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Long-term Impact of Soil Test and Targeted Yield Based Nutrient Management on Vertical Variability in Carbon Fractions of a Vertisol under Rice-wheat Cropping Sequence

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study the Long-term impact of soil test and targeted yield based nutrient management on vertical variability in carbon fractions of a Vertisol under rice-wheat cropping sequence.

Place and Duration of Study: This research trail was conducted during *rabi* season of 2020-21 in an on-going research programme of AICRP on STCR initiated during 2008 at the Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Study Design: The study has consisted of six treatments of nutrient management practices based on soil test and targeted yields of rice and wheat (T_1: Control; T_2: GRD; T_3: T.Y. 50 and 45 q ha^{-1} for rice and wheat; T_4: T.Y. 60 q ha^{-1}; T_5: T.Y. 50 and 45 q with FYM 5 t ha^{-1} for rice and wheat and T_6: T.Y. 60 q with 5 t FYM ha^{-1}) at different soil depths (0-15, 15-30 and 30-45 cm) which were replicated four times in a randomized block design.A total of 72 post- harvest soil samples of wheat were subjected to determination of carbon fractions across the soil depths.

Results: Results revealed that Carbon fractions in soil were significantly altered by nutrient

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management practices over soil depths. However, the highest contents of organic and inorganic carbon fractions in soil were obtained under T_6 having highest yield target of 60 q along with FYM 5 t ha^{-1} and the lowest in control. The results showed that contents of carbon fractions of soil were decreased with consecutive increase in soil depths except less labile carbon and inorganic carbon which increased with soil depths.

Keywords: Carbon fractions; STCR approach; rice-wheat cropping sequence; soil depth.

1. INTRODUCTION

Rice-wheat rotation is one of the most predominant cropping system, in India contributes 75% in the national food grain basket having total acreage of 44.10 and 31.36 M ha and total production of 121.03 and 107.86 Mt with productivity of 4.10 and 3.40 t ha^{-1} [1]. While, in Madhya Pradesh, the total area occupied by rice and wheat are 2.04 and 6.03 M ha with production of 4.12 and 18.58 Mt and productivity of 2.02 and 3.08 tha^{-1}, respectively [2].

Nutrient balance is one of the key indicators of temporal and spatial changes in soil quality. Soil is a big source or sink of atmospheric carbon depending on the cropping system, land uses and management practices and total carbon is sum of organic, elemental and inorganic forms of carbons in which soil organic carbon (SOC) is predictable to consist of various fractions depending on degree of decomposition, recalcitrance and turnover rate. Organic carbon fractions can be classified as very labile, labile, less-labile and recalcitrant which responds rapidly to any changes in carbon supply and considered to be important indicator of soil quality.

Use of STCR-INM (Soil test crop response-Integrated nutrient management) based fertilizer adjustment equations have proved very useful for prescribing fertilizer doses to crop grown in rice-wheat sequence to achieve higher productivity, improving available nutrients content in soil [3] and eliminates over or under usage of fertilizer inputs. It also not only helps in saving of fertilizers and improving the economy but also help in improvement of soil health.

2. MATERIALS AND METHODS

2.1 Technical Programme

The present study was conducted at the Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during *rabi* season of 2020-21 under the on-going research programme of AICRP on STCR on rice-wheat cropping sequence initiated originally from 2008. The study consisted of six treatments of nutrients management based on soil test and targeted yield of rice and wheat which had been replicated four times in a randomized block design with gross plot size of 5 x 5 m having 1.0 m spacing between plots and 1.0 m spacing between the replications.

2.2 Treatment Deities

T_1: Control (No fertilizer)
T_2: GRD for rice and wheat)
T_3: TY. 50 and 45 q ha^{-1} for rice and wheat
T_4: TY 60 q ha^{-1} for rice and wheat
T_5:TY 50 and 45 q + FYM 5 t ha^{-1} for rice and wheat
T_6: TY 60 q + FYM 5 t ha^{-1} for rice and wheat

2.3 Collection and Preparation of Soil Samples

Soil samples were collected in four sites with the help of post hole auger sampler at the experiment field from each treatment at the depths of 0-15, 15-30 and 30-45 cm after harvest of wheat crop during 2021. All the possible technical precautions as prescribed for standard soil sampling have been followed. The soil samples were collected in air tight plastic bags for carrying to the laboratory and processed through air-dried in shadow, grounded with wooden roller and passed through 2.0 mm stainless steel sieve and stored in polythene bags at room temperature. The stored soil samples were used for estimation of carbon fractions of soil.

2.4 Soil Carbon Fractions

In the present study organic, inorganic and total carbon contents in soil samples collected from different treatments of soil test and targeted yield of based nutrient management under long-term experiment of rice-wheat and soil depths were analyzed using standard procedures. In addition to it different fractions (very labile, labile, less labile and non-labile) of organic carbon were also determined. Total carbon in soil was estimated by dry combustion using CHNS analyzer. Inorganic carbon was determined using the procedure suggested by Jackson [4]. However organic carbon fractions were determined by following protocol:

- **Very labile:** Organic C oxidisable under 12 N H_2SO_4.
- **Labile:** Difference in oxidisable organic C extracted between 18 N and 12 N H_2SO_4 (18 N-12 N H_2SO_4).
- **Less labile:** Difference in oxidisable organic C extracted between 24 N and 18 N H_2SO_4.
- **Non-labile:** Residual organic C after reaction with 24 N H_2SO_4 when compared with the total organic carbon (TOC- 24 N H_2SO_4) known as recalcitrant.

2.5 Statistical Analysis

The data pertaining to each character of the soil was tabulated and analysed statistically by applying the standard technique analysis of variance for Randomized Block Design was worked out and the significance of treatments were tested to draw valid conclusion as described by Gomez and Gomez [5]. The differences of treatments mean were tested by ‘F’ test of significance on the basis of null hypothesis. Critical differences were worked out at 5 percent level of probability where ‘F’ test was significant. If the variance ratios (F-test) were found significant at 5% level of significance, the standard error of mean (SE m±) and critical differences (CD) were calculated according.

3. RESULTS AND DISCUSSION

3.1 Soil Organic Carbon Fractions

Results revealed that contents of very labile, labile, less labile and non-labile carbon in soil after harvest of wheat crops at different soil depths were significantly influenced by different treatments of STCR based nutrient management. Results revealed that contents of very labile, labile and non-labile carbon in soil decreased with increase in soil depths except less labile carbon was increased with increase in soil depths. Decrease in very labile, labile, and non-labile carbon may be attributed to presence of more undecomposed organic material at surface and less organic carbon in sub-surface soil resulted in poor aggregation. The findings are good agreements and well supported by Kumar et al. [6]. Similarly, results also obtained by Pant et al. [7].

Results also revealed that highest values of very labile, labile, less labile and non-labile carbon across the soil depths were obtained under higher fixed yield target of 60 q ha^{-1} of rice and wheat along with FYM 5 t ha^{-1} while lowest values control at all the soil depths. Higher carbon fractions under inorganic fertilizer along with FYM were might be because of more SOC due to which moderate the micro-environment and oxidation of soil carbon. Similar findings were also reported by Brar et al. [8], Zhang et al. [9], Bharali et al. [10] and Parminder et al. [11].

Table 1. Very labile carbon

Treatments	Very labile carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	**15-30**	**30-45**
T_1	1.55	1.41	1.23
T_2	1.83	1.70	1.55
T_3	1.98	1.85	1.67
T_4	2.17	2.08	1.91
T_5	2.15	2.09	1.97
T_6	2.41	2.33	2.25
SE m ±	0.09	0.08	0.08
CD $_{(p=0.05)}$	0.26	0.25	0.23

Table 2. Labile carbon

Treatments	Labile carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	**15-30**	**30-45**
T_1	1.13	0.99	0.87
T_2	1.25	1.13	0.99
T_3	1.29	1.20	1.08
T_4	1.35	1.27	1.13
T_5	1.33	1.28	1.19
T_6	1.43	1.37	1.29
SE m ±	0.06	0.05	0.05
CD $_{(p=0.05)}$	0.17	0.16	0.14

Table 3. Less labile carbon

Treatments	Less labile carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	15-30	30-45
T_1	1.27	1.33	1.35
T_2:	1.35	1.43	1.47
T_3	1.39	1.47	1.52
T_4	1.45	1.55	1.64
T_5	1.47	1.59	1.69
T_6	1.55	1.68	1.80
SE m ±	0.06	0.06	0.07
CD (p=0.05)	0.18	0.20	0.21

Table 4. Non-labile carbon

Treatments	Non- labile carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	15-30	30-45
T_1	1.15	1.11	1.03
T_2	1.21	1.15	1.07
T_3	1.24	1.18	1.11
T_4	1.29	1.21	1.14
T_5	1.31	1.25	1.20
T_6	1.38	1.33	1.29
SE m ±	0.06	0.05	0.05
CD (p=0.05)	0.17	0.16	0.15

3.2 Total Organic Carbon

Results showed that effect of different treatments of STCR based nutrient management on variability of total organic carbon (TOC) content in soil after harvest of wheat crop at different soil depths. It was clearly showed that the content of TOC in soil increased with application of NPK with and without integration of FYM as compared to without NPK application. Results further indicated that the content of TOC in soil was decreased with increase in soil depths which may be attributed to presence of more crop residue near surface which provide the substrate for microbes. The results of the present study are in good agreement with those reported by Zhang et al. [9] and Pant et al. [7].

3.3 Inorganic Carbon

Results showed that variability of inorganic carbon content in soil after harvest of wheat crop at different soil depths was significantly influenced by nutrient management practices based on soil test and targeted yield of rice and wheat. It was observed that the content of inorganic carbon in surface soil comparatively lower than the sub-surface soil. Results further revealed that the highest values (1.01, 1.03 and 1.05 g kg^{-1}) of inorganic carbon across the soil depths were obtained under higher fixed yield target of 60 q along with FYM 5 t ha^{-1} while lowest values (0.61, 0.65 and 0.68 g kg^{-1}) in control at all the soil depths. Inorganic carbon content in soil was higher in sub-surface soil might be because of leaching of carbonates and bicarbonates from surface to sub-surface due to production of organic acids after decomposition of crop residues. The findings are in close agreements and well supported by Singh and Wanjari [12], Kumar et al. [6], Bharali et al. [10], Samal et al. [13] and Kurbah et al. [14].

Table 5. Total organic carbon

Treatments	Total organic carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	15-30	30-45
T_1	5.10	4.84	4.48
T_2	5.64	5.41	5.08
T_3	5.90	5.70	5.38
T_4	6.26	6.10	5.82
T_5	6.26	6.21	6.05
T_6	6.77	6.71	6.63
SE m ±	0.27	0.26	0.25
CD (p=0.05)	0.81	0.79	0.75

Table 6. Inorganic carbon

Treatments	Inorganic carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	15-30	30-45
T_1	0.61	0.65	0.68
T_2	0.73	0.79	0.84
T_3	0.77	0.85	0.91
T_4	0.89	0.93	1.01
T_5	0.87	0.89	0.93
T_6	1.01	1.03	1.05
SE m ±	0.037	0.038	0.041
CD (p=0.05)	0.107	0.114	0.122

3.4 Total Carbon

Results revealed that variability of total carbon content in post- harvest soil of wheat crop across the soil depths was significantly affected by STCR based nutrient management treatments. It was clearly indicated that the content of total carbon in soil decreased with increase in soil depths might be because of less SOC in deeper layer. Results further revealed that higher fixed yield target of 60 q ha^{-1} of rice and wheat along with FYM 5 t ha^{-1} was found highest values (7.78, 7.74 and 7.68 g kg^{-1}) of total carbon content in soil. However, the lowest values (5.71, 5.49 and 5.16 g kg^{-1}) of total carbon in soil were obtained under control at respective soil depths. Higher content of total carbon in soil under integrated use of NPK nutrients with FYM in rice-wheat cropping system may be attributed to higher content of total organic carbon in soil due to moderate loss of soil organic carbon and high addition of organic matter. Results of the present study are in well agreement with those reported by Kumar et al. [6], Samal et al. [12], Kurbah et al. [14], Pant et al. [10].

Table 7. Total carbon

Treatments	Total carbon (g kg^{-1})		
	Soil depths (cm)		
	0-15	15-30	30-45
T_1	5.71	5.49	5.16
T_2	6.37	6.20	5.92
T_3	6.67	6.55	6.29
T_4	7.15	7.03	6.83
T_5	7.13	7.10	6.98
T_6	7.78	7.74	7.68
SE m ±	0.31	0.31	0.29
CD (p=0.05)	0.93	0.90	0.86

4. CONCLUSION

Quantification of changes in soil organic carbon and its fractions (very labile, labile, less labile and non-labile) under the influence of soil test and targeted yield based fertilization is needed for improving soil carbon sequestration and soil quality. Carbon fractions in soil were significantly affected by nutrient management practices at different soil depths. Highest contents of soil organic and inorganic carbon fractions were obtained under T_6 having highest yield target along with FYM and lowest in control. Whereas, carbon fractions of soil decreased with consecutive increase in soil depths except less labile carbon and inorganic carbon which increased with soil depths.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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