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# The Impact of Conservation Agricultural Practices on Soil Carbon and Nutrients, in Bako Tibe District, Western Oromia, Ethiopia

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**Abstract**
With the obcetives of assessing the effect of different conservation agriculture practices on soil carbon and nutrients in Bako District, six treartments were selected for the study namely: Monocropping (maize) without crop residue, Monocropping (maize) with crop residue, Crop rotation (mazie and haricot bean) with crop residue, Inter cropping (Haricot bean with maize) with crop residue and Pigeon pea shurb specie planted as a hedge row and including a near by grazing land (Orginal land use). A completely randomized design with four replications was used. A total of 48 composite soil samples (4 replication * 6 treatments * 2 soil depth: 0– 10 cm and 10–30 cm) were collected and analyzed for soil carbon and nutrients. The soils in the study area were moderately acidic, and contain medium level of AP, but low concentration of total N. Soil pH, SOC, TN, C:N, and AP did not significantly different among the treartments after four years of conservation agricutural practices. Therefore, conservation agriculture has little effect on SOC and other soil nutrients in short term, but it may take longer time to influence soil organic Carbon and nutrients in the study area.
**Keywords:** Crop rotation; grazing land; intercropping; nutrients; soil organic carbon; crop residue.

## 1. Introduction

Reducing soil resource degradation, increasing agricultural productivity, reducing poverty, and achieving food security are major challenges of the countries in tropical Africa. The causes of soil degradation in Ethiopia are cultivation on steep and fragile soils, erratic and erosive rainfall patterns, declining use of fallow, and limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, overgrazing and deforestation (Hurni, 1988; Belay, 2003). Management practices in the areas of intensive agriculture may affect soil properties as they vary according to soil formation factors such as parent material, topography and climate (Celik *et al.,* 2011).

Continuous cultivation with poor soil management including the removal of crop residues and burning, intensive tillage and monocropping leads to decline of soil fertility. Compared to tillage based agriculture, conservation agriculture (CA) has the potential to decrease soil loss, enhance levels of soil organic matter, increase plant available soil water, and save costs due to fewer or no tillage operations (Teklu, 2011). Current uses of different conventional agricultural practices are the major threat to land productivity and soil fertility decline in sub-Saharan Africa, but few studies were carried to identify the limitation of conventional agricultural practices. In Bako area maize is the main dominant crop and monocropping is the most common agricultural farming practice. The agricultural research institute has been undertaking a controlled study on different conservation agricultural practices on farmers land. Taking this opportunity, this research initiated to assess the impact of conservation agricultural practices namely: Monocropping with Residues (MCR), Crop rotation with residues (CRR.), Intercropping with Residues (ICR) and Pigeon Pea planted as a hedge row (PPH) on soil carbon and Nutrients.

## 2. Materials and Methods

### 2.1 Description of the study area

The study was conducted Bako district, western Oromia. Bako is located at 9° 08' N latitude and 37° 03' E longitude; about 251 km from Addis Ababa. The altitude where the soil samples collected was located ranged from 1670 to 1690 m.a.s.l. The long term weather information revealed that the area has unimodal rainfall pattern extending from March to October, but the effective rain is from May to September (Legesse *et al.*, 1987). The mean annual rainfall is about 1237 mm, with a peak in July. It has a warm humid climate with annual mean minimum and maximum temperature of 14 °C and 29 °C, respectively and the mean annual temperature is 20 °C. Soils at the study site are dominantly Nitosols with reddish brown colour. They are generally clay dominated with a pH in between 5- 6 [1]in surface soils (Legesse *et al.*, 1987).

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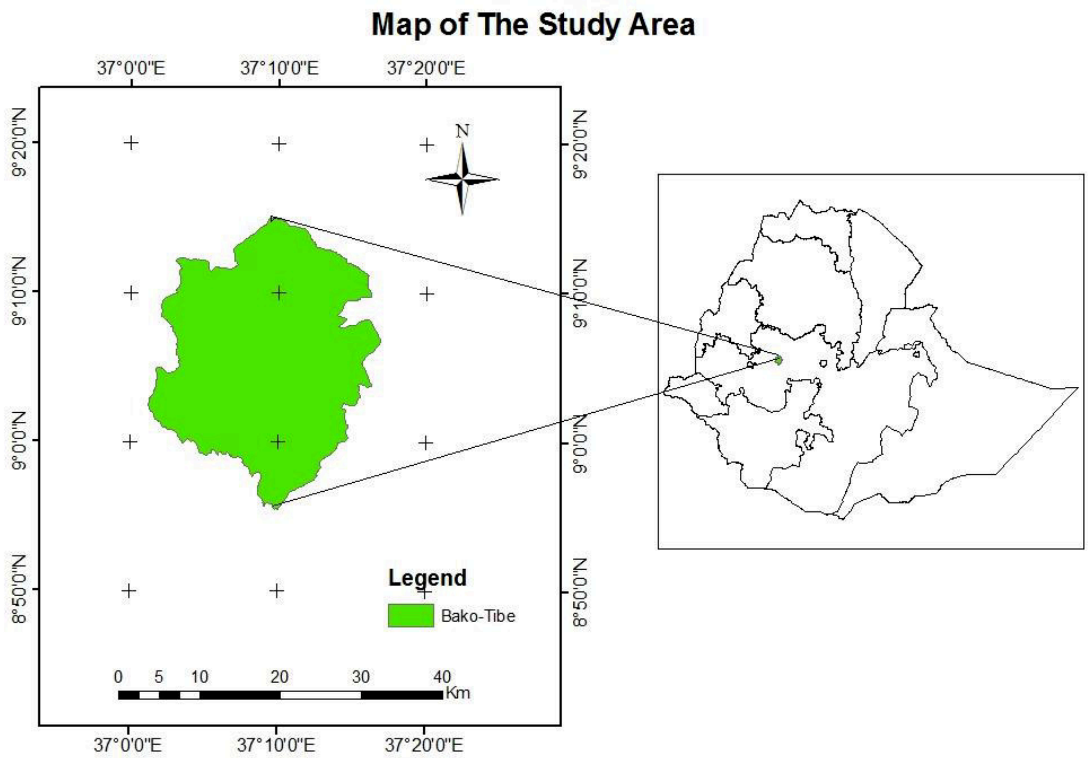


**Figure 1: Map of the Study area – Bako district.**

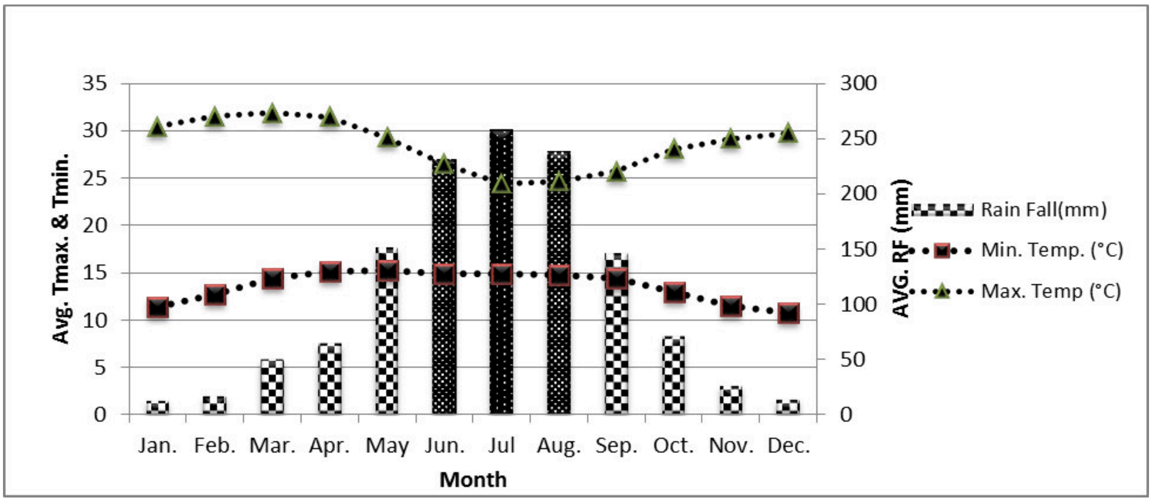


**Figure 2. Mean monthly rainfall (RF), maximum and minimum temperature (Temp.) of the study area (1961-2013).**

### 2.2 Soil Sampling and Laboratory analysis

Four plots (10m x 10m) were randomly selected in each of the six treatments arranged in a RCBD. To minimize border effect soil samples were collected from 8m * 8m plot since the main plots have a minimum distance of 1m between the plots. In each plot (8m*8m), the soil samples were collected from two soil depths (0-10 and 10-30cm) at the corners and centre of the plots. Then the samples from each plot were bulked to form a composite sample at 0-10 and 10-30 cm layers, and a total of 48 composite soil samples (6 treatments* 2 soil depths * 4 plots) were collected for the study. The six treatments in this study are Monocropping without crop residue, Monocropping with crop residue, Crop rotation with crop residue, Inter cropping with crop residue and Pigeon pea shrub specie planted as a hedge row and including a nearby grazing land (Original land use).

### 2.3. Statistical analysis

Laboratory results were analyzed using General Linear Model (GLM) procedure of SAS statistical software version 9.0.2004. Analysis of variance (ANOVA) was employed to test the variations. For significant differences, mean separation using LSD was conducted at 5 % level of significance.

## 3. Results and Discussion

### 3.1 Soil Carbon and nutrients

#### 3.1.1 SOC, Soil pH, TN and C:N Ratio

The interaction among the agricultural practices including the grazing land with soil depth was not significant for soil pH, SOC, TN, and C:N ratio (p=0.958, p=0.998, p=0.219, and p=0.140), respectively. Soil pH, SOC, TN, and C:N ratio were not significant (p=0.866, p=0.936, p=0.330 and p=0.196), among the agricultural practices and the grazing land. Depth wise SOC and TN were statistically significant (p=0.0035, and p= 0.0004), while, soil pH and C:N ratio were not significantly (p=0.589 and p=0.460), respectively different at a given soil depths (Table 1).

**Table 1: Summary of ANOVA for pH, SOC (%), N (%), AP (mg/kg), and C:N ratio under different agricultural practices and soil depths.**

| Source of variatio | Df | pH | | SOC (%) | | TN (%) | | C:N ratio | | AP (mg/kg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MS | P | MS | P | MS | P | MS | P | MS | P |
| Soil Depth (D) | 1 | 0.041 | 0.589 | 2.618 | 0.0035 | 0.031 | 0.0004 | 3.310 | 0.460 | 9.180 | 0.087 |
| Practices (P) | 5 | 0.051 | 0.866 | 0.067 | 0.936 | 0.002 | 0.330 | 9.260 | 0.196 | 1.270 | 0.827 |
| P*D | 5 | 0.028 | 0.958 | 0.013 | 0.998 | 0.003 | 0.219 | 10.610 | 0.140 | 2.340 | 0.568 |
| Error | 36 | 0.138 | | 0.267 | | 0.002 | | 5.940 | | 2.979 | |

Soil pH increased with soil depth. Different agricultural practices systems for four years had no effect on soil pH (Table 2). Generally, the soil pH values observed in the study area are within the range of moderately acidic soil as indicated by Foth and Ellis (1997). Several authors Abebe (1998), Islam and Weil (2000), Wakene and Heluf (2003) and Gebeyaw (2007) reported that the soil pH was lower in cultivated land than GL, and this was attributed to the depletion of organic matter because of intensive cultivation.

In contrast to these studies, in the present study the mean value of soil pH was relatively lower under agricultural practices than pigeon pea shrub planted as a hedge row and grazing land but no statistical difference was observed among all agricultural practices, pigeon pea shrub planted as a hedge row and grazing land. According to Du Preez, *et al*., 2001, experimental research revealed that soil pH was significantly higher under conservation agriculture than conventional agriculture practices after 11 years of practices. Based on this finding, the absence of difference under all agricultural practices and grazing land in the present study could be attributable to the age of conservation agriculture practices which was only four years old.

Soil Organic Carbon (SOC) concentration was not significantly different among the agricultural practices and the grazing land, while the overall mean of SOC concentration was in the range between 2.23 to 2.46%. Consistent with the present study, SOC was not affected by conservation agriculture within four years of practice when compared to conventional agriculture Bielders, *et al*., (2002), Ben-Moussa., *et al.,* (2010). In contrast, Nyamadzawo, *et al.,* (2008) and Gwenzi, *et al.,* (2009), reported that SOC was higher under conservation agriculture after five and ten years of practice, respectively. They attributed the low SOC content in continuous cultivated soils of conventional agriculture to reduced inputs of organic matter obtained from crop residues and frequent tillage which encouraged oxidation of organic matter. So, according to Nyamadzawo, *et al.,* (2008) and Gwenzi, *et al.,* (2009), the SOC might change after practicing conservation agricultural for greater than four years.

The mean of total N content varied from 0.15 to 0.20% under agricultural practices and the grazing land. After practicing conservation agriculture for four consecutive years, total N did not differ significantly when compared to conventional agriculture (Table 2). Following the rating of total N of > 1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and < 0.1% as very low N status as indicated by Landon (1991), all the agricultural practices and the GL have low content of total N. The low level of nitrogen in the practices may imply that fertilizer additions have not replaced the total N lost due to harvest removal, and /or leaching Malo *et al*., (2005). In agreement with the present study, Saito, *et al.,* (2010) reported that there was no significance difference in total N under conservation agriculture practices after practicing for four years in Benin. Whereas, Ben-Moussa., *et al.,* (2010), and Enfors, *et al*., (2010) reported that total N was significantly higher under four years' conservation agriculture practices than conventional due to the addition of manure on the experimental fields. Crop residue management, intercropping, and crop rotation in the present study can potentially increase total N in the soils, but the level of influence may depend on the age of the practice.

The mean C:N ratio was not significantly different among the agricultural practices and the GL, and the C:N ratio had a very narrow range between 12.2 and 15.4 (Table 2). A SOC with high C:N ratio is low in quality as compared to SOC with low C:N ratio due to the increased immobilization of N by micro-organisms Handayanto *et al*., (1997). As a general guideline, when the C:N ratio is greater than 30:1, N is immobilized by soil microbes while if C:N ratio is less than 20:1, there is a release of mineral N in to the soil environment. The N released in to the soil under the latter condition (C:N < 20:1) is available for plant uptake (Jones, 2003). In the present study, the C:N ratio was below 16.6 for all the soils in the study area which indicates that there could be release of available form of N to the soil system through the mineralization process of soil OM. The observed values of C:N ratios may suggest that there was no problem of N immobilization which could significantly affect the availability of N for crop uptake.

### 3.1.2 Available Phosphorus

Agriculture practices and or its interaction with soil depth was not significantly different (p=0.568) for available P (Table 1). According to Landon (1991) available soil P level of 5-15 mg/kg is rated as medium, and accordingly the available P of the study area was found in the medium range. Ben-Moussa., *et al., (*2010) reported that available P was similar in the soils of conservation agriculture when compared to conventional agriculture practices within four years of practices in Tunisia. In contrast, conservation agriculture practice the 11 years showed that available P increased when compared to conventional tillage practice Du Preez, *et al*., (2001). Based on these findings, the present study may suggest that the available P could change after exercising conservation agriculture for greater than four years of time.

**Table 2: Mean ± SE of total N (%), SOC (%), C:N ratio, AP (mg/kg) and pH of soil in relation to different agricultural practices including GL with soil depths.**

| Practices | Soil depth | TN (%) | SOC (%) | C:N ratio | AP (mg/kg) | pH |
|---|---|---|---|---|---|---|
| MC(-R) | 0-10cm | 0.16±(0.03)$^a$ | 2.44±(0.17)$^a$ | 16.62±(2.90)$^a$ | 7.50±(1.19)$^a$ | 5.50±(0.14)$^a$ |
| | 10-30cm | 0.14±(0.01)$^a$ | 2.02±(0.29)$^a$ | 14.17±(1.23)$^a$ | 6.30±(0.48)$^a$ | 5.60±(0.28)$^a$ |
| | Over all mean | 0.15±(0.02)$^A$ | 2.23±(0.19)$^A$ | 15.39±(1.53)$^A$ | 6.88±(0.64)$^A$ | 5.55±(0.11)$^A$ |
| MCR | 0-10cm | 0.20±(0.02)$^a$ | 2.57±(0.24)$^a$ | 12.67±(0.60)$^a$ | 7.80±(0.95)$^a$ | 5.50±(0.30)$^a$ |
| | 10-30cm | 0.15±(0.02)$^a$ | 2.11±(0.30)$^a$ | 14.07±(0.80)$^a$ | 7.00±(0.71)$^a$ | 5.70±(0.20)$^a$ |
| | Over all mean | 0.18±(0.02)$^A$ | 2.34±(0.19)$^A$ | 13.37±(0.53)$^A$ | 7.40±(0.64)$^A$ | 5.60±(0.17)$^A$ |
| CRR | 0-10cm | 0.20±(0.01)$^a$ | 2.61±(0.26)$^a$ | 13.30±(0.80)$^a$ | 7.00±(0.91)$^a$ | 5.60±(0.27)$^a$ |
| | 10-30cm | 0.16±(0.03)$^a$ | 2.22±(0.40)$^a$ | 14.64±(0.80)$^a$ | 8.00±(0.90)$^a$ | 5.70±(0.21)$^a$ |
| | Over all mean | 0.18±(0.02)$^A$ | 2.41±(0.23)$^A$ | 13.95±(0.59)$^A$ | 7.50±(0.63)$^A$ | 5.65±(0.16)$^A$ |
| ICR | 0-10cm | 0.18±(0.02)$^a$ | 2.53±(0.22)$^a$ | 14.50±(0.78)$^a$ | 7.30±(0.80)$^a$ | 5.60±(0.20)$^a$ |
| | 10-30cm | 0.16±(0.02)$^a$ | 2.06±(0.28)$^a$ | 13.00±(0.94)$^a$ | 6.80±(0.85)$^a$ | 5.70±(0.18)$^a$ |
| | Over all mean | 0.17±(0.01)$^A$ | 2.29±(0.19)$^A$ | 13.75±(0.63)$^A$ | 7.00±(0.53)$^A$ | 5.65±(0.11)$^A$ |
| PPH | 0-10cm | 0.22±(0.02)$^a$ | 2.77±(0.27)$^a$ | 12.90±(0.82)$^a$ | 8.30±(0.85)$^a$ | 5.90±(0.12)$^a$ |
| | 10-30cm | 0.16±(0.003)$^a$ | 2.16±(0.22)$^a$ | 13.20±(1.12)$^a$ | 6.30±(1.11)$^a$ | 5.70±(0.15)$^a$ |
| | Over all mean | 0.19±(0.01)$^A$ | 2.46±(0.20)$^A$ | 13.03±(0.64)$^A$ | 7.25±(0.35)$^A$ | 5.80±(0.09)$^A$ |
| GL | 0-10cm | 0.26±(0.05)$^a$ | 2.48±(0.19)$^a$ | 10.17±(1.34)$^a$ | 8.00±(0.75)$^a$ | 5.70±(0.10)$^a$ |
| | 10-30cm | 0.14±(0.01)$^a$ | 2.01±(0.25)$^a$ | 14.17±(0.66)$^a$ | 7.50±(0.65)$^a$ | 5.80±(0.14)$^a$ |
| | Over all mean | 0.20±(0.02)$^A$ | 2.24±(0.09)$^A$ | 12.17±(1.03)$^A$ | 7.87±(0.48)$^A$ | 5.75±(0.04)$^A$ |

**Means within a column for the same depth followed by the same letter are not significantly different from each other at p < 0.05. **Monocropping without Residues (MC(-R), Monocropping with Residues (MCR), Crop rotation with residues (CRR.), Intercropping with Residues (ICR), Pigeon Pea planted as a hedge row (PPH), Grazing land (GL).*

## 5. Conclusion

In the study area the local farmers widely practice traditional farming systems. This farming system involves intensive and continuous cultivation which highly depleted the soil fertility, reduced the production of the land and exposed the soil for leaching and erosion. The objective of the study was to assess the impact of conservation agricultural practices on soil carbon and nutrients. Accordingly, the results of the present study showed that the conservation agricultural practices did not influence the soil carbon and nutrients (soil pH, SOC, TN, C:N, and Av.P) within four years of practice. Therefore the present finding suggests that conservation agricultural practices namely: addition of crop residue, crop rotation with crop residue, intercropping with crop residue and Pigeon Pea planted as a hedge row (PPH) in Bako may require longer years of practice before their influence on soil chemical and physical properties are visible.

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**References**

Abebe Yadessa, 1998. Evaluation of the Contribution of Scattered *Cordia africana* Trees to Soil Properties in Cropland and Rangeland Ecosystems in Western Oromia, Ethiopia. M.Sc. Thesis, Swedish University of Agricultural Sciences, Sweden.112p.

Ahmed Hussein., 2002. Assessment of spatial variability of some physicochemical properties of soils under different elevations and land use systems in the western slopes of Mount Chilalo, Arsi. M.Sc. Thesis, Alemaya University, Ethiopia. 111p.

Bako Agricultural Research Center (BARC), 2013. Meteorological data records for the years 1961-2013.

Belay Simane, 2003. Integrated watershed management approach to sustainable land management (Experience of SARDP in East Gojjam and South Wollo). PP.127-136.

Ben-Moussa M., Ben-Hammouda, M., and Nouira, S., 2010. Comparative effects of conventional and no-tillage management on some soil properties under Mediterranean semi-arid conditions in north-western Tunisia. *Soil and Tillage Research.*106:247-253.

Bielders, C. L., Michels, K. and Bationo, A., 2002. On-farm evaluation of ridging and residue management options in a sahelian millet-cowpea intercrop. Soil quality changes. *Soil use and Management,* 18: 216-222.

Celik, I., Barut, Z.B., Ortas, I., Gok, M., Demirbas, A., Tulun, Y., Akpinar, C., 2011. Impacts of different tillage practices on some soil microbiological properties and crop yield under semi-arid Mediterranean conditions. *International Journal of Plant Production* 5:237-254.

Du Preez, C. C., Steyn, J. T., and Kotze, E., 2001. Long-term effects of wheat residue management on some fertility indicators of a semi-arid plinth sol. *Soil and Tillage Research,* 63: 25-33.

Enfors, E., Barron, J., Makurira, H., Rockström, J., and Tumbo, S., 2010. Yield and soil system changes from conservation tillage in dry land farming: A case study from north eastern Tanzania. Agricultural Water Management.

Foth, H.D. and B.G. Ellis., 1997. Soil fertility, 2nd Ed. Lewis CRC Press LLC., USA.

Gebeyaw Tilahun., 2007. Soil fertility status as influenced by different land uses in maybar areas of south Wello zone, north Ethiopia, M.Sc. Thesis Submitted to School of Graduate Studies, Alemaya University, Ethiopia. 86p

Gicheru, P., Gachene, C., Mbuvi, J., and Mare, E., 2004. Effects of soil management practices and tillage systems on surface soil water conservation and crust formation on a sandy loam in semi-arid Kenya. *Soil and Tillage Research,* 75:173-184.

Gwenzi, W., Gotosa, J., Chakanetsa, S., and Mutema, Z., 2009. Effects of tillage systems on soil organic carbon dynamics, structural stability and crop yields in irrigated wheat (triticum aestivum L.)-cotton (gossypium hirsutum L.) rotation in semi-arid Zimbabwe. *Nutrient Cycling in Agroecosystems,* 83:211-221.

Handayanto, E., Cadish, G., and Giller, K.E., 1997. Regulating nitrogen mineralization from plant residues by manipulation of quality. In: Cadish G and Giller KE (eds) Driven by Nature: Plant Litter Quality and Decomposition.

Hurni, H., 1988. Degradation and conservation of the resources in the Ethiopian highlands. *Mountain Research and Development*. 8: 123-130.

Islam, K.R., and Weil, R.R., 2000. Soil quality indicator properties in mid-Atlantic soils as influenced by conservation management. *Journal of Soil and Water Conservation* 55:69–78.

Jones, J.B., 2003. Agronomic handbook: management of crops, soils, and their fertility. CRC press LLC, N.W. Corporate Blvd., Boca Ratio, Florida.

Landon, J.R. (Ed.)., 1991. Booker tropical soil manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York.

Legesse Dadi, Gemechu Gedeno, Tesfaye Kumsa and Getahun Degu., 1987. Bako mixed farming zone, Wellega and Shewa Regions. Diagnostic survey report No. 1. Institute of Agricultural Research, Department of Agricultural Economics and Farming Systems Research, Addis Ababa, Ethiopia.

Malo, D.D., Schumacher, T.E., and Doolittle, J.J., 2005. Long-term cultivation impacts on selected soil properties in the northern Great Plains. *Soil and Tillage Research.*81: 277-291.

Nyamadzawo, G., Chikowo, R., Nyamugafata, P., Nyamangara, J., and Giller, K. E., 2008. Soil organic carbon dynamics of improved fallow-maize rotation systems under conventional and no-tillage in central Zimbabwe. *Nutrient Cycling in Agroecosystems,* 81:85-93.

Osunbitan, J. A., Oyedele, D. J., and Adekalu, K. O., 2005. Tillage effects on bulk density, hydraulic conductivity and strength of a loamy sand soil in southwestern Nigeria. *Soil and Tillage Research,* 82:57-64.

Saito, K., Azoma, K., and Oikeh, S. O., 2010. Combined effects of stylosanthes guianensis fallow and tillage management on upland rice yield, weeds and soils in southern Benin. *Soil and Tillage Research,* 107: 57-63.

Teklu Erkossa., 2011. Tillage effects on physical qualities of vertisol in the central highlands of Ethiopia. *African Journal of Environmental Science and Technology* 5:008-1016.

Wakene Negassa, and Heluf Gebrekidan, 2003. Influence of land management on morphological, physical-chemical properties of some soils of Bako, Western Ethiopia. *Agropedology* 13:1-9.