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IMPACT OF CONVERSION OF GRASSLAND TO AGROECOSYSTEM ON SOIL ORGANIC CARBON CONTENT IN DRY TROPICS

Priyanka Soni*, Chandra Mohan Kumar and Nandita Ghoshal

Centre of Advanced Study in Botany, Department of Botany, Institute of Science, Banaras Hindu University, Varanasi-221005 (U.P.) India

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The conversion of grassland to agroecosystem leading to loss of soil organic carbon is a major global challenge. Although the tropical soils are known to be vulnerable to the loss of carbon due to land use change yet, limited information is available, especially in the dry tropics. The present study was aimed to analyze the impact of conversion of grassland to agroecosystem in the dry tropics on the content of soil organic carbon, soil carbon stock, bulk density and porosity. This study was conducted in the experimental plots of Department of Botany, Banaras Hindu University. The soil organic carbon content was higher in the grassland (0.81%) than the agroecosystem (0.57 %). Same trend was observed in the case of soil carbon stock and soil porosity whereas the trend of the bulk density was reverse. It may be suggested that to increase the soil organic carbon and soil carbon stock in agroecosystems, management practices involving higher organic matter input to the soil should be recommended so that the agroecosystem would lead not only to long term sustenance of soil fertility and productivity but also sequester atmospheric carbon into the soil of dry tropics.

Key words: Carbon stock, Carbon sequestration, Dry tropics, Porosity, Soil organic carbon

Introduction

Quality and dynamics of soil organic carbon content exerts major influence on various soil functions and ecosystem services (Lal, 2016). The global soil carbon pool which is 2500 Gt carbon, consist of 1500 Gt of soil organic carbon upto the depth of 1m. The soil organic carbon exceeds the size of atmospheric pool (760 Gt) by 3.3 times and the size of the biotic pool (560 Gt) by 4.5 times (Lal, 2004). Soil organic carbon consists of the microbial biomass, their byproducts and the remains of the plants and animals at different stages of decomposition. It forms organo- mineral complexes by reacting with clay and minerals. Rate of turnover of soil organic carbon depends on the several physical, chemical, biological and ecological protective mechanisms of the soil matrix.

Almost half of the potentially vegetated land surface of earth has been subjected to land use change and resulted in conversion to croplands, pastures and rangelands (Zomer *et al*., 2017). Land use change from natural ecosystems to agroecosystems and various agricultural management strategies are reported to contribute about 24% of total global greenhouse gases emissions. Tropical soils are more vulnerable as about 75% depletion of carbon occurred due to the conversion of the natural grasslands to the agroecosystems (Lal, 2004).

Natural ecosystems like grasslands are generally less disturbed due to anthropogenic activities and maintain high vegetation cover and primary productivity which in turn maintain higher content of soil organic carbon. Accumulation of soil organic carbon in soil is largely dependent on the primary productivity and biodiversity of the vegetation (Lambers *et al*., 2004; Cotovsky *et al*., 2002). Extensive root systems of grasses and forbes contributed considerably to the accumulation and stabilization of soil organic carbon as contribution of roots in storage of soil organic carbon was considered to be more compared to the shoot biomass (Singh *et al*., 2009). Among the major terrestrial ecosystems, agroecosystems are mostly subjected to the anthropogenic activities and thus influences the soil carbon pool adversely (Cole *et al*., 1993). Grasslands are converted to agricultural lands by different management practices leading to deterioration

***Author for correspondence :** E-mail: sonipriyanka840@gmail.com

of soil quality and the carbon content. Global carbon cycle is strongly linked with the agricultural soil. Soil however can act both as a source and sink of carbon. The soil carbon pool can be increased by the carbon sequestration that means the transfer of atmospheric CO_2 and storing it by proper land use management. High biomass input and minimum disturbances improved soil structure inturn results into carbon sequestration.

It was estimated that by increasing the soil carbon pool by 4 % up to 3m depth, it would result into reduction of about 240 Pg of atmospheric CO_2-C which is equivalent to a reduction of more than 100 ppmv of atmospheric carbon dioxide (Lal, 2016). However, it poses a great challenge to achieve this goal of CO_2 reduction by C sequestration in soil. Maintaining the soil organic carbon pool above critical level (1.5-2 % in the root zone) is important for the soil structure and aggregation, nutrient retention, water retention efficiency, rhizospheric process and the emission of different gases in the atmosphere regulating climatic changes (Lal, 2016).

Distribution of soil organic carbon content throughout the surface of earth is not uniform. It varies with longitude, latitude, altitude and also with management practices. In general tropical soils have lower soil organic carbon content compared to the temperate soils. Even within tropics, great variability exists in soil organic carbon content depending upon temperature, precipitation, and biomass input (Zomer *et al*., 2017). Information related to changes in soil organic carbon and carbon stock due to conversion of grassland to agroecosystem is limited especially in the dry topics of India. This study was designed to analyze the impact of conversion of grassland to agroecosystem in dry tropics on soil organic carbon content and soil organic carbon stock, along with porosity and bulk density.

Materials and methods

This study was conducted in the cultivated plots of Botanical garden of Department of Botany, Banaras Hindu University at Varanasi (25^0 18'N Latitude, $83^0$1'E Longitude and 76 m above the mean sea level). The fields have been cultivated for decades and the present experimental plots have been maintained since 2002 with crop sequence of rice as rainy crop, barley or wheat as winter season crop followed by fallow during summer. No irrigation was provided to the plots to maintain a rainfed dryland condition. The grassland was left undisturbed having some common species like *Dichanthium annulatum, Cleome viscosa* L., *Corchorus capsularis* L., *Clerodendrum viscosum vent., Urochloa ramosa* (L.), *Cyperus rotundus* and others. Clipped biomasses of the grasses above 50-70 cm were left on the soil surface. Soil of the site had sandy loam texture, neutral ph, and pale brown coloured belonging to the order inceptisol.

A considerable seasonal variation in temperature and precipitation characterizes this dry tropical region. It includes a dry hot summer from April-June with temperature 30-48^{0}C, warm rainy season from July-September with high humidity (70-80 %) and temperature of 24-34^{0}C followed by a cool winter from November-February with temperature of 4-25^{0}C. 26^{0}C is the annual air temperature and about 1100mm annual rainfall is received of which 80% is received during the rainy season.

Soil sampling and analysis

Three samples were collected in the month of February 2018 in three replicates from grassland and cropland plots upto a depth of 10 cm and mixed homogeneously to make one composite sample per plot. The samples were air dried and sieved through a 2mm mesh screen for the analysis of the soil organic carbon, bulk density, moisture content and porosity. For the determination of bulk density, a known volume of soil was removed and oven dried for 16-24 hours at 105^{0}C, and calculated by the formula: [soil dry mass/soil volume] given by piper 1966. For the estimation of moisture content 10g sieved soil samples was removed and oven dried for about seven days for the dry weight and calculated by the formula: [fresh weight-dry weight/dry weight×100]. Porosity was determined by the equation: [1-bulk density/ particle density] where particle density assumed to be 2.65 mg/m^3. Soil organic carbon was determined by the dichromate titration and oxidation method (Kalembasa and Jenkinson, 1987) and the carbon stock was estimated as the product of bulk density and soil organic carbon.

Statistical Analysis

All the values were expressed as mean ± standard error (SE). Mean values were compared using Paired T-test for two samples. Significance of difference was indicated at $p < 0.05$ and $p < 0.01$.

Result and Discussion

The conversion of grassland to agroecosystems for the enhancement of the crop productivity leads to changes in the nutrient content and organic matter content. Due to the high soil organic matter content, lower soil compactness and lower disturbances in the grassland, there was increase in the moisture content and porosity and a decrease in the bulk density from the agroecosystem (Singh *et al*., 2009). Soil organic carbon content was significantly higher in the grassland (0.81 %) than the

Table 1: Changes in soil organic carbon content, soil carbon stock, bulk density and porosity due to conversion of grassland to agroecosystem in dry tropics. Values are mean ± standard error. In each column values having different alphabetic superscript are significantly different from each other ($P < 0.05$).

Sites	Parameters			
	Soil organic carbon (%)	Carbon stock (%)	Bulk density (g/cm³)	Porosity (%)
GL	$0.81^{a}\pm0.07$	$0.92^{a}\pm0.05$	$1.15^{a}\pm0.04$	$56.68^{a}\pm1.46$
AG	$0.57^{b}\pm0.05$	$0.72^{b}\pm0.08$	$1.26^{b}\pm0.02$	$52.54^{b}\pm0.79$

agroecosystem (0.57 %). Soil carbon stock also decreased significantly in cropland (0.71 %) as compared to the grassland (0.93 %). Soil porosity was also found to be higher in grassland (56.68 %) compared to the agroecosystem (52.54 %). However bulk density was more in case of agroecosystem (1.26 g/cm^3) than the grassland (1.15 g/cm^3) (Given in Table 1).

Grassland in the present study was protected and subjected to fewer disturbances due to anthropogenic activities leading to higher organic matter input into the soil through the continuous vegetation cover. Higher soil organic carbon content and lower bulk density was observed in this study (Steinbiss *et al*., 2008). Organic carbon in the grassland soil was perhaps chemically stabilized in aggregates and less exposed to microbial decomposition which might also explain the higher accumulation of soil organic carbon (Percival *et al*., 2000; singh *et al*., 2009). While in case of agroecosystem, since the major portion of the crop biomass were harvested out of the croplands, organic matter input was much lower than the grasslands as only plant roots and stubbles were left and this less organic input might be the reason for lower soil organic carbon (Singh and Ghoshal, 2011; Jenkinson and Rayner 1977; Paul *et al*., 1997; Tripathi and singh, 2009; Saha *et al*., 2010). Another reason for the reduction in the soil organic carbon might be the repeated tillage practice and ploughing activities which enhanced aggregate turnover leading to exposure of newer sites to microbial attack resulting in accelerated oxidation of soil organic matter (Bossuyt *et al*., 2002; Six *et al*., 2000; Kumar and Ghoshal, 2017).

Reduced soil organic carbon and soil aggregation due to reduced organic matter in the agroecosystem lead to increase in bulk density and reduction in porosity than the grassland (Celik 2005; Singh *et al*., 2009; Singh *et al.,* 2007). It was also reported by Arvidson (1998), reduced organic matter lead to high bulk density as a significant positive relationship existed between the soil organic carbon and bulk density. Similar trend was also reported by Chen *et al* (2010). Due to the conversion of grassland to agroecosystem in the present study reduction in 42% soil organic carbon, 22% carbon stock, 61 % moisture content, 7.3 % porosity and an increase of 8.73 % bulk density was observed.

Conclusion

Impact of conversion of grassland to agroecosystem was distinct in the present study as considerable decrease was found in the content of soil organic carbon, soil carbon stock, and porosity where as a significant increase was observed in bulk density. It may be suggested that to increase the soil organic carbon and soil carbon stock in agroecosystem management practices involving higher organic matter input to the soil should be recommended so that the agroecosystem would lead not only to long term sustenance of soil fertility and productivity but also sequester atmospheric carbon into the soil of dry tropics.

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