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# Assessment of soil microbial activity and nutrient availability following the application of Rice husk and poultry manure in Tomato farms

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**ABSTRACT**

This study evaluated the effects of organic amendments-rice husk and poultry manure-on soil microbial activity and nutrient availability in tomato farms in Nnewi, Nigeria. A randomized complete block design was employed with four treatments: control, rice husk, poultry manure, and a combination of both, each replicated thrice. Soil samples were analyzed for microbial activity via dehydrogenase enzyme activity and for available nutrients (N, P, K) at three stages: baseline, mid-season, and harvest. Results showed that the combined application significantly enhanced microbial activity (65.4 μg TPF $g^{-1}$ soil) and increased available nitrogen (18.5 mg $kg^{-1}$), phosphorus (16.8 mg $kg^{-1}$), and potassium (152.4 mg $kg^{-1}$) compared to other treatments. Organic amendments, especially when combined, improved soil biological functions and nutrient status, supporting sustainable tomato production. These findings underscored the potential of organic waste recycling to improve soil fertility and microbial health in tropical soils with low natural fertility.

**KEY WORDS:** *Organic amendments*; *Soil microbial activity*; *Rice husk*; *Poultry manure*; *Tomato*

## 1. Introduction

Soil health is fundamental to sustainable agriculture, influencing crop productivity, nutrient cycling, and overall ecosystem stability (Govaerts *et al.*, 2017). Among the various indicators of soil health, microbial activity and nutrient availability are critical parameters that reflect the biological and chemical status of the soil (Bardgett and Van der Putten, 2014). Microbial communities play vital roles in decomposing organic matter, mineralizing nutrients, and maintaining soil structure, thereby directly affecting plant growth and yield (Lal, 2015). Enhancing soil microbial activity can lead to improved nutrient cycling efficiency, reduced dependence on synthetic fertilizers, and increased resilience against soil degradation.

Organic amendments such as rice husk and poultry manure are widely used in agricultural practices to improve soil fertility and microbial dynamics (Obaren *et al.*, 2019). Rice husk, a lignocellulosic residue, is a slow-decomposing organic matter that can increase soil organic carbon and improve soil structure (Kumar *et al.*, 2020). Poultry manure, on the other hand, is rich

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in readily available nutrients such as nitrogen, phosphorus, and potassium, and contains diverse microbial populations that can positively influence soil microbial activity (Adegbite *et al.*, 2018). The combined application of these organic materials has the potential to synergistically enhance microbial activity and nutrient availability, leading to improved crop performance. In Nigeria, particularly in Nnewi, tomato cultivation is a significant agricultural activity contributing to local food security and income generation (Onyema *et al*., 2021). However, intensive farming practices and reliance on inorganic fertilizers have raised concerns about soil degradation, nutrient imbalance, and declining microbial diversity (Eze *et al.*, 2019). Incorporating organic amendments such as rice husk and poultry manure offers a sustainable approach to rehabilitate degraded soils, promote microbial health, and enhance nutrient cycling in tomato farms. Despite the recognized benefits of organic amendments, there remains a need for localized studies to evaluate their effects specifically within the Nnewi agro-ecological zone. Understanding how these amendments influence soil microbial activity and nutrient availability is crucial for developing integrated soil fertility management strategies tailored to the region. Therefore, this study aimed to assess the impact of rice husk and poultry manure applications on soil microbial activity and nutrient status in tomato farms in Nnewi, with the ultimate goal of identifying sustainable soil management practices that enhance tomato productivity.

## 2. Material and Methods

### 2.1 Study area

The experiment was conducted in Nnewi, Anambra State, Nigeria, located at latitude 6.0167° N and longitude 6.9167° E. The area experiences a humid tropical climate with an average annual rainfall of approximately 1500 mm, predominantly occurring between April and October. The temperature ranges from 25 °C to 32 °C, and the soil is predominantly Ferralsols, characterized by low natural fertility and poor organic matter content (Nwosu *et al.*, 2018). The climatic and soil conditions make Nnewi suitable for evaluating organic amendments' effects on soil microbial activity and nutrient dynamics.

### 2.2 Experimental design

A randomized complete block design (RCBD) was employed, with four treatments replicated three times. The treatments were as follows: Control (T1): No organic amendment applied; Rice Husk (T2): Application of rice husk at a rate of 5 tons per hectare; Poultry Manure (T3): Application of poultry manure at a rate of 3 tons per hectare; Combined (T4): Application of rice husk and poultry manure together at the above rates. Each plot measured 3 m × 3 m, with a 1 m buffer zone between plots to prevent cross-contamination.

### 2.3 Application of organic amendments

Prior to planting, rice husk was air-dried, milled into smaller particles, and evenly incorporated into the top 15 cm of soil at the specified rate. Poultry manure was composted for at least four weeks to reduce pathogen load and odor before application. The amendments were incorporated into the soil two weeks before transplanting tomato seedlings.

### 2.4 Soil sampling and analysis

*Soil samples were collected at three intervals*: before amendment application (baseline), mid-season (8 weeks after transplanting), and at harvest (16 weeks). Samples were taken from a depth of 0-15 cm using a soil auger, composited per plot, and transported to the laboratory for analysis.

*Microbial activity*: Soil microbial activity was assessed through the dehydrogenase enzyme activity method, which measures overall microbial oxidative activity (Tabatabai, 1994). The activity was expressed as micrograms of triphenyl formazan (TPF) formed per gram of soil per hour.

*Nutrient availability*: Available nitrogen (N) was determined using the Kjedahl digestion method, while available phosphorus (P) was measured using the Bray-1 extraction method (Anantha *et al*., 2015). Exchangeable potassium (K) was analyzed via flame photometry after ammonium acetate extraction.

### 2.5 Data analysis

The data collected were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 25.0. Treatment means were separated using Tukey's Honestly Significant Difference (HSD) test at a 5% significance level. F-values, degrees of freedom, and p-values were reported to evaluate the significance of treatment effects on soil microbial activity and nutrient availability.

## 3. Results and Discussion

### 3.1 Soil microbial activity

In **Table 1**, the effect of organic amendments on soil microbial activity, as indicated by dehydrogenase enzyme activity, was significantly influenced by treatment ($F(3,8) = 15.67$, $p < 0.001$). The combined application of rice husk and poultry manure (T4) resulted in the highest microbial activity ($65.4 \pm 2.3$ µg TPF $g^{-1}$ soil), which was significantly higher than the control (T1) ($42.7 \pm 1.8$ µg TPF $g^{-1}$ soil) (**Table 1**). Application of rice husk alone (T2) and poultry manure alone (T3) produced intermediate values of $55.2 \pm 2.0$ and $58.7 \pm 2.1$ µg TPF $g^{-1}$ soil, respectively.

The results clearly demonstrated that organic amendments significantly influence soil microbial activity and nutrient dynamics in tomato farming systems in Nnewi. The increased dehydrogenase activity, especially in the combined rice husk and poultry manure treatment, indicates enhanced microbial oxidative activity, which is essential for organic matter decomposition and nutrient mineralization (Tabatabai, 1994). This aligned with prior studies showing that organic inputs stimulate microbial biomass and enzymatic functions (Goyal *et al*., 2018).

**Table 1**: Soil microbial activity (Dehydrogenase enzyme activity) across treatments

| Treatment | Microbial Activity (µg TPF/g soil/hour) | Increase over control (%) |
|---|---|---|
| T1 (Control) | 42.70 ± 1.80 | 0.00 |
| T2 (Rice Husk) | 55.20 ± 2.00 | 29.40 |
| T3 (Poultry Manure) | 58.70 ± 2.10 | 37.50 |
| T4 (Combined) | 65.40 ± 2.30 | 53.00 |

### 3.2 Nutrient availability

The treatments significantly affected available nitrogen levels ($F (3, 8) = 12.45$, $p = 0.002$). The highest nitrogen availability was observed in the combined treatment (T4) ($18.5 \pm 0.7$ mg $kg^{-1}$ soil), contrasting with the control ($10.2 \pm 0.4$ mg $kg^{-1}$ soil) (**Table 2**). Organic amendments, especially poultry manure, enhanced nitrogen mineralization, increasing plant-available nitrogen. Similarly, phosphorus availability was significantly affected by treatments (F(3,8) = 10.89, p = 0.004) (**Table 3**). The highest P levels were recorded in the combined treatment (16.8 ± 0.6 mg/kg soil), significantly greater than the control (9.4 ± 0.3 mg/kg soil). The organic amendments contributed to increased P solubilization, possibly through microbial activity enhancement. The potassium levels also varied significantly among treatments (F (3,8) = 8.33, p = 0.007) (**Table 4**). The combined treatment showed the highest exchangeable K (152.4 ± 4.2 mg $kg^{-1}$ soil), significantly higher than the control (110.3 ± 3.8 mg $kg^{-1}$ soil). Organic amendments likely supplied K and stimulated microbial mineralization, enhancing K availability.

**Table 2**: Available nitrogen (mg $kg^{-1}$ soil) across treatments

| Treatment | Available N | Increase over Control (%) |
|---|---|---|
| T1 (Control) | 10.20 ± 0.40 | 0.00 |
| T2 (Rice Husk) | 13.50 ± 0.50 | 32.40 |
| T3 (Poultry Manure) | 17.20 ± 0.60 | 68.60 |
| T4 (Combined) | 18.50 ± 0.70 | 81.40 |

**Table 3**: Available phosphorus (mg $kg^{-1}$ soil) across treatments

| Treatment | Available Phosphorus | Increase over Control (%) |
|---|---|---|
| T1 (Control) | 9.40 ± 0.30 | 0.00 |
| T2 (Rice Husk) | 12.10 ± 0.40 | 28.70 |
| T3 (Poultry Manure) | 15.30 ± 0.50 | 62.80 |
| T4 (Combined) | 16.80 ± 0.60 | 78.70 |

The substantial increase in available nitrogen, phosphorus, and potassium in amended soils highlights the role of organic matter in improving soil fertility. Poultry manure, rich in nutrients, contributed more significantly to nutrient enhancement than rice husk alone but was most effective when combined, likely due to synergistic effects of organic matter and nutrient supply (Ogunlade *et al.*, 2015). The increased nutrient availability supports the hypothesis that organic amendments improve nutrient cycling through microbial activity, thereby enhancing crop productivity. Furthermore, the observed improvements in soil microbial activity and nutrient availability suggest favorable conditions for sustainable tomato production. Organic amendments not only replenish soil nutrients but also stimulate microbial communities that are critical for soil health and crop growth. These findings are consistent with earlier research indicating that organic amendments enhance soil biological activity and nutrient status, ultimately leading to better crop yields (Jha and Singh, 2017; Osonubi and Oladoye, 2019).

**Table 4**: Exchangeable potassium (mg $kg^{-1}$ soil) across treatments

| Treatment | Exchangeable Potassium | Increase over Control (%) |
|---|---|---|
| T1 (Control) | 110.30 ± 3.80 | 0.00 |
| T2 (Rice Husk) | 132.50 ± 4.00 | 20.20 |
| T3 (Poultry Manure) | 145.00 ± 4.10 | 31.60 |
| T4 (Combined) | 152.40 ± 4.20 | 38.10 |

## 4. Conclusion

The study demonstrated that the application of organic amendments, particularly the combined use of rice husk and poultry manure, significantly enhances soil microbial activity and nutrient availability in tomato farms in Nnewi. Organic amendments improved soil biological functions, as evidenced by increased dehydrogenase enzyme activity, and elevated levels of available nitrogen, phosphorus, and potassium. These improvements suggest that organic inputs foster a healthier soil environment conducive to nutrient cycling and microbial proliferation, which are essential for sustainable crop production. Therefore, integrating rice husk and poultry manure into tomato farming practices can be an effective strategy to improve soil fertility, boost crop yields, and promote sustainable agricultural systems in tropical soils with low natural fertility.

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