Original Research Article

Soil property variation under different conservation agriculture practices, in Bako Tibe District, West Shoa, Ethiopia

Abstract

*Conservation agriculture is claimed to be one of the solution for the problems of poor agricultural productivity in sub-saharan countries.The impact of conservation agriculture depends on environmental factors such as slope, vegetation, soil type, rain fall pattern and intended crops. This study was conducted from 2013 to 2014 with the obcetives of assessing the impact of different conservation agriculture practices on soil properties in Bako District, West Shoa, Ethiopia, using five 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 including a near by grazing land (Orginal land use). A completely randomized design with four replications was used. A total of 40 composite soil samples (4 replication * 5 treatments * 2 soil depth: 0– 10 cm and 10–30 cm) were collected and analyzed for selected soil propeties. 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 soil properties in short term, but it may take longer time to influence on different soil properties in the study area.*

Keywords**:** Crop residue; intercropping; soil property; mono cropping; conservation agriculture.

1. Introduction

Conservation agriculture (CA) is a widely-used terminology which refer to soil management systems that result in at least 30% of the soil surface being covered with crop residues after seeding of the subsequent crop (Jarecki MK and Lal R, 2003). CA practices are aiming to produce high crop yields while reducing production costs, maintaining the soil fertility and conserving water [Hobbs PR *et al.*, 2008]. It is not a single component technology but a system that includes the cumulative effect of three basic components, minimum soil disturbance, permanent soil cover and crop rotation tillage, in order to preserve soil health and productivity (West TO, Post WM, 2002). CA is receiving an increasing attention in sub-Saharan Africa as a sustainable alternative to contribute to food security and minimize environmental degradation (FAO, 2006) especially aiming to maintain and improve yield. All CA practices are not easy to apply, but farmers can increase their productivity benefits through labour cost saving, reduction of production cost, and improvement of soil fertility. Since one of the contributions of CA is labour saving, farmers can use the time they have saved to expand the area they cultivate, or even to start other enterprises that earn more money. CA increases soil moisture, and restores soil fertility, so stabilizing yields and improving production over the long term.

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 out to identify the limitation of conventional agricultural practices. One of the main challenges in Western Oromia generally and particularly to Bako district, where maize is the main stable and major producing crop, is continuous mono cropping with residue removal through burning and/or used for other purposes (Wakene N, *et al.*, 2011). Bako agricultural research centre 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: Mono-cropping with Residues (MCR), Crop rotation with residues (CRR.), and Intercropping with Residues (ICR) on different soil properties.

2. Materials and Methods

2.1 Description of the study area

The study was conducted Bako district, western Oromia. Bako is located at 9^{o} 08' N latitude and 37^{o} 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 ^{o}C and 29 ^{o}C, respectively and the mean annual temperature is 20 ^{o}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).

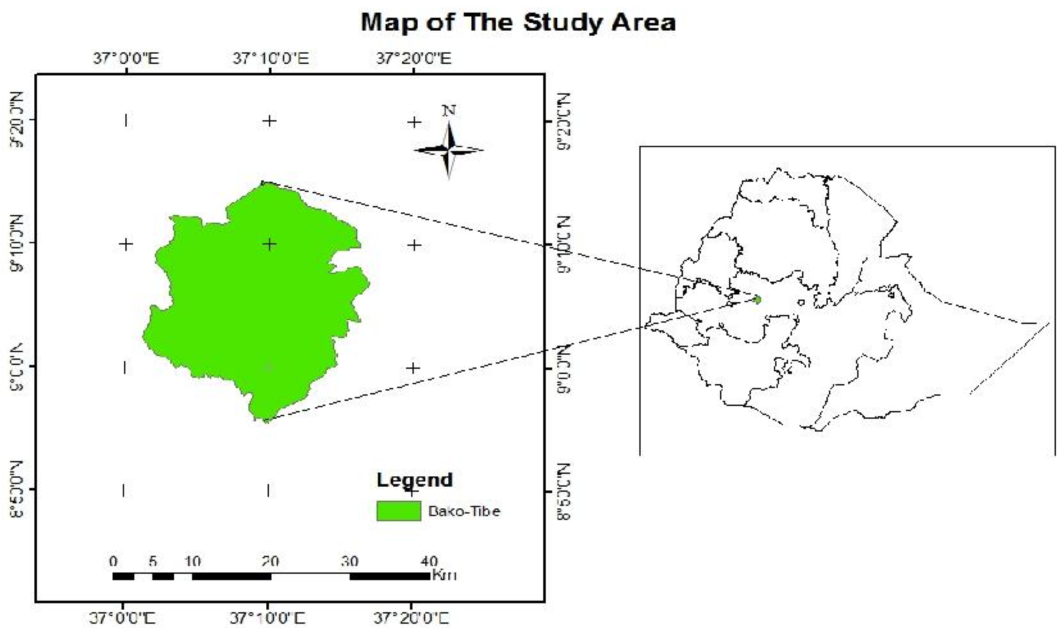

Figure 1: Map of the Study area – Bako district.

2.2 Soil Sampling and Laboratory analysis

Four plots (10m x 10m) were randomly selected in each of the five 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 40 composite soil samples (5 treatments* 2 soil depths * 4 plots) were collected for the study. The five treatments in this study are Monocropping without crop residue (maize), Monocropping with crop residue (maize), Crop rotation with crop residue (maize and haricoat bean), Inter cropping with crop residue (haricoat bean with maize) and a nearby grazing land (Original land use). The samples were first air-dried at room temperature and sieve (mesh size 2mm) in order to remove roots, litter and stones from the soil samples. Then soil samples were analyzed at Bako Agriculture Research Center (BARC) soil laboratory using all laboratory procedures.

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 Chemical Properties

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 variation	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). Hence, 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 grazing land, 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 grazing land but no statistical difference was observed among all agricultural practices, 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 could attribute to the age of conservation agriculture practices which were 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 grazing land 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 grazing land, 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 grazing land with soil depths.

Practices	Soil depth	TN (%)	SOC (%)	C:N ratio	AP (mg/kg)	pH
	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}
MC(-R)	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}
	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}
MCR	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}
	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}
CRR	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 mea	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}
	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}
ICR	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}
	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}
GL	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), Grazing land (GL).*

4. Conclusions and Recommendations

In the study area the local farmers widely practiced 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. Conservation agriculture per se is considered as one of the most effective management practices to obtain mutual benefits in terms of erosion control, carbon sequestration and reduced input of energy and labour. Based on this the objective of the present study focused on the impact assessment of different conservation agricultural practices on soil properties. Accordingly, the results of the present study showed that the conservation agricultural practices did not influence the soil properties like; soil pH, SOC, TN, C:N, and Av.P within four years of practice. Therefore; this finding suggests that conservation agricultural practices namely: addition of crop residue, crop rotation with crop residue, and intercropping with crop residue in Bako (study area) may require longer years of practice before their influence on different soil properties are visible. Thus, further study on CA practices in chronosequence should be considered to identify the years needed for the practices to bring impact on soil properties.

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