Current Innovation in Agriculture Science
Vol. 3, Issue 2, pp. 924-929
Research Article
ISSN (E): 3048-6009

Impact of Rice husk and poultry manure on soil moisture retention and drought tolerance in Tomato

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Received: 27 December 2025 | Accepted: 20 March 2026

DOI: https://doi.org/10.65791/cias.87

ABSTRACT

This study evaluated the effects of rice husk and poultry manure on soil moisture retention and drought tolerance in tomato plants cultivated in Nnewi, Anambra State. The experiment included four treatments: control (no amendment), rice husk (2 t ha^{-1}), poultry manure (2 t ha^{-1}), and a combined application of rice husk and poultry manure. Results showed that the combined treatment significantly improved soil moisture content, maintaining levels of 19.2% in week 1 and 13.0% in week 12, compared to 15.2% and 9.4% in the control. Plants subjected to the combined amendments exhibited less wilting (score of 1.2 versus 3.5 in control) and higher relative water content (78.4% compared to 65.3%). Additionally, this treatment resulted in increased plant height (89.5 cm vs. 75.4 cm) and higher fruit yield (21.7 kg ha^{-1} vs. 12.3 kg ha^{-1}). The findings suggested that organic amendments, particularly the combination of rice husk and poultry manure, enhance soil water retention, improve drought resilience, and boost tomato productivity in water-limited conditions. These results supported the use of organic waste materials as sustainable strategies for improving tomato cultivation in drought-prone regions.

KEY WORDS: *Soil moisture retention*; *Drought tolerance*; *Rice husk*; *Poultry manure*; *Tomato*

1. Introduction

Tomato (*Solanum lycopersicum*) is one of the most widely cultivated and economically significant vegetable crops in Nigeria and globally. Its high nutritional value, culinary versatility, and demand in both local and international markets make it a vital component of agricultural systems (FAO, 2020). However, tomato cultivation often faces challenges related to water availability, especially in regions like Nnewi, Anambra State, where erratic rainfall patterns and prolonged dry spells threaten optimal crop growth and yield (Olawuyi and Akinbobola, 2018). Water stress, particularly drought conditions, significantly affects tomato growth, leading to reduced fruit size, poor quality, and diminished yields (Adeniyi *et al.*, 2019). The capacity of soil to retain moisture plays a crucial role in mitigating drought stress and ensuring continuous water supply to plants (Kumar *et al.*, 2017). Therefore, improving soil moisture retention is essential for sustainable tomato production, especially in areas prone to water scarcity.

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Organic soil amendments, such as rice husk and poultry manure, have gained attention for their potential to enhance soil physical properties, including water retention, aeration, and nutrient supply (Ojo *et al*., 2016). Rice husk, a by-product of rice milling, is rich in lignocellulosic material and contains high levels of silica, which can improve soil's water-holding capacity (Adeniyi and Olaleye, 2020). Poultry manure, on the other hand, is nutrient-dense and can boost soil fertility, microbial activity, and organic matter content, thereby influencing soil structure and moisture dynamics (Eze and Nwankwo, 2017). Previous studies have indicated that organic amendments can improve soil physical properties; however, their combined effects on soil moisture retention and drought tolerance in tomato cultivation remain underexplored, particularly within the context of Nnewi's agro-ecological zone (Ibrahim *et al*., 2019). Understanding how these organic materials influence soil-water interactions can inform sustainable farming practices that reduce dependence on synthetic irrigation and fertilizers, thus promoting resilience against drought stress (Abiola and Olaleye, 2021). This study aims to evaluate the impact of rice husk and poultry manure, applied singly and in combination at different rates, on soil moisture retention and drought tolerance of tomato plants in Nnewi. The findings are expected to offer valuable insights into sustainable soil management strategies that enhance water conservation, improve crop resilience, and increase productivity under water-limited conditions.

2. Material and Methods

2.1 Research site

The experiment was conducted at the Agricultural Research Farm of Nnamdi Azikiwe University, Nnewi, Anambra State, Nigeria. The site is characterized by a tropical climate with a distinct dry season and means annual rainfall of approximately 1500 mm. The soil type is predominantly Nitisols, which are moderately weathered, well-drained, and suitable for vegetable cultivation.

2.2 Experimental design

A randomized complete block design (RCBD) was employed with four treatments replicated three times, resulting in 12 plots. The treatments included: T1: Control (no organic amendment); T2: Rice husk at 2 t ha^{-1}, T3: Poultry manure at 2 t ha^{-1}, T4: Combination of rice husk and poultry manure at 2 t ha^{-1} each. Each plot measured 3 m × 3 m, with a 0.5 m buffer zone between plots to prevent cross-contamination.

2.3 Preparation of organic amendments

Rice husk was air-dried and then shredded into smaller particles to facilitate incorporation. Poultry manure was air-dried to reduce moisture content and odor. Both amendments were analyzed for nutrient content before application to ensure consistency.

2.4 Soil preparation and amendment application

The soil was plowed and harrowed to a depth of 15 cm to break up clumps and incorporate organic amendments evenly. The respective treatments were applied uniformly across the designated plots: Rice husk and poultry manure were each applied at 2 t ha^{-1}, equivalent to approximately 4.5 kg per plot, based on the plot size. Organic materials were thoroughly mixed into the topsoil

(0-15 cm) to promote even distribution and interaction with soil particles.

2.5 Planting and crop management

Tomato seedlings (variety suitable for local conditions) were transplanted at a spacing of 60 cm × 60 cm, with three plants per hill. Standard agronomic practices were followed, including pest control, staking, and watering as necessary. No additional irrigation was provided to simulate drought conditions, relying solely on soil moisture retained by amendments.

2.6 Data collection

Soil Moisture Content: Soil moisture was measured at 0–15 cm depth using a time-domain reflectometry (TDR) probe at weekly intervals throughout the growing season. Measurements were taken early morning and late afternoon to account for diurnal variations.

2.7 Drought tolerance indicators

Plant physiological responses to drought stress, such as leaf wilting, stomatal conductance, and relative water content, were recorded biweekly. At maturity, plant height, number of fruits, and yield were documented.

2.8 Soil physical and chemical analysis

Baseline soil samples were collected prior to amendment application and analyzed for texture, pH, organic carbon, and nutrient content (N, P, K). Post-harvest soil samples were similarly analyzed to assess changes induced by treatments.

Data Analysis: Data were subjected to analysis of variance (ANOVA) using statistical software. Treatment means were compared using least significant difference (LSD) at 5% probability level.

3. Results and Discussion

The results clearly demonstrated that the application of organic amendments significantly influenced soil moisture retention, plant physiological responses to drought, and overall crop productivity.

3.1 Soil moisture content

Table 1 presented the soil moisture content at 0 - 15 cm depth across different treatments over the growing season. The control, which received no organic amendments, showed a steady decline in soil moisture from 15.2% in the first week to 9.4% by week 12. In contrast, soils treated with rice husk alone maintained higher moisture levels, starting at 17.8% in week 1 and decreasing to 11.5% in week 12. Similarly, poultry manure alone also improved moisture retention compared to the control, with values decreasing from 16.5% to 10.6% over the same period. The most significant improvement was observed in the combined treatment of rice husk and poultry manure, which maintained the highest soil moisture throughout the season, starting at 19.2% and reducing to 13.0% by week 12. This indicates that the combined application enhances the soil's capacity to retain water more effectively than either amendment alone.

The combination of rice husk and poultry manure resulted in the highest soil moisture retention throughout the season, with a significant difference ($p < 0.05$) from other treatments.

The high silica content in rice husk likely contributed to improved water-holding capacity by increasing soil porosity and reducing evaporation (Adesina *et al*., 2018). Poultry manure, rich in organic matter, improved soil structure and water retention via increased porosity and aggregation (Ogunlade *et al.*, 2020). The combined treatment synergistically enhanced these effects, leading to the highest moisture content observed at each interval.

Table 1: Impact of organic amendments on soil moisture content across different treatments

Treatment	Week 1	Week 4	Week 8	Week 12
Control (No amendment)	15.2%	12.5%	10.8%	9.4%
Rice Husk (2 t ha^{-1})	17.8%	15.3%	13.2%	11.5%
Poultry Manure (2 t ha^{-1})	16.5%	14.0%	12.1%	10.6%
Rice Husk + Poultry Manure	19.2%	16.8%	14.7%|	13.0%

Note: Data are means of three replicates.

3.2 Drought tolerance indicators

Leaf wilting score: In terms of drought tolerance, plants subjected to the combined treatment exhibited less wilting under dry conditions, with an average wilting score of 1.2, compared to a score of 3.5 in the control group. This suggested that the plants with the combined amendment experienced less physiological stress during drought periods.

Higher relative water content and lower wilting scores in the amended plots indicate improved drought resilience (Akinbode *et al*., 2019). These improvements can be attributed to increased organic matter and water-holding capacity, which buffered plants against water stress. The enhanced water status allowed plants to sustain physiological processes such as photosynthesis and transpiration, ultimately resulting in increased growth and yield.

Stomatal conductance and relative water content (RWC): As shown in **Table 2**, the measurements of relative water content (RWC) in tomato leaves at week 8 showed that plants in the combined treatment maintained the highest RWC at 78.4%, followed by those treated with rice husk alone at 72.8%, poultry manure at 70.5%, and the untreated control at 65.3%. Higher RWC indicates better water status within the plant tissues, translating into improved resilience against water scarcity.

Table 2: Impact of organic amendments on drought tolerance

Treatment	RWC (%) at Week 8
Control	65.3
Rice Husk	72.8
Poultry Manure	70.5
Rice Husk + Poultry Manure	78.4

Plant Growth and Yield: Plants amended with rice husk and poultry manure showed increased height and fruit yield (**Table 3**). Plant growth and yield data further reflected the positive impact of organic amendments. The tallest plants, reaching an average height of 89.5 cm, and those with the highest fruit yields of 21.7 kg ha^{-1}, were observed in the combined treatment group. Plants treated with rice husk alone also showed significant increases in height and yield, with averages of 82.7 cm and 16.8 kg ha^{-1}, respectively, compared to the control which averaged 75.4 cm in height and 12.3 kg ha^{-1} in yield. The poultry manure alone produced intermediate results, with plant height averaging 80.2 cm and yield at 15.4 kg ha^{-1}.

Overall, these findings suggest that organic amendments, especially when combined, improve soil moisture retention, enhance plant water status, reduce drought-related stress, and ultimately lead to increased growth and productivity of tomato plants under water-limited conditions.

Table 3: Impacts of organic amendments on plant growth and fruit yield

Treatment	Plant height (cm)	Fruit yield (kg ha^{-1})
Control	75.4	12.3
Rice Husk	82.7	16.8
Poultry Manure	80.2	15.4
Rice Husk + Poultry Manure	89.5	21.7

The positive effects of organic amendments on plant height and fruit yield corroborate previous findings that organic matter improves nutrient availability and soil health, thereby promoting plant vigor (Eze *et al*., 2021). The increased yield in the combined treatment underscores the importance of integrated organic amendments in mitigating drought effects and enhancing productivity.

4. Conclusion

These findings suggest that incorporating rice husk and poultry manure into soil management practices can be an effective strategy for improving soil moisture retention and drought tolerance in tomato production, especially in water-scarce regions like Nnewi. Such practices reduce reliance on external water sources and synthetic fertilizers, promoting sustainable and resilient farming systems.

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