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Growth and yield performance of cucumber (Cucumis Sativus L.) as influenced by soil amendments

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Abstract

Declining soil fertility is a major constraint to sustainable cucumber (Cucumis sativus L.) production in Nigeria. The study evaluated the effects of different soil amendments on the growth and yield of cucumber in the Southern Guinea Savannah ecological zone. The experiment was conducted at the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria, using a Randomized Complete Block Design with three replications. Treatments comprised NPK 20:10:10 fertiliser, horticultural waste compost, biochar from horticultural waste, poultry manure, biochar from poultry manure, and a control. All treatments contained 60 kg N/ha, except the control. Growth and yield data were subjected to analysis of variance, and treatment means were separated using Duncan's Multiple Range Test at the 5% probability level. Soil amendments significantly improved cucumber growth and yield compared with the control. NPK fertiliser recorded the highest vegetative growth for number of leaves (42.0), leaf area (1775.0 cm^2), number of branches (6.17), stem diameter (11.44a) and days to flowering (36.0). Poultry manure recorded the highest vine length (175.83a) and number of flowers (18.33) at 8 weeks after planting, while horticultural waste compost achieved the highest fruit weight (3.10 kg/plot), followed by biochar from poultry manure (2.77 kg/plot). Positive correlations were observed between vegetative growth traits and fruit yield. This study concludes that, while NPK fertiliser produced the highest vegetative growth across several parameters, horticultural waste compost and biochar from poultry manure produced the highest cucumber yields. Therefore, horticultural waste compost can substitute for biochar from poultry manure in cucumber production as a sustainable soil fertility management strategy.

Keywords: Biochar, Cucumber, Poultry manure, Soil amendments, Yield performance.

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Contribution of this paper to the literature

This study contributes to the literature by comparing organic, inorganic, and biochar-based soil amendments for cucumber production in Nigeria. It demonstrates that horticultural waste compost and biochar poultry manure improve cucumber yield, offering sustainable alternatives to synthetic fertilizers. The findings support improved soil fertility management and environmentally responsible agricultural practices.

1. Introduction

Cucumber (Cucumis sativus L.), which belongs to the plant family Cucurbitaceae, is an economically important vegetable crop widely cultivated in tropical and subtropical regions for its nutritional and commercial value. In Nigeria, its production has increased in response to rising consumer demand, short maturity period, and high market value [1, 2]. However, declining soil fertility, continuous cultivation, and poor soil management remain major constraints to sustainable cucumber production.

Inorganic fertilizers improve crop productivity, their high cost and indiscriminate use may contribute to soil degradation, nutrient imbalance, and environmental concerns [3, 4]. Organic amendments such as poultry manure, compost, and biochar have emerged as sustainable alternatives for improving soil fertility and crop performance. These amendments enhance soil structure, increase organic matter, improve nutrient availability, and support beneficial soil microorganisms. Biochar also improves soil water retention, reduces nutrient losses, and contributes to carbon sequestration, making it a climate-smart soil amendment [5, 6]. Furthermore, the conversion of horticultural waste into compost and biochar provides an environmentally friendly approach to waste management while supporting sustainable agricultural production [7].

Soil amendments such as compost, poultry manure, biochar, and NPK fertilisers have been widely studied, but important gaps remain in the literature that limit their effective application in sustainable agriculture. Horticultural waste composts are abundant but are often discarded indiscriminately, creating environmental problems. They are used as organic soil amendments, which can improve crop production while reducing environmental waste [8]. This study aimed to assess the effects of different soil amendments on cucumber growth and yield.

2. Materials and Methods

2.1. Experimental Site Description

The experiment was conducted at the National Horticultural Research Institute (NIHORT), Idi-Ishin Jericho GRA, Ibadan, Oyo State, located in the Southern Guinea Savannah ecological zone of Nigeria. The site lies at a longitude of 3° 50' E and a latitude of 3° 23' N, at an altitude of approximately 144 m above sea level. Mean annual rainfall ranges from approximately 1,200 to 1,500 mm, with the rainy season extending from March to October. The mean annual temperature is about 25.9–27.0°C, with maximum temperatures ranging from 28.4 to 37.3°C and minimum temperatures ranging from 21.8 to 24.8°C.

2.2. Soil Sampling and Analysis

Soil samples were randomly collected from different spots at the experimental site using a soil auger at a depth of 15 cm. The soil samples were mixed thoroughly, air-dried at ambient temperature, and analyzed for particle size distribution and chemical properties.

2.3. Experimental Materials

Cucumber variety (Poinsett) was selected for adaptability to the region's climate. Horticultural waste compost included cucumber, cabbage, lettuce, dried grasses, fresh grasses, spring onions, carrot, poultry waste, and water. The horticultural waste compost consisted of poultry waste and mango leaves sourced from NIHORT, Ibadan. NPK 20:10:10, applied at 60 kg N/ha, was procured from a reputable agro store in Ibadan.

2.4. Experimental Design and Layout

The experiment was arranged in a Randomized Complete Block Design (RCBD) with six treatments and three replications, giving a total of 18 plots. Each plot measured 4 m × 4 m, separated by 1 m walkways to minimize cross-contamination. Cucumber seeds were sown at 1 m × 1 m spacing, with 16 plants per plot, for a total plant population of 288.

2.5. Application of Treatments

All amendments were applied according to the experimental design, with treatments replicated to allow statistical comparison. Care was taken to avoid cross-contamination between plots by maintaining buffer zones and cleaning tools after each application. All inorganic amendments were incorporated into the soil two weeks before sowing of seeds.

T1 - NPK 20:10:10 (60 kg N/ha).
T2 - Horticultural waste compost (60 kg N/ha).
T3 - Biochar horticultural waste (60 kg N/ha).
T4 - Poultry Manure (60 kg N/ha).
T5 - Biochar Poultry Manure (60 kg N/ha).
T6 – Control.

2.6. Seed Sowing

Cucumber seeds (Poinsett variety) were sown on flatbeds at a spacing of 1 m × 1 m, with two seeds per hole. Thinning was done two weeks after sowing to maintain one healthy seedling per stand.

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2.7. Agronomic Management Practices

2.7.1. Weeding and Pest Control

Manual weeding was carried out at 4-week intervals. Hoe weeding was done at 4 and 8 weeks after sowing (WAS). Insect pests were controlled 5 weeks after sowing.

2.7.2. Staking

This was carried out 3 weeks after planting to provide structural support for cucumber vines. Bamboo stakes of approximately 1.5 – 2 meters were tied gently with jute ropes to avoid stem injury.

2.7.3. Harvesting

Fruits were harvested every two days from day 75 after planting. Harvesting was conducted at 2-day intervals after sowing, depending on fruit maturity. Fruits were harvested in the early morning or late evening when they were firm, and marketable fruits were separated, washed, labeled, and packed in ventilated crates before being transported to the laboratory for data recording.

2.8. Data Collection

Data on vegetative growth parameters were collected at 30 and 60 days after sowing (DAS), including vine length (cm), number of leaves, and leaf area (cm^2). Yield parameters included the number of fruits per plant, fruit length and diameter (cm), fruit weight (g), days to flowering, and total yield (t/ha).

2.9. Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using the General Statistical Package (GENSTAT), 4th edition (2015), while significantly different treatment means were separated using Duncan's multiple range test (DMRT) at a 5% probability level.

3. Results and Discussion

3.1. Soil Analysis of the Experimental Site

The results presented in Table 1 show the physical and chemical properties of the soil used at the study site. The analysis showed that the soil texture is loamy sand, with sand at 810 g/kg, silt at 130 g/kg, and clay at 60 g/kg. The soil pH was slightly acidic (6.0). The organic carbon content was low (4.51 g/kg), the nitrogen concentration was low (0.49 g/kg), and the available phosphorus concentration was 33.36 mg/kg. The baseline soil analysis showed low organic carbon, nitrogen, and potassium but high phosphorus, consistent with fertility constraints of tropical Alfisols. Such imbalances have been reported in Nigerian soils, where continuous cropping and poor organic matter replenishment lead to nutrient depletion [9]. The slightly acidic soil pH (6.0) was favorable for cucumber production, aligning with findings that cucumber thrives in moderately acidic soils [10].

Table 1. Particle size distribution and chemical properties of the experimental soil.

Properties	Values	Critical levels [9]	Remark
pH (1:1, H_2O)	6.0	6.6 – 7.2	Slightly acidic
Organic carbon (g/kg)	4.51	10 – 14	Low
Total nitrogen (g/kg)	0.49	1.6 -2.0	Low
Available phosphorus (mg/kg)	33.36	7 – 20	High
Exchangeable cations (cmol/kg)			
Ca	4.79		
Mg	1.06		
K	0.17	0.3 – 0.6	Very low
Na	0.87		
Exchangeable acidity	0.40		
Extractable micronutrient (mg/kg)			
Fe	81.00	30 - 35	High
Mn	78.50		High
Cu	1.03		Low
Zn	1.14		Low
Particle size distribution (g/kg)			
Sand	810		
Silt	130		
Clay	60		
Textural class	Loamy sand		

3.2. Chemical Properties of Soil Amendments

Table 2 presents the chemical properties of soil amendments used in this experiment. Poultry waste had the highest total C content (37.77), followed by biochar poultry waste (33.13), while horticultural waste compost and biochar horticultural waste had lower values (16.82 and 18.71, respectively). Total N was highest in the NPK treatment (3.66), and poultry waste had the lowest value (0.77). Available P was highest in biochar horticultural waste (1.35), and the lowest P value was recorded in horticultural waste compost (0.57). Horticultural waste compost supplied the most Ca (12.38) and a relatively high Mg content (0.90).

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Table 2. Chemical analysis of soil amendments.

Treatments	Total C	Total N	Avail. P	K	Mg	Ca	Na
Biochar Hort. waste	18.71	1.89	1.35	0.63	0.83	4.95	0.30
Biochar poultry waste	33.13	0.88	0.82	1.38	0.56	3.68	0.42
Poultry waste	37.77	0.77	0.69	0.92	0.56	2.35	0.28
Horticultural waste compost	16.82	1.16	0.57	0.88	0.90	12.38	0.31
NPK	-	3.66	0.83	9.63	0.29	0.16	2.32

Note: Avail. P = Available phosphorus.

3.3. Effect of Soil Amendments on Growth Parameters of Cucumber at 4 Weeks After Planting

Table 3 shows the influence of soil amendments on cucumber growth at 4 weeks after planting. NPK fertiliser produced the highest number of leaves (19.17), leaf area (740.83 cm^2), vine length (57.7 cm), and number of branches (3.33). Poultry waste produced the largest stem diameter (13.13 mm) and the earliest flowering (31.67 days). Biochar from horticultural waste compost recorded 8.5 leaves, 220.17 cm^2 leaf area, and 18.53 cm vine length, while biochar from poultry waste had 15.42 leaves and 13.4 cm vine length. The control treatment had moderate values, with 10.08 leaves, 229.83 cm^2 leaf area, and 23.15 cm vine length. Regarding vegetative growth response at 4 weeks after planting (WAP), NPK fertiliser produced the highest leaf number, leaf area, vine length, and branching. This agrees with Onwudiwe et al. [10], who found that NPK fertiliser significantly enhanced cucumber vegetative growth in Southeastern Nigeria. However, poultry waste amendment produced the largest stem diameter and earliest flowering, suggesting that organic inputs enhance reproductive emergence. Similar results were reported by Oke, et al. [11], who observed that poultry manure improved vegetative vigour and early flowering in cucurbits due to its high nitrogen and phosphorus content.

Table 3. Effect of soil amendments on growth parameters of cucumber at 4 weeks after planting.

Treatments	No. of leaves	Leaf area (cm^2)	Vine length (cm)	No. of branches	Stem diameter (mm)	No. of flowers	Days to flowering
Biochar Hort. waste	8.5e	220.17d	18.53d	0.96e	5.0d	2.67c	34.0b
Biochar poultry waste	15.42c	207.5e	13.4f	1.25c	4.88e	2.0d	32.0d
Poultry waste	16.17b	635.33b	55.11b	2.75b	13.13a	4.67a	31.67f
Horticultural waste compost	8.5f	199.58f	13.53e	0.75f	4.59f	2.0e	33.33c
NPK	19.17a	740.83a	57.7a	3.33a	7.79b	4.33b	35.0a
Control	10.08d	229.83c	23.15c	1.17d	5.52c	2.0f	32.0e
SE	2.36	97.80	8.44	0.44	1.98	0.50	0.56

Note: Means followed by the same letter in a column are not significantly different by DMRT at ($P<0.05$).

3.4. Effect of Soil Amendments on Growth Parameters of Cucumber at 6 Weeks After Planting

Table 4 presents the effect of soil amendments on cucumber growth at 6 weeks after planting (WAP). NPK recorded the highest number of leaves (28.92), leaf area (1100.0 cm^2), and stem diameter (8.99 mm), while poultry waste produced the longest vine length (107.51 cm) and earliest flowering was observed in poultry waste and Biochar poultry waste (32 days). Poultry waste also gave the highest flower count (10), closely followed by NPK (9.67). Biochar horticultural waste and poultry waste showed moderate growth, with leaf numbers ranging from 11.75 to 13.33 and vine lengths between 39.47 and 46.51 cm. Horticultural waste compost alone had the lowest performance, with only 22.2 cm vine length and 4.0 flowers. The control produced 16 leaves, 366.67 cm^2 leaf area, and 38.69 cm vine length, which were lower than NPK and poultry waste. This complementary effect highlighted the distinct roles of organic and inorganic amendments, where poultry waste enhanced vine elongation and reproductive traits, while NPK drove leaf expansion and stem robustness. Integrated nutrient management has been shown to optimize cucumber growth by combining organic and inorganic sources [12].

Table 4. Effect of soil amendments on growth parameters of cucumber at 6 weeks after planting.

Treatments	No. of leaves	Leaf area (cm^2)	Vine length (cm)	No. of branches	Stem diameter (mm)	No. of flower	Days to flowering
Biochar Hort. waste	13.33d	366.67d	39.47d	2.42c	6.25d	5.67c	34.0b
Biochar poultry waste	11.75f	333.33e	46.51c	1.92e	4.73f	5.0d	32.0e
Poultry waste	26.83b	1033.33b	107.51a	3.58b	8.31b	10.0a	32.0f
Horticultural waste compost	12.58e	298.33f	22.2f	1.5f	5.17e	4.0f	34.0c
NPK	28.92a	1100.0a	104.66b	4.15a	8.99a	9.67b	35.0a
Control	16.0c	366.67c	38.69e	2.33d	6.7c	5.0e	32.33d
SE	3.15	149.10	15.43	0.45	0.79	1.03	0.55

Note: Means followed by the same letter in a column are not significantly different by DMRT at ($P<0.05$). Hort. = Horticultural.

3.5. Effect of Soil Amendments on Growth Parameters of Cucumber at 8 Weeks After Planting

Table 5 shows the effect of soil amendments on cucumber growth at 8 weeks after planting. At eight weeks, the final vegetative assessment reveals the most mature differences among treatments. NPK produced the highest number of leaves (42.0), the largest leaf area (1775.0 cm^2), branches (6.17), and the thickest stem (11.44 mm). However, Poultry waste achieved the longest vine length among all treatments, measuring 175.83 cm, slightly above NPK (169.67 cm). Poultry waste also produced the highest number of flowers (18.33), slightly exceeding NPK (18.0). These findings are consistent with Ikeh, et al. [13], who reported that poultry manure enhanced reproductive traits in cucumber, while NPK promoted vegetative expansion. The results confirm that while NPK ensures rapid vegetative growth, poultry waste enhances reproductive vigor.

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Table 5. Effect of soil amendments on growth parameters of cucumber at 8 weeks after planting.

Treatments	No. of leaves	Leaf area (cm^2)	Vine length (cm)	No. of branches	Stem diameter (mm)	No. of flower	Days to flowering
Biochar Hort. waste	19.92d	583.33c	67.5d	4.33c	7.66d	11.33c	34.0b
Biochar poultry waste	17.58f	533.33e	52.83e	3.75d	7.66e	9.33e	32.0e
Poultry waste	27.17b	1708.33b	175.83a	5.58b	10.39b	18.33a	32.0f
Horticultural waste compost	18.5e	450.0f	39.17f	3.15f	6.46f	8.33f	34.0c
NPK	42.0a	1775.0a	169.67b	6.17a	11.44a	18.0b	36.0a
Control	22.33c	566.67d	67.92c	3.33e	8.23c	10.0d	32.33d
SE	4.75	244.93	25.06	0.52	0.76	1.77	0.70

Note: Means followed by the same letter in a column are not significantly different by DMRT at (P<0.05).

3.6. Effect of Soil Amendments on Yield of Cucumber

Table 6 presents the fruit yield for each treatment. Horticultural waste compost gave the highest yield weight at 3.10 kg/plot, followed closely by biochar poultry waste at 2.77 kg/plot. NPK yielded 1.90 kg/plot. Biochar with poultry waste yielded only 1.43 kg/plot, while biochar horticultural waste alone yielded 1.13 kg/plot. The control gave the lowest yield weight of 1.07 kg/plot. The highest number of fruits was recorded for horticultural waste compost (17 fruits/plot), followed closely by biochar poultry waste (15.33 fruits/plot), while the lowest number of fruits was recorded for the poultry waste treatment (7.00). The findings suggest that organic amendments can serve as sustainable alternatives, especially in resource-constrained farming systems. Eleduma [14] emphasized that horticultural waste compost significantly improved cucumber yield, reducing reliance on synthetic fertilisers. The relatively lower yields from biochar treatments may be attributed to their slow nutrient release, which may not match cucumber's rapid nutrient demand.

Table 6. Effect of soil amendments on yield of cucumber.

Treatments	Weight (kg/Plot)	Number of fruits
Biochar Hort. waste	1.13d	6.00c
Biochar poultry waste	2.77a	15.33a
Poultry waste	1.43c	7.00c
Horticultural waste compost	3.10a	17.00a
NPK	1.90b	5.33c
Control	1.07d	9.67b
SE	0.35	2.04

Note: Means followed by the same letter in a column are not significantly different by DMRT at (P<0.05).

4. Conclusion and Recommendation

This study concludes that while NPK fertiliser produced the highest vegetative growth across several parameters, horticultural waste compost and biochar poultry manure produced the highest cucumber yields. Therefore, the use of horticultural waste compost can be substituted for biochar poultry manure for cucumber production as a sustainable soil fertility management strategy.

Farmers should also adopt biochar as a soil amendment to improve soil health, enhance nutrient-use efficiency, and reduce reliance on synthetic fertilizers.

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