

RESPONSE OF SOIL CHEMICAL FERTILITY AND PEPPER (*CAPSICUM ANNUUM* L.) YIELD TO DIFFERENT ORGANIC MANURE AMENDMENTS

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Abstract

The optimization of the use of organic fertilization is a key factor to improve the agronomic productivity of vegetable crops in sustainable farming systems. The present study aimed to characterize the effect of the application of different organic manures on the yield components of pepper. The experimental design consisted of a control and four organic inputs of ten and fifteen tons per hectare of poultry manure, cow dung, pig manure, and composted manure. The agronomic variables recorded were the number of fruits and the fresh weight of fruit per stand. The results indicated that all organic manure treatments succeeded in promoting pepper production, which was significantly higher than the control treatment. Fruit production was the highest with the highest application rate of pig manure, with ninety-one fruits per stand, and statistically on the same level as the ten and fifteen tons per hectare rates of poultry manure. As far as fruit biomass is concerned, the highest fruit weight of about three hundred and thirty-seven g/stand and two hundred and eighty-three g/stand was obtained from the treatments of fifteen ton/ha poultry manure and fifteen ton/ha pig manure, respectively. On the other hand, cow dung had the lowest performance when compared to other organic inputs, similar to the baseline performance of the control group. In general, the results suggest that the application of 15 tonnes ha⁻¹ of poultry manure or pig manure is very effective in terms of the yield of pepper and the weight of fruit.

Keywords: Natural Fertilization, Fruit Weight, Yield of Pepper, Pig Manure, Poultry Manure.

1. INTRODUCTION

(*Capsicum annum*) belongs to the Solanaceae family and is a major vegetable crop farmed all over the world. It is prized for its many culinary applications and high nutritional profile. It contains more than thirty distinct carotenoids and significant levels of vitamins A, C, and E (Akbar et al., 2022; Muscolo et al., 2022). Over 36 million tons of pepper were produced worldwide in 2021, and market forecasts show that demand will increase through 2025 (FAO, 2021; Hakim et al., 2021). Despite its importance on a worldwide scale, production may be hampered by regional defects and agronomic difficulties. The supply and demand for pepper in Nigeria are drastically out of balance, especially in the country's southern region. This emphasizes how important it is to do research and implement extension programs in order to enhance post harvest management, productivity, and adaptation in the region. The average pepper production in this region is only 3.22 tons per hectare, which is far less than the national industry recommendation of 10 to 15 tons per hectare, even if the weather is ideal for

producing vegetables. This production gap, which restricts the amount and quality of items produced in various regions of Nigeria, is made worse by the challenges farmers have in applying effective fertilization techniques and managing pests and diseases. Pepper (*Capsicum* spp.) is a food

with great nutritive and pharmaceutical value, especially for its high levels of vitamins A and C. It is widely grown in a variety of soils from very fine sands to clay loams and silt loams, and is best grown on sandy loams (Anaya-Esparza et al., 2021). Pepper is a day-neutral crop and needs low to moderate rainfall annually (635-1200 mm) and a warm climate. The crop is sensitive to cooler temperatures, particularly between 4.4°C and 15.6°C, which can harm crop growth and development (Batiha et al., 2020; Azlan et al., 2022). Pepper cultivation is responsive to both organic and inorganic fertilizers, and nitrogenous and phosphoric nutrients are shown as the most important nutrients that play a significant role in the growth and yield of pepper. According to Hernández-Pérez et al. (2020), organic manures, which are made from plant and animal material, are vital to the enhancement of soil fertility, making nutrients available, improving soil structure, and increasing the diversity of soil microorganisms (Altuntaş & Ersoy, 2026; Prasad et al., 2025). These organic amendments break down slowly over time and provide a slow release of nutrients like nitrogen, phosphorus and potassium, maintaining a steady nutrient supply essential for good root development and optimum fruit growth (Darwish et al., 2025). Organic fertilizers have several agronomic and environmental advantages (Yang et al., 2025). It decreases the need for chemical fertilization, which limits soil degradation, acidification and pollution, e.g., nitrate leaching (Singh et al., 2026). Organic manures can add to soil chemical properties, which are important for soil fertility and plant health, such as pH, organic matter, and cation exchange capacity (Prashar et al., 2025). In addition, organic amendments improve soil microbial biomass and activity, aiding in nutrient mineralization and bio-availability, promoting strong root development and nutrient uptake (Dhaliwal et al., 2023; Brichi, et al., 2023). On the other hand, though inorganic fertilizers may increase crop yields at first, their over-application and persistent use have caused the deterioration of soil health and environmental issues in the long term. In some countries, like Nigeria, this has led to decreasing yields over time and soil degradation due to excessive use of inorganic fertilizers. Organic manures provide an alternative to improved soil properties, which will lead to better quality crops, higher yields, and are sustainable (Amanullah et al., 2019). Furthermore, organic fertilization has a positive effect on the pepper fruit quality, such as flavour, colour, shelf life etc., as it provides an equilibrium of nutrients. To obtain sustainable pepper production, it is necessary to combine organic manures and inorganic fertilizers (Panday et al., 2024). The integrated fertilization system helps to keep the soil healthy, reduce the environmental impact, improve nutrient use efficiency, increase yield, and improve the quality of the fruit. This holistic approach promotes agricultural sustainability and long-term productivity, aligning with sustainable farming practices.

2. METHODOLOGY

2.1 Study Area

The field study was carried out in the southwest Nigerian rainforest behind the Department of Agricultural Science at Adeyemi Federal University of Education, Ondo (Latitude 7°04'N, Longitude 4°49'E) (Ilori, 2024). Rainfall at the location averages 1650 mm per year, spread across 210–240 days between mid-March and mid-November. There is an early rainy season

from March to July and a late rainy season from August to November, according to the bimodal pattern of rainfall. With an average relative humidity of roughly 69%, August and September have the lowest average daily sunlight hours, ranging from 2.5 to 7. The sandy loam soils are part of the Ondo series and are categorized as Alfisol.

2.2 Treatment

The treatments consisted of cow dung at rates of 10tha⁻¹ and 15tha⁻¹, pig manure applied at 10tha⁻¹ and 15tha⁻¹, poultry manure at 10tha⁻¹ and 15tha⁻¹, compost manure at 10tha⁻¹ and 15tha⁻¹, along with a control group.

2.3 Experimental Materials

The pepper seed was grown in a seed tray filled with coco peat under a shed at the Department of Agric Science's research farm after being bought from an Agro store in the study region. A battery cage chicken farm provided the poultry manure. The cow manure came from a slaughterhouse. The teaching and research farm provided the pig manure. Animal dung, urine, and organic waste were combined to create compost manure.

2.4 Experimental Design

The treatments were arranged in a Randomized Complete Block Design (RCBD) with three (3) replicates. A total of 27 experimental units were maintained. The site was divided into 3 blocks representing the replicates, and was demarcated by 0.5m alleyways. Each block was divided into 9 plots of 2m×2m, and each block was demarcated by 0.5m alleyways.

2.5 Land Preparation

Using a conventional hoe, the experiment site was physically cleared, packed, pegged, and divided into 27 raised beds measuring 2 by 2 meters. Each block was divided by 0.5-meter alleyways and had eight or nine raised beds measuring two by two meters.

2.6 Treatment Application

Two weeks before transplanting, cow dung, poultry manure, pig manure, and compost manure were evenly applied to the plot and gently mixed into the soil with a hand hoe to allow the organic manure to mineralize. Ten and fifteen tons of cow dung, pig manure, compost manure, and poultry manure were applied per hectare.

2.7 Transplanting of Pepper Seedling

On the prepared beds, pepper seedlings were transplanted 45 cm apart. Each plot was kept at a population of 33 pepper stands.

2.8 Weeding

At two weeks interval, weeding was done manually with a hand-picking procedure starting from the time seedlings were transplanted.

2.9 Harvesting

When the fruits mature, it was collected every week, counted, and weighed with weigh balance device.

2.10 Data collection

2.10.1 Growth and yield of Data

For the purpose of measuring growth and yield metrics, three (3) pepper stands were chosen at random from each plot and tagged. Every two weeks, the number of leaves and branches was counted, and the height of the plant was measured using a meter rule.

2.11 Soil Sampling

2.11.1 Pre-treatment soil sample

The initial soil sample was taken before land preparation to determine the initial soil chemical properties.

2.11.2 Post-harvest soil sample

Another set of soil samples was taken from each block after harvest and processed for the determination of post-harvest soil chemical properties.

2.12 Determination of soil chemical properties

Extracts were analyzed for potassium (K), sodium (Na) by flame photometer and calcium (Ca), magnesium (Mg) by Atomic Absorption Spectrophotometry (AAS). Acidity was evaluated using 0.1N KCl extracts and 0.1N HCl, as per McLean (1964). Effective cation exchange capacity (ECEC) was obtained by adding NH₄OAc-extractable cations and 0.1N KCl extractable acidity. Micro-nutrients (Fe, Cu, Zn and Mn) were extracted by 0.1N HCl and quantified by AAS (AOAC 2000). The TEB/CEC ratio was used to determine percent base saturation.

2.13 Statistical Analysis

The soil properties, plant growth parameters, and yield variables collected were statistically analysed using analysis of variance (ANOVA). If a significant difference was found from the F test, the means were separated with the least significant difference (LSD) test to find the statistically distinct groups.

3. DISCUSSION OF FINDINGS

3.1 Pepper Yield Components under Varying Organic Manure Sources

Use of organic amendments had a significant effect on the yield components of pepper, as there was a definite dose dependence across the various manure types (Table 1). There were significant differences in total fruits per stand among the different fertilization regimes, with the highest number of fruits found in PGM15 (91.33), Pm15 (89.00), and Pm10 (78.00), and the three being statistically tied for the first tier of significance ($p < 0.05$). This significant increase in fruit production under both types of manure can partly be explained by the high initial mineralization rate and high availability of primary macro-nutrients (N and P) at the early flowering and fruit set stage of solanaceous crops. The average fruit weight/stand was used to illustrate a critical split between nutrient allocation and actual fruit biomass production. While PM10 was statistically similar to the higher application rates for fruit quantity, individual fruit weight (248.60 g/stand) was severely reduced, dropping to the secondary tier. The absolute maximum fruit weight was achieved under Pm15 (337.33 g/stand), followed closely by PGM15 (283.33 g/stand). The pattern strongly suggests that a lower organic loading rate (10 t ha⁻¹) can lead to synchronous reproductive branching and fruit initiation, but a higher nutrient loading rate (15 t ha⁻¹) is essential to ensure continuous photoassimilate

(sugar) transport through fruit-filling stages, to produce higher-quality, heavier fruits. In contrast, the lowest agronomic performances were recorded for cow dung treatments (CD10 and CD15) when compared with all the organic amendments tested. Notably, CD10 (32.60 fruits; 118.60 g/stand) failed to show any statistical improvement over the untreated control (15.60 fruits; 107.60 g/stand). This phenomenon is often a result of the higher C: N ratio of ruminant manure, which tends to have nutrient synchronisation issues. Cow dung contains a high amount of recalcitrant lignocellulosic compounds that can often cause temporary microbial immobilization of nitrogen in the rhizosphere, depriving the crop of essential mobile ions during critical periods. In summary, the results point to the importance of choosing a suitable manure source, as well as the mass application rate. Poultry and pig manure (15 t ha⁻¹) as animal wastes have the most favorable soil structure effect and are optimal for increasing the sink size (fruit number) and sink strength (fruit weight) in intensive pepper production.

Table 1: Yield components of pepper (*Capsicum annum* L) as influenced by different organic manure types and application rates

Manure sources	Application rate (t ha ⁻¹)	Number of fruits/ stands	Fruit weight (g ha ⁻¹)
Control	0	15.60 ^d	107.60 ^d
Poultry manure (PM)	10	78.00 ^a	248.60 ^b
	15	89.00 ^a	337.33 ^a
Cow dung (CD)	10	32.60 ^d	118.60 ^d
	15	54.00 ^b	207.33 ^b
Pig manure (PGM)	10	57.33 ^b	155.33 ^c
	15	91.33 ^a	283.33 ^a
Compost manure (CM)	10	45.60 ^c	180.00 ^c
	15	65.33 ^b	221.33 ^c

3.2 Initial Soil Chemical Properties at the Experimental Site

Table 2 displays the initial significant soil nutrient levels at the experimental site, highlighting deficiencies in critical nutrients required for crop production. Organic matter, total nitrogen (N), available phosphorus (P), and potassium (K) all fell short of the critical standards established by Delgado et al. (2024); total N was less than 0.15%, available P was less than 10–15 mg kg⁻¹, and K was less than 0.45 cmol kg⁻¹. These restrictions demonstrate how fertile the soil is and emphasize the necessity of external fertilizer inputs to promote healthy pepper growth. The low nutrient status is likely due to the site's ongoing, intense agriculture, which has reduced the soil's nutrient reserves.

Table 2: Initial Soil Chemical Properties of Soil at the experimental site

Chemical properties	Values
Organic Carbon %	1.50
Organic matter %	2.57
N %	0.13
P (mg/kg)	5.60
K (cmol/kg)	0.14
Na (cmol/kg)	0.25
Ca (cmol/kg)	4.60

Mg (cmol/kg)	2.30
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3.3 Effects of Organic Manures on the Leaf Nutrient Concentration of Pepper

Results in Table 3 present the impact of various organic manure treatments on the nutrient content of pepper leaves. The data indicate that, compared to the control, organic manure applications significantly ($P < 0.05$) enhanced leaf concentrations of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and ash content. However, no significant differences ($P > 0.05$) were observed in leaf nitrogen (N) and sodium (Na) levels among the treatments. Among the organic manures, the highest nutrient concentrations were consistently recorded in plants treated with 15 t ha⁻¹ of poultry manure and pig manure. Specifically, the 15 t ha⁻¹ pig manure treatment resulted in the highest leaf nitrogen content, closely followed by the same rate of poultry manure. Similarly, leaf phosphorus content was greatest under 15 t ha⁻¹ pig manure, with poultry manure at the same rate showing comparable values. Calcium concentration was highest in leaves from plots treated with 15 t ha⁻¹ poultry manure, followed by pig manure at the same application rate. Leaf sodium content remained unaffected by the manure treatments. The observed variation in leaf nutrient concentrations likely reflects differences in the nutrient composition of the organic manures and their respective mineralization rates, which influence the timing and extent of nutrient release to the soil and subsequent plant uptake. This analysis underscores the effectiveness of higher application rates (15 t ha⁻¹) of poultry and pig manures in improving the nutritional status of pepper plants, particularly for critical macro-nutrients such as N, P, K, Ca, and Mg, thereby supporting enhanced plant growth and productivity.

Table 3: Effects of organic manures on the leaf nutrient concentration of pepper

Trt	N%	P	K	Ca	Mg	Ash	Na
Mg/100g		(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	
Control	3.60a	17.03b	6.16b	3.17a	0.96b	14.17a	4.19b
Pm ₁₀	3.87a	17.55b	6.85b	3.23a	1.25a	13.49a	5.16a
Pm ₁₅	3.56a	18.98b	7.81a	3.33a	0.94b	14.81a	5.62a
CD ₁₀	3.62a	17.76b	8.24a	5.51b	0.72b	12.04a	4.36b
CD ₁₅	3.58a	17.37b	8.24a	2.50b	0.74b	12.49a	5.07a
PGM ₁₀	3.82a	17.79b	6.44a	2.47c	0.73b	12.73a	4.67b
PGM ₁₅	3.36a	22.13a	7.35a	2.76ab	0.77b	14.71a	5.05a
CM ₁₀	3.66a	15.87b	6.95a	2.53b	0.78b	8.96b	4.51b
CM ₁₅	3.79a	16.23b	6.24b	2.45c	0.71b	12.11a	5.68a

CONCLUSION

The study revealed that both the source of the organic amendments and the volumetric application rate of these amendments affect the nutritional status and the agronomic yield components of pepper (*Capsicum annuum* L.). The integration of these data sets leads to the following important conclusions: Non-ruminant animal manuring by application of poultry manure (PM) and pig manure (PGM) at high rates (15 t ha⁻¹) is the most effective manure management strategy for maximizing reproductive sinks under Yield Optimization via Non-Ruminant Wastes. The statistically best regime was that which yielded the most fruit per stand (89.00 and 91.33, respectively) and the total fruit weight. Manure-Specific Nutritional Pathways: The variations in yield observed are tightly linked with specific changes in tissue nutrients, not an increase in macro-nutrients. Pig manure (15 t ha⁻¹) is a very good fertilizer for leaf phosphorus (P) accumulation (22.13 mg/100g), while poultry manures optimize the

assimilation of potassium (K) and magnesium (Mg). The nutrient-use efficiency of Ruminant and Low-Rate Inputs: A poor nutrient-use efficiency is observed for ruminant-derived cow dung (CD), especially for the low rate of 10 t ha⁻¹. It did not affect the number of fruits or biomass compared to the untreated control group, so the reproductive yield benefit of increased leaf levels of some secondary ions (e.g., calcium) under cow dung does not necessarily equate to a higher reproductive yield. Finally, sustainable intensification of pepper should focus on using high-rate non-ruminant organic fractions (poultry or pig manure at 15 t ha⁻¹) rather than composted or ruminant sources to obtain the critical nutrient parameters in the leaf that are necessary for optimal crop loading and fruit fill.

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