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Evaluation of the Growth and Yield of Three Varieties of Pepper (*Capsicum Spp*) in Delta State, Nigeria

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Authors' Contributions

This work was carried out in collaboration among all authors.
All authors read and approved the final manuscript.

Research Article

ABSTRACT

A study was conducted in 2023 to evaluate three pepper varieties for growth and yield at the Teaching and Research Farm, University of Delta, Agbor. The varieties included Scotch Bonnet, Birth Eye Chili, and Melrose. The experiment followed a randomized complete block design with five replicates, measuring plant height, number of leaves per plant, leaf area per plant, stem girth, and fruit yield. Data analysis was performed using analysis of variance, with means separated by Duncan's Multiple Range Test at a 5% significance level. The results showed significant differences in growth and yield among the varieties. Scotch Bonnet had the tallest plants, while Melrose had the smallest. The number of leaves per plant was highest in Scotch Bonnet, with no significant difference among the varieties. Birth Eye Chili had the thickest stem girth, while Scotch Bonnet had the smallest. Leaf area per plant followed a similar pattern, with Melrose having the smallest. Melrose yielded the highest amount of fruit, while Birth Eye Chili had the least. Overall, Scotch Bonnet showed the best vegetative growth, while Melrose produced the highest yield. Therefore, Melrose is recommended for pepper production in the region. Extension service providers should focus on educating farmers about the benefits of cultivating the Melrose variety.

Keywords: Clay, growth characteristics, pepper, sand, soil, varieties, yield

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INTRODUCTION

Pepper (Capsicum spp.), a member of the Solanaceae family and Capsicum genus, is a highly valuable crop cultivated for both local consumption and commercial trade in various regions globally. In Nigeria, pepper holds significant economic importance, ranking as the third most produced vegetable crop after tomato and onion (Mustapha *et al*., 2021). Within sub-Saharan Africa (SSA), pepper is one of the most cultivated vegetables, with Nigeria contributing nearly half of the continent's total production (Obayelu *et al*., 2021). In fact, pepper is the second most cultivated vegetable in Nigeria (Abu *et al*., 2020), playing an essential role in the livelihoods of around 70% of farmers and traders, contributing to food security, income generation, and employment opportunities (World Bank, 2017; Opata *et al*., 2020). The pepper plant is an annual herb or shrub that thrives in tropical and subtropical climates. It is recognized for its unique pungency, vibrant color, bold flavor, and versatility in cooking. Additionally, the high content of capsaicin and oleoresin makes pepper valuable not only in culinary uses but also in medicinal applications. Beyond its consumption, pepper has considerable export potential, making it a key crop in several cultures worldwide.

Delta State, located in the southern region of Nigeria, offers distinctive agro-ecological conditions that may significantly influence the growth and productivity of various pepper varieties. These conditions, including temperature, humidity, and soil composition, play crucial roles in determining the success of pepper cultivation in the region (Ifeoluwa *et al*., 2021). Research by Olayanju *et al*. (2021) highlights the importance of local environmental factors in pepper growth. For instance, Akintoye *et al*. (2023) observed that certain pepper varieties perform better under specific soil pH levels and temperature ranges, which directly influence both fruit yield and quality. Furthermore, tailored agricultural practices such as integrated pest management (IPM) and optimized fertilizer application have been shown to boost pepper yield in regions with unique environmental conditions like Delta State (Adebayo *et al*., 2022). Understanding the impact of specific environmental factors on pepper growth and yield is crucial for advancing agricultural practices in Delta State and similar regions. The results of this study will provide actionable recommendations for farmers, contribute to the body of knowledge on pepper cultivation, and support sustainable agricultural development in Nigeria and beyond. The study will assess various growth and yield-related traits, including plant height, leaf count, flowering periods, fruit size, number of fruits, and total yield per plant. By comparing these varieties, the research will provide insights into the most suitable pepper varieties for cultivation, helping farmers make informed decisions to optimize productivity and enhance crop output. This could lead to improved agricultural practices in Delta State, contributing to the overall strengthening of the local agricultural economy. The findings of this study could also be applied to other regions of Nigeria and sub-Saharan Africa, where environmental conditions and agricultural practices vary, and thereby offering valuable insights for optimizing pepper farming across the continent.

This study seeks to evaluate the growth and yield performance of three distinct pepper varieties in Delta State, with the aim of identifying which variety is best suited to the specific environmental conditions of the region. The primary objective of this research is to evaluate and compare the growth and yield performance of three prominent pepper varieties in

Agbor, Delta State. The specific objectives of the study are to: examine the growth and yield characteristics of the three pepper varieties; and determine the variety that performs best in terms of these factors under Delta State's agro-ecological conditions

MATERIALS AND METHODS

Experimental Location

The experiment was conducted on May 27, 2023, at the beginning of the rainy season at the Teaching and Research Farm, University of Delta, located in Agbor, Delta State. Agbor is situated in the southern region of the Niger Delta, with geographic coordinates ranging from 5°00' to 6°04' East longitude and 5°00' to 6°30' North latitude, covering an area of 176,108 square kilometers (Umeri *et al*., 2023). The region experiences an average annual rainfall between 2000 and 3000 mm and maintains an average air temperature of 31°C (Olawoyin *et al.,* 2021).

Experimental Material

Pepper **(***Capsicum spp.*) seeds were received from the Delta State Agricultural Development Programme (Agricultural Input Purchase Center), Delta State.

Nursery Management

On April 30, 2023, pepper seeds were sown in a prepared bed located within a secondary forest near the experimental field at the Teaching and Research Farm, University of Delta, Agbor. The seeds were evenly distributed across the bed and covered with mulch to reduce moisture loss due to evaporation. Sowing was carried out in separate sections for each pepper variety throughout the research farm. To maintain consistent moisture levels, the nursery was irrigated twice daily—once in the morning and again in the evening. This irrigation schedule follows the methods outlined by Ademola *et al*. (2020).

Experimental Design

Three varieties of pepper were laid out in a randomized complete block design (RCBD) with five replicates. RCBD enhances result accuracy by minimizing environmental variability, thereby enabling clearer identification of treatment effects, which is particularly vital in agricultural studies (Ibrahim *et al*., 2020)**.**

Land Preparation

The experimental area was manually cleared, with all debris removed without resorting to burning. The land was subsequently surveyed and divided into plots, each measuring 1.35 meters by 1.2 meters, with 0.5-meter spacing between plots and replicates. In total, 15 plots were established, each containing 20 plants, resulting in a planting density of 24,333 plants per hectare across a total area of 0.003 hectares. Effective land preparation is crucial for promoting optimal root development and maximizing crop yield (Akinmoladun *et al*., 2022).

Seedlings were initially transplanted at a density of three per stand into beds that had been minimally prepared and later thinned to a single plant per stand. Weed control was carried out manually using a hoe during the second, fifth, and seventh weeks after planting (WAP), with additional weeding performed through rouging.

Soil Analysis

Prior to sowing and thinning of the seedlings, a soil survey was conducted. Composite soil samples were collected using

soil augers and transported to the laboratory. The samples were bulked, air-dried, and sieved through a 2mm mesh sieve. The bulked samples were then processed and tested for both physical and chemical properties.

Data Collection

Data were gathered on both vegetative and yield characteristics, as outlined below:

Vegetative Characteristics

Growth parameters were recorded at 2, 4, 6, 8, and 10 weeks after transplanting (WATP). Four plants from the net plot were selected and tagged for the collection of vegetative data. The following vegetative data were recorded:

i. **Plant Height (cm):** The height of four plants in each plot was measured using a tape measure, from the soil surface to the tip where the youngest leaves emerged, and the average height was recorded.

ii. **Number of Leaves per Plant:** The number of leaves on each of the four plants per plot was counted visually, and the average number was noted.

iii. **Stem Girth (cm):** A digital vernier caliper was used to measure the largest stem girth of four plants per plot, and the mean value was recorded.

iv. **Leaf Area per Plant (cm^2):** The leaf area for four plants was calculated using a graphical method, and the resulting area was multiplied by a coefficient of 0.62, based on the total number of leaves. The average leaf area was then recorded (Musa & Usman, 2016).

Yield Character

Fruit Yield (t/ha): The ripe fruits harvested from each plot were weighed using a balance, and this measurement was used to estimate the total fruit yield per hectare for each variety.

Data Analysis

The growth and yield data collected were analyzed using analysis of variance (ANOVA) with the GenStat version 15.2 (2012) software. Where significant differences were found, means were compared and separated using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

RESULTS

The soil characteristics of the experimental site are critical in assessing its suitability for pepper (Capsicum spp.) cultivation. The soil is classified as loamy sand, consisting of 82% sand, 7% silt, and 11% clay, which provides excellent drainage while still retaining moisture and essential nutrients, making it an ideal medium for growing peppers. With a slightly acidic pH of 5.75, the soil falls within the optimal pH range for pepper growth. *Oluwafemi et al. (2022)* suggest that slightly acidic soils, such as the pH of 5.75 found in this study, are favorable for pepper growth. The organic carbon content is moderate at 8.30 g/kg, contributing to improved soil fertility and supporting microbial activity. Nutrient levels indicate moderate fertility, with total nitrogen at 0.45 g/kg, available phosphorus at 10.00 mg/kg, and sufficient quantities of exchangeable calcium, magnesium, and potassium. The sodium content is low, reducing the risk of salinity issues. The

cation exchange capacity (CEC) is relatively low at 2.70 cmol/kg; indicating limited nutrient retention, although the 100% base saturation ensures that nutrients are readily available to the plants. While these soil properties suggest suitability for pepper cultivation, the low CEC calls for supplementary nitrogen and careful management of other nutrients to achieve optimal growth and yield. This aligns with the findings of Akinnifesi *et al*. (2023), who emphasize the need for supplemental nitrogen and proper soil management practices to optimize pepper yield. The application of fertilizers and organic amendments would help maintain soil fertility in the long term.

Table1:
Physico-chemical properties of the soil of the experimental site prior to planting

Parameters	**Values**
Sand	82.0
Silt (gkg^{-1})	7.0
Clay (gkg^{-1})	11.0
Textural Class	Loamy sand
pH (H^2O 1:1)	5.75
Organic carbon (gkg^{-1})	8.30
Total nitrogen (gkg^{-1})	0.45
Available phosphorus ($mgkg^{-1}$)	10.00
Exchangeable calcium ($cmolkg^{-1}$)	1.02
Exchangeable magnesium ($cmolkg^{-1}$)	0.46
Exchangeable potassium ($cmolkg^{-1}$)	1.05
Exchangeable sodium (cmolkg-1)	0.07
Total Exchangeable Bases ($cmolkg^{-1}$) [$Ca^{-1} + Mg^{2+} + K^{+} + Na^{+}$]	2.60
Total Exchangeable Acidity ($cmolkg^{-1}$) [$Al^{3+} + H^{+}$)	0.11
Effective cation exchange capacity ($cmolkg^{-1}$)	2.70
Base saturation %	100.00

Source: Authors (2024)

Vegetative Traits of Pepper at Agbor

The table presents the vegetative traits of three pepper varieties—Scotch Bonnet (SB), *Bird Eye Chili* (BEC), and *Melrose*—over a 10-week period after transplanting. The parameters measured include plant height, number of leaves per plant, stem girth, and leaf area per plant. Here is a breakdown of the findings and implications:

Plant Height

a. Scotch Bonnet showed the highest plant growth over the 10-week period, with a significant increase in height at weeks 6, 8, and 10 (28.52 cm and 29.50 cm, respectively).
b. Bird Eye Chili followed closely behind, with no significant difference in height compared to Scotch Bonnet until the later weeks.
c. Melrose exhibited a slightly lower growth trajectory, especially

noticeable at week 6 (24.50 cm) and week 8 (27.21 cm), where it had significantly shorter plants compared to Scotch Bonnet and Bird Eye Chili.

d. Implication**:** Scotch Bonnet exhibited superior growth in terms of height, making it potentially more robust for production, while Melrose lagged behind.

Number of Leaves per Plant

a. *Bird Eye Chili* had the highest number of leaves at all measured weeks, reaching 66 leaves at week 10, significantly more than both Scotch Bonnet and Melrose.
b. *Scotch Bonnet* and *Melrose* had similar leaf counts throughout the study, with Melrose showing slightly fewer leaves than Scotch Bonnet at week 6 (35 vs. 36).
c. Implication: The high leaf count in Bird Eye Chili suggests it may have a better capacity for photosynthesis and overall plant health, potentially leading to higher yields. In contrast, Scotch Bonnet and Melrose had moderate leaf growth.

Stem Girth

a. *Scotch Bonnet* showed the largest increase in stem girth, reaching 3.52 cm by week 10, while *Bird Eye Chili* and *Melrose* had somewhat lower growth in stem girth, with the latter showing a smaller increase overall.
b. Implication: The thicker stem girth in Scotch Bonnet may indicate stronger structural growth, which could support larger fruits and greater overall plant health. Melrose showed slower stem development, which could affect plant sturdiness and fruit production.

Leaf Area per Plant

a. *Scotch Bonnet* had the highest leaf area at weeks 2, 6, and 8 (example, 85.58 cm^2 at week 8), suggesting that it developed larger leaves earlier in the growth cycle.
b. *Bird Eye Chili* and *Melrose* showed slightly lower leaf area, with values around 72 cm^2 at week 10.
c. Implication: The larger leaf area in Scotch Bonnet at certain points could provide it with a greater photosynthetic area, supporting better growth and fruiting potential compared to Bird Eye Chili and Melrose, which had more moderate leaf expansion.

Critical Findings

a. *Scotch Bonnet* generally exhibited superior growth, with higher plant height, larger leaves, and thicker stems compared to *Bird Eye Chili* and *Melrose*.
b. *Bird Eye Chili* showed the best leaf production, while Melrose consistently performed the weakest in terms of plant height and leaf count.

Implications of Findings

a. *Scotch Bonnet* appears to be the most promising variety in terms of overall vegetative growth and could be preferred for environments that favor vigorous plant development.
b. *Bird Eye Chili* may be more suited for environments where high leaf production is desirable for increased photosynthesis.
c. *Melrose* may need improvement in terms of growth and vigor but could still be viable in certain conditions,

particularly where smaller plants are desired.

These findings suggest that selecting the right variety for pepper cultivation in Agbor will depend on the specific growth traits needed for optimal production, with Scotch Bonnet showing the most favorable characteristics. Yusuf *et al.*, 2024, in his study, confirm that Scotch Bonnet generally shows superior vegetative growth, especially in terms of plant height and stem girth. Ajala and Abubakar (2021)also reported in their study that varieties like Scotch Bonnet tend to show superior growth characteristics, which is in line with these findings that Scotch Bonnet had the highest plant height and stem girth. Top of Form. In Table 2, values with the same letter (s) superscript indicated in columns are not significantly different using DMRT at 5% level of probability.

Table 2:
Vegetative traits of pepper at Agbor

Parameter / Crop Variety	Weeks After Transplanting				
	2	4	6	8	10
Plant height					
Scotch Bonnet (SB)	13.25^{ns}	19.25^{ns}	26.50^{a}	28.52^{a}	29.50^{a}
Bird eye chili (BEC)	13.13	19.15	26.25^{a}	28.25^{a}	29.25^{a}
Melrose	13.20	19.05	24.50^{b}	27.21^{b}	28.05^{b}
Mean	13.19	19.15	25.75	27.99	28.93
DMRT	11.02	17.52	22.25	25.50	27.11
Number of leaves/plant					
Scotch Bonnet	15 ^{NS}	26^{NS}	36^{b}	42^{b}	65^{NS}
Birth eye chili (BEC)	15	25	45^{a}	56^{a}	66
Melrose	14	25	35^{b}	41^{b}	65
Mean	14.6	25.3	38.6	46.3	65.3
DMRT	13.22	24.12	34.13	40.99	64.20
Stem girth (cm)					
Scotch Bonnet	2.20^{NS}	2.25^{a}	2.75^{a}	3.45^{ab}	3.52^{a}
Birth eye chili	2.00	2.05^{c}	2.55^{ab}	3.52^{a}	3.56^{a}
Melrose	2.10	2.15^{b}	2.65 ^{b}	3.50^{a}	3.35^{b}
Mean	2.10	2.15	2.65	3.39	3.45
DMRT	1.12	1.49	1.93	2.32	2. 73
leaf area/plant (cm^2)					
Scotch Bonnet	27.52^{a}	41.56ns	62.43 ^{a}	85.58 ^{a}	72.26 ^{a}
Birth eye chili	26.65^{b}	41.52	59.80 ^{b}	80.00 ^{b}	72.05 ^{bc}
Melrose	27.05^{a}	41.50	60.05 ^{b}	81.05 ^{b}	72.22 ^{b}
Mean	27.07	41.52	60.76	82.21	72.17
DMRT	25.12	40.01	58.89	79.94	70.99

Source: Authors (2024)

Fruit Yield (t/ha) of Some Varieties of Pepper at Agbor

The table presents the fresh fruit yield (in tons per hectare, t/ha) for three pepper varieties—Scotch Bonnet, Bird Eye Chili, and Melrose—at the Agbor site. The values indicate the total yield of fresh fruits per hectare for each variety. Below is a breakdown of the findings and their implications:

Summary of Results

a. *Scotch Bonnet* yielded 16.72 t/ha, which is statistically similar to *Bird Eye Chili*, which produced 16.80 t/ha. Both these varieties have a comparable fruit yield.
b. *Melrose* had a significantly higher yield of 26.23 t/ha, which is substantially greater than the yields of both Scotch Bonnet and Bird Eye Chili.
c. The mean yield across all varieties was 20.00 t/ha, and the DMRT value was 15.71 t/ha, meaning any differences greater than 15.71 t/ha are statistically significant.

Summary of Findings

a. *Melrose* outperformed both *Scotch Bonnet* and *Bird Eye Chili* in terms of fresh fruit yield, with a much higher yield per hectare.
b. *Scotch Bonnet* and *Bird Eye Chili* had similar yields, and the difference between them is not statistically significant, indicating that both varieties perform similarly in terms of fruit yield under the conditions at Agbor.
c. The overall mean yield of 20.00 t/ha suggests that pepper farming in the region yields a moderate amount, but yields can be significantly enhanced depending on the variety chosen.

Implications of Findings

a. *Melrose* emerges as the most productive variety in terms of fresh fruit yield, making it an attractive option for farmers looking to maximize yield per hectare. Its significantly higher yield suggests that it may have better adaptability or efficiency in fruit production under the conditions at Agbor.
b. *Scotch Bonnet* and *Bird Eye Chili*, despite having similar yields, may not be as advantageous in terms of yield when compared to Melrose. However, they could still be preferred depending on other factors such as market demand, fruit quality, or specific environmental requirements.
c. The study highlights the potential for improving pepper yields in Agbor by selecting varieties with higher productivity like *Melrose*, but it also shows that *Scotch Bonnet* and *Bird Eye Chili* can be viable options, especially if factors other than yield are prioritized.

In conclusion, *Melrose* should be considered for higher yields, while *Scotch Bonnet* and *Bird Eye Chili* might still serve well depending on particular growing conditions or market preferences. This is similar to the findings of Chijioke and Afolabi (2023), who reported that varieties such as Melrose can outperform others in terms of fresh fruit yield. Values with the same letter (s) superscript indicated in columns are not significantly different using DMRT at 5% level of probability.

Table 3:
Fruit yield (t/ha) of some varieties of pepper at Agbor

Crop Variety	Fresh fruit yield (t/ha)
Scotch Bonnet	16.72b
Birth eye chili	16.80b
Melrose	26.23a
Mean	20.00
DMRT	15.71

Source: Authors (2024)

DISCUSSION AND CONCLUSION

Discussion

Environmental conditions and genetic factors during growth periods play a significant role in shaping the growth patterns of crops in various ecological zones of Nigeria (Tiamiyu *et al*., 2012). In this study, the plant height of different pepper varieties showed no significant differences. The tallest plant, SB, measured 29.50 cm, while Melrose was the shortest at 20.05 cm. However, the tallest variety did not correspond to the highest fruit yield, suggesting that plant height is not a critical determinant of yield. This finding challenges the assumption that taller plants are more productive. Research by Udoh *et al*. (2005) also found that the number of leaves per plant did not significantly affect pepper growth or yield. BEC had the highest leaf count at 66, with Scotch Bonnet and Melrose both having 65 leaves. This uniformity in leaf production may be attributed to similar environmental conditions, aligning with findings from Eke *et al*. (2008), who observed no significant leaf differences among pepper varieties.

Stem girth, important for plant stability, was found to vary significantly across the varieties, with BEC having the largest girth and SB the smallest. This trait influences the plant's resistance to lodging (Varmudy, 2011). Leaf area, although contributing to photosynthesis, did not show a significant link to the vegetative growth or fruit yield in SB, contrasting with Adetuyi *et al*. (2011), who suggested that larger leaf areas enhance fruit production. Fruit yield, a key selection criterion, showed significant differences among varieties, with Melrose yielding the most, though not significantly higher than other varieties. This supports the findings of Eshbaugh (2003), who also noted variations in yield among different pepper varieties.

In conclusion, while plant height, leaf number, and leaf area were not strongly correlated with fruit yield, factors such as stem girth and environmental conditions played a more significant role in growth and productivity. These findings highlight the importance of considering multiple factors when selecting pepper varieties for cultivation.

Conclusion

The results of the study indicated that the experimental site, prior to the cultivation of pepper, was characterized by loamy sand soil with a slightly acidic pH, moderate levels of organic carbon (8.30 g/kg), but was deficient in nitrogen (0.45 g/kg), available phosphorus (10 mg/kg), and exchangeable bases. It was concluded that the Melrose variety exhibited superior performance in terms of fruit yield, surpassing the other two varieties under

investigation. This conclusion was drawn based on consistent treatment applied across the three varieties in the same soil conditions, making Melrose the most suitable cultivar for the region of Agbor, Delta State. In light of these findings, the study recommends that agricultural extension services actively promote the adoption of the Melrose variety among local farmers. Given its proven high performance, the widespread adoption of Melrose would likely enhance pepper production in the study area. Farmers have expressed a clear need for guidance on the most appropriate pepper variety for their soil type, and extension services should therefore prioritize the dissemination of knowledge regarding the optimal cultivation practices for Melrose.

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Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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