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Kirti B Sarnaik
Soil Science and Agricultural Chemistry Section, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

SS Balpande
Soil Science and Agricultural Chemistry Section, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Swati V Thombe
Soil Science and Agricultural Chemistry Section, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Sagar N Ingle
Soil Science and Agricultural Chemistry Section, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author:
Kirti B Sarnaik
Soil Science and Agricultural Chemistry Section, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Impact of long-term organic practices on carbon pool of vegetables growing soil of Nagpur district, Maharashtra

Kirti B Sarnaik, SS Balpande, Swati V Thombe and Sagar N Ingle

Abstract
An understanding of the dynamics of soil organic carbon (SOC) as affected by organic practices is imperative for maintaining soil productivity and mitigating global warming. The objectives of this study were to investigate the effects of long-term organic practices on carbon pools was undertaken during 2018-19. The 32 soil samples were collected from certified organic and fertilized vegetable growing farmers field of selu and chinchabhavan village of Nagpur district from surface (0-15 cm) and sub-surface (15-30 cm) depth. The very labile carbon was recorded from 0.71 - 1.32 g kg^{-1} and labile ranges between 0.53 – 1.01 g kg^{-1}, less labile varied from 0.47- 0.91 g $kg^{-1}$and non labile is highest in fertilized vegetable crop in between 4.12 to 5.62 g kg $^{-1}$. Active pools are highest in FYM, Jivamrit, Ghanjivamrit and passive pool are found abundant in inorganic sources used. Active pool contributes 24.10% and passive pool were 75.96%. Thus the study shows that nutrient addition through organic sources can improve active carbon pool in soil.

Keywords: FYM, Jivamrit, Ghabjivamrit, carbon dynamics and vegetables

Introduction

In recent year the importance of soil organic carbon as a large sinc for global C has been increasingly recognised in strategies to control atmospheric CO2 level and the greenhouse effect (Lal, 2003) [10] Soil organic matter (SOM) plays a key role in the improvement of soil physical, chemical and biological properties (Oue´draogo E, *et al*., (2007) [16]. Conservation of the quantity and quality of soil organic matter (SOM) is considered a central component of sustainable soil management and maintenance of soil quality (Doran *et al* 1996) [6, 7]. Organic manure and inorganic fertilizer are the most common materials applied in agricultural management to improve soil quality and crop productivity (Verma S, Sharma PK 2007) [15, 20]. Many studies have shown that balanced application of inorganic fertilizers or organic manure plus inorganic fertilizers can increase SOC and maintain soil productivity.

World soils contain an important pool of active carbon (C) that plays a major role in the global carbon cycle (Lal, 1995; Melillo *et al*. 2002 and Prentice *et al*. 2001) [10, 14, 19] and therefore, the part it plays in the mitigation of atmospheric levels of greenhouse gases (GHGs), with special reference to CO_2. Soil organic carbon is thus an extremely valuable natural resource. Irrespective of the climate debate, the SOC stock must be restored, enhanced and improved. Indian soils have been extensively investigated for their carbon stocks.

Organic farming is a production system which avoids or largely exclude the use of chemical fertilizers, pesticides and growth regulators. It mainly depends upon crop rotation with leguminous crop, addition of crop residues, animal manures, green manuring, bio-fertilizers and bio-pesticides etc. Addition of organic amendments could represent important strategy to protect agricultural land from excessive soil resources exploitation and to maintain soil fertility. Soil organic matter is the key component because it influences soil physical, chemical and biological properties that defined soil productivity and quality (Doran and Parkin 1994) [6, 7].

The balanced application of organic nutrients source can enhance the condition of soil and yield of crop. SOM is responsible for the maintenance not only the soil physical condition of soil but also supplies essential plant nutrients for successful crop production.

The continuous application and adequate quantity of different organic sources (solid/liquids) is important to maintain the soil health and affect the nutrient use efficiency, biological properties and productivity reducing the loss of fertilizer N and reducing K and micronutrient the soil organic carbon significantly improved with the application of organic manures at higher levels. Due to continuous use of chemical fertilizer may cause imbalance in microflora and directly affected the biological properties. Scanty information is available on effect of FYM, Jivamrut and Ghanjivamrit on carbon pools, fertility status of soil and yield of various crops. Some vegetables growers in Nagpur district produce crops by only using organic inputs since 8 to 10 years. So, there is need to study carbon pools of their fields in comparison to fertilizers practices.

Materials and Methods

To achieve the established research objective, i.e., to study the effect of long-term organic practices on carbon pools of soil under vegetables. The 16 organic farms were studied in 2018. All the farms had been subjected to a system of control and certification of the certification body, based on inspections performed in 2017. All farms were converted to conduct organic production since last 12-15 years. The studied farms were located in Nagpur in the Selu (16 sample), Chinchbhavan (16 sample) both surface and sub-surface.

The survey was carried out on the soil of selu and chinchabhavan village of Nagpur district from certified and fertilized organically growing vegetables using organic sources like Jivamrit, Ghanjivamrit, FYM and inorganic sources. Vegetables crop like fenugreek, spinach, brinjal, okra. The organic manures were applied in soil before sowing and liquid fertilizer applied 3–4 times during growth period through spraying. Dose of inorganic fertilizer i.e. nitrogen, phosphorus and potassium were applied through DAP (18:46:00) & Urea (46:0:0), SSP (0:16:0) and. Organic fertilizers applied between 10 t ha^{-1} through FYM, Ghanjivamrit, @ 500 kg ha^{-1} and Jivamrit was applied @ 500 lit. ha^{-1}.

Total 32 surface soil samples (0-15 cm) and (15-30 cm) were collected from the selected villages of Nagpur district. The collected soil samples were air dried and grind with the help of mortar and pestle and sieve through 2 mm sieve and for the determination of organic carbon, soil samples further passed through 0.5 mm sieve. These soil samples was stored in polythene bags and were subsequently used for analysis of soil organic carbon pools. Soil Soil organic carbon determined by (Walkley and Black, 1934) [21, 22] using 36 N H_2SO_4 implying the recovery factor of 1.298 represents the total SOC pool. This fraction was sub-fractionated in to four different pools namely very labile (pool I: C_{VL}), labile (pool II: C_L), less labile (pool III: C_{LL}) and non-labile (pool IV: C_{NL}). Pools I and II together represent the active pool [Active pool=∑ pool I + pool II]; while pool III and pool IV together constitute the passive pool[Passive pool = ∑(pool III + pool IV)] of organic carbon in soils (Chan *et al*. 2001) [3] using 5, 10 and 20 ml of concentrated (36.0 *N*) H_2SO_4 that resulted in three acid-aqueous solution ratios of 0.5:1, 1:1 and 2:1 (corresponding to 12.0, 18.0 and 24.0 *N* of H_2SO_4, respectively). The amount of C, thus determined allowed the apportioning of total soil organic carbon into the following four according to their decreasing order of oxidizability

Pool I (C_{VL} very labile)	:	Organic C oxidizable by 12.0 *N* H_2SO_4
Pool II (C_L labile)	:	The difference in C oxidizable by 18.0 *N* and that by 12.0 *N* H_2SO_4
Pool III (C_{LL} less labile)	:	The difference in C oxidizable by 24.0 *N* and that by 18.0 *N* H_2SO_4
Pool IV (C_{NL} non-labile):	:	The difference between C_{tot} and oxidizable by 24.0 *N* H_2SO_4.

The pool I and II together represent the active pool [active pool = Σ (pool I + Pool II)] while pool III and pool IV together constitute the passive pool [Passive pool = Σ (pool III + Pool IV)] of organic C in soils (Chan *et al*. 2001) [3].

Results and Discussion

Effect of long-term organic practices on various carbon pools

Perusal of data (Table 1) indicates that very labile fraction of carbon pool was found highest (1.32 g kg^{-1}). This may be due to use of organic use of sources of FYM since last 8 years, which has resulted into significant increase in the very labile carbon pool. Similarly, it was reported by Das *et al*. (2016) [4, 5] that FYM treatment encouraged the accumulation of very labile carbon pool. While the lower values of very labile carbon recorded under inorganic fertilizer sources (0.71 g kg^{-1}). This may be due to long term application of fertilizers since last 8 to 10 years, which has resulted into significant decrease in the very labile carbon pool. Due to less recycling of organic inputs. It has been observed that the magnitude of very labile carbon is varying significantly in surface is 0.79- 1.32 g kg^{-1} and in sub-surface soil it is between (0.71 – 1.01 g kg^{-1}). Whereas the labile fraction of carbon pool was found highest (1.01 g $kg^{-1)}$ under the long-term organic sources in surface soil. This may be due to long term application of FYM since last 8 years, which has resulted into significant increase in the labile carbon pool. Similarly, it was reported by Kumar Awanish *et al*. (2018) [1] and Das *et al*. (2016) [4, 5] that FYM treatment was significantly superior over fertilizers. The lower values of very labile carbon recorded under inorganic sources (0.53 g kg^{-1}). It has been observed that the magnitude of very labile carbon is varying significantly in surface is (0.68 –1.01 g $kg^{-1)}$ and in sub-surface soil it is between (0.53 –0.90 g $kg^{-1)}$. However the highest less labile carbon (0.91 g kg^{-1}) was recorded under the long-term application of FYM in surface soil while this may be due to long term application of FYM, which has resulted into significant increase in the less labile carbon pool. Similarly, observation was reported by Moharana *et al*. (2017) [15] and Das *et al*. (2016) [4, 5] by the use of FYM various sources organic and fertilizers. Among all the lower value of less labile carbon were registered (0.31 g kg^{-1}) in spinach crops where use of Jivamrit takes place. However, the addition of 10 t FYM ha^{-1} may contribute to less labile pool of organic carbon. Based on the generated data, it was observed that the non-labile carbon was highest (5.62 g kg^{-1}) under long term use inorganic inputs were followed since last 8-10 years and lowest non-labile carbon found in okra is (4.12 g kg^{-1}). It has been observed that the magnitude of non-labile carbon is varying significantly in between (4.81 – 5.62 g kg^{-1}) in surface soil and (4.12 – 5.24 g $kg^{-1)}$ in sub-surface.

Table 1: Long term effect of various sources on carbon pool fractions at harvest of vegetable crops

Sources	Crops	Carbon pool (g kg -1)									
		V. L.		L.		L. L.		N. L.		TOC	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Regular addition of Jivamrit 500 litre ha^{-1} since 10 yr	Fenugreek	0.87	0.83	0.70	0.60	0.47	0.41	5.01	4.70	7.05	6.54
	Spinach	1.12	0.96	0.91	0.87	0.60	0.31	4.81	4.36	6.84	6.5
	Okra	0.91	0.87	0.90	0.80	0.81	0.40	4.99	4.82	7.61	6.89
	Brinjal	1.14	0.96	0.92	0.75	0.64	0.57	5.02	4.88	7.72	7.16
	Mean	1.01	0.90	0.86	0.75	0.63	0.42	4.96	4.69	7.31	6.77
Regular addition of Ghanjivamrit 500 kg ha^{-1} since 10 yr	Fenugreek	0.98	0.90	0.80	0.67	0.78	0.47	4.82	4.67	7.38	6.71
	Spinach	0.99	0.93	0.90	0.65	0.70	0.61	5.72	4.41	8.31	6.60
	Okra	1.25	0.99	0.80	0.69	0.90	0.66	5.01	4.82	7.96	7.16
	Brinjal	1.27	1.02	0.98	0.90	0.75	0.62	5.12	5.01	8.12	7.55
	Mean	1.12	0.96	0.87	0.72	0.78	0.59	5.16	4.72	7.94	7.01
Regular addition of FYM 10 t ha^{-1} since 8 yr	Fenugreek	1.30	1.08	0.99	0.94	0.91	0.89	5.12	4.98	8.32	7.89
	Spinach	1.01	0.98	0.86	0.76	0.82	0.71	5.18	4.87	7.87	7.32
	Okra	1.12	1.03	1.01	0.87	0.91	0.59	4.98	4.41	8.02	6.90
	Brinjal	1.32	0.97	0.97	0.89	0.87	0.62	5.10	4.12	8.26	6.60
	Mean	1.18	1.01	0.95	0.86	0.87	0.70	5.09	4.59	8.11	7.17
(46:0:0 N:P:K kg ha^{-1})	Fenugreek	0.87	0.72	0.70	0.68	0.68	0.63	5.18	5.11	7.43	7.14
(46:0:0 N:P:K kg ha^{-1})	Spinach	0.79	0.71	0.68	0.53	0.61	0.51	5.62	5.24	7.70	6.99
(64:46:0 N:P:K kg ha^{-1})	Okra	0.90	0.88	0.82	0.62	0.76	0.58	5.31	5.16	7.79	7.24
(64:54:0 N:P:K kg ha^{-1})	Brinjal	0.92	00.87	0.76	0.68	0.54	0.53	5.36	5.22	7.58	7.30
	Mean	0.87	0.79	0.74	0.63	0.64	0.56	5.37	5.18	7.62	7.17

V. L. very labile, L. Labile carbon, L. L. very labile, N.L. non labile, TOC. Total organic carbon

Contribution of different soil organic carbon fractions to total organic carbon

Total organic carbon is the sum of all pools shown in (Table 1). It was completed Ghanjivamrit, Jivamrit and fertilized vegetable crop. Soil organic carbon pools it was analysed and contribution of each pool was calculated against total organic carbon in percent. The data of the same is placed in (Table 2), indicates that the higher contribution of non-labile carbon pool to the total organic carbon, it was varied from 61.53 to 74.96% under use of organic and inorganic sources. Among all the pools, less labile carbon pool contributed less in range between 4.77 to 11.34%. The contribution of C_{VL}, C_L, C_{LL}, and C_{NL} towards total organic carbon under different treatments was in the range 13.28%, 10.81%, 8.37 %, and 67.35% respectively. The passive pool (C_{LL}+C_{NL}) contributed a relatively higher proportion (75.96%) than the active pool (C_{VL}+C_L) is (24.10%) similarly results were found by Das *et al.* (2016) [4, 5] on long-term effects of fertilizers and organic sources on soil organic carbon fractions under a rice-wheat system in Indo-Gangetic Plains of north –west India. Majumder *et al.* (2007) [13] also recorded similar contribution of passive pool of soil organic carbon towards total organic carbon under NPK and FYM treatments.

Table 2: Effect of various sources on active and passive pools of soil at harvest of different vegetable crops

Sources	Crops	Carbon pools (%)											
		V. L.		L.		A. P.		L. L.		N. L.		P. P.	
		0-15 Cm	15-30 cm	0-15 Cm	15-30 cm	0-15 cm	15-30 cm	0-15 Cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Regular addition of Jivamrit 500 litre ha^{-1} since 10 yr	Fenugreek	12.34	12.69	9.92	9.17	22.26	21.86	6.67	6.30	71.06	71.87	77.37	78.16
	Spinach	16.37	14.77	13.30	13.38	29.67	28.15	8.77	4.77	70.32	67.07	79.09	71.84
	Okra	11.95	12.62	11.82	11.61	23.77	24.26	10.64	5.80	65.57	69.95	76.21	75.75
	Brinjal	14.77	13.40	11.92	10.47	26.69	23.87	8.29	7.96	65.02	68.16	73.31	76.11
	Mean	13.85	13.37	11.74	11.15	25.59	24.53	8.59	6.20	67.99	69.26	76.49	75.47
Regular addition of Ghanjivamrit 500 kg ha^{-1} since 10 yr	Fenugreek	13.28	13.41	10.84	9.99	24.12	23.40	10.57	7.01	65.31	69.59	75.88	76.60
	Spinach	11.91	14.09	10.83	9.84	22.74	23.93	8.42	9.24	68.83	66.81	77.25	76.05
	Okra	15.70	13.82	10.05	9.64	25.75	23.46	11.31	9.21	62.93	67.31	74.25	76.52
	Brinjal	15.64	13.51	12.06	11.92	27.70	25.43	9.24	8.21	63.05	66.35	72.29	74.57
	Mean	14.13	13.70	10.94	10.34	25.07	24.05	9.88	8.41	65.03	67.51	74.91	75.93
Regular addition of FYM 10 t $ha^{-1}ha^{-1}$ since 8 yr	Fenugreek	15.62	13.69	11.90	11.91	27.52	25.60	10.93	11.28	61.53	63.11	72.46	74.40
	Spinach	12.83	13.39	10.93	10.38	23.76	23.77	10.41	9.70	65.81	66.53	76.22	76.23
	Okra	13.97	14.92	12.59	12.60	26.56	27.52	11.34	8.55	62.09	63.91	73.43	72.46
	Brinjal	15.98	14.70	11.74	13.48	27.72	28.18	10.53	9.40	61.74	62.42	72.27	71.82
	Mean	14.6	14.17	11.79	12.09	26.39	26.26	10.8	9.73	62.79	63.99	73.59	73.72
(46:0:0 N:P:K kg ha^{-1})	Fenugreek	11.70	10.08	9.42	9.52	21.12	19.60	9.15	8.82	69.71	70.17	78.86	78.98
(46:0:0 N:P:K kg ha^{-1})	Spinach	10.26	10.16	8.83	7.58	19.09	17.74	7.92	7.29	72.99	74.96	80.90	82.25
(64:46:0 N:P:K kg ha^{-1})	Okra	11.55	12.15	10.52	8.56	22.07	20.71	9.76	8.01	68.16	71.27	77.92	79.28
(64:54:0 N:P:K kg ha^{-1})	Brinjal	12.13	11.92	10.02	9.31	22.15	21.23	7.12	7.26	70.12	71.50	77.83	78.76
	Mean	11.41	11.07	9.69	8.74	21.10	19.82	8.48	7.84	70.24	71.97	78.87	79.81

V.L. very labile, L. Labile carbon, L. L. very labile, N.L. non labile, TOC. Total organic carbon, A.P. Active pool, P.P. Passive pool

Effect of long-term organic practices on active pool and passive pool

The data pertaining in (Table 2). gives the value of carbon pools i.e. active pool and passive pool indicates the higher contribution of non-labile carbon pool to the total soil organic carbon, it was also varied from 59.53 % to 73.63% under various application of sources. Active pool is highest (27.72 %) in brinjal crop where application of FYM takes place from 8 year in the proportion of 10 t $ha^{-1.}$ Active pool was lowest (17.74 %) in Spinach crop where application of inorganic sources takes place. Passive pool was lowest (71.82%) in brinjal crop and highest is (82.25 %) in spinach crop where application of inorganic sources takes place. Nath *et al*. (2015) reported that there was abundance on active pool in surface soil. The abundance of four soil organic carbon fractions was in the order non-labile carbon (67.35%) >very labile carbon (13.28%) > labile carbon (10.81%) > less labile carbon (8.37%). Contribution of very labile pool in Active pool was higher than the labile of pool both in surface and sub-surface soil. Similarly, non-labile pool have more contribution than less labile pool in passive pool in surface soils, than the passive pool in surface soils whereas higher passive pool than the active pool was observed in the sub surface soil.

Conclusions

On the basis of present study, it can be concluded that, nutrient addition through different organic sources can enhance organic carbon content in soil with the continuous use of organic sources for a period, of 11-18 years over inorganic fertilizer alone. Application of Ghanjivamarit @ 500 kg ha^{-1}, jivamrit @ 500 litre ha^{-1} and FYM @ 10 t ha^{-1} of organic inputs improves the active carbon pool.

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