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Soil organic carbon dynamics for different land uses and soil management practices in Mymensingh

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Abstract

Soil organic carbon (SOC) is an important component regulating soil fertility and crop productivity as well as global carbon cycle. This research was carried out in Mymensigh located in northern Bangladesh 24°45′14″N 90°24′11″E. The objective of this study was to investigate the effects of present land-use and soil management practices on SOC accumulation for the period of July to October, 2013. Different cropped land (single, double and triple cropped), agroforestry, fallow land and grass land were taken for determining SOC. Soil organic carbon was significantly varied in different land use pattern and soil management practices. Among all land use pattern the highest SOC was found under agroforestry and the lowest was found under fallow land. Organic carbon dynamics highly regulated by organic fertilizer application and tillage operation. The result of this study will help to develop future plan about land use and soil management regarding soil carbon dynamics and climate change mitigation.

INTRODUCTION

Soil plays an important role in global carbon cycle as it contains around three times more C than in atmosphere and 3.8 times more C than in biotic pool [1]. It can be a source or a sink of atmospheric C depending upon land use and management [2]. Land use and vegetation cover type influence soil erosion and C dynamics in soil [3]. Land management with less soil disturbance increased higher SOC accumulation, while intensive disturbance decreased SOC accumulation. Land use change from native ecosystem to cultivated ecosystem causes loss of soil carbon. On the other hand, vegetation development on abandoned agricultural land enhances the C sequestration. Thus study of land use changes in field level is needed to determine the fate of C in the system.

Soil organic carbon is greatly influence on soil properties and takes important role in agronomic production and environmental quality. C sequestration help to mitigated global warming, alleviated soil degradation and ensuring sustainable agriculture production [3]. Land use change (LUC) has contributed to soil degradation and changes in both quantity and quality of SOC which enhanced C emissions to atmosphere [4-5]. Rotations and intercropping systems and improved cultural system like minimum tillage, improved crop residue management and organic farming contribute to conservation and elevation of SOC.

The study of inter-relationship of land use and soil management with SOC dynamics is quite important in recommending sound land management practices to mitigate the impact of the climate change at the local to regional level. The interrelationship can be utilized to predict future scenarios of the carbon dynamics. However there is a scarcity of studies addressing land use change dynamics and its effect on C pool in ecosystem level in these regions. Therefore, a study was conducted in Mymensingh to determine the effect of land uses and soil management practices on soil organic carbon dynamics.

MATERIALS AND METHODS

A. Study Area

The location experiences a tropical monsoon-type climate, with a hot and rainy summer, and dry winter. Annual mean air temperature was 25.22 ℃ and the highest mean temperature is reached in the month of April. Annual rainfall was 2249 mm where 70% of the annual rainfall is received during monsoon season (June to August). The relative humidity varies from 60-98% with some diurnal fluctuations in the various seasons with annual average of 56.8. The soil is dark gray non-calcareous floodplain) with a sandy loam and loam texture [6].

B. Soil Sampling and analysis

Thirty six soil samples were collected from twelve different lands covering cropped land (single, double and triple cropped), agroforestry, fallow land and grass land. The soil sample was taken from the centre of each quadrate by driving a core sampler up to 30 cm depth. Soil cores were sectioned into 0-10, 10- 20 and 20-30 cm increments for 30 cm samples, then the soil was categorised as top soil (up to 10 cm) and Sub soil (up to 30 cm). The soils was collected by an augur and kept in polythene bags so that they remain in field moist condition. Before collecting sample from particular field relevant information regarding fertilizer application and tillage practices was collected from the concern farmer of that field. After completion of collecting soil samples, the unwanted materials like stones, granules, plant parts, leaves etc. were discarded from sample. The samples were dried at room temperature, crushed, mixed thoroughly and sieved with a 2 mm sieve. Composite samples were prepared by mixing the sieved soils and preserved in polythene. Soil samples were analyzed using wet oxidation methods of Walkley and Black [7]. All data were analyzed using SPSS statistical software version 16.0. Analysis of variance (ANOVA) was carried out using two-factor randomized complete plot design. Significant F-values were obtained; differences between individual means were tested using the LSD (Least Significant Difference) test.

RESULTS AND DISCUSSION

A. Soil carbon dynamics in different land use pattern

There was significant difference in SOC in different land use pattern. In our study the highest organic carbon was found under agroforestry system (1.438%) and the lowest organic carbon was found under fallow land (0.124% for 20-30 cm). Cropland and grassland organic carbon were found respectively 0.63% and 0.39% for top soil respectively [Fig. 1a]. It is well known that tree species strongly influence the forest floor in terms of C stock and chemistry, it also regulate annual carbon turn over. It was reported that the highest SOC stock found under forestland and the lowest under grassland [8]. Greater organic matter inputs in agroforestry systems contribute to the long-term storage of carbon (C) in the soil [9]. It was observed that organic carbon decreased when depth increased. Highest organic carbon found for 0-10 cm depth in all land use types. It was reported that SOC contents decreased usually with increasing soil depth, with significant differences in different horizon [10]. Differences of SOC also found under different agricultural land use pattern where crop intensification showed lower SOC accumulation and higher SOC depletion. In case of agricultural cropped land single and double cropped land found significant similar SOC in the top soil but lower in other depth. Higher SOC was found in double cropped land and lower in triple cropped land [fig. 1b].When soil used frequently for cultivation then more nutrient of soil used by the crop; intensify crop cultivation from cropland accelerate higher carbon loss than other ecosystem [11].

B. Soil carbon dynamics with fertilizer use and tillage operation

The soil SOC accumulation was dependent on the use of various fertilizers. The highest SOC concentration was obtained

where maximum Organic fertilizer was used for crop production. From the figure 2 it was observed that accumulation of SOC was less when field provided less than 50% nutrient from inorganic fertilization and it was a linear increasing SOC up to 80% of organic fertilization. It was reported that sole application of inorganic fertilizer can cause decline in soil organic carbon [12]. The agricultural management practices had greater effects on SOC; a 30% increase in SOC with green manure cultivation [13]. Fertilizer application has the greatest role for determining soil organic carbon among the factors affecting soil carbon dynamics. Because any of other factors fertilizer application is the most direct factors which regulate carbon pool. There was a distinct difference observed in SOC accumulation in different tillage system. When country plough used the amount of organic carbon for single cropping, double cropping and triple cropping were respectively 0.604%, 0.727%, and 0.340%. Other hand when power tiller used t 0.477%, 0.560%, and 0.269% respectively. From the study it was observed that the highest amount of organic carbon was found when country plough used and the lowest amount of organic carbon was found when power tiller used (Table 1). It was reported that a greater C sequestration was observed for minimum tillage because of fewer disturbances of soil and slow decomposition of organic carbon [14-15].

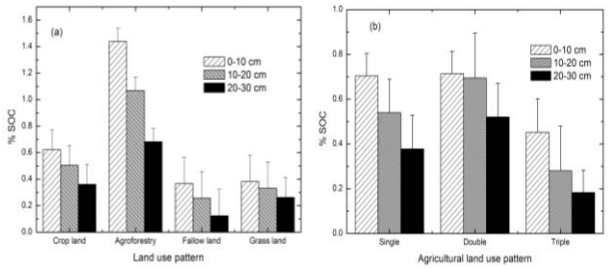

Fig. 1. Amount of organic carbon in different land use pattern. Bar represent standard errors.

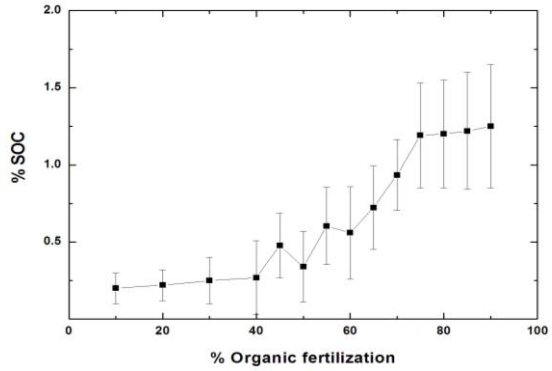

Fig. 2. Soil organic carbon in relation to % of organic fertilization. Bar represent standard errors.

Table 1. Difference of organic carbon for using country plough and power tiller

Different land use pattern	Amount of organic C (%) for using country plough			Amount of organic C (%) for using power tiller		
	Depth (cm)	Organic C (%)	Mean	Depth (cm)	Organic C (%)	Mean
Single cropping	0-10	0.733[b]	0.60[b]	0-10	0.675[a]	0.48[a]
	10-20	0.617[c]		10-20	0.463[c]	
	20-30	0.463[d]		20-30	0.293[d]	
Double cropping	0-10	0.849[a]	0.73[a]	0-10	0.579[b]	0.56[a]
	10-20	0.830[a]		10-20	0.560[b]	
	20-30	0.501[d]		20-30	0.540[b]	
Triple cropping	0-10	0.405[e]	0.34c	0-10	0.498[c]	0.27[b]
	10-20	0.366[f]		10-20	0.193[e]	
	20-30	0.250[g]		20-30	0.115[e]	

Letters indicate statistically significant differences in SOC affected by the different tillage in different crop intensities ($p<0.05$).

CONCLUSION

Most agricultural soils in the study area contain below their potential level of SOC where triple cropped area contained extremely lower level. The highest organic carbon was found under agroforestry which was 1.063% and the lowest organic carbon was found under fallow land which was 0.249%. Organic carbon dynamics highly regulated by organic fertilizer application. Soil organic matter contents in farmlands have influenced by changes in land use intensity and soil management effects. Conventional tillage leads to significant increase of the soil organic matter content. The study showed that the highest amount of organic carbon was found when country plough used and the lowest amount of organic carbon found when power tiller used. Soil organic carbon contents decreased usually with increasing soil depth. Highest organic carbon found for 0-10 cm depth and lowest organic carbon found for 20-30 cm depth. This study showed clearly that land use change and land management have direct influence on soil organic carbon accumulation. Therefore understanding and implementation of carbon sequestration process in agriculture will help to maintain climate change mitigation from agriculture.

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