

Organic carbon forms in Alfisol profile after Twenty Years of Cropping, Fertilization, Groundnut Shells and Farm Yard Manure Addition under Arid Conditions

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Abstract:

The objectives of this study were to examine the effects of 20 years of groundnut cropping with chemical fertilization (NPK), organic manuring (FYM or groundnut shells) and integrated use of these two inputs (INM) on crop yields, soil organic carbon (SOC), particulate organic carbon (POC) and microbial biomass carbon (MBC) in an Alfisol under arid conditions. Various nutrient management options significantly (<0.05) improved yield of groundnut pod over 20 years. The SOC improved significantly in surface layer (0-20 cm) from 0.31 % in control to 0.59 % in 50 % NPK + 4 t FYM ha⁻¹. With 50 % NPK + 4 t groundnut shells ha⁻¹ also the SOC improved markedly to 0.49 %. Interestingly, with integrated nutrient use, improvements in SOC were observed even up to 60 cm depth of the profile. Overall, there was a buildup of SOC in surface layers in all treatments. Profile mean POC increased from 0.09 % in control to 0.20 % in 50 % NPK + 4 t FYM ha⁻¹. Microbial biomass carbon (MBC) improved from 31.5-54.9 $\mu\text{g g}^{-1}$ soil in control to 39.5 -135.5 $\mu\text{g g}^{-1}$ soil with 50 % NPK + 4 t FYM ha⁻¹, whereas the highest MBC/OC ratio was found in 50 % NPK + 4 t groundnut shells ha⁻¹.

Introduction

Maintaining soil and crop productivity in the long term in continuous mono cropping systems is a major challenge in arid tropics. The arid tropical regions in India are characterized by low rainfall, sparse vegetation and poor soil fertility. The productivity of soils in these regions is related to the soil organic carbon (SOC) status, which is a critical component of soil quality. In this paper, we evaluated the impact of one such practice of continuously adding groundnut shells to meet 50% NPK requirement of the groundnut crop for 20 years in Alfisols in Anantapur region of southern India, on the soil biological properties and compared with other nutrient management practices like complete inorganic fertilizer application, only organic manure as FYM and integrated use of inorganic and organic forms of nutrients.

Materials and methods

A long-term field experiment was initiated in rainy season of 1985 with mono cropping of groundnut at Agricultural Research Station, Anantapur, Andhra Pradesh, India (77° 40' longitude and 14° 42' latitude MSL 350 m) under the All India Coordinated Research Project on Dryland Agriculture (AICRPDA). Experimental soil belongs to Rhodostalfs and falls under Voyalpadu soil series. Groundnut crop (variety: TMV-2) was grown during rainy season (June-October) during the 20 year period (1985-2004). The trial consisted of five treatments i.e. T1=Control (no fertilizer), T2=100% recommended dose of fertilizer (RDF) (20:40:40 N, P₂O₅, K₂O), T3=50% RDF+ 4t groundnut shells (GNS) ha⁻¹, T4= 50% RDF+ 4 t FYM ha⁻¹ and T5=100% organic (5t FYM ha⁻¹). Each treatment was replicated thrice in a randomized block design. N, P and K were applied in the form of urea, DAP and muriate of potash, respectively. For studying the SOC, MBC and other soil biological properties, depth-wise soil samples (20 cm interval) upto 1 meter were collected from the twenty years old (started in 1985) experimental plots during Feb 2005. Analysis of various physico-chemical properties of soils were done following standard methods. Organic carbon estimation was done by Walkley and Black method. For POC, The material retained on the sieve (<53 μm) was dried at 65 °C and ground for analysis of carbon concentration and expressed on dry weight equivalent. Soil microbial biomass carbon (MBC) by fumigation incubation technique.

Results and Discussion

Maintaining SOC levels in light textured soils of arid regions is critical for ensuring sustainable crop productivity. Regular application of organic manures is only way to achieve this, in view of the rapid break down of organic matter due to the prevailing high temperatures in arid tropics. However, availability of adequate quantities of organic manures is a major constraint with declined animal population and alternative uses of dung as fuel and crop residues as animal feed. Therefore the present study focused on evaluating the suitability of groundnut shells a renewable source to partially substitute chemical fertilizers and maintaining SOC. Continuous addition of organic amendments significantly improved SOC content over control. The control plot soil profile showed lowest SOC content between 0.15 to 0.31 % with a mean of 0.23 % while the highest SOC was found in 50 % NPK +4 t FYM ha⁻¹ which ranged between 0.18 to 0.59 % with mean of 0.39 %. The treatment of 100 % organic manure (5 t/ha/yr) also maintained higher SOC content with a profile mean of 0.34 %. In all the treatments, surface layers (0-20 cm) showed the maximum SOC which decreased gradually with depth. Regular addition of organic manures could improve SOC content of soil profile even up to 60 cm. Overall, treatments comprising of FYM application showed maximum SOC buildup, followed by 50 % NPK + 4 t groundnut shells ha⁻¹, 100 % NPK and control. However, in surface layer (0-20cm) of all the treatments there was a buildup of SOC as compared to that of 1985 (0.25%). Considerable improvement in soil MBC levels was observed with different organic amendments. Control profile showed MBC ranging from 31.5 to 54.9 µg g⁻¹ soil with a mean 45.16 µg g⁻¹ soil while 50 % NPK+4 t FYM ha⁻¹ showed a range of 39.5 to 135.5 µg g⁻¹ soil with a mean 85.02 µg g⁻¹ soil. Other two treatments 100 % organic and 50 % NPK + 4 t groundnut shells ha⁻¹ also showed higher MBC content over control. 100 % NPK applied plots showed SMBC content between control and organic treatments. Though the MBC content decreased with depth, significant improvements due to treatments were observed even up to 60 cm particularly with organic matter addition. Particulate organic carbon (POC) is the organic carbon fractions in 53-200 µm soil separates, was influenced by different nutrient management options. It ranged from 0.09 to 0.11 % in control to 0.10 to 0.38 % in 5t FYM ha⁻¹. Except in control where a more or less similar level of POC was maintained, remaining four treatments showed a decreasing trend with depth. Profile mean POC ranged from 0.10 % in control to 0.20 % in 50 % NPK +4 t FYM ha⁻¹.

Conclusions

Results from this 20 years long-term experiment clearly indicated that organic manures like FYM and crop byproducts like groundnut shells can substitute 50% of the NPK requirement of groundnut crop in an arid Alfisol and also help in maintaining better soil chemical and biological parameters. The study in particular showed that a wide C:N ratio material like groundnut shells which otherwise are wasted can be used to maintain soil health and support crop production even in light textured soils of arid zone of India. After 20 years of continuous cropping, fertilization and manuring improved biological properties of soils considerably. More importantly, this study clearly showed that even under arid conditions, regular additions of organic manures could improve soil organic carbon levels and thus warrants more efficient and integrated nutrient management strategies for long term sustainability of arid soils.