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AL Dhamak
Department of Soil Science and Agricultural Chemistry Vasantrao Naik Marathwada Krishi Vidypeeth, Parbhani, Maharashtra, India

SL Waikar
Department of Soil Science and Agricultural Chemistry Vasantrao Naik Marathwada Krishi Vidypeeth, Parbhani, Maharashtra, India

SS Shilewant
Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidypeeth, Parbhani, Maharashtra, India

Corresponding Author:
AL Dhamak
Department of Soil Science and Agricultural Chemistry Vasantrao Naik Marathwada Krishi Vidypeeth, Parbhani, Maharashtra, India

Long – term effect of integrated nutrient management on soil organic carbon fractions in vertisol under sorghum wheat cropping system

AL Dhamak, SL Waikar and SS Shilewant

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Abstract
The field experiment was conducted the year 2014-2015 on the old long-term fertilizer experiment started since 1983 to assess the long – term effect of integrated nutrient management on soil organic carbon fractions in vertisol under sorghum wheat cropping system. The study showed that there was slight decrease in soil bulk density and calcium carbonate increase in porosity and water holding capacity and slightly increase pH and EC of soil over 33 years of sorghum-wheat cropping system receiving organic manures in combination with inorganic fertilizer. And it was observed that various forms of carbon and fractions of humus tended to decrease with depth and use of organics like subabul and FYM in conjunction with NPK fertilizers exerted a remarkable impact on the distribution and built up of various carbon and humus fractions in soil.

Keywords: Integrated nutrient management, bulk density, porosity, organic carbon, TOC.

Introduction

Sorghum-wheat is one of the cropping sequence which is gaining popularity under intensive cultivation on Vertisol in the state of Maharashtra. The cereal-cereal cropping sequence has high requirements for major nutrients and may adversely affect crop production on long run and hence, adequate nutrient management for this cropping sequence needs attention for sustainable soil productivity. Chemical fertilizers/organic manures alone cannot sustain the desired levels of crop production under continuous farming. Integrated nutrient management is very essential which not only sustains high crop production over the years but also improves soil health and ensures safer environment. Green revolution has brought about spectacular increases in food grain production. But, after initial success, situation today has changed in quest of short-term gains without due consideration of long term sustainability. Integration of chemical and organic sources and their efficient management have shown promising results not only in sustaining the productivity but also in maintaining in soil health (Vijay Shankar Babu *et. al*, 2007) [14].

Carbon in soil exists in organic (soil organic carbon: SOC) and inorganic (soil inorganic carbon: SIC) forms; total carbon being the sum of both. Soil organic matter is a genetic term for all organic compounds in the soil except living roots and animals. Inorganic carbon in the soil occurs mainly in carbonate minerals, such as calcium carbonate ($CaCO_3$) and dolomite ($Ca Mg (CO_3)_2$.

Long-term experiments are the primary source of information to determine the effect of cropping systems on soil quality attributes like organic carbon, inorganic carbon and total organic carbon content that are most sensitive to management inputs and to ascertain the impact of long-term use of integrated nutrient on these attributes. (Kharche *et al.* 2013) [6]. The hypothesis of the investigation was that the long term application of balanced and imbalanced fertilization with or without manures under intensive cropping system may influence soil organic carbon fractions and biochemical properties.

Materials and methods

The Long Term Fertilization Experiment on sorghum-wheat crop rotation was established in deep black soils of (*Typic Haplustert*) survey No. 124 of Parbhani block of Central farm, Vasantrao Naik Marathwada Krish Vidyapeeth, Parbhani since 1983. The experiment laid out randomized block design with set of fourteen treatments (Table1) since 31 years and replicated thrice. The experimental soil is clayey in texture, calcareous in nature, moderately alkaline in reaction, low in available nitrogen, medium in phosphorous and high in potassium content.

The soil analysis was carried out at the end of every crop season by following standard methods of analysis and the changes in various soil properties as influenced by INM were studied. Organic carbon and inorganic carbon determined by Heated dichromate method for TOC Total organic carbon determined by dry combustion method, TOC as described by (Technical manual USETA, 2001) [12].

Table 1: Treatment Details

Treatments	Treatments	
	Kharif	**Rabi**
T_1	Control	Control
T_2	50% recommended (40:20:20) NPK kg ha^{-1} through fertilizer	50% recommended (60:30:30) NPK kg ha^{-1} through fertilizer
T_3	50% recommended (40:20:20) NPK kg ha^{-1} through fertilizer	100% recommended (120:60:60) NPK kg ha^{-1} through fertilizer
T_4	75% recommended (60:30:30) NPK kg ha^{-1} through fertilizer	75% recommended (90:45:45) NPK kg ha^{-1} through fertilizer
T_5	100% recommended (80:40:40) NPK kg ha^{-1} through fertilizer	100% recommended (120:60:60) NPK kg ha^{-1} through fertilizer
T_6	50% NPK kg ha^{-1} through fertilizer + 50% N through FYM	100% recommended NPK kg ha^{-1} through fertilizer
T_7	75% NPK kg ha^{-1} through fertilizer + 25% N through FYM	75% recommended NPK kg ha^{-1} through fertilizer
T_8	50% NPK kg ha^{-1} through fertilizer + 50% N through wheat straw	100% recommended NPK kg ha^{-1} through fertilizer
T_9	75% NPK kg ha^{-1} through fertilizer + 25% N through wheat straw	75% recommended NPK kg ha^{-1} through fertilizer
T_{10}	50% NPK kg ha^{-1} through fertilizer + 50% N through green manuring (*Glyricidia*)	100% recommended NPK kg ha^{-1} through fertilizer
T_{11}	75% NPK kg ha^{-1} through fertilizer + 25% N through green manuring (*Glyricidia*)	75% recommended NPK kg ha^{-1} through fertilizer
T_{12}	Farmers practice (40:20:20) NPK kg ha^{-1} and seed without carbofuron treatment	Farmers practice (60:30:30) NPK kg ha^{-1} and 100 kg seed ha^{-1}
T_{13}	75% NPK kg ha^{-1} through fertilizer + 25% N through subabul leaves	75% recommended NPK kg ha^{-1} through fertilizer
T_{14}	50% NPK kg ha^{-1} through fertilizer + 50% N through subabul leaves	100% recommended NPK kg ha^{-1} through fertilizer

Results and discussion

Changes in soil physical properties

Bulk density, porosity and water holding copacity

In this study, bulk density and porocity a very important physical properties of the soil showed perceptible variation in response to different nutrient management treatments (Table 2). The BD and porosity of soil varied from 1.29 to 1.41 Mg m^{-3} and 56.32% to 58.48% in soil 0-15 cm depth and 1.31 to 1.48 Mg m^{-3} and 52.60% to 57.96% in 15-30 cm depth respectively, while BD was increased and porosity was decreased with depth. It was recorded that integrated nutrient management showed significant impact on bulk density and Porosity at various depth, that application of 50% N through FYM, WS, GM with glyricidia and subabul leaves showed lower BD than the treatments comprising of 25% N through there organic manures and application of NPK through only inorganic fertilizers further increased the bulk density. This was mainly attributed to higher organic matter content of the soil which results into better aggregation of soil separates and a consequent increase in volume of micro pores in the manure treated plots Gawande (2015) [4], Bhattacharyya *et al.* (2004) [2], Meshram (2014) [7] and Rasool *et al.* (2008) [8]. Water holding capacity of soil is mainly governed by soil texture. Amongst all treatments, treatment T_6 recorded maximum water holding capacity (55.22%) followed by T_8 (54.80%), T_{10} (54.40%) in surface layer and T_6 recorded maximum water holding capacity (53.11%) followed by T_8 (52.82%), T_{10} (52.76%) in subsurface layer of soil (Table 2). This shows that addition of more organic manures reflects in to increaced WHC has been well documented by Bhattacharya. *et al.*, (2004) [2] and Selvi, *et al.* (2005) [11].

Table 2: Effect of integrated nutrient management on physical properties of soil under sorghum-wheat cropping sequence.

Treatment No.	Bulk density (Mgm^{-3})		Porosity (%)		WHC (%)	
	0-15 cm Depth	15-30 cm Depth	0-15 cm Depth	15-30 cm Depth	0-15 cm Depth	15-30 cm Depth
T_1	1.41	1.48	56.32	52.60	40.47	38.73
T_2	1.30	1.39	56.51	53.50	42.77	41.48
T_3	1.35	1.40	56.67	54.21	45.00	42.01
T_4	1.32	1.41	56.78	54.38	46.19	44.72
T_5	1.38	1.46	56.89	54.80	48.20	46.10
T_6	1.29	1.32	58.48	56.16	55.22	53.11
T_7	1.30	1.36	58.44	57.96	52.00	49.90
T_8	1.29	1.31	58.43	57.04	54.80	52.82
T_9	1.34	1.35	58.12	56.94	53.00	51.00
T_{10}	1.29	1.40	58.25	56.73	54.40	52.76
T_{11}	1.31	1.38	58.24	56.75	50.00	49.00
T_{12}	1.37	1.39	58.08	54.74	42.65	41.30
T_{13}	1.31	1.37	58.32	56.96	47.17	46.65
T_{14}	1.34	1.47	58.35	56.86	45.00	44.00
S.E.±	0.025	0.022	0.40	0.46	0.51	0.39
C.D. at 5%	0.075	0.064	1.16	1.34	1.50	1.15

Changes in soil physic-chemical properties

In the present study the pH value values were varied between 7.72 to 7.93 in surface soil (0-15 cm) and 7.75 to 7.97 in subsurface soil (Table 3). The soil pH values were at lower magnitude when crop received organic manures either through FYM, green manures, subabul leaves and wheat straw. Whereas, the pH values were at higher range under the long- term fertilization (Sawarkar *et al.* 2013) [10]. There was no significant variations seen but there were numerical changes in soil EC values. Combined application of manures and fertilizers showed less increase in EC as compared to only inorganic fertilizer application over initial soil EC. Calcium carbonate in soil varied from 63.00 to 69.00 g kg^{-1} at 0-15 cm depth and 64.00 to 70.00 g kg^{-1} at 15-30 cm depth but it was not much influenced by different nutrient management practices and increased with depth of soil. Increase in subsurface layer due to leaching of Ca and subsequent participation as a carbonate at a lower depth (Dhamak *et al*. 2014 and Waikar *et al*. 2003) [3, 15].

Table 3: Long term effect of integrated nutrient management on physic-chemical properties of soil under sorghum-wheat cropping sequence.

Treatment No.	pH		EC (dSm^{-1})		$CaCO_3$ (g kg^{-1})	
	0-15 cm Depth	15-30 cm Depth	0-15 cm Depth	15-30 cm Depth	0-15 cm Depth	15-30 cm Depth
T_1	7.93	7.90	0.33	0.34	64.00	64.00
T_2	7.92	7.97	0.33	0.33	68.00	68.00
T_3	7.91	7.95	0.32	0.30	66.00	66.00
T_4	7.74	7.75	0.36	0.39	65.00	65.00
T_5	7.80	7.83	0.32	0.36	68.00	68.00
T_6	7.72	7.82	0.31	0.38	64.00	64.00
T_7	7.70	7.92	0.30	0.38	68.00	68.00
T_8	7.81	7.86	0.32	0.38	65.00	65.00
T_9	7.72	7.94	0.34	0.39	63.00	63.00
T_{10}	7.76	7.91	0.30	0.36	68.00	68.00
T_{11}	7.75	7.91	0.34	0.36	69.00	69.00
T_{12}	7.78	7.89	0.36	0.39	65.00	65.00
T_{13}	7.79	7.81	0.37	0.39	65.33	65.33
T_{14}	7.72	7.82	0.38	0.39	63.50	63.50
S.E.±	0.071	0.032	0.04	0.06	2.47	2.47
C.D. at 5%	NS	NS	NS	NS	NS	NS

Changes in carbon fraction

Organic carbon, inorganic carbon and total carbon

The organic carbon, Inorganic carbon and The total organic carbon varied in the range of 7.50 to 10.60 g kg^{-1}, 7.60 to 9.10 g kg^{-1} and 15.50 to 18.70 g kg^{-1} at 0-15 cm depth and it was ranged from 5.00 to 8.30 g kg^{-1}, 8.00 to 8.70 g kg^{-1} and 14.10 to 16.80 g kg^{-1} at 15-30 cm depth, respectively and OC and inorganiccarbon highest in treatment T_6 and lowest value was obtained in T_1 control treatment at both the depths. In case of TOC, the treatment T_6 receiving 50% NPK through fertilizer + 50% NPK through FYM in *kharif* and 100% NPK through fertilizer in *rabi* and T_8 receiving 50% NPK through fertilizer + 50% N through wheat straw in *kharif* and 100% NPK in *rabi* showed high over rest of the treatments.

Table 4: Long term effect of integrated nutrient management on physic-chemical properties of soil under sorghum-wheat cropping sequence.

Treatment No.	Organic carbon (g kg^{-1})		Inorganic carbon (g/kg)		Total carbon (g kg^{-1})	
	0-15 cm Depth	15-30 cm Depth	0-15 cm Depth	15-30 cm Depth	0-15 cm Depth	15-30 cm Depth
T_1	7.50	5.00	8.00	8.50	15.50	14.10
T_2	7.70	5.80	8.00	8.30	15.70	14.10
T_3	8.20	5.30	8.10	8.50	16.30	14.80
T_4	7.90	6.00	8.30	8.60	16.20	14.60
T_5	8.40	6.50	8.00	8.50	16.40	15.00
T_6	10.60	8.30	9.10	8.70	18.70	16.80
T_7	7.80	7.00	8.00	8.40	16.40	15.40
T_8	10.30	7.90	7.90	8.50	18.20	16.40
T_9	9.00	6.90	8.00	8.00	17.00	14.90
T_{10}	9.80	7.50	7.90	8.50	17.70	16.00
T_{11}	8.90	6.80	8.00	8.30	16.90	15.10
T_{12}	8.00	6.20	7.90	8.50	15.90	14.70
T_{13}	8.60	6.60	7.60	8.40	16.30	16.00
T_{14}	9.60	6.90	7.80	8.50	17.40	16.00
S.E.±	0.62	0.54	0.55	0.58	0.63	0.56
C.D. at 5%	1.81	1.57	NS	NS	1.82	1.64

The trend of increasing organic carbon was significant when fertilizers were combined with organic manures viz. FYM, wheat straw, green manuring of glyricidia leaves or subabul leaves. Similer effect reported by Meshram (2014) [7], Sangeeta (2015) [9] and Katkar *et al*. (2011) [5]. The continuous application of organics in combination with inorganic fertilizer or otherwise had no significant influence on inorganic carbon content under various treatments, similar range of inorganic carbon content under various cropping systems was also recorded by Sangeeta (2015) [9]. The conjoint use of chemical fertilizers with FYM found beneficial for maintaining high total carbon contents compared to the use of only chemical fertilizers. TOC content in soil decreased with increase in depth of soil. Similar findings are reported by Gawande (2015) [4] and Arbad and Syed Ismail (2011) in long term fertilizer experiment found the highest total carbon in chemical fertilizers incorporated with FYM or FYM alone applied plots in Vertisol.

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