

Effect of Organic Amendments on Soil Carbon Stock, Yield and Quality of Sugarcane Ratoon

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Authors' contributions

This work was carried out in collaboration among all authors. Author RP conducted the experiment, collected observations and performed the statistical analysis and wrote the first draft of the manuscript. Authors SKT and CKJ designed the experiment and managed the analyses of the study. Author SKS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2018-20 to evaluate the effect of different organic amendments on yield and quality of sugarcane ratoon in calcareous soil at Crop Research Centre, farm at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. The experiment was conducted in randomized block design with 8 treatments viz. control, FYM (farmyard manure) @ 20 t ha⁻¹, biocompost (BC) @ 20 t ha⁻¹, vermicompost (VC) @ 5.0 t ha⁻¹, green manure with moong, sugarcane trash @ 10 t ha⁻¹, FYM + BC+ VC (1: 1: 0.5) @ 20 t ha⁻¹ and recommended dose of fertilizer (RDF) as NPK (170: 50: 60 kg ha⁻¹) and replicated thrice in sugarcane plant-ratoon system. The sugarcane plant crop was taken and after harvest of plant, the ratoon crop was initiated. Addition of organic amendments significantly increased the number of tillers, millable cane and ratoon cane yield which was at par with recommended dose of fertilizer. The cane juice quality was not affected due to different treatments. The mean cane yield (61.7 - 77.1 t ha⁻¹) and sugar yield (4.06-10.56 t ha⁻¹) varied significantly in organic added plots t ha⁻¹ which was found at par with RDF. The sugar yield followed the similar trends of cane yield. The SMBC (soil microbial biomass carbon), CO₂ evolution and carbon stocks were significantly higher in organic amendment

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added plots indicating improvement in soil carbon status. The highest value of CO₂ evolution, SMBC and carbon stocks were observed in the treatment receiving FYM+BC+VC in combination (1: 1: 0.5). Organic amendments had beneficial impact on restoration of soil carbon status, cane and sugar yield of ratoon crop of sugarcane in calcareous soil.

Keywords: Organic amendments; cane yield; juice quality; CO₂ evolution; soil carbon stocks.

1. INTRODUCTION

Sugarcane (*Saccharum* sp. hybrid) is one of the important cash crops of industrial importance next to cotton in India. It is also called as 'wonder cane' due to its multifaceted utility and the vast capability to encounter the demands of the increasing population. It is used for various purposes like production of jaggery, spirit, bio-fuels for generating electricity and this particular sector has acquired the most prosperous status as one of the pivotal agriculture based industries. It is cultivated in an area of about 5 Mha with an average productivity of 68 t ha⁻¹ while, in Bihar, it is cultivated in an area of about 3 Lha with an average productivity of 50 t ha⁻¹. It is long duration and nutrient exhaustive crop which removes about 1.2, 0.22, 2.83 kg N-P-K t⁻¹ of cane produced [1] grown extensively in tropical and subtropical climate. It has been observed in recent years that yield of sugarcane has reached a plateau due to decline in soil fertility status of soil especially soil organic carbon. Inadequate and imbalanced use of chemical fertilizer in India has created problems like depletion of soil organic matter, microbial communities and their activity, increase in soil compactions, declining nutrient status of soil which adversely affect the soil health and cane productivity.

The cane yield of in Bihar is lower mainly due to erratic and imbalanced use of chemical fertilizer and poor ratoon management. The available soil nutrients are low due to less addition of organic matter. Organic farming can be used as one of the alternatives for restoration of soil carbon status of soil and enhancing can yield. It also improves the health of agro ecosystem through biodiversity, nutrient biocycles, soil microbial and bio-chemical activities. A huge gap exists between the available quantity and utilized quantity. The application of organic amendments will be helpful for maintaining soil health and cane productivity especially ratoon yield. The present investigation was undertaken to study the effect of organic amendments on yield and quality of sugarcane ratoon in calcareous soil of Bihar.

2. MATERIALS AND METHODS

A field experiment was carried out during the year 2018-20 at Crop Research Centre farm at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. The experimental plot was medium upland, well drained and having uniform topography. The farm was situated at 25°98' N latitude, 85°67' E longitude and at an altitude of 52.0 m above mean sea level. The climate of the experimental site was subtropical. The experimental soil (0-30 cm) was collected before start of the experiment and after harvest of ratoon. The processed soil samples were used for analysis of chemical parameters. The experimental soil was sandy loam in texture, rich in free CaCO₃ (29.62%) with moderately alkaline pH, low in organic carbon (< 0.50%) and available N, K and medium in P. The mid-late sugarcane variety CoP 2061 was planted on February 2018 and harvested on March 2019. Then ratoon crop of sugarcane was taken which was harvested on February 2020. The laid out experiment was in randomized block design with eight treatments and three replications. The treatments comprised of control, FYM @ 20 t ha⁻¹, biocompost (BC) @ 20 t ha⁻¹, vermicompost (VC) @ 5.0 t ha⁻¹, green manure with moong, sugarcane trash @ 10 t ha⁻¹, FYM + BC+ VC (1: 1: 0.5) @ 20 t ha⁻¹ and recommended dose of fertilizer N, P and K (150: 85: 60 kg ha⁻¹). All the organic amendments and fertilizers were added both in plant and ratoon crop.

Total number of tillers was recorded at 150 days after ratooning (DAR). Number of millable cane (NMC) was counted at the time of harvesting and expressed in (x 10³ ha⁻¹). Three randomly selected detopped and detashed canes were weighed at the time of harvesting from each plot. The average weight per cane was determined. Soil samples were analyzed using standard procedure. The cane juice quality was estimated after harvest of the cane method described by Spencer and Meade [2]. The sugar yield was calculated as CCS (%) x cane yield (t ha⁻¹)/100.

3. RESULTS AND DISCUSSION

3.1 Yield Parameters

The data recorded for yield parameters and cane yield has been presented in Table 1. The maximum number of tillers ($171.99 \times 10^3 \text{ ha}^{-1}$) at 150 days after ratooning (DAR) was noticed in treatments (T_7) receiving FYM + biocompost + vermicompost (1: 1: 0.5) @ 20 t ha^{-1} while, maximum NMC ($112.20 \times 10^3 \text{ ha}^{-1}$) was noticed in treatment (T_8) receiving RDF followed by T_7 ($107.93 \times 10^3 \text{ ha}^{-1}$) and lowest in control ($61.27 \times 10^3 \text{ ha}^{-1}$). However, all the treatments (T_2 – T_8) were found at par with each other in terms of yield attributes and cane yield. This might be due to addition of organic manures enhanced the physical, chemical and biological environment of soil resulting favorable condition for release of nutrients while, direct application of chemical fertilizers increased the NPK levels in RDF. Similar observations were recorded by Thakur et al. [3]. Single cane weight was found non-significant on application of different treatments. The mean weight of single cane varied from 0.598-0.716 kg. The ratoon cane yield varied from 35.8-77.2 t ha^{-1} . The maximum yield (77.2 t ha^{-1}) was observed in treatments (T_8) receiving RDF and lowest was in control (35.8 t ha^{-1}). The cane yield in organic added plots (T_2 – T_7) ranged from 61.7 - 77.1 t ha^{-1} which was at par with RDF. The highest cane yield in fertilizer treated plots could be attributed to immediate and quick supply nutrients through chemical fertilizers while, addition of organic amendments enhanced the physical, chemical and biological properties of soil and increased the available nutrient status resulting the higher ratoon crop yield. Srivastava et al. [4] also found that the plant and ratoon crops yields of sugarcane were found at par with RDF due to addition of different bio-manures viz. farmyard manure, sulphitation press mud cake, biogas slurry and vermicompost applied @ 10 t ha^{-1} . These results are in close agreement with the findings of Thakur et al. [5], Jha et al. [6] and Sinha et al. [7].

3.2 Juice Quality (%) and Sugar Yield

The data recorded for juice quality and sugar yield due to application of different organic sources has been depicted in (Table 2). Addition of different treatments showed non-significant effect on brix, sucrose and purity percent due to application of different treatments. However, the highest value of brix (19.47%) and sucrose (17.24%) was observed in T_5 receiving green

manure with moong and lowest in control with (18.93%) in brix and (16.56%) in sucrose. The mean value of purity coefficient varied from 87.40-88.80%. The highest purity coefficient was recorded in T_2 (88.80%) and T_4 (88.80%) receiving farmyard manure @ 20 t ha^{-1} and vermicompost @ 5.0 t ha^{-1} respectively. However, numerically increased value of brix, sucrose and purity coefficient was recorded in all treatments receiving either organics (T_2 – T_8) or inorganic (RDF) over control (T_1). The application of different organic amendments significantly enhanced the sugar yield which varied from 4.06-10.56 t ha^{-1} due to different treatments. The maximum sugar yield was recorded in treatment T_7 (10.56 t ha^{-1}) receiving FYM+BC+VC (1: 1: 0.5) @ 20 t ha^{-1} . Sugar yield is the function of commercial cane sugar percentage and ratoon cane yield. The addition of different organic sources might have improved the physical condition of soil by reducing bulk density and increasing soil macropores for better root proliferation which finally enhanced the nutrient uptake by plant resulted in higher sugar yield. Similar findings were reported by Thakur et al. [3] and Sinha et al. [7] they stated that cane juice quality viz. brix, sucrose and purity coefficient in cane juice did not differ significantly due to different treatments. Commercial cane sugar (CCS) which is a function of cane yield and sucrose content exhibited similar trend of cane yield.

3.3 Carbon Parameters

The significant variation in CO_2 evolution soil microbial biomass carbon (SMBC) and soil organic carbon stocks (SOCS) observed after the harvest of ratoon crop due to different treatments (Figs. 1, 2 & 3). The highest value of CO_2 evolution, SMBC and SOCS were observed in the treatment T_7 ($65.04 \text{ mg } 100 \text{ gm}^{-1} \text{ soil day}^{-1}$), ($243.15 \text{ mg kg}^{-1}$), and (14.09 kg ha^{-1}) respectively, receiving FYM+BC+VC (1: 1: 0.5) @ 20 t ha^{-1} and lowest in control ($40.30 \text{ mg } 100 \text{ gm}^{-1} \text{ soil day}^{-1}$), ($135.64 \text{ mg kg}^{-1}$), and (8.78 kg ha^{-1}), respectively. The CO_2 evolution, SMBC and soil carbon stocks were at par with each other. However, the highest value was observed due to application of different organic amendments. This might be due to addition organic amendments improved the number of microorganisms in soil resulted in increased microbial activity and higher microbial respiration. The addition of organic amendments increased microbial population and its activities in soil resulted in significantly higher CO_2 evolution [8]. Choudhary et al. [9] also

stated that addition of organic amendments improved the soil properties and create a favorable soil environment for improving biological and microbial activities that resulted in increased SMBC. Mthimkhulu et al. [10] showed that addition of organic substances increased the soil organic carbon and accelerated the microbial activities in all treatments. Aher et al. [11] also found that the soil organic carbon (SOC) showed highest accumulation under the treatments receiving organic manures alone or in combination with liquid organics resulted 20-23% increase in SOC over control and 13-16% over

conventional farming under soybean (*Glycine max*, cv. JS 335) wheat (*Triticum durum*, cv. HI 8498) cropping system. Manna et al. [12] also reported increase in SOC with the application of FYM alone or in combination with recommended NPK fertilizers over absolute control and sole NPK fertilizer application. The significant increase in soil organic carbon stocks due to addition of organic amendments could be attributed to increase in the organic carbon content in soil and also improvement in bulk density. Similar findings were also recorded by Naik et al. [13] and Mulat et al. [14].

Table 1. Effect of organic amendments on yield attributes parameters and ratoon cane yield

Treatments	No of tillers (x 10 ³ ha ⁻¹)	NMC (x 10 ³ ha ⁻¹)	Single cane weight (kg)	Cane yield (t ha ⁻¹)
T ₁ : Control	99.62	61.27	0.598	35.9
T ₂ : FYM @ 20 t ha ⁻¹	153.72	101.33	0.653	66.7
T ₃ : Biocompost @20 t ha ⁻¹	152.65	99.00	0.664	64.5
T ₄ : Vermicompost @ 5.0 t ha ⁻¹	158.74	101.07	0.713	72.0
T ₅ : Green manuring with moong	165.57	90.87	0.681	61.8
T ₆ : Sugarcane trash @ 10 t ha ⁻¹	158.24	91.27	0.676	61.9
T ₇ : FYM + Biocompost + Vermicompost (1: 1: 0.5) @ 20 t ha ⁻¹	171.99	107.93	0.716	77.2
T ₈ : RDF (N-P ₂ O ₅ -K ₂ O)	162.69	112.20	0.685	77.3
SEm(±)	8.91	7.25	0.04	5.42
CD (P=0.05)	27.29	22.21	NS	16.60

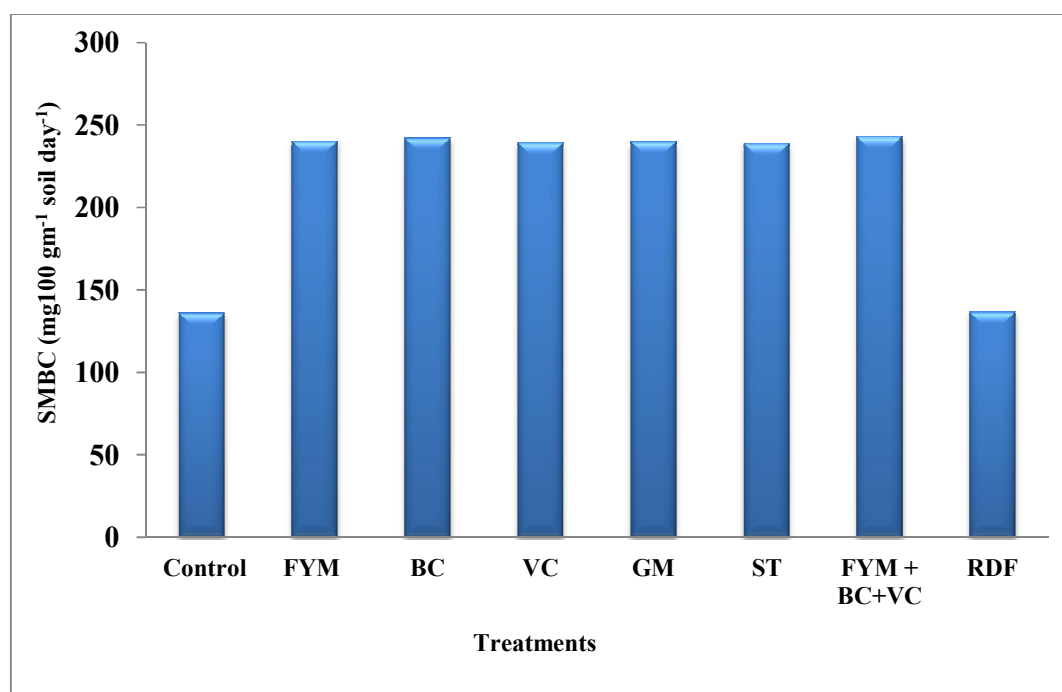


Fig. 1. Effect of different organic amendments on SMBC

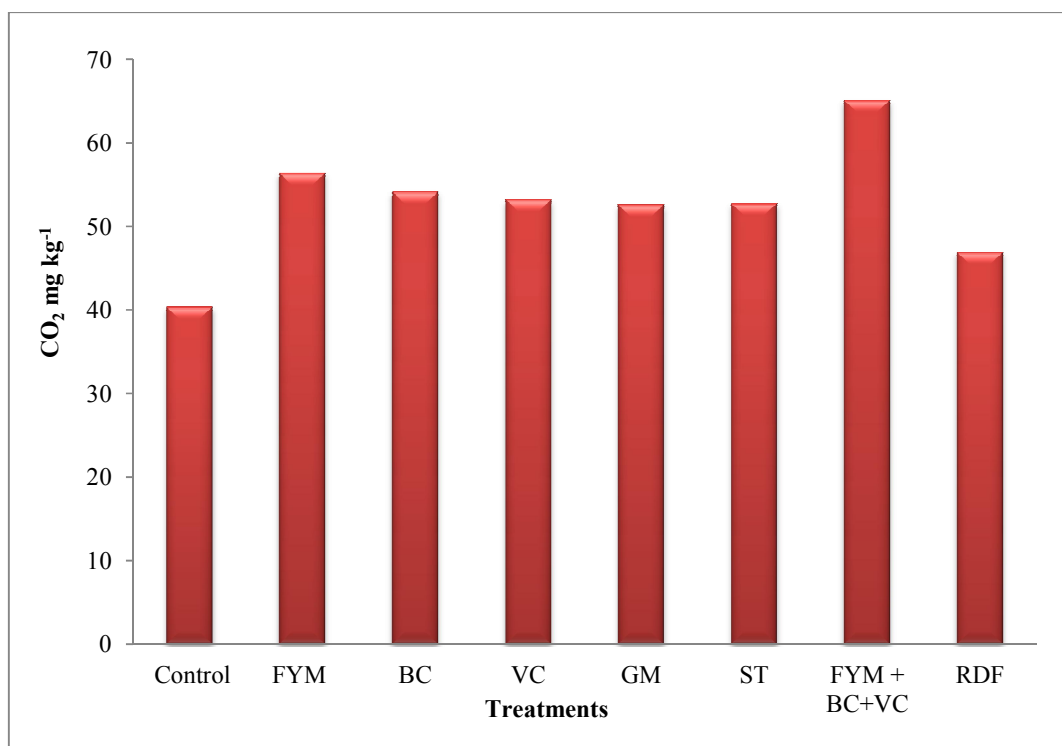


Fig. 2. Effect of different organic amendments on CO₂ evolution

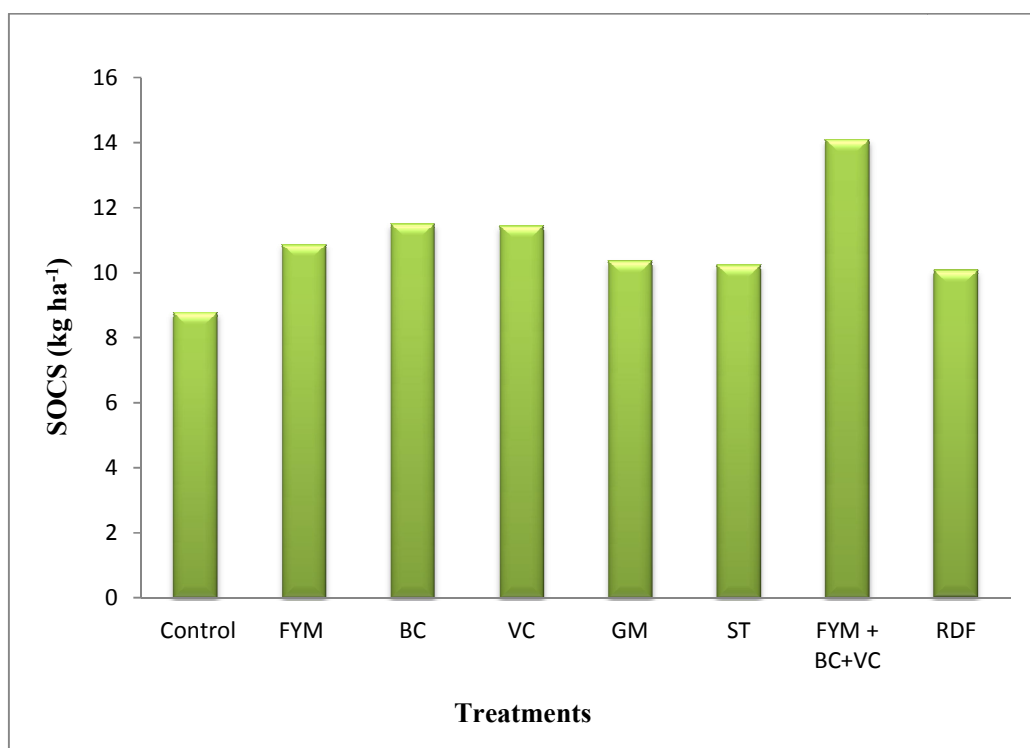


Fig. 3. Effect of different organic amendments on soil carbon stocks (SOCS)

FYM: Farm yard manure; BC: Biocompost @20 t ha⁻¹; VC: Vermicompost @ 5.0 t ha⁻¹, GM: Green manuring with moong, ST: Sugarcane trash @ 10 t ha⁻¹ RDF: (170 N-50 P₂O₅- 85 K₂O kg ha⁻¹)

Table 2. Effect of organic amendments on cane juice quality and sugar yield of ratoon cane

Treatments	Juice quality (%)			Sugar yield (t ha ⁻¹)
	Brix	Sucrose	Purity	
T ₁ : Control	18.93	16.56	87.40	4.06
T ₂ : FYM @ 20 t ha ⁻¹	19.33	17.17	88.80	7.94
T ₃ : Biocompost @20 t ha ⁻¹	19.13	16.71	87.33	7.40
T ₄ : Vermicompost @ 5.0 t ha ⁻¹	19.20	17.05	88.80	9.48
T ₅ : Green manuring with moong	19.47	17.24	88.57	8.48
T ₆ : Sugarcane trash @ 10 t ha ⁻¹	19.40	17.17	88.43	8.43
T ₇ : FYM + Biocompost + Vermicompost (1: 1: 0.5) @ 20 t ha ⁻¹	19.13	16.83	87.93	10.56
T ₈ : RDF (N-P ₂ O ₅ -K ₂ O)	19.07	16.71	87.60	6.83
SEm(±)	0.32	0.30	0.54	0.66
CD (P=0.05)	NS	NS	NS	2.02

4. CONCLUSIONS

Based on these results it may be concluded that addition of organic amendments like FYM @ 20 t ha⁻¹, biocompost (BC) @ 20 t ha⁻¹, vermicompost (VC) @ 5.0 t ha⁻¹, green manure with moong, sugarcane trash @ 10 t ha⁻¹ and FYM + BC+ VC (1: 1: 0.5) @ 20 t ha⁻¹ had beneficial impact on restoration of soil carbon status, cane and sugar yield of ratoon crop of sugarcane in calcareous soil of Bihar.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Menhi Lal, Singh AK. Importance of plant nutrients in sugarcane. *Fertilizer News*. 2002;47(11):91-98.
- Spencer GL, Meade GP. Sugarcane hand book. John Wiley and Sons, London; 1964.
- Thakur SK, Jha CK, Alam M, Singh VP. Productivity, quality and soil fertility of sugarcane (*Saccharum* spp complex hybrid) plant and ratoon grown under organic and conventional farming system. *Indian Journal of Agricultural Sciences*. 2012;82(10):896-899.
- Srivastava TK, Singh KP, Singh P, Suman A, Singh SR, Verma RR, Singh VK, Singh RK. Effect of bio-manures on soil quality, cane productivity and soil carbon sequestration under long-term sugarcane (*Saccharum officinarum*) plant-ratoon system in Indian sub-tropics. *Indian Journal of Agricultural Sciences*. 2018; 88(11):1696-1703.
- Thakur SK, Jha CK, Kumari G, Singh VP. Effect of Trichoderma inoculated trash, nitrogen level and biofertilizers on performance of sugarcane (*Saccharum officinarum*) in calcareous soils of Bihar. *Indian Journal of Agronomy*. 2010;55(4): 308-311.
- Jha CK, Sinha SK, Thakur SK. Enhancing soil fertility, nutrient uptake and sugarcane productivity through integrated use of Fe and organics in sub-tropical system. *Indian Journal of Ecology*. 2017;44(5):521-525.
- Sinha SK, Kumar V, Jha CK. Effect of integrated use of bio-compost and nitrogen on productivity and soil properties of sugarcane plant-ratoon system in calcareous soil. *Sugar Tech*. 2017;19(5):485-491.
- Kumari G, Thakur SK, Kumar N, Mishra B. Long term effect of fertilizer, manure and lime on yield sustainability and soil organic carbon status under maize (*Zea mays*) wheat (*Triticum aestivum*) cropping system in Alfisols. *Indian Journal of Agronomy*. 2013;58(2):89-95.
- Choudhary OP, Gill JK, Singh B. Water extractable carbon pools and microbial biomass carbon in sodic water irrigated soil amended with gypsum and organic manures. *Pedosphere*. 2013;23:88-97.
- Mthimkhulu S, Podwojewski P, Hughes J, Titshall L, Antwerpen RV. The effect of 72 years of sugarcane residues and fertilizer management on soil physico-chemical properties. *Agriculture, Ecosystems and Environment*. 2016;225:54-61.
- Aher SB, Lakaria BL, Kaleshananda S, Singh AB, Ramana S, Thakur JK, Biswas AK, Jha P, Manna MC, Yashona DS. Soil microbial population and enzyme activities under organic, biodynamic and

- conventional agriculture in semi-arid tropical conditions of Central India. *Journal of Experimental Biology and Agricultural Sciences*. 2018;6(5):763–773.
12. Manna MC, Sahu A, Rao A. Impact of long-term fertilizers and manure application on C-sequestration efficiency under different cropping systems. *Indian Journal of Soil Conservation*. 2012;40: 70-77.
 13. Naik SK, Maurya S, Bhatt BP. Soil organic carbon stocks and fractions in different orchards of eastern plateau and hill region of India. *Agroforestry Systems*. 2016;2-13.
 14. Mulat Y, Kibtret K, Bedadi B, Mohammed M. Soil organic carbon stock under different land use types in Kersa Sub Watershed, Eastern Ethiopia. *African Journal of Agricultural Research*. 2018; 13(24):1248-1256.

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