International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(7): 821-826
www.biochemjournal.com
Received: 15-04-2025
Accepted: 19-05-2025

Divya V Rane
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Dr. PD Raut
Assistant Professor, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Dr. SS Balpande
Assistant Professor, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India.

Dr. RN Katkar
Associate Dean (LAE), Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Dr. VM Ilorkar
Senior Scientist and Head, AICRP on Agroforestry, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Shweta B. Bhagat
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Corresponding Author:
Divya V Rane
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Effect of different decomposers on carbon and nitrogen fractions during composting of incense bamboo waste

Divya V Rane, PD Raut, SS Balpande, RN Katkar, VM Ilorkar, Shweta B Bhagat, Pooja P Kad, Pragati D Marape and Mrunali R Manekar

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i7Sk.4994

Abstract
The present study was undertaken to evaluate the effect of different decomposers on carbon and nitrogen fractions during the composting of incense s bamboo waste. The experiment was performed at the College of Agriculture, Nagpur (M.S.), under AICRP on Agroforestry (Futala farm), and spanned 45, 90, and 120 days. Eight treatment combinations were assessed, incorporating cow dung, poultry manure, and lignolytic fungi (*Phanerochaete chrysosporium*). The treatments were as follows: T_1 - BW (control), T_2 - BW + 10 kg CD, T_3 - BW + 5 kg PM, T_4 - BW + 10 kg CD + 0.2 kg LF, T_5 - BW + 5 kg PM + 0.2 kg LF, T_6 - BW + 5 kg CD + 0.06 kg N + 0.2 kg LF, T_7 - BW + 2.5 kg PM + 0.06 kg N + 0.2 kg LF, and T_8 - BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF. The application of combined decomposers accelerated the decomposition rate of incense bamboo waste. Among all treatments, T8 recorded the highest accumulation of carbon and nitrogen fractions, including very labile (8.74%), labile (3.24%), less labile (8.33%), and non- labile (10.44%) carbon, as well as ammoniacal nitrogen (0.026%) and nitrate nitrogen (0.037%). Results indicated dynamic shifts in organic carbon and nitrogen fractions, with labile carbon increasing while non-labile carbon exhibited a consistent decline. Ammoniacal nitrogen initially rose and then declined over time, whereas nitrate nitrogen continuously increased, suggesting effective mineralization. These findings highlight the role of microbial inoculants in promoting compost stability and nutrient maturity.

Keywords: Bamboo waste, composting, decomposition, decomposers

Introduction
The increasing generation of organic waste from agricultural, industrial, and household sources presents a growing challenge to sustainable waste management. Among these, incense bamboo sticks, widely used across India for religious and cultural practices, contribute significantly to biodegradable solid waste. These sticks are typically discarded after use, leading to environmental concerns such as pollution and poor sanitation if not managed properly. Composting offers an effective, eco-friendly, and economical method for recycling such organic waste into nutrient-rich organic manure. Bamboo serves as a key raw material in the incense stick (agarbatti) manufacturing sector. Recognized for its rapid growth, wide availability, renewable nature, and cost-effectiveness, bamboo is valued as a sustainable resource. Its versatility and accessibility have earned it the titles "green gold" and "poor man's timber." The use of bamboo in incense stick production significantly contributes to the rural economy by supporting household income generation, especially by creating livelihood opportunities and boosting the income of women.

The regulated breakdown of organic matter through microbial activity, referred to as composting, is a natural and environmentally friendly process (Misra *et al.*, 2003) [14]. It involves the microbial conversion of organic waste under moist, self-heating, and aerobic conditions. Composting proceeds through a sequence of microbial communities, including mesophilic, thermotolerant, and thermophilic species, which are essential for efficient decomposition. These microbes facilitate the breakdown of organic material by producing hydrolytic enzymes (Raut *et al.*, 2008) [18]. Understanding the dynamics of these enzymatic processes is crucial for evaluating the efficiency and progression of composting.

Analyzing and measuring enzyme activities during composting helps to understand the progression of organic matter breakdown and nitrogen conversion. It also offers insights into the compost's maturity and overall composting dynamics (Tiquia, 2002) [21].

Carbon and nitrogen are essential elements that play a critical role in compost stability and maturity. During composting, organic carbon undergoes mineralization, leading to the release of carbon dioxide and transformation into various carbon fractions, such as very labile, labile, less labile, and non-labile forms. Simultaneously, nitrogen transformations—through processes such as ammonification and nitrification—result in the formation of ammoniacal and nitrate nitrogen, which are crucial indicators of compost maturity and nutrient availability.

Labile carbon (Labile-C) is crucial for mineralization processes that release nutrients for plant uptake and serve as a primary energy source for soil microbial communities (Meena *et al.*, 2020) [13]. In contrast, non-labile carbon pools contribute significantly to maintaining soil health and functioning, owing to their varied chemical makeup and slower decomposition rates. Labile organic carbon (LOC) fractions are recognized as sensitive indicators of shifts in soil quality, as they respond quickly to environmental and management changes. This is primarily because LOC possesses a faster turnover rate and decomposes more rapidly than stable organic carbon fractions (Gu *et al.*, 2016) [8]. Given this responsiveness, the current study was designed to assess how different decomposer treatments influence the dynamics of carbon and nitrogen fractions in incense bamboo waste during composting. The core objective was to determine which combinations of decomposers most effectively accelerate compost maturity, improve nutrient stability, and enhance overall compost quality.

Materials and Methods

The present study was conducted during 2024-2025 to evaluate the feasibility and efficiency of composting incense industrial bamboo waste as a primary substrate. The composting trial was carried out over a period of 120 days at the Agroforestry Research Farm (Futala Farm), College of Agriculture, Nagpur, under the jurisdiction of Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra. The bamboo waste used for this experiment was sourced from an agarbatti (incense stick) manufacturing unit located in the MIDC industrial area, Butibori, Nagpur. This waste material, characterized by a high initial carbon-to-nitrogen (C:N) ratio of 121.09 (Table 1), required amendment with various organic, inorganic, and biological inputs to optimize microbial decomposition and balance the nutrient ratio. For each treatment, 20 kg of incense bamboo waste was weighed and amended with different decomposers including cow dung, poultry manure, urea, and lignolytic fungi (*Phanerochaete chrysosporium*), as per the treatment details. The moisture content was maintained at approximately 50% throughout the composting period, and manual turning was performed at regular intervals to ensure adequate aeration and uniform decomposition. Temperature monitoring was carried out at consistent intervals to track the composting dynamics.

The experiment was laid out in a Completely Randomized Design (CRD) comprising eight treatments, each replicated three times. Observations were recorded during the composting process and at the end of 120 days. The collected data were compiled, tabulated, and subjected to appropriate statistical analysis to assess treatment effects. The initial characteristics of incense industrial bamboo waste such as moisture content, total organic carbon, ash content, C:N ratio and Total Nitrogen were analyzed (Table 1). The characteristics of additives used for composting such as Total N, P, K, were also estimated (Table 2).

Carbon Fraction Analysis

To determine oxidizable carbon, modified concentrations of concentrated sulphuric acid (5 mL and 10 mL) were used instead of the 20 mL specified in the original Walkley and Black (1934) method. These variations created three different acid-to-aqueous ratios: 0.5:1, 1:1, and 2:1, corresponding to 12 N, 18 N, and 24 N concentrations of H_2SO_4. This approach enabled a comparative analysis of oxidizable organic carbon extracted under progressively stronger oxidizing conditions (Chan *et al.*, 2001) [5]. The oxidizable organic carbon was assessed using 5, 10, and 20 mL of concentrated sulphuric acid. When evaluated against total carbon content, this technique allowed the division of total organic carbon into four distinct fractions based on decreasing oxidizability:

- Fraction 1 (12 N H_2SO_4): Represents the organic carbon fraction that is oxidizable under the weakest acid strength (12 N H_2SO_4).
- Fraction 2 (18 N - 12 N H_2SO_4): Denotes the additional organic carbon oxidized between 12 N and 18 N acid strength.
- Fraction 3 (24 N - 18 N H_2SO_4): Indicates the organic carbon portion further oxidized under 24 N acid conditions, relative to 18 N. Notably, 24 N H_2SO_4 reflects the acid strength used in the standard Walkley-Black method.
- Fraction 4 (TOC - 24 N H_2SO_4): Accounts for the residual organic carbon not oxidized even under
- 24 N acid, estimated by comparing with total carbon content obtained via dry combustion.

Nitrogen fraction analysis

The quantification of mineral nitrogen forms (NH_4^+-N and NO_3^--N) in compost samples was carried out through extraction using 2M potassium chloride (KCl) in a 1:10 sample-to-solution ratio. Ammoniacal nitrogen (NH_4^+-N) was estimated by steam distillation with activated magnesium oxide (MgO) using a micro-Kjeldahl distillation apparatus, as outlined by Keeney and Nelson (1982) [10]. For nitrate nitrogen (NO_3^--N), the same protocol was followed after reducing nitrate to ammonium using Devarda's alloy.

Results and Discussion

Initial characteristics of incense bamboo waste on dry basis and decomposers used for composting: Initial characteristics of incense bamboo waste on dry basis and macronutrient content of decomposers used for decomposition were estimated and presented in Table 1 and 2, respectively.

Carbon fractions Very labial carbon

The very labile carbon content in incense bamboo waste compost varied between 5.30% to 6.54% after 45 days, 5.64% to 7.15% after 90 days, and 6.91% to 8.74% at 120 days of decomposition. As shown in Fig. 1, treatment T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF) exhibited the highest very labile carbon (8.74%), followed by T5 (BW + 5 kg PM + 0.2 kg LF). In contrast, T1 (BW only) recorded the lowest value (5.30%). The enhanced labile carbon content in amended treatments may be attributed to increased microbial biomass and rapid turnover, as supported by Ghani *et al.* (2003) [7]. The application of organic additives and microbial inoculants likely improved carbon mineralization, thereby promoting the formation of labile organic fractions (Awasthi *et al.*, 2018) [1].

Labial carbon: As illustrated in Fig. 2, the integration of all decomposers led to an increased labile carbon content. Over the decomposition period (45, 90, and 120 days), labile carbon in incense bamboo compost increased from 0.40% to 1.22%, 0.89% to 1.89%, and 1.91% to 3.24%, respectively. The highest labile carbon content (3.24%) was observed in T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF), followed by T5 and T7, while the lowest value (1.91%) was recorded in the control treatment T1 (BW). These results suggest that organic amendments significantly enhanced labile carbon formation during composting.

Less labial carbon: Figure 3 presents the variation in less labile carbon content during composting at 45, 90, and 120 days. The content increased progressively from 3.96% to 5.35%, 4.67% to 6.78%, and finally 6.89% to 8.33%. Treatment T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF) resulted in the highest content (8.33%), while the control (T1) had the lowest (6.89%). The accumulation of less labile carbon may be due to microbial transformation of more recalcitrant materials. Less labile carbon acts as an indicator of compost maturity and stabilization (Chan *et al.*, 2001) [5]. As the composting process advances, carbon fractionation progresses and less labile fractions accumulate due to microbial decomposition of lignocellulosic components (Meena *et al.*, 2023) [12].

Non-labial carbon

During the composting period (45, 90, and 120 days), non-labile carbon content in incense bamboo waste compost showed a declining trend from 37.89% to 29.72%, 34.25% to 17.65%, and 26.80% to 10.44%, respectively (see Fig. 4). The highest non-labile carbon (26.80%) was recorded in the control treatment (T1-BW), whereas the lowest (10.44%) was observed in T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF). This significant reduction in non-labile carbon suggests enhanced decomposition and mineralization due to the synergistic effect of organic and microbial amendments

Table 1: Initial characteristics of incense bamboo waste on dry basis and decomposers used for composting

Characteristics	Bamboo waste (dry basis)
Moisture content %	9.6
Organic carbon content %	49.65
Ash content %	4.78
C:N ratio	121.09
Total nitrogen %	0.41
Total phosphorous %	0.07
Total Potassium %	0.33
Iron (mg kg-1)	152.00
Zinc (mg kg-1)	20.31
Manganese (mg kg-1)	135.32
Copper (mg kg-1)	14.00

Table 2: Initial characteristics of decomposer used for composting

Decomposer material	Macronutrients%		
	N	P	K
Cow dung	0.72	0.26	0.65
Poultry manure	3.01	2.43	1.39

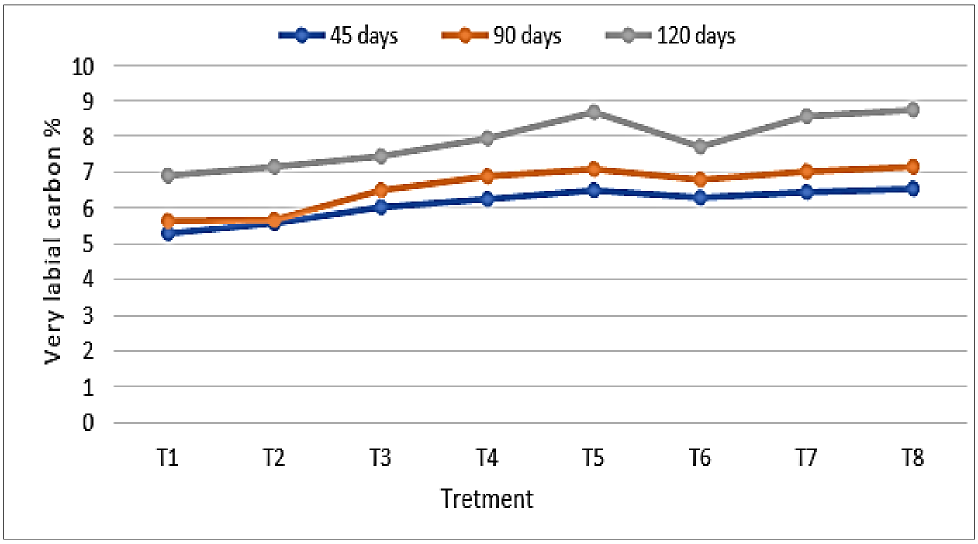

Fig 1: Changes in very labial carbon fraction content of incense bamboo waste compost as influenced by various treatments

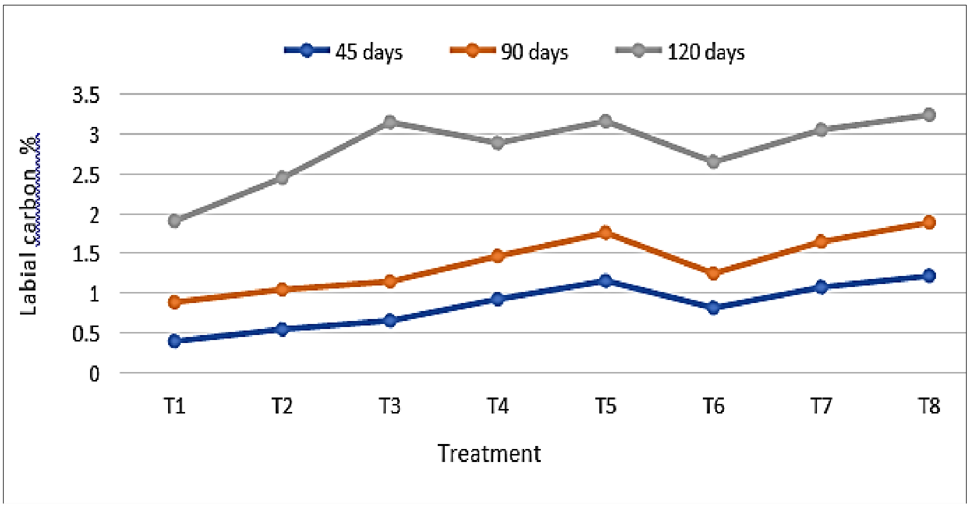

Fig 2: Changes in labial carbon fraction content of incense bamboo waste compost as influenced by various treatment

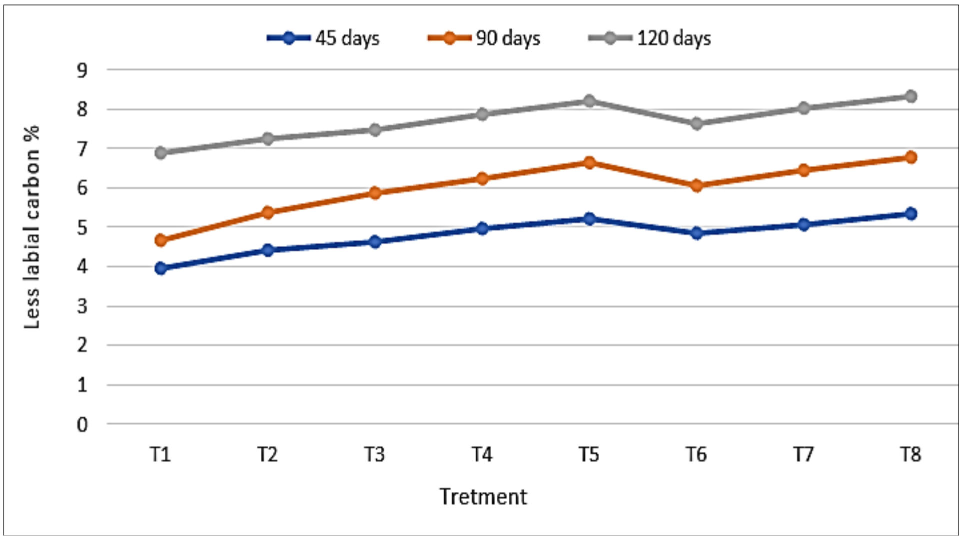

Fig 3: Changes in less labial carbon fraction content of incense bamboo waste compost as influenced by various treatments

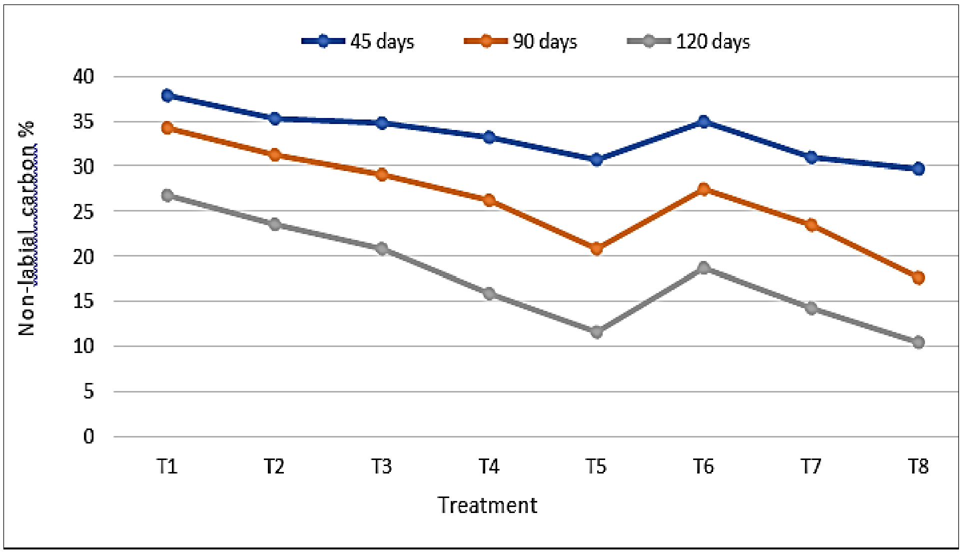

Fig 4: Changes non-labial carbon fraction content of incense bamboo waste compost as influenced by various treatments

Nitrogen fractions

Ammoniacal nitrogen (NH4+-N)

Throughout the composting period, the concentration of ammoniacal nitrogen declined gradually across all treatments (Table 3). On day 45, values ranged from 0.021% (control, T_1- BW) to 0.039% (T_8), with T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF) showing the highest concentration. By day 120, these values reduced to a range between 0.014% (T_1-) and 0.026% (T_8). This decline reflects the conversion of ammoniacal nitrogen into nitrate via nitrification, microbial assimilation, or volatilization of ammonia (NH_3), as reported by Pang *et al.* (2022) [17]. The initial rise followed by a reduction is a typical pattern in aerobic composting, indicating active nitrogen transformation and stabilization.

Nitrate nitrogen (NO3--N)

In contrast, nitrate nitrogen levels showed a consistent increase across the composting timeline (Table 4). Starting from 0.015-0.024% on day 45, the levels reached a maximum of 0.037% in T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF) by day 120. Control treatment (T1-BW) recorded the lowest concentration throughout. The upward trend in nitrate content suggests successful microbial nitrification and indicates advancing compost maturity. This transformation is a strong indicator of improved nitrogen availability and compost stability, consistent with the findings of Huang *et al.* (2004) [9].

Table 3: Changes in ammoniacal nitrogen during composting as influenced by various treatment

Treatments	Ammoniacal nitrogen (NH_4^+-N) %		
	Days		
	45	90	120
T_1-BW (Control)	0.021	0.017	0.014
T_2 - BW + 10 kg CD	0.025	0.019	0.016
T_3 - BW + 5 kg PM	0.029	0.021	0.018
T_4 - BW+ 10 kg CD+ 0.2 kg LF	0.035	0.023	0.020
T_5 - BW + 5 kg PM+ 0.2 kg LF	0.037	0.028	0.024
T_6-BW+ 5 kg CD + 0.06 kg N + 0.2 kg LF	0.033	0.022	0.021
T_7- BW + 2.5 kg PM + 0.06 kg N + 0.2 kg LF	0.035	0.025	0.022
T_8 - BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF	0.039	0.030	0.026
F test	Sig.	Sig.	Sig.
SE (m) ±	0.0007	0.0008	0.0007
CD at 5%	0.0022	0.0025	0.002

Table 4: Changes in nitrate nitrogen during composting as influenced by various treatment

Treatments	Nitrate nitrogen (NH --N) % 3		
	Days		
	45	90	120
T_1-BW (Control)	0.015	0.018	0.025
T_2 - BW + 10 kg CD	0.017	0.020	0.027
T_3 - BW + 5 kg PM	0.018	0.022	0.029
T_4 - BW+ 10 kg CD+ 0.2 kg LF	0.020	0.024	0.031
T_5 - BW + 5 kg PM+ 0.2 kg LF	0.022	0.029	0.035
T_6-BW+ 5 kg CD + 0.06 kg N + 0.2 kg LF	0.019	0.023	0.030
T_7- BW + 2.5 kg PM + 0.06 kg N + 0.2 kg LF	0.020	0.026	0.033
T_8 - BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF	0.024	0.030	0.037
F test	Sig.	Sig.	Sig.
SE (m) ±	0.005	0.0013	0.0019
CD at 5%	0.014	0.0039	0.0057

Conclusion

The findings of this study clearly demonstrate that the integration of cow dung, poultry manure, and lignolytic fungi significantly enhances the breakdown of incense bamboo waste. Among all combinations, treatment T8 (BW + 5 kg CD + 2.5 kg PM + 0.2 kg LF) was the most effective, yielding the highest labile carbon and nitrate nitrogen levels, along with the lowest non- labile carbon content. These results underscore the importance of using a diverse mix of organic and microbial inputs to accelerate composting, promote organic matter mineralization, and improve the overall quality and maturity of compost. Such strategies are essential for sustainable waste management and nutrient recycling in agriculture.

Acknowledgement

I am heartly thankful to centre for Bamboo Research and Training Centre (BRTC), Chandrapur, and especially to its director, Mr. Ashok Khadse (IFS) for providing the fellowship during my study of M.Sc Agriculture (Soil Science) research. Their generous assistance and encouragement throughout the study period are deeply acknowledged. Also I am sincerely thankful to scientists whose references cited here.

References

1. Awasthi MK, Pandey AK, Bundela PS, Wong JWC. Dynamics of bacterial and fungal communities during food waste composting using different bulking agents. Waste Manag. 2018;73:132-145.
2. Banger K, Toor G, Biswas A, Sidhu S, Sudhir K. Soil organic carbon fractions after 16 years of applications of fertilizers and organic manure in a Typic Rhodalfs in semi-arid tropics. Nutr Cycl Agroecosyst. 2010;86:391-399.
3. Li C, Ding S, Du C, He Y, Ma Z, Li G, *et al.* The transformation dynamics and homogeneity of different N fractions in compost following glucose addition. Agriculture. 2021;11:971.
4. Castellano A, Lopez MJ, Juan A, Gonzalez L, Estrella FS, Jurado MM, *et al.* Comparative analysis of phytotoxicity and compost quality in industrial composting facilities processing different organic wastes. J Clean Prod. 2019;252:119820.

5. Chan KY, Bowman A, Oates A. Oxidizable organic carbon fractions and soil quality changes in an Oxic Paleustalf under different pasture leys. Soil Use Manag. 2001;17(1):4-11.
6. Eklind Y, Kirchmann H. Composting and storage of organic household waste with different litter amendments. II: Nitrogen turnover and losses. Bioresour Technol. 2000;74(2):125-133.
7. Ghani A, Dexter M, Perrott KW. Hot-water extractable carbon in soils: A sensitive measurement for determining impacts of fertilisation, grazing and cultivation. Soil Biol Biochem. 2003;35(9):1231-1243.
8. Gu C, Liu Y, Mohamed I, Zhang R, Wang X, Nie X, *et al.* Dynamic changes of soil surface organic carbon under different mulching practices in citrus orchards on sloping land. PLoS One. 2016;11(12):e0168384.
9. Huang GF, Wong JW, Wu QT, Nagar BB. Effect of C:N ratio on composting of pig manure with sawdust. Waste Manag. 2004;24(8):805-813.
10. Keeney DR, Nelson DW. Nitrogen—Inorganic forms. In: Page AL, *et al.*, editors. Methods of Soil Analysis. Part 2. 2nd ed. Madison, WI: ASA and SSSA; 1982. p. 643-698.
11. Liu Q, Zhang Y, Chen H, Li R, Wang W. Microbial augmentation enhances nitrogen stabilization and compost quality. Waste Manag. 2021;157:70-8.
12. Meena AJ, Mali D, Meena RS, Jatav SS, Meena RH, Bamboriya JS, *et al.* Comparing the organic carbon fractions in composts of agricultural wastes at different temperatures and stages. J Soil Sci Plant Nutr. 2023.
13. Meena RS, Kumar S, Datta R, Lal R, Vijayakumar V, Brtnicky M, *et al.* Impact of agrochemicals on soil microbiota and management: A review. Land. 2020;9:34.
14. Misra RV, Roy RN, Hiraoka H. On-farm composting methods. Rome, Italy: Food and Agriculture Organization (FAO); 2003.
15. Moharana PC, Biswas DR, Ghosh A, Bhattacharyya AS, Meena MD. Effects of crop residues composts on the fractions and forms of organic carbon and nitrogen in subtropical Indian conditions. Soil Res. 2019.
16. Nayak AK, Gangwar B, Shukla AK, Mazumdar SP, Kumar A, Raja R, *et al.* Long term effect of different integrated nutrient management on soil organic carbon and its fractions and sustainability of rice-wheat system in Indo-Gangetic Plains of India. Field Crops Res. 2012;127:129-139.
17. Pang Y, Wang S, Liu Y, Zhang W, Li X. Ammonium stress alters bacterial community succession during sludge composting. Chemosphere. 2022;307:135939.
18. Raut MP, Prince William SP, Bhattacharyya JK, Chakrabarti T, Devotta S. Microbial dynamics and enzyme activities during rapid composting of municipal solid waste—a compost maturity analysis perspective. Bioresour Technol. 2008;99(14):6512-6519.
19. Sahoo UK, Singh SA, Gogoi A, Kenye A, Sahoo SS. Active and passive soil organic carbon pools as affected by different land use types in Mizoram, Northeast India. J Soil Sci Plant Nutr. 2019.
20. Tedla AB, Zhou X, Su B, Wan S, Luo Y. Labile, recalcitrant, and microbial carbon and nitrogen pools of a tallgrass prairie soil in the US Great Plains subjected to experimental warming and clipping. Soil Biol Biochem. 2009;41:110-117.
21. Tiquia SM. Evolution of extracellular enzyme activities during manure composting. J Appl Microbiol. 2002;92(4):764-75.

Affiliation Address

Pooja P Kad
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Pragati D Marape
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India

Mrunali R. Manekar
PG Scholar, Soil Science Section, College of Agriculture, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India