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SOIL CARBON POOL UNDER ORGANIC AND CONVENTIONAL CROP PRODUCTION SYSTEM OF SEMI ARID TROPICS

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Abstract

Regardless of land use, the results indicated significant differences in all the studied parameters. Total % SOC ranged from 0.52 to 0.72 for conventional farm samples (mean 0.62%) and 0.63 to 1.59 for the organic samples (mean 1.19). Bulk density (g/cc) ranged from 0.43 to 0.81 (mean 0. 62) for conventional and 0.17 to 0.28 (mean 0.20) organic farm soils. Organic manures increased microbial biomass carbon by 117% and dissolved organic carbon (DOC) concentration by 181% over conventional farming. The results suggested that organic matter is better protected in organic soils and are consequently less vulnerable to mineralization.

Introduction

Soil organic carbon (SOC) is regarded as the prime importance for maintaining soil quality and productivity. Higher SOC, a dominant component of soil organic matter (SOM), has been a significant aspect for improving overall greenhouse gas balance of the agricultural sector by enhancing the potential for soil C sequestration in organically managed soils as compared to conventional farming. In general, organic farming has been shown to increase the SOC content (Chai *et al*. 2015). It is worth revisiting the fate of SOC content under long-term organic vs conventional farming practices to increase credence of carbon build up in the soil.

Tamil Nadu is lying under the tropical region where the low status of organic carbon is prevailing primarily due to high temperature leading to higher rate of organic matter decomposition. Hence, maintenance of organic matter in this region is tough task faced by the farmers under cultivated soils.

There is growing evidence that modified soil management has the potential to increase SOC in agricultural systems across a range of environments (Eynard *et al*. 2005). Carbon accumulation in the soil is significantly influenced by changes in soil and crop management practices (Post 2001). Carbon pool in the soil can be reinstated through practice of conservation tillage with cover crops and crop residue mulch, efficient nutrient cycling with compost and manure and other sustainable soil and water management practices (Lal 2004). Increased root growth can enhance carbon input and therefore increase soil carbon fractions (Liu *et al*. 2014). Organic manures and compost applications resulted in higher SOC content compared to the same amount of inorganic fertilizer applications (Gregorich *et al*. 2001).

The SOC content of Tamil Nadu soils has been severely depleted over recent years due to unprecedented expansion and intensification of agriculture and is often below the critical limit (less than 0.50%) for soil and crop functions. Increasing concerns for environmental and human health have stimulated interest in organic agriculture.

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In Tamil Nadu, there have been no adequate studies out on the physical, chemical and biological properties of the soils organic agriculture. The farmers of the western agro-climatic zone of Tamil Nadu follow extensive millet, cotton and tapioca based cropping systems with a variety of conservation practices (e.g. fallow, manure application, green manuring, multivarietal seed technique). The effects of these practices on the changes in SOC have not yet been fully quantified in the region.

With this backdrop the study was undertaken to evaluate the effect of chemicals and organic inputs on soil carbon pools in different cropping system under the western agro-climatic zone of Tamil Nadu in the tropical regions. Soil samples were collected from the surface soils of conventional agricultural land and organic agriculture land in the comparative study.

Materials and Methods

Western agro-climatic zone of Tamil Nadu (semi arid tropics) was purposively selected for this study because more numbers of farmers are practicing organic farming and certified organic area is increasing day by day. Two sites (Site A and site B) were selected in the first area lied at the Tamil Nadu Agricultural University, Coimbatore district, Tamil Nadu. Site 1 was managed organically 100% organic (organic manures equivalent to 100% N requirement of the system) since from 2007 onwards which have a different cropping pattern (A1). The other site is located 700 m away from the organic farm and undergoes conventional cultivation was selected (A2).

The second area was in an irrigated field comprised of two farmers fields (1 certified organic field and other conventional field) at Sathyamangalam, in Erode district with four study sites are as; Site B1 (Inorganic field (tapioca grown entirely), site B2 (Organic cumbu), site B3 (Organic tapioca) and site B4 (Organic coconut + turmeric). Two farms were selected which had similar landforms and climatic conditions. The soil type is black to loamy. The 8 acres of organically managed farm was identified from the survey as having been managed without the use of chemicals since last 28 years. The other farm is located 400 m away from the organic farm and undergoes conventional cultivation, selected as a reference.

Soil samples were collected from the following sites of organic and inorganic fields. Sampling sites from each farm was demarcated in a random manner in order to cover the sample collection from the entire field. Samples were collected separately by a random selection from an each site and a surface (0 - 15 cm soil layer) using a small core sampler. The soil samples collected from the farmer’s field were found to be wet. A part of the wet sample was kept separately for microbial analysis. The soil samples collected from different sites of farmers were kept in clean polyethylene bags, labeled and brought to the laboratory for analyses. Randomly collected samples from each location (5 samples from each site) were pooled separately to obtain a composite soil sample. Each soil sample of about 1 kg was processed into powder form and collected after air drying them at room temperature. The samples were sieved through 2 mm sieve and three replicates of each sample used for the further analysis at Centre of Excellence in Sustaining Soil Health, Anbil Dharmalingam Agricultural College & Research Institute, Trichy, Tamil Nadu.

Soil organic matter was analyzed following Walkely and Black (1934). Organic matter (%) = Total organic carbon (%) × 1.72.

Fifty ml of deionized water was added into 10 g of soil and shaken in a horizontal shaker for one hour. Then it was subjected to centrifuge for 30 min at 8000 rpm. The solution was filtered through Whatman No. 1 filter paper and filtrate was collected and stored in the freezer until analysis. Dissolved organic carbon was determined by the dichromate acid oxidation method (Ciavitta *et al.* 1989).

The microbial biomass carbon (Cmic) was determined by chloroform fumigation- extraction method as described by Vance *et al*. 1987. Twenty gm of fresh soil sample was taken and fumigated with ethanol free chloroform in a vacuum desiccator for 24 hrs. Then it was extracted with 0.5 M K_2SO_4 and filtered. Ten ml of filtrate was taken in a 250 ml conical flask and was treated with 10 ml of 0.035 N $K_2Cr_2O_7$ and 20 ml of conc. H_2SO_4. The content was digested on a hot plate at 150 - 170^{0}C for 30 min and cooled. After addition of 25 ml of distilled water and 5 ml of phosphoric acid it was titrated against 0.04 N FAS using diphenylamine indicator. A nonfumigated set was done by following all the steps except fumigation. Carbon content was calculated using the titration value. MBC was calculated by subtracting the extracted C in unfumigated samples from that measured in fumigated samples. The value of MBC was represented in mg/kg dry soil.

Results and Discussion

Bulk density was influenced by management practices and green manures integration. The bulk density of organically managed soils was found more than the inorganic soil under both the study areas having the least difference between each of them (Fig. 1). Among the six sites, the highest bulk density was found in site A2 (0.81 g/cc) followed by site B1 (0.43 g/cc) both received 100 per cent inorganic fertilizers. While, the lowest bulk density, i.e. 0.17 g/cc was found under site B2 (where cumbu was cultivated organically) which was at par with other 2 sites of farmers organic field.

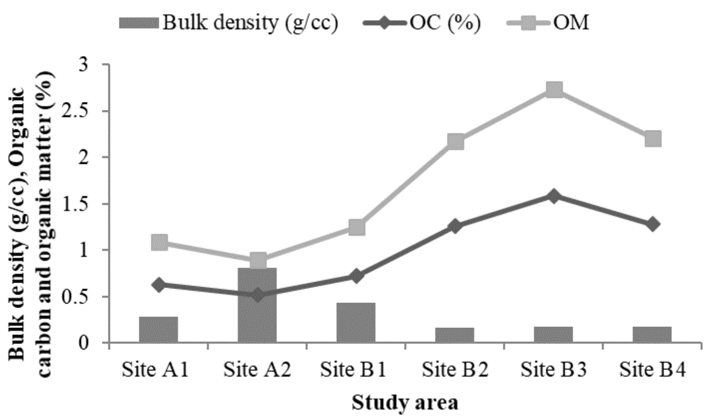

Fig. 1. Influence of organic and conventional management practices on soil bulk density (g/cc), organic carbon and organic matter (%).

The decrease in bulk density in the organic sites might be due to the improvement of the structural status of soil by judicious application of organic manures. The addition of root and plant biomass through multi varietal seeds and green manures and to the conversion of some micro-pores into macro-pores because of the cementing action of organic acids and polysaccharides which are formed during the decomposition of organic residues by higher microbial activities for better aggregation. This also increases the porosity of soil. Sheeba and Kumarswamy (2001) observed a decrease in bulk density with increase in organic matter content which supports the present study. The increase in bulk density under conventional farming has been attributed to the deterioration of the structure with nitrogen fertilizers when applied alone or in combination with other inorganic fertilizers and less residue retention in the soil. This result is in conformity with the findings of Tadesse *et al*. (2013).

In this study, total organic carbon concentration varies among the different sites, and followed the order of: organic tapioca > organic coconut + turmeric > organic cumbu > inorganic tapioca > organic tomato > inorganic tomato. Organic tapioca has an increase of 90 per cent organic matter over the reference soil. Irrespective of the sites, farms receiving organic inputs having of increased total organic carbon. The data presented in Fig. 1, reveals that the content of soil carbon varied from 0.63% soil in organic field to 1.59% soil. Among the six sites, the lowest organic carbon content was found in site A2 (0.52%) followed by site B1 (0.72%) both received 100 per cent inorganic fertilizers. While, the highest organic carbon content i.e. 1.59% was found under site B3, which was at par with others 2 sites of farmer's organic field and 0.63% was noticed under the organic farm maintained at the University. With regard to organic matter, the highest organic matter (2.73%) was found under site B3 which was found in other 2 sites of farmer's organic field and 1.08 per cent of organic matter was noticed under the organic farm maintained at the University.

This result shows that under conventional farming, continuous cultivation of these soils accelerate depletion of the soil organic carbon content without the addition of carbon biomass in soil. This indicated that carbon inputs from this system through underground and left-over above ground plant residues at harvest were not sufficient to maintain soil carbon content under the prevailing climatic conditions of the study area. In connection to this, because of less biomass C return of harvested land and greater C losses because of aggregate disruption, increased aeration by tillage and crop residue burning (Girma 1998).

In contrast, higher soil organic carbon contents of soils under organic farming sites are probably due to higher litter production and N fixation by the leguminous biomass added through green manuring and multi varietal seeds. This study showed that long-term application of different organic manures with green manure affected SOC in a distinct way (Bharani *et al*. 2018). The study area is lying under the tropical region where the decomposition takes place at a faster rate led to low retention of soil organic matter. The farmer is keeping on replenishing the soil organic matter from time to time by not leaving soil as barren land even after harvest. However, in case of conventional field, only the leaf droppings of concern crop were added to soil as biomass. No such special care was taken to recharge soil organic matter of the soil.

The perusal of the data in Fig. 2 indicated that the concentration of dissolved organic carbon in surface soil of the study area. It was found that all soil and different land use types had a noticeable variation in their DOC concentrations. In the site A, conventional tomato field had 38 mg/kg with no addition of organic manures and 106 mg/kg in the treatment receiving 100% organic manures on N equivalent basis. Whereas in the farmer's field (site B), the content of dissolved organic carbon was higher (182 mg/kg) in site B4 which was under tapioca cultivation than the reference conventional plot (68 mg/kg). It indicates that DOC is more dynamic with the management practices and Long *et al*. (2015) reported that manure application resulted in a seasonal variation of soil DOC. This suggests that the important source of dissolved organic carbon is the light fraction constituting mainly plant residues in the form of stubbles, roots and to a lesser extent leaves in the cultivated soil. The addition of organic matter into soil may accelerate mineralization and enhance the release of DOC in the soil (Kalbitz *et al*. 2005). Mineral fertilization introduced relatively little inorganic materials in a soil, hence resulted in to little DOC accumulation in soil (Zsolnay and Gorlitz 1994).

Farming practices can greatly influence soil biological activity and had a significant effect on soil microbial biomass carbon in different soils at different locations (Fig. 2). Locations with less bulk density and best structured soils have significantly higher amounts of MBC as compared to locations with normal textured soils i.e. site B2 to B4. Under conventional farming, the MBC was lowest (99 mg/kg) at site A2, while it was highest at site B1 (129 mg/kg).

Similarly, the values of lowest and highest MBC were found to be 203 and 445 mg /kg in site A1 and B2, respectively under organic farming. Rapid increase in microbial biomass following incorporation of cereals and legume residues has also been reported by others (Zhang *et al*. 2004). The results of present study showed an increasing about 100 to 220% in soil microbial biomass carbon with adoption of organic farming. The organic manures receiving fields provided a steady source of organic carbon to support the microbial community compared to conventional ones and provides a congenial environment for its growth. Anderson and Domsch (1989) reported that manure amendments increased microbial biomass carbon by a factor of 2 to 3 compared with the control, whereas the N fertilizer had little effect on it.

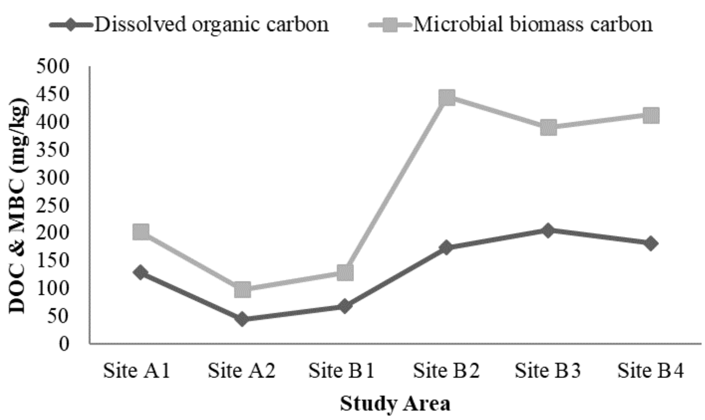

Fig. 2. Influence of organic and conventional management practices on soil dissolved organic carbon and microbial biomass carbon (mg/kg).

The results clearly revealed that the practice of organic farming resulted in higher carbon retention in soil as compared to application of chemical fertilizer alone. Compared with conventional farming, organic farming systems had more total carbon inputs, in particular from multi varietal seeds and green manure plant materials and added animal manure, which resulted prominent increase of total SOC and its various carbon pools. The adoption of this practice by the farmers of the region will be helpful in improving soil health and in sustaining crop productivity on long-term basis.

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