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Impact of organic, inorganic and integrated nutrient management practices on carbon pool and yield of perennial, annual and seasonal crops grown in Nagpur District

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Abstract
The present study on impact of organic, inorganic and INM practices on carbon pool and yield of perennial, annual and seasonal crops was studied during 2019-20. The total four villages were selected for study and their GPS location were recorded. The surface (0-15 cm) and sub-surface (15-30 cm) soil samples from each field were collected after harvest of Nagpur mandarin, Pigeonpea and Paddy. The total of 72 (surface and subsurface) samples were collected. The results revealed that, the highest very labile carbon was recorded 1.30 gkg^{-1} (surface) and 1.27 gkg^{-1} (subsurface), labile carbon 1.02 gkg^{-1} (surface) and 0.98 gkg^{-1} (subsurface), less labile carbon 0.91 g kg^{-1} (surface) and 0.89 gkg^{-1} (subsurface) under the regular addition of organic fertilizers like FYM in case of Nagpur mandarin and non-labile carbon was recorded 5.97 gkg^{-1} (surface) and 5.82 gkg^{-1} (subsurface) under the use of inorganic fertilizers. The lower values of C_{VL} were recorded 0.77 gkg^{-1} (surface) and 0.74 gkg^{-1} (subsurface), C_L was recorded 0.55 gkg^{-1} (surface) and 0.48 g kg^{-1} (subsurface), C_{LL} was registered 0. 41 gkg^{-1} (surface) and 0.37 gkg^{-1} (subsurface) where fertilizers applied through inorganic sources. It was observed that the non-labile carbon was lowest 3.73 gkg^{-1} (surface) and 3.52 g kg^{-1} (subsurface) under integrated nutrient management practices. Active pools are highest in organic and INM practices and passive pool is found abundant where inorganic sources were used. There existed a significant correlation between carbon fractions and yield of crops grown under organic and INM practices, but showed no significant correlation with carbon fractions and yield of crops grown under inorganic farming. Under conventional management, the agronomic relevance of SOM with regard to nutrient supply is much lower than under organic.

Keywords: Carbon pool, management practices, perennial, annual and seasonal crops, yield

Introduction

Soils are the largest carbon reservoirs of the terrestrial carbon cycle. Soil, if managed properly, can serve as a sink for atmospheric carbon dioxide (Jha *et al.*, 2012) [7]. The global soil carbon (C) pool of 2500 gigatons (Gt) includes about 1550 Gt of soil organic carbon (SOC) and 950 Gt of soil inorganic carbon (SIC). The soil C pool is 3.3 times the size of the atmospheric pool (760 Gt) and 4.5 times the size of the biotic pool (560 Gt). The SOC pool represents a dynamic equilibrium of gains and losses. Conversion of natural to agricultural ecosystems cause depletion of the SOC pool by as much as 60% in soils of temperate regions and 75% or more in cultivated (Lal, 2004) [8].

Among various carbon pools, the soil carbon pool is the largest and most important since it has a higher capacity to store carbon as compare to vegetation and atmosphere. Soils can store substantial amount of atmospheric carbon. Soils of the tropics soils are a major reservoir of the terrestrial carbon (C) pool estimated at about 1550 Pg (petagram=10^{15}g = 1 billion metric tonnes = 1 gigatonnes = 1 Gt) for organic and 750-950 Pg for inorganic components to 1m depth. The influence of soil organic carbon pools on yield is both direct and indirect as the soil organic carbon plays multifunctional role such as buffering, restoring and supplying of plant nutrients etc. It is a store house of all soil microorganisms inhabiting soil, improve physical, chemical and biological properties of soil.

Globally, one third of the arable land is in agriculture. Agricultural soil has dual nature as it also serves as a potential sink for atmospheric carbon as soil organic carbon (SOC), which contributes to improve productivity and quality (Brar *et al.*, 2013) [3]. Therefore, agricultural soils are the largest reservoirs of carbon.

Improved agricultural practices have a great potential to increase the amount of carbon in the soil so adoption of recommended management practice in agriculture contributes not only to soil productivity but also helps to mitigate adverse effect of excessive carbon dioxide emission and climate change. Productivity gains with an increase in the SOC pool are large, especially when combined with judicious input of fertilizers, irrigation and other amendments. Increases in SOC concentration enhance crop productivity in soils with a clay content lower than 20 per cent, and in soils of sandy-loam and loamy-sand texture. In most soils, the relation between SOC content and crop yield is linear up to a limit (20 per cent of SOC) beyond which it levels off. In some soils, an increase in crop yield due to an increase in the SOC pool is primarily related to an increase in the labile fraction, which may have a narrow ecological optimum. The critical limit of total SOC content, below which crop yield declines by about 20 per cent is 1.1 per cent for most soils of the tropics and 2.0 per cent for soils of the temperate regions. In unfertilized soils, in which breakdown of soil organic matter is necessary to supply nutrients and maintain yields, there may be a critical level of SOC below which insufficient nutrients are mineralized to sustain satisfactory yields.

Application of inorganic fertilizers results in higher soil organic matter (SOM) accumulation and biological activity due to increased plant biomass production and organic matter returns to soil in the form of decay roots, litter and crop residues. Integrated nutrient management (INM) aims at achieving efficient use of chemical fertilizers in conjunction with organic manures. The crop productivity increases from the combined application of chemical fertilizers and organic manures. Such combination contributed to the improvement of physical, chemical and biological properties of soil. Integrated use of organic manure and chemical fertilizers improved soil carbon pools *viz*. organic carbon, total carbon, inorganic carbon, water soluble carbon, light fraction carbon, particulate organic carbon, labile and non-labile carbon pools and maintain soil health and fertility.

Material and Methods

The present investigation was undertaken to identify the different organic, inorganic and integrated nutrient management farms (farmer's field) from Chichbhavan, Gangner, Savner and Selu of Nagpur district growing Nagpur mandarin, Pigeonpea and Paddy crop. Total 72 samples were collected from surface (0-15 cm) and sub-surface (15-30 cm) soil from each field. The soil samples were further used for studying Carbon pool fractions i.e. Pools I, Pools II, pools III and Pools IV. The yield of Nagpur mandarin, pigeonpea and paddy was recorded at the time of harvesting by plotting 10*10 size plot and yield was expressed in quintals per hectare.

Table 1: GPS readings of selected villages

Sr. No.	Village	GPS Location	
		Latitude	Longitude
1.	Chichbhavan	21^o 06'	79^o 05'
2.	Gangner	21^o 23'	79^o 32'
3.	Savner	21^o 10'	79^o 19'
4.	Selu	21^o 10'	79^o 32'

The visits to farmers field were done, discussed with them about selection of his field for the study and informed him about the importance of study. Eighteen samples (surface + subsurface) were collected from each village after harvest of Nagpur mandarin, Pigeonpea and Paddy. Sampling was done at surface (0-15 cm) and sub-surface (15-30 cm). The samples were processed and analyzed in the laboratories of Soil Science and Agricultural Chemistry section, College of Agriculture, Nagpur during 2019-2020. The soil samples were analyzed for Soil organic carbon (SOC) determined by Walkley and Black, (1934) 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) [4] 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 different pools 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 H_2SO_4 and that by 12.0 N H_2SO_4
Pool III (C_{LL} less labile)	:	The difference in C oxidizable by 24.0 N H_2SO_4 and that by 18.0 N H_2SO_4
Pool IV (C_{NL} non-labile):	:	The difference between C_{toc} 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) [4]. Statistical analysis involving the coefficient of correlation between carbon pools and yield of Nagpur mandarin, pigeonpea and paddy was analyzed and interpreted as per the procedure described by Panse and Sukhatme (1985) [12].

Results and Discussion

Very labile carbon

The highest very labile carbon was recorded in Nagpur mandarin 1.30 g kg^{-1} (surface) at Chichbhavan and 1.27 g kg^{-1} (subsurface) at Gangner under the regular addition of organic fertilizers like FYM (Table 2) and the lower value was recorded 0.77 g kg^{-1}(surface) and 0.74 g kg^{-1} (subsurface) under inorganic fertilizers sources to pigeonpea at Gangner and Chichbhavan respectively. This highest value may be due to use of organic sources like FYM since last 8-10 years, which has resulted into significant increase in the very labile carbon pool. Das *et al*. (2016) [5] recorded that FYM treatment encouraged the accumulation of very labile carbon pool and lowest value may be due to long term application of chemical fertilizers since last 8 to 10 years, which has resulted into significant decrease in the very labile carbon pool.

Labile Carbon

The data showed the highest labile carbon 1.02 g kg^{-1} (surface) and 0.98 g kg^{-1} (subsurface) was recorded under the application of organic fertilizers to Nagpur mandarin at Gangner. This may be due to long term application of FYM since last 8-10 years, which has resulted into significant increase in the labile carbon pool. The lowest value of labile carbon 0.55 g kg^{-1} (surface) and 0.48 g kg^{-1} (subsurface) was recorded under the application of inorganic fertilizers to pigeonpea at Savner. The application of inorganic NPK fertilizer fails to sequestrate SOC, only the application of organic manure alone has showed effective for sequestrating soil organic carbon. Hema *et al.* (2019) [6] reported that, soil C_L increased as a result of the manure application than by the application of inorganic fertilizer alone.

Less-Labile Carbon

The data in respect of less labile carbon under use of various sources of nutrient have been compiled and depicted in table 2. The highest less labile carbon 0.91 g kg^{-1} (surface) and 0.89 g kg^{-1} (subsurface) was recorded under the long-term application of organic sources of fertilizers like FYM in soil to Nagpur mandarin at Chichbhavan. Similar, observation was reported by Moharana *et al*. (2012) [9] and Das *et al*. (2016) [5] due to the use of various sources organic fertilizers. The lower value of very labile carbon was registered 0.41 g kg^{-1} (surface) and 0.37 g kg^{-1} (subsurface) where the fertilizers were applied through inorganic sources to paddy at Savner. The value of less labile carbon was observed highest in application of organic fertilizers followed by INM and inorganic practices (Table 2).

Non-labile carbon

The lowest non-labile carbon was recorded in surface (3.73 g kg^{-1}) and subsurface (3.52 g kg^{-1}) was recorded under integrated nutrient management practices to pigeonpea at Chichbhavan. However, highest non-labile carbon was recorded in surface (5.97 g kg^{-1}) and subsurface (5.82 g kg^{-1}) soil due to addition of fertilizers through inorganic sources to Nagpur mandarin at Gangner (Table 3). Bhattacharya *et al.* (2007) [2] reported that use of FYM with incorporation of crop residue reduces the non-labile pools. The surface soils have higher non labile carbon than the sub surface soils as the soils are clayey in texture the carbon compound may have less migration in subsurface.

Table 2: Effect of various organic, inorganic and INM practices on carbon pool fractions at harvest of crops

Sr. No.	Practice	Crops	Carbon pool (g kg^{-1})									
			V.L.		L.		L.L.		N.L.		TOC	
			S	SS	S	SS	S	SS	S	SS	S	SS
Chichbhavan												
1	Organic	Paddy	1.28	1.20	0.96	0.94	0.89	0.86	4.48	4.35	7.61	7.35
		Pigeonpea	1.23	1.19	0.87	0.84	0.81	0.79	4.33	4.21	7.24	7.03
		Nagpur mandarin	1.30	1.24	0.98	0.94	0.91	0.89	4.22	4.18	7.41	7.25
2	Inorganic	Paddy	0.86	0.84	0.71	0.69	0.41	0.39	5.21	4.94	7.19	6.86
		Pigeonpea	0.78	0.74	0.62	0.57	0.49	0.45	5.93	5.59	7.82	7.35
		Nagpur mandarin	0.81	0.77	0.65	0.63	0.57	0.55	4.83	4.69	6.86	6.64
3	INM	Paddy	0.95	0.93	0.82	0.79	0.88	0.85	4.27	4.14	6.92	6.71
		Pigeonpea	0.88	0.85	0.83	0.82	0.79	0.75	3.73	3.52	6.23	5.94
		Nagpur mandarin	1.08	0.95	0.80	0.77	0.69	0.65	4.07	4.27	6.64	6.64
Gangner												
1	Organic	Paddy	1.25	1.20	0.91	0.87	0.86	0.83	4.83	4.66	7.85	7.56
		Pigeonpea	1.18	1.11	0.86	0.85	0.83	0.81	4.61	4.54	7.48	7.31
		Nagpur mandarin	1.29	1.27	1.02	0.98	0.90	0.86	4.62	5.57	8.68	7.23
2	Inorganic	Paddy	0.82	0.82	0.69	0.61	0.65	0.51	5.97	5.82	8.13	7.76
		Pigeonpea	0.77	0.75	0.74	0.73	0.71	0.68	5.89	5.62	8.11	7.78
		Nagpur mandarin	0.78	0.77	0.66	0.59	0.54	0.53	5.15	4.89	7.13	6.78
3	INM	Paddy	0.98	0.96	0.88	0.85	0.77	0.68	4.41	4.32	7.04	6.81
		Pigeonpea	0.96	0.89	0.86	0.82	0.79	0.74	4.09	4.05	6.70	6.50
		Nagpur mandarin	1.02	0.95	0.91	0.90	0.69	0.65	4.36	4.27	6.98	6.77
Savner												
1	Organic	Paddy	1.17	1.12	0.93	0.90	0.88	0.85	4.85	4.76	7.83	7.63
		Pigeonpea	1.18	1.15	0.88	0.86	0.82	0.79	4.67	4.51	7.55	7.31
		Nagpur mandarin	1.26	1.24	0.97	0.94	0.89	0.85	4.18	4.08	7.30	7.11
2	Inorganic	Paddy	0.80	0.76	0.68	0.66	0.44	0.37	5.91	5.76	7.83	7.55
		Pigeonpea	0.78	0.77	0.55	0.53	0.52	0.48	5.03	4.99	6.88	6.77
		Nagpur mandarin	0.81	0.79	0.58	0.48	0.45	0.37	5.73	5.36	7.57	7.00
3	INM	Paddy	0.97	0.94	0.81	0.79	0.68	0.63	4.36	4.23	6.82	6.59
		Pigeonpea	0.94	0.90	0.88	0.85	0.61	0.59	4.23	4.05	6.66	6.39
		Nagpur mandarin	1.04	0.95	0.83	0.71	0.69	0.65	4.41	4.27	6.97	6.58
Selu												
1	Organic	Paddy	1.21	1.19	0.96	0.94	0.87	0.81	4.88	4.81	7.92	7.75
		Pigeonpea	1.19	1.15	0.87	0.85	0.83	0.79	4.65	4.62	7.54	7.41
		Nagpur mandarin	1.26	1.21	0.99	0.95	0.91	0.86	5.12	4.88	8.28	7.90
2	Inorganic	Paddy	0.78	0.75	0.72	0.66	0.47	0.45	5.73	5.62	7.70	7.48
		Pigeonpea	0.76	0.74	0.65	0.61	0.54	0.46	5.86	5.59	7.81	7.40
		Nagpur mandarin	0.81	0.78	0.67	0.61	0.47	0.44	5.13	4.93	7.08	6.76
3	INM	Paddy	0.95	0.91	0.82	0.79	0.67	0.52	4.27	4.09	6.71	6.31
		Pigeonpea	0.91	0.87	0.78	0.66	0.71	0.57	4.09	3.91	6.49	6.01
		Nagpur mandarin	1.08	0.96	0.85	0.73	0.69	0.64	4.41	4.32	7.03	6.65

Active pool and passive pool

The values of active and passive carbon pools were calculated and data is presented in table 3. The calculation indicates the higher contribution of passive pool recorded in inorganic (80.55%), INM (73.12%) and organic (71.66%) amongst the various application of sources. The highest value of active pool was observed in Nagpur mandarin crop at Chichbhavan (30.77%) due to application of organic fertilizers and its lowest value was observed in pigeonpea crop at Chichbhavan (17.90%) due to the application of inorganic fertilizers. However, the lowest value of passive pool was recorded in Nagpur mandarin at Chichbhavan (69.23%) and its highest value was recorded in pigeonpea crop at Chichbhavan (82.10%) where fertilizers applied through inorganic sources. Nath *et al.*, (2015) [10] 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 (65.46%) >very labile carbon (13.76%) > labile carbon (11.14%) > less labile carbon (9.65%). The contribution of very labile pool in active carbon pool was higher than the labile pool, both in surface and sub-surface soil. Similarly, non-labile pool has more contribution than less labile pool in passive carbon pool in surface soils. However, slightly higher less labile carbon in subsurface soils.

Yield of Nagpur mandarin

The yield of Nagpur mandarin was obtained between 13.7 – 19.9 t ha^{-1} with the use of different management practices with mean of 152.16 q ha^{-1}. The maximum yield (19.9 t ha^{-1}) was obtained under the practice of integrated nutrient management at Selu location. The minimum yield (13.8 t ha^{-1}) was obtained under the application of organic fertilizers at Gangner location.The yield of Nagpur mandarin under organic, inorganic and INM practices are under the range of 13.7 – 14.7 t ha^{-1}, 14 – 19.8 t ha^{-1} and 14.5 – 19.9 t ha^{-1} respectively i.e., INM > inorganic > organic. The average yield of Nagpur mandarin under INM and inorganic practices was more or less same. Kamatyanatti *et al.* (2019) noted that increase in yield was mainly attributed to relative increase in the availability of nutrients and better solute uptake by the plants. The effectiveness of chemical fertilizers was greatly enhanced, when it was applied along with FYM.

Table 3: Effect of organic, inorganic and INM practices on active and passive pools of soil at harvest of crops

Sr. No.	Practice	Crops	Carbon pool (%)											
			V.L.		L.		A. P		L.L.		N.L.		P. P	
			S	SS	S	SS	S	SS	S	SS	S	SS	S	SS
Chichbhavan														
1	Organic	Paddy	16.82	16.33	12.61	12.79	29.43	29.12	11.70	11.70	58.87	59.18	70.57	70.88
		Pigeonpea	16.99	16.93	12.02	11.95	29.01	28.88	11.19	11.24	59.81	59.89	70.99	71.12
		NM	17.54	17.10	13.23	12.97	30.77	30.07	12.28	12.28	56.95	57.66	69.23	69.93
2	Inorganic	Paddy	11.96	12.24	9.87	10.06	21.84	22.30	5.70	5.69	72.46	72.01	78.16	77.70
		Pigeonpea	9.97	10.07	7.93	7.76	17.90	17.82	6.27	6.12	75.83	76.05	82.10	82.18
		NM	11.81	11.60	9.48	9.49	21.28	21.08	8.31	8.28	70.41	70.63	78.72	78.92
3	INM	Paddy	13.73	13.86	11.85	11.77	25.58	25.63	12.72	12.67	61.71	61.70	74.42	74.37
		Pigeonpea	14.12	14.31	13.31	13.80	27.43	28.11	12.67	12.63	59.90	59.26	72.57	71.89
		NM	16.26	14.31	12.04	11.60	28.30	25.90	10.39	9.79	61.32	64.31	71.70	74.10
Gangner														
1	Organic	Paddy	15.92	15.87	11.59	11.51	27.52	27.38	10.96	10.98	61.53	61.64	72.48	72.62
		Pigeonpea	15.78	15.18	11.50	11.63	27.27	26.81	11.10	11.08	61.63	62.11	72.73	73.19
		NM	16.48	14.63	13.03	11.29	29.50	25.92	11.49	9.91	59.00	64.17	70.50	74.08
2	Inorganic	Paddy	10.09	10.57	8.49	7.86	18.57	18.43	8.00	6.57	73.43	75.00	81.43	81.57
		Pigeonpea	9.49	9.64	9.12	9.38	18.62	19.02	8.75	8.74	72.63	72.24	81.38	80.98
		NM	10.94	11.36	9.26	8.70	20.20	20.06	7.57	7.82	72.23	72.12	79.80	79.94
3	INM	Paddy	13.92	14.10	12.50	12.48	26.42	26.58	10.94	9.99	62.64	63.44	73.58	73.42
		Pigeonpea	14.32	13.69	12.83	12.62	27.14	26.31	11.78	11.38	61.07	62.31	72.86	73.69
		NM	14.60	14.03	13.03	13.29	27.63	27.33	9.88	9.60	62.49	63.07	72.37	72.67
Savner														
1	Organic	Paddy	14.94	14.68	11.88	11.80	26.82	26.47	11.24	11.14	61.94	62.39	73.18	73.53
		Pigeonpea	15.63	15.73	11.66	11.76	27.28	27.50	10.86	10.81	61.85	61.70	72.72	72.50
		NM	17.26	17.44	13.29	13.22	30.55	30.66	12.19	11.95	57.26	57.38	69.45	69.34
2	Inorganic	Paddy	10.22	10.07	8.68	8.74	18.90	18.81	5.62	4.90	75.48	76.29	81.10	81.19
		Pigeonpea	11.34	11.37	7.99	7.83	19.33	19.20	7.56	7.09	73.11	73.71	80.67	80.80
		NM	10.70	11.29	7.66	6.86	18.36	18.14	5.94	5.29	75.69	76.57	81.64	81.86
3	INM	Paddy	14.22	14.26	11.88	11.99	26.10	26.25	9.97	9.56	63.93	64.19	73.90	73.75
		Pigeonpea	14.11	14.08	13.21	13.30	27.33	27.39	9.16	9.23	63.51	63.38	72.67	72.61
		NM	14.92	14.44	11.91	10.79	26.83	25.23	9.90	9.88	63.27	64.89	73.17	74.77
Selu														
1	Organic	Paddy	15.28	15.35	12.12	12.13	27.40	27.48	10.98	10.45	61.62	62.06	72.60	72.52
		Pigeonpea	15.78	15.52	11.54	11.47	27.32	26.99	11.01	10.66	61.67	62.35	72.68	73.01
		NM	15.22	15.32	11.96	12.03	27.17	27.34	10.99	10.89	61.84	61.77	72.83	72.66
2	Inorganic	Paddy	10.13	10.03	9.35	8.82	19.48	18.85	6.10	6.02	74.42	75.13	80.52	81.15
		Pigeonpea	9.73	10.00	8.32	8.24	18.05	18.24	6.91	6.22	75.03	75.54	81.95	81.76
		NM	11.44	11.54	9.46	9.02	20.90	20.56	6.64	6.51	72.46	72.93	79.10	79.44
3	INM	Paddy	14.16	14.42	12.22	12.52	26.38	26.94	9.99	8.24	63.64	64.82	73.62	73.06
		Pigeonpea	14.01	14.48	12.01	10.98	26.02	25.46	10.93	9.48	63.05	65.06	73.98	74.54
		NM	15.36	14.44	12.09	10.98	27.45	25.41	9.82	9.62	62.73	64.96	72.55	74.59

S= surface (0-15cm), SS= surface (15-30cm) NM=Nagpur mandarin

Yield of pigeonpea

The yield of pigeonpea was obtained between 12-19 q ha^{-1} with the use of different management practices with mean of 16.33 q ha^{-1}. The maximum yield (19 q ha^{-1}) was obtained under integrated nutrient management practice at Chichbhavan location. The minimum yield (12 q ha^{-1}) was obtained under the application of organic fertilizers at Savner location. The yield of pigeonpea under organic, inorganic and INM practices are under the range of 12 – 17 q ha^{-1}, 15 - 18 q ha^{-1} and 17 – 19 q ha^{-1} respectively i.e., INM > inorganic > organic. Singh (2007) reported that maximum grain yield and stover yield of pigeon pea were observed with the application of 50% RDF + 5 t FYM/ ha over the other treatments. Pandey *et al.* (2013) [11] reported that application of FYM @ 5.0 t ha^{-1} or vermicompost @ 2.5 t ha^{-1} with 100% RDF proved equally effective for enhancing the grain yield of pigeon pea and both produced significantly higher grain yield than RDF alone.

Yield of paddy

The yield of paddy was obtained between 20 to 34 q ha^{-1} with the use of different management practices with mean of 27.5 q ha^{-1}. The maximum yield (34 q ha^{-1}) was obtained under integrated nutrient management practice at Gangner location. The minimum yield (20 q ha^{-1}) was obtained under the application of organic fertilizers at Savner location. Baishya *et al.* (2015) [1] noted that the crop receiving higher amount of nutrients through organic and inorganic sources recorded higher growth and yield. The lowest yield of paddy was found with the application of organic manures alone as compared to integrated nutrient management practices.

Table 4: Yield of crops under organic, inorganic and INM practices.

Practice	Crops/ Villages	Chichbhavan	Gangner	Savner	Selu
		Yield			
Organic	Paddy (q ha^{-1})	22	24	20	28
	Pigeonpea (q ha^{-1})	14	15	12	17
	Nagpur mandarin (t ha^{-1})	13.7	13.8	14.2	13.8
Inorganic	Paddy (q ha^{-1})	27	28	24	30
	Pigeonpea (q ha^{-1})	16	16	15	18
	Nagpur mandarin (t ha^{-1})	14.9	14.0	14.5	19.5
INM	Paddy (q ha^{-1})	32	34	26	32
	Pigeonpea (q ha^{-1})	19	17	18	19
	Nagpur mandarin (t ha^{-1})	15.1	14.5	14.7	19.9

Correlation of crop yield with carbon pool of Paddy, Pigeonpea and Nagpur mandarin crops under organic, inorganic and INM farming system

The correlations of crop yield with carbon pool of organic, inorganic and INM farming system under seasonal, annual and perennial crops were worked out and presented in table 8. The results revealed that, there was highly significant positive correlation of labile fraction (r= 0.768), very labile carbon fraction (r= 0.576), less labile carbon fraction (r= 0.644), active pool (r= 0.606) and found significant negative correlation of non-labile carbon fraction (r= -0.634) and passive pool (r=-0.616) with yield of these crops under organic farming system. Brar *et al.* (2015) [3] reported that the improved SOC concentration continuously from the initial level of 2.03 g kg^{-1} to 5.20 g kg^{-1} and SOC pool with application of FYM over 36 years might have also responsible for higher yields in treatments receiving FYM. However, in inorganic farming system crop yield had not showed any positive or negative significant correlation with carbon pool of seasonal, annual and perennial crops. Increase in chemical fertilizer amount had no significant relation with carbon fractions.

Whereas, in INM farming system crop yield had also recorded highly significant and positive correlation with very labile carbon fraction (r= 0.825), labile carbon fraction (r= 0.557), active pool (r= 0.669) and passive pool (r=0.569) of seasonal, annual and perennial crops.

Table 5: Correlation of crop yield with carbon pool of organic, inorganic and INM farming system under seasonal, annual and perennial crops.

Yield	Organic	Inorganic	INM
VL	0.576*	0.537	0.825**
L	0.768**	0.249	0.557*
LL	0.644*	0.061	-0.437
NL	-0.634*	-0.409	0.045
AP	0.606*	0.377	0.669*
PP	-0.616*	-0.477	0.569*

**Significance at 1% is (0.684) and *significance at 5% is (0.553)

Conclusions

There existed a significant relation between carbon fractions and yield of crops grown under INM and organic practice, increase in chemical fertilizer amount had no significant relation with carbon fraction. Crop yield of Nagpur mandarin, Pigeonpea and Paddy were recorded higher under the practice of integrated nutrient management than organic and inorganic farming system i.e., INM > Inorganic > Organic.

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