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RESEARCH PAPER

Effects of Crop Management Practices on Selected Soil Physicochemical Properties in Bako Tibe District, Western Ethiopia

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Abstract

Indecorous land use and management systems have a negative effect on soil properties, which is related to the sustainability of agricultural production. With this in view, the study was conducted to investigate the effects of crop rotation on selected soil physicochemical properties in Bako Tibe district, Western Ethiopia. The composite soil samples were collected randomly from three cropping systems with similar slopes adjacent to each other. Selected soil physicochemical parameters were analysed by using standard procedures. The dominant textural classes of the soils under all crops were sand clay loam at 0-20 cm and sandy clay at 20-40 cm soil depth. The highest bulk density (1.29 gcm-3) and lowest bulk density (1.27 gcm-3) was observed under continuous maize and Maize Faba Bean -wheat. The highest (6.68) and lowest (5.66) soil pH values were observed in Maize-Faba Bean-Wheat and Continues Maize, respectively. The highest (3.85%) and lowest (3.10%) soil organic carbon was observed under Maize Faba Bean Wheat and Continues Maize, respectively. The highest (0.42%) and lowest (0.28%) mean of total nitrogen contents were observed under Maize- Faba Bean -Wheat and continuous maize, respectively. The mean values of cation exchange capacity range from 33.38 to 30.97meq100g-1 under the cropping system. The soil physicochemical parameters decreased from Maize- Faba Bean -Wheat to Maize- Faba Bean and Continues Maize. Therefore, selected soil physicochemical properties under continuous maize should be needed through educating and training farmers on integrated land management for sustainable crop production.

Keywords: Bako-Tibe, crop management, faba bean, maize and soil properties

Introduction

Soil is the base of nourishing life on earth and sustains the maintenance of all terrestrial ecosystems (Belay, 2003). Reducing soil resource degradation, increasing agricultural productivity, reducing poverty and achieving food security are major challenges of the countries in Africa. However, soil fertility decline has been one of the most challenging and limiting factors for food insecurity in the region. Land degradation through soil erosion and nutrient depletion is a major concern in Ethiopia, given the strong negative impacts on crop productivity, food security, the environment and quality of life (MoARD, 2010).

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 (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). The overall productivity and sustainability of a given agricultural sector is highly dependent on the fertility and physicochemical characteristics of soil resources (Mohammed *et. al.*, 2005).

Depletion of soil nutrients is a reversible constraint as long as soil test-based fertilizer application is in place (Fassil and Charles, 2009). However, assessing soil fertility status is difficult because most soil chemical properties either change very slowly or have large seasonal fluctuations; in both cases, it requires long-term research commitment (Taye and Yifru, 2010). Soil and water conservation practices are influential tools that enable the productive potential of the soil. Management practices to sustain crop yields are necessary to conserve or enhance soil quality (Aziz *et al.*, 2009).

The periodic assessment of important soil properties and their responses to changes in land management are necessary in order to improve and maintain the fertility and productivity of soils (Wakene and Heluf, 2003). Although knowledge of soil quality status plays a vital role in enhancing production and productivity of the agricultural sector on a sustainable basis, currently only a little scientific information is available on the magnitude of soil quality changes under different land uses and crop production systems. In addition, the information on the management system of soil quality is pertinent to sustainable crop production in the country in general and in the study area in particular.

The expansion of agriculture to meet the demands of the growing population such as food and fiber at the expense of vegetated lands is the most significant historical change in all parts of the world (Liebman *et al.*, 2003). Poor soil management practices, including the removal of crop residues and burning, intensive tillage, and mono-cropping farming practices that expose the soil to leaching and erosion lead to a decline in soil fertility. One of the main challenges in Western Oromia generally and particularly in Bako district, where maize is the main staple and major producing crop, is continuous mono-cropping with residue removal through burning and/or used for other purposes (Wakene, 2001). In the study area, the losses of soil physicochemical properties were because of different anthropogenic factors such as mono-cropping, land degradation, removal of crop residue and animals' manure for different purposes. Therefore, the objective was to evaluate the effects of crop management practices on soil physicochemical properties in Bako Tibe District, Western Ethiopia.

Materials and methods

Description of Study Areas

The study was conducted in Bako Tibe District, West Shewa Zone, Oromia Regional National State Ethiopia. It is 250 km away from Finfinnee and 125 km away from Ambo town (Figure 1). This District has a longitude and latitude of 9°08′N 37°03′E with an altitude ranging from 1727 to 1778 meters above sea level (masl) (CSA, 2007). The study area was covered by natural forest 20 years back. But today almost all of them have disappeared due to rapid increase in population and high deforestation in order to obtain more land for cultivation, grazing, timber, charcoal and settlement. The total area of the BakoTibe District is 63,988.17 ha of land, out of the total area 42,916.28 ha (67.07%) cultivable land, 980.2 ha (1.53%), grazing land, 1891.85ha (2.96%) Built up (covered in buildings, roads etc), 5207.97 ha (8.14%) forest land, 9581.04 ha (14.97%) bush and shrubs land, 3410.83 ha (5.33%) Wetland (Figure 2).

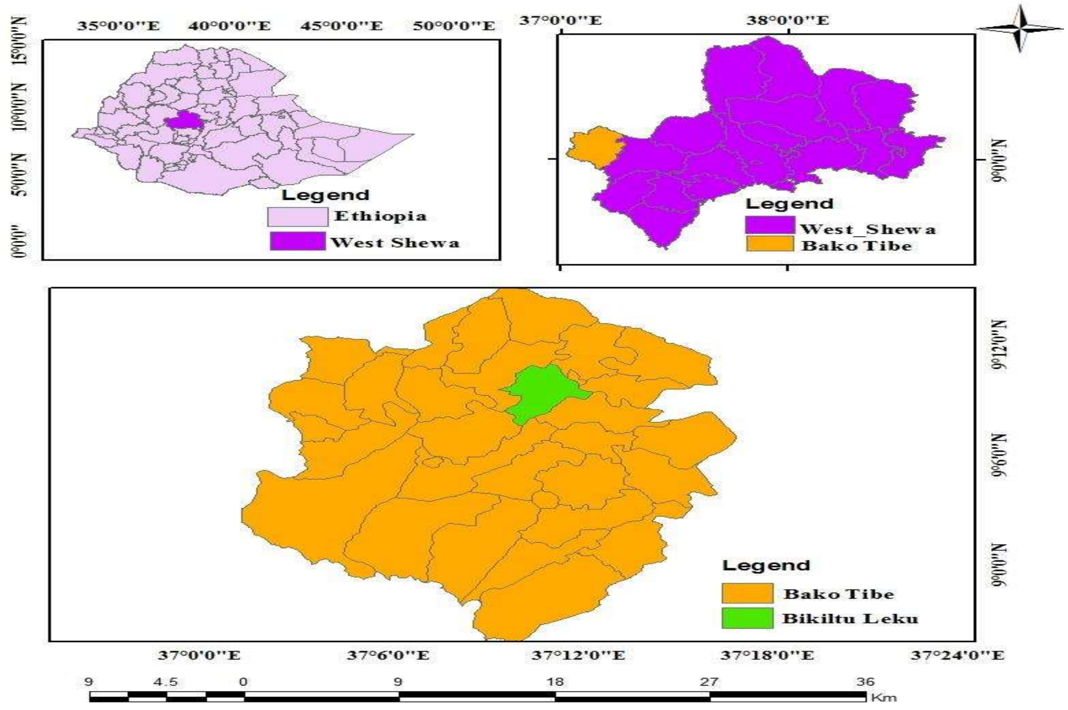

Figure 1.Map of the Study Area

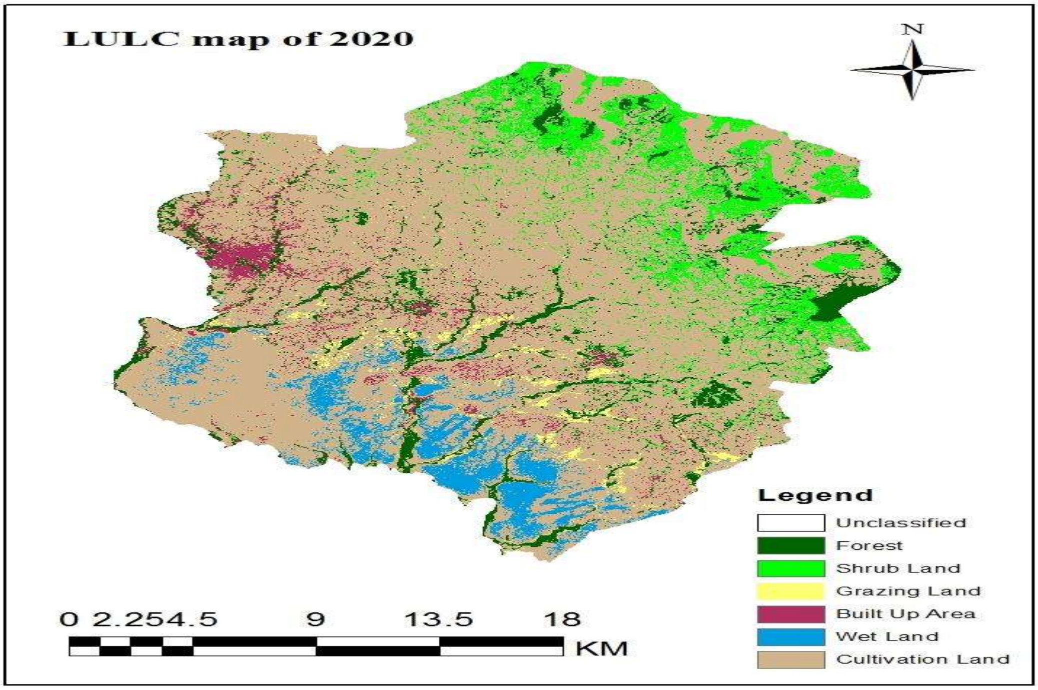

Figure. 2. Land Use Land Cover Map of the Study Area

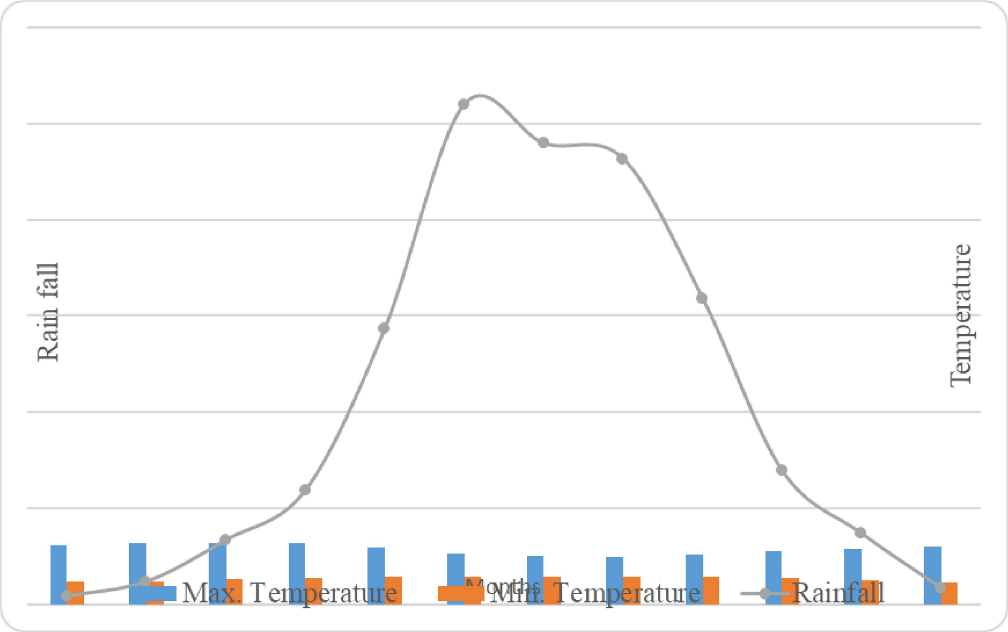

Figure 3.Mean annual rainfall and Temperature for fifteen years (2005-2019), (BARCMS, 2020)

Climatic condition of the study area

The major Agro-ecological zones of the study area are semi-arid, sub-humid and humid with unimodal rainfall characteristics. The area receives an average rainfall annually of 1257.98 mm and the temperature (^{0}C) ranges from 13.42^{0}C to 28. 73^{0}C. The rainy season extends from May to September and maximum rain is received in the months of June to August (BARCMS, 2020).

Major soil types and vegetation

The major soil types of the area were 55% red soil (Biyyoo Diimaa), 15% black cotton soil Vertisols (Biyyoo Gurraacha) and 25 % brown soil (Biyyoo Magaala) (BARC, 2014). The most dominant soil in the area is reddish brown Nitisols. The textural class of soil in the study area was dominated by clay and loam. The area is endowed with diverse vegetation species ranging from little dense and old natural forests in pocket areas at the tips of both up and downstream sides, to the patch of sparse shrub-grass complex in various areas. Dominant tree species in the area include Cordia africana (Waddeessa), Ficus vista (Qilxuu), Croton mycrostachyus (Bakkanniisa), and the exotic tree species Eucalyptus camalduleses (Baargamoo Diimaa (BARDO, 2019).

Farming System

The area is known for the mixed crop-livestock farming system in which cultivation of Maize (Zea mays L), Niger seed (Guizota abyssinicaL.), Potato (Solanum tuberosumL.), Sweet potato (IpomoeabatatasL.), Hot pepper(Capsicum frutescence L.) and Mango (Mangifera indicaL.), Banana (Musaspp.), Sugarcane (Saccharum officinarumL.), teff (Eragrostis tef (zucc.) and Haricot bean (Phaseolus vulgaris L.) are the major cropping activities. Maize and pepper were the dominant crops grown in the area (BARDO, 2015). Mixed farming is the major economic activity that involves crop and livestock production systems. Livestock production is an essential part of the farming system as nearly most of the land preparation is done with ox-drawn ploughs.

Site selection

During site selection, the general geography of the area was identified, purposively. The criteria used to select the kebele where three selected different crop cultivation systems for more than 5 years, continuous maize cultivation, maize_faba bean cultivation and maize - faba bean - wheat cultivation dominantly and Biqiltu laku kebele was considered as the representative of the district.

Soil Sample Collection

The soil samples were taken from different crop management systems using the transect sampling method. Samples were taken from each cropping system (continuous Maize cultivation, Maize- Faba bean rotation and Maize -Faba bean–wheat rotation) from two soil depths (0-20 cm and 20-40 cm) by transecting (X) method. The investigation was made on 1ha of each crop rotation system and mono-cropping practices.

A one ha plot (1 ha) for each cropping system or practice was (100 x100 m) for continuous Maize cultivation, maize-faba bean cultivation and maize–faba bean–wheat rotation for soil sample collection. Accordingly, three adjacent sites under different land use types (continuous maize, continuous maize-faba- bean and continuous maize-faba-bean-wheat cultivated) were selected for this study, with similar slope, elevation, fertilization, liming and erosion and aspect in each crop management practice. Then representative soil sampling sites were selected based on the above criteria and crop management history.

In each study site continuous maize cultivation, maize_ faba bean cultivation and maize–faba bean-wheat cultivation of about one ha is randomly outlined from which representative soil samples were taken. For the determination of bulk density (BD), undisturbed soil samples were taken from each cultivated land by core sampler. A total of 18 composites (3 land use types* 2 depth *3 replication) disturbed soil samples were air-dried, grinded with mortar and pestle and passed through 0.5 mm mesh sieve for OC and TN and 2 mm for the other parameters.

Air-dried samples were stored in polythene bags to prevent contamination and minimize soil moisture loss, to obtain fine air-dried soil in which the particle size analyses were performed using the pipette method (Day, 1965). From both soil depths and different crop management practices, soil samples were prepared and packed in fresh polythene bags and transported to the soil testing center for further analysis at Bako Agricultural Research Center for the analysis of soil physicochemical properties.

Soil Sample Analysis

Soil texture was determined by the Bouyoucos hydrometer method (Bouyoucos, 1951).

Soil bulk density was measured from the undisturbed soil samples as per the procedure described by Jamison *et al.* (1950), while particle density (Pd) was measured using the pycnometer method at the Bako research center.

Soil pH was measured in 1:2.5 soils: H_2O and soils: KCl solutions using a combined glass electrode pH meter (Chopra and Kanwar, 1976). Exchangeable basic cations (Ca^{2+}, Mg^{2+} and K^{+}) were determined by saturating the soil samples with 1M NH_4OAc solution at pH 7.0. Exchangeable Ca and Mg were determined by using atomic absorption spectroscopy (AAS), while exchangeable Na and K were measured by flame photometers from the same extract (Chapman, 1965). The cation exchange capacity (CEC) of the soil was determined at pH 7 from the NH4+ saturated samples that were subsequently replaced by K from a percolated KCl solution (Chapman, 1965). Soil organic matter was determined by using rapid titration methods and then its contents were estimated from the organic carbon content by multiplying with 1.724 (Walkley and Black 1934). OM = OC x 1.724. The total N contents of the soil were determined by the wet-oxidation procedure of the Kjeldahl method (Bremner and Mulvaney, 1982). Available P was extracted by the Bray II Method (Bray and

Kurt, 1965). The percent base saturation (PBS) of the soil samples was calculated from the sum of the base exchangeable cations (Ca, Mg and K) as a percentage of CEC.

Statistical Analysis

Crop management practices and soil depth were used as independent variables and the soil physicochemical parameters as dependent variables and the significant difference of soil physicochemical were tested using analysis of variance (ANOVA) following the general linear model (GLM) procedure at ($P <0.01$ and 0.05) significant levels. The least significant difference (LSD) test and correlation analysis were employed to assess the mean difference and the association between soil variables and crop rotation types. Correlations among the soil properties were checked by Pearson product-moment correlation test (two-tailed) at $P < 0.05$.

Results and discussion

Soil Physical Properties

Soil texture

The highest mean values of the particle size distribution (51%) and lowest (45.70%) sand content were observed under continuous maize and Maize -Faba bean-wheat crop management practices, respectively (Table 1).

The silt fraction was highly significantly ($P<0.05$) different under the cropping system and soil depth (Table 1). The highest (16.5%) and lowest (12.3%) silt content was observed under maize-faba bean-wheat and continuous maize cropping systems, respectively (Table 1). The silt content of the soil increases from continuous maize to maize-faba bean and maize-faba bean-wheat cropping system. As soil depth increased from 0-20 cm to 20-40 cm silt content of the soil decreased due to the OM content of topsoil than subsoil.

The sand percentage and silt content at 0-20 cm soil depth were greater than 20-40 cm soil depth. Under the cropping system from continuous maize, maize-faba bean and maize-faba bean-wheat silt content of the soil was increased but the sand content was decreased this showed that the cropping system enhanced the silt contents of the soil. Sand particles were not significantly and negatively correlated with clay at correlation coefficients ($r = -0.840^{**}$). Silt particles were significantly and positively correlated with pH, OM, TN, Ca, Mg and CEC at ($r=0.892^{**}$, 0.769^{*}, 0.757^{**}, 0.643^{**}, 0.759^{**} and 0.684^{*}), respectively (Table 4). Sand was negatively correlated with clay ($r = -0.840^{*}$) (Table 4).

This is in agreement with Rao and Mathuva (2000) found that maize following annual legumes was 32 - 49% more profitable than continuous maize. Also, Brady and Weil, (2002) reported that pedologic processes such as erosion, deposition, illuviation and weathering which are shaped by management practices can alter the texture of soils.

Bulk density

The mean values of the bulk density of the selected cropping system were presented (Table 1). The bulk densities ranged from 1.27 to 1.29 gcm^{-3} among cropping systems (Table 1). The highest (1.29 gcm^{-3}) and lowest (1.27 gcm-3) bulk density values of soils were observed under continuous maize and maize-faba bean-wheat, while the highest (1.28 gcm^{-3}) and lowest (1.27 gcm^{-3}) bulk density values of soils were observed at 0 -20 cm and 20 - 40 cm depth, respectively (Table 2).

The lowest (1.27 gcm^{-3}) bulk density value in maize-faba-bean-wheat cropping system soils is due to its relatively higher SOM, total porosity and low clay particle compared with maize-faba bean and continuous maize. Lower bulk density is good for agricultural soil because low bulk density encourages plant root penetration and allows easy movement of water and air in the soil.

Table 1. Mean comparison of soil physical properties under cropping system and soil depth

Cropping system	Sand(%)	Silt (%)	Clay(%)	TC	BD (gcm^{-3})	TP(%)	AWHC(%)	FC (%)	PWP(%)
M-FB-W	45.70	16.5^{a}	38.3	SC	1.27	47.28	14.64	37.3^{a}	26.4
M-FB	47.17	14.7^{ab}	38.7	SC	1.28	45.24	13.49	36.4^{ab}	25.2
CM	51.00	12.3^{b}	36.7	SC	1.29	45.79	12.88	35.1^{b}	25.5
LSD (5%)	NS	**	NS		NS	NS	NS	*	NS
Soil depth (cm)									
0 -20	48.2	15.78^{a}	36.22	SCL	1.27	51.6^{a}	13.43	33.44^{b}	24.2^{b}
20 -40	47.3	13.22^{b}	39.56	SC	1.28	40.6^{b}	13.90	39.07^{a}	27.2^{a}
LSD (5%)	NS	*	NS		NS	**	NS	*	*

LSD = least significant difference NS=Not significant; * = significantly different; ** = highly significantly different; BD= Bulky density; TP = Total Porosity; CM = continuous Maize; M-FB = Maize Faba bean; M-FB-W = Maize –Faba bean –Wheat, AWHC=Available water holding capacity, FC= Field Capacity, PWP=Permanent wilting point

This is in agreement with Shirani *et al*. (2002) reported that continuous ploughing at the same depth leads to the formation of a hard pan in the lower layers over a period of time which hinders the deeper penetration of roots into soil and results in a temporary water logging situation during irrigations. Similarly, Mulugeta (2004) reported that soil BD increased in the 0-20 and 20-40 cm layers relative to the length of time the soils were subjected to cultivation.

The bulk density and total porosity are inversely proportional to each other. As bulk density increases, total porosity decreases and vice versa. The bulk densities of the study area increased from maize-faba bean-wheat to maize-faba bean and continuous maize-cultivated land. As compared to maize-faba bean-wheat, the bulk density of the soils of maize-faba bean and continuous maize was increased on both depth and cropping system land (Table 1). As bulk density increases above its range, the physicochemical quality of the soil of the area lowers. This is in agreement with Fu *et al*. (2004) reported that soil quality levels can be reduced due to bulk density applied to different land use types.

Total porosity

The total porosity was highly significantly ($P < 0.05$) affected by soil depth but non-significantly affected by cropping system affected (Table 1). The total porosity of the soil can be used as an indication of the degree of compaction in soil in the same way as bulky density. Accordingly, the mean porosity of selected crop rotation (continuous maize, maize-faba bean and maize-faba bean-wheat) ranges between 45.24 to 47.28 % under the cropping system. The highest (47.28 %) mean total porosity was observed in the soils of the maize-faba bean-wheat, and the lowest (45.79%) was observed under the soils of continuous maize cultivation. At 0-20 cm soil depth higher TP was recorded.

Total porosity decreases as bulk density increases from 0-20 cm to 20-40 cm depth due to the decrease of OM and OC from surface to sub-surface. The lowest total porosity in continuous maize was due to lower SOM, bulk density and is the result of higher removal of crop residue for fuel, method of harvesting, and slow decomposition of maize residues removing crop residues for cleaning land for the next season. The higher values of total porosity corresponded to the higher amount of OM and lower bulk density values.

A decline in total porosity in the soils of continuous maize and maize-faba bean and cropping system as compared to soils of maize-faba bean-wheat were attributed to a reduction in pore size distribution and it is also closely related to the magnitude of SOM loss which depending on the intensity of soil management practices. Thus, increased soil bulk density and decreased total porosity in continuous maize and maize-faba bean soils of the studied area indicate a trend towards lower soil quality compared with maize-faba bean-wheat which has low Bulk density and higher total porosity. The highest total porosity was due to the higher low Bulk density. Likewise, Mulugeta *et al.* (2005) found an increase in the 0-10 cm and 10-20 cm layers relative to the length of time the soils were subjected to cultivation after deforestation.

Soil moisture content

The available water holding capacity of the soil was non-significantly ($P \leq 0.05$) different under the cropping system and soil depth (Table 1). Field capacity and permeant wilting point were highly significantly ($P \leq 0.05$) different by soil depth (Table 1). While field capacity was significantly ($P \leq 0.05$) different under the cropping system (Table 1). The highest (14.64 %) mean available water holding capacity was observed under MFBW, and the lowest (12.88%) was observed under the soils of CM cultivation. As soil depth increases from 0-20 cm to 20-40 cm soil SMC (available water holding capacity, field capacity and permanent wilting point) also increases (Table 1). Soil moisture content (field capacity, permanent wilting point and available water holding capacity) increased from 0-20 cm to 20-40 cm soil depth. The result agrees with Wakene (2001); and Ahmed (2002) reported that soil water contents at field capacity, permanent wilting point and available water holding capacity increased with depth for the soils under different management practices.

Available water holding capacity was significantly and negatively correlated with silt content of soil (-0.553) (Table 5). The field capacity of the soil was positively and highly correlated with a permeant wilting point at (0.65) (Table 4)

Soil chemical properties

Soil pH

The soil pH-H_2O value was highly significantly ($P < 0.05$) affected under different cropping systems and soil depths (Table 2). Under all cropping systems soil pH-H_2O values were found to be acidic (Table 2). The soil pH (H_2O) values ranged from 6.68 to 5.66 among cropping systems of land. The highest pH-H_2O (6.68) and the lowest pH-H_2O (5.66) of soil were observed under the maize-Faba bean-Wheat and Continuous Maize, respectively (Table 2).

The lowest pH-H_2O (5.66) value of soil pH-H_2O was observed under the Continuous Maize cultivated land due to the leaching of exchangeable basic cations (Ca Mg, K and Na) from the surface of soils, intensive cultivation, continuous removal of basic cations by harvested crops and continuous use of fertilizer such as ammonium base fertilizer. Soil pH was decreased under the cropping system from maize-Faba bean-Wheat to maize-Faba bean and Continuous Maize. The soil under maize-Faba bean-Wheat and maize-Faba bean was slightly acidic but the soil under Continuous Maize cultivation was moderately acidic (Table 2). The lowest soil pH-H_2O (5.66) under continuous maize cultivated land might be due to leaching and erosion problems, and low availability of nutrients.

The highest pH -H_2O (6.68) value of soil was recorded in maize-faba bean-wheat due to higher accumulation of OM and higher exchange of basic cations. Similarly, Gebeyaw (2015) reported that higher mean values of pH were observed within the surface soils (0-20 cm soil depth). It is also in line with Wakene and Heluf (2003) who reported that the use of acidifying mineral fertilizers and intensive cultivation enhanced the leaching of basic cations and oxidation of organic matter reduced soil pH. The pH (H_2O) was significant and positively correlated with SOM (0.738) and it was negatively correlated with bulk density (-0.477) (Table 4).

Table 2. Mean comparison of selected soil chemical properties under cropping system and soil depth

Cropping system				
	pH (H_2O)	OM (%)	TN (%)	Av. P (ppm)
M-FB-W	6.68^a	6.64^a	0.42^a	6.01
M-FB	6.13^b	6.29^a	0.31^{bc}	5.88
CM	5.66^c	5.34^b	0.28^c	5.69
LSD (%)	**	**	**	NS
Soil depth (cm)				
0 -20	6.43^a	6.53^a	0.36^a	6.16
20 - 40	5.88^b	5.65^b	0.32^b	6.15
LSD (%)	**	**	*	NS

LSD = least significant difference NS=Not significant; * = significantly different; ** = highly significantly different; OM = Organic Matter; TN = Total Nitrogen; Av. P = Available phosphorus; CM = continuous Maize; M-FB = Maize Faba bean; M-FB-W = Maize –Faba bean –Wheat

Soil organic matter

The mean values of the SOM of the study area under maize-faba bean, maize-faba bean-wheat and continuous maize were presented in Table 2. Soil OM content was significantly ($P < 0.05$) affected by crop management practices and soil depth (Table 2). The SOM ranged from 5.34 to 6.64% under cropping management practices (Table 2). As per the rating of Landon (1991) the soil OM contents of the study area rated as high under the maize-faba bean-wheat, maize-faba-bean, and continuous maize cropping system at 0-20 cm soil depth and medium at 20-40 cm depth, respectively (Table 2).

The highest (6.64%) soil OM content was observed in the maize-faba bean-wheat followed by maize-faba bean (6.29%), and the lowest (5.34 %) was observed under continuous maize. At 0-20 cm soil depth 6.53% mean soil OM content was observed followed by 5.65% at 20-40 cm soil depth (Table 2). The average content of soil OM decreased from maize-faba bean-wheat to maize-faba bean and continuous maize due to difference in source OM added or removed from each cropping system. As soil depth increased soil OM decreased because of decomposition of crop residues on the topsoil (Table 2).

The soil OM is directly proportional to the presence of soil OC obtained by multiplying by 1.724. The highest OM under the maize-faba bean-wheat cropping system is mainly due to the accumulation and decomposition of legume crop residues on upper surfaces and reduced plant residues as compared to the subsurface soil. The lowest content of SOM under continuous maize computed to maize-faba bean and maize-faba bean-wheat may be due to poor soil conservation such as continuous cultivation, method of harvesting, unbalanced amount of OM removed or added to soil and removal of crop residue for fuel and feed from continuous maize cultivated land of study area.

Total nitrogen and Available phosphorus

The total nitrogen was significantly ($P < 0.05$) affected by the cropping system and it was significantly ($P < 0.05$) by soil depth (Table 2). The mean of the total nitrogen ranges from 0.28 to 0.42% among cropping systems of the study area. The highest (0.42) mean total nitrogen was observed in the MFBW cropping system and the lowest (0.28) was observed under CM, at 0-20 cm while the highest (0.36%) was in maize-faba bean-wheat, the lowest total nitrogen (0.32%) under continuous maize cropping system at 20-40 cm depth, respectively (Table 2).

An addition of a relatively higher plant green manure and residues might have contributed to the highest (0.42%) amount of continuous maize under maize-faba bean-wheat rotation, while a minimal rate of decomposition under continuous maize (0.28%) may result in the lowest TN, respectively. The decline of total nitrogen from maize-faba bean-wheat to maize-faba bean and continuous maize cultivated lands might be due to the susceptibility of nitrogen to leaching problems, high rainfall, erosion and poor soil conservation practice were reasons for the reduction of total nitrogen in the study area. Similarly, Nega (2006); and Teshome *et al.* (2013) reported that average total N declined with increasing depth from surface to subsurface soils. Also, Sanginga *et al.* (2002) reported the availability of extra nitrogen through biological nitrogen fixation and other rotation effects. Gugino *et al.* (2009) reported that including legumes in crop rotation is a useful strategy for increasing microbial biomass responsible for nitrogen mineralization. Soil conservation and management practices such as cropping systems are important to maintain and increase the total nitrogen of continuous maize cultivated land.

The highest available phosphorus (6.16 ppm) observed at 0-20 cm soil depth might be due to higher organic matter on the surface soil than under subsurface soil (20-40 cm). This finding is in agreement with Wakene and Heluf (2003) who described that the lowest available phosphorus content both in the surface soil layer and throughout the depth was recorded under cultivated land due to continuous intensive cultivation for soils of the Bako area acidic Alfisols. Also, Achalu *et al.* (2013) reported that more than optimum (highest) available P concentration could be observed from a lower concentration of Al-Fe and higher fertilization of inorganic fertilizers and maximum values of organic matter.

Exchangeable base

The mean values of the exchangeable Mg of selected cropping systems (continuous maize, maize-faba bean and maize-faba bean-wheat) are presented in Table 3. The exchangeable Mg was significantly ($P \leq 0.05$) influenced by the cropping systems (Table 3). The mean of exchangeable Mg ranges from 4.70 to 6.42 (cmolckg-1) among cropping systems (Table 3). At 0-20 cm depth soil mean value of Mg was 5.49 cmolckg-1and at 20-40 cm soil depth 4.81 cmolckg-1 (Table 3). As per the ratings of FAO (2006), the mean exchangeable Mg is high for all cropping system types at both depths (Table 3). The highest exchangeable Mg (6.42 cmolckg^{-1}) was observed under the maize-faba bean-wheat, the lowest (4.70 cmolckg^{-1}) exchangeable Mg was observed under continuous maize (Table 3). The highest exchangeable Mg observed in the surface soils might be due to the higher accumulation of OM and plant residue cover on the upper surface of the soil. The lowest exchangeable Mg is due to lower pH, SOC, continuous removal with crop harvest, continuous cultivation and poor conservation practices of land which result in the leaching of basic cations from the top soils of cultivated land. Likewise, Huluf and Wakene (2006) reported that continuous cultivation enhances the depletion of $Ca^{2+}$and Mg^{2+}, especially in acidic tropical soils.

The exchangeable Ca was highly significant ($P < 0.05$) and influenced by crop rotation (Table 3).

Table 3. Mean comparison of exchangeable bases and CEC under cropping system and soil depth

Cropping system	Exch K	Exch Ca	Exch Mg	CEC
		cmol$_c$kg^{-1}		
M-FB-W	0.91	10.58^{a}	6.42^{a}	33.38
M-FB	0.86	8.98^{b}	6.53^{a}	31.57
CM	0.83	$8,08^{b}$	4.70^{b}	31.97
LSD (5%)	NS	**	*	NS
Soil depth (cm)				
0 - 20	0.89	9.72	5.49	33.43^{a}
20 – 40	0.84	8.71	5.81	30.52^{b}
LSD (5%)	NS	NS	NS	**

LSD = least significant difference NS = Not significant; Exch K =Exchangeable potassium; Exch Ca =Exchangeable Calcium; Exch Mg = Exchangeable Magnesium; CEC =cation Exchangeable Capacity; CM=Continuous maize; M-FB = maize- faba bean and M-FB- W= Maize- faba bean – wheat, = significant; ** =highly significant.

The mean exchangeable Ca ranges from 8.08 to 10.58 (cmolckg^{-1}) among cropping systems and exchangeable Ca ranges from 8.71 to 9.72 cmolckg^{-1} at 0-20 cm to 20 cm - 40 cm soil depth, respectively (Table 3).

The highest (10.58 cmolckg^{-1}) exchangeable Ca was observed under maize-faba bean-wheat followed by maize-faba bean (8.98 cmolckg^{-1}). This may be due to the higher SOM and plant material. The lowest exchangeable Ca (8.08 cmolckg^{-1}) in the soils of continuous maize cultivation might be due to the relatively lower soil pH, SOM, continuous cultivation and method of harvesting and removal of crop residues for fuel. This is in agreement with Abera and Kefyalew (2017) reported lower exchangeable Ca^{2+} in the surface horizon of the cultivated field due to the removal of Ca with crop harvest. The exchangeable Ca increased from continuous maize cultivated land to maize-faba bean and maize-faba bean-wheat in both soil depths. As per the ratings of FAO (2006), the mean exchangeable Ca contents were high under maize-faba bean-wheat and medium for maize-faba bean and continuous maize at both soil depths (Table 3).

The mean of exchangeable K ranges from (0.83 to 0.91 cmolckg^{-1}) among cropping systems (Table 3). The highest (0.91 cmolckg^{-1}) mean exchangeable K was observed under the maize-faba bean-wheat followed by maize-faba bean (0.86 cmolckg^{-1}), the lowest (0.83 cmolckg^{-1}) exchangeable K in continuous maize; while the lowest (0.84 cmolckg^{-1}) exchangeable K in CM at 0-20cm and 20-40cm soil depth, respectively (Table 3).

The higher exchangeable K content in the soils of the maize-faba bean-wheat and maize-faba bean than that of the continuous maize could be due to the high OM content. The lowest exchangeable K in continuous maize compared with maize-faba bean-wheat and maize-faba bean may be due to lower pH, intensive cultivation and removal with crop harvest and other poor management practices that enhance its losses. This is in agreement with Berhanu (2016) high intensity of weathering, intensive cultivation and use of acid-forming inorganic fertilizers has been reported to affect the distribution of K in soils and enhance its depletion. This might be the possible reason for the relatively low exchangeable K in soils of continuous maize cultivated soil. As per the ratings (FAO, 2006), the mean exchangeable K contents were high under the cropping system at both soil depths.

Cation exchange capacity

The cation exchange capacity of the soil was highly significantly affected by soil depth (Table 3). The means of cation exchange capacity range from 30.97 to 33.38 cmolckg^{-1} under the cropping system (Table 3). The CEC of soil was increased from continuous maize, maize-faba bean and maize-faba bean-wheat due to higher soil OM in maize-faba bean-wheat compared with maize-faba bean and continuous maize cultivated land, but when two soil depths are compared higher CEC was observed at 0-20 cm due to higher SOM and clay content which resulted in lower CEC observed at 20-40 cm due to lower clay soil particles compared with 0-20 cm soil depth. This result indicated that the cation exchangeable capacity of soil is directly related to soil OM and clay particles of soil.

The highest CEC (33.38 cmolckg^{-1}) was observed under the soils of maize-faba bean-wheat followed by maize-faba bean (31.57 cmolckg^{-1}), whereas the lowest (30.97 meq100g^{-1}) was observed under continuous maize. At 0-20 cm and 20-40 cm of soil depth mean value of CEC were (33.43 cmolckg^{-1}) followed by maize-faba bean (30.52 cmolckg^{-1}), respectively (Table 3). Similarly, Lechisa *et al*. (2014) reported that the highest CEC was observed in forest land (16.53 cmolckg^{-1}) while the lowest was observed in cultivated land (7.63 cmolckg^{-1}). Also, Haile (2007) reported that the low level of clay and humus in soil is low in CEC, whereas soil high in clay and humus has a higher in CEC. As per the rating of (FAO, 2006) CEC of the study area was rated as high under all cropping system land (maize-faba bean, continuous maze and maize-faba bean-wheat) at both depths..

Table 4. Pearson`s Correlation coefficient (r) among selected soil physicochemical quality.

SQI	PH	OC	OM	TN	av.p	ex.Ca	ex.Mg	ex.K	CEC	Cly	Slt	Snd	Bd	TP	AWHC	FC	PWP
PH	1																
OC	.657**	1															
OM	.738**	.741**	1														
TN	.738**	.724**	.714**	1													
av.p	.362	.307	.331	.208	1												
ex.Ca	.629**	.538*	.688**	.756**	.111	1											
ex.Mg	.690**	.712**	.643**	.749**	.112	.550*	1										
ex.K	.408	.082	.323	.324	.519*	.507*	.196	1									
CEC	.420	.442	.323	.737**	.174	.608**	.336	.202	1								
Cly	-.038	-.295	.045	.027	-.117	.020	-.077	-.089	.106	1							
Slt	.892**	.778**	.769**	.757**	.369	.643**	.759**	.418	.395	-.153	1						
Snd	-.440	-.150	-.434	-.460	-.117	-.400	-.341	-.166	-.374	-.84**	-397	1					
Bd	-.477*	-.539*	-.421	-.458	-.67**	-.248	-.312	-.206	-.396	-.098	-.57*	.428	1				
TP	.342	.401	.384	.324	.329	.215	.078	.226	.039	-.126	.250	-013	-.16	1			
AWHC	-.336	-.445	-.429	-.385	-.165	-.309	-.307	-.338	-.139	-.096	-.55*	.376	.364	-.412	1		
FC	-.209	-.356	-.300	-.006	-.270	-.077	.096	-.034	.149	.477*	-.24	-.33	.124	-62**	.406	1	
PWP	-.211	-.442	-.296	-.108	-.307	-.078	-.303	-.030	-.029	.397	-.35	-.17	.137	-.369	.443	.65**	1

*= significant at $p<0.05$ and**= significant at $p<0.01$; BD = Bulk Density, TP= Total porosity, Av. P = Available Phosphorous, CEC = Cation Exchange Capacity,(Exch. Mg, Ca, K = Exchangeable Magnesium, Calcium ,Potassium, respectively) TN = Total Nitrogen, OM = Organic Matter, AWHC = Available water holding capacity, FC= Field capacity ,PWP = Permanent wilting point ,OC= organic Carbon,

Conclusion

Continuous crop system has a negative effect on soil physicochemical properties, which is related to the sustainability of agricultural production. The most important problem for soil physicochemical properties was intensive cultivation, the wide practice of mono-cropping systems, erosion and leaching problems, deforestation and the continuous use of acid-forming inorganic fertilizers rather than organic fertilizers for production used agriculturally.

As the maize-faba bean-wheat cropping system changed to other continuous cultivation caused a significant decline in soil physicochemical properties which contributed to low agricultural production and productivity. The soil quality decreased from maize-faba bean-wheat rotation to maize-faba bean and continuous maize cultivated land, respectively. Soil physicochemical properties were maintained relatively under the maize faba-bean-wheat rotation, compared with maize-faba-bean and continuous maize cultivated. Therefore, from three cropping systems soil management under continuous maize should be needed. Thus, in order to change the current situation of improper cropping system and its management to proper cropping system and management, this study recommended detailed and periodic research work, educating and training of farmers on proper rotation and techniques of soil and water conservation, adopting integrated soil managements such as organic fertilizers, reducing intensive cultivation and liming to decrease soil acidity for replenish the degraded soil physicochemical properties and sustainable agricultural production in the study.

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