Soil carbon sequestration in semi arid tropics - impact of long-term improved management on soil carbon sequestration of Vertic inceptisols in the semi arid tropics of central peninsular India

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Abstract

The objectives of this study were to examine the impact of 11 years of sequential cropping under improved and traditional management on crop yield, soil organic carbon (SOC) and microbial biomass C (MBC) in Vertic Inceptisols under semi arid condition. Improved management comprised of sowing on broadbed-and-furrow landform and additions of nutriments through composted crop residues and pruning of Glyricidia sepium(L) used as an hedge between plots of this modality, while traditional management consisted of sowing on grade land form and no addition of organic sources of nutriment. The higher SOC content was found in medium depth soil under improved management, which ranged between 1.07% and 1.2% with a mean of 1.13%, the lower SOC content is recorded in medium depth traditional management, which ranged between 0.51% and 0.94% with a mean value of 0.66%. The SOC content increased between 2002 and 2006 with higher value for improved management (+0.42%) compared to traditional management (+0.28%). The MBC content is not influenced by management system and soil depth.

Introduction

In the semi arid tropic (SAT) low soil organic carbon (SOC) content and inappropriate management of water resources are associated with low crop yields. Low SOC content in the SAT also provides an opportunity for sequestering more carbon in soil. However the challenge is to identify sustainable C sequestration crops and management options in India SAT with the aim of assessing impact of soil management option along with cropping systems

Material and methods

A long-term field experiment was initiated in 1995 rainy season at the ICRISAT research station, Patancheru (78 16' longitude, 17 32' latitude and 540 m elevation), Andhra Pradesh, India. Experimental soil is Vertic Inceptisols from the Kasireddipali series with a general slope of 2% and a variation in soil depth from 30 cm to 90 cm (depth of black soil). After many years of grassed-fallow, the land was developed in a 15 ha watershed. For this experiment four hydrological units were selected, depending on soil depth (90 cm to 50 cm and <50 cm) and system management (improved and traditional): 1) medium depth improved management, 2) medium depth traditional management, 3) shallow depth improved management, 4) shallow depth traditional management. Each year, both management systems received 18 kg P ha^{-1} as single superphosphate and the same pest control management. Improved management comprised of sowing on broadbed-and-furrow landform and addition of nutriments through composted crop residues and pruning of Glyricidia sepium(L) use as hedge between plots of this modality; while traditional management consisted of sowing on flat land form and no addition of organic sources of nutrient. From 1995 to 2004 rainy seasons, soybean/pigeonpea intercropped and soybean + chickpea sequential (rainy season: soybean; post rainy season: chickpea) were grown. After 2005, for nutriment management reasons, sequential cropping system was replaced by maize + safflower. However in 2006 the weather did not allow to grow maize, therefore it was replaced by sorghum. Each treatment (soil depth/management system/cropping system) is replicated three times in a split plot block design. In order to study the SOC, MBC and other soil properties, three cores were collected on each replication following a diagonal to obtain depth-wise composite samples up to 90 cm (0-15, 15-30, 30-60, 60-90). The collection was realized in December 2006 after soybean and sorghum harvest. For this study the data set is based on 96 composite samples analysed following standard methods.

Results and discussion

Due to the prevailing high temperature in SAT, which generates a rapid break down of organic matter, regular application of organic matter is the only way to maintain SOC levels in soils of arid regions in view to ensure sustainable crop productivity. However, with declined animal population and alternative uses of dung as fuel and crop residues as animal feed, the availability of adequate quantities of organic manures is a major constraint. Therefore the present study focused on evaluating the improved management as a tool to fight soil erosion and maintain SOC. The highest soil C concentration is noticed for improved management in medium depth soil, which ranged between 1.07% and 1.2% with mean of 1.13%. The lowest SOC content is recorded in medium depth traditional management which ranged between 0.51% and 0.94% with a means value of 0.66%. In shallow soil mean values are similar between improved and traditional management. Among all the treatments, the surface layer (0-15 cm) showed the maximum SOC, which decreased quickly between the top layer and the second layer (15-30cm) and then decreased gradually with soil depth. SOC content decreased between 1995 and 2002. However between 2002 and 2006 all the treatments showed a SOC build-up with higher value for improved management (0.42%) compared to traditional management (0.28%). SOC build-up is higher in the top layer compared to sub layers but they are well distributed throughout the profile due to swell-shrink properties of the soil. Soil MBC ranged between 260 and 434 $\mu g\ g^{-1}$ with a mean of 318 $\mu g\ g^{-1}$ for surface sample (0-15 cm) and ranged between 104 and 297 with a mean of 206 $\mu g\ g^{-1}$ in deeper layers.

Conclusion

Results from this 11-year long-term experiment indicated that improved management options allow a higher SOC content in medium depth soil (90-50 cm of black soil) Vertic Inceptisols. These findings have demonstrated that by adopting holistic approach with legume, land, water and nutriment management options potential of Vertic Inceptisols can be harnessed for sequestering C in soil along with increasing productivity for sustainable livelihoods.