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Impact of different cropping and different nutrient management practices on soil carbon pools and soil carbon stock in vertic ustropept

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Abstract
A research work was initiated to study the soil carbon pools and carbon stock as influenced by different cropping and nutrient management practices in Vertic Ustropept in the experiment which was initiated during 2013 as long term field experiment in TNAU, Coimbatore. Various nutrient management practices viz., organic, inorganic and integrated practices with different crops like brinjal, chilli and tomato were tried in the research. SOC and active pools of SOC viz., labile carbon(LC) and water soluble carbon(WSC) and soil carbon stock(SCS) after 6 years of treatment application revealed, application of 100% organics in brinjal recorded higher SOC, LC, WSC and SCS (12.30g/kg), (1.31g/kg), (193mg/kg) and (18.5t/ha) respectively. This research indicated that long-term application of 100% organics exerted significant effect on the active pools of soil organic carbon.

Keywords: Nutrient managements, cropping, carbon pools, soil carbon stock, vegetable crops

1. Introduction

Enhancing soil organic matter (SOM) concentration is necessary to improve soil health and environmental safety. Conversion of natural to agricultural ecosystems depleted the global soil organic carbon (SOC) pool by 50 to 100 Pg (billion tons) of C, and this trend is continuing by conversion of forests and savannas to agriculture in the tropics (Wairiu and Lal, 2003) [1]. Agricultural soils are also significant sink for carbon (C) through formation of SOM. Annual average rate of depletion of SOC following the change in land use to agriculture is often much greater than the rate of SOC sequestration upon adoption of recommended management practices (RMPs). Restoration of the SOM pool in agricultural soils occurs through adoption of RMPs (Lal, 2006) [2], which increase C input into the soil and decrease C decomposition, thereby creating a positive C balance and making soil a net sink. In general, application of organic fertilizers and especially manure, either alone or in combination with inorganic fertilizers, increases SOC concentration (Purakayastha *et al*., 2008) [3]. There is a critical need for the development of best management practices that enhance SOC sequestration. Regular additions of organic materials to soil are required to improve and maintain SOC pools (Marinari *et al*., 2000) [4]. Organic manures and compost applications resulted in higher SOC content compared to same amount of inorganic fertilizers. Application of insufficient or excess amount of fertilizers and improper management may cause harmful effect on both soil and crops productivity. Hence soil management is consider as an importance practice in agriculture. The overall strategy for increasing and sustaining crop yields at a high level must include an integrated approach to the management of soil nutrients, along with other complementary measures. An integrated approach recognizes that soils are the storehouse of most of the plant nutrients essential for plant growth and that the way in which nutrients are managed will have a major impact on plant growth, soil fertility and agricultural sustainability. The quantification of SOC in relation to various crop management practices is of prime importance in identifying sustainable systems for SOC dynamics in soil. Soil organic carbon refers to the sum total of different heterogeneous organic substances, which may be simply divided into stable and labile organic carbon fractions (Wander, 2004) [5]. Labile organic carbon is sensitive to soil management practices and thus provides the better management of carbon dynamics in short-term to medium term effect than total carbon alone. This is extremely important to understand the effects of cropping practices and soil types on SOC storage, which could influence yield sustainability and soil quality. In general, SOC content was greater than inorganic C content in Alfisols and Aridisols, and inorganic C was larger than organic C in Vertisols and Inceptisols. In Inceptisols, maize-based systems showed more inorganic as well as organic C content (Srinivasarao *et al.*, 2009) [6].

India produces about 54 million tonnes of vegetables from 3.2 million hectares. but it's share on the world trade is miserably low (1%). With the above points in view, the present study was undertaken to study the impact of different cropping and different nutrient management options on soil carbon pools and soil carbon stock in Vertic Ustropept.

2. Materials and Methods

To study the impact of different cropping and different nutrient management options on soil carbon pools and soil carbon stock, soil samples were collected during June 2018-19 from the already existing and ongoing Network Project On Organic Farming field experiment at TNAU, Coimbatore. The experiment was started with six treatments comprising organic, integrated and inorganic with three different cropping C_1 - Brinjal (CO-2), C_2 - Chilli (Ananya) & C_3 - Tomato (Shivam). The experiment was laid out in a strip plot design with three replications. The experimental treatments were as follows: T_1 - 100% Organic (FYM), T_2 - 100% Inorganic (NPK alone), T_3 - 50% Organic (FYM + Vermicompost) + 50% Inorganic, T_4 - 75% Organic + 3% Panchagavya FS, T_5 - State Recommendation / Farmer's practice & T_6 - 75% Organic (FYM + Vermicompost) + 25% Inorganic.The soil samples were collected from the field experiment at 0-15 cm depth during kharif season. All the samples were brought to the laboratory and air dried and ground in a wooden pestle and mortar to pass through a 2mm sieve. The samples were stored in polyethylene bags for determination of various soil chemical attributes. The soil organic carbon content was determined by oxidation with potassium dichromate in a sulphuric medium and titration of the excess dichromate with ferrous sulfate (Walkley and Black, 1934) [7]. Labile carbon in the soil samples was determined by method of Chan *et al*. (2001) [8]. Bulk density was determined by the cylindrical method Yang *et al.* (2016) [9]. Soil carbon stock was (Tonnes carbon per hectare) (t C/ha) was calculated by multiplying SOC (%) with Soil Bulk Density (Mgm^{-3}) and Soil Sampling Depth (cm) (Bhattacharyya *et al.*, 2011) [10].

3. Result and Discussion

3.1 Total soil organic carbon

The data pertaining to the influence of different cropping and nutrient management on SOC is given in Table1. The result showed that irrespective of different crops, T_1 (100% Organic (FYM)) (11.3g/kg) recorded highest SOC which shows significant difference among other nutrient management practices followed by T_6 (75% Organic + 25% Inorganic) (11.0g/kg) and T_3 (75% Organic + 50% Inorganic) (10.7g/kg). Panwar *et al.* (2010) [11] reported that the SOC was greater in organic and integrated management practices, which is attributed to more C going to soil via organic manure addition. Irrespective of different nutrient management practices, C_1 (Brinjal) (10.9g/kg) recorded highest SOC which shows significant difference among other crops. This indicates that the SOC was influenced by different cropping. Kumar (2016) [12] suggested that the application of organic manures enhanced the SOC as compared inorganic fertilizers in *S. melongena* field. Interaction effect of different cropping and nutrient management practices shows that C_1 (Brinjal) with T_1 (100% Organic (FYM)) nutrient management practice recorded highest SOC (12.3g/kg). The combination of T_1 (100% Organic (FYM)) and C_1 (Brinjal) shows highly significant difference and it has an greater influence on SOC. Lou *et al*. (2011) [13] indicated that the total SOC concentration were not significantly changed by the 20 year of fertilizer treatments, but they were significantly increased by the manure treatments in a vegetable cropping system of northeast China.

Table 1: Influence of different cropping sequences and nutrient management on soil organic carbon

Treatments	Organic carbon (g/kg)			
	C_1	**C_2**	**C_3**	**Mean**
T_1	12.3	11.6	9.9	11.3
T_2	9.9	8.5	8.6	9.0
T_3	10.9	10.4	10.7	10.7
T_4	10.9	9.9	10.9	10.6
T_5	10.1	9.9	9.5	9.8
T_6	11.2	10.8	10.9	11.0
Mean	10.9	10.2	10.1	
	SEd		CD	
C	0.08		0.23	
T	0.11		0.25	
C*T	0.25		0.55	

C_1 – Brinjal, T_1 - 100% Organic (FYM), T_4 - 75% Organic + 3% Panchagavya FS
C_2 – Chilli, T_2 - 100% Inorganic (NPK alone), T_5 - State Recommendation / Farmer's practice
C_3 – Tomato, T_3 - 50% Organic + 50% Inorganic, T_6 - 75% Organic + 25% Inorganic

3.2 Soil labile carbon

The influence of different cropping and nutrient management on soil labile carbon (LC) is shown in Table 2. The result showed that irrespective of different crops, T_1(100% Organic (FYM)) recorded highest soil LC (1.30g/kg) followed by T_6 (75% Organic + 25% Inorganic) (1.29g/kg) and these treatments shows significant difference from T_5 (State Recommendation) and T_2 (100% Inorganic (NPK alone)).(Whalen *et al*., 2014) [14] examined that the application of organic manure increases labile organic C fractions by enhancing microbial activities in organically amended treatments thereby increasing the conversion of plant residue-C into labile forms of organic C. Irrespective of different nutrient management practices, C_1(Brinjal) recorded highest soil LC (1.27g/kg). Interaction effect of different cropping and nutrient management practices shows that C_1 (Brinjal) with T_1 (100% Organic (FYM)) nutrient management practice recorded highest soil LC (1.31g/kg). Lou *et al.* (2011) [13] reported that, soil LC increased as a result of the manure application than by the application of inorganic fertilizer alone. The balanced NPK fertilizer fails to sequestrate SOC. The organic manure alone is effective for sequestrating C in vegetable crops.

Table 2: Influence of different cropping sequences and nutrient management on soil labile carbon

Treatments	Labile carbon (g/kg)			
	C_1	C_2	C_3	Mean
T_1	1.31	1.28	1.30	1.30
T_2	1.21	1.15	1.20	1.19
T_3	1.29	1.28	1.27	1.28
T_4	1.28	1.26	1.27	1.27
T_5	1.23	1.19	1.18	1.20
T_6	1.30	1.29	1.28	1.29
Mean	1.27	1.24	1.25	
	SEd		CD	
C	0.01		0.03	
T	0.01		0.03	
C*T	0.01		0.06	

C_1 - Brinjal, T_1 - 100% Organic (FYM), T_4 - 75% Organic + 3% Panchagavya FS
C_2 – Chilli, T_2 - 100% Inorganic (NPK alone), T_5 - State Recommendation / Farmer's practice
C_3 – Tomato, T_3 - 50% Organic + 50% Inorganic, T_6 - 75% Organic + 25% Inorganic

3.3. Water soluble carbon

The results on the influence of different cropping and nutrient management on water soluble carbon (WSC) is given in Table 3. The result showed that irrespective of different crops, WSC was significantly higher in T_1 (100% Organic (FYM)) (189mg/kg) which is followed by T_6 (75% Organic + 25% Inorganic) (186mg/kg) and T_3 (50% Organic + 50% Inorganic) (185mg/kg). The same result was given by Tripura *et al*. (2018) [15], highest WSC was observed in treatment receiving FYM alone followed by treatment with continuous addition of FYM in association with 100 % NPK fertilizers. The results are also in agreement with Yagi *et al*. (2005) [16] who attributed the same to the priming effect of the application of inorganic N or fresh organic material to the soil which stimulates the microbial activity and mineralization of N forms present in SOC helping thereby in decomposition of SOC with rapid release of WSC fraction. Irrespective of different nutrient management practices, WSC was significantly higher in C_1 (Brinjal) (178mg/kg). Lou *et al*. (2011) [13] showed that the WSC in the field of vegetable crops, the treatments having organic and inorganic was 1.7 times higher than the inorganic fertilizer alone. Interaction effect of different cropping and nutrient management practices shows that C_1 (Brinjal) with T_1(100% Organic (FYM)) nutrient management practice recorded significantly higher WSC (193mg/kg). Dutta *et al.* (2018) [17] reported the WSC was 12.1% and 24.7% higher under organic management practice over the inorganic and integrated management practice respectively. This might be due to addition of plant residues and microbial activity. Liu *et al.*, (2018) [18] was observed that the plant biomass increased in vegetable crops.

Table 3: Influence of different cropping sequences and nutrient management on water soluble carbon

Treatments	Water soluble carbon (mg/kg)			
	C_1	C_2	C_3	Mean
T_1	193	185	187	189
T_2	156	151	152	153
T_3	188	183	185	185
T_4	178	174	175	176
T_5	163	164	162	163
T_6	190	183	185	186
Mean	178	173	174	
	SEd		CD	
C	1.28		3.56	
T	1.74		3.88	
C*T	3.44		7.50	

C_1 - Brinjal, T_1 - 100% Organic (FYM), T_4 - 75% Organic + 3% Panchagavya FS
C_2 – Chilli, T_2 - 100% Inorgani0c (NPK alone), T_5 - State Recommendation / Farmer's practice
C_3 – Tomato, T_3 - 50% Organic + 50% Inorganic, T_6 - 75% Organic + 25% Inorganic

3.4. Bulk Density

The report obtained on the influence of different cropping and nutrient management on soil bulk density (BD) is represented in Table 4. The result showed irrespective of different crops, the T_2 (100% Inorganic (NPK alone) (1.24gm/cc) recorded significantly higher BD than other nutrient management practices and T_1 (100% Organic (FYM)) recorded lowest BD (1.05gm/cc). Brar *et al*. (2013) [19] reported that the BD decreased as rates of organic manure addition increased. Irrespective of different nutrient management practices, C_3 (tomato) recorded higher BD (1.13 gm/cc) and C_1 (brinjal) recorded lowest BD (1.08gm/cc). Sharma *et al.* (2000) [20] observed that BD was significantly lower in 100% NPK +FYM plot than inorganically treated plots in vegetable field. Interaction effect of different cropping and nutrient management practices shows that C_1 (Brinjal) with T_1 (100% Organic (FYM)) nutrient management practice recorded lowest soil bulk density (1.00 gm/cc). Dutta *et al.* (2018) [17] resulted that the lower bulk density under organic management over the years could be attributed to the to the conversion of some micro-pores into macro-pores due to cementing action of organic acids and polysaccharides formed during the decomposition of organic residues by higher microbial.

Table 4: Influence of different cropping sequences and nutrient management on soil bulk density

Treatments	BD (Mgm^{-3})			
	C_1	C_2	C_3	Mean
T_1	1.00	1.05	1.09	1.05
T_2	1.21	1.22	1.29	1.24
T_3	1.06	1.07	1.06	1.06
T_4	1.05	1.09	1.07	1.07
T_5	1.13	1.16	1.19	1.16
T_6	1.04	1.08	1.07	1.06
Mean	1.08	1.11	1.13	
	SEd		CD	
C	0.01		0.03	
T	0.01		0.03	
C*T	0.01		0.06	

C_1 - Brinjal, T_1 - 100% Organic (FYM), T_4 - 75% Organic + 3% Panchagavya FS
C_2 – Chilli, T_2 - 100% Inorganic (NPK alone), T_5 - State Recommendation / Farmer's practice
C_3 – Tomato, T_3 - 50% Organic + 50% Inorganic, T_6 - 75% Organic + 25% Inorganic

3.5. Soil carbon stock

The results on soil carbon stock (SCS) by the influence of different cropping and nutrient management on is presented in Table 5. The result shows irrespective of different crops, T_1 (100% Organic (FYM)) recorded highest SCS (17.6 t/ha) which is non-significant with T_6 (75% Organic + 25% Inorganic) (17.5 t/ha). Liu *et al*. (2013) [21] also reported that the SOC stock was significantly higher in the organic manure treatments (FYM, NP+FYM) compared with the only inorganic fertilizer (N, NP). Irrespective of different nutrient management practices, C_1 (Brinjal) was recorded significantly higher SCS (17.6 t/ha) than others. The crop which is having higher residues could retain higher amount of SCS. Interaction effect of different cropping and nutrient management practices shows that C_1 (Brinjal) with T_1 (100% Organic (FYM)) nutrient management practice recorded highest SCS (18.5 t/ha). Koga, (2017) [22] resulted that decrease in SCS in chemical fertilizers - normal residue input with the lowest carbon input and an increase in manure fertilizer - higher residue input with the highest carbon input.

Table 5: Influence of different cropping sequences and nutrient management on soil carbon stock

Treatments	Soil carbon stock (t/ha)			
	C_1	C_2	C_3	Mean
T_1	18.5	18.3	16.2	17.6
T_2	18.0	15.6	16.6	16.7
T_3	17.3	16.7	17.0	17.0
T_4	17.2	16.2	17.5	16.9
T_5	17.1	17.2	17.0	17.1
T_6	17.5	17.5	17.5	17.5
Mean	17.6	16.9	17.0	
	SEd		CD	
C	0.11		0.32	
T	0.19		0.43	
C*T	0.35		0.75	

C_1 - Brinjal, T_1 - 100% Organic (FYM), T_4 - 75% Organic + 3% Panchagavya FS
C_2 – Chilli, T_2 - 100% Inorganic (NPK alone), T_5 - State Recommendation / Farmer's practice
C_3 – Tomato, T_3 - 50% Organic + 50% Inorganic, T_6 - 75% Organic + 25% Inorganic

4. Conclusion

In our study, the concentration of soil carbon pools (LC, WSC and SCS) were higher in T_1 (100% organic) followed by T_6 - 75% Organic (FYM + Vermicompost) + 25% Inorganic. The lower rate of carbon was observed in T2 (100% organic). Brinjal crop can fix higher amount of OC, LC, WSC and SCS than others this may be due to the production of higher crop residues. Hence, to maintain the soil health, organic alone or organic combined with inorganic can be recommended. In vertic ustropept, it will be the best to follow 100% organic alone or 75% Organic (FYM + Vermicompost) + 25% Inorganic in brinjal crop during karif season to maintain good soil quality with highest carbon content.

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