and methods

2.1 Description of the study areas

The study was conducted in six locations in Southern part of Ethiopia, which include: Kontela with Luvic Calcisols (Siltic), Taba with Haplic Lixisols (Siltic) and Haplic Lixisols (Humic), Jole Andegna with Haplic Luvisols (Humic), Tenkaka Umbulo with Haplic Calcisols (Humic), Alage with Haplic Calcisols (Chromic) and Huletegna Choroko with Andic Lixisols (Humic) and Andic Cambisols (Humic). The dominant textural classes of the soils are loam and clay loam. Kontela and Alage are located in Oromiya region, whereas Taba, Jole Andegna, Tenkaka Umbulo and Huletegna Choroko are in Southern Nations, Nationalities and Peoples Regional State of Ethiopia.

2.1.1 Kontela

The Kontela site is located 5 and 120 km north of Zeway and Hawassa, respectively, and 155 km south of Addis Ababa. The site lies between 07°58’09.7” to 07°58’48.5” N latitude and 38°43’09.9”to 38°43’18.3” E longitude with altitude ranging from 1642 to 1646 m.a.s.l. (Table 1). According to the data from the nearby meteorological station at Zeway (2000 – 2013), the mean annual rainfall at the Kontela village is 706 mm with the rainy season extending from March to September. The mean annual temperature is 21°C, whereas the mean annual minimum and maximum temperatures are 18°C and 28°C, respectively (Fig. 2). The major crops and vegetation in the area include maize (*Zea mays* L.), barley (*Hordeum vulgare*), wheat (*Triticum aestivum*) and haricot bean (*Phaseolus vulgaris*), whereas the native vegetation is dominated by Acacia (*Faidherbia albida*).

2.1.2 Alage

The Alage site is located 60 km south of Zeway town and 220 km south of Addis Ababa. The coordinates of the pedon site are 07°32’21.8” N latitude and 38°24’51.3” E longitude with altitude of1600 m.a.s.l**.** (Table 1). The mean annual rainfall at Alage is 693 mm with the main rainfall season extending from March to September. The mean annual temperature is19.8°C with mean annual minimum and maximum temperatures of 13°C and 27°C, respectively (Fig.2). The major crops and vegetation in the area include maize, barley, wheat, haricot bean, sorghum (*Sorghum bicolor*), and hot pepper (*Capsicum frutescens* L.) with Acacia as the dominant vegetation.

2.1.3 Tenkaka Umbulo

Tenkaka Umbolu is located 21km west of Hawassa city within the geographical coordinates between 07°01’19.9” to 07°01’26.7” N latitude and 38°20’23.6”to 38°20’18.8” E longitude and altitude ranging from 1717 to 1727 m.a.s.l. (Table 1). The mean annual rainfall at Tenkaka Umbulo is 932 mm with the main rainy season extending from April to October. The mean annual temperature is 21°C with mean annual minimum and maximum temperatures of 13°C and 28°C, respectively (Fig.2). The major crops and vegetation in the area include maize, haricot bean, sugar cane (*Saccharum officinarum*), enset (*Ensete ventricosum*) and kale (*Brassica oleracea* L. var. acephala DC), Acacia sp. and Cordia (*Cordia africana*) are the dominant vegetation.

2.1.4 Huletegna Choroko

Huletegna Choroko is located 4 and 87 km northwest of Halaba and Hawassa towns, respectively, and 314 km south of Addis Ababa. Its lies between 07^{o}20’34.5”to 07^{o}20’21.9”N latitude and 38^{o}06’30.0” to 38^{o}06’31.1”E longitude with altitude ranging from 1807 to 1808 m.a.s.l. (Table 1). The mean annual rainfall at Huletegna Choroko village is 952 mm and the main rainfall season extending from March to October. The mean annual temperature is 19°C with mean annual minimum and maximum temperatures of 13 and 26°C, respectively. The major crops and vegetation in the area include maize, hot pepper, finger millet (*Eleusine coracana*), haricot bean, tef (*Eragrostis tef*) and sorghum, whereas Acacia sp., Cordia, Croton (*Croton macrostachyus*), and Erithrina (*Erythrina* spp.) are the dominant vegetation.

2.1.5 Taba

Taba site is located 8 and 24 km north of Bodity and Sodo towns, respectively, within the geographic coordinates between 07^{o}00’49.9” to 07^{o}01’01.9”N latitude and 037^{0}53’57.6” to 037^{o}54’03.1”E longitude, and altitude ranging from 1910 to 1915 m.a.s.l. (Table 1). The mean annual rainfall at Taba village is 1153.89 mm with the main rainfall season extending from March to September. The mean annual temperature is 15.5°C with mean annual maximum and minimum temperatures of 20°C and 10°C, respectively. The major crops and vegetation in the area include maize, taro (*Colocasia esculenta* L. Schott & Endl.), kale, sweet potato (*Ipomoea batatas*), banana (*Saging Musa sapientum* L.), enset, yam (*Dioscorea alata*), sugar cane, and haricot bean. The vegetation is dominated by Cordia, avocado (*Persium americana*), mango (*Mangifera indica*), and caster bean (*Risunus cominis*).

2.1.6 Jole Andegna

The site is located 12.5 km north of Butajira town and 119.5 km south of Addis Ababa. Its geographical extent is between 08°12’25.9” to 08°11’19.8” N latitude and 38°27’33.2” to 38°27’22.9” E longitude with altitude ranging from 1896 to 1923 m.a.s.l. (Table 1). The mean annual rainfall at Jole Andegna was 937 mm and the main rainfall season extending from March to October. The mean annual temperature is 18.7°C and mean maximum and minimum temperatures are 26.4°C and 10.9°C, respectively (Fig. 2). The major crops and vegetation in the area include maize, haricot bean, faba bean (*Vicia faba*), hot pepper, tef, and sorghum, whereas the vegetation is dominated by Acacia and Croton.

2.2 Soil Sampling

Soil samples were collected randomly from farmers’ fields representing each type of the experimental soil using augur. The samples were collected from 0-15cm and 15-30cm depths with three replications. For each replication 15 subsamples were collected and composited.

Table 1. Location and physiographic settings of the study sites.

Location	Geographic location		Slope (%)	Altitude (m.a.s.l)
	Latitude	Longitude		
Taba	07°01’01.9”	37°53’57.6”	3	1915
Huletegna Choroko	07°20’34.5”	38°06’30.0”	1	1807
Jole Andegna	08°12’25.9”	38°27’33.2”	9	1923
Kontela	07°58’09.7”	38°43’09.0”	4	1646
Alage	07°32’21.8”	38°24’51.3”	9	1600
Tankaka Umbulo	07°01’19.9”	38°20’23.6”	10	1717

2.3 Laboratory analyses

The soil samples were air dried in the laboratory and ground to pass 2mm sieve. Particle size analysis was carried out by the modified sedimentation hydrometer procedure (Bouyoucos, 1951). The pH of the soils was determined in H_2O (pH-H_2O) 1:2.5 soil to solution ratio using a pH meter. Organic carbon content of the soils was determined following the wet combustion method of Walkley and Black as outlined by Sahlemedhin and Taye (2000). Soil total nitrogen was analyzed by wet-oxidation procedure of the Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus was analyzed using the Olsen sodium bicarbonate (pH 8.5) extraction method and determined using a spectrophotometer at 882 nm. Exchangeable basic cations and the cation exchange capacity (CEC) of the soils were determined using the 1*M*NH_4OAc (pH 7) method as outlined by Sahlemedhin and Taye (2000). Exchangeable Ca and Mg in the leachate were determined using atomic absorption spectrophotometer (AAS), whereas K and Na were measured using aflame photometer. Available micronutrients (Fe, Mn, Zn, and Cu) contents of the soils were extracted by diethylene triamine pentaacetic acid (DTPA) method (Tan, 1996) and the contents in the extract were determined by AAS.

3. Results and discussions

The result of soil analyses indicated that the values of all the analyzed soil parameters varied between soil depths within and among soil types (Tables 2 and 3). Organic carbon content was decreased with depth in Luvic Calcisols (Siltic), Haplic Calcisols (Humic), Haplic Luvisols (Humic) and Andic Lixisols (Humic), whereas it was increased with depth in the rest of the soil types (Table 2). The organic carbon content in Luvic Calcisols (Siltic), Andic Lixisols (Humic) and Haplic Lixisols (Siltic) ranged between medium (1.5-2.5%) and high (>2.5%) as stated by (Maria and Yost, 2006), whereas it was high in Andic Cambisols (Humic) and Haplic Lixisols (Humic). The organic carbon content in Haplic Calcisols (Chromic), Haplic Calcisols (Humic) and Haplic Luvisols (Humic) was medium, which is in agreement with the finding reported by Taye and Yifru (2010). Abay et al. (2015) also reported that the organic carbon content of surface soils (0-30 cm) was medium in Haplic Calcisols (Chromic) and high in the rest of the other soils. Calcium carbonate ($CaCO_3$) content increased with depth in all types of soils (Table 2). According to FAO (2006), the $CaCO_3$ content of Luvic Calcisols (Siltic) and Haplic Calcisols (Chromic) was high (>15%) and medium (5-10%), respectively, in both depths, whereas it was low (<2%) in the rest of the soils. The high $CaCO_3$ content in Luvic Calcisols (Siltic) around Zeway could reduce the availability of micronutrients such as Zn and Fe. The pH values of these soils were 8.0 and 8.2 (Table 2), which could reduce the availability of micronutrients in these soils (Hazelton and Murphy (2007) through the adsorption of the micronutrients on the negatively charged surface of hydroxyl ions. The soil reactions of the other soil types also indicated that all types of soils were alkaline with pH ranging from 7.3 to 7.8 and micronutrients’ availability is also expected to be reduced in these soils. The electrical conductivity (EC) of all types of soils was low (<0.8 dS m^{-1}) that indicates all soils did not have salinity problem. The total nitrogen content generally ranged between low (<0.2%) and medium (0.2-0.5%) (Table 2). In Haplic Calcisols (Humic) and Andic Cambisols (Humic), total nitrogen content was medium but it was low in Haplic Lixisols (Siltic). On the other hand, the total nitrogen content varied between low and medium in Luvic Calcisols (Siltic), Haplic Calcisols (Chromic), Haplic Luvisols (Humic), Andic Lixisols (Humic) and Haplic Lixisols (Humic). According to Landon (1991), the available phosphorus content was medium (5-15 mg kg^{-1} soil) in both depths of all types of soils (Table 2).

According to Landon (1991), the cation exchange capacity (CEC) of soils can be classified as low (<15 Cmol (+) kg^{-1} of soils), medium (15-25 Cmol (+) kg^{-1} of soils) and high (>25 Cmol (+) kg^{-1} of soils). As it can be seen from Table 3, the CEC of the study soils varied between medium and high with depth and types of soils.

It was high in both depths of Luvic Calcisols (Siltic) and Haplic Luvisols (Humic), but increased and deceased with depth, respectively. In Haplic Calcisols (Chromic) and Haplic Lixisols (Humic), CEC was medium and decreased with depth, whereas in Haplic Calcisols (Humic), Andic Cambisols (Humic) and Haplic Lixisols (Siltic), it was medium and increased with depth. It was remained constant between depths of Andic Lixisols (Humic) with medium value. According to the classification by Landon (1991), the exchangeable calcium (Ca) and potassium (K) contents of all soils were high (>10 Cmol (+) kg^{-1} of soils and >0.6 Cmol (+) kg^{-1} of soils, respectively) (Table 3). The exchangeable magnesium (Mg) content of Haplic Calcisols (Humic) and Haplic Luvisols (Humic) was high (>3 Cmol (+) kg^{-1} of soils) in 0-15cm depth but medium (1.5-3 Cmol (+) kg^{-1} of soils) and low (<1.5 Cmol (+) kg^{-1} of soils), respectively, in 15-30cm depth. The exchangeable sodium (Na) content varied between medium and high in the study soils. It was high (>0.7 Cmol (+) kg^{-1} of soils) in Luvic Calcisols (Siltic), Haplic Calcisols (Humic) and Andic Cambisols (Humic) in both depths. In the rest of the soils it was varied between medium (in 0-15cm) and high (in 15-30cm), except in Haplic Lixisols (Humic) where it was high in 0-15cm and low in 15-30cm depth. Generally, exchangeable Na was increased with depth. Although the exchangeable Na was high in most of the soils, the exchangeable sodium percentage (ESP) was below 15% and too low to cause sodicity. The base saturation percentage (%BS) was >60 and rated as high (Hazelton and Murphy, 2007) in both depths of all types of soils reflecting the large amount of weatherable minerals in the soils (Engdawork, 2002). The high contents of exchangeable bases in the surface layers of the soils resulted in high percent base saturation (CRI, 2012). Since the base saturation percentage directly affects the ratio of cations on the exchange sites to cations in soil solution, it should be considered for appropriate fertilizer application (Abay et al., 2015).

The medium and high CEC values could be attributed to medium and higher OC contents of the soils in Andic Lixisols (Humic), Andic Cambisols (Humic), Haplic Calcisols (Chromic), Luvic Calcisols (Siltic), Haplic Calcisols (Humic), Haplic Lixisols (Siltic) and Haplic Lixisols (Humic), whereas that of Haplic Luvisols (Humic) was likely due to the presence of smectitic clay. Similar findings were reported by Abay et al. (2015). The CEC can determine appropriate fertilizer applications and amount of nutrients needed to correct imbalances. High CEC values indicate that a soil has a greater capacity to hold cations and requires higher rates of fertilizer that can increase its cation level to provide adequate crop nutrition. Whereas, low CEC soils hold fewer nutrients, and are likely subject to leaching of mobile "anion" nutrients that leads to the requirement for split applications of several nutrients (Hamza, 2008). The ratio of Ca to Mg in most cases was above 3 indicating the balance between the two minerals (Engdawork, 2002).

Table 2. Organic carbon, $CaCO_3$, pH, EC, TN and AvP of the study soils

Type of soil	soil depth (cm)	OC%	OM%	$CaCO_3$ %	pH	EC (dSm^{-1})	TN%	Av P mg kg^{-1} soil
Luvic Calcisols (Siltic)	0-15	4.8	8.3	17	8.0	0.19	0.42	12.1
	15-30	2.4	4.2	21	8.2	0.17	0.18	12.3
Haplic Calcisols (Chromic)	0-15	2.1	3.7	4.5	7.4	0.17	0.16	7.54
	15-30	2.3	4.0	5.3	7.6	0.18	0.25	8.88
Haplic Calcisols (Humic)	0-15	2.3	3.9	2.1	7.5	0.06	0.25	13.31
	15-30	2.2	3.8	3.2	7.3	0.06	0.27	11.39
Haplic Luvisols (Humic)	0-15	2.3	4.0	1.5	7.5	0.12	0.19	11.96
	15-30	1.8	3.1	2.3	7.3	0.10	0.50	12.30
Andic Lixisols (Humic)	0-15	2.9	5.0	1.2	7.7	0.13	0.30	9.50
	15-30	1.8	3.1	2.1	7.7	0.18	0.17	10.50
Andic Cambisols (Humic)	0-15	2.5	4.4	1.0	7.4	0.11	0.24	7.20
	15-30	2.9	4.9	2.0	7.8	0.23	0.24	10.7
Haplic Lixisols (Siltic)	0-15	1.7	2.9	1.5	7.5	0.29	0.08	14.8
	15-30	3.0	5.2	2.5	7.5	0.11	0.12	13.5
Haplic Lixisols (Humic)	0-15	2.8	4.8	1.0	7.67	0.19	0.21	14.2
	15-30	4	6.9	2.1	7.26	0.31	0.12	14.5

Like the other soil parameters, micronutrient contents of the soils were different both in depth and type of soil (Table 3), which is in agreement with Nayyar et al. (2001) who stated that micronutrient contents vary in different areas depending on the soil properties and management conditions. All micronutrients (Fe, Cu, Zn and Mn) were generally decreased with depth which is in line with the finding reported by Mulugeta and Sheleme (2010).

According to Havlin et al. (1999), the content of Fe was medium (2.5 -4.5 mg kg^{-1} soil) in both depths of Haplic Calcisols (Humic), Andic Cambisols (Humic) and in 0-15 cm depth of Haplic Lixisols (Siltic), whereas it was low (<2.5 mg kg^{-1} soil) in both depths of the rest of the soils. The content of Cu was high in both depths of Haplic Luvisols (Humic), but it was low (<0.4 mg kg^{-1} soil) in both depths of the rest of the soils.

Similar findings were reported by Abay et al. (2015). The Zn content of Haplic Luvisols (Humic) in both depths was high (>1 mg kg^{-1}), whereas it was low in both depths of the rest of the other soils. Manganese was low (<1 mg kg^{-1} soil) in both depths of Luvic Calcisols (Siltic), Haplic Calcisols (Chromic) and Haplic Luvisols (Humic) but it was high in both depths of the other soils (Table 3). The low micronutrients in most of the soils suggested the need for application of fertilizers containing Zn, Fe, Cu and Mn for crop production.

Table 3. Exchangeable bases and micronutrients of the study soils

Type of soil	soil depth (cm)	CEC	Ca	Mg	K	Na	ESP	% BS	Fe	Cu	Zn	Mn
		Cmol (+) kg^{-1} of soils							mg kg^{-1} soil			
Luvic Calcisols (Siltic)	0-15	43.9	29.1	1.7	1.5	1.0	2.28	75.8	0.23	0.40	0.36	0.50
	15-30	44.9	30.1	1.7	1.2	0.7	1.56	75.1	0.38	0.33	0.33	0.23
Haplic Calcisols (Chromic)	0-15	26.7	17.3	0.9	2.3	0.4	1.50	79.0	0.53	0.22	0.22	0.47
	15-30	25.7	16.7	1.6	2.6	0.8	3.11	84.9	0.70	0.15	0.15	0.45
Haplic Calcisols (Humic)	0-15	20.1	11.7	2.6	2.3	1.5	7.46	85.3	2.94	0.27	0.27	1.23
	15-30	21.3	13.0	3.0	2.1	1.8	8.45	88.9	2.37	0.18	0.19	1.18
Haplic Luvisols (Humic)	0-15	40.6	25.4	2.0	0.6	0.4	0.99	69.7	1.42	1.47	1.47	0.58
	15-30	38.9	24.8	3.1	0.6	0.7	1.54	74.5	1.06	1.29	1.3	0.40
Andic Lixisols (Humic)	0-15	21.7	14.1	1.3	1.7	0.5	2.30	84.3	1.60	0.27	0.27	1.30
	15-30	21.7	12.5	2.1	1.6	0.7	3.23	78.4	1.61	0.26	0.26	1.30
Andic Cambisols (Humic)	0-15	20.6	12.0	2.0	1.5	0.9	4.37	79.9	2.56	0.40	0.38	1.50
	15-30	21.7	13.3	1.1	1.3	1.8	8.29	81.8	2.48	0.25	0.25	1.30
Haplic Lixisols (Siltic)	0-15	19.6	13.6	1.3	1.2	0.6	3.06	84.7	3.25	0.28	0.38	1.30
	15-30	20.7	13.5	0.8	1.1	1.1	5.31	79.5	1.59	0.38	0.28	1.50
Haplic Lixisols (Humic)	0-15	23.2	15.0	1.2	1.8	1.4	6.03	84.2	1.71	0.27	0.27	1.90
	15-30	20.3	13.2	1.1	1.7	0.3	1.48	80.5	1.34	0.24	0.24	1.80

Correlation among soil properties in 0-15cm depth of the soils was indicated in Table 4. Organic carbon was positively correlated with pH, total nitrogen and $CaCO_3$ indicating that an increase of OC in calcareous soils can form $CaCO_3$ and OC is the major source of nitrogen. There was also a positive correlation between OC and CEC indicating organic matter can increase negative charges in the soil that can hold cations. Organic carbon was observed to be negatively correlated with available phosphorus (P) which might be attributed to the precipitation of P with $CaCO_3$ caused by increased OC. Organic carbon was also negatively correlated with Fe, Zn, Cu and Mn which might be attributed to the strong chelation between the metals and organic matter that can reduce the availability of the micronutrients. This is in line with McKenzie (1992) who stated that excessive chelation of organic matter in the soil with micronutrients can cause deficiencies of micronutrients. Calcium carbonate was positively correlated with pH but it was negatively correlated with available P, Zn, Fe, Cu and Mn which might be attributed to the precipitation of these nutrients with $CaCO_3$. Soil reaction was positively correlated with total nitrogen and CEC, but it was negatively correlated with available P, Zn, Fe, Cu and Mn indicating their availability is low at high pH (McKenzie, 1992; Mesfin Abebe, 2007) because high pH is responsible for their oxidation that can reduce their availability (Kumar and Babel, 2011). CEC was positively correlated with cationic micronutrients indicating soils with high CEC (high negative charges) can hold large amounts of micronutrients due to more availability of exchange sites on soil colloids (Kumar and Babel, 2011). Zinc and Fe were negatively correlated with Cu indicating application of Zn and Fe in to soils can reduce the availability of Cu.

Table 4. Correlation between soil physicochemical properties within 0-15cm depth

	OC	$CaCO_3$	pH	EC	TN	CEC	Ca	Mg	K	Na	AvP	Zn	Fe	Cu	Mn	BSP
OC	1	0.6***	0.7***	-0.03	0.4*	0.6***	0.6***	-0.1	0.01	0.03	-0.23	-0.3*	-0.5**	-0.06	-0.4**	-0.3
$CaCO_3$		1	0.5**	0.1	0.4*	0.3	0.3	-0.3	-0.03	0.01	-0.32	-0.1	-0.4**	-0.1	-0.3	-0.2
pH			1	-0.02	0.2	0.3	0.34*	-0.1	-0.03	0.1	-0.05	-0.2	-0.3	-0.2	-0.3	-0.02
EC				1	0.1	-0.01	0.1	-0.4*	0.02	-0.3	0.1	0.2	-0.3*	-0.1	0.1	-0.03
TN					1	0.4*	0.4*	0.3	0.1	0.4*	-0.3	-0.1	-0.3	-0.1	-0.2	0.01
CEC						1	1***	0.1	-0.4**	-0.2	-0.2	-0.6***	-0.5***	0.5***	-0.2	-0.7***
Ca							1	0.1	-0.4*	-0.2	-0.1	-0.6***	-0.6***	0.5***	-0.2	-0.6***
Mg								1	-0.1	0.5***	0.03	-0.1	0.3*	0.1	0.2	0.3
K									1	0.2	-0.04	0.4*	0.1	-0.7***	-0.3*	0.5***
Na										1	0.3	0.1	0.3	-0.3*	-0.1	0.4*
AvP											1	0.2	0.4*	-0.1	0.1	0.4*
Zn												1	0.3	-0.3	0.4*	0.5***
Fe													1	-0.2	0.2	0.4*
Cu														1	0.5***	-0.6***
Mn															1	-0.01
BSP																1

4. Conclusion

The result of soil analyses indicated that the values of all the analyzed soil parameters varied between soil depths within and among soil types indicating that soil fertility management plan should consider soil types and depths. Organic carbon was positively correlated with total nitrogen indicating that OC is the major source of N in the soils, whereas pH was negatively correlated with available P, Zn, Fe, Cu and Mn indicating these nutrients decrease with increasing pH. Generally, the status of macronutrients and organic carbon was moderate but micronutrients were low. Therefore, soil fertility management plan in the soils of the study areas should consider the improvement of macronutrients and micronutrients associated with pH reduction and improvement of nutrients placement for better production of different crops.

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