ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF SOIL UNDER WHEAT (*Triticum aestivum*) BASED CROPPING SYSTEM IN HETOSA WOREDA, ARSI ZONE, SOUTH EAST ETHIOPIA.

M.Sc THESIS

By

SISAY TADDESE ALEMU

JUNE, 2015

JIMMA, ETHIOPIA

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Sisay Taddese Alemu

Submitted to Jimma University, School of Graduate Studies, College of Agriculture and Veterinary Medicine, Department of Natural Resources Management, In Partial Fulfillment of the Requirements for the Degree of Master of Science in Natural Resource Management in Specialization of Soil Science.

JUNE, 2015

JIMMA, ETHIOPIA

Jimma University College of Agriculture and Veterinary Medicine

Thesis Submission Request Form (F-05)

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Program of study: Natural Resource Management (specialization in soil science)

TITLE: ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF SOIL UNDER WHEAT *(Triticum aestivum)* BASED CROPPING SYSTEM IN HETOSA WOREDA, ARSI ZONE, SOUTH EAST ETHIOPIA.

I have completed my thesis research work as per the approved proposal and it has been evaluated and accepted by advisors. Hence, I hereby kindly request the department to allow me to present the findings of my work and submit the thesis.

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DEDICATION

This thesis manuscript is dedicated to my beloved wife for all the sacrifices, wishes and praiseworthy to my success in all my endeavors.

DECLARATION

I proclaim that, this thesis is my original work, all sources materials used are acknowledged, never submitted to any organization wherever for the award of any academic degree and nor be published by anyone without the acquiescence of the author.

Name: Sisay Taddese Signature: _______________

Place: Jimma University Date of submission: _____________

BIOGRAPHICAL SKETCH

The author, Sisay Taddese Alemu, was born on 2 January 1986 G.C at Tiyo Woreda, in East Arsi Zone of Oromia Regional State, Ethiopia. He attended his primary education at Areta Cufa elementary school and Assela junior school, and secondary education at Assela comprehensive secondary school. After high school, he joined Hawassa University Wando Genet College of Forestry and Natural Resource in 2005 and graduated B.Sc Degree in Natural Resource Management in 2007. Afterward, he was employed as expert of soil and water conservation in Jimma Zone Setema Woreda Agriculture Office until August 2012. In September 2012, he joined the School of Graduate Studies of Jimma University College of Agriculture and Veterinary Medicine to pursue his Master of Science Degree in Natural Resource Management in Specialization of Soil Science.

ACKNOWLEDGEMENT

First of all I would like to thanks the almighty GOD for his abundant blessing that flourished my thoughts and fulfilled my ambitions and my modest efforts in the form of this write up. Conducting of this thesis research from proposal, fieldwork, and to the final write up of the thesis could not have been fruitful if it were not for the generous assistance of individuals and institutions. In the first place, I am profoundly indebted to my major advisor Mr. Endalkachew Kissi and co-adviser Dr. Tesfaye Shimbir for their encouragement, willingness to supervise my research and their valuable comments from early stage of proposing the research to the final thesis research results write up. I also extend my special thanks to the staff members of Agricultural Office and farmers of Hetosa Woreda for their unreserved cooperation during my data collection. I am glad to convey my sincere thanks to member of NRM department in Jimma University College of Agriculture and Veterinary Medicine. Moreover, my special thanks go to Setema Woreda Agriculture Office for sponsoring my graduate study. Then, I would like to express my heartfelt gratitude to my wife and family for their dedication in bringing me up and for their strong support throughout my academic career. Finally, I owe an enormous thank to my wonderful friends like Bayu Dume, Tesfaye Dhugo and Behailu Etana their support and endorsement have been invaluable for which and I am always grateful.

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
Av.P	Available phosphorus
BD	Bulk density
CEC	Cations exchange capacity
C.V	Coefficient of variance
Ex.Ca	Exchangeable calcium
Ex.Mg	Exchangeable magnesium
Ex.K	Exchangeable potassium
Ex.Na	Exchangeable sodium
HWOARD	Hetosa Woreda Office Agriculture and Rural Development
GPS	Global positioning system
LSD	List significance difference
NRM	Natural Resource Management
PA	Peasant association
PBS	Percent of base saturation
P.V	P-value
SPSS	Statistical package of social science
SEM	Standard error mean
SOM	Soil organic matter
SOC	Soil organic carbon
TN	Total nitrogen

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ABSTRACT

Soil fertility plays a key role in crop production. However, due to intensive and continuous cultivation of agricultural land in Ethiopia, soil fertility has been decline. Therefore, the objective of this study was to assess the impact of wheat based cropping system on soil fertility in Hetosa Woreda. To achieve the objective a composite soil samples were collected from five cultivation fields, with three replication and two depths (0-15, 15-30cm). Totally, 30 soil samples were brought to laboratory from wheat rotated with legumes and cereals fields with simple random sampling system. The two-way ANOVA were used to compare the effects of wheat based cropping systems at different soil sampling depth with their interaction on selected soil physicochemical properties at $P<0.05$*. There was a significantly (*$P<0.05$*) higher value of soil BD in wheat-wheat and wheat-barley than wheat-bean and wheat-pea cropping system. The wheat-wheat and wheat-barley cropping systems didn't pose any changes in the values of pH, SOM, Av.P, CEC, PBS and basic cations. Similarly, mean comparison for wheat-bean and wheat-pea cropping system reveal that there were no significant changes in the value of pH, SOM, TN, Av.P, CEC,* Ca^{2+}, Mg^{2+}, K^{+}, *ex.*Na^{+} *and PBS while soil pH in wheat-maize was significantly different from the entire cropping systems. As compared to the adjacent continuous wheat cultivation, wheat-barley, wheat-bean, and wheat-maize cropping system increased SOM by 0.5%, 19.5%, and 3.7% and TN by 5%, 20% and 5%, respectively. Similarly, the value of Av.P, pH and CEC is increased by 39.6%, 12.3% and 19. 9% at the surface layer of wheat-bean while decreased by 15.4%, 0.9%, and 5.5% in the subsurface, respectively. The BD, sand and clay were significantly higher (*$P < 0.05$*) in wheat-maize cropping system at the subsurface whereas the pH, SOM, Av.P, ex.*Ca^{2+}, *ex.*Mg^{2+}*, CEC, and PBS were higher in wheat-bean cropping system at the surface. Generally, the cultivation of wheat-bean and wheat-pea cropping systems improve the selected properties of soil while wheat-barley and wheat-maize in comparison with continuous wheat cropping systems had adverse effects on the soil physicochemical properties of the study area. Therefore, it is recommended to include grain legume in wheat based cropping system for sustaining the soil fertility level.*

Key words: Cereal, Crop rotation Grain legume, Soil fertility, Soil properties.

1. INTRODUCTION

1.1. Background and Justifications

Soil fertility decline has been taking place over large parts of the world. It occurs mainly through intensive and extensive cultivation as well as inadequate nutrient replacement (Ali, 1999). Pay *et al.* (2001) stated that in the Sub-Saharan Africa nutrient mining accounts about 7% of the sub-continental agricultural gross domestic product. Similarly, soil fertility often changes in response to land use, cropping patterns and land management practices (Rahman and Ranamukhaarachchi, 2003). Moreover, intensive tillage practices especially in the tropical and subtropical climate could result physical determination and compaction in crop root zone, loss of soil organic matter and declining of soil fertility (Adeyemo and Agele, 2010). Therefore, repeatedly growing of the same crop on the same land can reduce soil health and at the same time it lead soil mineral depletion, change in soil structure, and accumulation of toxic substances such as excess Al^{+3}, Fe^{+3} and Cu^{+2} in the soil (Fageria *et al*., 2011).

Unwise crop production and poor soil management practice have generally resulted in a reduction of soil organic matter levels and finally result in gradual decline of soil nutrient status. However, soil nutrient restoration has been possible with fallow lands, and crop rotations (FAO, 2005). Inclusion of legumes in crop rotations increase soil health and help to add soil nitrogen as well as organic matter content and increase organic fertility of the soil. So that, the cereal-legume based crop rotation shows improvement in soil fertility of most soil types (Ahmad *et al*., 2010). According to the report of Fageria (2009) the development of cereal-legume crop rotation brought improvement in physical and chemical properties of the soil. Besides, the legume-based rotations has been economically viable and saying acceptable to farmers as an alternative to continuous cereals cultivation (Zuhair and John, 2006). For example, soil nutrients are higher in velvet-bean-maize rotation than continuous maize, soybean-maize and cowpea-maize cropping system (Okpara and Igwe, 2014).

In Ethiopia, highland plateau have sufficient rainfall and better soil types that vary in soil nutrient status are found suitably for crop production. However, due to the higher population, the crop lands have been subjected to put under continuous cultivation. This leads to high nutrient depletion and decreasing farm sizes and fallow periods (Mati, 2006; Tegegne, 2000). Tamire (1997) reported that, in the dry sub-humid and semi-arid highlands of Ethiopia, the cereal mono cropping is the most dominant farming system. Many farmers live in where do not normally practice crop rotation scheme, inter-cropping, mulching, and manure addition on their farm fields. In addition, dung and crop residues are still used as fuel and livestock feeds, respectively. However, few farmers in some part of the highland rotated cereals with lentil, field pea, faba bean and linseed (Taye and Yifru, 2010).

The values of soil physico-chemical properties are affected by different factors. Studies reveal that, the extent and distribution of soil properties have been changed due to the effect of land use type (Leila *et al.*, 2011; Teshome *et al.,* 2013); cereal types and biomass removal at different landscape (Ali *et al.,* 2012) and nutrient management strategies such as crop rotation with the application of compost, manure and mineral fertilizer effect (Ailincai *et al.*, 2008; Akbari *et al.*, 2011; Clain *et al.,* 2013). However, infrequent information is available on the effects of wheat based cropping system on the soil fertility in many parts of Ethiopia including Arsi Zone. Therefore, this study is amid at assessing the effects of wheat based cropping systems on selected soil properties in Hetosa Woreda, East Arsi Zone.

1.2. Objectives

1.2.1. General objective

- To assess the effects of wheat (*Triticum aestivum*) based cropping systems on selected soil physico-chemical properties in Hetosa Woreda, East Arsi zone.

1.2.2. Specific objectives

- To assess the effect of wheat based cropping systems on selected soil physical properties in Hetosa Woreda, East Arsi Zone
- To assess effect of wheat based cropping systems on selected soil chemical properties in the study area.

2. LITERATURE REVIEW

2.1. Concept of Soil Fertility

Soil fertility is the status of a soil with respect to its ability to supply elements essential for plant growth without a toxic concentration of any element. Thus, soil fertility focuses on an adequate and balanced supply of elements or nutrients to satisfy the needs of plants; because plants have evolved in different climates, soils, and accordingly their needs for the essential nutrients and tolerances of the toxic elements have found to be variable (Henry and Boyd, 1988). Nutrient requirements of crops are depends on yield level, crop species, soil type, climatic conditions, and soil biology. Nutrient deficiencies in crop plants occur due to soil erosion, leaching, intensive cropping, denitrification, soil acidity, immobilization, heavy liming of acid soils and low application rates of inorganic nutrients (Fageria, 2009). These soil mineral nutrients include all essential soil nutrients other than C, H, and O_2, which derived from CO_2, H_2O and N that originally came from atmospheric N_2. Essential soil nutrients can be metals K, Ca, Mg, Fe, Zn, Mn, Cu, and Mo and the nonmetals N, P, S, B, and Cl (Bennett, 1993).

2.2. Effect of Cropping System on Soil Fertility

2.2.1. Physical properties of soil under different cropping system

Textures: the mean values of soil particle distribution in different land use type are resulted higher value of clay at the surface while sand and silt at the subsurface layer of soil. This could be due to the contribution of OM through addition of manures, mulching of its residue as well as crops residue from outfield (Bahilu *et al.*, 2014). Correspondingly, Tolossa (2006) indicated that, the clay and silt particle distribution is higher at the surface layer of soil while sand is at the subsurface layer of maize cultivation land. Furthermore, the clay content in soils under sole cropping is lower than in soil under mixed cropping. This may be attributed to soil erosion in sole cropping (Adamu and Maharaz, 2014). In addition, Pravin *et al.* (2013) stated that, the bulk density had high degree of positive correlation with sand content, while negative with clay and silt content of soil.

Relatively higher sand content is recorded in grassland soils followed by that of enset and maize fields in the upper depth, whereas in the bottom depth silt is found to be higher in grassland soils and then maize and enset fields. On the other hand, higher content of clay is recorded in the surface layer of maize farms. Although, texture is inherent property, this might be accredited to accelerated weathering; because of disturbance during continuous cultivation (Alemayehu and Sheleme, 2013). Similarly, the values of sand and clay particle are varied with soil depth, in which the highest value is at the surface while the lowest is at the subsurface. The higher clay fraction in soil under farmland than grazing land use types perhaps resulted; due to the fact that cultivation promotes further weathering processes as it shears and pulverizes the soil and changes the moisture and temperature regimes (Awdenegest *et al.,* 2013).

Bulk density: is a measure of the soil compactness. It relates to the pore size distribution, water-holding capacity, and soil aeration. SOM management and tillage practices can modify BD. BD in rice based cropping system is higher than maize based cropping system. This is because of higher SOM in maize based cropping system, which is favorable for a good soil structure and the tillage practices in rice based cropping system, with common soil paddling that compact the soil, resulting in a high BD (Basu and Michael, 2004).

Moreover, Joerg and Martin (2009) stated that, the intensity of soil BD may not be determined exclusively by the effects of soil texture, but could also be affected by SOM and or SOC concentration. As stated by Pravin *et al*. (2013), the BD is influenced by soil texture, SOM content, available macronutrients, and cultivation practices. The soil BD decreases as the primary (N, P, K) and secondary (Ca, Mg) macronutrients contents in the soil increases, because the BD had a strong negative correlation with available total primary macronutrients and secondary macronutrients in the soil. Clayey soils tend to have lower BD and higher porosities than sandy soils.

Difference in soil BD with soil depth scored, higher value in the subsurface layer than in the surface soil layer, indicating the tendency of BD to increase with soil depth due to the effects of weight of the overlying soil and the corresponding decrease in SOM content. The relatively lower BD in the top surface than in the lower layer may reflect OM concentration (Awdenegest *et al.*, 2013). Furthermore, compared with the conventional tillage, the rotational cropping system tillage are decreased soil BD, increased macro aggregate content of the soil tilth, and greatly improved soil structure. This is because no tillage can loosen the soil and eliminate soil compaction caused by random wheel traffic (Xianqing *et al.*, 2012).

A general trend of decrease in the values of BD down the depth layer is observed, indicating thereby a subsequent decrease in compactness of the soil with an increase in soil depth. This may be attributed to an increasing trend of clay content down the depth of the soil (Aastha and Rai, 2013). Moreover, Karl (2004) described that, in the upper layer of soil, biological activity (roots, animals) can act to reduce resistance and soil BD while at lower depths soil texture, gravel content and structure may increase soil resistance and soil BD. So that, soil particle size distribution, particle roughness, SOM content, mineralogy of the clay fraction, and structure all can determine BD.

The low content of OM in cultivated land and grassland soil might have resulted in low infiltration rate. This is because a decrease in SOM increases soil BD and decrease soil porosity. Pearson's correlation coefficient showed that, the BD is inversely correlated with the OM. This confirms that alteration in the content of OM results in the change of soil BD value. The practice of plowing in cultivated soil also tends to lower the quantity of SOM. This value are related with reduced biomass return as a result of removal of plant and animal organic sources, and livestock grazing that enhances OM loss by hastening oxidation (Tsehaye and Mohammed, 2013). Additionally, the report of Abebe (2012) showed that, in both wheat and teff cultivated field the BD of the soil layers increased with increasing soil depth due to the compactions imposed by the increasing mass of overlying soil layers, the relatively higher mineral and lower OM contents of the underlying soil layers.

2.2.2. Chemical properties of soil under different cropping system

Soil reaction: the pH value in 2-year wheat-pea cropping system is higher than the 2-year wheat-fallow cropping system. The value variations were due to inorganic fertilizer application (Murphy *et al*., 2008). However, the soil under wheat-wheat had the highest pH value than wheat-barley, wheat-canola, and wheat-clover cropping system with the application of two levels N fertilizer. The relatively higher pH in wheat- wheat rotations might be due to the rapid mineralization of their residues compared to other cropping systems with consequent release of exchangeable cations to elevate the soil pH (Akbari *et al.*, 2011). In other case, the highest pH value is appeared in the wheat-maize than wheat-legumes, wheat-rice cropping system. This is due to the highest salinity content observed in wheat-legumes cropping system than wheat-maize cropping system (Sayyad *et al.*, 2013).

The soil pH increased as depth increased due to an increase in the concentrations of base forming cations such as Ca^{2+}, Mg^{2+} as well as Na^{+} and also it increased with depth in cropping system of continuous wheat, wheat-grass, and wheat-legume due to fertilizer application (Abebe, 2012; Miglierina *et al*., 2000). Additionally, the pH values increased with soil depth because less H^{+-} ions is released from decreased OM decomposition, which is caused by decreased OM content with depth (Abay and Sheleme, 2012). In contrast, Adeyemo and Agele (2010) stated that, the pH value decreased with soil depth of different tillage practice. This is due to the higher value of OM at the surface.

According to the report of Anita *et al.* (2007), concerning the cropping system effects on pH, both surface and subsurface layer of soybean-corn cropping system resulted in higher values than continuous corn. In addition, the pH value is decreased along the depth and then launch to increase value consecutively. In both cropping system, the highest value of pH is found at the very deep layer of soil whereas the least is at the medium. Lower pH with continuous corn may be due to the doubling of N fertilizer amounts.

The extent of calcium carbonate acts as a pH buffer, maintaining a soil pH in the range of 7 to 8 in most calcareous soils (Angela *et. al*, 2008; Loeppert and Suarez, 1996); because, the value of pH is positively correlated with calcium carbonate (Abid *et al*., 2007). When pure calcium carbonate, is dissolved in CO_2 free water (higher CO_2 reduces the alkalinity), hydrolysis to produce a solution with a pH of 9.95. So, if the pH fall below seven it might indicate that little or no calcium carbonate in the soil (Dan, 1957). Correspondingly, Sule and Mustafa (2007) reported that, the presence of calcareous soil could result increment in the value of pH; this is due to the higher amount of calcium carbonate.

Soil organic carbon: the effect of different cultivation patterns on SOC is varying at different level of depth. At 0-20cm depth, almonds cultivation has the higher value of SOC and wheat has the lower. At 20cm depth, almonds cultivation again has the higher SOC while chickpeas, grapes, and wheat have the lower. Decrease in SOC can occur because of cultivation, soil confusion, acceleration in biodegradation of SOM, soil erosion, loss of SOM and nitrogen, because of flowing water. Almonds cultivation enjoys the higher vegetation cover and had high SOM; while, chickpea and wheat cultivations feature the lower amount of SOM (Ali *et al*., 2012). Additionally, the pea-wheat-maize-flower-grass-legume has higher value of SOC than maize-maize, wheat-maize, pea-wheat-maize cropping system. This is due to influence of long-term NP fertilization and organic manure to cropping system (Ailincai *et al.*, 2008).

On the other point, the average value of OC in wheat-summer-legume-wheat cropping system followed by wheat-fallow-wheat cropping system had the higher concentration of OC than wheat-summer cereal-wheat cropping system. The inorganic fertilizer and crop residues retention enhanced the wheat-summer-legume-wheat cropping system to have the higher value of OC (Mohammad *et al*., 2012).Likewise, the subsurface of cultivation land had higher amount of SOC than no tillage. However, the higher SOC is found in the surface layer of no-tillage than cultivation land. This is due to the accumulation and turning down of crop residue to a depth by moldboard cultivation (Dolan *et al*., 2006).

Moreover, Aastha and Rai (2013) stated that, the SOC content is decreased down the depth of soil in the cultivated lands. This is due to the lower OM content. In other case, the corn monoculture had somewhat higher OC concentrations than the soybean-corn cropping system. The extent of OC is decreased with the escalating depth of soil. Both cropping system had higher value at the surface and least at the subsurface. This might be due to continuous corn had the higher amount of residue left on the cropping field (Anita *et al.*, 2007).

There is a very strong relationship between soil particles (clay-silt-sand) and SOC with the order of clay› silt› sand. It is observed that as the amount of clay in soil increased, the amount of SOC also increased, where this is indicated by a close relationship between SOC and clay. Clay constitutes organo-mineral complexes by combining with SOC in soil, and helps to retain carbon within the soil for long periods. Since the soils contain 2:1 type clay minerals, the carbon entering into the layers are flipped and thus protected against oxidation or clay decreases SOC oxidation as well as weathering of organisms. Some metals in soil, clay minerals, Ca and Fe constitute complexes with carbon in soil and protect carbon (Sakin, 2012).

Soil organic matter: is originated from plant tissue. Plant residues contain 60-90% moisture. The remaining dry matter consists of C, O_2, H and small amounts of S, N, P, K, Ca and Mg. Although present in small amounts, these nutrients are very important from soil fertility management point of view. The total amount and partitioning of SOM in the soil is influenced by soil properties i.e. texture, pH, temperature, moisture, aeration, soil biological activities, clay mineralogy, the quantity of annual inputs of plant and animal residues. A complication is that, SOM in turn modifies many of these soil properties. Soil organisms use SOM as food. As they break down the SOM, any excess nutrients (N, P and S) are released into the soil in forms that plants can use. This released process called mineralization. The waste products produced by micro-organisms are also called SOM. The declining of SOM has apparently caused significant impacts on the continuous decline of soil nutrient pools. Because the SOM is the principal source of plant nutrients and helps to sustain soil fertility by mineralization as well as nutrient retention (FAO, 2005).

The relatively low SOM under cultivated soils as compared to native ecosystems could be accredited to intensive cultivation, which aggravates oxidation of OC and complete removal of crop residues in the cultivated land (Teshome *et al.*, 2013). The SOM increased in the no-till pulse than no-till continuous wheat as well as winter pea manure/forage organic system. The lower value is due to exclude of N fertilizer application (Clain *et al*., 2013). Similarly, the practice of plowing in cultivated soil also tends to lower the quantity of SOM (Tsehaye and Mohammed, 2013). Furthermore, the SOM content decreases from fallow land to mono cropping and mixed cropping farmlands. This can be due to the humus formed by fallen leafs and dead plant decaying on the surface. The comparatively low OM in mixed cropping system may be attributed to their lost through extensive cultivation and multi cropping (Yahaya *et al.,* 2014**)**.

Tillage and annual plowing are known to affect SOM mineralization by stirring the soil, disrupting aggregates, and increasing aeration (Mulugeta, 2004). Again, the SOM have a strong negative correlation with BD of soil samples. Therefore, the SOM increases when the BD of soil decreases (Pravin *et al.*, 2013). As stated by Aastha and Rai (2013), the SOM becomes highest in the surface layer of cultivated lands than subsurface, which contributed by the residues of flora and fauna, and gradually decreases down the depth of the soil. According to Power (1990); Herridge (1982); Rafael *et al.* (2001), soils in which legumes had historically been grown tend to have a higher level of SOM, which improves soil fertility. Moreover, use of legumes in a cropping system may lead to an improvement in soil structure through changes in SOM content, soil microbial activity, and deep root growth, which facilitates root penetration by the following cereal crop. In the same way, the highest value of SOM is found in soil treated with legume residue; because SOM is the major product of crop residue decomposition (Ogbodo, 2011). Additionally, the main source of SOM is the crop residues. The types of crops grown, the amounts of root as well as shoot biomass and type of residues management can affect SOM content (Rahman and Ranamukhaarachchi, 2003).

Total nitrogen: decline in SOM content is an obvious reason to expect low N content. The lower N value in the cultivated land can probably be explained by reduced use of crop residues, a higher soil disturbance because of tillage and absence of SOM management. The other reason could be continuous cropping without replacement of nutrients, while crop residues (sorghum stalks and sesame straw) are collected and burned for ease of cultivation and protection of pests (Eshetu, 2011). In other case, velvet-bean/maize cropping system had higher value of N followed by cowpea-maize, soybean-maize cropping system with maize having the least. This is due to fertilizer application, residue contribution and cropping system (Okpara and Igwe, 2014).

Moreover, the high N content is recorded probably due to the high SOC content. The main reason for this was high precipitation. Although not very strong, the positive relationships have been found between clay and N; whereas the correlations between N and silt as well as sand were negative. In addition, the concentration of N is high in areas where the SOC is high. This verifies that there is a positive relationship between N and SOC (Sakin, 2012).

The cultivation of almonds at 0-20cm depth had high N while wheat cultivation has the lower. At > 20cm depth, almonds cultivation again has the higher N whereas chickpeas, wheat, and grapes are the lower. Decrease in soil N can occur because of cultivation and soil erosion (Ali *et al.*, 2012). Furthermore, Abay and Sheleme (2012) stated that, the TN content of the soil is lower in the subsurface and higher in the surface layer of soil. Its content decreased with depth due to decline of SOM content. Results further reveal that, cropping pattern are affect TN in surface soil (0-20 cm), but not the sub-surface soil (20-40 cm). The maximum TN is recorded in cereal-legume cropping system in both the surface and sub-surface soil, than the cereal-cereal cropping system (Ahmad *et al*., 2010).

The corn monoculture has the lower TN concentration than the soybean-corn cropping system. The amount of TN is decreased along with increasing depth in which, both cropping system have higher value at the surface and least at the subsurface. Lower soil N in continuous corn resulted from the residue left on the field and the subsequent N immobilization in residue decomposition, from N fixation of soybean in the soybean-corn cropping system (Anita *et al.*, 2007). By nature, cereals are incapable of fixing the free atmospheric N appreciably like legumes (Taye and Yifru, 2010). Moreover, this leguminous residue decomposed faster because of low C: N ratio increased the mineral N pool in soil (Mohammad *et al.*, 2012).

The level of TN content is relatively higher when the soil was in manure plot of field pea than under maize. This is due to the SOM formation (Asfaw, 2001). Correspondingly, at the surface layer TN is greater for the three-year corn-soybean-wheat cropping system than continuous soybean. All cropping system has higher value of TN at the surface while lower at the subsurface (Stacy, 2013). As maintained by Alemayehu and Sheleme (2013) there is a positive correlation between SOC and TN at the surface and subsurface layer. This shows that the contribution of SOC to TN is high.

Available phosphorus: is the 2nd major element for plant growth. It is an integral part of adenosine diphosphate and adenosine triphosphate; the two compounds involved in almost all energy transformations in plants. Perhaps the availability of this nutrient is the most dynamic in the soil. Beside other factors, its availability is controlled by soil pH, clay content, calcareousness and SOM percentage (Sarwar *et al*., 2008). It is observed more commonly that, SOM hinders phosphorus sorption, thereby enhancing availability. Humic acids and organic acids often reduce phosphorus fixation through the formation of complexes (chelates) with Fe^{2+}, Al^{3+}, Ca^{2+} and other cations that react with phosphorus (Allen and David, 2006).

The Av.P values in multiple cropped plots are higher than the sole cropped plot. That is the low OM in the soil may likely be direct the N and P to low; because mineralization of OM is known to considerably contribute to the concentrations of both. The application of good organic manure is important for the maintenance of Av.P to the crops (Adamu and Maharaz, 2014). In addition, the Av.P is higher under the sorghum compared to the soybean field. This is attributed to the fact that, in comparison with sorghum, the soybean crop is a high P consumer (Sunday *et al.,* 2011).

The cropping systems of sesbania-rice-wheat have the higher value of Av.P than mungbean-rice-wheat, cowpea-rice-wheat, rice-berseem, rice-lentil and rice-wheat. This is due to the effect of green manure and residue decomposition that release nutrients to the soil (Ali *et al.,* 2012). The pea-wheat-maize-sunflower-legumes and perennial grasses cultivation land contain the higher value of mobile P followed by pea-wheat-maize while the lowest is in wheat-maize whereas wheat-continuous cropping had the medium of them. This might be due to long-term fertilization and organic manure effect as well as crop residue contribution (Ailincai *et al.,* 2008).

As maintained by Stacy (2013), the lower soil P concentrations are found in the continuous corn and corn-soybean-wheat cropping system than in continuous soybean while corn-soybean is intermediate between the other cropping system and continuous soybean. Soil P concentrations decreased with depth. The differential removal of soil P by different crop species is likely, the main cause for these differences.

Cations exchange capacity: exchangeable cations refer to the positively charged ions, which are loosely attached to the edge of clay particles or OM in the soil. The cations that are usually found in combination with the soil exchangeable site are consisting of Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, H^{+} and Al^{3+}. The ex.Na^{+} and ex.K^{+} contributed very small proportion to the CEC than ex.Ca^{2+} and ex.Mg^{2+}; because the divalent cations are retained in higher extent by the soil colloidal particles, because of their higher selectivity ability than the monovalent cations. Therefore, the CEC of soils varies with its texture, clay mineralogy, and OM contents. Thus, sandy soils had lower CEC values than clay soils, because the coarse-textured soils are commonly lower in both clay and humus contents (Shiferaw, 2012).

In accordance with the OC content, CEC values of the soil decreased consistently from grassland to maize. This is also evident from the positive and high correlation of CEC with OC for the surface and subsurface depths. The depletion of OC because of intensive cultivation could reduce the CEC of the soils under maize land (Alemayehu and Sheleme, 2013). Additionally, the wheat and teff cropping system has the lowest CEC value at the surface, as a result of clay contribution (Okubay, 2012). In the same case, the CEC of soils in the agricultural land is lower for the topsoil and higher for the subsoil. The lower CEC of the surface in the agricultural land is due to continuous crop cultivation of wheat and barley, crop residue burning and consequently soil erosion (Mosayeb *et al*., 2011). Similarly, the low CEC in cultivated land is in line with the low clay and SOM contents of the soils under this land use type (Teshome *et al.*, 2013).

The value CEC in 2-year wheat-pea cropping system has the higher value than 2-year wheat-fallow cropping system. These variations of values are resulted due to SOM content (Murphy *et al*., 2008). Likewise, it is a general truth, that both clay and colloidal SOM have the ability to absorb and hold positively charged ions. Thus, soils containing high clay and OM have high CEC (Eshetu, 2011). The increase in CEC of the soil with organic soil amendments would probably be due to the negative charge arising from the carboxyl groups of the SOM (Wani, 2010).

The concentration of TN, OC, exchangeable bases (K^{+}, Ca^{2+}, and Mg^{2+}), CEC, Av.P, and Av.K are higher in the surface layer than in the sub-soil. This showed that, more nutrients are concentrated in the surface soil than in the sub-soil; implying that, the agricultural crops grown on this soil can access nutrients in their rooting depth (Abay and Sheleme, 2012). Additionally, at the surface level, the mean values of CEC in the corn-soybean and corn-soybean-wheat cropping system with corn are higher than in the continuous soybean. For the corn-soybean, continuous soybean and corn-soybean-wheat cropping system, CEC is declined along with depth for crop cultivation. This lower value may be related with continuous cultivation effect (Stacy, 2013). In addition, according to the report of Tsehaye and Mohammed (2013), the degradation of SOM had left the soil of cultivated land with low CEC. Soil CEC is important for maintaining soil fertility as it influence the total quantity of nutrients available to plants at the exchange site

Exchangeable calcium: the mean values of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), show that the fallow land is very rich in the base elements than mono cropping and mixed cropping; with ex.Ca^{2+} being the most abundant cations in the soil (Yahaya *et al.,* 2014). Likewise, relatively low ex.Ca^{2+} in cultivated soil is attributed to their continuous removal with crop harvest and soil pH concentration. The distribution pattern of exchangeable bases have been characterized in the order of Ca^{2+}> Mg^{2+}> K^{+} >Na^{+} (Tsehaye and Mohammed, 2013). The ex.Ca^{2+} is higher under enset field, whereas lower under maize and grassland in both surface and subsurface. The low ex.Ca^{2+} observed under maize farms may be due to leaching, soil erosion and crop harvest (Alemayehu and Sheleme, 2013). In areas where the soil was non-calcareous, the Ca^{2+} content is very low; therefore, there is no possibility for P fixation and limitation due to Ca^{2+} (Rahman and Ranamukhaarachchi, 2003).

As stated by Castro *et al.* (2005), in cropping system the soybean-oats had higher value of ex.Ca^{2+} than soybean-wheat. The higher concentrations of ex.Ca^{2+} are stored in the surface layer in each of the cropping system. This may be due to higher SOM and pH value in the cropping system. Furthermore, the average value of ex.Ca^{2+} in the top soil layer was higher in common bean cultivation compared with the subsurface soil layer (Fageria *et al.,* 2007). According to Okpara and Igwe (2014), the ex.Ca^{2+} is higher in legume-cereal cropping system (velvet-bean/maize cropping system) than in continues maize. This is due to fertilizer application, residue contribution and the cropping system.

Exchangeable magnesium: is the predominant cation in the exchangeable sites. The higher ex.Mg^{2+} shows that, the soil parent material primarily rich in basic cations. This is due to divalent cations are retained in higher concentrations for longer periods by the soil colloidal particles, because of their higher selectivity coefficient over the monovalent cations. The mean value of ex.Mg^{2+} contents in the subsurface is higher than the surface layer of wheat and barley cultivation land. This variation may be related with the application of inorganic fertilizer as a treatment activity (Okubay, 2012).

The highest average value of ex.Mg^{2+} is found in soybean-pisum cropping system; while the lowest is in soybean-wheat cropping system. The content of ex.Mg^{2+} decreased with depth in the cropping system of soybean with pisum and wheat, in which the highest concentrations occurring at the surface layer of soil depth (Castro *et al.,* 2005). Likewise, the velvet-bean/maize cropping system has higher value of ex.Mg^{2+}, than soybean-maize cropping system with maize-maize have the least value of ex.Mg^{2+}. This is due to the residue application (Okpara and Igwe, 2014).

As maintained by Anita *et al.* (2007), the contents of ex.Mg^{2+} increased with soil depth, under the cultivated land**.** This indicates that, there is higher down ward leaching of basic cations in the crop field. Similarly, these lowest values of ex.Mg^{2+} also related to the influence of intensity of cultivation and abundant crop harvest with little or no use of input. Correspondingly, the low ex.Mg^{2+} in cultivated soil is related to their continuous removal with crop harvest. As the level of SOM is low to release nutrients, soil erosion is also responsible for the low content of ex.Mg^{2+} in cultivated soil (Tsehaye and Mohammed, 2013). In addition, the report of Alemayehu and Sheleme (2013) showed that, the higher and lower values of ex.Mg^{2+} are found under enset and maize fields, respectively. The low ex.Mg^{2+} observed under maize farms may be resulted due to leaching, soil erosion and crop harvest.

Exchangeable potassium: in the cropping system of different legume, the higher contents of OM, N, Av.P and Av.K is found in sesbania-rice-wheat cropping system; while the lowest is in rice-wheat cropping system. This is because; sesbania-rice-wheat cropping system can contribute the highest residue for mineralized SOM. As a result, it is incorporated into the soil as green manure crop, which indicates that sesbania is much more beneficial to soil health than any other legume crop (Ali *et al.*, 2012). Likewise, the higher value of mobile K is found in pea-wheat-maize cropping system followed by wheat continuous cropping than pea-wheat-maize-sunflower-legume; whereas the lower is in wheat-maize cropping system. The mobile K supply in wheat-maize cropping system is lower because of the high K consumption by these crops and unfavorable conditions of soil structure, which influenced the mobile K supply from soil stock and organic residues/manure (Ailincai *et al.*, 2008). As stated by Castro *et al.* (2005), the highest average value of ex.K^+ is found in soybean-crotalaria cropping system whereas the lowest is in soybean-cajanus cropping system. The higher value of ex.K^+ is recorded in the surface layer, while the lower is at the subsurface layer of cajanus and crotalaria cropping system. Furthermore, in all cropping system, ex.K^+ is higher in soybean-legume cropping system than maize-legume cropping system. This is due to the crop residue contribution for better SOM mineralization and application of NPK fertilizer.

There is a variation in the overall concentration of ex.K^+ with land use types and soil depth. The higher ex.K^+ is found under farmland than in the grazing land. Also, the higher value of ex.K^+ is at the upper layer of all land use types. The higher concentration of ex.K^+ in the top surface layer suggests that; vegetation pumps bases such as K^+, $Ca^{2+}$and Mg^{2+} from the subsoil to the topsoil (Awdenegest *et al.*, 2013).

The value of ex.K^+ is decreased from surface to subsurface layer but it started to increase at sub-subsurface layer. The low availability ex.K^+ may be attributed to fixation (Abay and Sheleme, 2012). The application of organic soil (Wani, 2010) amendments can improve the P, K^+ and Ca^{2+} contents in the soil. According to Berhanu (2011), the lowering of Av.K at the cultivated fields probably linked with the low CEC, so that the high CEC clay soils is often had higher value of K^+ content. The more clay a soil has, the greater its ability to hold and release positively charged cations like K^+. Continuous cultivation and leaching may be the reasons for the declining of Av.K without the extra input of K^+ fertilizer.

Exchangeable sodium: the concentration of ex.Na^+ is the smallest part in the exchange complexes. The ex.Na^+ is varied with land use types, but not with respect to soil depth and the interaction effects. The highest value of ex.Na^+ is resulted in the open grassland than farmland

(Awdenegest *et al.*, 2013). In another case, the values of ex.Na^+ are found to be higher under enset at the surface, while in the subsurface the higher ex.Na^+ is recorded in grassland soils followed by that of maize fields (Alemayehu and Sheleme, 2013). Moreover, each of the ex. Mg^{2+} and ex.Na^+ is enhanced in the soybean compared to the sorghum field. This is maybe; the initially applied poultry manure can boost the status of thus nutrient in the soil (Sunday *et al.*, 2011).

In the cultivation of wheat and teff, the exchangeable cations like Mg^{2+} and Na^+ are increased with soil depth. This is due to intensive cultivation of land, which modified the leaching (Okubay, 2012). Furthermore, the higher value of ex.Na^+ is obtained at the bottom than the upper layer. This can be attributed to adsorption of Ca^{2+} and Mg^{2+} at the soil surface (Abay and Sheleme, 2012). This lower value of Na^+ may be taken as an opportunity, because, Na^+ concentration is not recommendable to high level, as it deteriorates soil structure and make the soil liable for soil erosion, and devoid of beneficial organisms. In addition, it can be detected with successive increase with escalating soil depth in wheat growing highlands (Taye and Yifru, 2010).

Percentage of base saturation (PBS): is higher for fallow land and mono cropping system than mixed cropping. This implies that, the soil under fallow and mono cropping are more fertile, because soil with a high PBS contain greater amount of the essential plant nutrients (K^+, Ca^{2+} and Mg^{2+}) for use by plants (Yahaya *et al.*, 2014). In another case, Tsehaye and Mohammed (2013) described that, the PBS in cultivated soil is extensively higher than the grassland. The high PBS content in the soil of cultivated land is apparently attributed to increased weathering and the subsequent release of cations. The higher value of PBS reveals that, there is low vulnerability of the soil to leaching. Moreover, changes in the value of PBS in soybean rotated with rye and pisum are using different no-tillage management systems could result higher value at the surface and lower at the subsurface layer. It appears that, the boost in the values of total exchangeable bases in soybean than maize plots, are accounted for the increase of PBS in all rotations (Castro *et al.*, 2005).

In the cultivation of wheat and teff, the PBS decreased consistently with depth. This is due to low loss of OM from the surface layer to a depth of cultivation land (Okubay, 2012). The higher PBS is recorded under grassland than maize at the surface layer; while at the subsurface maize have a higher value than grassland. This might be due to cultivation intensity (which enhances the leaching of basic cations), soil erosion, and biomass loss during crop harvest (Alemayehu and Sheleme, 2013). In contrast to that, Awdenegest *et al.* (2013) state that, the PBS did not vary with land use types, soil depth, and the interaction effects. However, the PBS is relatively lower under the farmland than grassland, but the higher value of PBS is recorded at the subsurface layer of farmland. This may be due to animal manure and residues, which are provide Ca^{2+}, K^{+}, P, Mg^{2+} and higher OM.

3. METHODS AND MATERIALS

3.1. Description of the Study Area

The study is conducted in Hetosa Woreda which is located 150 km among from South East of Addis Ababa and 25 km from Assela, the capital city of East Arsi Zone (Fig. 1). Geographically, the area lays between $8^{o}00^{'}$ to $8^{o}02'$ N and $39^{o}07^{'}$ to $39^{o}10^{'}$E. This area is found at altitude ranges of 700-3970 meter above sea level. The rainfall distribution of the study area is unimodal with an average annual of 827mm. The average minimum and maximum temperature of the area is 14^{o}c and 27^{o}c, respectively. The study area has a semi-arid and dry sub-humid agro-ecological characteristic in the rift valley. In the study area agricultural practice is performed with rain based cropping system; because almost all of the accessed river water is not sufficient and suitable for irrigation as an alternative. The major types of soil in Arsi Zone are Nitisols, Umbrisols and Vertisols (MoA, 1984; Mohammed and Solomon, 2010).

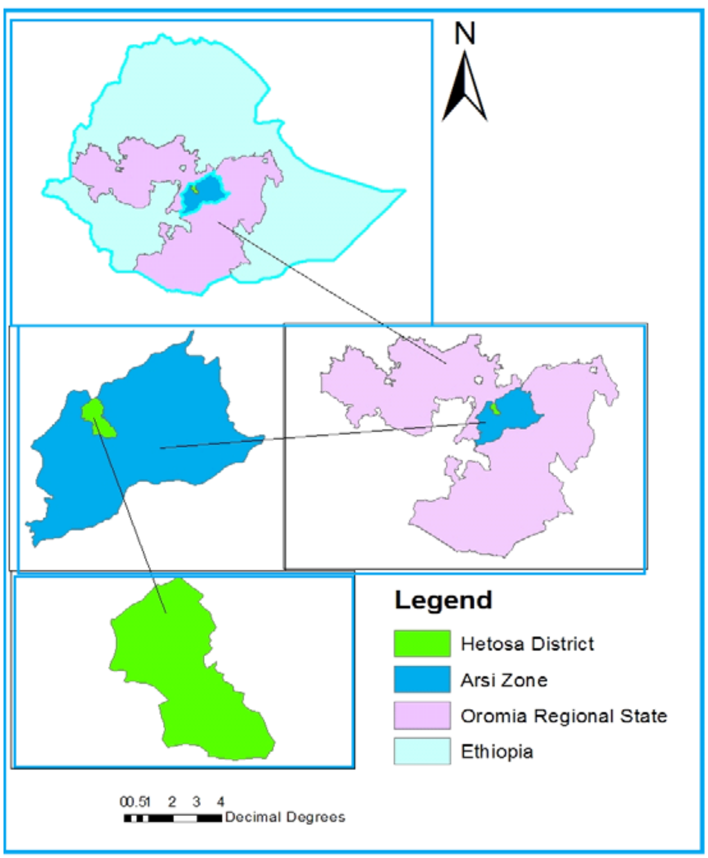

Figure 1. Map of the study area

The land use type is categorized as cultivated land (46%), mountain and shrub land (24%), forestland (7%), grazing land (14%) and others (9%). Farmers of this Woreda are depending on cereal crop cultivation as a major source of revenue generation. The types of crops dominantly grown in this Woreda are bread wheat (*Triticum aestivum L.*), food barley (*Hordeum vulgare*), faba beans (*Vicia faba*), field pea (*Pisum sativum*), maize (*Zea mays L.*), teff (*Eragrostis teff*), and sorghum (*Sorghum bicolor*) (HWOARD, 2013). Since wheat cultivation consumes less labors and time for plowing, sowing and harvesting, farmers of the study area continuously cultivate wheat for 3 to 10 years without fallow. However, after a minimum of 3 and maximum of 10 years wheat cultivation, then it replaced by barley, bean, pea and maize for refreshing the depleted soil nutrients.

3.2. Study Area Selection and Soil Sampling Methods

For this study, Hetosa Woreda was purposively selected from Arsi Zone due to wheat based cropping system is commonly practiced in this area. Prior to collecting soil samples, contacts with Agricultural Office expertise and discussions were made in order to acquire information about the cultivation and cropping system in the area. Then after, reconnaissance field survey was carried out and the croplands with continuously cultivated wheat for four years and replaced by other crops, as well as cultivated without the addition of fertilizer, farmyard manure, and compost in the past one year on nearly the same topographies and slope (gentle) were identified. Subsequently, the study area was purposely stratified into wheat-wheat, wheat-barley, wheat-pea, wheat-bean, and wheat-maize cropping system. This was because; cultivation of different crops rotation system in alternative with continuous cropping system had diverse effects on soil properties (Ailincai *et al.,* 2008). Based on the above criteria, to achieve the intended objective, the adjacently situated cultivation land of wheat based cropping system in which, wheat-wheat taken as a control were selected.

Afterward, composite soil samples were collected from the 5 cultivation fields with 3 replications and 2 soil sampling depths. A total of 30 soil samples were brought for laboratory analysis with simple random sampling system. Two techniques were used to obtain soil samples within the plots. These were undisturbed (core sampling) and disturbed soil sample from each sampling depth using 2 cm diameter stainless steel sampling auger. One composite soil sample was collected from each replication at 0-15cm and 15-30cm depths. For each composite soil samples, soils composed from 10 sampling points were cautiously mixed with a plastic bag (Shaw Environmental, Inc, 2009). The well-mixed soils sample were stored in zip-lock plastic bags and placed in a cooler to keep the samples at a moderate temperature. Besides, each disturbed soil sample was air dried and sieved with a stainless steel of 2-mm mesh sieve in order to remove stones, roots, and large organic residues before conducting analyses for soil chemical and physical characteristics. The analyses of the soil physical and chemical properties were carried out in soil laboratory of Jimma University, College of Agriculture and Veterinary Medicine and the analysis not done in Jimma University was conducted at Debrezeit Agricultural Research Center.

3.3. Analysis of Soil Physical Properties

The physical properties of soil were conducted based on the following standard laboratory procedures. Particle size distribution was determined by the hydrometer method (Houba *et al*., 1989). Hydrogen peroxide (H_2O_2) was used to destroy the SOM and sodium hexametaphosphate $(NaPO_3)_6$ as well as sodium carbonate (Na_2CO_3) was used as soil dispersing agent and one or two drops of amyl alcohol was used for foam reduction. Soil bulk density was determined by using undisturbed core sampling method after drying the soil samples in an oven at $105^{o}{}_{C}$ to constant weights (Blake and Hartge, 1986). For bulk density calculation, the mass of each empty core (*a*), and the mass of each core with its dry soil (*c*) were used as follow:

$$\text{Bulk Density (gm/cm3)} = \frac{\text{Weight of Oven dry soil in gm } [c-a]}{\text{Volume of core in cm 3}}$$ (Dadey *et al*., 1992)

Relative change in soil properties due to barley, bean, pea and maize as compared to adjacent cultivated land of continuous wheat cropping: in which ‘’ a’’ is the soil property measured on the barley, bean, pea and maize cropping system while ‘’ b’’ is the soil property measured on the adjacent site of continuous wheat cultivation. This relative change is calculated by the following formula:

$$\text{Relative change} = \frac{(a - b) * 100}{b}$$

3.4. Analysis of Soil Chemical Properties

Selected soil chemical properties such as pH (H_2O), SOC, SOM, CEC, TN, Av.P, ex.Ca^{2+}, ex.Mg^{2+}, ex.K^+, ex.Na^+ and PBS were determined using the following standard procedures. Soil pH (H_2O) was measured using the glass electrode method with in a supernatant suspension of 1:2.5 soils: liquid on a mass to volume basis. The pH meter was calibrated with buffer solutions of pH 4, 7 and 10 as its necessity. The pH was measured in the suspension by using standard pH meter after 30 minute stirring (IITA, 1979). The SOC was determined by using Walkley and Black wet digestion method. One gram of soil was reacted with a mixture of 10mL of 1N $K_2Cr_2O_7$ solution and 20mL of 98 % H_2SO_4. The excess dichromate solution was titrated against 1M ferrous sulphate after addition of 200mL distilled water, 10mL of 85 % phosphoric acid and 1mL of indicator solution (0.16 % barium diphenylamine sulphate (Nelson and Sommers, 1996). Following the standard practice that SOM was composed of 58% C (Nelson and Sommers, 1996), the SOC was multiplied by a factor of 1.724 to obtain SOM.

The Av.P content of the soil was analyzed using 0.5M sodium bicarbonate extraction solution (pH 8.5) of Olsen method (Van Reeuwisk, 1992). TN was identified using the Kjeldahl digestion, distillation and titration method, based on the principle that the SOM is oxidized by treating the soil with 96% concentrated 0.1N H_2SO_4. During the oxidation, nitrogen in the organic nitrogenous compounds being converted into NH_4SO_4. The acid traps NH_4^+ ions in the soil, which are librated by distilling with 0.1N NaOH solution. The liberated NH_4^+ is absorbed in H_3BO_3 and back titrated with standard H_2O and K_2SO_4 is added to raise the boiling point as described by Bremmer (1996). The soil CEC and exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, and Na^+) were determined after extracting the soil samples by ammonium acetate method (1N NH_4OAc) at pH 7.0 (Houba *et al*., 1989).

Furthermore, CEC was estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Chapman, 1965). The exchangeable Ca^{2+} and Mg^{2+} in the ammonium acetate leachate were measured by atomic absorption spectrophotometer (AAS) (Van

Reeuwisk, 1992). The 1 ml original ammonium acetate leachate was dropped into test tube, then adds 9ml of 0.55% $LaCl_3$ solution, and homogenizes it. The exchangeable Ca^{2+} and Mg^{2+} in the sample solution were measured by AAS at wavelength of 422.7nm and 285.2nm respectively. The ex.K^+ and ex.Na^+ were determined by using flame photometer method with a wavelength of 768 and 598nm, respectively (Houba *et al*., 1989). PBS was calculated by dividing the sum of the charge equivalents of the base-forming cations (Ca^{2+}, Mg^{2+}, K^+, and Na^+) by the CEC of the soil and multiplying by 100 (Fageria *et al*., 2011).

3.5. Statistical Analyses of Data

The data were analyzed using SAS software version 9.2 for mean comparison (SAS, 2008) and correlation analysis by SPSS version 16. The two-way analyses of variance (ANOVA) were used to compare the effects of wheat based cropping systems, soil sampling depth and interaction of cropping system and soil depth on selected soil physicochemical properties. The least significance difference (LSD) was used to separate considerably differing treatments mean when significant effects were found at $P<0.05$. Moreover, Pearson's correlation co-efficient was used to decide the selected soil physico-chemical properties direction and their degree of association at 1% and 5% probability levels.

4. RESULTS AND DISCUSSION

4.1. Effect of Cropping Systems on Physical Properties of Soil

4.1.1. Texture

The results of the study presented in table 1 indicated that there was a significant ($P<0.05$) variation in soil particle distribution due to the cropping systems except sand fractions. The mean value of silt fraction under wheat-maize land was significantly varied from entire cropping system except wheat-pea. The clay content of soil in wheat-wheat cultivated area was significantly different ($P<0.05$) from wheat-bean, wheat-pea and wheat-maize but non-significant from wheat-barley cropping systems. The higher (43.18 %) and lower (42.03%) mean values of clay were found in wheat-pea and wheat-wheat cropping system respectively. This result was in line with the report of Adamu and Maharaz (2014) who reported that, the clay content in soils under sole cropping was lower than in soil under mixed cropping. This may be attributed to soil erosion in sole cropping system for long period of time. Furthermore, many authors (Power, 1990; Herridge, 1982; Rafael *et al.*, 2001) reported that, the use of legumes in a cropping system lead to improve the soil structure through changes in SOM content which further reduce soil erosion that contributed the relative increment under such site. On the contrary, the higher (41.46%) value of silt was measured in wheat-wheat cropping system. The textural class of the soil under all cropping systems was silt clay.

Statistically the significantly ($P < 0.001$) higher value of clay (43.79%) and silt (41.54%) percentage was recorded at the surface layer of the studied area whereas highest (18.33%) mean value of sand was in the subsurface layers (Table 1). The relatively higher values of clay and silt distribution at the surface layer of soil were resulted due to intrinsic properties of parent material, mineral weathering, soil organic matter content and the extent of moisture as well as water movement, which determined the leaching of fine particle. Correspondingly, Tolossa (2006) indicated that, the clay and silt particle was higher at the surface layer of soil while sand was at the subsurface layer of maize cultivation land. Similarly, the report of Bahilu *et al.* (2014) point out that, the higher mean value of clay was observed at the surface while sand and silt at the subsurface layer of soil due to SOM addition from manures and crops residue. Whereas the finding of the study showed in table 1 revealed that the textural class of the surface and subsurface layer was silt clay and clay respectively.

Table 1. Cropping system and soil sampling depths effect on selected physical properties (BD, Sand, Silt, Clay) of the soils (α=0.05) and mean ± SEM.

Cropping system	BD(g/cm3)	Sand (%)	Silt (%)	Clay (%)	Soil textural class
		Cropping system			
Wheat-wheat	1.27±0.03[a]	16.51±0.38[a]	41.46±0.29[a]	42.03±0.09[c]	Silt clay
Wheat-barley	1.27±0.01[a]	16.40±1.02[a]	41.16±1.03[a]	42.44±0.29[bc]	Silt clay
Wheat-bean	1.08 ±0.10 [b]	16.18±1.22[a]	41.20±1.03[a]	42.63±0.39[ab]	Silt clay
Wheat-pea	1.11±0.07 [b]	16.15±1.00[a]	40.67±0.04[ab]	43.18±1.04[a]	Silt clay
Wheat-maize	1.24±0.04[a]	16.90±1.01[a]	40.02±0.46[b]	43.08±1.02[a]	Silt clay
LSD	0.1121	0.820	0.972	0.5816	
P.V	***	ns	**	***	
		Depth			
0-15cm	1.09±0.04[b]	14.67±0.18[b]	41.54±0.29[a]	43.79±0.23[a]	Silt clay
15-30cm	1.28±0.01[a]	18.33±0.16[a]	39.89±0.16[b]	41.79±0.1[b]	Clay
P.V	****	****	****	****	
C.V (%)	7.27	4.21	4.9	5.44	
LSD	0.06	0.47	0.56	0.37	

N.B: BD= Bulk density, P.V= P-value, C.V = Coefficient of variation, LSD = Least significant difference. Mean ± SEM (standard error mean). The same values of letters are non-significant. * shows P ≤0.05, **P≤0.01, ***P≤0.001 and **** P≤0.0001.

Among percentage value of clay, silt and sand obtained under interaction of cropping systems with depths were significantly (P<0.05) diverse except sand content at the surface layer of wheat-pea and wheat-maize cropping system. The highest values of clay (44.63%) and silt (43.05%) contents were recorded at the surface layer of the wheat-pea and wheat-bean, respectively. However, sand content was highest (19.20%) at the subsurface layer of the wheat-maize (Table 2). Although texture was inherent property, this might be attributed to accelerated weathering due to disturbance during cultivation and the SOM enhancement of soil structure and extent soil microorganism. The present study is in agreement with the finding of Alemayehu and Sheleme (2013) indicated that, clay and silt particle distribution had no extensive difference with sampling depths in the cultivated land. Similarly, Awdenegest *et al.* (2013) had reported that in the farmland the value of silt was higher at the surface whereas sand was at the subsurface. The lowest interaction mean values of clay (41.73%) and silt (38.99%) were observed in the wheat-pea and wheat-maize cropping system at the subsurface respectively while the lowest sand (13.50%) was at the surface layer of wheat-bean.

4.1.2. Bulk density

Concerning the effect of cropping systems on soil BD, the result exhibited that soils cultivated with wheat-bean was significantly (P<0.05) differed from wheat-maize, wheat-barley and wheat-wheat cropping systems. But, wheat-bean and wheat-pea had insignificant variation (Table 1). The result in table 1 indicated that the highest (1.27 g/cm3) mean value of BD was observed in soils cultivated with wheat-wheat as well as wheat-barley and the lowest (1.08g/cm^3) was in wheat-bean cropping system. The cultivation of wheat-bean reduces the value of BD by 14.96%. This lower mean value of BD under wheat-bean was observed due to the higher SOM formation from the residue of bean whereas the higher BD under wheat-wheat site was because of use of wheat crop residue for animal fodder. This study was in line with the results of Pravin *et al*. (2013), and Joerg and Martin (2009) who mentioned that the BD was mainly determined by OM contents. The report of Xianqing *et al.* (2012) also indicated that in comparison with the conventional practice, the rotational cropping system was decreased the soil BD.

Table 2. The cropping system and soil sampling depths interaction effect on physical properties (BD, Sand, Silt, Clay) of soil (α=0.05) and mean ± SEM.

Cropping system	BD(g/cm3)		Sand (%)		Silt (%)		Clay (%)	
	Depth							
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Wheat-wheat	1.26 ± 0.01^{de}	1.27 ± 0.01^{d}	15.66 ± 0.01^{f}	17.36 ± 0.01^{e}	42.11 ± 0.01^{c}	40.81 ± 0.01^{e}	42.23 ± 0.01^{e}	41.83 ± 0.01^{g}
Wheat-barley	1.25 ± 0.03^{e}	1.28 ± 0.01^{c}	14.2 ± 0.01^{h}	18.60 ± 0.01^{c}	42.71 ± 0.01^{b}	39.61 ± 0.02^{h}	43.09 ± 0.01^{d}	41.79 ± 0.01^{h}
Wheat-bean	0.85 ± 0.01^{h}	1.30 ± 0.02^{b}	13.46 ± 0.01^{i}	18.90 ± 0.004^{b}	43.05 ± 0.01^{a}	39.34 ± 0.01^{i}	43.49 ± 0.01^{c}	41.76 ± 0.01^{i}
Wheat-pea	0.95 ± 0.01^{g}	1.26 ± 0.01^{de}	14.63 ± 0.02^{g}	17.67 ± 0.01^{d}	40.74 ± 0.01^{f}	40.60 ± 0.01^{g}	44.63 ± 0.01^{a}	41.73 ± 0.01^{j}
Wheat-maize	1.15 ± 0.02^{f}	1.32 ± 0.01^{a}	14.65 ± 0.02^{g}	19.15 ± 0.003^{a}	41.06 ± 0.01^{d}	38.99 ± 0.03^{j}	44.29 ± 0.01^{b}	41.86 ± 0.01^{f}
P.V	****		****		****		****	
C.V (%)	8.02		3.30		3.88		4.56	
LSD	0.017		0.0612		0.0536		0.017	

N.B: BD= Bulk density, P.V= P-value, C.V = Coefficient of variation, LSD = Least significant difference. Mean ± SEM (standard error mean). The same values of letters are non-significant. * shows P ≤0.05, **P≤0.01, ***P≤0.001 and **** P≤0.0001.

The significantly higher mean value of BD was found at the subsurface (1.28g/cm^3) than surface (1.09 g/cm^3) layer. This showed that the investigated soils had a compacted layer in the subsurface. The lower value of BD at the surface layer was observed due to crop residue effect and an increase of SOM. Similarly, the finding of Awdenegest *et al.* (2013) explained that, the higher BD in subsurface soil was due to the effects of weight of the overlying soil and the corresponding decrease in SOM content. Basu and Michael (2004) also reported that the soil with higher SOM had low BD under different cropping system. In contrast, Aastha and Rai (2013) specified that, a decrease in the values of BD down the depth layer was observed because of subsequent decrease in compactness of the soil with increase in soil depth. This may be associated with an increasing trend of clay content down the depth of the soil.

All cropping systems at both surface and subsurface layers had a significantly different value of mean BD with the exception of non significance between wheat-wheat and wheat-barley cropping system at surface and wheat-pea at subsurface layers, and also at subsurface layer there was insignificance between wheat-wheat and wheat-pea including wheat-wheat of surface. The highest (1.32g/cm^3) value of BD was recorded at the subsurface layer of the wheat-maize cropping system while the lowest (0.85g/cm^3) was in wheat-bean cropping system of surface layer (Table 2). As the result obtained from the calculation of relative change indicate, in comparison with continuous wheat cultivation, the value of BD was increased by 4.76% at the subsurface layer of soil in wheat-maize cropping system. As a result of lower maize crop residue left due to high need for firewood and cause the lower value of SOM, wheat-maize had the highest value of BD. However, the lower soil BD on the wheat-bean and wheat-pea cropping system could be resulted due to the highest SOM, clay percentage and the minimum intensity of cultivation that lead to less disturbance of the soil structure.

Moreover, soil BD was negative and significantly correlated with the SOM (r = -0.86**), and clay (r = -0.74**) (Table 8). In other case, Karl (2004) obtained that, in the upper soil, biological activity can act to reduce soil BD while at lower depths soil texture and gravel content may increase soil BD. Tsehaye and Mohammed (2013) confirmed that, the decrease in SOM increases soil BD. The finding of Abebe (2012) also showed that, in both wheat and teff cultivated field, the soil BD was increased through increasing soil depth due to the compactions imposed by the increasing mass of overlying soil layers, and lower SOM contents of the underlying soil layers.

4.2. Effect of Cropping Systems on Chemical Properties of Soil

4.2.1. Soil reaction

The pH of the study area soil ranges from 7.11 to 8.04 (Table 3 and 4). Although the area received 827 mm rain fall, according to the soil pH fertility rating (Appendix 1) established by Brindha and Elango (2014), the soil was varies from neutral to moderately alkaline. The basic value of pH was achieved as a result of calcareousness nature of soil in the rift valley where buffering capacity of clay, CEC and OM were high. Similarly, Sule and Mustafa (2007) explained that the presence of higher amount of calcium carbonate in calcareous soil could result increment a value of pH. The soil pH in the wheat-maize (7.28) cropping system was significantly ($P<0.05$) differed from the whole cropping system. The cultivation of wheat-pea (7.51) and wheat-bean (7.52) were insignificantly varied from each other. Likewise no significant variation was observed between wheat-bean and wheat-pea as well as among wheat-wheat and wheat-barley cropping systems (Table 3). The highest mean value pH-H_2O of 7.52 was recorded from wheat-bean cropping system while the lowest value of 7.11 was in wheat-wheat cropping system. The value of soil pH in wheat-bean cropping system was increased by 5.8% probably due to bean crop residues left in the cultivated field, which the decomposition of this residue enables mineralization of SOM to boost the basic cations that allow the raising of the soil pH in the area. This result agrees with the finding of Murphy *et al*. (2008) who showed that the pH value in 2-year wheat-pea cropping system was higher than wheat-fallow cropping system. This finding also agreed with the report of Sayyad *et al.* (2013) in which, the highest pH value appeared in the wheat-legumes than wheat-non legumes crops, wheat-rice cropping system.

Comparing the effect of soil depth on pH, the higher (7.65) value of pH was at the surface, while the lower (7.02) was at the subsurface as shown in (Table 3). This could be due to the rainfall amount in this area might be not adequate to leach of basic cations obtained from calcareous materials that enhance the pH concentration in the soil. In line with this, Angela *et al*. (2008) and Loeppert and Suarez (1996) indicated that, the higher value of calcium at the surface enable the soil to had higher value of pH on the top layer because of the calcium carbonate acts as a pH buffer, and maintaining a soil pH in the range of 7 to 8 in most calcareous soils. This finding was contradicting with the results of different studies in Ethiopia (Abebe, 2012; Abay and Sheleme, 2012).

Table 3. Cropping system and soil sampling depths effect on selected chemical properties (pH, OC, OM, TN, Av.P) of the soils (α=0.05) and mean ± SEM.

Cropping system	pH (H_2O)	OC (%)	OM (%)	TN (%)	Av. P (ppm)
			Cropping system		
Wheat-wheat	7.11±0.03[c]	2.05±0.11[b]	3.54±0.18[b]	0.20±0.01[c]	5.01±0.27[b]
Wheat-barley	7.19±0.08[c]	2.06±0.16[b]	3.56±0.28[b]	0.21±0.01[b]	5.06±0.45[b]
Wheat-bean	7.52±0.24[a]	2.46±0.35[a]	4.23±0.70[a]	0.24±0.03[a]	5.99±0.92[a]
Wheat-pea	7.51±0.22[a]	2.44±0.28[a]	4.21±0.48[a]	0.24±0.03[a]	5.78±0.71[a]
Wheat-maize	7.28±0.13[b]	2.13±0.26[b]	3.67±0.44[b]	0.21±0.02[b]	5.10±0.63[b]
LSD	0.085	0.232	0.4394	0.0021	0.663
P.V	***	***	***	***	**
			Depth		
0-15cm	7.65±0.08[a]	2.75±0.08[a]	4.74±0.14[a]	0.26±0.008[a]	6.72±0.2[a]
15-30cm	7.02±0.01[b]	1.73±0.03[b]	3.00±0.05[b]	0.19±0.002[b]	4.16±0.1[b]
P.V	****	****	****	****	****
C.V (%)	4.7	8.77	8.77	8.08	9.57
LSD	0.13	0.13	0.23	0.01	0.36

N.B: pH, OC= Organic carbon, OM= Organic matter, TN= Total nitrogen, Av.P= Available phosphorus, P.V= P-value, C.V = Coefficient of variation, LSD = Least significant difference. Mean ± SEM (standard error mean). The same values of letters are non-significant. * shows P ≤0.05, **P≤0.01, ***P≤0.001 and **** P≤0.0001.

With respect to the interaction effect of cropping system and soil depths on mean value of pH, the result presented in table 4 showed that significant (P<0.05) variation except wheat-barley, wheat-bean as well as wheat-barley and wheat-pea cropping system at the subsurface layer. The mean pH value (8.04) of wheat-bean cropping system was significantly higher from the other cropping types at the surface but at the subsurface, it was (6.99) statistically lower than the all cropping system except wheat-maize (6.97) and wheat barley (7.01). In the surface layer the value of pH was increased by 12, 29% and 2.79% in crop cultivation of wheat-bean and wheat-barley, respectively but decreased by 1.14% in the subsurface of wheat-maize cropping system. In conformity of this finding, the report of Anita *et al.* (2007) specified that, the surface layer of legume and non legume cropping system resulted in higher values of pH than continuous non legume crops. The lower (7.16) soil pH in the wheat-wheat cropping system of surface layer than the adjacent cropland at the same layer that it was considerably higher (7.05) in the subsurface layer. Generally, the value of pH was decreased with descending soil depth in all cropping system (Table 4). This variation of value was resulted due to residue accretion, level of SOM formation and clay percentage within and along the cropping system and depth. As a result, clay (r =0.89**), and SOM (r=0.97**) had a strong positive and significant correlation with soil pH

(Table 8). Besides, it was increased due to reduction in basic cations. Similarly, According to Abid *et al*. (2007), the value of pH was positively correlated with calcium carbonate.

4.2.2. Organic matter and Organic carbon

The mean values of SOM and SOC showed in table 3, had a significant ($P<0.05$) variation across different cropping systems. The SOM and SOC in the wheat-bean and wheat-pea cropping system were significantly different compared with wheat-barley, wheat maize and wheat-wheat cropping system at $P<0.05$. But cultivation of wheat-wheat was not significantly varied from wheat-barley and wheat-maize cropping system. Moreover results in table 3 also showed that statistically, SOM and SOC were not significantly different in the wheat-bean and wheat-pea cropping system. According to the classification of SOM as per the ranges suggested by Tabi *et al*. (2012), the soils of the area were found in the range of medium (2-4.2%) to high rate (4.2-6%).

The soil organic carbon content of wheat-wheat, wheat-barely, wheat-maize, wheat-pea, and wheat-bean were 2.05, 2.06, 2.13, 2.44 and 2.46% respectively. This revealed that the soils cultivated with wheat-bean cropping system had the higher value of SOM (4.23%) and SOC (2.46%) and the lower SOM (3.59%) and SOC (2.05%) were in the wheat-wheat cropping system (Table 3). As compared to adjacent continuous wheat cultivated land, wheat-bean and wheat-pea cropping system increased SOM by 19.50% and 18.93%, respectively. Similarly, several authors (Power, 1990; Herridge, 1982; Rafael *et al.*, 2001) reported that, soils in which legumes have been grown tend to have a higher level of SOM, which improves soil fertility. Likewise, Ailincai *et al.* (2008) stated the higher value of SOC was scored in the pea-wheat-maize-grass-legume cultivation land than maize-maize, wheat-maize, pea-wheat-maize cropping system. The result of Mohammad *et al.* (2012) as well confirmed that, the average value of SOC in wheat-summer-legume-wheat cropping system had the higher concentration of SOC than wheat-summer cereal-wheat cropping system. This was due to crop residues retention enhanced the wheat-summer-legume-wheat cropping system to have the higher value of SOC. Correspondingly, Ogbodo (2011) reported that, the highest value of SOM was found in soil under legume residue cropping land than non-residue; because SOM was the major product of crop residue decaying. Moreover, Ahmad *et al.* (2010) indicated that, inclusion of legumes in cropping system increase soil health and help to add soil nitrogen and SOM content and organic fertility of most soil type.

With respect to the soil depths, the significantly higher average value of SOM (4.740%) and SOC (2.75%) were observed in the surface than subsurface (3.00% SOM and 1.73% SOC) layer (Table 3). This variation was occurred due to the more residue accumulation on the surface layer and their decomposition. Correspondingly, Aastha and Rai (2013) indicated that, due to shortage of organic matter source, the SOC content decreased along the depth of the soil. Concerning the effect of wheat based cropping system by soil depth, the entire cropping system had a significant ($P<0.05$) variation at both the surface and subsurface layer with the exception of SOM in wheat-wheat (3.13%) and wheat-pea (3.13%) cropping system, and SOC in wheat-barley (1.69%) and wheat-bean (1.68%) as well as wheat-wheat (1.82%) and wheat-pea (1.82%) cropping system at the subsurface layer (Table 4). The higher and the lower values of SOM and SOC contents at surface layer were recorded under wheat-bean and wheat-wheat cropping system, respectively.

The relative change indicate that SOM was increased by 41.12% and 18.52% in the surface layer of wheat-bean and wheat-maize cropping system, respectively whereas decreased to 6.71% and 14.7% in wheat-barley and wheat-maize cultivation land at the subsurface, respectively. The difference in SOM and SOC value was attributed to the consequence of continuous cultivation that aggravates OM oxidation, and biomass loss through harvest, variation in residue decomposition. Similarly, Rahman and Ranamukhaarachchi (2003) described that, the main source of SOM was the crop residues. The types of crops grown, the amounts of root as well as shoot biomass and type of residues management can affect SOM content. Furthermore, the report of Tsehaye and Mohammed (2013) showed that, the practice of plowing in cultivated soil tends to lower the quantity of SOM. Moreover, Mulugeta (2004) also indicated that, tillage was known to affect SOM mineralization by stirring the soil, disrupting aggregates and increasing aeration. The report of Ali *et al*. (2012) also showed that, almonds cultivation had the higher SOC at the surface, while wheat cultivation was lower.

4.2.3. Total nitrogen

The study result indicated that among the wheat based cropping system, the TN found under the wheat-wheat (0.20%) cropping system was significantly ($P<0.05$) varied from the all cropping system. However, the TN content in the cultivation of wheat-bean (0.24%) and wheat-pea (0.24%) as well as wheat-maize (0.21%) and wheat-barley (0.21%) cropping system had no significant variation (Tables 3). The higher TN value was obtained from the wheat-bean (0.24%) and wheat-pea (0.24%) cropping system whereas the lower was from the wheat-wheat field (0.20%). The values of TN in wheat-bean and wheat-pea cropping system were increased by 20% whereas wheat-barley and wheat-maize increased by 5%; in comparison with land cultivation with continuous wheat. This higher value of TN was probably related with the higher N-fixing capacity of wheat-bean and wheat-pea cropping system. The report of Okpara and Igwe (2014) also showed that, the velvet-bean-maize cropping system had higher value of TN than cowpea-maize. Similarly, the report of Mohammad *et al.* (2012) explained that, the leguminous crop residues were decomposed faster because of low C: N ratio and increase the mineral N pool in the soil. Furthermore, Eshetu (2011) had reported that, the lower N value in the cultivated land could be resulted by reduced use of crop residues, a higher soil disturbance through tillage, continuous cropping, and absence of SOM management.

Table 4. The cropping system and soil sampling depths interaction effect on chemical properties (pH, OC, OM, TN) of soil ($\alpha=0.05$) and mean ± SEM.

Cropping system	pH (H_2O)		OC (%)		OM (%)		TN (%)	
	Depth							
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Wheat-wheat	7.16±0.01^{e}	7.05±0.01^{f}	2.29±0.003^{e}	1.82±0.003^{f}	3.94±0.01^{e}	3.13±0.01^{f}	0.22±0.001^{d}	0.19±0.001^{e}
Wheat-barley	7.36±0.01^{d}	7.01±0.01^{gh}	2.43±0.01^{d}	1.69±0.003^{g}	4.19±0.01^{d}	2.92±0.01^{g}	0.23±0.001^{c}	0.19±0.001^{e}
Wheat-bean	8.04±0.03^{a}	6.99±0.01^{h}	3.23±0.003^{a}	1.68±0.003^{g}	5.56±0.02^{a}	2.90±0.01^{h}	0.30±0.001^{a}	0.19±0.001^{e}
Wheat-pea	7.99±0.1^{b}	7.03±0.01^{g}	3.07±0.003^{b}	1.82±0.003^{f}	5.29±0.01^{b}	3.13±0.01^{f}	0.30±0.001^{a}	0.19±0.001^{e}
Wheat-maize	7.57±0.1^{c}	6.97±0.01^{i}	2.71±0.02^{c}	1.55±0.003^{h}	4.67±0.01^{c}	2.67±0.01^{i}	0.25±0.001^{b}	0.17±0.001^{f}
P.V	****		****		****		****	
C.V (%)	3.93		5.6		5.54		4.1	
LSD	0.0311		0.0103		0.0165		0.0044	

N.B: pH, OC=Organic carbon, OM=Organic matter, TN=Total nitrogen, P.V= P-value, C.V = Coefficient of variation, LSD = Least significant difference**.** Mean ± SEM (standard error mean). * shows $P\leq0.05$, $^{**}P\leq0.01$, $^{***}P\leq0.001$ and **** $P\leq0.0001$. The same values of letters are non-significant.

The TN content (0.26%) measured at surface soil was significantly higher than the value (0.19 %) recorded in the subsurface soil (Table 3). This decline of value from surface to subsurface was also related with the minimum amount of SOM at the bottom and clay. It was also suggested by Abay and Sheleme (2012) that the TN content of the soil was lower in the subsurface and higher in the surface layer due to decreasing soil organic matter. The Pearson's correlation coefficient presented in table 8 indicate that, there was a positive and significant correlation of SOM (r=0.99**) and clay (r=0.87**) with TN content

The mean values of TN obtained under wheat-pea and wheat-bean of surface layer were significantly (P<.05) different from the all interaction of cropping system and depths. However, it was insignificantly different between wheat-bean and wheat-pea at surface soil and as well as at subsurface. At the surface layer of cultivation land, the higher TN value (0.30%) was recorded in wheat-bean and wheat-pea cropping system while the lower (0.22%) was in the wheat-wheat cropping system (Table 4). On the other hand, wheat-maize had the lower (0.17%) interaction mean value of TN than the whole cropping system at the subsurface layer of soil. The result observed under the relative change indicates that the values of TN increased by 36.36% at the surface layer of wheat-bean and wheat-pea and reduced by 10.53% at the subsurface layer of wheat-maize cropping system. This difference implies that, the highly utilization of the N nutrient by maize crop and also relatively their deep root help to uptake from sub surface layer with a minimum replenishment through residue decomposition.

In line with this study, the report of Anita *et al.* (2007) signified that, the corn monoculture had the lower TN concentration than the soybean-corn cropping system and also the TN was decreased along with depth. The highest mean value of TN under wheat-pea and wheat-bean of surface layer was probably due to the fact that nitrogen fixation nature of these legume crops and high crop residues. Likewise, Ahmad *et al*. (2010) indicated that, the maximum TN was recorded in cereal-legume cropping system in both the surface and subsurface soil than the cereal-cereal cropping system. Moreover, Stacy (2013) showed that, at the surface layer TN was significantly greater for the 3-years cropping system of different crops than continuous crop. The report of Taye and Yifru (2010) specified that, by nature cereals were incapable of fixing the free atmospheric nitrogen appreciably like legumes. Furthermore, Sakin (2012), and Alemayehu and Sheleme (2013) confirmed that, the concentrations of N were high in areas where the SOC was high.

According to the soil TN rating documented by Tabi *et al.* (2013) and Shiferaw (2012), the TN concentration in wheat-bean and wheat-pea cropping system was rated as high (0.23-0.30%); while in wheat-wheat, wheat-barley and wheat-maize cropping system was medium (0.13-0.23%) range (Appendix 1). Correspondingly, the TN content of the surface of the entire cropping system was rated as high, except wheat-wheat rated as medium. Moreover, the TN content in the whole cropping system was rated as medium in the subsurface layer of soil.

4.2.4. Available phosphorus

The analytical result presented in table 3 showed that, the mean of Av.P (5.10ppm) measured under wheat-maize cropping system was significantly ($P<0.05$) different from wheat-bean (5.99ppm) and wheat-pea (5.78ppm) cropping system but had no significant variation from wheat-barley (5.06 ppm) and wheat-wheat (5.01 ppm). Besides, the content of Av.P in the wheat-bean (5.99ppm) and wheat-pea (5.78ppm) cropping system were almost found to be the same. In the same way, the cultivation of wheat-barley (5.06 ppm) and wheat-wheat (5.01 ppm) contain insignificantly different value of Av.P. Among the cropping systems, the highest (5.99 ppm) and the lower (5.01 ppm) value of Av.P were observed under the wheat-bean and wheat-wheat farm land, respectively (Table 3). This difference was associated with the SOM content, percentage of clay distribution, CEC and pH value. Especially, the lower Av.P content in the wheat-wheat cropping system was resulted, because of the smaller biomass contribution and low OM content, which released phosphorus during its mineralization. Due to this reason the value of Av.P was increased by 19.56%, 1% and 1.8% in wheat-bean; wheat-barley and wheat-maize cropping land respectively, in comparison with continuous wheat cultivation.

Similarly, the report of Adamu and Maharaz (2014) showed that, the Av.P in multiple cropped plots were higher than the sole cropped due to low P formation during SOM mineralization. Likewise, Ailincai *et al.* (2008) discussed that, the pea-wheat-maize-sunflower-legumes cultivation land contains the higher value of mobile P while the lower was in wheat-maize, but wheat-continuous cropping had the medium P value. Sarwar *et al*. (2008) also conferred that, the Av.P was controlled by soil pH, clay, calcareousness, and SOM. Moreover, in agreement with this finding, Allen and David (2006) explained that, the SOM hinders phosphorus sorption, thereby enhancing availability. Humic and organic acids often reduce phosphorus fixation through the formation of complexes with Fe^{3+}, Al^{3+}, Ca^{2+}, and other cations that react with phosphorus.

Table 5. Cropping system and soil sampling depths effect on selected chemical properties (CEC, Basic cations, PBS) of the soils (α=0.05) and mean ± SEM.

Cropping system	CEC (cmol(+)/kg)	Basic exchangeable cations (cmol(+)/kg)				PBS (%)
		Ex.Ca	Ex.Mg	Ex.K	Ex.Na	
			Cropping system			
Wheat-wheat	23.93±0.20[b]	11.01±0.43[c]	2.63±0.07[b]	0.52±0.07[b]	0.09±0.001[a]	59.50±1.84[c]
Wheat-barley	24.17±0.69[b]	11.54±0.72[c]	2.68±0.11[b]	0.53±0.07[b]	0.09±0.004[a]	61.15±1.96[bc]
Wheat-bean	25.72±1.57[a]	13.32±1.54[a]	3.09±0.31[a]	0.57±0.09[a]	0.10±0.006[a]	65.25±3.58[a]
Wheat-pea	25.63±1.16[a]	12.85±1.27[ab]	3.01±0.24[a]	0.59±0.11[a]	0.11±0.009[a]	63.80±3.44[a]
Wheat-maize	24.33±1.14[b]	12.10±1.0[bc]	2.68±0.20[b]	0.59±0.09[a]	0.10±0.004[a]	63.01±2.34[ab]
LSD	1.28	1.1711	0.2632	0.03	0.021	2.441
P.V	**	***	***	**	Ns	***
			Depth			
0-15cm	26.94±0.38[a]	14.56±0.39[a]	3.21±0.08[a]	0.77±0.02[a]	0.11±0.003[a]	69.05±0.87[a]
15-30cm	22.84±0.18[b]	9.98±0.02[b]	2.42±0.02[b]	0.37±0.01[b]	0.09±0.001[b]	56.31±0.26[b]
P.V	****	****	****	****	****	****
C.V (%)	4.35	7.47	7.27	8.45	8.39	3.98
LSD	0.74	0.62	0.14	0.03	0.01	1.41

N.B: CEC=Cations exchange capacity, ex.Ca=Exchangeable calcium, ex.Mg=Exchangeable magnesium, ex.K=Exchangeable potassium, ex.Na=Exchangeable sodium, PBS=Percent of base saturation, P.V= P-value, C.V = Coefficient of variation, LSD = Least significant difference**.** Mean ± SEM (standard error mean). The same values of letters are non-significant. * shows P ≤0.05, **P≤0.01, ***P≤0.001 and **** P≤0.0001.

The significant difference was observed with depth in which the higher value of Av.P (6.72 ppm) and the lower (4.16ppm) was recorded at the surface and subsurface layer, respectively (Table 3). This reveals that, phosphorus at the subsurface layer was less available because of lower amount of SOM for source of P, as well as high fixation of P at lower pH and clay of subsurface area. The Pearson's correlation matrix (Table 8) also showed a positive and significant relationship between Av.P and SOM (r=0.99**), pH (r=0.97**) and clay (r=0.87**) at 1% significance level. According to the soil fertility rating of Av.P content (Appendix 1) documented by Benbi and Brar (2009), the surface layer of the study area had the medium (5-9 ppm) rate while the subsurface had the low (2-5 ppm) rating value of Av.P.

A significantly different value of Av.P content was observed among all interaction effect of cropping systems and depths at 5% level of significance. The higher (7.82-ppm) and the lower (5.60-ppm) value of Av.P at surface were recorded under wheat-bean and wheat-wheat cropping system, respectively (Table 7). Regarding subsurface layer, the higher (4.41 ppm) value of Av.P content was achieved in wheat-wheat area whereas the lower (3.69 ppm) value was in the wheat-maize cropping systems. At the subsurface layer, the value of Av.P was decreased in wheat-bean, wheat-pea and wheat-maize cropping system by 15.42%, 0.45% and 16.33%, respectively. Similar finding was reported by the report of Stacy (2013) and Ali *et al.* (2012) specified that, the lower value of soil P was found in the continuous cropping than rotations and also according to Ali *et al.* (2012), it decreased with soil depth.

4.2.5. Cations exchange capacity

When comparing the effect of cropping system, the cultivation of wheat-maize had a significantly different value of CEC (23.93 cmol (+)/kg) than wheat-bean (25.72 cmol (+)/kg) and wheat-pea (25.63 cmol (+)/kg) cropping system at $P<0.05$ and no significant difference was observed from wheat-wheat (23.93 cmol (+)/kg) and wheat-barley (24.17 cmol (+)/kg) (Table 5). Table 5 also indicted that, the mean value of CEC was non-significantly varied between the wheat-bean and wheat-pea cropping system. The soil in the cultivation of wheat-bean had the highest value (25.72 cmol (+)/kg) of CEC whereas wheat-wheat had the lowest (23.93cmol (+)/kg). Relatively the value of CEC was increased by 7.48% in wheat-bean cropping system due to higher SOM and high proportion of clay particle content in wheat-bean and the depletion of SOM as a result of organic material removal during crop harvest in wheat-wheat cropping system.

This agrees with the report of Murphy *et al*. (2008), the CEC value in 2-year wheat-pea cropping system had the higher value than 2-year wheat-fallow cropping system. Eshetu (2011) also explained that, both clay and colloidal OM had the ability to absorb and hold positively charged ions. Thus, soils containing high clay and OM contents had high CEC. The concentration of this soil CEC was also affected by cultivation depths, and the surface layer of soil was significantly ($P<0.05$) different from the subsurface. The surface layer of soil had the higher CEC (26.94 cmol (+)/kg) than subsurface layer value (22.84cmol (+)/kg) (Table 5). This higher value of CEC at surface could be resulted due to high basic cations. This finding was agreed with Abay and Sheleme (2012) who had reported that, the concentration of CEC was higher in the top soil than subsoil.

Results in table 7 shows that, the value of soil CEC was significantly different (P<0.05) in all cropping system at both surface and subsurface layer of soil. Relatively, the highest CEC values at the surface of the soil was attained under wheat-bean (29.23cmol (+)/kg) followed by that of wheat-pea (28.22 cmol (+)/kg) cropping system while the lowest was under wheat-wheat (24.38 cmol (+)/kg) site. Nevertheless, at the subsurface layer of soil, the higher (23.48 cmol (+)/kg) value was in wheat-wheat cropping system, while the lower (21.78cmol (+)/kg) was in wheat-maize cropping system. In all cropping system, the CEC value was declined along with depth for crop cultivation. The cultivation of wheat-bean and wheat-maize cropping system increased the value of CEC by 19.89% and 10.25% at the surface whereas decreased at the subsurface by 5.45% and 7.24%, respectively.

Table 6. The cropping system and soil sampling depths interaction effect on chemical properties (basic cations) of soil (α=0.05) and mean ± SEM.

Cropping system	Basic exchangeable cations (cmol(+)/kg)							
	Ex.Ca		Ex.Mg		Ex.K		Ex.Na	
	Depth							
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Wheat-wheat	11.96 ± 0.01^{e}	10.05 ± 0.01^{f}	2.78 ± 0.04^{e}	2.48 ± 0.10^{f}	0.67 ± 0.01^{d}	0.38 ± 0.01^{e}	0.10 ± 0.01^{c}	0.09 ± 0.006^{cd}
Wheat-barley	13.14 ± 0.01^{d}	9.94 ± 0.01^{h}	2.92 ± 0.10^{d}	2.43 ± 0.03^{g}	0.68 ± 0.01^{d}	0.38 ± 0.01^{e}	0.10 ± 0.01^{c}	0.09 ± 0.001^{cd}
Wheat-bean	16.76 ± 0.01^{a}	9.87 ± 0.01^{i}	3.79 ± 0.01^{a}	2.39 ± 0.10^{h}	0.75 ± 0.03^{c}	0.36 ± 0.01^{f}	0.12 ± 0.01^{b}	0.09 ± 0.001^{cd}
Wheat-pea	15.68 ± 0.01^{b}	10.01 ± 0.01^{g}	3.54 ± 0.01^{b}	2.48 ± 0.10^{f}	0.83 ± 0.10^{a}	0.35 ± 0.01^{f}	0.13 ± 0.004^{a}	0.08 ± 0.001^{d}
Wheat-maize	14.32 ± 0.01^{c}	9.87 ± 0.01^{i}	3.12 ± 0.03^{c}	2.23 ± 0.10^{i}	0.79 ± 0.01^{b}	0.39 ± 0.01^{e}	0.11 ± 0.003^{bc}	0.10 ± 0.001^{c}
P.V	****		****		****		****	
C.V (%)	6.62		4.74		4.37		4.19	
LSD	0.017		0.0152		0.0155		0.0098	

N.B: ex.Ca=Exchangeable calcium, ex.Mg=Exchangeable magnesium, ex.K=Exchangeable potassium, ex.Na=Exchangeable sodium, P.V = P-value, C.V = Coefficient of variation, LSD = Least significant difference. Mean ±SEM (standard error of means). The same letters of values are non-significant. . * shows P ≤0.05, **P≤0.01, ***P≤0.001 and **** P≤0.0001.

Likewise, Stacy (2013) reported that, at the surface layer the mean values of CEC in the corn-soybean-wheat cropping system was higher than in the continuous soybean. Alemayehu and Sheleme (2013) showed that, the depletion of OC as a result of intensive cultivation could reduce the CEC of the soils under maize land than grassland. Moreover, the correlation value shown in table 8 indicated that the concentration of SOM (r=0.99**), pH (r=0.98**) and clay (r =0.82**) percentage had a strong and significantly positive association with the value of soil CEC.

Similarly, the report of Tsehaye and Mohammed (2013) indicated that, degradation of SOM had left the soil with low CEC due to strong and positive relationship of CEC with SOM.

According to the classification of soil CEC as per the ranges suggested by Berhanu (2011) (Appendix 1), the value of CEC in wheat-bean and wheat-pea cropping system was rated as high (25-40 cmol (+)/kg) range, while wheat-wheat, wheat-barley and wheat-maize were rated to moderate (15-25 cmol (+)/kg). Similarly, the CEC value at the surface layer was rated as high except wheat-wheat cropping system which was rated as moderate. The whole cropping systems of the subsurface layer were rated as moderate. This was due to low contribution of negative charge surface of SOM and clay percentage at subsurface layer.

4.2.6. Basic exchangeable cations

The value of exchangeable Ca^{2+}, Mg^{2+} and K^{+}, were significantly ($p<0.05$) affected by land use systems whereas ex.Na^{+} was not significantly ($p>0.05$) affected. The analytical results indicate that, the cultivation of wheat-bean resulted in significantly higher value of ex.Ca^{2+} and ex.Mg^{2+} while ex.k^{+} is under both wheat-pea and wheat-maize cropping system (Table 5). There is no difference in Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} under wheat-wheat, and wheat-barley cultivation land. Similarly, this insignificant variation of value of exchangeable cations were observed between wheat-bean and wheat-pea cropping system. Moreover, the obtained result from relative change indicates that, the value of ex.Ca^{2+} and ex.K^{+} in wheat-barley, wheat-bean and wheat-maize cropping system were increased by 4.81%, 20.98%, 9.9%, and 9.62%, 1.9%, 13.46% respectively. But, the cultivation of wheat-bean and wheat-pea increased the value of ex.Mg^{2+} by 17.49% and 14.45%, respectively.

The finding of, Okpara and Igwe (2014) showed that, due to residue contribution the ex.Ca^{2+} and ex.Mg^{2+} were higher in legume-cereal cropping system than in continues maize. Similarly, the report of Tsehaye and Mohammed (2013) indicated that, low ex.Ca^{2+} and ex.Mg^{2+} in cultivated land was attributed to their continuous residue removal with crop harvest and soil pH concentration. The report of Ailincai *et al.* (2008) showed that, the higher value of mobile K was recorded in pea-wheat-maize followed by wheat-wheat, whereas the lower was in wheat-maize cropping system due to the higher K^+ consumption by wheat-maize. Similarly, the report of Berhanu (2011) indicated that, the low of Av.K in the cultivated fields probably allied with the continuous cultivation, low pH, clay and CEC. Similarly, Sunday *et al.* (2011) reported that, ex.Na^+ was improved in the soybean compared to the sorghum field due to poultry manure application.

The mean value of ex.Ca^{2+} , Mg^{2+}, K^+ and Na^+ were significantly varied with soil depth, that means, the higher value were resulted at the surface than subsurface layer (Table 5)**.** The correlation matrix also showed that, the positive and significant relationship of basic cations with SOM, clay and pH at $P<0.01$(Table 8). This was due to higher OM incorporation from residue into the soil surface, which gradually decomposed and released nutrients to the soils. Similarly, the higher percentage of clay at the surface retains leaching of basic cations; because of its higher flocculated structure and higher CEC formation on negatively charged surface. This is in line with Abay and Sheleme (2012) that, the value of ex.K^+ was decreased with depth due to fixation.

The soil fertility rating which documented by Brindha and Elango (2014); Pam and Brian (2007) specify that, the value of ex.Ca^{2+} was high in all cropping system whereas ex.Mg^{2+} and K^+ were medium in wheat-wheat, wheat-barley and wheat-maize cultivation land. Similarly, this rate shows that the ex.Na^+ was low under wheat-bean, wheat-pea and wheat-maize cropping system (Appendix 1). Compared to wheat-wheat cultivation land the relatively higher concentrations of ex.Ca^{2+} and Mg^{2+} contents recorded in soils of wheat-bean and wheat-pea could be attributed to the residue contribution for soil organic matter formation.

At both surface and subsurface layers, the mean value of ex.Ca^{2+} and ex.Mg^{2+} was significantly ($P<0.05$) different among the entire cropping system in the study area; apart from wheat-bean, and wheat-maize for ex.Ca^{2+} and wheat-pea for ex.Mg^{2+} cropping system at the subsurface layer. Unlike wheat-bean, wheat-pea, the mean value of ex.K^+ and Na^+ in wheat-wheat and wheat-barley cropping system pose insignificant ($P<0.05$) variation at both surface and subsurface layer. In comparisons, the highest value of ex.Ca^{2+} and ex.Mg^{2+} was recorded at the surface layer of wheat-bean cropping system whereas the lowest was at the subsurface layer of wheat-maize (Table 6). Furthermore, the significantly highest value of ex.K^+ and Na^+ was found at the surface layer wheat-pea cropping system, whereas lowest at the bottom layer of the soil. The occurrence of this difference could be attributed to the difference in the clay percentage, crop residue contribution from its decomposition, soil parent material, crop harvest with no use of input and the SOM together with pH value of the cropping system. In harmony, the report of Castro *et al.* (2005) showed that, the crop rotations with soybean-oats had higher ex.Ca^{2+}, ex.Mg^{2+} and ex.K^{+} than soybean-wheat due to SOM as well as pH and this value was higher at the surface layer.

Table 7. The cropping system and soil sampling depths interaction effect on chemical properties (Av.P, CEC, PBS) of soil (α=0.05) and mean ± SEM.

Cropping system	Av. P (ppm)		CEC (cmol(+)/kg)		PBS (%)	
			Depth			
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Wheat-wheat	5.60 ± 0.01^{e}	4.41 ± 0.01^{f}	24.38 ± 0.01^{e}	23.48 ± 0.01^{f}	63.61 ± 0.1^{e}	55.39 ± 0.03^{j}
Wheat-barley	6.06 ± 0.01^{d}	4.06 ± 0.01^{h}	25.71 ± 0.01^{d}	22.62 ± 0.01^{h}	65.52 ± 0.1^{d}	56.77 ± 0.03^{h}
Wheat-bean	7.82 ± 0.01^{a}	3.73 ± 0.01^{i}	29.23 ± 0.01^{a}	22.20 ± 0.01^{i}	73.26 ± 0.04^{a}	57.24 ± 0.1^{g}
Wheat-pea	7.58 ± 0.01^{b}	4.39 ± 0.003^{g}	28.22 ± 0.01^{b}	23.04 ± 0.01^{g}	71.50 ± 0.1^{b}	56.10 ± 0.1^{i}
Wheat-maize	6.51 ± 0.01^{c}	3.69 ± 0.01^{j}	26.88 ± 0.01^{c}	21.78 ± 0.01^{j}	68.24 ± 0.1^{c}	57.78 ± 0.03^{f}
P.V	****		****		****	
C.V (%)	5.17		4.04		2.88	
LSD	0.0165		0.017		0.1448	

N.B: Av.P= Available phosphorus, CEC=Cations exchange capacity, PBS- Percent of base saturation, P.V = P-value, C.V = Coefficient of variation, LSD = Least significant difference**.** Mean ± SEM (standard error mean). The same letters of values are non-significant. * shows P ≤0.05, **P≤0.01, ***P≤0.001 and **** P≤0.0001.

4.2.7. Percent of base saturation

Relating to the effect of cropping systems on soil PBS, the result indicated in table 5 show that soils cultivated with wheat-wheat (59.50%) was significantly (P<0.05) different from the whole cropping system apart-from wheat-barley (61.15%) cropping systems. The cultivation of wheat-maize (63.01%) had significantly different value of PBS than wheat-wheat (59.50%) cropping system, but not significantly varied from the others cropping system. Additionally, the highest PBS was recorded under wheat-bean cropping fields (65.25%) followed by wheat-pea (63.80%), while the lowest was in wheat-wheat (59.50%) cropping system (Table 5). The report of FAO (2005) explained that, the PBS was higher for fallow land than mixed cropping. As stated by Tsehaye and Mohammed (2013), PBS in cultivated soil was higher than the grassland due to weathering and the subsequent release of cations.

Based on the distribution of basic cations and cations exchange capacity of the soil, the higher (69.05%) value of PBS was found at the surface while the lower (56.31%) was at the subsurface layer. Correspondingly, Okubay (2012) revealed that, in the cultivation of wheat and teff, the PBS were decreased consistently with depth. The PBS had positive and significant correlation with basic cations and CEC (r =0.93**) (Table 8). According to guidelines for rating of soil fertility indicators suggested by Brindha and Elango (2014); Pam and Brian (2007), the value of PBS in the whole cropping system of the study area at the surface layer was rated as high (60-80%) while the subsurface was moderate (40-60%) (Appendix 1). The value of PBS in the study area was increased by 2.77%, 9.66%, 7.23% and 5.9% in wheat-barley, wheat-bean, wheat-pea and wheat-maize cropping system, respectively due to the return extent of litter or crop residues to the soils through SOM formation and decomposition.

The results presented in table 7 indicate that, the value of PBS in the entire cropping system was significantly different at the surface and subsurface layer of the soil. However, the highest (73.26%) value of PBS was at the surface layer of wheat-bean, while the lowest (55.39%) was under wheat-wheat cropping system at the subsurface layer. This variation of value was resulted due to the difference in the value of CEC, exchangeable cations (which were released during SOM mineralization) and negatively charged surface of clay particle. The result obtained from wheat-bean and wheat-pea cropping system indicates that, the value of PBS was increased by 15.17% and 12.40% at the surface and 3.34% and 1.24% at the subsurface layer, respectively. This is in line with the report of Castro *et al.* (2005) that, the PBS in soybean rotated with rye and pisum were higher at the surface and lower at the subsurface layer. Similarly, Alemayehu and Sheleme (2013) showed that, the higher value of PBS was recorded under maize farm while lower in grassland at the subsurface layer, due to crop harvest and cultivation intensity (enhances leaching and erosion). Likewise, the report of Awdenegest *et al.* (2013) indicated that, the PBS was relatively higher at the surface layer of the grassland and subsurface layer of farmland.

Table 8. Pearson's correlation matrix for some selected physical and chemical properties of soil.

	pH	BD	OM	OC	TN	Av.P	Clay	Silt	Sand	CEC	Ca	K	Mg	Na	PBS
pH	1														
BD	-0.93**	1													
OM	0.97**	-0.86**	1												
OC	0.97**	-0.86**	1**	1											
TN	0.99**	-0.89**	0.99**	0.99**	1										
Av.P	0.97**	-0.85**	1**	1**	0.99**	1									
Clay	0.89**	-0.74**	0.88**	0.88**	0.87**	0.87**	1								
Silt	0.46**	-0.35*	0.60**	0.60**	0.55**	0.62**	0.24 ns	1							
Sand	-0.85**	0.68**	-0.93**	-0.93**	-0.89**	-0.94**	-0.77**	-0.80**	1						
CEC	0.98**	-0.89**	0.99**	0.99**	0.98**	0.98**	0.82**	0.59**	-0.92**	1					
Ca	0.98**	-0.86**	0.99**	0.99**	0.98**	0.98**	0.91**	0.52**	-0.91**	0.98**	1				
K	0.89**	-0.67**	0.92**	0.92**	0.91**	0.92**	0.94**	0.46**	-0.88**	0.90**	0.94**	1			
Mg	0.98**	-0.90**	0.99**	0.99**	0.99**	0.98**	0.82**	0.62**	-0.62**	0.91**	0.97**	0.87**	1		
Na	0.87**	-0.90**	0.99**	0.99**	0.86**	0.84**	0.91**	0.28ns	-0.75**	0.83**	0.88**	0.90**	0.81**	1	
PBS	0.95**	-0.78**	0.96**	0.96**	0.95**	0.95**	0.92**	0.49**	-0.89**	0.93**	0 .99**	0.97**	0.93**	0.90**	1

**, * shows that the correlation is significant at the p<0.01 and p<0.05 level respectively.

5. SUMMARY AND CONCLUSION

The practice of wheat based cropping systems and soil sampling depths were significantly ($P<0.05$) influenced the content and distribution of selected physical and chemical properties of soil in the study area, due to current crop management system. Among the cropping system, the BD content was significantly ($P<0.05$) higher in wheat-wheat and wheat-barley cropping system than wheat-bean and wheat-pea. The value of silt in wheat-maize was significantly different than the total cropping system apart from wheat-pea. Except sand and BD, all of the soil properties were declined with soil sampling depth under all cropping system. Furthermore, the value of soil pH, SOC, SOM, Av.P, ex.Ca^{2+}, ex.Mg^{2+} and CEC in wheat-bean was significantly different from wheat-wheat, wheat-barley, and wheat-maize except wheat-pea cropping system. Likewise, the value of ex.K^{+} and clay was considerably higher in wheat-pea than wheat-wheat and wheat-barley cropping system.

Regards to the interaction of cropping systems with soil sampling depths, the concentration of Av.P, SOC, SOM, pH, CEC, ex.Ca^{2+}, ex.Mg^{2+} and PBS at surface layer were higher under wheat-bean followed by wheat-pea than the others cropping systems. However, without sand and clay percentage the value of silt, pH, SOM, SOC, TN, Av.P, ex.Mg^{2+} and CEC were lowest in wheat-maize cropping system at the subsurface layer of soil than the whole cropping system. The result of relative change obtained from the cultivation of wheat-bean indicate that the value of SOM, TN and CEC are increased by 19.5%, 20% and 7.48% whereas in wheat-pea cropping system it increased by 18.93%, 20% and 7.1%, respectively.

In general, the study conducted on assessment of wheat based cropping systems on selected soil physicochemical properties showed that, the cropping system with wheat-bean can maintain the soil nutrients than wheat-pea, wheat-maize, wheat-barley and wheat-wheat cropping system. Hence, crop rotation was superior to continuous wheat cropping for improvement of soil fertility in this study area. Thus, it preserves soil fertility through adequate organic residue left after harvest that keeps SOM at optimum level. Therefore, it is recommended that; farmers in the study area have to use wheat-bean followed by wheat-pea cropping system than wheat-wheat, wheat-maize and wheat-barley cropping system. Likewise, incorporate improvement on the cropping system; those enhance the loss of soil nutrients due to longevity of farming system. For the upcoming, it is better to further study the soil nutrient at physical, chemical and biological level through soil and plant analysis together with physical observation in order to have the overall understanding of the area.

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APPENDIX

Appendix 1.Ratings the mean value of soil pH, SOC, SOM, CEC, TN, Av.P, ex.Ca^{2+}, ex.K^{+}, ex.Mg^{2+}, ex.Na^{+} and PBS.

Rating	pH
Strongly acid	<5.1
Moderately acid	5.2- 6
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Moderately alkaline	7.4-8.4
Strongly alkaline	>8.5

Brindha and Elango (2014).

Rating	SOC%	SOM%	CEC (cmol (+)/kg)	TN%	Av.P(ppm)
V.high	>2.90	>6.0	>40	>0.30	>20
High	1.74-2.90	4.2-6.0	25-40	0.23-0.30	9-20
Medium	1.16-1.74	2-4.2	15-25	0.13-0.23	5-9
Low	0.6-1.16	1-2	5-15	0.05-0.13	2-5
V.low	<0.6	<1	<5	<0.05	<2
	Abay and Sheleme (2012); Shiferaw (2012).	Tabi *et al.* (2012/13)	Berhanu (2011); Tabi *et al.* (2013)	Shiferaw (2012); Tabi *et al.* (2013)	Benbi and Brar (2009)

Rating	Ca (cmol (+)/kg)	K(cmol (+)/kg)	Mg (cmol (+)/kg)	Na (cmol (+)/kg)	PBS (%)
V.high	>20	>2	>8	>2	>80
High	10-20	0.7-2	3-8	0.7-2	60-80
Medium	5-10	0.3-0.7	1-3	0.3-0.7	40-60
Low	2-5	0.2-0.3	0.3-1	0.1-0.3	20-40
V.low	<2	0-02	0-0.3	0-0.1	0-20

Brindha and Elango (2014); Pam and Brian (2007).

N.B: pH= pH-value; OC=Organic carbon; OM = Organic matter; TN=Total nitrogen; Av. P = Available phosphorus; CEC= Cations exchange capacity; Ca= Calcium; Mg=Magnesium; K=Potassium; Na= Sodium; PBS=Percent of base saturation.