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Carbon dynamics as influenced by various nutrient management strategies in the Inceptisols (Typic Ustropept) of Puducherry

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ABSTRACT

Soil constitutes the largest dynamic reservoir of carbon on earth, making it a critical component of the global carbon cycle. The proportion of C in various labile pools is more important for nutrient availability and C sequestration in soils. Hence, to study the carbon dynamics under various nutrient management strategies, an incubation experiment was conducted in a soil belonging to the Bahour soil series, which occupies 12.72% of the soils of Puducherry. The incubation experiment was carried out with fifteen treatments *viz.,* farmer's practice, blanket recommendation, STCR-NPK alone @ 160, 170, 180 q ha^{-1} yield target and STCR + organic manures (FYM/ Vermicompost/ Poultry manure) with 160, 170 and 180 q ha^{-1} yield target and control with three replications for 120 days. The soil samples were drawn at 0, 40, 80, and 120 days of incubation and analyzed for various labile carbon fractions. The results indicated that organic carbon content declined with the days of incubation up to 80 DAI and then slightly increased to 120 DAI. The highest organic carbon content was observed with STCR+ Vermicompost treatments. The rate of decrease in organic carbon was highest in STCR (160 q ha^{-1}) + Poultry manure treatment (-9.62 mg/kg/day) followed by STCR (160 q ha^{-1}) + Vermicompost (-9.00 mg/kg/day) and the least in STCR + NPK alone treatment (-4.81 mg/kg/day). The carbon fractions *viz.* WSC decreased up to 80 DAI and after that increased, but HWSC followed a decreasing trend at 40 DAI, increased at 80 DAI, and again decreased at 120 DAI. The WSC and HWSC were found to be the highest in STCR+ Vermicompost treatment, which was comparable to STCR+ poultry manure. The POXC content showed a significant decrease with the advancement of incubation, where it reduced from 2406.79 (0 DAI) to 1790.40 mg kg^{-1} (120 DAI). Unlike WSC and HWSC, a continuous reduction was noticed in POXC content during incubation. The rate of decrease in POXC content was maximum in STCR+ NPK alone (-10.500 mg kg^{-1}) and control (-10.320 mg kg^{-1}), whereas the minimum rate of decline of 3.472 mg/kg/day was associated with STCR + vermicompost treatment. The study clearly established the superiority of conjoint application of STCR-based nutrient addition with any one of the organic manures, *viz.* poultry manure, FYM, and vermicompost in maintaining the organic carbon content in soil at the end of the incubation period. Moreover, the STCR+ organics based nutrient management practice will definitely contribute to the sequestration of C in soil by reducing the labile carbon pools and promoting the accumulation of SOC.

Keywords: Carbon fractions, C sequestration, Labile carbon, STCR + Organics, Nutrient management

INTRODUCTION

Soil organic carbon (SOC) is one of the important soil quality indicators that affect the soil's physical, chemical, and biological properties and plays a pivotal role in functions of agricultural soils such as aggregate formation, nutrient cycling, water retention, and habitat provision for biodiversity (Bhardwaj *et al*., 2019). Enhancing the concentration of SOC is essential to improve soil health and environmental safety. Besides, SOC also plays an important role in climate regulation, potentially increasing C sequestration, offsetting fossil-fuel emissions, and counteracting yield reduction created by extreme weather events (Lal, 2004).

Despite the importance of SOC, its depletion is one of the main threats to agricultural soils. Agricultural soils also sink significantly of carbon through the formation of SOM. The annual average rate of depletion of SOC following the change in land use is often much greater than the rate of SOC sequestration upon adoption of recommended management practices. Restoration of the SOM pool in agricultural soils occurs through adopting practices that increase C input into the soil and decrease C decomposition, creating a positive C balance and making soil a net sink. Applying organic manures, either alone or in combination with inorganic fertilizers, generally increases SOC concentration (Bhardwaj *et al*., 2023a). The fortification of organic manures, retention of crop residues, reduced tillage practices, use of bio-fertilizers, integrated nutrient management techniques and improved varieties of field crops, soil test-based fertilizer applications, *etc*., are some of the attempts to enhance organic C levels in soil and to attain agricultural sustainability and profitability (Bhardwaj *et al*., 2022).

Integrated plant nutrition supply system involving organic and inorganic sources of nutrients enhances crop productivity, resource use efficiency, and soil fertility with minimum environmental trade-offs (Chen *et al.,* 2011; Dobermann *et al*., 2003; Bhardwaj *et al*., 2023b; Wu and Ma, 2015). Organic manures such as FYM, poultry manure, vermicompost, *etc*. are very active and important for soil. It furnishes a portion of macro and micronutrients, protects the soil against erosion, supplies the cementing substance for desirable soil aggregate formation, and loosens the soil. It is necessary to frame out a nutrient management strategy (with and without organic sources) for efficient fertilizer management based on soil testing that would also increase nutrient recovery and soil quality.

The inductive cum targeted yield model of Ramamoorthy *et al.* (1967) is unique in determining soil test-based optimum fertilizer doses for attaining specific yield levels that can be attained with good agronomic practices. Ramamoorthy and Velayutham (1971) suggested that soil test calibration that was expected to establish a correlation between the levels of soil nutrients quantified in the laboratory and crop response to fertilizers in the experiment fields permit balanced fertilization, and that should be the basis of fertilizer application. A fertilizer recommendation on yield target is typical in the sense that this method not only signifies soil test-based fertilizer recommendations but also the level of yield the farmer expects to achieve if good agronomic practices are practiced. The targeted yield concept maintains equilibrium between 'feeding the plant' and 'feeding the soil'. The method provides a logical basis for judicious use of chemical fertilizers and a balance between soil available nutrients and applied nutrients from external sources.

Among the soil C fractions, labile carbon, which exhibits characteristics of fast decomposition, has the potential as an indicator of soil functions, in particular, nutrient cycling, soil aggregate formation, carbon sequestration, and habitat provision for biodiversity (Else *et al.,* 2019). On the other hand, recalcitrant carbon pools take more time to decompose and are not readily available to microorganisms (Lal, 2004). Therefore, both pools, recalcitrant and labile, can elucidate how the soil has been used and which management is adequate to increase carbon stocks, mainly in tropical conditions (Stevenson, 1994). In this context, agricultural measures that are aimed at increasing SOC stocks are becoming a priority worldwide. Though numerous research studies have studied the long-term effects of nutrient management practices on SOC and labile C fractions, little attention has been paid to the short-term effects of different nutrient management practices on C fractions in soil. Considering these, the research has been carried out to study the influence of various nutrient management strategies on carbon fractions in the Bahour soil series of UT of Puducherry.

MATERIALS AND METHODS

For conducting the incubation experiment, an unfertilized surface soil (0 – 15 cm) was collected from a farmers holding of Karikalampakkam village in Nettapakkam commune of Pondicherry district, UT of Puducherry, India. The study area comes under coastal alluvial plain (PC1) classified as fine, mixed isohyperthermic, *Typic Ustropept* with an area of 12.72 percent. According to agroclimatic zonal classification, the study area is located at 11° 56′ N latitude and 79° 66′ E longitude. Koppen classifies the climate of the experimental field - Geiger system as tropical, wet, and dry, similar to that of coastal Tamil Nadu. Summer starts from April, when maximum temperatures frequently hit the 41°C mark. The average maximum temperature is 36°C. Minimum temperatures are in the order of 28 – 32 °C. This is followed by a period of high humidity and occasional rainfall from June to September. The northeast monsoon sets in during the middle of October, and Puducherry gets the bulk of its annual rainfall during the period from October to December. The annual rainfall is 1240 mm.

The soil of the experiment field belongs to the Bahour soil series, which occupies 12.72 percent of the soils of the Pondicherry district. The soil belongs to fine, mixed, isohyperthermic, *Typic Ustropept*. Initial characterization revealed that the soil texture was sandy loam with clay content of 13.34 percent, silt content of 21.44 percent, and sand fraction of 62.33 percent. The bulk density of the soil was 1.33 Mg m^{-3}, particle density was 2.50 Mg $m^{-3,}$ and porosity was 46.80 percent. The pH of the soil was 7.66, and the EC was 0.690 dS m^{-1}. The soil's cation exchange capacity was 23.20 cmol (p^+) kg^{-1}. The exchangeable cations reported in the order of calcium (10.42 cmol (p^+) kg^{-1}) followed by magnesium (7.25 cmol (p^+) kg^{-1}), sodium (2.19 cmol (p^+) kg^{-1}) and potassium (1.16 cmol (p^+) kg^{-1}). The soil's total N, P, and K contents were 0.179, 0.062, and 0.204 percent, respectively. The fertility status of the soil was low in available N (210 kg ha^{-1}) and medium in organic carbon (6.90 g kg^{-1}) and high in available P (34 kg ha^{-1}) and available K (320 kg ha^{-1}). The water-soluble carbon (WSC), hot water-soluble carbon (HWSC), and permanganate oxidizable carbon (POXC) contents were 118.23, 133.64, and 2066.22 mg kg $^{-1}$, respectively.

A laboratory incubation experiment was conducted in the Department of Soil Science and Agricultural Chemistry, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, UT of Puducherry, in 2022. The treatments were as follows: T_1: Control, T_2: Farmer's practice, T_3: Blanket recommendation, T_4: STCR (160 q ha^{-1}) – NPK alone, T_5: STCR (170 q ha^{-1}) – NPK alone, T_6: STCR (180 q ha^{-1}) – NPK alone, T_7: STCR (160 q ha^{-1}) + FYM, T_8: STCR (170 q ha^{-1}) + FYM, T_9: STCR (180 q ha^{-1}) + FYM, $T_{10:}$ STCR (160 q ha^{-1}) + Vermicompost, T_{11}: STCR (170 q ha^{-1}) + Vermicompost, T_{12}: STCR (180 q ha^{-1}) + Vermicompost, T_{13}: STCR (160 q ha^{-1}) + Poultry manure, T_{14}: STCR (170 q ha^{-1}) + Poultry manure and T_{15}: STCR (180 q ha^{-1}) + Poultry manure. For STCR treatments, the existing fertilizer prescription equations developed for Bhendi by Karunaprabhu (2018) in the Bahour soil series were utilized. The fertilizer doses were computed using the fertilizer prescription equations developed under NPK alone and IPNS. The organic manures *viz*., FYM, vermicompost, and poultry manures were added @ 12.5 t ha^{-1}. The quantities of N, P, and K contributed through FYM is (30% Moisture), 0.53, 0.27, and 0.51% NPK, vermicompost is (35% Moisture), 1.06, 0.51 and 0.56% NPK and poultry manure is (37% Moisture), 1.32, 1.12 and 1.20% NPK, respectively was subtracted from the inorganic fertilizer doses and applied for STCR - IPNS treatments.

Fertiliser sources such as urea, SSP, MOP, and organic manure sources such as FYM, vermicompost, and poultry manure were added to plastic pots containing 1 kg of soil and thoroughly mixed as per the treatments. After thorough mixing, distilled water was added to bring the gravimetric water content of the soil to field capacity. The soil samples with different treatments in four sets in Completely Randomized Design were maintained separately. The moisture content was maintained throughout the experimental period by correcting the water loss periodically. Destructive sampling was done at 0, 40, 80, and 120 days after incubation and analyzed for C fractions. Moisture factor was computed and applied to express the results on oven dry basis. Labile pools of soil carbon were estimated by adopting standard procedure, which is briefed hereunder.

Water-soluble carbon and hot water-soluble carbon were estimated as described by Ghani *et al*. (2003). Soil samples were weighed into 100 ml polypropylene centrifuge tubes. They were extracted with 30 ml of distilled water for one hour in a rotary shaker, centrifuged for 30 minutes at 10000 rpm, and filtered. From this, 5 ml of supernatant was pipetted into a conical flask and treated with 5 ml 0.07 *N* $K_2Cr_2O_7$, 10 ml concentrated H_2SO_4, and 5 ml H_3PO_4. The sample was digested at 150 °C for 30 minutes using a water bath, the contents were cooled by adding 200 ml distilled water and titrated against 0.035*N* ferrous ammonium sulphate using diphenylamine indicator. This fraction of the SOC was classified as 'WSC'. Further, 30 ml of distilled water was added to the sediments in the same centrifuge tubes and shaken on a rotary shaker for 1 minute to suspend the soil in water. The tubes were capped and treated for 16 hours in a hot water bath at 80 °C. At the end of the extraction period, tubes were shaken to ensure that HWSC released from the SOM was fully suspended in the extraction medium. These tubes were centrifuged for 30 minutes and filtered, and the carbon content was determined as in the case of WSC and classified as 'HWSC'.

Permanganate oxidizable carbon was estimated as described by Blair *et al*. (1995). Finely ground samples (2 g) were taken in a centrifuge tube and oxidized with 25 ml 333 *mM* $KMnO_4$ by shaking for 1 hour. The tubes were centrifuged for 5 minutes at 4000 rpm, and 0.1 ml of supernatant was diluted to 25 ml with double distilled water. The concentration of $KMnO_4$ was measured at 565 nm wavelength using a spectrophotometer. The change in concentration of $KMnO_4$ was used to estimate the amount of organic carbon oxidized, assuming that 1.0 *mM* of MnO_4 was consumed (Mn^{7+} - Mn^{4+}) in the oxidation of 0.75 *mM* (9.0 mg) of carbon. The organic carbon content was estimated by the Chromic acid wet oxidation method as outlined by Walkley and Black (1934).

Statistical analysis

The analytical data were subjected to statistical scrutiny following the procedure outlined by Gomez and Gomez (1976). Correlation and regression analysis were carried out using the SPSS package. The data on labile carbon fractions were statistically analyzed using analysis of variance (ANOVA) in a CRD and compared by critical difference at 5 percent significance level. Pearson's coefficient analysis was used for correlation.

RESULTS AND DISCUSSION

Water Soluble Carbon

Water-soluble carbon (WSC) is considered the most active component of SOM and is the main energy source for soil microorganisms. The WSC is the primary source of mineralizable N, P, and S, and it influences the availability of metal ions in soils by forming soluble complexes. The highest mean WSC content was recorded on the initial day of incubation (137.55 mg kg^{-1}), which was on par with the 120th day of incubation and significantly differed from the 40th and 80th day of incubation. The WSC content has declined with the advancement of the incubation period up to 80th day and then slightly increased in the 120th day of incubation (Table 1). The highest amount of mean WSC content was registered in STCR (180 q ha^{-1}) + Vermicompost treatment (137.93 mg kg^{-1}), which was on par with STCR (170 and 160 q ha^{-1}) + Vermicompost, STCR (180 and 170 q ha^{-1}) + Poultry manure. The lowest amount (85.10 mg kg^{-1}) of WSC content in control was comparable with STCR - NPK alone treatments.

The interaction effect revealed that the highest amount of WSC was noticed in STCR + Vermicompost and STCR + Poultry manure treatments at the 120th day of incubation. In order to evaluate the different treatments with respect to C release, an attempt was made to quantify the change in the different fractions of C in each of the treatments imposed by simple linear regression analysis. The highest rate of release was observed in STCR (160 q ha^{-1}) + Poultry manure (0.1830 mg kg^{-1} day^{-1}) (Table 4), and a decrease in the rate of release was in STCR + NPK alone treatment and control. The simple correlation analysis showed that the WSC was positively correlated with HWSC, POXC, and organic carbon (Table 3).

The decrease in the WSC content up to 80th day of incubation in STCR + organic manure added treatments might be due to the reduction in mineralization rate and also the increased consumption of WSC as an energy source by the microorganisms. The positive correlation observed between WSC with HWSC, POXC, and organic carbon further supports the more intense activity of microorganisms and, thus, the more decomposition of soil organic matter and labile organic carbon. Similar results were also reported by Rajakumar (2019) and Rajakumar *et al*. (2022). However, in the case of STCR + NPK alone treatments, the WSC content decreased from the initial to the end of the incubation period, which might be due to the lack of carbon available to microorganisms. The increase in WSC content was more in STCR (180 q ha^{-1} + vermicompost (62.08%) followed by Poultry manure

Table 1. Changes in the water soluble carbon and hot water soluble carbon content of soil at different stages of incubation

Treatments	Water soluble carbon (mg kg^{-1})					Hot water soluble carbon (mg kg^{-1})				
	Incubation period (days)				Treatment (T) mean	Incubation period (days)				Treatment (T) mean
	0	40	80	120		0	40	80	120	
T_1	118.23	85.45	70.44	66.26	85.10	133.64	120.21	109.84	92.62	114.08
T_2	137.20	110.46	99.60	141.50	122.19	169.91	133.36	147.62	136.22	146.78
T_3	141.60	112.60	103.20	139.60	124.25	162.32	130.82	142.30	128.52	140.99
T_4	118.48	88.80	71.60	68.60	86.87	131.79	121.86	111.32	94.66	114.91
T_5	118.56	89.70	72.60	70.20	87.77	128.68	119.72	108.36	95.62	113.10
T_6	117.32	89.00	73.80	71.80	87.98	133.20	119.16	110.22	93.56	114.04
T_7	139.80	112.60	102.80	159.40	128.65	171.32	138.28	152.66	141.20	150.87
T_8	144.30	116.80	105.30	161.40	131.95	176.12	141.62	157.32	143.48	154.64
T_9	146.60	112.00	101.60	158.80	129.75	168.46	142.20	159.60	145.20	153.87
T_{10}	141.40	119.60	110.40	166.20	134.40	184.30	148.60	162.46	150.34	161.43
T_{11}	148.60	117.90	112.80	170.40	137.43	188.66	152.32	165.30	148.34	163.62
T_{12}	152.80	120.80	108.20	169.90	137.93	182.30	149.36	163.68	147.78	160.78
T_{13}	140.00	118.40	108.00	167.80	133.55	183.66	147.32	160.36	145.00	159.09
T_{14}	147.80	116.80	104.20	170.90	134.93	187.36	150.16	162.52	143.20	160.81
T_{15}	150.60	122.20	106.60	166.40	136.45	184.28	148.22	164.12	149.88	161.63
Stage (S) mean	137.55	108.87	96.74	136.61		165.73	137.55	145.18	130.38	
CD (0.05)	S	T	T x S		S	T	T x S			
	2.20	4.27	8.54		2.78	5.39	10.79			

(60.34%) and FYM (52.46%) addition compared to control.

Hot Water Soluble Carbon

HWSC is a sensitive indicator of the ecosystem changes. Being a component of the labile SOM and also being closely related to soil microbial biomass and micro aggregation, it can be used as one of the soil quality indicators in a soil-plant continuum. This fraction is extracted after WSC using hot distilled water, extracting soil microbial biomass, simple organic compounds, and hydrolyzable compounds under the given extraction conditions (Weigel *et al.*, 2011). Over the advancement of the incubation period, the HWSC follows a decreasing trend up to 40th day of incubation and an increasing trend at 80th day of incubation and again decreased at 120th day of incubation. Hot water soluble carbon content was recorded at different days of incubation, and it was found that STCR (170 q ha^{-1}) + vermicompost recorded maximum mean HWSC (163.62 mg kg^{-1}) which was comparable with STCR + Poultry manure and STCR (160 and 180 q ha^{-1}) + Vermicompost treatments. The lowest mean HWSC was recorded in control (114.08 mg kg^{-1}), which was comparable to STCR - NPK alone treatments (Table 1).

The interaction effect between treatment and days of incubation was significant. The result of simple regression analysis showed that the rate of decrease of HWSC content was found to be maximum in the case of STCR (170 q ha^{-1}) + NPK treatment (0.3586 mg kg^{-1} day^{-1}) (Table 4). The simple correlation showed that the HWSC content was positively correlated with WSC, POXC, and organic carbon (Table 3).

The extraction of carbon with hot water resembles an ongoing mineralization process. The HWSC, which constitutes the soil microbial biomass, simple organic compounds, and easily hydrolyzable carbon, might have decomposed and converted into WSC. This may be the reason for the decline in the HWSC over incubation time. It was also further confirmed from the present study, i.e., the increase in WSC content was recorded at 120 DAI. The findings were in line with Demise *et al*. (2014), Rajakumar (2019), Rajakumar *et al.* (2022).

Permanganate Oxidizable Carbon

Another important labile carbon fraction is the POXC, which encompasses all readily oxidizable organic components, including humic materials and polysaccharides, which generally accounts 5 - 30 percent of SOC (Blair *et al.,* 1995; Blair, 2000; Graham *et al.,* 2002). This is usually extracted using potassium permanganate solution (333mM). Culman *et al*. (2012) stated that the POXC was closely related to the smaller and heavier particulate organic carbon, indicating that POXC reflects a relatively stabilized pool of active soil carbon.

Data on the effects of organic and inorganic manure on POXC at different days of incubation is presented in Table 2. As the incubation period progresses, the POXC follows a decreasing trend up to 120th day of incubation. The highest mean POXC content was noticed in STCR + Vermicompost treatments, which were comparable to STCR + poultry manure treatments. The lowest mean POXC content was recorded in treatments that didn't receive any fertilizer and organic manures, followed by STCR - NPK alone treatments. The interaction effect revealed that the maximum POXC content was found in STCR (160 q ha^{-1}) + Vermicompost treatment on the initial day of incubation.

The POXC content was found to be positively correlated with WSC, HWSC, and Organic carbon (Table 3). From the results, it could be inferred that the POXC content showed a significant decrease with the advancement of incubation, where it reduced from 2406.79 mg kg^{-1} (0 DAI) to 1790.40 mg kg^{-1} (120 DAI). Unlike WSC and HWSC, a continuous reduction was noticed in POXC content during incubation. To assess the release of POXC content, simple regression analysis was carried out, which revealed that the treatment STCR + NPK alone (-10.500 mg kg^{-1}) and control (-10.320 mg kg^{-1}) recorded the maximum rate of decrease, whereas the minimum rate of decrease of 3.472 mg kg^{-1} day^{-1} was associated with STCR + vermicompost treatment (Table 4). The addition of carbon-rich material together with easily available inorganic N source would have helped in the proliferation of soil microorganisms, resulting in faster depletion of the labile carbon pool. This is in agreement with Manna *et al.* (2007), Rajakumar (2019) and Rajakumar *et al.* (2022).

Organic Carbon

The change in organic carbon content due to incubation is one of the important parameters that could be directly related to the release of ions from the added organics. The results indicated that organic carbon content has been declined with the advancement of the incubation period up to 80th day, and then it was slightly increased at 120th day (Table 2). The highest organic carbon content was observed with the application of STCR + Vermicompost treatments. The organic carbon content of the soil was found to decrease with an increase in incubation days up to 80th day, which is due to the availability of a larger pool of the less resistant fractions that were broken down and recycled, thus resulting in lower contents remaining

Table 2. Changes in the permanganate oxidizable carbon and organic carbon content of soil at different stages of incubation

Treatments	Permanganate oxidizable carbon (mg kg^{-1})					Organic carbon (g kg^{-1})				
	Incubation period (days)				Treatment (T) mean	Incubation period (days)				Treatment (T) mean
	0	40	80	120		0	40	80	120	
T_1	2066.22	1936.22	1082.36	975.04	1514.96	6.89	6.56	6.42	6.30	6.54
T_2	2231.22	2005.00	1975.22	2096.00	2076.86	7.98	7.44	7.12	6.91	7.36
T_3	2315.20	2028.00	1966.10	2082.00	2097.83	8.00	7.30	7.16	6.94	7.35
T_4	2088.12	1952.12	1090.12	980.26	1527.66	7.01	6.62	6.45	6.33	6.60
T_5	2076.52	1948.20	1098.16	985.32	1527.05	6.98	6.67	6.48	6.39	6.63
T_6	2092.32	1946.36	1088.22	978.36	1526.32	6.89	6.69	6.40	6.35	6.58
T_7	2432.66	2036.00	1987.00	2102.00	2139.42	7.91	7.38	6.86	6.96	7.28
T_8	2551.32	2236.00	1966.00	2090.00	2210.83	7.98	7.26	6.98	7.05	7.32
T_9	2530.20	2139.00	1999.00	2078.00	2186.55	7.80	7.28	6.88	6.92	7.22
T_{10}	2661.36	2386.00	2096.00	2126.00	2317.34	8.05	7.58	6.94	7.06	7.41
T_{11}	2626.12	2318.00	2110.00	2110.00	2291.03	7.98	7.46	6.88	7.11	7.36
T_{12}	2602.32	2300.00	2126.00	2096.00	2281.08	7.90	7.62	6.96	7.14	7.41
T_{13}	2606.22	2310.00	2076.00	2112.00	2276.06	8.00	7.30	6.76	6.90	7.24
T_{14}	2599.66	2288.00	2116.00	2098.00	2275.42	7.86	7.16	6.80	6.98	7.20
T_{15}	2622.36	2298.00	2105.00	2082.00	2276.84	7.98	7.22	7.10	7.05	7.34
Stage (S) mean	2406.79	2141.79	1792.08	1790.40		7.68	7.17	6.81	6.83	
CD (0.05)	S	T	T x S		S	T	T x S			
	37.28	72.20	144.40		0.13	0.25	0.50			

Table 3. Results of simple correlation analysis between carbon fractions (n = 15)

	WSC	HWSC	POXC	OC
WSC	1.000			
HWSC	0.985**	1.000		
POXC	0.978**	0.997**	1.000	
OC	0.978**	0.977**	0.973**	1.000

** - Significant at 1% level of significance

at 80th day of incubation, so the organic carbon decreased as the incubation period increased. The mineralization process occurs when organic manures are added to soil. Thus, the OC content in soil decreases with time. Similar results were also reported by Follett *et al.* (2007), Roy and Kashem (2014), Rajakumar and Ammal (2016), Rajakumar and Sankar (2019), Sarkar and Bandyopadhyay (2018), Diwale *et al.* (2020) and Thite *et al.* (2022). Further slight increase in 120th day of incubation might be due to the decomposition of resistant components of organic manures by microbial population or decomposition of the microorganism itself.

The present study revealed that the organic carbon content was lower in STCR - NPK alone treatments at 120th day of incubation than STCR + organics treatment which could clearly indicate that the addition of organic manures, *viz.,* poultry manure, FYM and vermicompost showed its superiority in maintaining the organic carbon content in soil at the end of the incubation period. The microorganisms might utilize the released carbon from organic manures for their development; because of this, a decline in organic carbon content was observed up to 80th day of incubation, and later period it might have been released at 120th day of incubation, especially in organic manure added treatments when compared to STCR + NPK alone treatment.

The decrease in organic carbon over a period was verified with simple linear regression analysis which indicated that the highest decrease was observed in STCR (160 q ha^{-1}) + Poultry manure treatment (-9.62 mg kg^{-1} day^{-1}) followed by STCR (160 q ha^{-1}) + Vermicompost (-9.00 mg kg^{-1} day^{-1}) and the least in STCR + NPK alone treatment (-4.81 mg kg^{-1} day^{-1}) (Table 4). It was clearly noticed that there was a significant change in the rate of decomposition of organic manures when applied along with either STCR or blanket recommendation, which could be attributed to the increased biological activity in the organic manure added treatments.

Table 4. Results of simple regression analysis between carbon fractions (Y) and days of incubation (X)

Treatments	WSC			HWSC			POXC			Organic carbon		
	R^2	Intercept	Rate of change (mg kg^{-1} day^{-1})	R^2	Intercept	Rate of change (mg kg^{-1} day^{-1})	R^2	Intercept	Rate of change (mg kg^{-1} day^{-1})	R^2	Intercept	Rate of change (mg kg^{-1} day^{-1})
T_1	0.876**	110.73	-0.4270	0.991**	134.09	-0.3340	0.887**	2134.07	-10.320	0.936**	6.829	- 4.84
T_2	0.167*	121.88	0.0921	0.147*	123.72	0.1560	0.239**	2142.18	-4.089	0.957**	7.892	- 8.83
T_3	0.106*	126.56	0.0998	0.165*	114.23	0.1950	0.415**	2212.05	-4.123	0.875**	7.848	- 8.32
T_4	0.886**	111.89	-0.4171	0.983**	117.83	-0.3400	0.888**	2155.49	-10.460	0.925**	6.934	- 5.56
T_5	0.882**	112.09	-0.4055	0.994**	104.43	-0.3586	0.889**	2145.60	-10.310	0.941**	6.924	- 4.95
T_6	0.869**	110.74	-0.3794	0.987**	133.21	-0.3196	0.892**	2156.32	-10.500	0.942**	6.869	- 4.81
T_7	0.160*	121.30	0.1225	0.171*	152.32	0.1830	0.447**	2295.56	-4.740	0.828**	7.783	- 8.42
T_8	0.140*	125.98	0.0995	0.192*	158.35	0.1176	0.715**	2458.92	-4.132	0.750**	7.778	- 7.74
T_9	0.153*	125.82	0.0655	0.269*	153.09	0.1928	0.669**	2411.04	-4.742	0.847**	7.676	- 7.60
T_{10}	0.114*	124.62	0.1630	0.174*	165.83	0.1998	0.861**	2601.75	-3.742	0.833**	7.949	- 9.00
T_{11}	0.182*	128.38	0.1510	0.158*	171.45	0.1720	0.863**	2554.48	-4.391	0.740**	7.836	- 8.02
T_{12}	0.139*	132.12	0.0978	0.116*	164.66	0.1535	0.885**	2536.02	-4.232	0.772**	7.846	- 7.46
T_{13}	0.127*	122.60	0.1830	0.168*	164.79	0.2076	0.832**	2533.55	-4.290	0.795**	7.816	- 9.62
T_{14}	0.158*	126.42	0.1420	0.125*	169.20	0.1826	0.867**	2526.96	-4.190	0.697**	7.650	- 7.53
T_{15}	0.123*	131.68	0.0795	0.101*	165.37	0.1930	0.878**	2548.95	-4.535	0.748**	7.770	- 7.32

* Significant at 5 % level of significance, ** Significant at 1 % level of significance

CONCLUSION

The present study conducted in the Bahour soil series of UT of Puducherry demonstrated the distinct effect of nutrient management practices on soil carbon fractions. The results indicated that organic carbon content declined with the days of incubation up to 80 DAI and then slightly increased to 120 DAI. The highest organic carbon content was observed with the application of STCR+ Vermicompost treatments. The carbon fractions *viz.* WSC decreased up to 80 DAI and thereafter increased, but HWSC followed a decreasing trend at 40 DAI, which increased at 80 DAI and again decreased at 120 DAI. The WSC and HWSC were found to be the highest in STCR+ Vermicompost treatment, which was comparable to STCR+ poultry manure. The POXC content showed a significant decrease with the advancement of incubation, where it reduced from 2406.79 (0 DAI) to 1790.40 mg kg^{-1} (120 DAI). Unlike WSC and HWSC, a continuous reduction was noticed in POXC content during incubation.

The study clearly established the superiority of conjoint application of STCR-based nutrient addition with any organic manures, *viz.* poultry manure, FYM, and vermicompost in maintaining the organic carbon content in soil at the end of the incubation period. Moreover, the STCR+ organics-based nutrient management practice will contribute to the sequestration of C in soil by reducing the labile carbon pools and promoting the accumulation of SOC.

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