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EFFECT OF DIFFERENT CONSERVATION AGRICULTURAL PRACTICES ON SOIL PHYSICAL AND CHEMICAL PROPERTIES, IN BAKO TIBE DISTRICT, WEST SHOA, ETHIOPIA

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ABSTRACT

The study was conducted to assess the effect of different conservation agriculture on soil physical and chemical properties in Bako District. 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 as a hedge row and including a near by grazing land (Orginal land use) were selected for the study. 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 physical and chemical properties. Addational undisturbed core samples were also collected to determine soil bulk density (g /cm^3). The particle size distributions of the soils were similar in the agricultural practices and grazing land. Bulk density was not significantly different among the agricultural practices including grazing land. 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 properties in short term, but it may take longer time to influence soil properties in the study area.

KEYWORDS: Crop Rotation, Grazing Land, Intercropping, Soil Chemical Properties, Soil Organic Carbon, Crop Residue

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 as a hedge (PPH) on soil physical and chemical properties.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted around Bako Agricultural Research Center (BARC), 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).

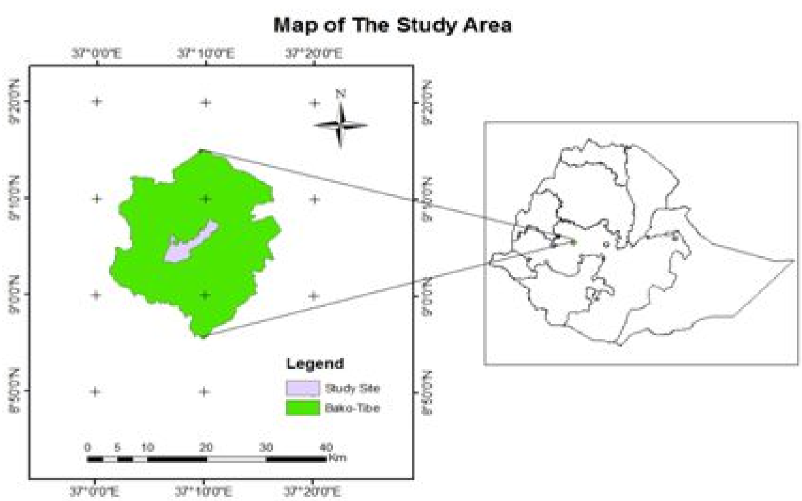

Figure 1: Map of the Study Area – Bako District

Soil Sampling and Laboratory Analysis

Soil sampling was carried out in December 2013. Four plots (10m x 10m) were randomly selected in each of the six treatments arranged in a CRD. 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

[1] BARC (Bako Agriculture Research Center)

plots) were collected for the study. The six treatments in this study are 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 as a hedge row and including a nearby grazing land (Original land use). For soil bulk density determination, a separate representative intact soil samples were collected by using core samplers.

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. Pearson Correlation analysis was also preformed to reveal the relation between some soil properties.

RESULTS AND DISCUSSION

Soil Physical Properties

Particle Size Distribution

The interaction of agricultural practices and soil depth were not significant (p=0.99) for particle size distributions (Table 1). Silt and Clay were statistically significant (p=0.029, and p=0.011), respectively different in the depths, while, sand fraction were not significant (p=0.244) at a given soil depths (Table 1). The mean particle size distributions of the soils were not significantly different among the practices and grazing land (Table 2).

Table 1: Summary of ANOVA for Soil Particle Size Distribution & BD Under d/t Practices & Soil Depths

Source of Variation	Df	Sand		Silt		Clay		BD	
		MS	P	MS	P	MS	P	MS	P
Soil Depth (D)	1	70.080	0.244	36.750	0.029	200.080	0.011	0.002	0.746
Practices (P)	5	23.200	0.800	2.350	0.892	33.283	0.326	0.006	0.868
P*D	5	2.783	0.998	0.300	0.999	2.483	0.993	0.003	0.975
Error	36	49.970		7.140		27.580		0.016	

The texture at all soil depths were more or less the same across the agricultural practices including the grazing land. The similarity in texture signifies that farming practices had little impacts on soil forming processes as parent materials did not change in short period of time since the duration of the agricultural practices is four years. As Brady and Weil, (2010) reported, management practices do not alter the textural class of a soil. White (1997) also stated that soil texture is one of the inherent soil physical properties less affected by management practices.

Bulk Density

The interaction of the agricultural practices including the grazing land by soil depth was not significant (p=0.975) for bulk density (Table 1). As the soil depth increases the bulk density of the soil also increases. Similarly, Ahmed (2002) reported that soil bulk density under both cultivated and grazing lands increased with increasing soil depths. With the four years of conservation agriculture practices the mean value of bulk density of the soil was not significantly (p=0.868) different among the agricultural practices and the grazing land (Table 2). Other studies by Gicheru, *et al.*, (2004), Gwenzi, *et al.*, (2009) and Enfors, *et al.,* (2010) in Tanzania, Kenya, and Zimbabwe, respectively reported that there was no significant difference in soil bulk density under conservation and conventional agricultural practices within four and five years practices. While, Osunbitan, *et al.,* (2005) reported that significantly lower soil bulk density was recorded less than eight years of conservation agricultural practice than conventional practices. So based on these findings, the soil bulk density may be affected or altered after practicing conservation agriculture for greater than four years of time.

Table 2: Mean ± SE of BD (g/cm^3), Particle Sizes and Textures of the Soils in Relation to Different Agricultural Practices Including GL with Soil Depths

Practices	Soil Depth	BD g/cm^3	Sand %	Silt %	Clay %	Textural Classes
MC(-R)	0-10cm	1.13±(0.04)^a	56.50±(4.19)^a	11.75±(1.11)^a	31.75±(3.28)^a	SCL
	10-30cm	1.15±(0.08)^a	53.50±(2.53)^a	10.00±(1.29)^a	36.50±(1.66)^a	
	Over all mean	1.14±(0.04)^A	55.00±(2.34)^A	10.85±(0.85)^A	34.12±(1.92)^A	
MCR	0-10cm	1.12±(0.09)^a	56.50±(4.25)^a	11.50±(1.26)^a	32.00±(3.03)^a	SCL
	10-30cm	1.17±(0.08)^a	54.80±(3.20)^a	9.50±(1.85)^a	35.75±(1.65)^a	
	Over all mean	1.15±(0.06)^A	55.60±(2.48)^A	10.50±(1.11)^A	33.88±(1.75)^A	
CRR	0-10cm	1.19±(0.07)^a	57.00±(4.50)^a	11.25±(1.11)^a	31.75±(3.35)^a	SCL
	10-30cm	1.22±(0.08)^a	55.30±(3.70)^a	9.25±(1.93)^a	35.50±(2.47)^a	
	Over all mean	1.21±(0.05)^A	56.10±(2.70)^A	10.30±(1.10)^A	33.60±(2.05)^A	
ICR	0-10cm	1.13±(0.07)^a	57.00±(4.08)^a	11.25±(1.49)^a	31.75±(2.63)^a	SCL
	10-30cm	1.17±(0.07)^a	53.30±(3.25)^a	9.50±(1.94)^a	37.25±(1.55)^a	
	Over all mean	1.15±(0.05)^A	55.13±(2.52)^A	10.37±(1.18)^A	34.50±(1.75)^A	
PPH	0-10cm	1.19±(0.04)^a	57.80±(4.19)^a	11.25±(0.85)^a	31.50±(3.57)^a	SCL
	10-30cm	1.20±(0.06)^a	57.00±(3.44)^a	9.25±(0.85)^a	33.75±(2.72)^a	
	Over all mean	1.20±(0.03)^A	57.40±(2.51)^A	10.30±(0.67)^A	32.63±(2.12)^A	
GL	0-10cm	1.17±(0.02)^a	54.00±(2.27)^a	9.75±(0.48)^a	36.25±(2.53)^a	SC
	10-30cm	1.17±(0.02)^a	50.50±(1.55)^a	8.75±(0.95)^a	40.75±(2.10)^a	
	Over all mean	1.17±(0.02)^A	52.25±(0.43)^A	9.25±(0.41)^A	38.50±(0.32)^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 as a hedge (PPH), Grazing land (GL). ***SCL=Sandy clay Loam, SC= Sandy Clay.

Soil Chemical Properties

Soil pH, SOC, TN and C: N Ratio

The interaction among the agricultural practices including the GL 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 GL. 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 3).

Table 3: 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 4). 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 PPH and GL but no statistical difference was observed among all agricultural practices, PPH and GL. 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 GL 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 GL, 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 GL. After practicing conservation agriculture for four consecutive years, total N did not differ significantly when compared to conventional agriculture (Table 4). 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 4). 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.

Available Phosphorus

Agriculture practices and or its interaction with soil depth was not significantly different (p=0.568) for available P (Table 3). 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 4: 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 $p < 0.05$.

CONCLUSIONS

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 different soil physical and chemical properties. Accordingly, the results of the present study showed that the conservation agricultural practices did not influence the soil physical and chemical properties (BD, 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 as a hedge (PPH) in Bako may require longer years of practice before their influence on soil chemical and physical properties are visible.

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