Eco. Env. & Cons. 29 (3) : 2023; pp. (1213-1218)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i03.032

Carbon Stock Estimates in Some Crop Fields of Kurnool District, A.P., India

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(Received 21 January, 2023; Accepted 20 March, 2023)

ABSTRACT

In the era of climate change, sustained management of cultivated areas has become important. Agricultural land use management is a vital initiative towards removing carbon from the atmosphere and its inclusion in farming systems. In India it has received little attention. Thus this study aims to provide information on the soil carbon stocks in crop lands of 3 selected areas of Kurnool district, A.P., India. In present study all the studied crop fields have the bulk density < 1.10 g/cm^3. It indicates that all these soils are clay soils. All the crop fields have the low SOC (%) and SOC stocks. To enhance SOC stocks and improve agricultural productivity which is vital for the socio – economic development of India, there is a need to promote effective land use management practices in farming systems.

Key words: *Soil Organic Carbon, Farming systems, Land use management, Sustainable management, Socio-economic development*

Introduction

Soil organic carbon (SOC) stock has an enormous significant constituent in any terrestrial ecosystem and is any divergence in its profusion and composition has important effects on many of the processes that occur within this system (Vasconcelor *et al*., 2014; Imamoglue and Dengiz, 2016). It plays an important role in the global carbon cycle (Janzen, 2004). It is necessary for the maintenance of nutrients and water in highly weathered soils with low cation exchange capacity (Rawls *et al*., 2003), in maintaining soil structure (Bronick and Lal, 2005) , nurturing vigorous soil microbial communities (Wilson *et al*., 2008) and providing fertility for crops (Schmid *et al*., 2011). The rate of litter decomposition is highly limiting the amount of labile soil carbon and it depends upon multiple factors including soil water content, P^H and temperature (Devevre and Horwath, 2000; Griggio *et al*., 2008; Knorr *et al*., 2005; Noordwijk *et al*., 1997). Understanding soil carbon sequestered in different agro ecosystems is fundamentally required to justify effects of land conversions to carbon stocks and their global warming potential.

Soils are considerably important in influencing global carbon cycle dynamics because they serve as the link between the atmosphere and the vegetation. The 2015 Status of the Worlds Soil Resources Report highlights that more carbon resides in soil than in the atmosphere and all plant life combined (FAO & ITPS, 2015). Although some soil carbon comes from mineral resources, the vast majority of it is derived from plants. As plants grow and die they depart or-

([1]Assistant Professor (Rtd.), [2,3,4, 5,6,7] PG Students) ganic carbon based compounds in the soil of varying size and chemical compounds. Under the right conditions soil fauna metabolize these compounds and excrete some of it into the soil. Thus the SOC varies with overall plant density. SOC has much longer residence time in soils than in the vegetation. But plants are only the strategy that can remove carbon from the atmosphere and reduces atmospheric CO_2 (Schlesinger, 1990). The role of soils and SOC in the climate systems has been widely recognized and validated in various studies. SOC quality and quantity in different parts of the world, as affected by climate change and measures to enhance SOC are insufficiently investigated.

Regarding the soil sector, global 'C' pools are difficult to approximate because of still limited knowledge about specific properties of soil types (Sambroek *et al*., 1993; Batjes, 1996), the high spatial variability of soil 'C' even within one soil unit (Cerri *et al.,* 2000) and the different effects of the factors controlling the soil organic 'C' cycle (Pastor and Post, 1986; Parton *et al.,* 1987). Thus regional studies are necessary to process global estimations obtained by aggregation of regional estimates mainly at district level. The importance of an understanding of the National Carbon Pool levels is reinforced by the statements of the United Nations Frame Work Convention on Climate Change (UNFCCC) signed at Rio de Janeiro in 1992.

Carbon storages in agricultural lands are highly varied from field to field. Many factors like agricultural practices, irrigation, fertilizer application, residue management and diverse crop rotations limit the carbon storage capacity. Many researchers agree and their results have confirmed that soil organic carbon associated with different land uses varies dramatically at the regional or catchment scale (DavidWhite II *et al*., 2009; Zhang *et al*., 2011; Jaiarree *et al*., 2011).

Crop land was the land use type in which rock fragment were most often totally unseen. The land use induced changes in soil organic carbon (SOC) stocks are the major ambiguity and in life cycle assessments of tropical agriculture products. Different farming systems could be characterized on their above ground and below ground carbon characteristics. However, despite the global recognition of agricultural land use management as vital initiative towards removing carbon from the atmosphere, its inclusion in farming systems in India have received little attention. Thus this study aims to provide information on the soil carbon stocks in crop lands of 3 selected areas of Kurnool district, A.P., India. These results will be useful to the agricultural practitioners to address land use change and adopt appropriate land use management practices to enhance soil organic carbon capacity and fertility of cropland soils.

Objectives of the study

- To estimate the soil organic carbon (SOC) stocks within different land uses.
- To recommend options to raise SOC stocks in the area.
- The focus on crop lands is due to the need for sustained management of cultivated areas has become important in the era of climate change.

Materials and Methods

Kurnool is one of the Rayalaseema Districts in South – West of Andhra Pradesh, situated within the geographical co ordination of 14^{o} – 54′ and 16^{o} – 11′ of the Northern latitude and 76^{o} – 58′ and 78^{o} – 25′ of the Eastern longitude. The altitude of the district varies from 1000 feet above the sea level. It is bounded on the North by Mahaboobnagar district, on the South by Anantapur district and Kadapa district, on the West by Karnataka state and on the East by Prakasam district with Nallamala forest.

Climate of the area

The agriculture of this region is characterized by as hot, semi arid moist with dry summers and mild winters. The mean annual temperature varies from 37.5 ^{o}C to 42.5 ^{o}C. The mean summer (April – June) temperature varies from 32 ^{o}C – 34 ^{o}C rising to a maximum of 42 ^{o}C in May and the mean winter (December – February) temperature varies from 22.5 ^{o}C to 27.9 ^{o}C. The mean annual rainfall varies from 274 to 620 mm.

Soils of the area

The total geographical area of the district is 43.49 lakh acres of which 29.93 lakh acres is under cultivation, which forms 68.8%. The gross cropped area of the district is 8.60 lakh hectares of which 1.60 lakh hectares (14.58%) is irrigated through canals, wells and other sources. 85.4% of gross cropped area is cultivated under rainfall conditions. Based on physical characteristics of the district, the land capability of the district has been categorized in to 9 classes.

The present croplands selected for study falls in Class V, i.e. Creep belt plains and black soil plains, where the soils are moderately well drained. The ground water potential is very fair. The soil erosion is moderate.

Methodology

Soil samples were collected from the pits dugged into 20 X 20 cms. In selected crop fields in three replicates and brought it to the laboratory to estimate its carbon stock by using the following formula –

$$\text{SOC (t/ha)} = 1000 \text{ X } \frac{\text{Bulk density}}{100} \times \text{SOC (\%)}$$

$$\text{Soil Organic Carbon (SOC\%)} = \frac{V1 - V2}{W} \times 0.3$$

$$\text{Bulk density (g/cm}^3) = \frac{\text{Dry weight of soil (g)}}{\text{Volume of the soil (cm}^3)}$$

Determination of Bulk density

To obtain the dry weight of soil, the soil samples taken to the laboratory were weighed in oven proof containers after they were dried in conventional hot air oven at 105 ^oC for about 2 hrs.

Volume of the soil = Ring volume (cm^3) = 3.14 X r^2 X Ring height

In present study

Ring diameter = 20 cm. i.e radius (r) = 10cm.

Ring height = 20 cm.

Then Ring Volume = 3.14 X 10 X 10 X 20 = 6280 cm^3

Ring Volume = Volume of the soil = 6280 cm^3

Estimation of SOC (%)

The Soil Organic Carbon (SOC %) was estimated in the laboratory by Walkley and Black method (1934) as it is widely followed in many laboratories because it is rapid and affordable.

Correlation studies

The coefficient correlation was estimated to the bulk density values and Soil organic carbon (%) values; bulk density and Soil carbon stocks (t/ha) and Soil organic carbon (%) and Soil carbon stocks (t/ha).

Results and Discussion

Results

Among the five crop fields i.e. Zea maize, Jowar, Cotton, Brinzal and Banana, the Jowar cultivated fields was shown highest SOC stocks (2.1 t/ha.) followed by Brinzal (2.0 t/ha), Cotton and Zea maize with 1.9 t/ha. and banana (1.4 t/ha).

The bulk densities were almost equal in the studied fields, i.e 0.94 & 0.93. SOC (%) was high in Jowar (2.2) followed by Brinzal (2.1) Zea maize (2.07), cotton (2.04) and banana (1.4)

The above values indicated that the SOC stocks are directly proportional to the SOC (%) values.

The correlation coefficient studies conducted between bulk density and SOC (%) was shown as -0.6. It indicated a strong downhill (negative) linear relationship.

The correlation coefficient studies conducted between bulk density and SOC stocks was shown as -0.5. It also indicated a strong downhill (negative) linear relationship.

The correlation coefficient studies conducted between SOC (%) and SOC stocks was shown as 0.99, i.e. 1. It indicated a perfect uphill (positive) linear relationship.

Among the five crop fields i.e. Red gram, Zea maize, Jowar, Cotton and Chilli cultivated fields, the chilli cultivated crop fields was shown highest SOC stocks (2.5 t/ha) followed by Jowar (2.12 t/ha), red gram (2.1 t/ha), zea maize (1.8 t/ha) and cotton (1.395 t/ha).

The bulk density was high for chilli crop field (0.094) followed by Zea maize, jowar and cotton fields (0.093) and Red gram field (0.092).

The SOC (%) was high in chilli (2.7) followed by red gram and jowar fields (2.28), Zea maize (1.95) and cotton (1.5).

The above values indicated a direct proportion between the SOC stocks and SOC (%) and no relation with the bulk density.

The correlation coefficient studies conducted between bulk density and SOC (%) was shown as 0.33. It indicated a weak uphill (positive) linear relationship.

The correlation coefficient studies conducted between Bulk density and SOC stocks was shown as 0.346. It also indicated a weak uphill (positive) linear relationship.

The correlation coefficient studies conducted between SOC (%) and SOC stocks was shown a 0.999. It indicated a perfect uphill (positive) linear relationship.

Among the five crop fields, i.e. Red gram, black gram, chick pea, chilli and cotton cultivated fields, Chick pea and cotton cultivated fields was shown highest SOC stocks (2.2t/ha) followed by chilli (1.97 t/ha), Red gram (1.7 t/ha) and black gram (1.6 t/ ha.).

The bulk density was high for black gram cultivated fields (0.095) followed by chilli cultivated crop field (0.094), red gram and cotton cultivated fields (0.093) and chick pea cultivated crop field (0.092).

SOC (%) was high in chick pea field (2.4) followed by cotton (2.37), Chilli (2.1), Red gram (1.86) and black gram (1.68) fields.

The above values indicated that the SOC stocks are directly proportional to the SOC (%) values and more or less inversely proportional to the bulk density.

The correlation coefficient studies conducted between Bulk density and SOC (%) was shown as -0.77, i.e 0.8. It indicated a strong down hill (negative) linear relationship.

The correlation coefficient studies conducted between bulk density, SOC stocks was shown as i.e -0.8. It also indicated a strong downhill (negative) linear relationship.

The correlation coefficient studies conducted between SOC (%) and SOC stocks was shown as 0.99, i.e 1. It indicated a perfect uphill (positive) linear relationship.

During the study period cotton is cultivated in all the three regions. The bulk density is equal i.e. 0.093 in all the studied areas. SOC (%) is higher in Pagidyala (2.37%) followed by Thandrapadu (2.04%) and Pasupula (1.5%). Soil carbon stocks are higher in Pagidyala (2.2t/ha) followed by Thandrapadu (1.9t/ha) and Pasupula (1.4t/ha).

Red gram crops are cultivated in two of the studied regions – Pagidyala and Pasupula. Bulk density is almost equal in both the regions, 0.093 and 0.092 respectively. SOC (%) and Soil organic carbon stocks are higher in Pasupula (2.28% and 2.1t/ha) followed by Pagidyala (1.86% and 1.7t/ha).

Chilli is also cultivated in two studied regions - Pagidyala and Pasupula. Bulk density is equal in both the regions, i.e 0.094. SOC (%) and Soil organic carbon stocks are higher in Pasupula (2.7% and 2.5t/ ha) followed by Pagidyala (2.1% and 2.0t/ha).

Jowar is also cultivated in two studied regions – Thandrapadu and Pasupula. Bulk density is equal in both the regions, i.e 0.093. SOC (%) are almost equal in both the regions, i.e 2.25% and 2.28% respectively and Soil organic carbon stocks are equal i.e 2.1t/ha in both the areas.

Discussion

There is an ongoing discussion about whether climatic factors or the differences in soil mineralogy and land use history contribute most to distinct tropical SOC dynamics (Feller *et al*., 1997). Differences in rooting depth and tillage on crop lands directly influence the "C" distribution in the soil profile. Regular soil disturbance during tillage or harvesting is one of the main reasons for low crop land SOC stocks (Lal, 1997), because SOC stocks linearly depend on both SOC concentration and bulk density. High soil organic carbon may be due to the rapid decomposition of litter in the favourable environment. Bulk density might be of interest as an important soil property. It is the fine soil stock of the investigated soil layer that is of interest since it contains the SOC.

Bulk density is an indicator of soil compaction. It is dependent on soil texture and the densities of soil mineral (sand, silt and clay) and organic matter particles as well as their packing arrangement.

Generally loose, porous soils and those rich in organic matter have lower bulk density. Sandy soils have relatively high bulk density since total pore space in sands is less than that of silt or clay soils. Fine textured soils such as silt and clay loams that have good structure have higher pore space and lower bulk density compared to sandy soils.

According to USDA Natural Resources Conservation Service, if ideal bulk density for plant growth is $< 1.10\ g/cm^3$ the soil texture is clay. In present study all the studied crop fields has the bulk density $< 1.10\ g/cm^3$. It indicates that all these soils are clay soils. The low bulk density maybe due to consistently ploughing to the same depth or using a limited crop rotation without variability in root structure or root depth. Enhanced soil organic carbon (SOC) has favorable effects on physical, chemical and biological activities of the soil for good crop yields (Ardo and Olsson, 2003). The different farming systems could be characterized the carbon characteristics (Atsivor *et al*., 2001; Marks *et al*., 2009).

According to Wang *et al*. (2010), the amount of SOC in an agricultural soil is an indicator of soil productivity. In this study all the crop fields has the low SOC (%) and SOC stocks. According to Singh *et al*. (2007) low levels of organic carbon in our soils could be attributed to high rates of oxidation of SOC due to high temperature in tropics and frequent cultivation.

According to Katyal *et al.* (2001) soils in tropical regions like India are low in SOC as they fall under the influence of arid, semiarid, sub-humid climates and this is a major factor contributing poor productivity.

Thus, there is a need to promote effective land use management practices in farming systems to enhance SOC stocks and improve agricultural productivity which is vital for the socio – economic development of India.

The following are considered for viable and attainable options to increase SOC in the study area.

- Promotion of residue retention on crop lands.
- Farmers should store the residue and use them as mulch.
- Introduction of alley cropping that diversity farm income, improve crop production and provide protection and conservation benefits to crops.
- Alley cropping also creates a micro climate from the increased shade and reduced wind, which in turn increases water use efficiency by crops.
- Weeds are better controlled and increased nutrient flow improves soil fertility without the use of fertilizers.

Conclusion

Bellassen *et al*. (2010) stated that Kyoto protocol through the United Nations Framework Convention on climate change (UNFCCC) has created an economic opportunity for carbon credits in the near future. This can create opportunities for farmers to have an additional source of income and likely start a process that will consider carbon credit policy or incentives options for cropland soils in India.

A lot of soil organic carbon research should be conducted at the local or small scale levels to provide an accurate baseline data for a proper national soil carbon inventory for India. This will be helpful in preparing the country for carbon sequestration projects under the CDM of the Kyoto protocol.

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