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Assessment of the Physicochemical Properties and Macro Nutrients of Surface Soil in Shewa Robit, Amhara Regional State, Ethiopia

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Abstract

This study was conducted in Shewa robit, Amhara Regional State, Ethiopia by collecting the composite samples to compare the three different study districts (*Kebele* 1, *Kebele* 2, and *Kebele* 3) during November- January 2013 cropping season. The study was made at a total of thirty sampling sites and each district covered 225m^2 sampling area. Composite samples of surface soil were collected using special auger from a depth of 0-15 cm. The laboratory analysis results indicated that the electric conductivity, organic carbon, moisture content, bulk density, nitrogen, phosphorus and potassium of the soil were showed significant variations while, the soil pH and soil texture were not showed significant variations ($P<0.05$). As the phosphorus and organic carbon content was lower than the recommended level, it needs environmentally and socially acceptable integrated nutrient management practices like agro-forestry systems, crop rotation, organic inputs, chemical fertilizers, and improved crop varieties that can be adapted to local farming situation should be implemented for sustainable agricultural development in the study area.

Keywords: Auger, macro nutrient, physicochemical properties, soil fertility, surface soil.

Introduction

Ensuring food security for the ever-increasing world population has direct relation with physicochemical property, fertility and productivity of soil. The overall productivity and sustainability of a given agricultural sector is highly dependent up on the fertility and physicochemical characteristics of soil resources (Wakene, 2001; Mohammed *et. al*., 2005). Surface soil is the region of soil in which most of biological activities takes place. In general, there is a higher nutrient availability in the surface soil than other soil (Curl and Truelove, 1986; Yong and Crowley, 2000).

In Ethiopia, agriculture is the back bone of the national economy. It accounts approximately 50% of the Gross Domestic Product (GDP) and 90% of its foreign exchange earnings (EEA, 2001). It is obvious that sustainable and high agricultural production needs fertile and productive soils. However, the FAO (1998) report shows that 24% of Ethiopia's soil face moderate to very severe fertility constraints affecting the key farming regions. According to IFPRI (2010), the major causes of nutrient depletion include farming without replenishing nutrients over time (loss through continuous crop harvest), removal of crop residue, low level of fertilizer use and unbalanced application of nutrients. Soil characterization in relation to evaluation of fertility status of the soils of an area is an important aspect in context of sustainable agricultural production (Singh and Mishra, 2012).

Periodic assessment of important soil physical, chemical and biological properties and their responses to changes in land management is necessary to apply appropriate agricultural technologies and effective design of soil fertility management techniques; and to improve and maintain fertility and productivity of soil (Wakene and Heluf, 2003). Despite the fact that information about soil physicochemical property and fertility status plays a vital role in enhancing production and productivity of the agricultural sector; there is still little information about the physicochemical property and fertility status of soils of the study area. Therefore, this study was conducted to assess the physicochemical characteristics and macro nutrients of surface soils in Shewa robit, Amhara Regional State, Ethiopia.

Materials and Methods

Study area:

The experiment was conducted on 3 districts (*Kebele* 1, *Kebele* 2, and *Kebele* 3) in Shewa robit, North Shewa Zone of the Amhara Regional State, Ethiopia, during November- January 2013 cropping season. The area is located at 115 km northeast from Addis Ababa, the capital city. The average maximum temperature in all the study areas was 25.6^{o}C during the year of study. The districts are situated between 10°00' to 10^{0}55'N latitude and 39°53' to 40^{0}00'E longitude with an altitude of 1280 mean above sea level. Shewa robit is endowed with a high potential for agricultural production. Crops previously grown on the experimental area were *Sorghum* (*Sorghum bicolor*), maize

(*Zea mays*), Timbaho (Tobacco), teff (*Eragrostis tef*) and Masho *(Vigna radiata*). *Kebele* 1 is located 5.5 km in the north direction from Shewa robit. It has a moderate slope and the land has been cultivated sorghum, maize, and tobacco for vegetables with some grass-covered areas mainly used for the grazing of cattle. *Kebele* 2, which is about 8 km East of Shewa robit, has a gentle slope and the land has been used for only 3 years for the cultivation of sorghum and Masho. While *Kebele* 3, located within 4 km in the south direction of the town, is a nearly flat slope and its farmland has been cultivated for 13 years primarily for sorghum, maize, teff and wheat.

Methods:

Both the physicochemical properties and macro nutrients of the soil were analysed by collecting composite samples from a depth of 0-15 cm. The study was made from a total of thirty sampling sites and each district covered $225m^2$ sampling area (10 sites). The soil samples were air-dried, crushed and passed through a 2-mm sieve and then mixed thoroughly to obtain a homogeneous mixture. The soil pH was determined in a soil:water (1:2.5) mixture using a pH meter following the method of Juo (1978). The electrical conductivity was measured by using calibrated conductivity meter (CW6120). Soil organic carbon was assessed according to Piper (1950). Moisture content and bulk density were determined according to the method of Jackson (1973) and the texture class of the soil was determined by soil textural triangle, following the method of Juo (1978). Nitrogen content was estimated by modified micro Kjeldhal method (Jackson, 1967). Available phosphorus was determined by the method of Kitson and Mellon (1944) while potassium was determined by a flame photometer.

Data presentation and statistical analysis:

The results were presented as an average of five determinations (n=5) ± standard error (SE) and the data were analysed with ANOVA using SPSS Software (Version 20, SPSS Inc., Chicago USA). The *Kebeles* soil means were separated using the Least Significant Differences (LSD) test at 5% level of significance.

Results and Discussion

The results of physicochemical and macro nutrients of the soils of study area are presented in table 1 and figure 1 respectively. From the physicochemical properties the electric conductivity, organic carbon, moisture content and bulk density of the soil were showed significant variation while, the soil pH and soil texture were not varies significantly ($P<0.05$). The soil pH, which varies from 6.2 to 6.7, lies within the preferred range for most crops. The electric conductivity of the three *Kebeles* soils had significant difference and based on the LSD test, all the three *Kebeles* showed significant variation at $P< 0.05$ (Table 1). The maximum value was recorded from *Kebele* 1 while the minimum was from *Kebele* 2. The electrical conductivity values of the three district soils can be classified as Index 0 in the ADAS recommendations (ADAS, 1973) and all were found within the normal range and suitable for most crop production. The fertility of soil is highly interrelated with its organic matter which has an influence on the physical, chemical and biological properties of the soil. It is well known that under continuous agricultural practice, the organic matter content in the top soil will decrease. The organic carbon content in all studied soil samples were found very low (< 4%). This may be attributed to intensive agricultural practices that aggravate organic carbon oxidation (Wakene and Heluf, 2003; Taye and Yifru, 2001). Based on the LSD test, the moisture content of *Kebele* 3 soil showed significantly lower (8.5%), while *Kebele* 1, soil has significantly higher moisture content (10.5%) ($P< 0.05$). The bulk densities of the studied soils were equal or less than 1.44, which is common in cultivated soils. The low bulk density found in soils from *Kebele* 2, indicates that the soils are not compacted and have more porosity. This is beneficial to root activity, water infiltration, and overall growth of crops. Soil with very high bulk density can limit root growth, aeration and availability of less mobile essential plant nutrients such as P and K (Dolan, 1992; Achalu *et. al*, 2012). The texture class of the soils varies from clay loam to black clay loam. Loam soil texture can be classified as excellent for most crop cultivation. The soil texture is the most determinant soil physical property largely determines its utilization (Hassink, 1992; Hugo *et. al.*, 2002).

Table 1. Physicochemical properties of surface soils of study area.

Soil property	***Kebele* 1**	***Kebele* 2**	***Kebele* 3**
pH	6.7 ± 0.02	6.4 ± 0.05	6.2 ± 0.05
Electrical conductivity (dSm^{-1})	1.9 ± 0.02	1.6 ± 0.02	1.8 ± 0.02
Organic carbon (%)	1.52 ± 0.04	1.66 ± 0.02	1.62 ± 0.05
Moisture (%)	8.5 ± 0.04	10.5 ± 0.04	10.8 ± 0.05
Bulk density ($g\ cm^{-3}$)	1.24 ± 0.04	0.84 ± 0.02	1.27 ± 0.06
Sand (%)	30.4 ± 0.04	31.5 ± 0.03	33.1 ± 0.03
Silt (%)	28.5 ± 0.05	24.7 ± 0.03	24.4 ± 0.04
Clay (%)	43.8 ± 0.03	45.2 ± 0.01	45.8 ± 0.06
Textural class	Red clay loam	Clay loam	Black clay loam

Note: Data represent the Mean±SE of the five replicates

The available nitrogen content showed significant variation at P<0.05 (Fig. 1). The LSD test showed that *Kebele* 3 has significantly higher nitrogen content (980 ± 5.1 mg Kg^{-1}) while *Kebele* 2 showed lower value (648 ± 7.5 mg Kg^{-1}), but it showed insignificant variation with *Kebele* 1 (Fig. 1). In general the nitrogen content in all the soils is high, ranging between 640 - 980 mg Kg^{-1}. The main source of both N and P in the farmlands is organic matter. The available phosphorus content showed significant variation at P<0.05 (Fig. 1). From all the macro nutrients, phosphorus has the most complicated chemistry. Phosphorus occurs in soil in both organic and inorganic forms, the inorganic form being more important for crop nutrition. Low available phosphorus is indicative of acute deficiency. There is a similarity among all the soil samples in a very low phosphorus level which falls between Index 0-1 categories (ADAS, 1973). At this level, there is a possibility of failure of crops production. The cultivated soils of *Kebele* 3 have slightly higher phosphorus content than the rest two *Kebeles* soils. The difference could be accounted for by the P fertilizer application over the years in the cultivated areas. The available potassium content showed significant variation at P<0.05 (Fig. 1). Available potassium content is medium (237±5.6 mg Kg^{-1}) in the *Kebele* 2 soil but high in the other two soil samples (>281.6 mg Kg^{-1}) (Singh and Mishra, 2012). This may be due to the continuous use of animal waste for several years in those two locations. However, the lower potassium content of *Kebele* 2 may be related with the high leachable capacity of potassium due to its sloppiness of the area. According to the farmers, good yields are obtained for maize and corn crops in both *Kebele* 1 and *Kebele* 3 farms. Similarly, wheat yield obtained from *Kebele* 2 is good, while its maize yield is poor. Similar to our findings Gunes *et al.* (2003) reported that yield has direct relation with potassium content.

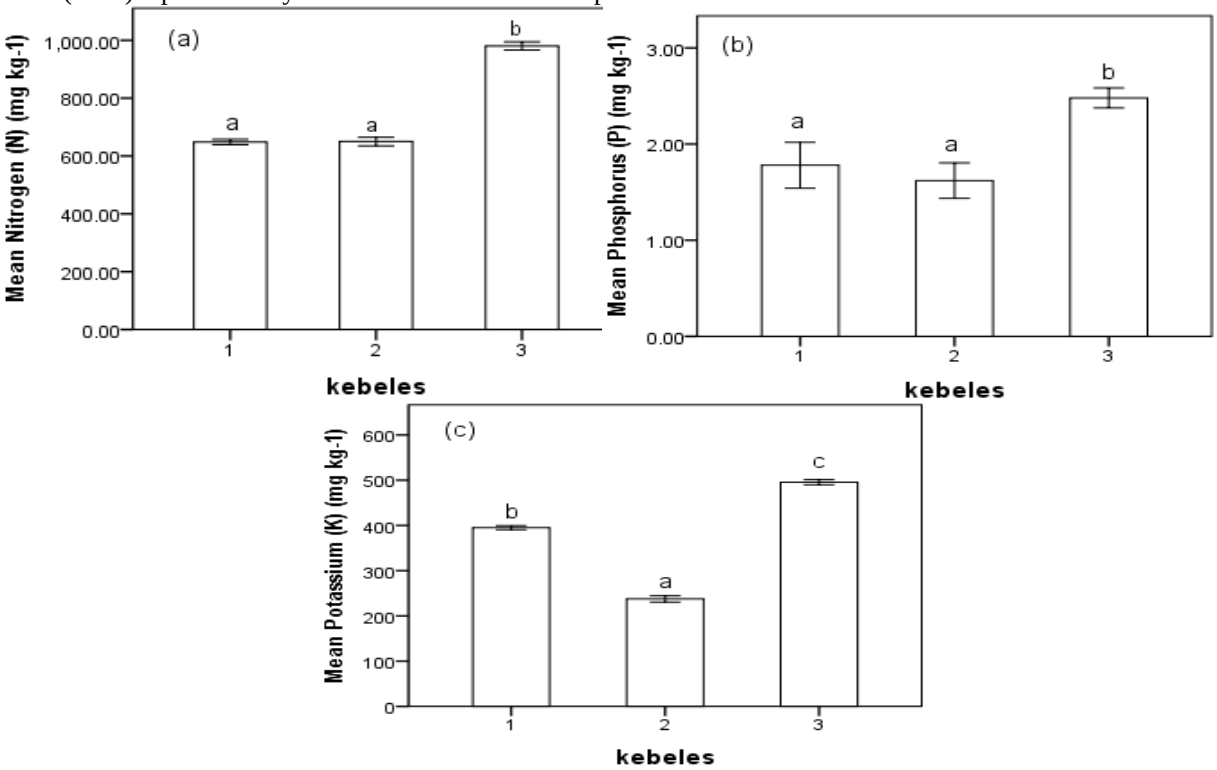

Fig. 1(a-c): The mean value of (a) Nitrogen, (b) Phosphorus, (c) Potassium of the soils of study area.
Note: Bars represent Mean±SE of the five replicates and designated with the same letter are not significantly different between the *Kebeles* soil (p<0.05).

Conclusions

The physicochemical characteristics of Shewa robit surface soils of the three *Kebeles* have been determined. Based on the ANOVA result, most of the physicochemical parameters such as electric conductivity, organic carbon, moisture content and bulk density of the soil were showed significant variation while, the soil pH and soil texture were not showed significant variation at P<0.05. on the other hand, results from the macro nutrient analysis show that two macronutrients (N, K) are found optimal while available P is deficient for major crops such as maize, wheat, teff and corn grown in the area. In order to obtain optimal yield for the cereal crops in the studied area, phosphorus and organic carbon content of the soils needs to improve through application of fertilizers and improved drainage activities. Moreover further study is recommended to assess the micro nutrient status of the area.

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