Vietnam Journal of Agricultural Sciences

ISSN 2588-1299

VJAS 2024; 7(3): 2195-2207
https://doi.org/10.31817/vjas.2024.7.3.02

Investigating the Influence of Inorganic and Organic Fertilizers on the Growth and Yield of Three Varieties of Okra (*Abelmoschus esculentus*)

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Abstract

Fertilizers play an important role in enhancing crop yield, plant growth, and the fertility of the soil. This research was conducted at the Faculty of Agriculture Teaching and Research Farm, University of Port Harcourt, Nigeria to investigate the influence of inorganic fertilizer (urea) and organic manure (spent mushroom substrate and poultry manure) on the yield and growth parameters of three okra cultivars (Clemson Spineless, Perkins Long Pod, and a local assertion). The treatments were 4.0g of urea, 150g and 200g of poultry manure, 150g and 200g of spent mushroom substrate, and a control treatment (no fertilizer), and were laid in a completely randomized design (CRD) with three replications. The results revealed that the okra cultivars responded positively to both organic manures when compared with urea and the control group. Poultry manure significantly enhanced the growth and yield parameters across all varieties, with Perkins Long Pod exhibiting the highest performance. The highest plant height (62.77cm) was observed in Perkins Long Pod with 150g of poultry manure, while Clemson Spineless and the local variety reached 42.5cm and 44.77cm, respectively, with 200g of spent mushroom substrate. Urea application led to the maximum leaf area (123.7 cm²) and leaf area index (0.085) in Clemson Spineless. Fruit yield was the highest in the local variety with 200g of poultry manure, achieving 967.8 kg ha^{-1}, followed closely by 200g of spent mushroom substrate at 945.9 kg ha^{-1}. The study concluded that the Perkins Long Pod variety and poultry manure are the most suitable for maximizing okra yield in tropical environments.

Keywords

Okra, *Abelmoschus esculentus*, Organic and inorganic fertilizers, Yield

Received: June 9, 2024
Accepted: September 24, 2024

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Introduction

Okra (*Abelmoschus esculentus*) is a widely cultivated vegetable in Nigeria and some tropical and sub-tropical countries. Okra is a member of the *Abelmoschus* genus and species *esculentus* of the *Malvaceae* family (Linnaeus, 1753). It is particularly cherished in Nigeria for its mucilaginous attributes (Benchasri, 2012). The primary focus of cultivating okra is its edible "pods," commonly prepared and consumed in African nations such as Nigeria, Egypt, and Sudan. Notably, the mucilaginous substance derived from okra has been employed to treat ulcers, alleviate hemorrhoids, and aid in sugar processing as a cleansing agent (Petropoulos *et al*., 2018; Chand *et al*., 2024). The tender pods of okra contain essential vitamins including A, C, and traces of B vitamins (Dorni *et al*., 2017). Beyond its culinary merits, okra is a valuable source of calcium, contributing to strengthening bones and preventing fractures, along with other nutrients promoting overall health (Agregán *et al*., 2023). Interestingly, the seeds of okra can be roasted and used as a coffee substitute. This vegetable has historically been a dietary staple for many, particularly among rural communities and those with limited incomes in tropical and subtropical regions, including Nigeria (Gloria *et al*., 2017). Satisfying the nutritional demands of okra during its growth and development requires careful attention to the diverse elements supplied by fertilizers. However, fertilizers vary in their concentrations of the essential nutrients necessary for optimal plant growth (Singh *et al*., 2013).

Maintaining soil productivity poses a significant challenge for tropical farmers (Jat *et al*., 2012). Traditionally, farmers have shifted crop cultivation across fields to capitalize on fertile soils, avoiding the use of fertilizers. However, this approach is no longer sustainable to meet the rising demands of a growing population (Jayne *et al*., 2014). Soils in tropical regions suffer from compromised fertility and erosion, leading to nutrient depletion and shifts in soil organism populations. While inorganic fertilizers can boost crop yields and enhance soil characteristics like pH, nutrient content, and availability, their use is constrained by factors such as scarcity, expense, nutrient imbalances, and soil acidity (Uka *et al*., 2013). To address these challenges, the application of organic manure has been proposed as a strategy to uphold and enhance soil fertility (Timsina, 2018; Cai *et al*., 2019). Efficient utilization of animal manures sustains long-term crop productivity by immobilizing nutrients prone to leaching. Nutrients within these manures are gradually released and retained in the soil for extended periods, resulting in lasting effects that foster improved root growth and heightened crop yields (Rayne & Aula, 2020). Manure is typically administered at higher rates compared to inorganic fertilizers. When used in substantial amounts, they yield residual benefits for subsequent crop growth and yield (Makinde & Ayoola, 2012; Timsina, 2018). According to Hoang *et al*. (2023), using organic fertilizer under stringent principles results in healthy and environmentally friendly agricultural produce.

Consequently, animal waste, which can be transformed into organic manure has emerged as a preferable and necessary alternative for enhancing okra production, particularly in tropical regions. The inclusion of organic fertilizers is imperative due to their abundant nutrient contents, user-friendly handling, and straightforward application. However, regarding quantity, the volume of poultry manure needed for cultivation is lower than that of cow, goat, and sheep manure (Okorogbona & Adebisi, 2012). Small-scale farmers benefit from reduced production costs as poultry manure tends to be more economical than NPK or urea fertilizers. In the context of Nigeria, hindrances to successful okra production and the cultivation of other vegetables include weed management, appropriate tillage practices, utilization of low-yield varieties, and sub-optimal planting density as well as soil fertility (Lyagba *et al*., 2012).

Due to variations in fertilizer concentrations, the growth rate and yield of plants can differ significantly locally and across different regions depending on soil conditions and other characteristics (Belete *et al*., 2018). Hence, there is a compelling requirement to explore and analyze the impacts of varying levels of both inorganic and organic fertilizers on the growth and yield of okra particularly in the southern part of Nigeria. Furthermore, previous studies on okra cultivation have predominantly focused on the influence of organic and/or inorganic fertilizers on the growth and yield of a single variety of okra (Atijegbe *et al.*, 2014; Khandaker *et al.*, 2017; Aluko *et al.*, 2020, Unagwu *et al.*, 2021; Kumar *et al.*, 2023). This narrow focus has left a significant gap in understanding how these fertilizers interact with different okra varieties under controlled conditions. Our study aimed to fill this gap by investigating the effects of organic (poultry manure and spent mushroom substrate) and inorganic (urea) fertilizers on the growth and yield of multiple okra varieties. Specifically, this study sought to identify an ideal variety and the possible integration of organic and inorganic fertilizers that would give optimum yields of Clemson Spineless, Perkins Long Pod, and a local variety of okra, and analyze the performance and effects of urea, poultry manure, and spent mushroom substrate on each of the varieties listed above. By employing a comprehensive approach that integrated multiple fertilizer types and okra varieties, our research provides novel insights into optimizing okra production and thereby contributing to more sustainable and efficient agricultural practices.

Materials and Methods

Sources of materials

The okra varieties utilized in the study included known varieties and a local variety. The known varieties, Clemson Spineless and Perkins Long Pod were sourced from Agrotropic Ltd. in Rivers State, Nigeria. Clemson Spineless is renowned for its spineless pods, making them easier to handle and harvest, while the Perkins Long Pod variety is distinguished by its elongated pods and high yield potential. The local variety of okra was obtained from the Ogoni community in Rivers State, Nigeria, and is known for its adaptability to the local climate and soil conditions.

The fertilizers used in the study were urea, poultry manure, and spent mushroom substrate, all sourced from the Faculty of Agriculture Teaching and Demonstration Farm at the University of Port Harcourt, Nigeria. Urea is a nitrogen-rich synthetic fertilizer widely used for promoting vigorous plant growth. Poultry manure is an organic fertilizer rich in essential nutrients like nitrogen, phosphorus, and potassium, and is beneficial for improving soil fertility and structure. Spent mushroom substrate, a by-product of mushroom cultivation, is rich in organic matter and nutrients and is used in enhancing soil health and promoting sustainable agricultural practices.

Experimental design and treatments

A potted experiment was conducted at the University of Port Harcourt Teaching and Research Farm in Nigeria from June to September 2019. Before the experiment was carried out, soil samples were collected and analyzed for pH, soil organic matter, and the presence of essential nutrients including nitrogen, phosphorus, and potassium. The study employed a two-factor experiment in a completely randomized design (CRD). Factor A was the okra cultivars (Clemson Spineless, Perkins Long Pod, and a local assertion), and Factor B was the fertilizer treatments (urea, poultry manure, spent mushroom substrate, and a control). Six fertilizer treatments, namely 4grams of urea, 150grams of poultry manure, 200grams of poultry manure, 150grams of spent mushroom substrate, 200grams of spent mushroom substrate, and a control treatment with no fertilizer application, were applied to each cultivar, with three replications per treatment. This design allowed for the assessment of different fertilizer treatments on the growth and yield of okra, providing a comprehensive comparison of their effects under controlled conditions.

Sowing, treatments, and intercultural practices

Okra seeds were soaked in water for about 2 hours before planting to break the seed dormancy and help speed up the germination process. Fifty-four (54) bags 40-45cm in width were filled with 10kg of sterilized soil and perforated to ensure proper aeration and drainage. Seeds were sown directly into the soil at the rate of four seeds per hole at a depth of 1.5cm. This was later thinned to one plant per bag. Twenty-eight (28) days after planting (seedling stage), the treatments were applied (poultry manure, urea, and spent mushroom substrate) using the ring method of application. The bags were kept free from weed infestation and irrigation was carried out when required.

Harvesting

At 56 days after planting, fruiting and harvesting started. The pods were carefully harvested by hand using a sharp knife to avoid injuring the plants. Harvesting was done once a week for three weeks.

Collection of data

Measurements commenced three weeks after planting (3 WAP) and continued at weekly intervals. Data collection focused on both the growth and yield parameters of okra. The growth parameters were plant height, number of leaves, leaf area, and leaf area index. The yield parameters encompassed the number of fruits per plant, fresh weight of fruits per plant, total fruit yield per variety, fruit length, and fruit diameter per plant. Plant height was measured using a wooden meter ruler from the base of the plant above the ground to the tip of the highest leaf. The number of leaves was determined by visually counting the leaves on each plant, excluding the young leaves at the growing point. The number of fruits was recorded by counting the fresh fruits harvested from each plant. Fruit length and diameter were measured using a meter ruler and a caliper, respectively. The fresh weight of the fruits was measured in grams using an electric-sensitive scale. Leaf area was calculated by recording the length and width of a leaf from each plant and applying the formula: Leaf Area = Length * Width * 0.75. Fruit yield (kg ha^{-1}) was calculated using the formula: Fruit Yield = (Fresh Weight * 10,000) / Land Area. The leaf area index (LAI) was determined by taking the average leaf area from each treatment level and using the formula: LAI = Leaf Area / Land Area. These measurements provided a comprehensive assessment of the okra plants' growth and yields under different treatment conditions.

Statistical analysis

Data collected for each parameter were recorded and subjected to analysis of variance (ANOVA) using SPSS 25.0, and the means were separated using the least significant difference (LSD) test at the $P \leq 0.05$ probability level.

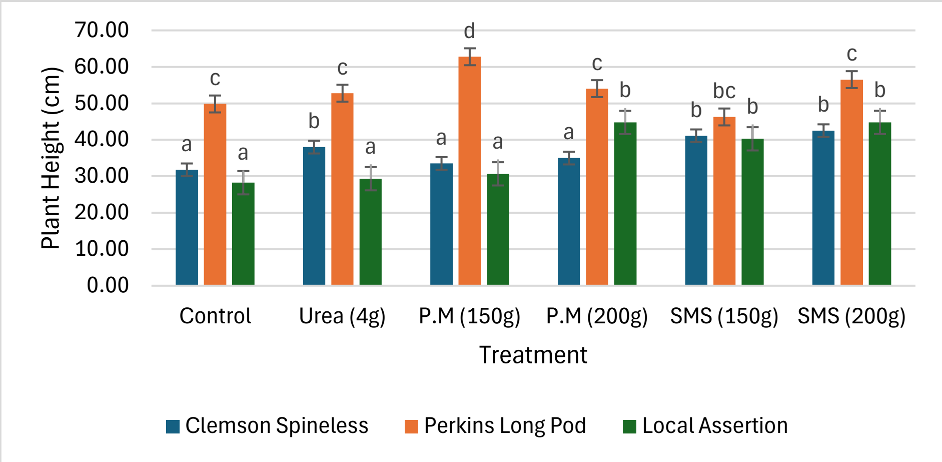
Results

Plant Height

The effects of urea, poultry manure, and spent mushroom substrate on the plant height of the okra varieties are shown in **Figure 1**. There were differences in the mean plant heights after the treatment applications and the results also showed that plant height was influenced by varietal differences. The Perkins Long Pod variety produced taller plants, followed by the local assertion and Clemson Spineless. At 10 weeks, the highest plant height (62.77cm) was found in the poultry manure 150g treatment for Perkins Long Pod, while the highest plant heights for Clemson Spineless (42.5cm) and the local assertion (44.77cm) were found in the spent mushroom substrate 200g treatment. For the Perkins Long Pod variety, spent mushroom substrate 200g had the second highest height (56.5cm), followed by poultry manure 200g (54.03cm), which was not significantly different from those of urea 4g (52.7cm) and the control (49.8cm), and the shortest height was found in spent mushroom substrate 150g (46.27cm). The second highest plant height for Clemson Spineless was recorded in spent mushroom substrate 150g (41.1cm), followed by urea 4g (38cm), poultry manure 200g (35cm), and poultry manure 150g (33.5cm), and the shortest height was found in the control (31.7cm). For the local assertion, the second highest plant height was found in poultry manure 200g (44.75cm), followed by spent mushroom substrate 150g (40.2cm), poultry manure 150g (31cm), and urea 4g (29.33cm), with the control having the shortest height (28.23cm).

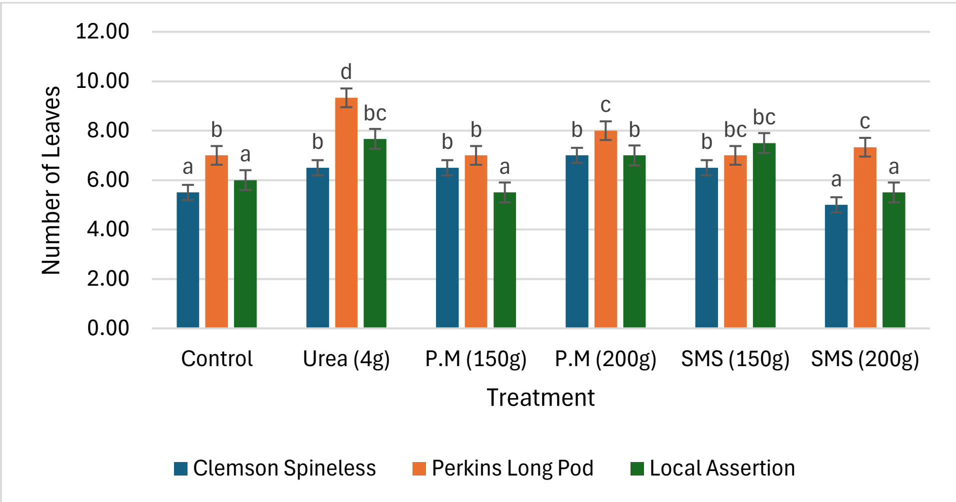
Number of Leaves

The results of the effects of urea, poultry manure, and spent mushroom substrate on the number of leaves are shown in **Figure 2**. Applying 4g of urea 10 weeks after planting produced a higher number of leaves (9.3) for the Perkins Long Pod variety, followed by poultry manure 200g (8), and spent mushroom substrate 200g (7.3). There were no differences among the number of leaves of spent mushroom substrate 150g, poultry manure 150g, and the control, which had the least number of leaves (7). For Clemson Spineless, the highest number of leaves was recorded in poultry manure 200g (7), there were no significant differences among the number of leaves of urea 4g (6.5), poultry manure 150g (6.5), and spent mushroom substrate 150g (6.5). The least number of leaves was observed in spent mushroom substrate 200g (5). The highest number of leaves for the local assertion was found in urea 4g (7.7), which was not statistically different from that of spent mushroom substrate 150g (7.5) or poultry manure 200g (7). The fewest numbers of leaves were found in spent mushroom substrate 200g (5.5) and poultry manure 150g (5.5), which were not different from the control (6).



*Note: *P.M Poultry Manure *SMS – Spent Mushroom Substrate *Means of each bar followed by the same letters are not significantly different at the LSD P ≤0.05 probability level within cultivars and across treatments.*

Figure 1: Effect of Nitrogen Source on Plant Height



*Note: *P.M Poultry Manure *SMS – Spent Mushroom Substrate *Means of each bar followed by the same letters are not significantly different at the LSD P ≤0.05 probability level within cultivars and across treatments.*

Figure 2: Effect of Nitrogen Source on the Number of Leaves

Leaf Area

The results of the effects of urea, poultry manure, and spent mushroom substrate on leaf area are presented in **Figure 3**. The results showed that the different cultivars differed regarding leaf area. The Clemson Spineless variety had the largest leaf area (123.7 cm^2) in urea 4g, followed by poultry manure 200g (105.37 cm^2), spent mushroom substrate 150g (99.15 cm^2), poultry manure 200g (96.57 cm^2), spent mushroom substrate 200g (85.17 cm^2), and the control, which had the least leaf area (53.37 cm^2). The second largest leaf area was observed in the Perkins Long Pod variety with a value of 113.07 cm^2 for poultry manure 150g, followed by urea 4g (104.8 cm^2), poultry manure 200g (97.63 cm^2), spent mushroom substrate 200g (82.47 cm^2), the control (66.07 cm^2), and the least leaf area was found in spent mushroom substrate 150g (62.13 cm^2). The local assertion had the least leaf area generally with a value of 96.55 cm^2 observed in poultry manure 150g, followed by poultry manure 200g (94.15 cm^2), spent mushroom substrate 200g (89.67 cm^2), urea 4g (77.3 cm^2), and the least was found in the control (54.47 cm^2).

Leaf Area Index

The effects of urea, poultry manure, and spent mushroom substrate on the leaf area index of the okra varieties are shown in **Figure 4**. In the control treatment, the leaf area index results showed differences among the varieties with Perkins Long Pod having an index of 0.045, and Clemson Spineless and the local variety with the same index value of 0.037. For urea 4g, Clemson Spineless had a higher index of 0.085, followed by Perkins Long Pod (0.072) and the local assertion (0.053). Poultry manure 150g had the highest leaf area index of 0.077, found in the Perkins Long Pod variety, followed by Clemson Spineless with an index of 0.072 and the local assertion with an index of 0.067. For poultry manure 200g, there were no differences among the varieties, and the same trend was observed in spent mushroom substrate 200g. However, there were differences among the varieties in spent mushroom substrate 150g with Clemson Spineless having the highest index of 0.068, followed by the local assertion with 0.051, and Perkins Long Pod with 0.043.

Number of Fruits

The effects of urea, poultry manure, and spent mushroom substrate on the number of fruits/plant are presented in **Figure 5**. The application of poultry manure 150g produced a higher number of fruits (8.0) for the Perkins Long Pod variety, followed by spent mushroom substrate 200g (6.0), poultry manure 200g (5.0),

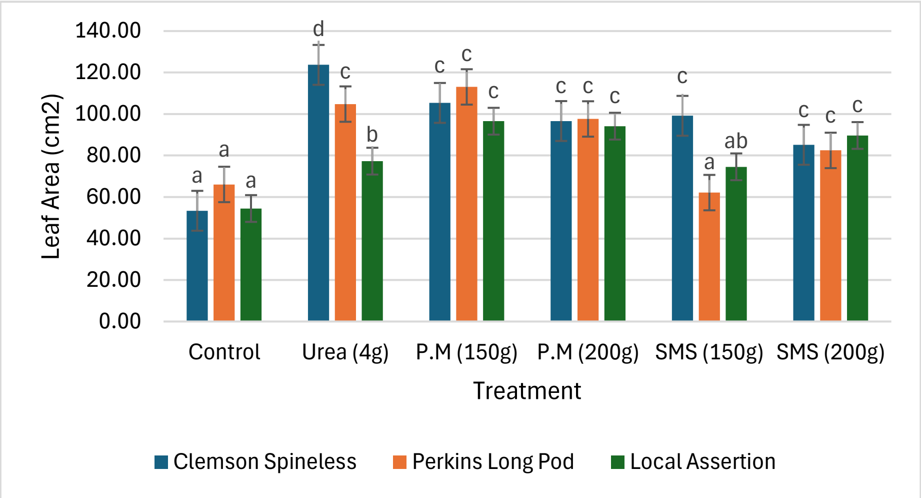


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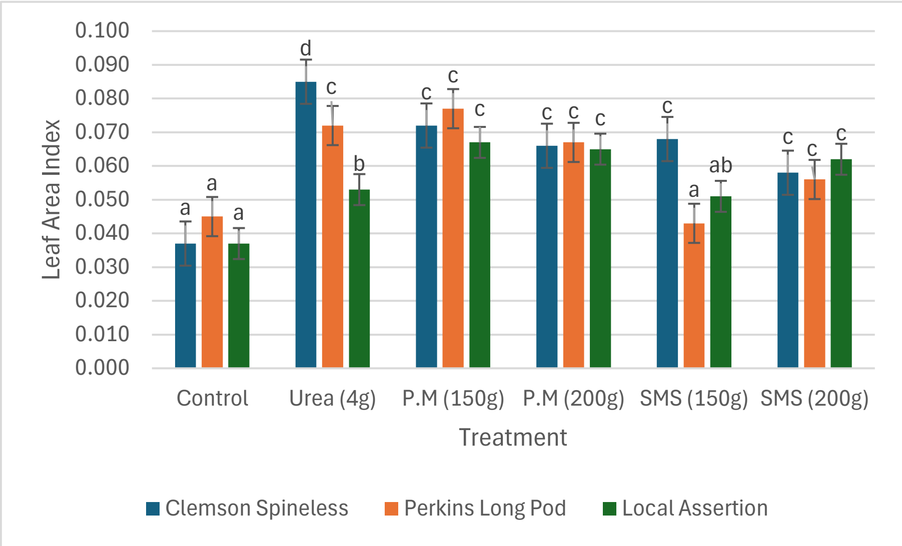
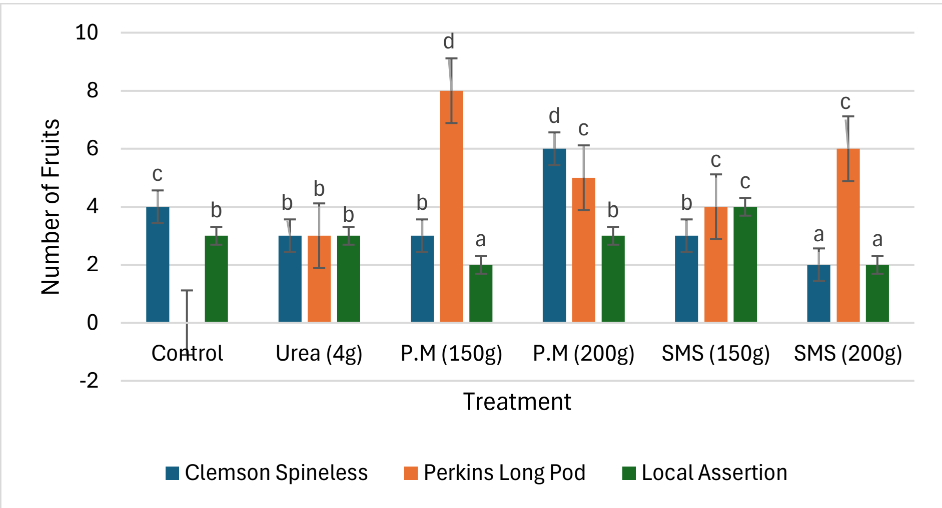
Figure 3: Effect of Nitrogen Source on Leaf Area

and spent mushroom substrate 150g (4.0). The least number of fruits was found in urea 4g (3) and the control did not produce any fruit. The Clemson Spineless variety generally had the second highest number of fruits for the application of poultry manure 200g (6.0), followed by the control (4.0). The application of poultry manure 150g, spent mushroom substrate 150g, and urea 4g had the same number of fruits (3.0), and the least number of fruits was recorded in spent mushroom substrate 200g (2.0). The highest number of fruits for the local assertion was found in spent mushroom substrate 150g (4.0), followed by poultry manure 200g (3.0), urea 4g (3.0), and the control (3.0). The least was observed in spent mushroom substrate 200g and poultry manure 150g, with an average of 2.0 fruits each.



*Note: *P.M Poultry Manure *SMS – Spent Mushroom Substrate *Means of each bar followed by the same letters are not significantly different at the LSD P ≤0.05 probability level within cultivars and across treatments.*

Figure 4: Effect of Nitrogen Source on the Leaf Area Index



*Note: *P.M Poultry Manure *SMS – Spent Mushroom Substrate *Means of each bar followed by the same letters are not significantly different at the LSD P ≤0.05 probability level within cultivars and across treatments.*

Figure 5: Effect of Nitrogen Source on the Number of Fruits/ Plants

Fresh Weight of Fruits

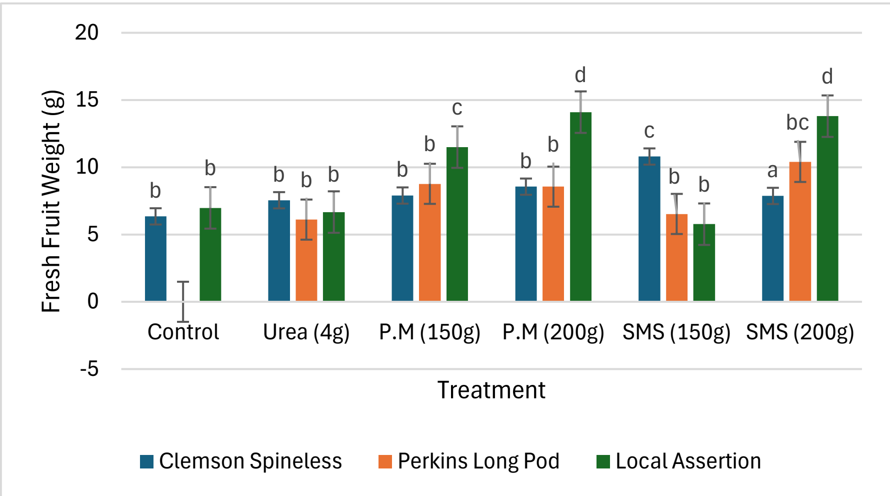
The effects of urea, poultry manure, and spent mushroom substrate on the average fresh weight of fruits are shown in **Figure 6**. The local assertion had the heaviest fruits (14.13g) when compared with the Clemson Spineless (10.79g) and Perkins Long Pod varieties (10.44g). In the control treatment, the local assertion produced heavier fruits (6.98g), followed by Clemson Spineless (6.35g), and although a noticeable difference existed between them, such a difference was not significant. For the urea 4g treatment, Clemson Spineless had the heavier pods (7.55g), followed by the local assertion (6.85g) and the Perkins Long Pod variety (6.11g). However, when poultry manure was increased from 150g to 200g, there were significant increases in the fruit weights for the Clemson Spineless cultivar (7.90g to 8.56g) and the local assertion (11.49g to 14.13g), but a decrease in pod weight for the Perkins Long Pod cultivar (8.77g to 8.58g). But when spent mushroom substrate was increased from 150g to 200g, the fresh weight of fruits for the Clemson Spineless variety decreased (10.79g to 7.87g) while those of the Perkins Long Pod cultivar and the local cultivar increased significantly (6.53g to 10.44g and 5.77g to 13.81g, respectively).

Fruit Length

The effects of urea, poultry manure, and spent mushroom substrate on the fruit length of the okra varieties are presented in **Figure 7**. A significant cultivar effect was observed in the fruit length. Generally, the Perkins Long Pod variety produced longer fruits in all the treatments, followed by the Clemson Spineless cultivar, and the local variety had the least, except in the control where the Perkins Long Pod cultivar had no fruits. In the control treatment, the local assertion had the highest fruit length (5.63cm) compared to the Clemson Spineless variety (5.13cm).

Fruit Diameter

The results presented in **Figure 8** reveal that the local assertion had the highest fruit diameter (8.00cm) recorded in spent mushroom substrate 200g and the least for the local assertion was found in urea 4g (4.10cm). The Clemson Spineless cultivar had the second highest fruit diameter (6.25cm) found in spent mushroom substrate 200g and the least for this cultivar was found in the control (4.20cm). The Perkins Long Pod variety generally had the smallest fruit diameters overall with its widest in spent mushroom substrate 200g (5.97cm) and its least in urea 4g (4.33cm).



*Note: *P.M Poultry Manure *SMS – Spent Mushroom Substrate *Means of each bar followed by the same letters are not significantly different at the LSD P ≤0.05 probability level within cultivars and across treatments.*

Figure 6: Effect of Nitrogen Source on the Fresh Weight of Fruits

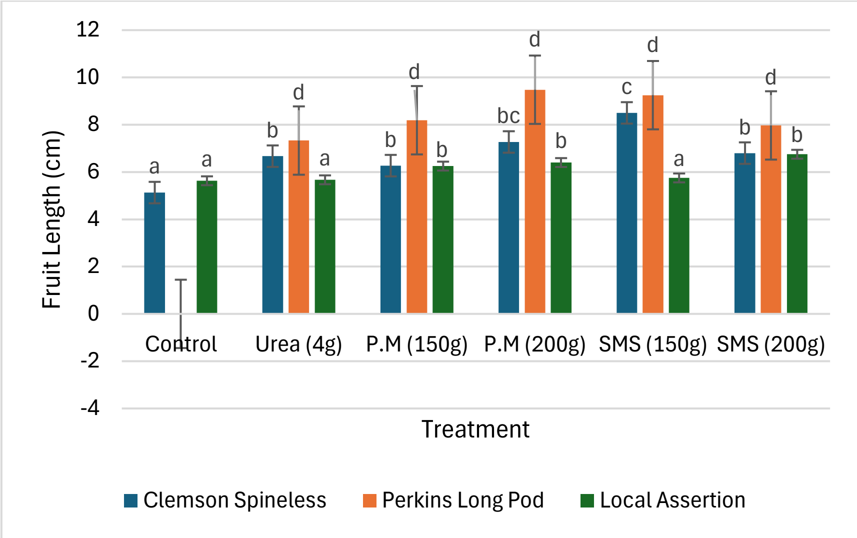


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Figure 7: Effect of Nitrogen Source on Fruit Length

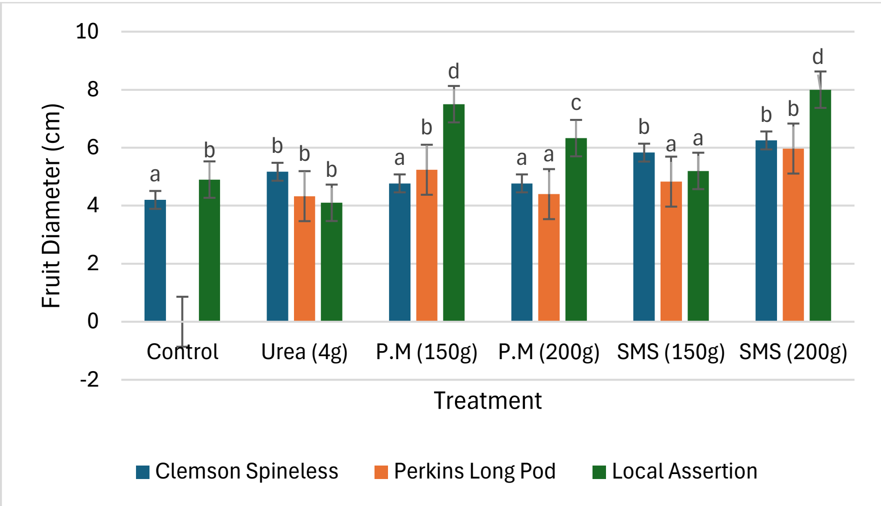

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Figure 8: Effect of Nitrogen Source on Fruit Diameter

Fruit Yield

The results presented in **Figure 9** show the effects of urea, poultry manure, and spent mushroom substrate on the fruit yield of the okra varieties. At 10 weeks after planting, the maximum fruit yield of 967.8 kg ha^{-1} was recorded in the local assertion for poultry manure 200g, followed by spent mushroom substrate 200g (945.9 kg ha^{-1}), poultry manure 150g (786.9 kg ha^{-1}), the control (478.1 kg ha^{-1}), urea 4g (469.2 kg ha^{-1}), and the lowest yield was in spent mushroom substrate 150g (395.2kg ha^{-1}). In the Clemson Spineless variety, the highest fruit yield was observed in the application of spent mushroom substrate 150g with a yield of 739.1 kg ha^{-1}, followed by poultry manure 200g (586.3 kg ha^{-1}), poultry manure 150g (541.1 kg ha^{-1}), spent mushroom substrate 200g (539 kg ha^{-1}),

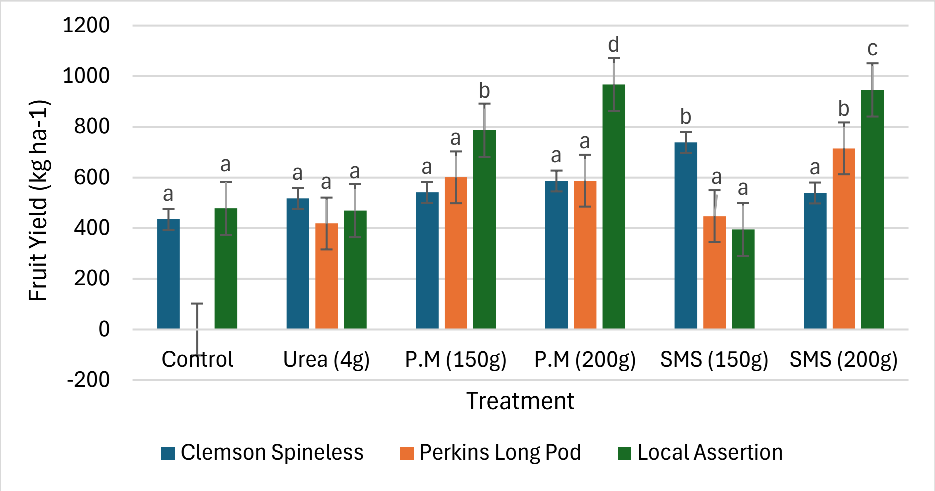

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Figure 9: Effect of Nitrogen Source on Fruit Yield

urea 4g (517.1 kg ha^{-1}), and the least was found in the control (434.9 kg ha^{-1}). The application of spent mushroom substrate 200g had the maximum yield of 715.1 kg ha^{-1} for the Perkins Long Pod variety, followed by poultry manure 150g (600.7 kg ha^{-1}), poultry manure 200g (587.7 kg ha^{-1}), spent mushroom substrate 150g (447.3 kg ha^{-1}), and the lowest yield was recorded in urea 4g (414.8 kg ha^{-1}).

Discussion

The growth and yield disparities observed among the various okra varieties could be attributed to the inherent genetic differences among them. Each distinct variety tends to demonstrate a unique response to varying rainfall levels. The significant differences noted in some of the growth and yield parameters of the okra varieties across treatments were likely influenced by a combination of genetic predisposition and environmental factors. Furthermore, differing rates of nutrient absorption and utilization of the three varieties across treatments could also contribute to increases in the growth and yield of the okra plants (Matthew & Toyin, 2023).

The application of urea 4g had a significant effect on the number of leaves, leaf area, and leaf area index when compared to the other treatments. For the Perkins Long Pod variety and the local assertion, urea 4g resulted in the maximum number of leaves (9.3 and 7.7, respectively), while the minimum number of leaves was found in the Clemson Spineless variety (6.5). This could be due to the high nitrogen content (46%) in urea. Nitrogen is an important element in photosynthesis and helps in the production of greener leaves. The application of urea also had the highest leaf areas of 123.7 cm^2 in the Clemson Spineless variety, 104.8 cm^2 for the Perkins Long Pod variety, and 77.3 cm^2 for the local assertion. It also influenced the leaf area index, having the highest value of 0.085 for the Clemson Spineless variety. The leaf area index measures the photosynthetic active area of a plant and indicates how much light is trapped by the plant. This explains why urea had the highest effect on the leaf area index values. According to Piao *et al*. (2019), nitrogen plays a robust role in stimulating growth by facilitating the expansion of the crop canopy and improving the capture of solar radiation. This outcome is consistent with the findings of Adekiya *et al*. (2018), who observed that the application of urea fertilizer at a rate of 120 kg ha^{-1} led to optimal growth and balanced mineral composition in okra.

The utilization of poultry manure resulted in the highest measurements across several parameters, namely plant height, fruit count, average fruit weight, fruit length, and fresh fruit yield per hectare. It is noteworthy that the applications of 150 g plant^{-1} and 200 g plant^{-1} of poultry manure yielded significant increases in plant growth and yield. These results are consistent with the findings of Onwu *et al.* (2014) and Tswanya *et al.* (2017), who established that poultry manure contributes to increased yield and yield components in okra cultivation. However, the effects of poultry manure varied among the different okra varieties, possibly due to their distinct responses. This variance could be attributed to the particular genetic makeup of each variety and the beneficial impact of manure on augmenting soil levels of essential nutrients like nitrogen, phosphorus, and potassium. This, in turn, enhanced the overall growth and developmental processes of the plants (Mubarak, 2014). Furthermore, poultry manure notably positively influenced the leaf area of the okra plants, with the Perkins Long Pod variety (113.07 cm²) and the local assertion variety (96.55 cm²) recording the highest leaf areas. This observation aligns with the findings of Uka *et al.* (2013), who noted that the application of poultry manure led to the production of the largest leaf areas. Also, the pronounced response in fruit yield (kg ha^{-1}) can be attributed to the homogeneity of the pot environment and the facilitative effect of poultry manure on the solubilization of plant nutrients thereby leading to an elevated nutrient uptake by the plants. This finding harmonizes with those of Amhakhian & Isaac (2016), who noted a significant increase in growth as well as enhanced yield and yield components in okra as a result of poultry manure application compared to other organic manures. Similar outcomes were achieved by Ezeibekwe *et al.* (2009), who observed the highest levels of flowering, fruiting, and fruit biomass in response to poultry manure.

Spent mushroom substrate 200g recorded the highest plant heights in the Clemson Spineless variety and the local assertion (42.5cm and 44.77cm, respectively). Spent mushroom substrate 150g also positively influenced the number of leaves of the Clemson Spineless variety, where it had values not significantly different from those of poultry manure 200g, poultry manure 150g, and urea 4g. Regarding the yield components of the okra plants, spent mushroom substrate 150g recorded the highest number of fruits in the local assertion and the highest fruit length in the Clemson Spineless variety. Spent mushroom substrate 200g positively influenced the fresh fruit yield as well as the fruit diameter, having the largest diameters for all three cultivars compared to the other fertilizers used. This finding aligns with the observations made by Ojobor *et al.* (2014) and Dada *et al.* (2014), who asserted that the introduction of organic manure into the soil brings about enhancements in both the growth and yield attributes of cultivated crops. Furthermore, these applications of organic manure contributed to improvements in the physical and chemical characteristics of the soil.

The Perkins Long Pod variety exhibited greater height, longer pods, and quicker onsets of germination and flowering compared to the Clemson Spineless and local assertion varieties. However, the Clemson Spineless variety demonstrated a similar yet superior growth rate in comparison to the local assertion variety. These findings align with the conclusions drawn by Reddy *et al.* (2012), who highlighted variances in growth and crop yield attributed to the distinct genetic compositions and cultivar differences within the okra plant population. It's worth noting that the genetic makeup of okra plays a predominant role in determining plant height (AdeOluwa & Kehinde, 2011). Mukhtar *et al.* (2014) documented that genetic factors significantly enhance growth parameters in plants, as evident from the variations observed among different cultivars. Similarly, Mkhabela *et al.* (2022) emphasized the role of the genetic makeup in accounting for differences in growth parameters among okra plants.

Conclusions

The outcomes derived from this experiment highlight the positive influence of applying both organic manure sources (poultry manure and spent mushroom substrate) on the growth and yield of the okra varieties (Clemson Spineless, Perkins Long Pod, and a local assertion). Notably, the results indicated a more favorable response to the organic manure (poultry manure) compared to urea and the control treatments. Furthermore, the Perkins Long Pod okra variety demonstrated the most promising growth and yield outcomes. In a broader sense, the control pots exhibited a relatively lower performance when contrasted with the other treatments, except in the instances of plant height and fruit count, where it fared better than the urea treatment.

Based on our research outcomes, we strongly suggest integrating organic manure into crop cultivation practices. Poultry manure stands out as the most advantageous and preferred option among all organic manures. It was not only shown to be highly effective but also holds the advantage of being easily accessible and economically viable. In comparison, obtaining spent mushroom substrate necessitates access to mushroom cultivation farms, making it a less accessible choice for many farmers. Therefore, considering its availability and cost-effectiveness, poultry manure emerged as the prime recommendation for farmers. Based on our study findings, the optimal application rate of poultry manure is suggested at 10 tons per hectare. Furthermore, the Perkins Long Pod variety of okra is notably endorsed as the most suitable cultivar.

Acknowledgments

We would like to express our deepest gratitude to the faculty and staff of the University of Port Harcourt Teaching and Research Farm and others who contributed to the successful completion of this study.

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