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Studies on the transformations of carbon under different nutrient management practices and cropping systems in Vertisol of Northern Transition Zone of Karnataka

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Abstract: A long-term field experiment on the transformations of carbon under different nutrient management practices and cropping systems in Vertisol (Typic Haplustert) of Northern Transition Zone of Karnataka was initiated during 2004-05 at the Institute of Organic Farming, Main Agricultural Research Station Farm, UAS, Dharwad. Hundred per cent organic nutrient management practice recorded statistically higher organic and total carbon (TC) at surface (6.7 and 20.6 g/kg, respectively) and subsurface (4.8 and 15.3 g/kg, respectively) than inorganic, integrated and RDF+FYM. Similarly, water-soluble carbon (WSC) and labile carbon (LC) contents were significantly higher in 100 per cent organic nutrient management practice both at surface (56.7 and 960.5 mg/kg, respectively) and subsurface (42.3 and 818.5 mg/kg, respectively) soil layers than other nutrient management practices. Noticeable improvement was seen in all the forms of carbon content in the soil under organic nutrient management practice.

Key words: Carbon transformation, Cropping systems, Nutrient management practices

Introduction

Soil organic matter (SOM) is of fundamental importance in maintaining soil fertility The SOM pool comprises of active, intermediate/slow and passive pools, which act as sensitive indicators of soil quality. Labile carbon (LC) is the pool of carbon primarily influenced by new organic matter contributed annually and has a significant role in microbial nitrogen turnover and supply. Since, LC turns over relatively and rapidly, it is considered as the most active fractions of soil organic carbon (SOC) which is highly related to soil physico-chemical properties and fertility. Labile fraction is typically required for a better assessment of the effects of management on soil properties. Water soluble carbon (WSC) is defined as entire pool of water-soluble carbon either sorbed or sediment particles or dissolved in interstitial pore water and is considered the most mobile and reactive soil carbon source and its characterization is an important issue for soil ecology. It plays role in many biogeochemical processes. Good farming practices have the potential to make such soil a net sink for C thereby attenuating CO_2 load in the atmosphere and improving soil fertility and hence productivity. Organic matter is key factor in improving overall productivity of cropping system.

Material and methods

The long-term field trial on performance evaluation of important crops/cropping systems under organic farming is in progress on a fixed site since 2004-05 under Network Project of Organic Farming at the Institute of Organic Farming, University of Agricultural Sciences, Dharwad. The present investigation on the transformations of carbon under different nutrient management practices and cropping systems in Vertisol of Northern Transition Zone of Karnataka was under taken during 2012-13 *rabi* season. The average annual rainfall was 711.8 mm, fairly well distributed from April to November. The mean maximum temperature varied from 27.3°C (July, August) to 36.9°C (April) whereas, mean minimum temperature varied from 12.7°C (December) to 21.8°C (May). The mean monthly highest and the lowest relative humidity was 89 (July) and 47 per cent (January), respectively.

The organic, inorganic, integrated (50% organic+50% inorganic) and RDF+FYM strips of 15 m were laid out with the cropping systems as sub plots of 20 m length in strip design. Across the four main strips of organic, inorganic, integrated and RDF+FYM nutrient management practices, five cropping systems mainly groundnut-sorghum, soybean-wheat, maize-chickpea, pigeonpea + soybean and cotton + peas were followed. The soils were collected from the field after the *rabi* crop of the year 2012-13 from two depths (0-30 cm and 30-60 cm) for the estimation of carbon fractions. Standard procedures were followed for the estimation of carbon fractions. Water-soluble carbon was determined using the method as described by McGill *et al.* (1986). The 10 g of soil in 20 ml of distilled water was centrifuged for one hour at 500 rpm and the supernatant aliquot was filtered. The 10 ml of the filtrate was treated with 5 ml of 0.07N $K_2Cr_2O_7$, 10 ml of 98 per cent H_2SO_4 and 5 ml of 83 per cent H_3PO_4 and the mixture was digested at 150ºC for 30 minutes. Cooled samples were titrated against 0.01N ferrous ammonium sulphate by using diphenylamine indicator. Labile carbon was determined by $KMnO_4$ oxidation method (Blair *et al.*, 1995). Three g of soil sample was treated with 25 ml of 33 per cent $KMnO_4$ and shaken for 24 hours on a reciprocal shaker. After centrifuging at 2000 rpm for 5 min, the samples were filtered. The absorbance of the filtrate of the samples was measured at 565 nm in a double beam spectrophotometer. Total carbon was determined by taking a known amount of soil in a porcelain dish and kept in muffle furnace at 400ºC temperature for 4 hours. The difference in the weight of the soil sample was calculated as the total carbon content. The data collected from the laboratory analysis were subjected to statistical analysis. Standard statistical methods were used (Gomez and Gomez, 1984).

Results and discussion

Mineralizable organic carbon differed statistically among the different nutrient management practices in soil, at both the depths (0-30 cm and 30-60 cm) (Table 1). It ranged from 5.2 to 6.7 g per kg in surface and from 3.0 to 4.8 g per kg in subsurface soil. Statistically high mineralizable organic carbon content in soil at 0-30 and 30-60 cm was recorded in organic nutrient management practice (6.7 and 4.8 g/kg, respectively) and was significantly superior over other nutrient management practices. This could be attributed to the addition of organic materials for several years from external sources as well as due to continuous return of large amount of crop residues in the form of roots and stubbles to soil (Sudhir and Siddaramappa, 1995). Similar results were reported by Kundu *et al.*, 2007 and Kukal *et al.*, 2009. The mineralizable organic carbon content in soil was not significantly influenced by the cropping systems.

The different nutrient management practices significantly influenced WSC in soil and it ranged from 38.4 to 56.7 mg per kg at the surface and from 26.6 to 42.3 mg per kg at the subsurface layers of soil (Table 2). The organic nutrient management practice recorded significantly higher WSC content in soil (56.7 mg/kg at 0-30 cm and 42.3 mg/kg at 30-60 cm) and might be attributed to increased SOC. The WSC content is considered as the most active component of SOM (McGill *et al.*, 1986). Higher amount

Table 1. Effect of nutrient management practices and cropping systems on mineralizable organic carbon content (g/kg) in soil

Cropping systems (CS)	Nutrient Management Practices (NM) 0-30 cm					30-60 cm				
	NM1	NM2	NM3	NM4	Mean	NM1	NM2	NM3	NM4	Mean
CS1	6.7	6.2	5.9	5.2	6.0	4.6	3.7	3.4	2.9	3.6
CS2	6.6	6.3	5.5	5.2	5.9	4.7	3.7	3.5	3.1	3.7
CS3	6.6	6.2	5.7	5.3	6.0	5.0	3.6	3.4	3.0	3.8
CS4	6.8	6.3	5.9	5.4	6.1	4.8	3.8	3.6	3.2	3.8
CS5	6.8	6.2	5.8	5.1	5.9	4.7	3.5	3.5	3.1	2.0
Mean	6.7	6.2	5.7	5.2		4.8	3.7	3.4	3.0	

For comparing means of	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
NM	0.09	0.33	0.08	0.42
CS	0.11	NS	0.20	NS
NM x CS	0.18	NS	0.25	NS

Table 2. Effect of nutrient management practices and cropping systems on water-soluble carbon content (mg/kg) in soil

Cropping systems (CS)	Nutrient Management Practices (NM) 0-30 cm					30-60 cm				
	NM1	NM2	NM3	NM4	Mean	NM1	NM2	NM3	NM4	Mean
CS1	57.2	49.8	45.6	39.8	48.1	41.2	38.2	32.7	25.6	34.4
CS2	56.0	50.4	45.5	37.4	47.3	42.8	38.2	33.7	26.7	35.4
CS3	56.9	52.5	44.4	38.3	48.0	42.7	38.8	33.0	27.6	35.5
CS4	56.0	51.9	45.7	38.7	48.1	43.2	39.5	35.0	26.5	36.1
CS5	57.7	49.5	44.2	37.7	47.2	41.7	37.2	32.9	26.6	34.6
Mean	56.7	50.8	45.1	38.4		42.3	38.4	33.5	26.6	

For comparing means of	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
NM	0.74	2.55	0.49	1.69
CS	2.46	NS	1.07	NS
NM x CS	2.41	NS	1.33	NS

Table 3. Effect of nutrient management practices and cropping systems on labile carbon content (mg/kg) in soil

Cropping systems (CS)	Nutrient Management Practices (NM) 0-30 cm					30-60 cm				
	NM1	NM2	NM3	NM4	Mean	NM1	NM2	NM3	NM4	Mean
CS1	976.7	836.0	801.0	733.0	836.7	820.3	758.0	694.3	620.3	723.3
CS2	965.0	854.0	798.7	712.0	832.4	810.3	746.3	697.3	626.7	720.2
CS3	946.7	882.7	799.3	726.3	838.8	824.0	740.0	707.3	620.3	722.9
CS4	985.3	873.7	811.3	726.0	849.1	817.3	756.0	709.3	632.3	728.8
CS5	928.7	857.0	800.3	721.0	826.7	820.3	733.7	697.7	620.7	718.1
Mean	960.5	860.7	802.1	723.7		818.5	746.8	701.2	624.1	

For comparing means of	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
NM	5.95	20.59	6.43	22.26
CS	6.81	NS	8.15	NS
NM x CS	12.77	NS	11.41	NS

CS1: Groundnut-Sorghum CS2: Soybean-Wheat CS3: Maize-Chickpea CS4: Pigeonpea + Soybean CS5: Cotton + Peas
NM1: Organic NM2: Integrated NM3: RDF+FYM NM4: Inorganic

Table 4. Effect of nutrient management practices and cropping systems on total carbon content (g/kg) in soil at two depths

Cropping systems (CS)	Nutrient Management Practices (NM)									
	0-30 cm					30-60 cm				
	NM1	NM2	NM3	NM4	Mean	NM1	NM2	NM3	NM4	Mean
CS1	20.6	18.3	16.0	12.1	16.7	15.2	13.1	11.2	9.2	12.2
CS2	20.8	18.6	15.7	11.9	16.8	14.7	12.9	11.1	8.8	11.9
CS3	20.6	18.6	15.4	12.3	16.7	15.7	12.8	11.4	8.5	12.1
CS4	20.0	18.5	16.4	12.4	16.8	15.4	13.2	11.7	8.7	12.3
CS5	20.9	18.1	15.8	11.6	16.4	15.4	13.4	11.2	8.1	12.0
Mean	20.6	18.4	15.9	12.1		15.3	13.1	11.3	8.7	

For comparing means of	S.Em.± (0-30 cm)	C.D. at 5% (0-30 cm)	S.Em.± (30-60 cm)	C.D. at 5% (30-60 cm)
NM	0.32	1.10	0.29	1.00
CS	0.58	NS	0.48	NS
NM x CS	0.60	NS	0.46	NS

CS1: Groundnut-Sorghum CS2: Soybean-Wheat CS3: Maize-Chickpea CS4: Pigeonpea + Soybean CS5: Cotton + Peas
NM1: Organic NM2: Integrated NM3: RDF+FYM NM4: Inorganic

of WSC content in soil in organic plots could be due to greater C input through FYM and enhanced crop productivity (Kundu *et al.*, 2007 and Kukal *et al.*, 2009). The WSC content in soil did not differ significantly with the cropping systems.

Significantly higher LC content in soil at surface and subsurface layer was recorded in organic nutrient management practice (960.5 and 818 mg/kg, respectively) (Table 3) which might be due to the application of FYM or any other organic manure in the form of vermicompost and green manure as well as the higher turnover of root biomass (Moharana *et al.*, 2012). The higher content of LC in soil at surface layer is attributed to the addition of crop residue and manures to the surface layer (Brar *et al.*, 2013).

Total carbon was computed by: Total Carbon = Organic carbon + Water-soluble carbon + Labile carbon + Non-labile carbon. The nutrient management practices showed significant effect on the TC content in soil and it ranged from 12.1 to 20.6 g per kg at 0-30 cm and from 8.7 to 15.3 g per kg at 30-60 cm and significantly higher TC content in soil was observed in the organic nutrient management practice (Table 4) and it could be due to greater C input through FYM and enhanced crop productivity (Kundu *et al.*, 2007 and Kukal *et al.*, 2009). The maximum accumulation of TC was observed in the treatment receiving continuous application of FYM (Varalakshmi *et al.*, 2005 and Verma and Mathur, 2009).

Thus, results of the present investigation revealed that organic nutrient management practice enhanced all the fractions of carbon namely OC, WSC, LC and TC thereby, improving the fertility status of soil.

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