Carbon Sequestration in Sugarcane Plant-soil System as Influenced by Nutrient Integration Practices under Indo-Gangetic Plains of India

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Authors' contributions

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

Original Research Article

ABSTRACT

Sugarcane is a multi-purpose crop. The capability of sugarcane crop to sequestrate carbon into soil and plant is of great importance. Under this study the carbon sequestration in planted sugarcane and their rhizospheric soil under different nutrient management practices was assessed. As IPCC reported, that the rising temperature of earth surface resulted of GHGs emission which causes global warming. In order to stabilize the global temperature, the anthropogenic CO_2 has to be

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mitigated to a significant level and the surplus atmospheric CO_2 in plants and soil has to be sunk, under this circumstance, sugarcane cultivation plays pivotal role in utilising CO_2 since it is a C_4 plant having high efficiency of utilising CO_2 during photosynthesis. There is another intervention might be enhancing the CO_2 capture by changing the nutrient management practices which enhances chlorophyll synthesis by the way of increasing nitrogen efficiency in sugarcane. The different treatment composition enhances photosynthesis where more CO_2 has been captured. Thus the sugarcane crop and rhizospheric soils act as important carbon sinks in decarbonisation of atmosphere that ultimately reduces carbon level and causes the global cooling.

Soil Properties and Carbon Storage: The results showed that soil physical properties and chemical properties were significantly differed among treatments due to application of different organic amendments over control. Soil organic carbon (SOC) was analysed which ranges from 0.47 to 0.67%. The different organic amendments treatments had a considerable effect on soil bulk density and porosity with significant improvement in soil carbon storage.

Plant Carbon Storage: The carbon stocks in different sugarcane plant parts, including roots, shoots and leaves were significantly different. The highest amount of carbon stock was found in leaves (877.08 kg ha^{-1}) under T_6 followed by roots (668.74 kg ha^{-1}) in T_2 and carbon stock in shoots (422.77 kg ha^{-1}) in T_5 showing that 30.41% and 107.58% more carbons were stored in the leaves as compared to the roots and shoots while in roots 58.18% more carbon stored in comparison to shoots. The total carbon storage in sugarcane biomass including aboveground parts and belowground part i.e. roots, in different treatment was significantly different. The mean value of carbon stored in the aboveground parts (leaves and stalks) was significantly higher (1239.65 kg ha^{-1}) than that of underground plant part (621.73 kg ha^{-1}) (roots). The results showed that the sugarcane farming practices have promising effect for carbon sequestration and consequently enhancing the mitigation of climate change impacts.

1. INTRODUCTION

Sugarcane is a perennial grass cultivated commercially over 90 countries with widespread global area of approximately 26×10^6 ha and worldwide harvest of 1.83 billion tones [1]. Sugarcane is mainly used for sugar production. It is also used for livestock feeding and producing ethanol as a biofuel [2]. However, the capability of sugarcane crop being C4 plant to sequestrate carbon into plant and soil is of great importance. The leading cause of climate change is greenhouse gasses (GHGs), including carbon dioxide (CO_2) mainly emitted from human's unsustainable activities [3]. As Inter-governmental Panel on Climate Change [4] reported, that the temperature of earth surface is expected to rise by 1.4°C to 5.8°C at the end of the century, due to GHGs emission and global warming, so in order to stabilize the global temperature, the anthropogenic CO_2 has to be mitigated [5] and the surplus atmospheric CO_2 in plants and soil has to be sunk, under this circumstance, sugarcane cultivation plays pivotal role in utilising CO_2 from atmosphere since, it is a C_4 plant having high efficiency of utilising solar radiation and consuming more amount of CO_2 during photosynthesis. Certain interventions helpful in enhancing CO_2 capture by the nutrient integration strategy which ultimately enhances chlorophyll synthesis by the way of increasing nitrogen efficiency. The sustainable approaches might be enhancing the CO_2 capture by sugarcane farming [6,7]. The cropland soils act as important carbon sinks [8] which play a potential role in reduction of atmospheric carbon [9]. Previous studies have indicated that leaving sugarcane leaves and trashes on soil, improves physical, chemical and biological properties of soil [10]. Mulching with the sugarcane residues on the soil improves soil biological activity [11], decreases soil bulk density [12], enhances soil aggregation & infiltration rate [13] and reduces gas emissions compared to the traditional burning of crop residue after harvesting. A farm with burned residues had 30% lower carbon content particulate organic matter and microbial biomass carbon than those of a farm where the trashes and residues were left on the soil [14]. A survey also showed that leaving the sugarcane residue biomasses in soil returned a remarkable organic matter compared to the soils where the sugarcane residues were burned [15]. On the other hand, heavy sugarcane biomass in above and underground parts of the soils could act as important pools for carbon sequestration and consequently enhancing the mitigation of climate change impacts (Ref.). However, there is not

much research carried out on the capability of carbon sequestration in sugarcane farms in India. This study therefore was conducted to examine the status of carbon sequestration in sugarcane farmlands in Bihar. The total area of sugarcane cultivation is about 3.15 lakh ha in a flat plain managed with plant cultivation system in Bihar. As per the mean value of carbon stored by sugarcane farming @1861.37 kg/ha only Bihar state can sequester carbon up to 586.33 M kg/ha through sugarcane farming. The different treatment composition enhances photosynthesis where more CO_2 has been captured. Under this study the carbon sequestration in planted sugarcane and soil under different nutrient management practices were assessed. This paper is written with the Objectives as, to estimate carbon storage in sugarcane plant and soil system; to evaluate the changes in soil physical, chemical and biological properties; as well as correlation study among soil properties and carbon storage.

2. MATERIALS AND METHODS

2.1 Experimental Site and Treatment Details

The experiment conducted at chhawaniya experimental farm in the year 2022-2023 near the Burhi Gandak river in Bihar, India, situated at coordinates 26.0039° N, 85.6753° E. at an altitude of 52.0 m above sea level. This site experiences an annual rainfall of 1909 mm, a relative humidity of 80.45%, and an average temperature of 22.45 °C. This site falls within the ustic moisture regime of the subtropical region of India. The experimental soil is classified as Entisols order, Fluvents suborder and Typic Ustifluvent great group.

The experiment was conducted with eight treatments and three replications in a randomized complete design, the treatment details are as follows. T_1: Control; T_2: FYM @ 20 t ha^{-1}; T_3: BC @20 t ha^{-1}; T_4: VC @ 5.0 t/ha; T_5: GM with mung; T_6: ST @ 10 t ha^{-1}; T_7: FYM + BC + VC; T_8: RDF. Notation: FYM: farm Yard Manure; BC: Biocompost; VC: vermicompost; GM: green manure; ST: sugarcane trash. (Ref. and all abbreviations in complete at first time).

2.2 Soil Sampling and Laboratory Analysis

The soil samples were randomly collected at 0-30 cm top layer and soil organic carbon was analysed in laboratory following the standard procedure (Ref.). Simultaneously, both aboveground and underground parts of sugarcane plants (at any sugarcane growth stage) were sampled and the carbon content of each part was measured separately. The total soil organic carbon and sequestrated carbon in plant parts like root, stem and leaves were analysed. The air-dried soil samples were sieved through a 2-mm screen and prepared for analysis in the soil laboratory. Soil texture was determined using the hydrometer method [16]. Soil pH was determined using an electric pH meter [17] and electrical conductivity (EC) was determined from a soil-water (1:1) suspension using an electric conductivity meter [18]. Soil bulk density was determined using a core sampler of 8 cm diameter and soil organic carbon (SOC) was measured using wet titration method (Walkley and Black 1934). Method is old, not present in references list, there are many modern method in scientific field literature.

2.3 Plant Sampling Laboratory Analysis

Five plant samples were taken from each treatments randomly, each within an area of 1 m^2 before the harvesting. The plant samples were weighted immediately to estimate the ground biomass. The leaves and stems were subsequently separated and dried in an oven at 65°C (Ref.) till get the two constant weigh and then re-weighted. The plant underground parts including roots and basal parts were also sampled within the depth of 0-60 cm and dried in an oven and then weighted accordingly. In order to determine plant organic carbon, the leaves, stems and roots were hammer-milled to pass through a 0.5 mm sieve. The carbon content was then determined using a CHN (Complete name first time) analyzer and the mean values were used for the statistical analysis using the ANOVA procedure.

3. RESULTS AND DISCUSSION

3.1 Soil Properties and Carbon Storage

The soil physical properties under different treatments are summarized in Table 1. The treatments include various organic amendments such as FYM, BC, VC, GM with mung, ST (Abbreviation list or complete names), as well as inorganic amendments. The soil physical parameters like sand, silt, and clay composition, moisture content, bulk density and pore space, mechanical resistance were recorded. Across all treatments, the soil composition in terms of sand,

silt, and clay content showed minimal variation. However, it is noteworthy that treatments involving organic amendments generally exhibited slightly higher sand content compared to the control and RDF treatments. Conversely, clay content was slightly higher in treatments involving ST and RDF compared to organic amendment treatments. These variations, although minor, might have implications for soil structure and water retention capacity. The moisture content of the soil varied significantly among treatments, with FYM + BC + VC treatment showing the highest moisture content (42.15%) followed by ST (44.97%) and VC (43.21%). Conversely, the control treatment exhibited the lowest moisture content (36.42%). This indicates that organic amendments, particularly a combination of FYM, BC, and VC, can significantly improve soil moisture retention, which is crucial for plant growth and drought resistance. The finding is in accordance with the work of Mishra et al. [19]. Bulk density, an indicator of soil compaction, was notably lower in treatments involving organic amendments compared to the control and RDF treatments. Among the organic amendments, BC and FYM + BC + VC treatments exhibited the lowest bulk density, suggesting improved soil structure and porosity. This was further supported by higher pore space percentages observed in these treatments, indicating better aeration and water infiltration capacities. The bulk density and pore space reported in this study are consistent with previous research findings [20], which suggest that organic amendments positively influence to decrease bulk density and increase macro-porosity in soils. Mechanical resistance, representing soil strength or compaction, showed considerable variation among treatments. BC treatment exhibited the lowest mechanical resistance (1.54 MPa), indicating softer and less compacted soil, while the control treatment showed the highest resistance (1.65 MPa). This suggests that organic amendments, particularly BC, can mitigate soil compaction and improve soil workability, facilitating root growth and nutrient uptake Sharifi et.al. [21]. Overall, the results demonstrate that organic amendments, especially a combination of FYM, BC, and VC, positively influence soil physical properties, enhancing moisture retention, reducing compaction, and improving soil structure and porosity. These findings underscore the importance of incorporating organic inputs practices in promoting sustainable soil management and enhancing sugarcane

productivity that ultimately sequester more carbon from atmosphere.

3.2 Chemical Properties of Rhizospheric Soil under Experimental Field

Table 2 presents the soil chemical properties and the organic carbon storage (SOC) in rhizospheric soil of planted sugarcane under different treatments.

3.3 pH and Electrical Conductivity (EC)

The pH values of soil ranged from 8.14 to 8.59 across different treatments, indicating alkaline soil conditions. There were no significant differences in pH among treatments, suggesting that the application of organic amendments or RDF did not significantly alter soil acidity. Similarly, EC values varied slightly among treatments, reflecting variations in soil salinity levels. Overall, the soil remained within acceptable ranges for sugarcane cultivation. The optimal soil pH for sugarcane can range from slightly acidic to alkaline, depending on the specific conditions of the plantation. Organic matters help optimising the pH of soil making it suitable for uptake of nutrients, this matching with the work of Rusli et al. [22].

3.4 Soil Organic Carbon (SOC) and its Carbon Storage

The soil organic carbon content ranged from 0.47% to 0.67% across treatments, with the highest value observed in the sugarcane trash treatment and the lowest in the FYM + BC + VC treatment. However, when considering SOC storage, which takes into account soil depth and bulk density, the ST treatment exhibited the highest SOC storage (1376.85 t/ha), followed by VC (1174.50 t/ha) and RDF (1287.00 t/ha). Conversely, the FYM + BC + VC treatment showed the lowest SOC storage (902.40 t/ha). These results suggest that incorporating ST or VC can significantly enhance SOC storage, contributing to soil fertility and carbon sequestration. Soil organic carbon is affected directly by the farm management practices such as crop type, manure application, tillage intensities, irrigation efficiency, harvesting approaches and the life period of crop plants [23,24]. It has been reported that soil texture particularly clay content have a key role in capability of soil carbon sequestration [25]. This is consistent with the results reported by

Ghanbarian et al. [26] and Sadeghi and Raeini [7]. However, according to another research, soil bulk density and sand content had negative effects on soil carbon storage. This result is in accordance with the results of a study conducted by Suman et al. [27] who reported that reduction in soil bulk density would lead to increase in SOC of sugarcane farms. It seems that the differences in chemical and physical properties of soil in different nutrient management as outlined above might have caused the considerable differences in soil organic carbon content.

3.5 Available Macro and Secondary Nutrients

The availability of nutrients such as nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) varied among treatments while there were no significant differences in available N among treatments, ST @ 10 t ha^{-1} treatment exhibited significantly lower available phosphorus compared to other treatments.. The sugarcane trash treatment exhibited the highest levels of available N (284.36 kg/ha), available P (24.48kg/ha), available K (193.05 kg/ha), and available S (16.98 mg/kg), indicating efficient nutrient cycling and decomposition of organic matter. Conversely, the FYM + BC + VC treatment showed the lowest levels of available nutrients, suggesting potential limitations in nutrient release and availability. These findings highlight the importance of selecting appropriate organic amendments to meet the nutrient requirements of sugarcane crops. Conversely, RDF treatment showed the highest available phosphorus content. Available potassium content was highest in ST @ 10 t ha^{-1} treatment, while available sulphur content showed no significant differences among treatments. Overall, the results demonstrate that organic amendments, particularly ST and VC, can positively influence soil chemical properties, enhance SOC storage, and improve nutrient availability. However, the effectiveness of organic amendments may vary depending on factors such as application rate, soil type, and environmental conditions.

3.6 Carbon Sequestration in Different Cane Parts

The plant sequestered carbon (kg ha^{-1}) content in different plant parts of planted sugarcane

under various treatments is summarized in Table 3. The below-ground carbon storage, primarily in roots, ranged from 586.45 to 668.74 kg ha^{-1} across treatments. The highest below-ground carbon storage was observed in the FYM @ 20 t ha^{-1} treatment, while the control treatment exhibited the lowest storage. Treatments involving organic amendments generally showed higher below-ground carbon storage compared to the control and RDF treatments. The above-ground carbon storage, including stems and leaves, ranged from 398.77 to 422.77 kg ha^{-1} for stems and 779.14 to 872.15 kg ha^{-1} for leaves across treatments. The highest above-ground carbon storage in stems was observed in the ST @ 10 t ha^{-1} treatment, while the highest storage in leaves was observed in the BC @ 20 t ha^{-1} treatment. Again, treatments involving organic amendments generally showed higher above-ground carbon storage compared to the control and RDF treatments. The results of this study also indicated that sugarcane leaves and roots had higher carbon storage than shoots (Table 3). Several studies have found that perennial plants with woody organs had higher potential to reserve the organic carbon compared to annual plants [26]. Overall, 1291.82 kg ha^{-1} (66%)) carbon storage belonged to the aboveground plant organs of T$_6$ and 668.74 kg ha^{-1} belonged to the roots of sugarcane of T$_2$ showing that the considerable carbon storage capability of sugarcane. The total stored carbon above ground, comprising stems and leaves, ranged from 1201.91 to 1291.82 kg ha^{-1} across treatments. The highest total stored carbon above ground was observed in the ST @ 10 t ha^{-1} treatment. Additionally, the total stored carbon (combining below-ground and above-ground carbon) ranged from 1774.11 to 1947.19 kg ha^{-1}, with the highest value observed in the ST @ 10 t ha^{-1} treatment. The carbon sequestration values reported in this study align with previous research findings [28], which suggest that organic amendments positively influence carbon storage in agricultural systems. Overall, the results indicate that treatments involving organic amendments contribute to higher carbon sequestration in both below-ground and above-ground cane parts compared to conventional treatments. This highlights the importance of organic farming practices in enhancing carbon sequestration potential in sugarcane cultivation, which can contribute to mitigating climate change impacts. However, further research is needed to assess the long-term effects of these treatments on carbon sequestration and soil health.

Table 1. Effect of different organic and inorganic amendments on soil physical properties under sugarcane cultivation

Treatments	Sand (%)	Silt (%)	Clay (%)	Moisture content (%)	Bulk density (gcm^{-3})	Pore Space (%)	Mechanical Resistance (Mpa)
T$_1$	31.83	54.75	13.42	36.42	1.37	45.42	1.65
T$_2$	32.86	53.89	13.25	41.08	1.39	46.16	1.74
T$_3$	33.13	53.61	13.26	43.92	1.32	45.65	1.54
T$_4$	31.63	54.12	14.25	43.21	1.35	47.49	1.63
T$_5$	32.16	55.69	12.15	39.56	1.36	46.25	1.59
T$_6$	32.65	53.23	14.12	44.97	1.34	46.53	1.61
T$_7$	31.73	53.83	14.44	42.15	1.28	45.13	1.52
T$_8$	31.15	54.89	13.96	38.45	1.32	45.18	1.58
Mean Value	32.14	54.25	13.60	41.22	1.34	45.97	1.61
SEm ±	1.6	0.69	0.49	1.31	0.02	0.79	0.03
CD (P=0.05)	2.1	1.98	1.26	3.98	0.09	2.38	0.08

Note: T1: Control; T2: FYM @ 20 t ha-1; T3: BC @20 t ha-1; T4: VC @ 5.0 t/ha; T5: GM with mung; T6: ST @ 10 t ha-1; T7: FYM + BC + VC; T8: RDF.(Abbreviations or complete first time)

Table 2. Effect of different organic and inorganic amendments on soil chemical properties and soil organic carbon storage of planted sugarcane field

Treatments	pH (1:2.5)	EC (dSm^{-1})	SOC (%)	Soil organic carbon storage* (t/ha)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (mg/kg)
T$_1$	8.14	0.82	0.51	1025.51	254.18	22.04	139.62	15.69
T$_2$	8.16	0.54	0.49	1021.65	219.32	19.15	120.59	14.38
T$_3$	8.15	0.48	0.59	1168.20	228.04	23.23	151.62	15.29
T$_4$	8.53	0.62	0.58	1174.50	284.36	22.98	152.38	16.49
T$_5$	8.59	0.68	0.53	1081.20	235.42	24.48	123.69	16.98
T$_6$	8.49	0.38	0.67	1376.85	168.52	21.14	172.32	16.42
T$_7$	8.16	0.62	0.47	902.40	238.26	18.98	152.18	15.93
T$_8$	8.43	0.73	0.65	1287.00	258.04	21.09	193.05	13.04
Mean Value	**8.33**	**0.61**	**0.56**	**1129.66**	**235.77**	**21.63**	**150.68**	**15.53**
SEm ±	0.06	0.02	0.05	39.51	9.4	0.97	5.79	0.63
CD (P=0.05)	0.21	0.08	0.16	138.9	28.20	2.92	17.93	1.97

*Soil organic carbon storage (t/ha) = 1 ha× soil depth (m) × soil bulk density (g/cm^3) ×SOC (%)

Table 3. Effect of different organic and inorganic amendments on plant sequestered carbon (kg ha^{-1}) in different parts of planted sugarcane

Treatments	Stored carbon (kg ha^{-1})				
	below ground	above ground		Total stored carbon above ground	Total stored carbon (kg ha^{-1})
	Roots	Stems	Leaves	stem+ leaf	Root+ Stem+ Leaf
T$_1$	586.45	403.12	784.54	1187.66	1774.11
T$_2$	668.74	420.12	785.48	1205.6	1874.34
T$_3$	598.12	398.77	872.15	1270.92	1869.04
T$_4$	645.31	405.87	862.31	1268.18	1913.49
T$_5$	616.69	422.77	779.14	1201.91	1818.60
T$_6$	655.37	414.74	877.08	1291.82	1947.19
T$_7$	596.53	419.64	867.14	1286.78	1883.31
T$_8$	606.61	412.15	792.15	1204.3	1810.91
Mean Value	621.73	412.15	827.50	1239.65	1861.37
SEm ±	17.29	7.97	24.61	26.31	49.51
CD (P=0.05)	53.82	23.78	73.63	84.23	163.32

Table 4. Correlation coefficients among different soil properties and SOC%

	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	Bulk density (gcm^{-3})	Pore Space (%)	Mechanical Resistance (Mpa)	pH (1:2.5)	EC (dSm^{-1})	SOC (%)
Sand (%)	1									
Silt (%)	-0.50443	1								
Clay (%)	-0.3725	-0.61342	1							
Moisture (%)	0.522121	-0.77546	0.355895	1						
Bulk density (gcm^{-3})	0.28321	0.25712	-0.53539	-0.31101	1					
Pore Space (%)	0.165652	-0.14636	0.005791	0.478477	0.448434	1				
Mechnical Resistance (Mpa)	0.206593	0.013519	-0.20349	-0.23237	0.900452	0.387794	1			
pH (1:2.5)	-0.30522	0.36479	-0.11291	0.144917	0.101304	0.601097	-0.06322	1		
EC (dSm^{-1})	-0.72655	0.78556	-0.17978	-0.91598	0.115572	-0.36154	0.039509	-0.0564	1	
SOC (%)	-0.03448	-0.19752	0.243831	0.332486	-0.13615	0.225035	-0.19117	0.535278	-0.37008	1

3.7 Correlation Coefficients among Different Soil Properties and SOC

Table 4 displays correlation coefficients among different soil properties and the Soil Organic Carbon (SOC %) in the given dataset. Correlation coefficients range from -1 to 1, where -1 indicates a strong negative correlation, 1 indicates a strong positive correlation, and 0 suggests no correlation. Sand (%) and SOC (%): The correlation coefficient between sand content and SOC% is -0.03448, indicating a very weak negative correlation. This suggests that there is little to no relationship between the sand content in the soil and the percentage of soil organic carbon Arunrat et al. [29]. Silt (%) and SOC (%): The correlation coefficient between silt content and SOC% is -0.19752, indicating a weak negative correlation. There is a slight tendency for higher silt content to be associated with lower SOC% [30]. Clay (%) and SOC (%): The correlation coefficient between clay content and SOC% is 0.243831, indicating a weak positive correlation. This suggests that higher clay content in the soil may be associated with a slightly higher percentage of SOC. Moisture (%) and SOC (%): The correlation coefficient between soil moisture and SOC% is 0.332486, indicating a moderate positive correlation. This suggests that as soil moisture increases, there may be a tendency for higher SOC%. Bulk Density (gcm^{-3}) and SOC (%): The correlation coefficient between bulk density and SOC% is -0.13615, indicating a weak negative correlation. There is a slight tendency for higher bulk density to be associated with lower SOC%. Pore Space (%) and SOC (%): The correlation coefficient between pore space and SOC% is 0.225035, indicating a weak positive correlation. This suggests that higher pore space in the soil may be associated with a slightly higher percentage of Soil Organic Carbon. Mechanical Resistance (Mpa) and SOC (%): The correlation coefficient between mechanical resistance and SOC% is -0.19117, indicating a weak negative correlation. There is a slight tendency for higher mechanical resistance to be associated with lower SOC%. pH and SOC (%): The correlation coefficient between pH and SOC% is 0.535278, indicating a moderate positive correlation. This suggests that higher pH levels in the soil may be associated with a higher percentage of SOC. EC (dSm^{-1}) and SOC (%): The correlation coefficient between electrical conductivity (EC) and SOC% is -0.37008, indicating a moderate negative correlation. This suggests that higher electrical conductivity may be associated with lower

SOC%. In summary, while some correlations are weak, the results suggest that soil properties such as clay content, soil moisture, pH, and electrical conductivity may have some influence on the percentage of SOC in the given dataset [31].

4. CONCLUSION

The findings of this study underscore the potential of sugarcane cultivation as a substantial carbon pool in India. Through the accumulation of high biomass and the retention of crop residues on the soil surface, sugarcane cultivation contributes to carbon storage, soil protection against erosion and enhancement of crop productivity. It is concluded that a promising effect of sugarcane cultivation on carbon sequestration, with significant improvements in soil physical and chemical properties due to the application of various organic amendments was occurs. Moreover, the carbon storage in different parts of the sugarcane plant demonstrates the efficacy of sugarcane farming practices in carbon sequestration. However, to fully validate these findings, it is imperative to continue this study over multiple cycles of sugarcane cultivation, including ratoon crops. Overall, sugarcane farming emerges as an effective strategy for carbon sequestration, contributing to the mitigation of climate change impacts and the reduction of atmospheric carbon levels. Thus the sugarcane crop and rhizospheric soils act as important carbon sinks in decarbonisation of atmosphere that ultimately reduces carbon level and causes global cooling.

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sequestration in plant-soil system" and for their financial support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anaya CA, Huber-Sannwald E. Long-term soil organic carbon and nitrogen dynamics after conversion of tropical forest to traditional sugarcane agriculture in East Mexico. Soil and Tillage Research. 2015; 147:20–29.
2. Goldemberg J. Ethanol for a sustainable energy future. Science. 2007;315(5813):808-810. Graham MH, Haynes RJ, Meyer JH. Soil organic matter content and quality: effects of fertilizer applications, burning and trash retention on a long-term sugarcane experiment in South Africa. Soil Biology and Biochemistry. 2002;34(1):93-102.
3. D'Alessandro DM, Smit B, Long JR. Carbon dioxide capture: prospects for new materials. Angewandte Chemie International Edition. 2010;49(35):6058-6082.
4. IPCC, (Intergovernmental Panel on Climate Change). Mitigation of climate change. Cambridge University Press. 2015;3:1435 p.,
5. Davis SJ, Caldeira K, Matthews HD. Future CO_2 emissions and climate change from existing energy infrastructure. Science. 2010;329(5997):1330-1333.
6. Scharlemann JP, Tanner EV, Hiederer R, Kapos V. Global soil carbon: understanding and managing the largest terrestrial carbon pool. Carbon Management. 2014;5(1):81-91.
7. Sadeghi H, Raeini MGN. Capability investigation of carbon sequestration in *Artemisia aucheri* bioss. International Journal of Environmental Science and Technology. 2016;13(1):159-164.
8. Nadeu E, Gobin A, Fiener P, Van Wesemael B, Van Oost K. Modelling the impact of agricultural management on soil carbon stocks at the regional scale: The role of lateral fluxes. Global Change Biology. 2015;21(8):3181-3192.
9. Lal R. World cropland soils as a source or sink for atmospheric carbon. Advances in Agronomy. 2001;71:145-191.
10. Meier EA, Thorburn PJ, Wegener MK, Basford KE. The availability of nitrogen from sugarcane trash on contrasting soils in the wet tropics of North Queensland. Nutrient Cycling in Agroecosystems. 2006;75(13):101-114.
11. Yadav RL, Prasad SR, Singh R, Srivastava VK. Recycling sugarcane trash to conserve soil organic carbon for sustaining yields of successive ratoon crops in sugarcane. Bioresource Technology. 1994;49(3):231-235.
12. Tominaga TT, Cassaro FAM, Bacchi OOS, Reichardt K, Oliveira JCM, Timm LC. Variability of soil water content and bulk density in a sugarcane field. Soil Research. 2002;40(4):604-614.
13. Galdos MV, Cerri CC, Cerri CEP. Soil carbon stocks under burned and unburned sugarcane in Brazil. Geoderma. 2009;153 (3-4):347-352.
14. Alireza Azizi, Gholamabbas Ghanbarian, Ali Hassanli, Mahmoud Shomeili. Carbon sequestration in sugarcane plant and soil with different cultivation systems, Iran Agricultural Research. 2020;38(2):47-54. magiran.com/p2124820.
15. De Figueiredo EB, Panosso AR, Romão R, La Scala N. Greenhouse gas emission associated with sugar production in southern Brazil. Carbon Balance and Management. 2010;5(1):3.
16. Bouyoucos GJ. Hydrometer method improved for making particle size analyses of soils. Agronomy Journal. 1962;54(5): 464-465.
17. Page AL, Miller RH, Keeney DR. Methods of soil analysis. Part 2: Chemical and microbiological properties. American Society of Agronomy. Madison, WI; 1982.
18. Carter MR. Soil sampling and methods of analysis. CRC Press; 2008.
19. Mishra P, Sahoo TR, Rahman FH, Mohapatra N, Sahoo PK, Mohapatra RK, Mishra SN. Effect of different mulching on moisture content in soil, weed dynamics and yield of tomato (*Lycopersicon esculentum* L.) in post flood situation in coastal Odisha. Journal of Experimental Agriculture International. 2020;32-38.
20. Rivenshield A, Bassuk, N. Using organic amendments to decrease bulk density and increase macroporosity in compacted soils. Arboriculture and Urban Forestry. 2007;33.
21. Sharifi MA, Mohsenimanesh A. Soil mechanical resistance measurement by an

unique multi-cone tips horizontal sensor. Int. Agrophysics. 2011;26.

22. Rusli LS, Abdullah R, Yaacob JS, Osman N. Organic amendments effects on nutrient uptake, secondary metabolites, and antioxidant properties of *Melastoma malabathricum* L. Plants (Basel). 2022;6; 11(2):153.

23. West TO, Marland G. A synthesis of carbon sequestration, carbon emissions, and net carbon flux in agriculture: Comparing tillage practices in the United States. Agriculture, Ecosystems & Environment. 2002;91(1-3):217-232.

24. Smith P. Carbon sequestration in croplands: the potential in Europe and the global context. European Journal of Agronomy. 2004;20(3):229-236.

25. Reeder JD, Schuman GE. Influence of livestock grazing on C sequestration in semi-arid mixed-grass and short-grass rangelands. Environmental Pollution. 2002; 116(3):457-463.

26. Ghanbarian G, Hassanli A, Rajabi V. Comparing potential carbon sequestration of different parts of mountain almond and grape plants and soil in Fars province.

Journal of Natural Environment. 2015; 68(2):257265.

27. Suman A, Singh KP, Singh P, Yadav RL. Carbon input, loss and storage in sub-tropical Indian Inceptisol under multi-ratooning sugarcane. Soil and Tillage Research. 2009;104(2):221-226.

28. Gao YH, Luo P, Wu N, Chen H, Wang GX. Grazing intensity impacts on carbon sequestration in an alpine meadow on the eastern Tibetan Plateau. Research Journal of Agriculture and Biological Sciences. 2007;3(6):642647.

29. Arunrat N, Kongsurakan P, Sereenonchai S, Hatano R. Soil organic carbon in sandy paddy fields of northeast thailand: A review. Agronomy. 2007;2020(10):1061.

30. Matus FJ. Fine silt and clay content is the main factor defining maximal C and N accumulations in soils: A meta-analysis. Sci Rep. Mar. 2021;19;11(1):6438.

31. Nosetto MD, Jobbágy EG, Paruelo JM. Carbon sequestration in semi-arid rangelands: Comparison of *Pinus ponderosa* plantations and grazing exclusion in NW Patagonia. Journal of Arid Environments. 2006;67(1):142156.

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