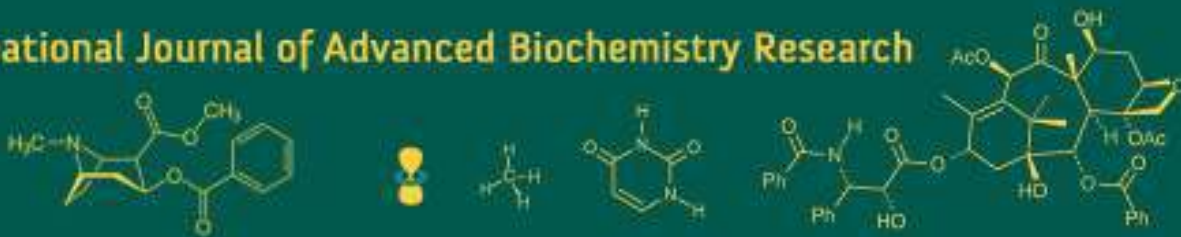


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Tanu
 Department of Soil Science,
 CCS Haryana Agricultural
 University, Hisar, Haryana,
 India

Kavita
 Department of Soil Science,
 CCS Haryana Agricultural
 University, Hisar, Haryana,
 India

Devraj
 Department of Soil Science,
 CCS Haryana Agricultural
 University, Hisar, Haryana,
 India

Shivam
 Department of Soil Science,
 CCS Haryana Agricultural
 University, Hisar, Haryana,
 India

Quality assessment of phosphocomposts prepared from different organic wastes and their impact on wheat yield

Tanu, Kavita, Devraj and Shivam

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Abstract

To attain the objective of present investigation, phosphocomposts were prepared using different organic wastes i.e: C1-{cow dung + pressmud (2:1)} + RP (3:1), C2-{cow dung + pressmud (3:1)} + RP (3:1), C3-{cow dung + poultry manure (2:1)} + RP (3:1), C4-{cow dung + poultry manure (3:1)} + RP (3:1), C5-{cow dung + mustard cake (2:1)} + RP (3:1), and C6-{cow dung + mustard cake (3:1)} + RP (3:1). At day 60, all composts were inoculated with phosphorus-solubilizing microorganisms. For assessing chemical and microbiological properties, samples were collected at 0, 15, 30, 45, 60, 75, and 90 days. Results revealed that during the period of composting, values of EC and pH progressively increased. Values of EC raised from 2.15-3.05 dS m⁻¹ at day 0 to 4.51-5.64 dS m⁻¹ at day 90, while pH increased from 5.21-7.78 at day 0 to 6.45-8.20 at day 90. The C:N ratio of phosphocomposts narrowed from 21.58-65.70 at day 0 to 8.54-21.42 at day 90 with marked reductions in carbon fractions. TOC decreased from 33.66-40.64% to 18.43-22.89% and WSC from 3.07-4.24% to 0.18-0.71% over the composting duration. Nitrogen dynamics revealed total nitrogen (TN) increased from 0.70-2.07% at day 0 to 0.97-2.49% at day 90. Ammonium-N (NH₄⁺-N) originally ranged from 802-1170 mg kg⁻¹, peaked at day 45, and reduces to 196.67-353 mg kg⁻¹ by day 90, whereas nitrate-N (NO₃⁻-N) progressively increased from 42.73-58.77 mg kg⁻¹ to 303.67-809.67 mg kg⁻¹. Yield of wheat under all phosphocomposts treatments was lower than that under RDF, although C6 produced the highest yield among the composts. Although chemical indices indicate apparent compost maturity, poor crop response due to low rock phosphate solubility suggests that present maturity parameters studied are insufficient for phosphocomposts and require further refinement.

Keywords: Phosphocomposts, organic waste, chemical properties, yield

Introduction

The excessive and injudicious use of chemical fertilizers in modern agriculture systems has led to depriving soil fertility and the development of unfavorable physical, chemical, and biological soil conditions, beside increased risks of environmental pollution.

Imbalance nutrient management can aggravate greenhouse gas emissions, nutrient leaching, and groundwater contamination, threatening the quality of both soil and water (Jilkova & Angst, 2022; Azim *et al.*, 2023; Li *et al.*, 2024) [34, 7, 43]. Consequently, there is an urgent need to reduce reliance on synthetic fertilizers and investigate alternatives that emphasize sustainable nutrient management sources. The application of both organic fertilizers as well as composts improve soil physical, chemical and biological properties, improve organic carbon content, and encourage microbial activity, but the direct application of undecomposed organic wastes may adversely affect plant growth due to high C:N ratios of organic waste and the presence of phytotoxic compounds such as volatile fatty acids and phenolics (Kirchmann & Widen, 1994; McClelland *et al.*, 2022) [39, 46]. Therefore, organic wastes must be processed through standardized composting techniques to produce mature, stable and phytotoxin-free compost suitable for agriculture (Zmora-Nahum *et al.*, 2007; Bernal *et al.*, 2009; Dev Raj & Antil, 2011, 2012) [72, 10, 54, 55].

Phosphocomposting produces phosphorus-enriched organic manures by incorporating phosphate-rich minerals, such as rock phosphate (RP), into the composting process. RP is a non-renewable primary raw material for phosphatic fertilizers, but most of the phosphate reserve of India's are low-grade (<20% P₂O₅) and not found suitable for production of

Corresponding Author:
Tanu
 Department of Soil Science,
 CCS Haryana Agricultural
 University, Hisar, Haryana,
 India

conventional fertilizer (FAI, 2010). Co-composting of RP with organic wastes boosts its agronomic efficiency and fertilizing potential (Ditta *et al.*, 2018; Hellal *et al.*, 2019) [18, 31]. Biological inoculation with phosphate-solubilizing microorganisms during composting further enhances availability of phosphorus by producing organic acids such as citric, malic, fumaric, succinic, and oxaloacetic acids, which helps in solubilization of phosphate and improve nutrient transformations over the composting (Kong *et al.*, 2020; Sarr *et al.*, 2020; Benbrik *et al.*, 2021; He Y. *et al.*, 2022; He J. *et al.*, 2022 and Mohamed *et al.*, 2022) [40, 60, 9, 28-29, 47]. The quality of prepared phosphocomposts is commonly assessed via chemical and biological stability and maturity indices, including pH, EC, TOC, WSC, C:N ratio, nutrient content, and microbial activity (Zmora-Nahum *et al.*, 2005; Bernal *et al.*, 2009; Khater, 2015) [73, 10, 38]. Since composition of nutrient depends on characteristics of feedstock, phosphocomposts prepared from different organic wastes like animal manure, agro-industrial waste, municipal trash, and invasive weeds, can vary widely in phosphorus content, nutrient distribution, and agronomic performance (Gagnon *et al.*, 2012; Wei *et al.*, 2015; Grigatti *et al.*, 2017; Oliveira *et al.*, 2019; Kauser & Khwairakpam, 2022; Zuhair *et al.*, 2022) [20, 69, 26, 52, 36, 74]. Mixing nutrient-rich organic substrates, such as poultry manure, mustard oil cake, and pressmud, has been observed to enhance nutrient concentration and minimize heavy metal content, further improving quality of compost (Sultana *et al.*, 2018) [65]. Wheat (*Triticum aestivum* L.) is a important staple crop of India and a vital contributor to national food security. Phosphorus is the second nutrient which is among the key macro-nutrients that are the limiting nutrient in most agricultural soils after nitrogen and whose lack remains the

limiting factor to crop productivity (Shehzad *et al.*, 2022) [63]. Lager track of cultivated soil including those in Haryana state are categorized as either low or medium available phosphorus, which requires the frequent application of external phosphorus inputs in order to support the production of wheat (Anonymous, 2011) [3]. At the same time, the high reliance on imported phosphatic fertilizers in India is viewed as a cause of economical viability and nutrient sustainability in the long term, thus the necessity of localized, sustainable nutrients (Anonymous, 2022-23) [4]. Phosphocomposts generated as a result of co-composting of organic residues with rock phosphate in this regard provide a good alternative with regard to partially replacing chemical fertilizers and enhancing soil health and nutrient availability. In this connection, the current research was conducted to

- Assess changes in chemical and biological properties during phosphocomposting and at compost maturity, and
- Examine the effects of prepared phosphocomposts on wheat yield.

2. Material and Methods

2.1 Raw Materials

For the preparation of phosphocomposts, Pressmud was collected from sugarmead in Yamunanagar, mustard cake was sourced from a nearby store, and cow dung and poultry manure was collected from LUVAS Dairy Farm in Hisar, Haryana. Phosphorus solubilizing microorganisms (PSMs) were created utilizing culture media in the laboratory at the College of Basic Sciences and Humanities, CCSHAU HISAR. Udaipur rock phosphate (URP) was collected from Rajasthan Mines and Minerals Limited, Udaipur, Rajasthan.

Table 2.1: Quantity of raw material used for making different phosphocomposts

Character	Cow dung (kg)	Pressmud (kg)	Poultry manure P.M (kg)	Mustard cake M.C (kg)	Udaipur rock phosphate U.R.P (kg)	Total material (kg)
C ₁	7.50	3.75	-	-	3.75	15
C ₂	8.44	2.81	-	-	3.75	15
C ₃	7.50	-	3.75	-	3.75	15
C ₄	8.44	-	2.81	-	3.75	15
C ₅	7.50	-	-	3.75	3.75	15
C ₆	8.44	-	-	2.81	3.75	15

Table 2.2: Chemical characteristics of raw materials used in phosphocomposts preparation

Character	Cow dung	U.R.P	Pressmud	M.C	P.M
pH (1:10)	7.50	-	7.49	6.77	7.71
EC (dS/m)	7.12	-	4.33	4.44	2.48
O.C (%)	42.46	-	34.78	44.34	40.34
Total N (%)	1.24	-	1.21	5.21	2.43
Total P (%)	0.20	7.64	2.79	1.80	2.49
Total K (%)	0.77	-	2.30	1.2	0.99
Fe (ppm)	1708	0.99	1949	1131	1908
Cu (ppm)	10	530	128	28.88	44
Mn (ppm)	144	80	291	31.77	397
Zn (ppm)	84	88	343	78.90	247

2.2 Preparation of phosphocomposts

Composting was carried out using two cow dung to substrate ratios i.e. i.e., 2:1 and 3:1, with pressmud, poultry manure, and mustard cake. For the 2:1 ratio, 7.50 kg of cow dung was mixed with 3.75 kilogram kg of pressmud, poultry manure, and mustard cake in treatments C₁, C₃, and C₅, respectively, whereas for the 3:1 ratio, 8.44 kg cow dung

was combined with 2.81 kg of the respective substrates in treatments C₂, C₄, and C₆. All treatments were made in three replications. Powdered Udaipur rock phosphate (URP; 100 mesh, 7.6% P) was mixed homogeneously with cow dung then inoculated with a slurry of jaggery solution, fertile soil, and well-decomposed manure. The composting material was put in covered plastic tubs and afterwards transferred to large covered plastic pots for further decomposition. To maintain aerobic conditions and consistent moisture, the compost was turned every 15 days for a total of 90 days. The phosphate-solubilizing microorganism (PSM) culture was introduced on 60th day of composting to promote phosphorus solubilization. Optimum moisture content was maintained throughout the composting duration.

2.3 Analysis of phosphocomposts

To analyse changes in chemical characteristics during the composting period, samples were obtained at 0, 15, 30, 45, 60, 75, and 90 days after complete mixing of compost.

Around 200 g of compost from each treatment was treated with a few drops of toluene, air-dried, crushed, and passed through a 1 mm screen before being stored separately in polythene bags for further analysis. The pH and EC of dried compost samples were measured in a 1:20 (w/v) compost-distilled water suspension using a combined glass electrode for pH and a conductivity bridge for EC, following Jackson. The loss in organic matter was calculated by periodic weighing, and ash content was determined by ignition at 550 °C for 1 h. Total organic carbon was calculated using the equation: Total C (%) = (100 – % Ash) / 1.724.

Water-soluble carbon was extracted in a 1:20 ratio as described by Walkley and Black (1934) [75]. Microbial biomass carbon was determined by the chloroform fumigation-extraction method, in which 10 g compost samples were fumigated for 24 h with ethanol-free CHCl₃ then extracted using 0.5 M K₂SO₄, and microbial biomass carbon was calculated as the difference between fumigated and non-fumigated extracts (Vance *et al.*). Total nitrogen was determined using the micro-Kjeldahl method (Chopra and Kanwar), while NH₄⁺-N and NO₃⁻-N were extracted with 2 M KCl following Hesse. The C:N ratio of the compost was calculated by dividing total organic carbon by total nitrogen content for each sampling interval.

2.4 Crop trial

A screen house experiment was conducted during 2024-25 at the Department of Soil Science, CCS Haryana Agricultural University, Hisar on wheat (cv.WH 1124) in a completely randomized block design with three replications on loamy sand soil texture. The treatments comprised of T₁: Control, T₂: RDF (150-60-60 kg/ha), T₃: NK +C₁ {C₁ dose : 2.449 g/pot} + Rock Phosphate (RP) (3:1), T₄: NK +C₂ {C₂ dose : 2.778 g/pot} + RP (3:1), T₅: NK + C₃ {C₃ dose: 1.974 g/pot} + RP (3:1), T₆: NK + C₄ {C₄ dose : 2.298 g/pot} + RP (3:1), T₇: NK + C₅ {C₅ dose : 1.659 g/pot} + RP (3:1), T₈: NK +C₆ {C₆ dose : 1.746 g/pot} + RP (3:1). NK dose was given by urea (0.652g/pot) and MOP (0.2 g/pot) respectively in T₂ to T₈ treatments. For RDF, DAP dose was given 0.261 g/pot in T₂ treatment, weight of the soil per pot was 4 kg. The soil used for the pot experiment with wheat had an initial pH of 8.6, EC of 0.1 dS m⁻¹, organic carbon content of 0.23%, available nitrogen of 32 mg kg⁻¹, available phosphorus of 5.52 mg kg⁻¹, and available potassium of 58 mg kg⁻¹. The DTPA-extractable micronutrient contents were 3.23 mg kg⁻¹ Zn, 0.25 mg kg⁻¹ Mn, 0.49 mg kg⁻¹ Cu, and 0.30 mg kg⁻¹ Fe. Ten seeds of wheat were sown per pot and thinning was done after emergence to five uniform plants per pot. The crop was irrigated with deionized water as required to maintain optimum soil moisture throughout the experiment. Wheat plants were harvested at maturity, and grain yield, straw yield (dry matter), and total biomass were recorded for each.

2.5 Statistical analysis: The data obtained in this study was subjected to the statistical analysis under three factorial CRD using OP Stat software, developed by the Department of Statistics at CCS HAU, Hisar.

3. Result and Discussion

3.1 Assessment of physio-chemical parameters during different days of phosphocomposts

3.1.1 Physical Characteristics of Compost

At t day 90, all compost treatments attained a stabilized granular structure and uniform dark grey colour, which was an indicator of compost maturity. Even though minor remnants of the initial feedstock materials were still there, all mixtures had defined indications of stabilization. At this stage, secondary consumers were seen in all treatments, and it indicates that there is sustained biological activity during the later phases of composting. There was no foul odours were detected at the end of the composting period.

3.1.2 pH and EC

The dynamics of pH and EC recorded during phosphocomposting serve as key indicators of process efficiency and maturity of compost, as both parameters strongly controls microbial activity, enzymatic transformations as well as nutrient availability (Voberkova *et al.*, 2020) [67]. In this study, pH increased steadily across all treatments from day 0 to day 90, indicating progressive compost stabilization (Fig.1). Initially pH ranged from 5.21 (C6) to 7.78 (C3), with a marked increase during the first 60 days related to the active decomposition phase, followed by stabilization during maturation. By day 90, treatment C3 recorded the highest pH (8.20), followed by C1 and C4 (8.10), whereas C5 and C6 recorded relatively lower pH values all over the composting period. The increase in pH attributed to ammonification of organic nitrogen, degradation of organic acids, and the formation of humic substances, which impart buffering capacity and stabilize pH during later stages of composting (Avnimelech *et al.*, 1996; Awasthi *et al.*, 2016; Ravindran *et al.*, 2017) [5, 6, 56]. Similar results were also reported in several research studies (Shantha *et al.*, 2009; Zhan *et al.*, 2021; Haouas *et al.*, 2021; Kumar *et al.*, 2024) [62, 71, 27, 41].

EC also showed a steady and significant increase during the composting period across all treatments, which indicates progressive mineralization and accumulation of soluble ions (Fig.2). The initial EC values varied from 2.15 dS m⁻¹ (C1) to 3.05 dS m⁻¹ (C6), with the most noticeable rise taking place between 15 and 60 days, which corresponded with increased microbial activity and the breakdown of organic matter. By day 90, C3 had the highest EC (5.64 dS m⁻¹), followed by C5 and C4, while C2 had the lowest EC (4.51 dS m⁻¹).

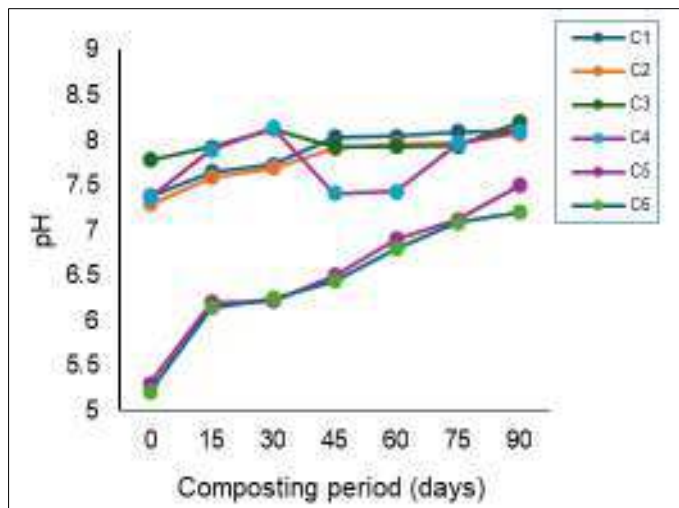


Fig 1: pH

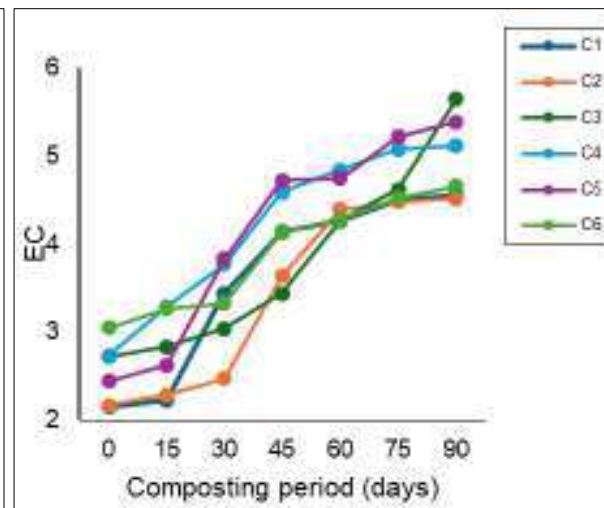


Fig 2: EC

The increase in EC attributed to the release of inorganic salts such as nitrate, ammonium, phosphate, potassium, and other exchangeable cations during decomposition of organic matter, as well as concentration effects resulting from moisture loss and mass reduction of organic substrates. Results of present study are in line with the findings reported by others researchers (Zeng & Wang, 2009; Brajendra *et al.*, 2016; Ghoneim *et al.*, 2017; Kumar *et al.*, 2023; Ge *et al.*, 2024; Li *et al.*, 2024) [70, 13, 23, 43, 42]. Although elevated EC may pose salinity concerns for sensitive crops (Alavi *et al.*, 2017; Waqas *et al.*, 2019) [1, 68], the observed EC trends, together with stabilized pH values, confirm systematic physicochemical transformations and indicate the attainment of mature, nutrient-enriched phosphocompost by the end of the composting period.

3.1.3 Total organic C and water soluble C

The total organic carbon (TOC) and water-soluble carbon (WSC) changes during phosphocomposting indicated progressive microbial degradation and carbon

mineralization. Throughout all treatments, TOC decreased significantly during the 90-day composting period, with the most pronounced reduction observed during the first 60 days, associated with the active decomposition phase (Fig.3). Initial TOC values varied from 33.66% in C3 to 40.64% in C6, whereas the lowest values at maturity (day 90) were reported in C2 (18.43%), C3 (19.67%), and C6 (21.27%), with C5 sustaining the greatest TOC (22.89%). The reduction in TOC arises from microbial respiration, which releases CO₂, and the transformation of labile carbon into more stable humic compounds, reducing the fraction of total carbon in mature compost (Biswas & Narayanasamy, 2002; Goyal *et al.*, 2005; Said-Pullicino *et al.*, 2007; Banta & Dev, 2009; Reza *et al.*, 2017; Zhan *et al.*, 2021) [12, 24, 58-59, 8, 57, 71]. Mean TOC over the composting period was highest in C1 (31.56%) and lowest in C3 (26.34%), and analysis of variance confirmed that composting duration, organic waste composition, and their interaction significantly influenced TOC dynamics ($p < 0.05$).

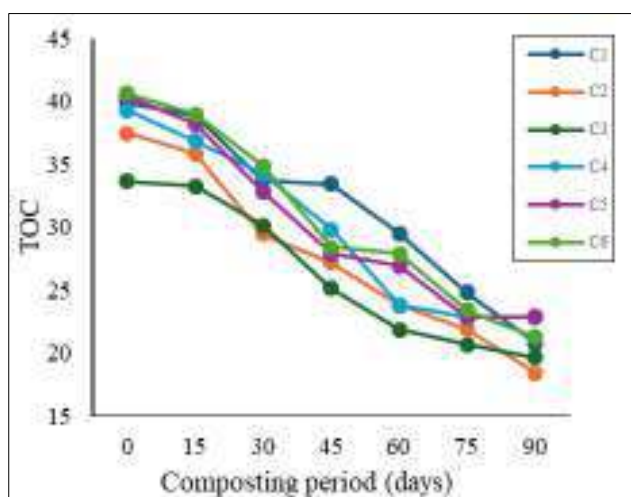


Fig 3: TOC

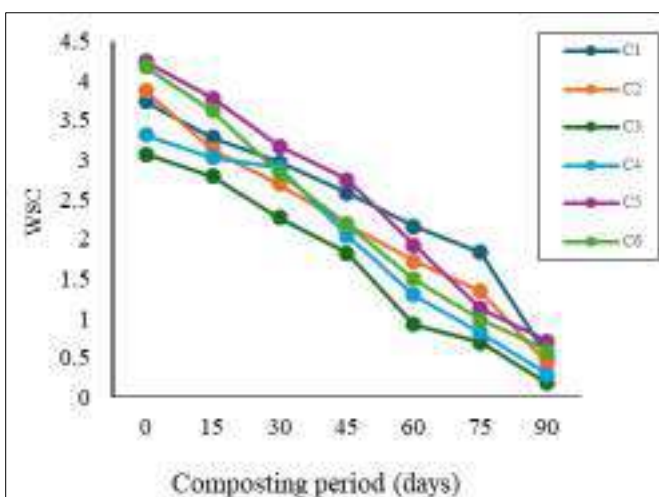


Fig 4: WSC

Similarly, WSC, a measure of compost maturity and the labile carbon content, dramatically decreased in all treatments (Fig. 4), indicating that microbes used readily degradable substrates and transformed soluble carbon into more complex, stable humified molecules. (Garcia *et al.*, 1991; Bernal *et al.*, 1998; Zmora-Nahum *et al.*, 2005;

Hernández *et al.*, 2006; Castaldi *et al.*, 2008; Chefetz *et al.*, 1998; Said-Pullicino *et al.*, 2007; Hussain *et al.*, 2017; Moharana *et al.*, 2020; Kumar *et al.*, 2023) [21, 11, 73, 32, 14, 16, 58-59, 33, 42]. The initial WSC ranged from 3.07% to 4.24%, with the first 60 days exhibiting the more pronounced decrease. At day 90, C3 had the lowest WSC (0.18%) while C5 had

the highest (0.71%). C5 had the greatest mean WSC values (2.53%) for the whole composting time, whereas C3 had the lowest (1.68%). The WSC levels below 1.7% at maturity suggest all phosphocomposts gained sufficient stability (Bernal *et al.*, 1998) [11]. The observed temporal trends in TOC and WSC are consistent with other studies on aerobic composting of organic wastes, highlighting the preferential degradation of labile carbon fractions during the active composting phase (Li *et al.*, 2009; Chang *et al.*, 2009; Azim, Vahabi, & Wu, 2023) [44, 15, 7].

3.1.4 Total N

The composting duration and the different organic waste had a significant impact on the total nitrogen (TN) content of phosphocomposts, which increased steadily from day 0 to day 90 (Fig. 5). The rise in TN was more noticeable after 30 days, continuing consistently until the end of composting, suggesting progressive microbial activity and mineralization dynamics. By day 90, C5 had the highest TN (2.49%), while C1 had the lowest (0.97%). The mean TN values were

recorded highest with C5 (2.07%) and lowest with C2 (0.70%). The rise in TN during composting is mostly related to the loss of carbon through microbial respiration, which concentrates nitrogen in the remaining compost matrix, as well as to the relative retention of nitrogen compared to losses of volatile solids and ammonia (Nagarajan *et al.*, 1985; Singh *et al.*, 1992; Bernal *et al.*, 1998) [50, 64, 11]. Additionally, the greater TN in treatments containing mustard cake, such as C5, is attributable to the elevated nitrogen input from this substrate in the 2:1 cow dung-mustard cake mixture. Similar tendencies of increased TN during composting have been widely recorded in varied organic waste combinations, including farm wastes, chicken manure, and agro-industrial byproducts (Thakur *et al.*, 2014) [66]. The continuous accumulation of TN, along with corresponding carbon loss, shows the critical role of microbial breakdown and substrate composition in increasing nitrogen enrichment and overall nutritional quality of mature phosphocomposts.

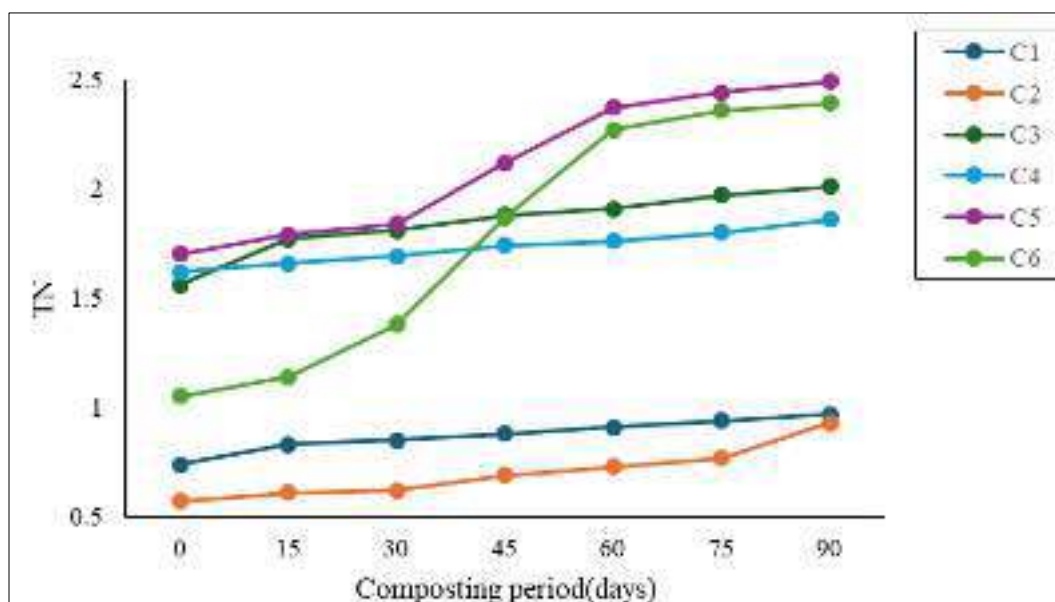


Fig 5: Total nitrogen

3.1.5 Ammonical -N and nitrate-N

The change in Ammonium-N ($\text{NH}_4^+\text{-N}$) and nitrate-N ($\text{NO}_3^-\text{-N}$) during phosphocomposting demonstrated the successive microbial transformations of nitrogen and are important markers of compost maturity. Ammonium-N concentrations increased in all treatments during the first 45 days, peaked at 802-1170 mg kg^{-1} , and then gradually decreased to 196.67-353.00 mg kg^{-1} by day 90. In contrast, nitrate-N showed a steady increase during the composting period, initially varying from 42.73-58.77 mg kg^{-1} at 0 day

to 303.67-809.67 mg kg^{-1} at day 90, with C5 displaying the largest accumulation at maturity. The results of present study are in line with the finding reported by other researchers (Alexander, 1977; Li, Liu, & Chi, 2009; Zeng & Wang, 2009; Raj & Antil, 2012) [2, 44, 70, 55] who suggested that aerobic composting is characterized by an inverse connection between $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$, which reflects the shift from ammonification during early proteolysis to nitrification in later stages.

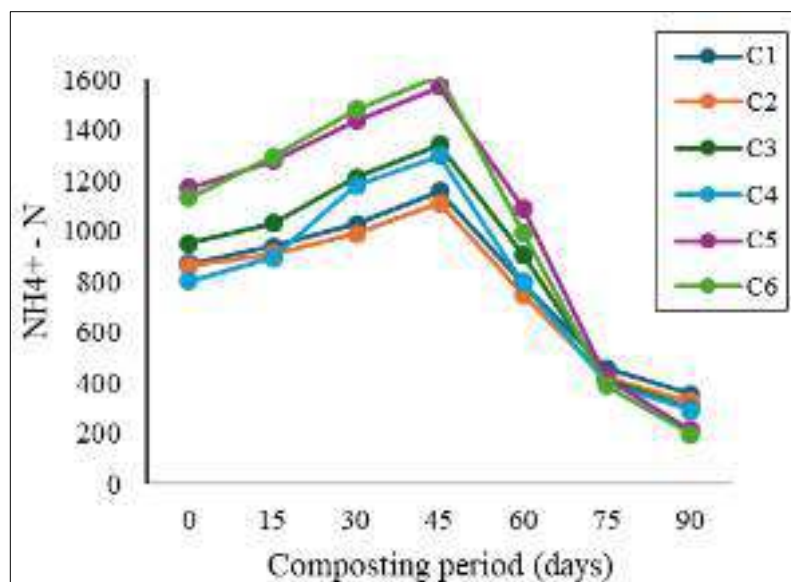


Fig 6: Temporal Variation of NH₄⁺-N during Composting Under Different Treatments

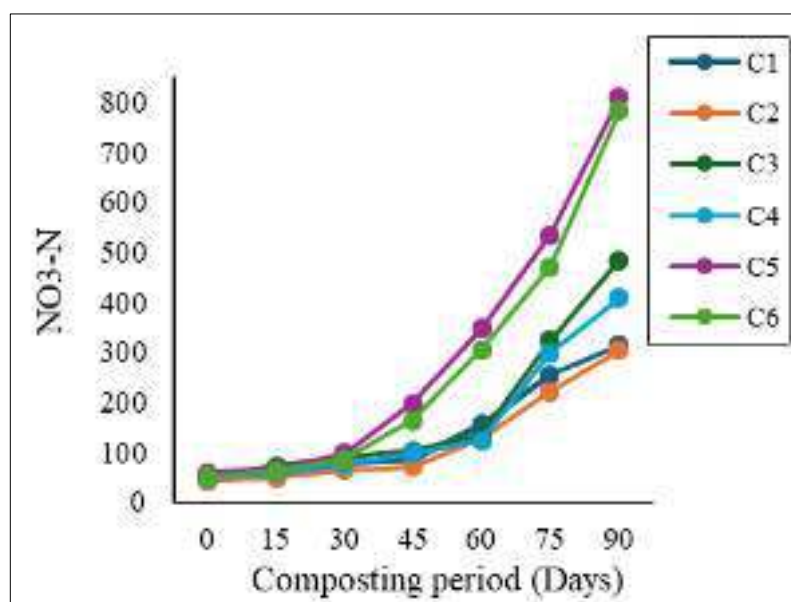


Fig 7: Effect of Composting Duration on NO₃⁻-N Accumulation

Protein breakdown aids in the initial build-up of ammonium, whereas nitrification and ammonia volatilization especially in thermophilic environments with high pH drive its subsequent decrease (Finstein & Miller, 1985; Jimenez & Garcia, 1992) [19, 21]. As the compost transitions from the thermophilic to the maturation phase, the increased activity of nitrifying bacteria is reflected in the increase in nitrate-N after 45 days (Li, Zhang, & Chen, 2024) [43]. The observed NH₄⁺-N decrease paired with NO₃⁻-N increase suggests successful nitrogen transformation and verifies that the phosphocomposts acquired maturity by the conclusion of the 90-day composting period.

3.1.6 Carbon-to-Nitrogen (C:N) Ratio

Over the course of the 90-day composting period, the carbon-to-nitrogen (C:N) ratio of phosphocomposts showed a significant and continuous reduction, indicating the breakdown of organic matter and the stabilization of nutrients. Initial C:N ratios ranged from 21.58 to 65.70, with an overall mean of 37.98, and the most substantial drop

occurred during the first 45-60 days, coinciding to the active microbial decomposition phase (Fig. 8). By day 90, C6 had the lowest C:N ratio (8.54), whereas C1 continued to have the highest value (21.42). Over the course of the composting process, C2 had the greatest mean C:N values (41.73), while C3 had the lowest (14.59). The decrease in C:N ratio is related to microbial degradation of carbon-rich labile organic matter, leading to CO₂ and H₂O losses, while nitrogen is comparatively retained or concentrated in the compost, resulting in a declining of ratio (Mohamoud & Sharanappa, 2002; Satisha & Devarajan, 2007; Raj & Antil, 2011; Khan & Sharif, 2012; Hellal *et al.*, 2013) [48, 61, 54, 37, 30]. Treatments C3, C4, C5, and C6 reached C:N ratios below 15, and all except C1 were below 20, confirming that the phosphocomposts reached maturity. These results are consistent with prior studies reporting declining C:N ratios as a reliable indicator of compost stabilization and suitability for agricultural application (Goyal *et al.*, 2005; Wei *et al.*, 2015) [24, 69].

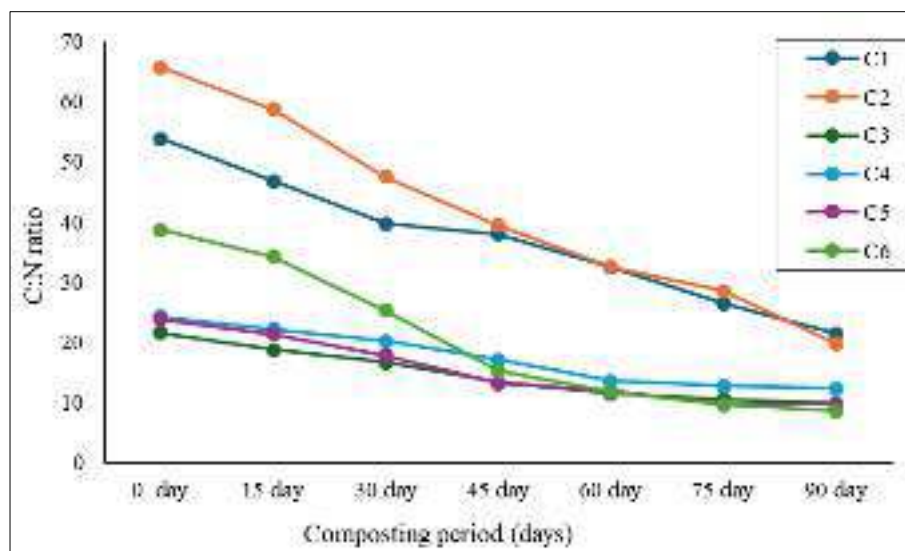


Fig 8: C:N ratio

3.2 Grain and straw yield

The data (Fig. 9) showed that effects of prepared phosphocompost and chemical fertilizer application on wheat grain and straw yield was significant. Grain yield varied from 3.72 to 10.23 g pot⁻¹ and straw yield from 7.44 to 13.69 g pot⁻¹. The highest grain (10.23 g pot⁻¹) and straw (13.69 g pot⁻¹) yields were obtained under the recommended NPK fertilizer treatment (T₂), reflecting the rapid availability of inorganic nutrients where as the lowest yields recorded in the control (T₁). Among compost-amended treatments, T₈ (compost C6) recorded the higher grain (9.66 g pot⁻¹) and straw (12.65 g pot⁻¹) yields, followed by T₇ and T₆, while all compost treatments significantly outperformed

the control. Similar type yield responses results reported by other researchers under inorganic P fertilization (Deshmukh and Tiwari, 1996; Maynard 1989; Patel *et al.*, 2024) [17, 45, 53] attributed to higher water-soluble P and improved nutrient uptake efficiency (Nishant & Biswas, 2008; Grant *et al.*, 2001) [51, 25]. The relatively lower yield under phosphocompost treatments suggests limited immediate P availability from RP-based composts, despite compost maturity, indicating that phosphocomposts contribute to soil fertility improvement but partially substitute chemical P fertilizers for short-duration crops such as wheat (Biswas & Narayanasamy, 2002; Raj & Antil, 2011; Moharana *et al.*, 2020) [12, 54, 49].

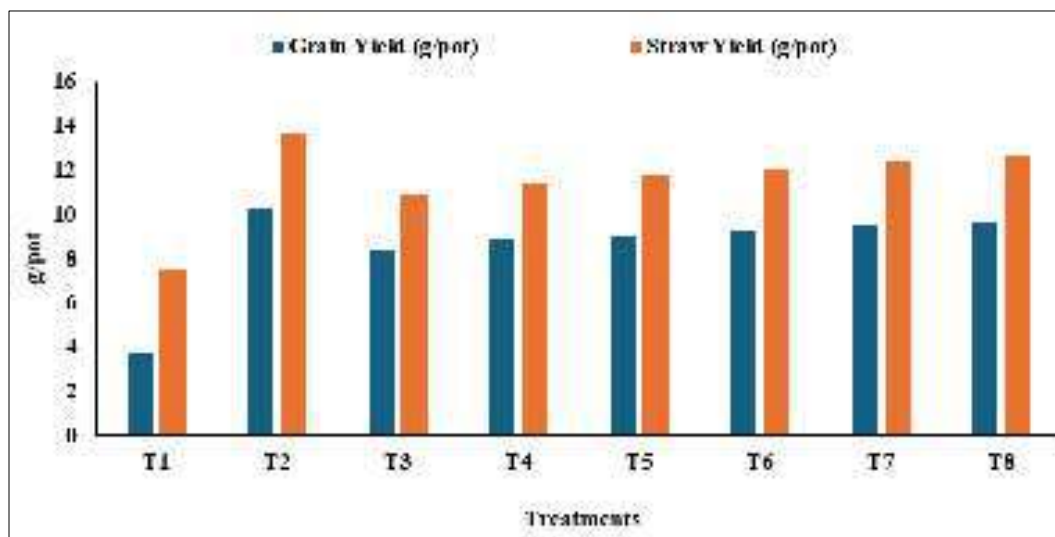


Fig 9: Grain and straw yield of wheat

4. Conclusion

The present investigation clearly showed that transformation in biochemical and physicochemical properties over the compost preparation demonstrated compost stabilization and maturity. Progressive reductions in total organic carbon and water-soluble carbon revealed active microbial mineralisation and humification activities, resulting in enhanced compost quality. The attainment of water-soluble carbon levels below the stated maturity threshold (1.7%) after 90 days, coupled with the convergence of pH toward

near-neutral values, proved the creation of stable and agronomically acceptable composts.

All treatments compost maturation was further supported by the steady decrease in the C:N ratio and the change in nitrogen fractions. The addition of nutrient-rich organic substrates, especially poultry manure and mustard cake, to rock phosphate greatly increased the phosphocomposts nutrient enrichment, particularly their nitrogen content, highlighting the significance of substrate composition in determining compost quality. Due to the restricted

immediate phosphorus availability from rock phosphate, all matured phosphocomposts considerably increased wheat growth and yield when compared to the unfertilized control, but their agronomic performance was still lower than that of inorganic fertiliser. Overall, phosphocomposting represents an effective waste valorization and nutrient-recycling approach that supports sustainable soil fertility management and long-term soil health, while its integration with reduced doses of chemical fertilizers may further enhance crop productivity.

5. Acknowledgment

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