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ORIGINAL PAPER

Comparing the Organic Carbon Fractions in Composts of Agricultural Wastes at Different Temperatures and Stages

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Abstract
This experiment aimed to look at active and passive soil organic carbon percentages during composting different agricultural wastes at different temperatures. It is essential to understand how various agricultural wastes composting oxidase the carbon (C) during decomposition at various temperatures. The highest C content in the crop residce was recorded in the gliricidia (42.1) and the lowest in the cotton stalk (36.2), while the highest temperature (41.35 °C) recorded during the decomposition in the (T_4) 40% wheat (*Triticum aestivum*) straw (WS) + 40% cotton (*Gossypium hirsutum*) stalk (SCS) + gliricidia (*Gliricidia sepium*) leaf (GL) at 70 days and the lowest temperature (20.25 °C) in the T_1 100% WS at 119 days. The experimental pits comprising six treatments were laid out in a completely randomized design with four replications. Treatments were as follows: (T_1) 100% WS; (T_2) 100% SCS; (T_3) 50% WS + 50% SCS; (T_4) 40% WS + 40% SCS + GL; (T_5) 30% WS + 30% SCS + 20% GL + 20% sorghum (*Sorghum bicolour*) stubbles (SS); and (T_6) 25% WS + 25% SCS + 25% GL + 25% SS. This study showed that with an increase in the decomposition period, the C pools significantly had higher levels of very labile content (18.64 g kg^{-1}) and labile content (5.65 g kg^{-1}). Less labile content (0.45 g kg^{-1}) was recorded in T_6, whereas the highest non-labile content (37.98%) was recorded in T_1. These C pools reached their maximum concentrations at the last phase of T_6 decomposition. This work therefore provides a roadmap for further research into the science of soil organic carbon fractions (active and passive) during composting at various temperatures. The experiment's hypothesis may offer a guidance on strategies and techniques for appropriate decomposition methodology of agricultural waste, as well as the function of enriched materials. It will be useful for researchers, producers, and planners to know the organic C fractions in composts of agricultural wastes at different temperatures and stages.

Keywords Carbon pools · Crop residues · Glyricidia leaf · Rock phosphate

1 Introduction

Crop residues have expanded in volume quickly as global cereal grain output has increased. Crop waste is now directly burned, turned into soil, or removed from the fields for use as fuel, feed, charcoal, and building materials. Crop waste is frequently used for various purposes, including thatching, composting, animal feed, cooking fuel, and other things (Prasad et al. 2012 and 2020). However, a significant amount of agricultural residue is left in the fields unutilized, and getting rid of it is a major problem (Naresh et al. 2017). Having a high nutrient potential, India alone produces 500–550 million tons of crop residues annually (Jain et al. 2014). To carry out well-timed field tasks and sow future harvests, a substantial amount of crop residue is burned in the field (Jat et al. 2021).

In current practice, the short period (10–20 days) between sowing the subsequent crop and harvesting the one before it in today's automated and intensive cropping systems is a major contributor to on-farm crop waste burning (Jain et al. 2014). A significant amount of agricultural waste can be quickly and easily disposed of by burning it in place (Naresh et al. 2017). In addition to the greenhouse gases in the atmosphere (GHGs), it also produces aerosols, soot particles, C monooxide (CO), C dioxide (CO_2), nitrous oxide (N_2O), ammonia (NH3), Sulphur dioxide (SO_2), volatile organic compounds (VOCs), and other harmful components and gases (Nagar et al. 2020). Similarly, ongoing crop residue burning increases

Extended author information available on the last page of the article the millions tons of net nutrient losses from the soil in various ways, raising the input cost for crop production, necessitating millions of dollars in investments, and accelerating soil degradation (Meena and Kumar 2022). Some efficient and sustainable techniques to reduce crop residue burning and recycle nutrients into the soil include residue mulching, in situ incorporation, composting, biochar formation, mechanized methods, and several others (Porichha et al. 2021). However, the usefulness of these technologies depends on how crop residues are applied and how quickly they degrade, as well as on the type of soil, climate, crops, cropping system, and tillage practices. Crop residues can be economically viable, agronomically productive, and socially acceptable if managed adequately. Soil health and environmental security depend on identifying and creating location-specific interventions for recommended technologies to be widely used (Banerjee et al. 2020, 2021; Meena et al. 2020b).

The biological decomposition of organic materials under regulated conditions is a natural process known as composting (Misra et al. 2003). Composting is a good way to maximise the use of crop residues while offering a wide range of environmental and economic benefits (Mor et al. 2016; Bindu and Manan 2018). Farmyard manure (FYM), which is made from composted crop residues, increases soil moisture, nutrient content, microbial activity, and productivity (Lohan et al. 2018). However, crop residue composition, C/N ratio, pH, the amount of moisture, the temperature, and aeration may all affect the composting process (Bhuvaneshwari et al. 2019). Soil organic C (SOC) is one of the most commonly used soil quality indicators. Improving physical, chemical, and biological qualities affects fertility and production in terrestrial eco-systems. It is also useful for anticipating climate change and its effects (Kirschbaum 2000; Sahoo et al. 2019).

Net global CO_2 emissions increased to 31 billion tons by 2010, and it is anticipated to reach a record-breaking 43.1 billion tons in 2022. In addition to accelerating climate change (Kaushal et al. 2021), this rising CO_2 concentration in the atmosphere also poses a severe environmental danger in the form of land degradation. A staggering 24% of the world's CO_2 emissions come from agriculture, including intensive crops, forestry, land-use changes, and poor farm management (IPCC 2014). Therefore, it is crucial to find ways to reduce C emissions and store them in the soil (Sanderman and Baldock 2010). Organic matter (OM) in the agroecosystem is being depleted due to current agricultural methods (Lal et al. 1998). Because it increases the cation exchange capacity of the soil and supplies nutrients and a habitat for the microbial community, soil organic matter (SOM) is a crucial component of soil fertility and biology (Balota et al. 2014). More than half of the C in sandy soils is lost from the SOM due to the abuse of natural ecosystems for agricultural purposes (Lal 2004).

Materials with labile or rapidly degrading half-lives ranging from a few days to a year, made up of the active C pool. The majority of bacteria's readily available food and the majority of nitrogen (N) that is rapidly mineralized are present in the active pool, according to Benbi and Richter (2002). Labile-C is primarily in charge of mineralization activities that supply nutrients to plants and provide energy and C to soil microbes (Meena et al. 2020a). Furthermore, soil microbial biomass (SMB) is a biogeochemical and biological process indicator and an active pool of soil OM dynamics (Lundquist et al. 1999). Non-labile C pools play an important role in soil function and health and come in various chemical compositions and breakdown stages. Humic compounds account for 60–80% of the total organic carbon (TOC), with humic being the most abundant, followed by fulvic acid or humic acid (Almeida et al. 2014). Labile organic carbon (LOC) fractions in soil are considered sensitive and early indicators of soil quality changes. Because LOC has a significantly shorter turnover period and a higher turnover rate than more stable organic C in soils, it reacts faster to changes in management techniques (Gu et al. 2016). Because of their high biological activity, LOC fractions play an important role in the C cycle and may be used as early and sensitive markers of soil organic carbon (SOC) changes (Banger et al. 2010).

C stabilisation is essential for better agricultural management and SOM storage (Meena et al. 2021). C sequestration and stabilization are inextricably linked (Liao et al. 2020; Kumar et al. 1998). Increased C sequestration stabilization could help reduce the greenhouse effect (Goh 2004). The process of C stabilization has not yet been completely understood, and it is influenced by various circumstances (Meena et al. 2020b). Labile pools improve soil enzymatic activity, nutrient dynamics, and crop productivity due to changes in total organic C (Sharma et al. 2020). Increase critical labile-C, safeguarding labile-C pools at risk of loss, and sequestering C are all ways to reduce global warming and improve soil quality (Segun et al. 2021). In response to changes in SOC supply, microbial biomass C, particle OMC, and highly oxidisable SOC are labile SOC fractions (Das et al. 2016). The main participant in the soil ecosystem and services is SOM. Crop residue integration can improve soil quality by increasing the amount of organic C (SOC) in the soil. Most studies focus on determining the amount of OM in soil. As a result, it is critical to understand how decomposition agents and temperature affect SOC percentages in composts. This research offers guidance on strategies and techniques for appropriate decomposition of agricultural waste and the function of enriched materials. It is critical to understand this to decompose C fractions promptly.

2 Materials and Procedures

2.1 Experimental Site

The experiment was laid out in a completely randomized design at the Research Farm of the Department of Soil Science and Agricultural Chemistry, Dr P.D.K.V., Akola, MH (Fig. 1) (elevation 287 to 316 m above sea level, latitude 20.7° N, and longitude 77.07° E), which comes under the western plateau and hills region agro-climatic zone. The soil texture of the experimental farm was medium black to deep black. Completely randomized design at the Research Farm of the Department of Soil Science and Agricultural Chemistry.

2.2 Climate and Weather

The average maximum and minimum temperatures during this study were 43.7 and 10.5 °C, respectively. Between 33 and 88% of the relative humidity was present. The monthly variations in weather data for 2018 are presented (Supplementary Table S1).

2.3 Treatments

Experimental pits, comprising six treatments, were laid out in a completely randomized design with four replications. Each pit is filled with 100 kg of compostable material per the treatment. (T_1) 100% wheat (*Triticum aestivum*) straw (WS); (T_2) 100% shredded cotton (*Gossypium hirsutum*) stalk (SCS); (T_3) 50% WS + 50% SCS; (T_4) 40% WS + 40% SCS + 20% *Gliricidi* (*Gliricidia sepium*) leaf (GL); (T_5) 30% WS + 30% SCS + 20% GL + 20% sorghum (*Sorghum bicolour*) stubbles (SS); (T_6) 25% WS + 25% SCS + 25% GL + 25% SS. The rock phosphate at 12%, the PDKV decomposer at 1 kg Mg^{-1}, the element sulphur at 5% (50 kg Mg^{-1}), the urea at 1% (10 kg Mg^{-1}), and cow dung slurry at 1% (10 kg Mg^{-1}) were used to enrich all the treatments. The chemical compositions of raw materials (enriched materials and crop residues) are presented in Tables 1 and 2.

2.4 Composting Process

Wheat straw, shredded cotton stalk, gliricidia leaf, and sorghum stubble were among the agricultural trash employed in composting. The pile's dimensions were 3.0 m long, 1.5 m wide, and 1.0 m high. To achieve the appropriate C:N ratio (around 20–30), piles were built by merging agricultural detritus. To enrich compost, urea solution (1%), rock phosphate (12%), and sulphur (5%), added via gypsum, were added to the total weight of agricultural waste, followed by *phosphorus soluble bacteria* (PSB) and *Trichoderma viride* (1 kg Mg^{-1}). When the temperature within the pile decreased for three days in a row, they were rotated. The moisture

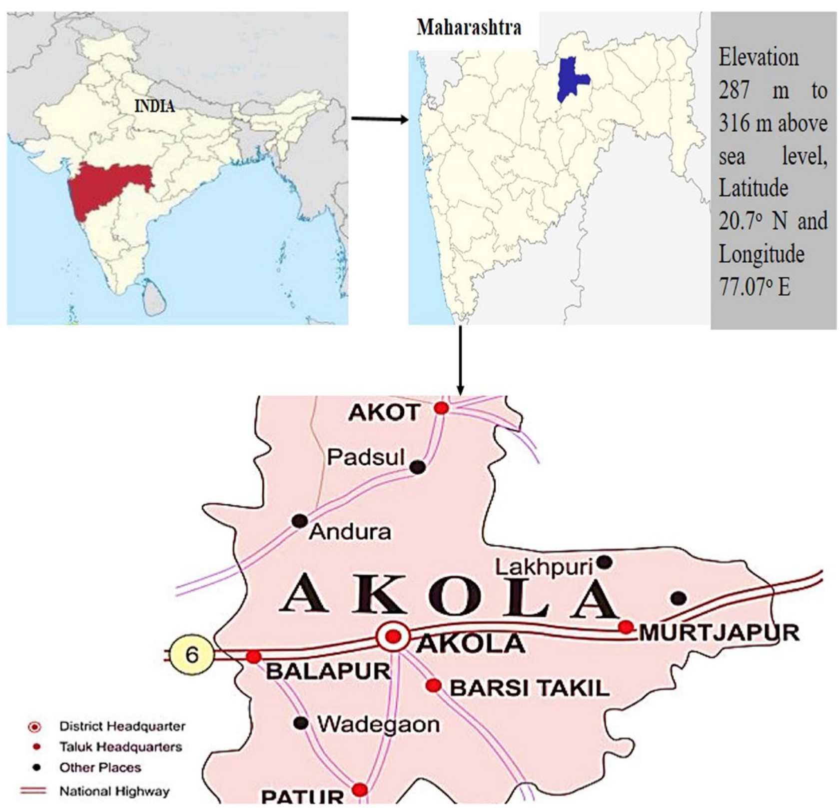


Fig. 1 Experimental location

Table 1 Chemical composition of rock phosphate

Chemical composition of rock phosphate	Content
Total P(%)	20.00
Water soluble P (%)	0.0030
Citrate soluble P(%)	1.100
Potassium (K%)	0.130
Calcium (Ca%)	9.00
Magnesium (Mg%)	3.480
Sulphur (S%)	0.400
Iron (Fe mg kg^{-1})	5870
Manganese (Mn mg kg^{-1})	904.0
Zinc(Zn mg kg^{-1})	213.0
Copper (Cu mg kg^{-1})	40.0

content was initially fixed at between 60 and 70% (w/w), and it was kept within the range by watering during turning operations at seven-day intervals. These management actions were carried out during the bio-oxidative phase of degradation, which lasted up to 90 days. The experiment was done in the shade to avoid excessive rain and sun exposure, with the piles covered with polythene. After 90 days of decomposition, treatment-specific piles were gathered in one location and left to cure for another 30 days, for 120 days. Temperatures inside the heaps were recorded regularly. Temperature changes during the decomposition of enriched compost are presented in Table 3.

2.5 Sampling Strategy

Samples were collected from each replication. To create composite samples, sub-samples taken from inside each pile were thoroughly mixed and homogenised, dried in an oven at 70 °C, powdered, and then sieved through 2 mm sieves before being used for chemical analysis. The composting process was sampled at different stages (15, 30, 60, 90, and 120 days after decomposition), depending on the thermal conditions inside the piles for C fraction analysis. At each sampling time, a sample of about 500 g was taken and mixed adequately for analysis.

2.6 C Fraction Analysis

Using 36 N H_2SO_4, the modified Walkley and Black method (Walkley and Black 1934) was used to determine the organic C pools, indicating that the recovery factor 1.298 represents the total SOC pool (Table 4). This fraction was divided into four pools: very labile (pool I: C_{VL}), labile (pool II: C_L), less labile (pool III: C_{LL}), and non-labile (pool IV: C_{NL}). The active pool of organic C in soils is made up of Pools I and II [active pool = $\sum$ (pool I + pool II)], whereas the passive c is made up of pools III and IV combined [Passive pool = $\sum$ (pool III + pool IV)]. Three acid-aqueous solutions were used in ratios of 0.5:1, 1:1, and 2:1 using 5, 10, and 20 mL of concentrated (36 N) H_2SO_4 (corresponding to 12.0, 18.0, and 24.0 N of H_2SO_4, respectively) (Chan et al. 2001). The

Table 2 Chemical composition of crop residues and gliricidia leaves

Crop residues	Chemical composition									C:N
	C (%)	N (%)	P (%)	K (%)	S (%)	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg⁻1)	Cu (mg kg^{-1})	
Sorghum stubbles	37.7	0.47	0.21	1.13	0.12	41	131	67	12.02	80.2
Wheat straw	40.1	0.51	0.18	0.89	0.14	45	124	56	9.55	78.6
Cotton stalk	36.2	0.48	0.16	0.68	0.09	37	119	61	13.11	75.4
Gliricidia leaves	42.2	2.87	0.33	1.24	0.17	62	161	89	13.25	14.9

Table 3 Temperature changes during the decomposition of enriched compost

Treatment	Temperature change (°C)																	
	D0	D7	D14	D21	D28	D35	D42	D49	D56	D63	D70	D77	D84	D91	D98	D105	D112	D19
T_1	34.25	37.36	35.38	35.63	35.50	31.60	35.00	35.00	35.00	35.35	38.90	37.85	40.03	42.08	36.50	31.73	27.08	20.25
T_2	33.48	39.70	35.60	35.58	35.15	36.33	39.20	37.78	37.78	37.85	37.83	36.38	42.00	37.58	38.30	32.23	28.38	25.93
T_3	34.73	41.58	36.45	36.00	35.88	35.35	36.45	36.68	36.68	35.40	37.45	37.95	39.93	40.30	37.55	33.10	29.30	25.58
T_4	34.93	42.35	36.03	38.00	36.98	36.95	39.98	35.05	35.05	34.98	41.35	39.80	38.63	40.53	38.33	32.10	27.78	25.85
T_5	34.50	40.90	35.43	35.98	36.98	34.80	36.48	37.15	37.15	37.23	36.80	39.20	39.18	41.55	36.75	33.13	27.90	27.78
T_6	35.30	41.00	36.18	36.48	36.23	34.08	36.88	35.65	35.65	35.88	35.65	38.55	40.63	39.48	39.40	33.88	28.48	26.60
SE(m) ±	0.45	0.28	0.33	0.24	0.24	0.28	0.33	0.39	0.39	0.30	0.58	0.51	0.46	0.46	0.49	0.21	0.26	2.48
CD at 5%	NS	0.83	NS	0.71	0.71	0.83	0.99	1.17	1.16	0.89	1.73	1.54	1.39	1.38	1.47	0.65	0.79	NS

D, days

total SOC could be divided into four pools thanks to the amount of C discovered in this manner.

2.7 Statistical Anaysis

The data were examined using the "analysis of variance" (ANOVA) standard procedure (Gomez and Gomez 1983).

3 Results

3.1 Very Labile C Pools

The very labile C concentration in compost prepared from various agricultural wastes ranged from 6.01 to 9.95, 6.47 to 10, 8.45 to 11.63, 10.42 to 14.88, and 13.01 to 18.64 g kg^{-1} after 15, 30, 60, 90, and 120 days of decomposition, respectively, as shown in Fig. 2. T_6, which is composed of 25% WS + 25% SCS + 25% GL + 25% SS, had the highest very labile C content (18.64 g kg^{-1}) and was found to be at par with T_5, which is composed of 30% WS + 30% SCS + 20% GL + 20% SS, followed by T_4, which is composed of 40% WS + 40% SCS + 20% GL and 50% WS + 50% SCS, and T_1, which is composed of 100% WS. T_2 had a substantially lower value (13.01) during decomposition and is composed of 100% SCS. The combination of gliricidia leaf and other crop residues resulted in a higher content of very labile C.

3.2 Labile C Pools

The periodical changes in labile C during composting are presented in Fig. 3. After 15, 30, 60, 90, and

Table 4 According to their decreasing order of oxidizability

Organic C oxidizable by 12.0*N* H_2SO_4	Pool I (C_{VL} very labile)
Difference in Coxidizable by18.0 *N* and that by 12.0 *N*H_2SO_4	Pool II (C_L labile)
Difference in C_{tot} oxidizable by 24.0*N* and that by 18.0 *N*H_2SO_4	Pool III (C_{LL} less labile)
Difference between C and oxidizable by 24.0*N* H_2SO_4	Pool IV (C_{NL} nonlabile):

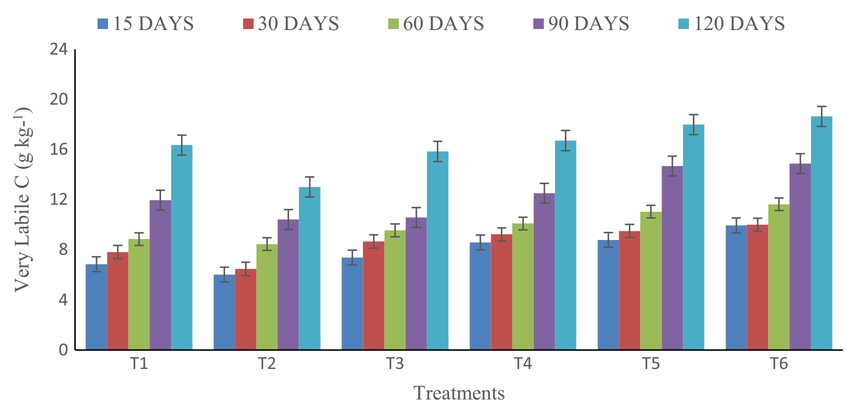


Fig. 2 Changes in very labile carbon over time as crop residues decompose. T_1, 100% wheat (*Triticum aestivum*) straw (WS); T_2, 100% shredded cotton (*Gossypium hirsutum*) stalk (SCS); T_3, 50% WS + 50% SCS; T_4, 40% WS + 40% SCS + 20% *Gliricidi* (*Gliricidia sepium*) leaf (GL); T_5, 30% WS + 30% SCS + 20% GL + 20% sorghum (*Sorghum bicolour*) stubbles (SS); T_6, 25% WS + 25% SCS + 25% GL + 25% SS

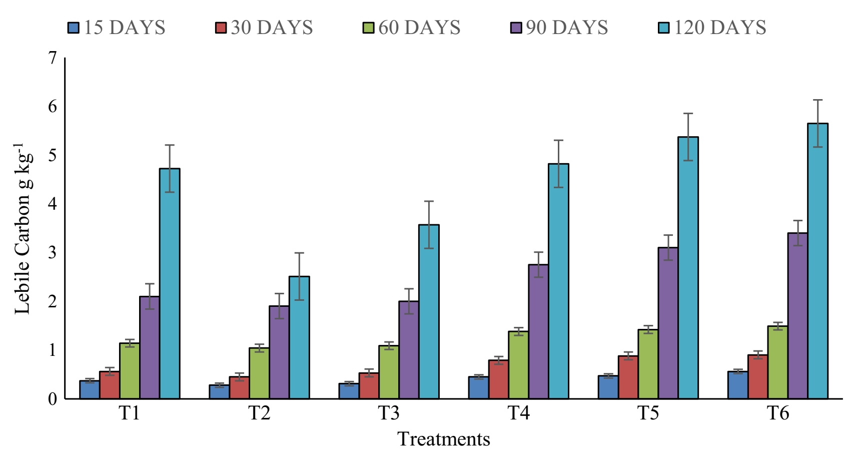


Fig. 3 Changes over time in the amount of labile carbon as crop residue decomposes. T_1, 100% wheat (*Triticum aestivum*) straw (WS); T_2, 100% shredded cotton (*Gossypium hirsutum*) stalk (SCS); T_3, 50% WS + 50% SCS; T_4, 40% WS + 40% SCS + 20% *Gliricidi* (*Gliricidia sepium*) leaf (GL); T_5, 30% WS + 30% SCS + 20% GL + 20% sorghum (*Sorghum bicolour*) stubbles (SS); T_6, 25% WS + 25% SCS + 25% GL + 25% SS

120 days of decomposition, the labile C content in compost made from various agricultural wastes ranged from 0.28 to 0.56, 0.45 to 0.90, 1.04 to 1.49, 1.90 to 3.40, and 2.51 to 5.65 g kg^{-1}, respectively. The significance was recorded in T_6, composed of 25% WS + 25% SCS + 25% GL + 25% SS, had the highest labile content (5.65 g kg^{-1}) and was found to be on par with T_5, followed by T_4 and T_1. During decomposition, a lower value (2.51) was recorded in T_2, composed of 100% SCS.

3.3 Less Labile C Pools

The periodical changes in less labile C during composting are presented in Fig. 4. After 15, 30, 60, 90, and 120 days of decomposition, the less labile C content in compost prepared from various agricultural wastes ranged from 0.31 to 0.45, 0.58 to 0.85, 0.66 to 0.90, 0.69 to 0.98, and 1.66 to 2.28 g kg^{-1}, respectively. T_6 had the significantly highest less labile content (0.45 g kg^{-1}). The lower value (0.31) was recorded in T_2.

3.4 Non-labile C Pools

After 15, 30, 60, 90, and 120 days of decomposition, the non-labile C content in compost prepared from various agricultural wastes ranged from 33.68 to 37.98%, 28.03 to 33.60%, 27.45 to 32.24%, 24.73 to 28.48% and 22.29 to 25.14%, respectively. The periodical changes in non-labile C during composting at the decomposition stages are shown in Fig. 5. After 15 days of decomposition, the highest (37.98%) and lowest (33.68%) non-labile contents were recorded in T_1 and T_6, respectively. At the end of composting (120 days later), the highest (25.14%) and lowest (22.29%) non-labile contents were recorded in T_1 and T_6, respectively.

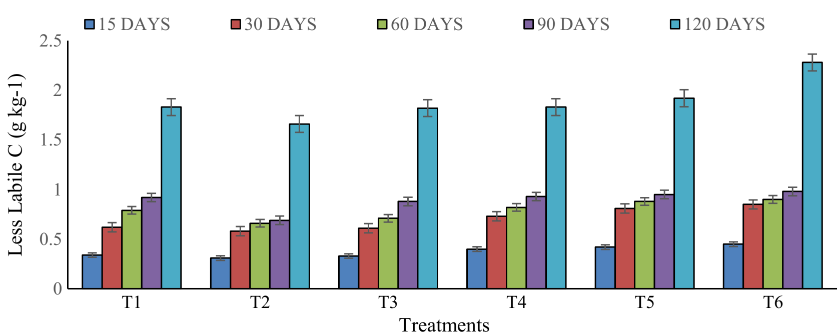
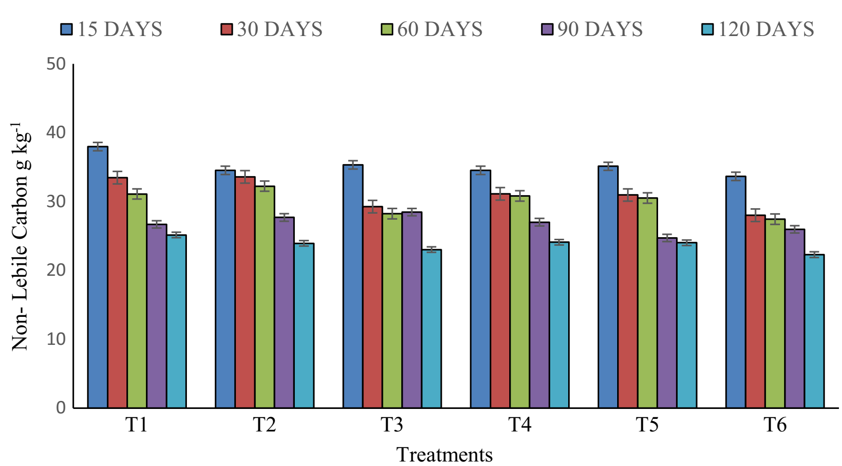


Fig. 4 Changes over time in the less labile content as crop residues decompose. T_1, 100% wheat (*Triticum aestivum*) straw (WS); T_2, 100% shredded cotton (*Gossypium hirsutum*) stalk (SCS); T_3, 50% WS + 50% SCS; T_4, 40% WS + 40% SCS + 20% *Gliricidi* (*Gliricidia sepium*) leaf (GL); T_5, 30% WS + 30% SCS + 20% GL + 20% sorghum (*Sorghum bicolour*) stubbles (SS); T_6, 25% WS + 25% SCS + 25% GL + 25% SS

Fig. 5 Changes over time in the non-lebile carbon. T_1, 100% wheat (*Triticum aestivum*) straw (WS); T_2, 100% shredded cotton (*Gossypium hirsutum*) stalk (SCS); T_3, 50% WS + 50% SCS; T_4, 40% WS + 40% SCS + 20% *Gliricidi* (*Gliricidia sepium*) leaf (GL); T_5, 30% WS + 30% SCS + 20% GL + 20% sorghum (*Sorghum bicolour*) stubbles (SS); T_6, 25% WS + 25% SCS + 25% GL + 25% SS



3.5 Crop Residce C Content and Decomposition Temperature

The highest C content in the crop residce was recorded in the gliricidia (42.1) and lowest in the cotton stalk (36.2). While the highest temperature (41.35 °C) recorded during the decomposition in the T_4 at 70 days, and lowest temperature (20.25 °C) in the T_1 at 119 days (details are presented in Tables 2 and 3).

4 Discussion

Composting has emerged as the preferred method of treating organic wastes in order to produce a stable, sterile product that can be used as an organic amendment. Some researchers reported similar results for composting the various agricultural wastes (Sayara et al. 2020). This study provides the information needed to know the organic C fractions in composts of agricultural wastes at different temperatures and stages.

The very labile, labile, and less labile C pools were significantly highest in T_6, which contains rock phosphate, PDKV decomposer, element sulphur, urea, and cow dung slurry along with 25% wheat straw, 25% shredded cotton stalk, 25% gliricidia leaf, and 25% sorghum stubble. The combination of gliricidia leaf (a legume crop) and other crop residues resulted in a higher content of C pools. This might be due to gliricidia leaves containing 2.8–3% N which increases microbial biomass during decomposition and increases labile C pools. Thus, the incorporation of crop residues, especially legume crops, along with enriched materials is crucial for preserving SOC and microbial biomass and improving the availability of nutrients. Similarly, it was reported that the NPK + farmyeard manure (FYM) promoted the formation of a highly labile C pool (Das et al. 2016). A 4-year wheat–greengram cropping sequence in the IGP of India resulted in increased soil organic C (easily oxidisable and oxidisable forms of organic C) and N pools when RP-enriched composts and fertilisers were used in conjunction with each other (Moharana et al. 2019). Management of residues and fertilisers, an increase in dissolved organic C and microbial biomass C, and the distribution of light and heavy components of C in soils at deeper layers (Naresh et al. 2018). Crop residues and manure treatments produced greater SOC content than the NPK treatment (Ding et al. 2012). Because applied nutrients have a priming effect on newly formed organic materials in the soils, applying fertilizers and manure may increase labile C content. These changes increase microbial activity, which aids in SOC breakdown by allowing labile C to be excreted quickly (Das et al. 2016). Compared to the control, long-term straw mulching significantly increased POC, TOC, and active C fraction content (Mi et al. 2019; Meena et al. 2022a, b). Our findings back up previous reports of higher TOC input in treatments containing 100% NPK + FYM. Greengram biologically fixing atmospheric N_2 increased total N with the application of enriched compost, probably as a result by Moharana et al. (2012) and Ghosh et al. (2018).

The highest non-labile C content was reported in T_1, composed of 100% wheat straw. The higher C:N ratio of wheat straw may cause this. It takes a long time to decompose the wheat straw residues. The decomposition rate is influenced by vegetation, climate, and the microbial community. Plant type is a key factor affecting the composition of microbial communities in soil (Garbeva et al. 2004). Rice straw and *Typha angustifolia* have significantly different plant litter qualities, and root exudates affect the composition of the bacterial community in the soil (Baudoin et al. 2003). Similarly, according to some researchers, vegetation had a stronger influence on bacterial community structure than soil chemical properties or climate, with vegetation having a greater overall impact (Chim et al. 2008). The rise in recalcitrant C in NPK + FYM plots could be explained by resistance brought on by the biochemical properties of organic chemicals present in OM or plant materials (Pradhan and Meena 2023; Meena and Pradhan 2023). According to a study by Belay-Tedla et al. (2009), FYM application improved lignin and lignin-like compounds, the main components of resistant C pools. The increased breakdown of labile compounds and accumulation of recalcitrant materials over time in NPK + FYM plots, in addition to higher organic inputs, may be the cause of the higher amounts of recalcitrant C under NPK + FYM than under NPK (Lopez-Capel et al. 2008).

Agricultural wastes are inoculated with *phosphorus-soluble bacteria* (PSB) and *Trichoderma viride* (1 kg ton^{-1}) to speed up decomposition and increase compost maturity. Various authors (Baudoin et al. 2003; Das et al. 2016) have seen comparable results when using various temperature and inoculants to hasten the composting process or enhance the compost quality based on the C content in the residence (Tables 2 and 3).

The composting reaction rate, also known as waste mass reduction or respiration rate, measures how quickly waste is decomposed. Temperatures in the 30–45 °C range were discovered to have the highest composting activity. Temperature is the most important factor in influencing composting reaction rates since it affects microbial metabolic rates and population structure. The optimal temperature for microorganisms results in faster breakdown and higher labile C pools. Similar results have been reported that a higher temperature (35 °C) promotes SOC mineralization (Franzluebbers et al. 2001; Pérez-Lomas et al. 2010). The source of

SOC mineralization processes (dehydrogenase activity) may be increased biological activity, which is typically connected to amendment and high-temperature incubation. Therefore, it is recommended to integrate agricultural waste and RP-enriched compost to increase C quality because this strategy would provide a long-term management option for maintaining soil quality and crop performance.

5 Conclusions

Combining agricultural wastes with enrichment material helps to enhance the nutrient status of composts, maintain total SOC, and increase labile organic C fractions. According to this study, the highest C pools were reported on the final stage of decomposition in compost, comprised of 25% wheat (*Triticum aestivum*) straw (WS); + 25% shredded cotton (*Gossypium hirsutum*) stalk (SCS) + 25% *Gliricidi* (*Gliricidia sepium*) leaf (GL) + 25% sorghum (*Sorghum bicolour*) stubbles (SS) (T_6). This might be because gliricidia leaves contain 2.8¬3% N, which increases microbial biomass and the optimal temperature for microorganisms, resulting in faster breakdown and higher labile C pools. Compost made from 25% WS + 25% SCS + 25% GL + 25% SS (T_6) degraded during agricultural residue degradation.While T_6, which is composed of 25% WS + 25% SCS + 25% GL + 25% SS, had the highest very labile C content (18.64 g kg–1), it was found to be on par with T_5, which is composed of 30% WS + 30% SCS + 20% GL + 20% SS, followed by T_4, which is composed of 40% WS + 40% SCS + 20% GL and 50% WS + 50% SCS, and T_1, which is composed of 100% WS. The findings of this experiment may pass the information to the producers, planners, and academics for a better understanding of the organic C fractions in various composts made from agricultural waste at various temperatures.

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Data Availability Most of the data are available in all tables and figures of the manuscripts.

Declarations

Conflict of Interest The authors declare no competing interests.

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