RESEARCH ARTICLE

Exploring the Effectiveness of Human Waste Compost in Improving Agricultural Soil: A Comparative Study with Poultry Manure, Cow Dung, and Vermicompost

Samanta Islam[1], Asif Raihan[2*]

[1]Department of Environmental Science and Engineering, Jatiya Kabi Kazi Nazrul Islam University, Mymensingh 2220, Bangladesh
[2]Institute of Climate Change, National University of Malaysia, Bangi 43600, Selangor, Malaysia

Corresponding Author: Asif Raihan. Email: asifraihan666@gmail.com
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Abstract
The heightened application of chemical fertilizers to enhance agricultural output jeopardizes agricultural and environmental sustainability. The present study assessed the influence of various organic amendments on soil properties. The experimental design encompassed a Randomized Complete Block Design, with treatments that included a control group along with vermicompost, human waste compost, poultry manure, and cow dung. The primary focus of the experiment was to evaluate multiple soil attributes, such as soil texture, pH, electrical conductivity (EC), organic matter (OM), total nitrogen (N), available phosphorus (P), exchangeable potassium (K), available sulfur (S), and exchangeable sodium (Na), to determine the impact of different manure applications. The findings of the study confirmed significant alterations in soil physicochemical parameters due to the application of these treatments. Notably, poultry manure and vermicompost exhibited the most substantial positive effects on total nitrogen, resulting in increases of 0.16% and 0.14%, respectively. In cases of phosphorus deficiency, both poultry manure and human waste compost were found to be effective in increasing soil phosphorus levels. Moreover, vermicompost and poultry manure were found to enhance the exchangeable potassium levels, with values of 0.467 and 0.432 meq/100 g soil, respectively. Sulfur content was notably higher in plots treated with poultry manure (20.5 ppm), followed by vermicompost (17.87 ppm) and human waste compost (17.21 ppm). Additionally, the treatment with human waste compost exhibited the highest electrical conductivity (243 µs/cm), while poultry manure had the most significant impact on increasing organic matter, showing a substantial 2.76% increment. The study's findings advocate for a transition from chemical fertilizers to compost fertilizers, which would enhance agricultural soil and promote sustainability in both agriculture and the environment.

Keywords: Human waste; Manure; Soil; Nutrition; Composting

Introduction
Over the past four decades, Bangladesh has made significant strides in its efforts to ensure food security for its large population (Islam et al., 2020). Among various approaches aimed at boosting agricultural productivity,

there has been a notable shift in the use of fertilizers and cultivation practices by farmers (Muhie, 2022; Raihan, 2023). Soil organic matter, typically in the range of 2.5% to 3.0%, is a critical factor influencing soil fertility, nutrient availability, and crop yields (Smith & Hughes, 2002). Unfortunately, in Bangladesh, the majority of soils contain less than 1.7% organic matter (Shil et al., 2016). This deficiency in organic matter has hindered soil fertility, posing challenges to crop production throughout the country. Consequently, the supplementation of nutrients in the form of fertilizers has become an integral part of agricultural practices across most of the nation (FAO, 2011). Regrettably, this heavy reliance on inorganic fertilizers has led to a gradual decline in the inherent fertility of the soil over the years (Rahman & Barmon, 2019). For example, the prevalent use of inorganic fertilizers such as NPK has had a significant impact on plant growth, development, and yield (Sanwal et al., 2007). However, excessive NPK application can result in soil infertility, degradation, and contamination of surface and groundwater resources (Onuh et al., 2008). The continuous use of chemical fertilizers like urea can further deteriorate soil properties by causing nutrient imbalances and micronutrient deficiencies (Shukla et al., 2022). The long-term use of chemical fertilizers has also been associated with serious consequences, including soil acidification, imbalanced nutrient levels, disruption of the rhizosphere micro-ecological environment, and altered activity of heavy metal ions in the soil (Lin et al., 2019). Additionally, fertilizer production introduces pollutants into the environment (Rahman et al., 20221; Raihan et al., 2023a), releasing toxic air pollutants and untreated waste into water bodies, leading to environmental pollution (Chandini et al., 2019). In addition to ensuring food production and nutritional security, it is equally crucial to prioritize the preservation of soil health and environmental well-being (Das et al., 2022).

The current global context emphasizes the adoption of eco-friendly agricultural practices for sustainable food production (Raihan et al., 2022; 2023b; 2024). Using organic manure is considered an ecologically sound agricultural practice that not only supports crop production but also enhances biodiversity and soil biological activities (Usman et al., 2016). Organic manure serves as an excellent source of plant-available nutrients and promotes the optimal growth of microbial populations and activities (Bhunia et al., 2021). Numerous studies have highlighted the importance of organic manure as a sustainable and environmentally friendly fertilizer (Han et al., 2016), which improves plant health and productivity (Palm et al., 1997). This recycling process allows nutrients present in organic materials to return to the soil in a form that is readily available for plants (Ahmad et al., 2007). Given the substantial amount of waste materials generated in modern times, the conversion of these materials into organic manure has become a viable option. Organic matter sources such as animal manure, human waste, food waste, yard waste, sewage sludge, and composts have long been recognized in agriculture as beneficial for plant growth, yield, and soil fertility (Pajura, 2024). Composted organic materials contain essential nutrients for plant growth, particularly nitrogen (N) and phosphorus (P) (Beltrán et al., 2006). These organic manures help restore and sustain the inherent properties of the soil, enhance soil biological activities, and potentially increase crop yields without the use of chemicals, making them safe for human consumption (Mrunalini et al., 2022). Organic fertilizers release nutrients slowly, providing a longer-lasting source of nutrition for plants, while inorganic fertilizers release and lose nutrients more rapidly (Han et al., 2016). Properly utilizing organic manure, such as cow dung, human compost, vermicompost, and others, improves soil texture, structure, humus content, color, aeration, water retention capacity, and microbial activity (Chaudhari et al., 2021). With increasing global focus on the environmental impacts of intensive agriculture (Raihan & Tuspekova, 2022), organic manure is recognized as an eco-friendlier alternative. In Bangladesh, urban areas face significant challenges in managing organic waste due to rapid urbanization (Sujauddin et al., 2008). Large-scale composting of urban organic waste could address these issues, reducing waste accumulation and supporting healthy agricultural practices while contributing to a cleaner environment (Almendro-Candel et al., 2019). Among the various organic waste products, dairy manure and poultry waste can serve as valuable components for producing organic manure. Vermicompost, another popular organic manure, contains essential plant nutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B) (Kale et al., 2012), making it a suitable option for Bangladesh. Interestingly, human excreta are also being utilized to create compost manure in Bangladesh, although its use has not yet become widespread. While several studies in Bangladesh have examined the effects of organic composts on crop growth and soil properties, none have explored the potential use of human waste compost as a source of organic nutrients for soil improvement. However, research in other countries has highlighted the richness of human waste compost in essential nutrients, particularly nitrogen (N) and phosphorus (P), which are crucial for plant growth and soil fertility (Häfner et al., 2023; Sanwal et al., 2007). In China, researchers have found that human waste compost can increase crop yields, ensuring both crop quality and soil health (Liu et al., 2021).

The application of toilet compost has been shown to alleviate soil acidification and salinity, underscoring its positive impact on soil chemical properties (Sangare et al., 2015). Additionally, research has demonstrated that the use of treated human excreta can enhance maize crop production and water efficiency in rain-fed agriculture (Guzha et al., 2005). Consequently, this study aims to assess the efficacy of human waste compost in comparison to three others commonly used organic manures in Bangladesh. With these insights in mind, our research endeavors to conduct a comprehensive comparative analysis of the effects of human excreta, cow dung, vermicompost, and poultry manure on the physical and chemical properties of soil, aiming to recommend the most suitable organic manure for enhancing soil quality. Compost enhances soil structure by adding carbon and supplying essential nutrients for plants. Besides serving as a source of essential plant nutrients including nitrogen (N), phosphorus (P), and potassium (K), it enhances the physico-chemical and biological characteristics of the soil. Compost serves as a vital fertilizer by enhancing soil health and production, mitigating greenhouse gas emissions, and generating social and economic advantages. The research on compost fertilizer is significant due to its potential to enhance soil health, decrease waste, and alleviate climate change. The study's findings support a shift from chemical fertilizers to compost fertilizers, which would improve agricultural soil and foster sustainability in agriculture and the environment.

Materials and Methods

Study area and soil properties

The experiment took place between January 2021 and March 2021, consisting of two distinct parts of Bangladesh. The first part of the experiment primarily focused on the effects of organic amendments on soil quality improvement, while the second part, which pertains to the impact of these amendments on the growth of red amaranth, will be addressed separately in another paper.The research site was situated in a subtropical climate region characterized by moderately high temperatures, humidity, and substantial rainfall during the Kharif season (April to September), with intermittent strong winds. In contrast, the Rabi season (October to February) was marked by limited rainfall and relatively cooler temperatures. The site fell within the agroecological zone (AEZ-9) of the Old Brahmaputra Floodplains, characterized by non-calcareous dark grey floodplain soil, as per the classification by the Food and Agriculture Organization (FAO, 2001).

Further details regarding the soil characteristics will be explored below:

Table 1. Soil Properties of the experimental field

Characters		Definition/Value
Location		Environmental Science Field Laboratory, Bangladesh Agricultural University, Mymensingh, 24°75´ N Latitude and 90°50´ E longitude
Morphology	Land type	Medium high land, an elevation of 18 m above the sea level
	General soil type	Non-calcareous Dark Grey Floodplain Soil
	Parent materials	Old Brahmaputra river-borne deposits
	Soil series	Sonatola
	Drainage	Poor drainage system
	Flood level	Above flood level
	Topography	Fairly leveled
	Vegetation	Rice crop is grown year-round
Physical properties	Textural classes	Silty loam
	Soil moisture	24.80%
	Sand	30.24%
	Silt	58%
	Clay	11.75%
Chemical properties	Soil pH	6.57
	Total Nitrogen	0.10%
	Available Phosphorus	6.20 ppm
	Exchangeable Potassium	0.142 me/ 100 g soil
	Organic matter content	1.15%
	Organic Carbon	1.20%

Source: Department of Soil Science, Bangladesh Agricultural University, Mymensingh, 2021

Experimental design

The experiment was conducted following a Randomized Complete Block Design (RCBD) with three replications. A total of 15 plots, each measuring 2 m × 2 m, were arranged, maintaining a 0.5 m separation between blocks and between individual plots. The assignment of all experiment treatments to the unit plots within each replication was done randomly.

The field experiment comprised five distinct treatments, each designated as follows: Control (T0), Vermicompost (T1), Human Waste Compost (T2), Poultry Manure (T3), and Cow Dung (T4). The nutritional characteristics of these fertilizers, along with the corresponding application rates per plot, are detailed in Table 2.

Table 2: Summary of the treatments applied in the experimental plots

	Definition	% N	% P	% K	
T0	Control (no fertilizer)				No fertilizer
T1	Vermicompost	1.48	0.67	0.94	4 kg
T2	Human waste compost	1.23	0.86	0.31	5 kg
T3	Poultry Manure	1.52	0.62	0.53	4 kg
T4	Cow dung	0.73	0.38	0.26	8 kg

Experimental procedures

Land preparation

The experimental plot was prepared through a series of steps. Initially, it was opened using a country plow, followed by plowing and cross-plowing, which were repeated up to five times. Subsequently, laddering was carried out at appropriate intervals to ensure that the plot was finely pulverized and well-prepared. Throughout the land preparation process, any weeds and remnants from previous crops were diligently collected and cleared from the area to achieve optimal soil tilth conditions

Application of organic amendments

All of the vermicompost, human waste compost, cow dung, and poultry manure were applied during the final stage of land preparation. The quantity of compost needed for each plot was determined according to the plot's area. Following the application of composts, the land was left undisturbed for approximately one month to allow for the gradual and natural integration of the compost materials with the soil.

Collection of soil sample

Soil samples were collected post-harvest from the experimental field using an auger. Samples were taken from five distinct locations within each experimental plot, reaching a depth of 0-5 cm. These individual samples were then meticulously combined to create a composite soil sample

Soil analysis

Upon gathering the soil samples, any extraneous materials such as rocks, plant roots, leaves, and other debris were meticulously removed. Subsequently, the samples were air-dried, thoroughly mixed, and ground until they could pass through a sieve. The processed soil samples were then stored in clean plastic bags, ready for subsequent mechanical and chemical analyses

The chemical analysis of the soil samples was conducted at the Soil Science Department of BAU (Bangladesh Agricultural University), Mymensingh. The analysis encompassed various soil properties, including soil texture, pH levels, electrical conductivity (EC), organic matter content, total nitrogen (N), availability of phosphorus (P) and sulfur (S), as well as the levels of exchangeable potassium (K) and exchangeable sodium (Na).

The particle size distribution of the soil was determined using the hydrometer method outlined by Piper (1965). The textural class of the soil was determined by plotting the percentages of sand, silt, and clay on Marshall's triangular coordinate diagram, following the USDA system.

Soil p^H was measured with the help of a glass electrode p^H meter using a water suspension of 1:2:5 as described by Jackson (1962). Besides, soil pH levels were measured using a glass electrode pH meter. A water suspension of soil at a ratio of 1:2:5 was prepared, as described by Jackson (1962). Organic matter content in the soil was determined using the wet oxidation method developed by Walkley and Black (1934). This method involves oxidizing organic matter with an excess of K2Cr2O7 solution in the presence of FeSO4. The organic matter content was calculated by multiplying the organic carbon amount by the Van Bemmelen factor of 1.73 and expressed as a percentage. Nitrogen content in the soil was estimated using the micro-Kjeldahl method. In this method, the soil was digested with a mixture of 30% H_2O, concentrated H_2SO_4, and a catalyst blend of K_2SO_4:$CuSO_4$:Se powder in a specific ratio (100:10:1). Nitrogen in the digest was determined by distillation with 40% NaOH, followed by titration of the distillate with 0.1 N H_2SO_4 (Page et al., 1989). Available phosphorus was extracted from the soil by shaking it with a 0.5 M $NaHCO_3$ solution at pH 8.5, following the method of Olsen (1954). The phosphorus content in the extract was determined by developing a blue color through $SnCl_2$ reduction of phosphomolybdate complex solution and measuring it with a spectrophotometer. Available P was calculated using a standard curve.

Flame emission spectrometry (FES) and flame atomic absorption spectrometry were used to determine the levels of exchangeable bases such as potassium and sodium extracted from soil by leaching with ammonium acetate solution. The cation content in the leachate was analyzed by FES. The air-dried soil sample was weighed, packed into a sample extraction setup, and extracted by leaching with 4x50 ml ammonium acetate solution. The leachate was collected in a 250 ml volumetric flask, diluted to 250 ml with double reverse osmosis water, and analyzed for exchangeable K using FES and exchangeable Na using atomic absorption spectrometry. Available sulfur content in the soil was determined by extracting soil samples with a 0.15% CaCl2 solution, as described by Page et al. (1989). The sulfur content in the extract was measured turbidimetrically using BaCl2 and an acid solution, with spectrophotometry at a wavelength of 420 nm.

Statistical analysis

Following the analysis of all physiological and chemical parameters of the soil, analyses of variance (ANOVA) were conducted to assess the influence of the different manures on these parameters. The statistical analysis was performed using the R software, which is well-suited for conducting ANOVA and other statistical tests to determine significant differences and relationships in data.

Results and Discussion

The well-decomposed cow dung, poultry manure, vermicompost, and human waste compost were applied and thoroughly incorporated into the soil as necessitated by the experimental requirements. Additionally, intercultural operations were carried out as needed throughout the experiment to maintain the crop's growth and health.

Effect of organic amendments on soil properties

Soil texture

The soil analysis revealed that, on average, the sand content was 24.4%, silt content was 60.8%, and clay content was 14.8% (as depicted in Figure 1). These results indicate that the textural class of the study area ranged from silty loam to loam. The vertical bar in the figure represents the standard deviation. These findings are consistent with those reported by Kale et al. (2012) in their assessment of the effects of organic residue compost on the development of soil physicochemical characteristics. Silty soil is characterized by a fine, powdery texture and is known for its high fertility. Soil with a healthy structure feels crumbly to the touch and provides ample space for air, water, and energy to move freely.

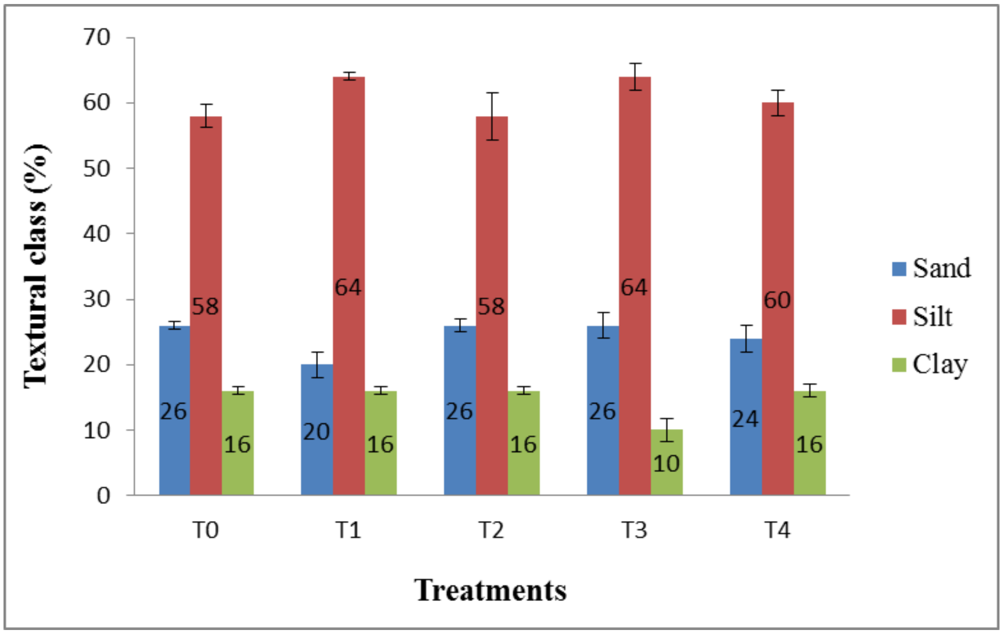

Figure 1. Influence of organic amendments on soil textural class

Soil pH

The average pH values of the soil after harvest were measured to be 6.77, 6.88, 6.73, 6.61, and 6.53, each influenced by the application of different treatments (Figure 2). The vertical bars in the figure represent the standard deviation. Significant variations in pH values were observed, particularly in treatments T1, T3, and T4, at a significant level of 5%.

The highest pH value (6.88) was recorded in the plot treated with vermicompost (T4), while the lowest pH value (6.53) was observed in the plot treated with cow dung (T4). The numerical order of decreasing soil pH, from highest to lowest, was T1 < T0 < T2 < T3 < T4. It's worth noting that the application of organic composts appeared to lead to a decrease in soil pH within a span of 1 to 2 months, likely due to the release of acids during the decomposition process.

These observations align with findings from Tester (2017) and Whalen et al., (2000), who noted that the addition of organic composts could improve soil pH and electrical conductivity. Additionally, Adeniyan and Ojeniyi (2005) reported that the application of organic composts had positive effects on soil pH, salt content, and macronutrient concentrations in the soil.

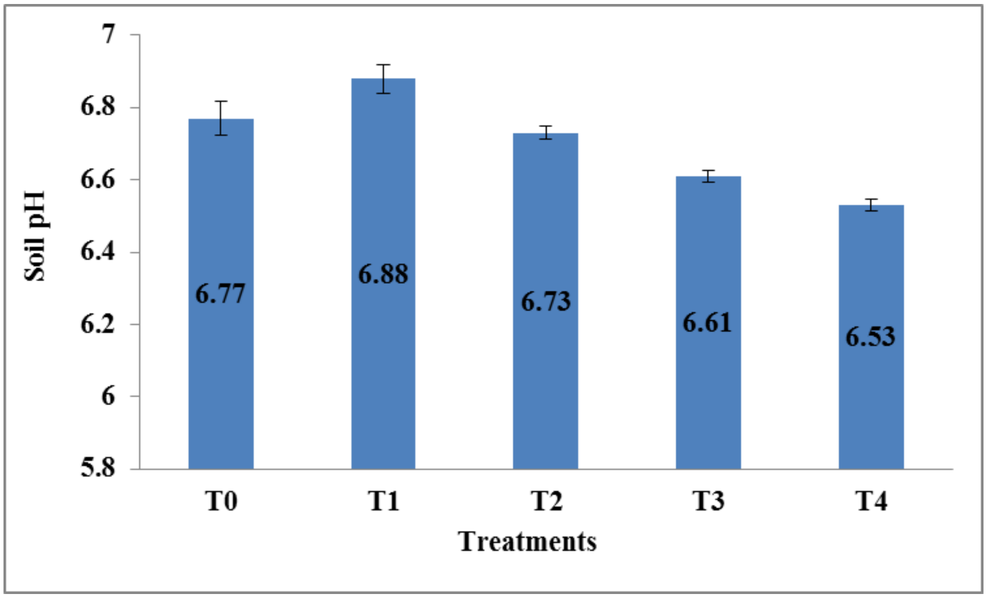

Figure 2. Influence of organic amendments on soil pH

Electrical conductivity

The average electrical conductivity (EC) values for different treatments were recorded as follows: T0 (control) - 189 µs/cm, T1 (vermicompost) - 203 µs/cm, T2 (human waste compost) - 243 µs/cm, T3 (poultry manure) - 229 µs/cm, and T4 (cow dung) - 208 µs/cm (as illustrated in Figure 3). The vertical bars in the figure represent the standard deviation. Notably, the soil EC values were higher in all treatments compared to the control (T0).
The highest EC value (243 µs/cm) was observed in the T2 treatment (human waste compost), while the lowest EC value (189 µs/cm) was recorded in the control (T0). The increase in EC can likely be attributed to the mobility of ions, their valences, and their relative concentrations. This observation aligns with the findings of Islam et al. (2011), who reported an improvement in soil electrical conductivity with the application of organic manures. Similarly, Kale et al. (2012) noted an increase in electrical conductivity following the application of organic fertilizer.

Organic matter

The average organic matter (OM) content in the soil after harvest varied across treatments, with values of 1.15% for T0 (Control), 2.35% for T1 (vermicompost), 1.98% for T2 (human waste compost), 2.69% for T3 (poultry manure), and 1.73% for T4 (cow dung) (as shown in Figure 4). The vertical bars in the figure represent the standard deviation. Significantly, the OM content displayed variations as influenced by the different treatments at a significance level of 5% (as indicated in Table 3). The soil's organic matter content ranged from 1.15% to 2.69% after harvesting the crops, with the highest value (2.69%) recorded in the poultry manure treatment (T3) and the lowest in the control treatment (T0). This increase in organic matter content aligns with the findings of previous research. Islam et al. (2011) and Tester (2017) both reported significant increases in soil organic matter content following the application of organic manure. Additionally, Allen and Zink (2008) noted an increase in organic matter levels in the soil after the application of farmyard manure and green manure.

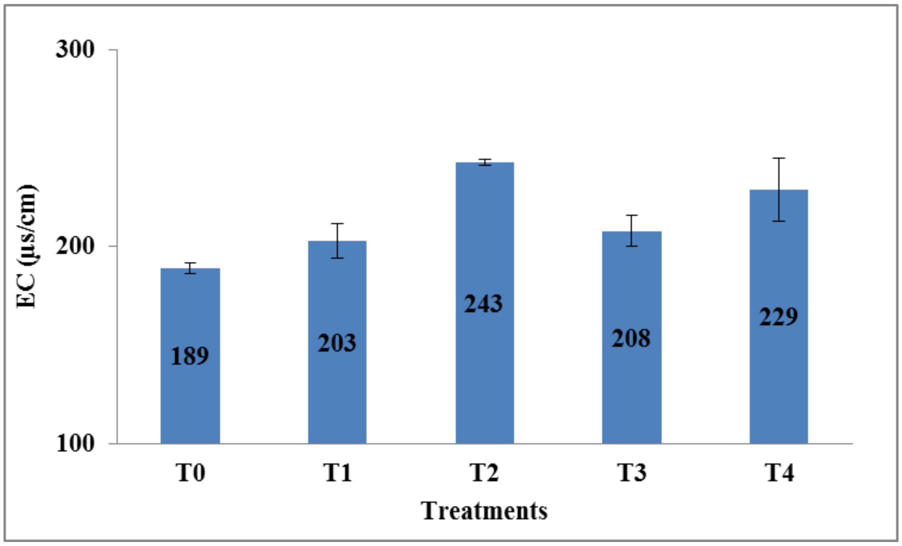

Figure 3. Influence of organic amendments on electrical conductivity (EC)

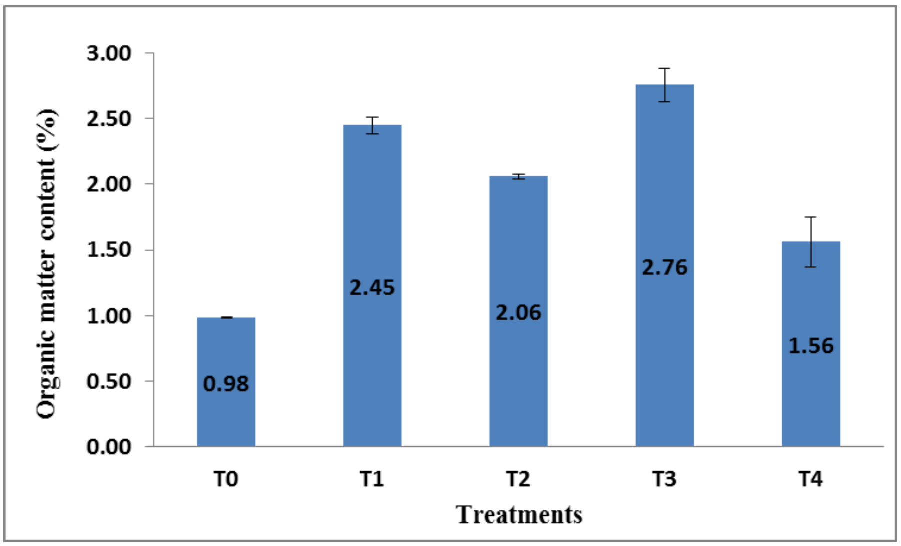

Figure 4. Influence of organic amendments on the organic matter content

Total nitrogen

In the post-harvest soil, the average nitrogen (N) content varied across treatments, with values of 0.084% for T0 (Control), 0.127% for T1 (vermicompost), 0.139% for T2 (human waste compost), 0.145% for T3 (poultry manure), and 0.118% for T4 (cow dung) (as depicted in Figure 5). The highest N content (0.145%) was observed in the plot where poultry manure was applied (T3), while the lowest value (0.084%) was found in the control (T0). The vertical bars in the figure represent the standard deviation.

These results suggest that the application of organic manures contributed to higher total N concentrations in the soil compared to the control. This aligns with the findings of various researchers, including Havlin et al. (2012), Khatik and Dikshit (2001), and Ojeniyi (2008), who reported that the use of organic manure increased total N concentrations in the soil. Furthermore, Kashem et al. (2015) noted that vermicompost had higher available N and P contents in the soil compared to other treatments.

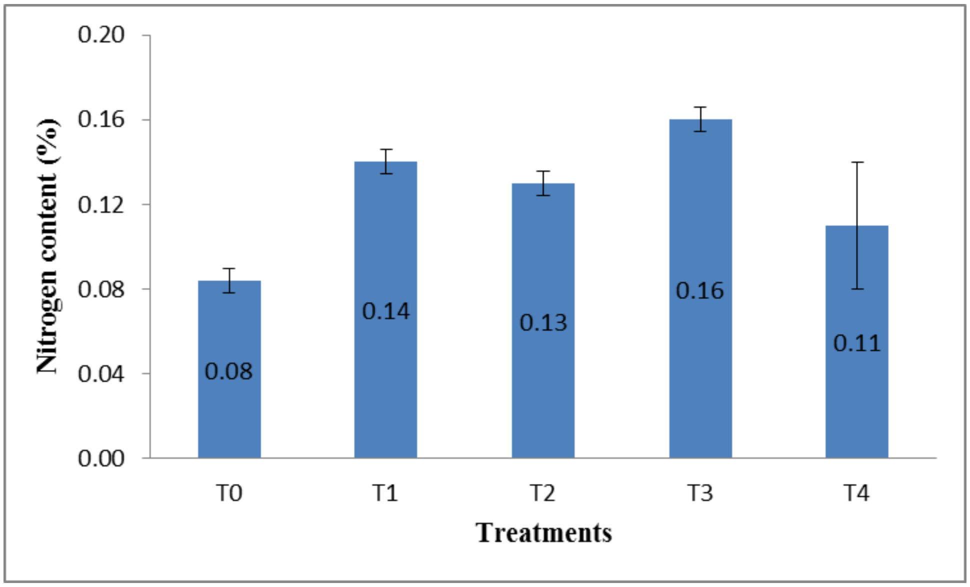

Figure 5. Influence of organic amendments on nitrogen content

Available phosphorus

The average phosphorus (P) content in the post-harvest soil varied among treatments, with values of 6.19 ppm for T0 (Control), 8.66 ppm for T1 (vermicompost), 6.54 ppm for T2 (human waste compost), 6.96 ppm for T3 (poultry manure), and 6.49 ppm for T4 (cow dung) (as illustrated in Figure 6). The available P content in the soil ranged from 6.19 ppm (T0) to 8.66 ppm (T1). The vertical bars in the figure represent the standard deviation. Significant variations in available P content were observed in the T2 and T3 treatments at a 5% significance level (as indicated in Table 3).

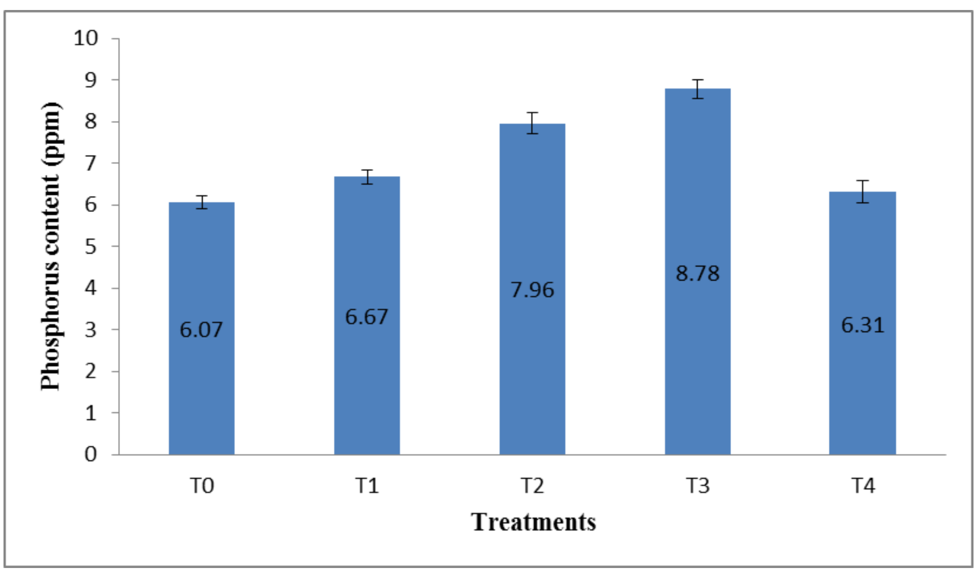

Figure 6. Influence of organic amendments on phosphorus content

Soils treated with organic manures exhibited higher levels of available P compared to the control. This increase in available P is likely due to the release of more P during the decomposition of organic manure. These findings are consistent with the reports of Onuh et al. (2008) and Rahman et al. (2014), which suggested that the application of organic manures can enhance available P content in the soil.

Exchangeable potassium

In the post-harvest soil, the average potassium (K) content varied among treatments, with values of 0.144 meq/100g for T0 (Control), 0.467 meq/100g for T1 (vermicompost), 0.352 meq/100g for T2 (human waste compost), 0.438 meq/100g for T3 (poultry manure), and 0.313 meq/100g for T4 (cow dung) (as shown in Figure 7). The vertical bars in the figure represent the standard deviation. These results indicate significant variations in K content across the different treatments.

Organic manure treatments, particularly vermicompost (T1) and poultry manure (T3), resulted in higher K content in the soil compared to the control (T0). These findings suggest that the application of organic manures can increase the K content in the soil.

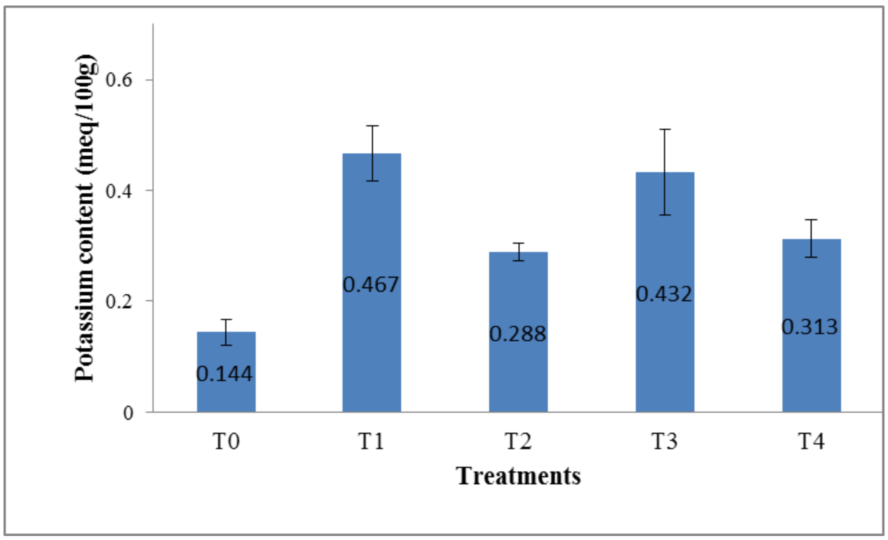

Figure 7. Influence of organic amendments on potassium content

The highest exchangeable potassium (K) content was observed in soils treated with vermicompost (T1), while the lowest exchangeable K content was found in the control (T0). These results suggest that the application of organic manures, particularly vermicompost, led to higher levels of exchangeable K in the soil compared to the control. This aligns with previous research findings, such as those reported by Ouédraogo et al. (2001), which showed that the significant effect of organic manures improved exchangeable K levels in the soil. Similar results have also been reported by other studies, including Ojeniyi (2008), Onuh et al. (2008), and Palm et al. (1997).

Exchangeable sodium

In the post-harvest soil, the average sodium (Na) content varied among treatments, with values of 0.956 meq/100g for T0 (Control), 2.63 meq/100g for T1 (vermicompost), 3.13 meq/100g for T2 (human waste compost), 3.36 meq/100g for T3 (poultry manure), and 2.87 meq/100g for T4 (cow dung) (as shown in Figure 8). The vertical bars in the figure represent the standard deviation.

The highest exchangeable Na content was obtained from the poultry manure treatment (T3), while the lowest exchangeable Na content was found in the control (T0). These results indicate that exchangeable Na content was higher in soils treated with organic manures compared to the control. This finding aligns with the results reported by M. Rahman et al. (2014), who found that the application of organic manures increased the total nitrogen, potassium, magnesium, and sodium content in the soil.

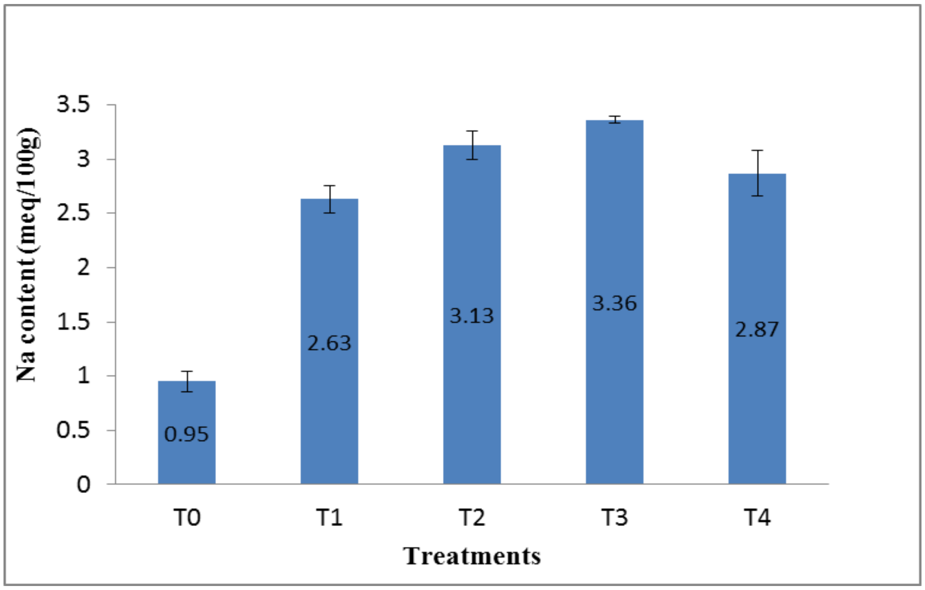

Figure 8. Influence of organic amendments on sodium (Na) content

Available sulphur

The average sulfur (S) content in post-harvest soil varied among treatments, with values of 10.42 ppm for T0 (Control), 17.87 ppm for T1 (vermicompost), 17.21 ppm for T2 (human waste compost), 20.5 ppm for T3 (poultry manure), and 15.74 ppm for T4 (cow dung) (as shown in Figure 9). The vertical bars in the figure represent the standard deviation. The sulfur content in the soil did not differ significantly among the different treatments at the 5% significance level (as indicated in Table 3). The highest S content was obtained in the poultry manure treatment (T3), while the lowest S content was found in the control (T0). Soils treated with organic manures showed higher values of available S compared to the control. This increase in available S in organic manure-treated soils may be attributed to the release of more available S during the decomposition of organic manure. Similar findings were reported by M. Rahman et al. (2014), who found that organic composts increased the sulfur content in the soil.

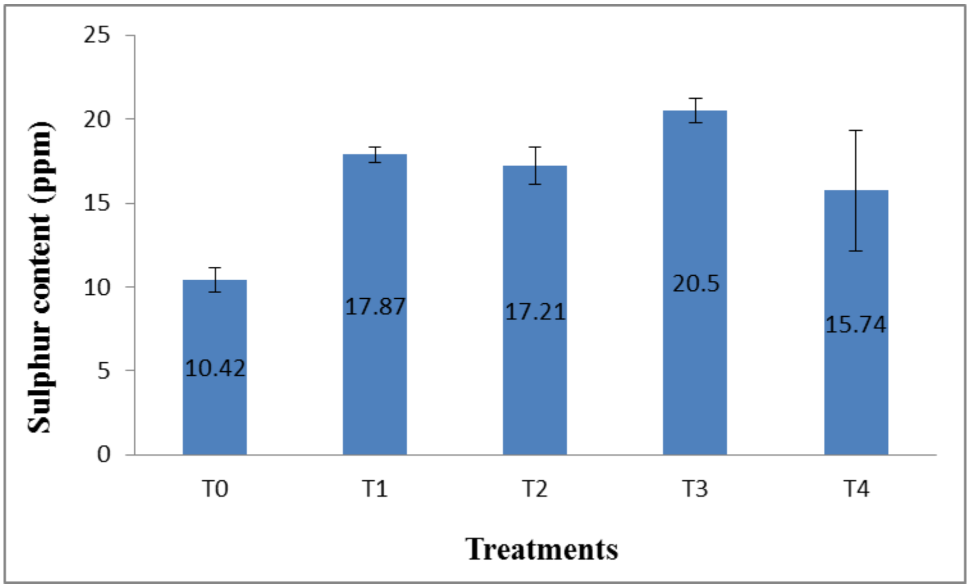

Figure 9. Influence of organic amendments on sulfur content

Table 3. Effect of organic amendments on soil properties at the end of the experiment

	Treatments					
	T_0	T_1	T_2	T_3	T_4	
pH	6.77 b	6.88 a	6.73 b	6.61 c	6.53 d	*
Electrical conductivity (µs/cm)	189 c	202.67 bc	243 a	208 b	229 a	*
Organic matter (%)	0.98 e	2.45 b	2.06 c	2.76 a	1.56 d	*
Total N (%)	0.08 c	0.14 ab	0.13 b	0.16 a	0.11 b	*
Available P (ppm)	6.17 d	6.67 c	7.96 b	8.78 a	6.31 cd	*
Exchangeable K (Meq/100g)	0.14 c	0.46 a	0.28 b	0.43 a	0.31 b	*
Exchangeable Na (Meq/100g)	0.95 c	2.63 b	3.13 a	3.36 a	2.87 b	*
Available S (ppm)	10.42 c	17.80 ab	17.21 b	20.56 a	15.74 b	*
Sand	26.33 a	20 b	26 a	26 a	24 a	*
Silt	58 b	63 a	58 b	64 a	60 ab	*
Clay	15.67 a	16.33 a	15.67 a	10 b	16 a	*

Note: * = 5% level of significance, in the case of soil properties, the column having a common letter (s) do not differ significantly at 5% level; Here, T_0 = no fertilizer, T_1 = vermicompost, T_2 =human waste compost, T_3 = poultry manure, T_4 = cow dung

Conclusion

This study aims to evaluate the effectiveness of human waste compost relative to poultry manure, cow dung, and vermicompost in Bangladesh. The experimental design included a Randomized Complete Block Design. The results and discussion clearly demonstrate the significant improvement in soil quality with the application of organic manures. Poultry manure and vermicompost had the most substantial positive effects on total nitrogen, with increases of 0.16% and 0.14%, respectively. In cases of phosphorus deficiency, poultry manure and human waste compost were effective in increasing soil phosphorus levels, with values of 8.78 and 7.96 ppm, respectively. Vermicompost and poultry manure enhanced exchangeable potassium, with values of 0.467

and 0.432 meq/100 g of soil, respectively. Sulfur content was notably higher in plots treated with poultry manure (20.5 ppm), followed by vermicompost (17.87 ppm) and human waste compost (17.21 ppm). The highest electrical conductivity was observed in the human waste compost treatment (243 μs/cm). Poultry manure had the most substantial impact on increasing organic matter, with a 2.76% increment.

The study's findings advocate for a transition from chemical fertilizers to compost fertilizers, which would enhance agricultural soil and promote sustainability in both agriculture and the environment. However, the choice of organic manure should depend on specific soil nutrient deficits. For example, if there is a phosphorus deficiency in the soil, poultry manure and human waste compost may be the best options for achieving optimal results. Encouraging farmers to use organic amendments in agriculture can help maintain soil quality, improve crop yields, and contribute to environmental sustainability. Further experiments with varietal trials in different regions of Bangladesh are recommended to explore the effectiveness of various organic amendments compared to conventional practices.

Declaration

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Authors contribution: Samanta Islam contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Samanta Islam and Asif Raihan. All authors read and approved the final manuscript.

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