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Short Communication

Carbon sequestration of Luvisols as influenced by cropping system of Abela Lida, Southern Ethiopia

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Abstract

Assessing and quantifying carbon stock by taking into consideration the type of land use and soil type would have great contribution for an appropriate land use decision and sustainable carbon soil stock management. The main target of the research was to examine the impact of cropping systems on carbon stock of Luvisols of Abela Lida, Southern Ethiopia. Three representative adjacent cropping systems (enset, coffee and maize-haricot bean intercropping) were considered for the study. The soil organic carbon (SOC) ranged from 1.72 to 2.75%, medium to high status, respectively. The highest mean value of SOC (2.75%) was obtained in soils under coffee. The lowest (1.72%) SOC was obtained under the soils of maize-haricot bean intercropping. There was significant difference (P≤ 0.05) in soil organic carbon stock under the different cropping systems. Soil under coffee cropping systems had significantly higher values of SOCst (51.01.9 Mg ha^{-1}) than enset and maize-haricot bean (46.61 and 34.58 Mg ha^{-1}, respectively). It could be concluded that cropping systems have significant influence on SOC status and carbon stocks of the soils of an area. Therefore, it is important and advisable to consider cropping systems of a given area for sustainable soil carbon management.

Keywords: Land use, organic carbon, soil management.

Introduction

The main sources of carbon are organic materials, plant and animals. The accumulation of carbon in the soil system has great importance for climate related issues and sustainable agriculture[1]. It is also considerable soil health and fertility quality assessment[2]. Due to these facts, it has got great consideration this days[4].

Soils have the capacity to absorb and retain carbon from the atmosphere as long as there is sustainable and appropriate soil management[5]. It has been believed that soils contain the largest C in terrestrial ecosystems[6] with C stock of (~ 1500 Pg), which is two and three fold that held in the atmosphere and vegetation, respectively[7]. In the other hand, the global emission of soil carbon dioxide is well recognized as one of the largest contributor to worldwide carbon fluxes[8]. As a result special emphasis has been given for carbon sequestration[9].

Carbon stock of an area could be highly influenced by soil management practices. Humans could positively or negatively affect the status of soil organic carbon through their management practices like addition of organic fertilizers, forestation, deforestation, soil and water conservation practices[10,11]. Generally, the cropping systems have great impact on controlling SOC levels[12,13]. Therefore, assessing and quantifying carbon stock would have great contribution for an appropriate land use decision and sustainable carbon soil stock management for the study area, where there is little information in this regard. It has also been suggested that periodic monitoring on soil quality attributes within an ecosystem can provide a useful way to control land degradation and achievement of sustainable management[11]. Moreover, it is important to have data that would enable to examine soil carbon change through time[14].

Materials and methods

The research was done at Abela Lida, mid altitude parts of Shebedino district of Sidama zone in southern region of Ethiopia. The mean annual precipitation and temperature range 1200-2500 mm and 12-20^{o}C, respectively[15]. The soil type of the study area is Chromic Luvisols[16] and it is locally characterized as Shakado, Kakacha and Dora. The base for their classification is the fertility status of the soils. Shakado soils are found near the farmers' house, which developed through the continuous application of organic manure and house refuses, and have deep top soils of very dark brown color. The soil is friable and very easy to manipulate. This type of soil is mainly planted enset and coffee along with high value fruits and vegetables. Kakacha soils are less fertile than Shakado. They are found at some distance from the homestead and seldom received manure and used mainly to maize-haricot bean cropping. Dora soils, on the other hand are characterized as the least fertile soils of the area and very small area support coffee plantation, although the trees give production once in two years.

Three representative adjacent cropping systems (enset, coffee and maiz-haricot bean intercropping) were considered for the study. In each cropping system, three composite soil samples were taken by thoroughly mixing forty subsamples that had been taken randomly in three replications within 0 to 20cm depth. The samples were prepared and analyzed using standard laboratory procedures.

Bulk density, particle size distribution and OC were analyzed by core sampling, Bouyoucos hydrometer and Walkley and Black method, respectively[17-19].

The SOCst of the different cropping systems was calculated with the following equation[21]:

$$Carbonstock = \frac{SOC}{100} * bulkdensity * soildepth * 100$$

To test whether there was significant difference in SOCst among the considered cropping systems, statistical analysis was carried out using SAS software version 9.2[22].

Results and discussion

Selected soil physical and chemical properties of the study area: The textural class of the study area was loam, irrespective of the cropping systems (Table-1). The highest 29.08% mean value of clay was obtained from maize-haricot bean cropping system, whereas relatively the lowest 24.07% mean value of clay was recorded under enset cropping system. In previous study, it was stated that highest clay content of soils was recorded under maize and the suggested reason was due to accelerated weathering as the result of disturbance caused by continuous cultivation as compared to enset and coffee cropping systems that have minimum disturbance[23]. The highest 40.65% mean value of silt was recorded under enset, while the lowest 36.64% was obtained under maize-haricot bean intercropping. With respect to sand, the highest 39.01% mean value was recorded under coffee cropping system.

The mean values for bulk density of surface soils 0-20cm of the considered cropping systems ranged from 0.93 1.02gm/cm^3. Brady and Weil[24] indicated that the range of bulk density between 0.8 and 1.2g /cm^3 is a typical characteristic of loamy A horizon. Bulk density values of the soils in enset and coffee cropping systems are relatively lower as compared to that of maize-haricot bean intercropping. The reasons for relatively lower bulk density in the case of enset and coffee cropping systems might be intensive manure application, decomposition of fallen leaves, left over of harvesting and processing. Herric and Lal[25] stated that application of dung increase the macro-pores which in turn reduces bulk density. Relatively the highest bulk density was in maize-haricot bean intercropping. These soils did not receive application of manure and very little crop residues left in the field.

The mean soil pH values of the considered cropping systems ranged from 6.31 to 7.59. The highest mean soil pH value 7.59 recorded in soils under enset, which might be due to the relatively high amount of manure application. Previous study confirmed that addition of organic fertilizers could increase soil pH[26,27]. Moreover, decomposition of the large enset leaves biomass, left over of harvesting and processing enrich exchangeable bases that are responsible for high soil pH values. The mean pH value 6.52 under coffee was relatively low, basic cations removal due to harvesting might be the reason. Heavy cropping coffee could lower level of potassium and the pH could fall[28]. Relatively the lowest mean value of pH was recorded under maize-haricot bean. The reason might be due to long-term cultivation and fertilization. Nitrogen containing fertilizers also potentially lower soil pH[29].

The effluence of cropping system on carbon stock of Luvisols: The status of organic carbon ranged from 1.72 to 2.75% (Table-2), medium to high status respectively[30]. The highest mean value of SOC 2.75% was recorded in soils under coffee, which might be due to the decomposition of fallen leaves of shade trees and grasses. Generally, the mean values of SOC were high in coffee and enset cropping systems. The application of manure and decomposition of fallen leaves might be the reason. The no tillage practices of the farmers in these cropping systems may also contribute these values. Long term no tillage systems protect SOC through formation of stable sand and silt sized particles[31]. It was reported that the status of SOC was high no tillage farm[32]. The lowest mean value 1.72% SOC was recorded under the soils of maize-haricot bean intercropping. The reason could be continuous oxidation and complete crop residue removal for different purposes.

Table-1: Mean values of selected soil physical and chemical properties under different cropping systems.

Cropping system	Particle size distribution (%)			Textural Class	Bulk density (gm cm^{-3})	pH
	Clay	Silt	Sand			
Enset	24.07	40.65	35.28	Loam	0.96	7.59
Coffee	21.62	39.37	39.01	Loam	0.93	6.52
Maize-haricot bean	29.08	36.64	34.28	Loam	1.02	6.31

Table-2: Influence of cropping systems on carbon stock of Luvisols.

Cropping system	SOC (%)	SOCst (Mg ha^{-1})
Enset	2.44	46.61^{b}
Coffee	2.75	51.01^{a}
Maize-haricot bean	1.72	34.58^{c}
LSD (0.05)		3.25
CV (%)		4.61

The mean values of SOCst of the copping systems ranged between 34.58 to 51.01Mg ha^{-1}. Significant differences $p < 0.05$ were observed in mean values of SOCst among the cropping systems (Table-2). The highest mean value of SOCst 51.01Mg ha^{-1} was obtained in coffee cropping system. In the other hand, the lowest mean value 34.38Mg ha^{-1} was obtained in maize-haricot bean intercropping. Comparable result was obtained from cultivated land of Kersa sub watershed, eastern Ethiopia[33].

Conclusion

The findings of the research clearly indicated that soil organic carbon contents and carbon stock could be influenced by cropping systems of an area. The organic content and carbon stock of coffee and enset cropping systems were greater than the maize-haricot bean intercropping. It is therefore important and advisable to consider cropping systems of a given area to optimize organic carbon status and carbon stock of the soils in sustainable manner.

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