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RESEARCH ARTICLE

# Effect of Fertilization on Economic Production of Okra (*Abelmoschus esculentus* (L) Moench) in Uyo, Southeastern Nigeria

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## ABSTRACT

The present study examined how fertilizer affects okra's economic productivity. The experiment was replicated three times using a randomized complete block design (RCBD). The treatments included two rates of inorganic fertilizers (100kg/ha NPK and 200kg/ha NPK), three rates of organic fertilizers (poultry manure-Pm) (5, 7.5, and 10 t/ha), and one control (no fertilizer). Analysis of variance was performed using collected data. At 5% probability, significant means were compared with the least significant difference. Results demonstrated significant okra growth and production differences. In both cropping seasons, 10 t/ha Pm increased okra fruit yield to 15.15 and 15.20 t/ha and fruit number to 22.94 and 22.85. In the 2021 and 2022 cropping seasons, 7.5t/ha of Poultry manure (PM) yielded 14.81 and 14.91 t/ha fruits, whereas 200kg/ha yielded 12.98 and 13.40 t/ha. The control treatment produced the lowest fruit yield, 3.55 and 3.54 t/ha in both cropping seasons. The treatment of 7.5t/ha PM had the highest economic returns to management; N 1,068,350 and N 1,273,700 with a cost-benefit ratio of 3.09 and 3.47, respectively while the least; N 26,550 and N 65,000 with 0.09 and 0.2 cost-benefit ratio, respectively was recorded in the control treatment. Treatment of 7.5t/ha was recommended for higher yield and economic production of okra in Uyo, southeastern Nigeria.

***Keywords:*** okra, fertilizer, and fruit yield and economic return

## INTRODUCTION

The fruit vegetable okra [*Abelmoschus esculentus* (L.) Moench] is grown for immature fruits and fresh young leaves. The fresh fruits' mucilaginous property makes okra essential (Ikeh et al., 2013). This is a foremost Nigerian fruit vegetable crop. Okra is vital to household income, early maturation of most types, and high nutritional value. Therefore, Nigeria and other West African countries grow and produce it (Ekunwe et al., 2017). Okra has fiber, vitamin C, vitamin B9, and antioxidants. When grain crops are scarce in impoverished nations, its edible fruit provides protein, vitamins, and minerals (Kota et al., 2022).

In Nigeria, especially in southern Nigeria, soil deterioration is widespread due to continual farming, population growth, and static land availability. A recent study has focused on organic manure fertilizer. Organic manure improves soil fertility and numerous qualities, according to Adeniyan and Ojeniyi (2003). Essien et al. (2018) found that organic manure increases all green vegetable development metrics. Animal manure offers all macro and micronutrients in accessible forms, increasing soil's physical and biological qualities (Ikeh et al., 2012a). Madukwe et al. (2008) found that organic manure, especially poultry manure, boosted cowpea nodules and yield and amended deteriorated soils.

More understanding of sustainable okra production with fertilizers in an ultisol of southeastern Nigeria impedes soil fertility development and okra productivity. Sustainable agricultural production requires soil fertility management in the humid tropics. If soil erosion is controlled and organic matter, physical, and nutritional characteristics are preserved, tropical soils under continuous cultivation can be economically productive.

Due to urbanization and population increase, most soils in Akwa Ibom are acidic, cultivated, and have limited fallow periods. Burning, erosion, and poor organic matter soil also deplete N. Due to nitrogen depletion, okra yields can only be increased with fertilizers. Man's creation of inorganic fertilizer has increased soil productivity beyond short or no fallow. Many farmers apply organic and inorganic fertilizers at varied rates to improve soil for a bumper harvest. Municipal trash and nitrogen fertilizer increased okra growth and output, according to Ikeh et al. (2013), despite rising demand for okra in Nigeria and low stallholder okra yield. Do farmers need to think that okra production can generate adequate income? Or is okra production unprofitable? Okra cultivation, marketing, processing, and use have been studied in many Nigerian regions (Ngbede et al., 2012; Nwaobiala and Ogbonna, 2014: Law-Ogbomo et al., 2013). However, nothing is known about Okra's fertilizer-responsive economic productivity in Uyo, southern Nigeria. Okra growers need cost-effective fertilizer rates to maximize profits.

## MATERIALS AND METHODS

### *Experimental site and cropping history*

In 2021 and 2022, the experiment was conducted in the University of Uyo Teaching and Research Farm, Akwa Ibom State, Nigeria. Uyo is situated between latitudes $4^0 30^0$ and $5^0 27^0$N and longitudes $7^0 50^0$E and $80^0 20^0$E. This humid tropical rainforest zone in southeastern Nigeria with 2,500 mm of annual rainfall, 314 hours of monthly sunshine, and 28ºC mean annual temperature. Uyo evaporates 2.6 $cm^2$ and has 79% yearly relative humidity. Rainfall in Uyo is bimodal. It rains from March to November, with a brief period of relative moisture stress in August called "August Break" (Peters et al., 1989). In February–April, temperatures are high (Enwezor et al., 1990). Fluted pumpkin, water leaf, and maize were grown on the experimental site before it was followed for a year.

### *Land Preparation*

This site was cleaned manually with machetes. After outlining the field with tape, rope, and pegs for spacing, spades built 3m x 2m seedbeds. 1 m pathways separated seedbeds.

### *Soil sampling and analysis*

Before planting, soil augers collected composite soil samples at 0-30 cm depths. The soil samples were labeled and sealed in plastic bags before analysis in the lab. The soil samples were air-dried, crushed, sieved through a 2.0 mm mesh, labeled, and stored for physicochemical examination in the lab. Also, poultry manure was collected from the University of Uyo Department of Animal Science poultry unit in Uyo, Akwa Ibom State. Chemical characteristics were analyzed in the University of Uyo Soil and Crop Laboratory in Akwa Ibom, Nigeria.

### *Experimental plot size, design, and treatments*

The 40m × 20m experiment plot was fully utilized. Every plot size was 5m x 5m. Each plot and block were one metre apart. The experiment was conducted three or two times using a Randomized Complete Block Design (RCBD). The treatments included two rates of inorganic fertilizers (100 kg/ha NPK and 200 kg/ha NPK), three rates of organic fertilizers (Poultry Manure-PM) (5, 7.5, and 10 t/ha), and one control (no fertilizer).

### *Source of experimental materials*

The experiment employed Okra variety-TAE-38 from the National Horticultural Research Institute (NIHORT) sub-station in Mbato Okigwe, Imo state, Nigeria.

### *Agronomic Practices*

The 4th week of March in 2021 and 2022 planting was done. Three 60 cm × 60 cm seeds were drilled and trimmed two to three weeks later. Manual weeding with a native hoe was done twice at 3 and 7 WAP. Seedbed preparation two weeks before sowing included poultry manure as organic fertilizer. The treatment foundation was inorganic fertilizer (N.P.K-15:15:15) which was applied at 3 WAP. The application method was rung.

### *Data collection and analysis*

Growth, yield, and yield factors were evaluated: Counting the branches on each plant yielded the information needed to calculate the number of branches per plant. The number of completely formed leaves on each plant was counted to determine the number of leaves per plant. Fresh fruit yield per plant: By counting the number of tubers on each plant, the total quantity of fresh tubers was calculated. Yield of fresh fruit (t/ha): The weight per plot was measured using a weighing scale, and the result was converted to tons per hectare. Analysis of Variance (ANOVA) was performed on all of the collected growth and yield data, and treatment means that indicated significance at the 5% level of probability were divided using the Least Significant Difference (LSD) test.

## RESULTS

The 2021 and 2022 cropping seasons indicated acidic soil with pH values of 5.30 and 5.20, respectively (Table 1). Organic matter was low in the 2021 and 2022 farming seasons, 1.58 and 1.32 %. High P (mg/kg) was 56.71 and 59.40. Ca, Mg, Na, and K exchangeable bases were low (**Table 1**). The particle size study showed 85.30 % and 86.70 % sand in 2021 and 2022, 8.80 % and 8.10 % clay, and 5.90 % and 5.20% silt. The particle size analysis showed loamy sand during the experiment.

Fertilizer administration significantly affected leaves per plant (P<0.05) at 3, 6, and 9 weeks post-planting (WAP) in both cropping seasons (**Table 2**). In the 2021 cropping season, 10 t/ha PM treatment increased leaves per plant by 6.90, 22.59, and 43.59 at 3, 6, and 9 weeks after planting (WAP). The 2022 cropping season had 6.87, 21.35, and 41.33 leaves per plant in 10t/ha PM treatment. In 2021 and 2022, 7.5t/ha PM treatment at 9 WAP had 40.20 and 39.90 leaves per plant.

In the 2021 and 2022 cropping seasons, 200 kg/ha NPK treatment at 9 WAP generated 27.42, 34.22, and 33.83 leaves per plant. The control treatment had the fewest leaves per plant (3.41, 6.50, 8.11 in 2021 and 6.50, 6.45, 8.90 in 2022).

The influence of fertilizer application on number of branches per plant varied considerably (P<0.05) at 3, 6, and 9 WAP in both cropping seasons (**Table 3**). Increased fertilizer rate increased the number of branches per plant in both types. The control treatment had the fewest branches, while 10t/ha Pm had the most. In 2021, 10t/ha Pm had the most branches per plant: 3.51, 17.71, and 24.99 at 3, 6, and 9 WAP. In 2022, 10t/ha PM treatment had 3.71, 19.38, and 25.33 number of branches per plant at 3, 6, and 9 WAP. Treatment of 7.5 t/ha Pm had 23.40 and 23.56 branches per plant at 9 WAP in 2021 and 2022. Control had the fewest number of branches per plant.

Table 4 shows fertilization-induced fruit production. The results indicated substantial differences (p<0.05) among treatments. 10 t/ha Pm increased fresh fruit production per plant to 22.94 and 22.85 in 2021 and 2022. In 2021 and 2022, 7.5 t/ha Pm produced 20.41 and 21.11 fresh fruits per plant. The 200kg/ha NPK treatment yielded 12.22 and 13.54 fresh fruits. 3.13 and 3.25 fruits per plant were the lowest in the control treatment.

The 2021 and 2022 agricultural seasons yielded 15.05 and 15.10 t/ha of fruit from 10t/ha Pm fertilizer, and it was followed by 14.81 and 14.91 t/ha in 7.5t/ha Pm treatment. In both cropping seasons, 200kg/ha NPK generated 12.98 and 13.40 t/ha, while 100kg/ha produced 10.40 and 9.91. The control treatment yielded the least fresh fruit, 3.55 and 3.54 t/ha in 2021 and 2022.

Table 5 shows how fertilizer affects production costs. The 200kg/ha NPK treatment cost the most, N 430,700 and N 448,400, in the 2021 and 2022 agricultural seasons and it was followed by N 390,700 and N 406,400 in 100 kg/ha NPK treatment. Production cost for 10t/ha Pm treatment was N 360,700 and N 379,400 in 2021 and 2022. In both cropping seasons, the control treatment had the lowest production costs, N337, 250 and N324, 400.

Gross revenue from okra as influenced by fertilizer application is shown in Table 5. The highest gross revenue, N 1,429,750 and N1661000 was recorded in the treatment of 10 t/ha Pm. This was followed by N 1,406,950 and N 1640100 recorded in the treatment of 7.5t/ha Pm in both cropping seasons. The gross revenue in 200kg/ha was N 1,233,100 and 1,403,600 in both cropping seasons. The least gross revenue in both cropping seasons, N

318,250 and N 389, 400 were recorded in the control treatment.

The effect of fertilizer application on net return to okra farmers is presented in Table 5. The highest net revenue was observed in the treatment of 7.5t/ha Pm, 1,068,350, and 1,273,700 in the 2021 and 2022 cropping seasons and it was followed by N 1,064,500 and N 1,271,600, respectively, recorded in the treatment of 10 t/ha Pm. Treatment of 7.5t/ha Pm had the highest cost-benefit ratio of 3.09 and 3.47, meaning every N1 input will increase N3.09 in 2021 and 3.47 in 2022.

**Table 1.** Soil physicochemical properties of the experimental site before planting

| Soil Parameter | 2021 | 2022 |
|---|---|---|
| Soil pH | 5.30 | 5.20 |
| Ec (ds/m) | 0.112 | 0.110 |
| Organic matter (%) | 1.58 | 1.32 |
| Total Nitrogen (%) | 0.06 | 0.06 |
| Available P (mg/kg) | 56.71 | 59.40 |
| Exchangeable Base (cmol/kg) | | |
| Ca | 2.10 | 2.03 |
| Mg | 1.33 | 1.14 |
| Na | 0.04 | 0.06 |
| K | 0.08 | 0.24 |
| Particle Size (%) | | |
| Sand | 85.30 | 86.70 |
| Silt | 5.90 | 5.20 |
| Clay | 8.80 | 8.10 |

**Table 2.** Number of leaves per plant as influenced by fertilizer application

| Treatment | 2021 | | | 2022 | | |
|---|---|---|---|---|---|---|
| | Weeks after Planting | | | Weeks after Planting | | |
| | 3 | 6 | 9 | 3 | 6 | 9 |
| 0 | 3.41 | 6.50 | 8.77 | 3.50 | 6.45 | 8.90 |
| 100kg/ha NPK | 3.44 | 12.48 | 20.56 | 3.50 | 12.59 | 21.43 |
| 200kg/ha NPK | 3.43 | 14.75 | 34.42 | 3.55 | 14.88 | 33.83 |
| 5t/ha Poultry Manure (PM) | 6.17 | 19.42 | 28.81 | 6.33 | 20.03 | 27.22 |
| 7.5t/ha PM | 6.60 | 20.30 | 40.20 | 6.79 | 20.41 | 39.90 |
| 10t/ha PM | 6.90 | 22.59 | 43.59 | 6.87 | 21.35 | 41.33 |
| LSD(P<0.05) | 1.95 | 2.67 | 2.78 | 1.84 | 2.51 | 2.92 |

**Table 3.** Number of branches per plant as influenced by fertilizer application

| Treatment | 2021 | | | 2022 | | |
|---|---|---|---|---|---|---|
| | Weeks after Planting | | | Weeks after Planting | | |
| | 3 | 6 | 9 | 3 | 6 | 9 |
| 0 | 0.00 | 1.14 | 5.32 | 0.00 | 1.33 | 5.56 |
| 100kg/ha NPK | 0.15 | 5.77 | 10.81 | 0.11 | 6.60 | 11.23 |
| 200kg/ha NPK | 0.41 | 6.14 | 15.19 | 0.20 | 8.18 | 15.71 |
| 5t/ha Poultry Manure (PM) | 2.32 | 10.71 | 18.33 | 2.17 | 10.20 | 19.01 |
| 7.5t/ha PM | 2.48 | 12.80 | 23.40 | 2.33 | 11.93 | 23.56 |
| 10t/ha PM | 3.51 | 17.71 | 24.99 | 3.71 | 19.38 | 25.33 |
| LSD(P<0.05) | 1.33 | 2.55 | 3.41 | 1.52 | 2.61 | 3.72 |

**Table 4.** Yield and yield component of okra as influenced by fertilizer application

| Treatment | 2021 | | 2022 | |
|---|---|---|---|---|
| | Number of Fruits/Plant | Fresh Fruit Yield (t/ha) | Number of Fruits/Plant | Fresh Fruit Yield (t/ha) |
| 0 | 3.13 | 3.35 | 3.25 | 3.54 |
| 100 kg/ha NPK | 10.41 | 10.40 | 10.39 | 9.91 |
| 200 kg/ha NPK | 12.22 | 12.98 | 13.54 | 13.40 |
| 5 t/ha Poultry Manure (PM) | 14.71 | 12.70 | 14.60 | 12.76 |
| 7.5 t/ha PM | 20.41 | 14.81 | 21.11 | 14.91 |
| 10 t/ha PM | 22.94 | 15.15 | 22.85 | 15.20 |
| LSD (P<0.05) | 3.23 | 2.45 | 3.18 | 2.55 |

**Table 5.** Cost of production and economic returns to management as influenced by fertilizer application

| Cost of Farm Operations | 2021 Fertilizer rates | | | | | | 2022 Fertilizers rates | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 100 | 200 | 5 | 7.5 | 10 | 0 | 100 | 200 | 5 | 7.5 | 10 |
| Bush clearing | 115,700 | 115,700 | 115,700 | 115,700 | 115,700 | 115,700 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 |
| Tillage | 83,000 | 83,000 | 83,000 | 83,000 | 83,000 | 83,000 | 86,900 | 86,900 | 86,900 | 86,900 | 86,900 | 86,900 |
| Soil Analysis | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| Planting Material | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 |
| Fertilizer/ Application | - | 80,000 | 120,000 | 25,000 | 35,500 | 55,000 | - | 82,000 | 124,000 | 28,000 | 42,000 | 65,000 |
| Weeding | 81,000 | 81,000 | 81,000 | 81,000 | 81,000 | 81,000 | 85,500 | 85,500 | 85,500 | 85,500 | 85,500 | 85,500 |
| Miscellaneous | 10,500 | 10,500 | 10,500 | 10,500 | 10,500 | 10,500 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 |
| TCP | 310,700 | 390,700 | 430,700 | 335,700 | 346,200 | 365,700 | 324,400 | 406,400 | 448,400 | 352,400 | 366,400 | 389,400 |
| Pod Yield (t/ha) | 3.55 | 10.40 | 12.98 | 12.70 | 14.89 | 15.05 | 3.54 | 9.91 | 13.40 | 12.76 | 14.91 | 15.10 |
| Gross Revenue | 337,250 | 988,000 | 1,233,100 | 1,206,500 | 1,414,550 | 1,429,750 | 389,400 | 1090100 | 1474000 | 1403600 | 1640100 | 1661000 |
| Net Revenue | 26550 | 597,300 | 802,400 | 870,800 | 1,068,350 | 1064050 | 65000 | 683,700 | 1025600 | 1051200 | 1273700 | 1271600 |
| Cost/ Benefit Ratio | 0.09 | 1.53 | 1.86 | 2.59 | 3.09 | 2.91 | 0.2 | 1.68 | 2.29 | 2.98 | 3.47 | 3.27 |

* Miscellaneous: Cost of transportation and insect pest control.  Based on the prevailing market price of okro at the farm gate in 2021 and 2022. The cost of a ton of okro was N95,000 in 2021 while the cost of a ton was 110,000 in 2022.

## DISCUSSION

Experimental fertility was poor in organic matter, total nitrogen, and exchangeable bases. The experimental site's low fertility may be due to extensive land usage without effective soil management and conservation. Organic fertilizer was needed to boost soil fertility. The results showed that organic and mineral fertilizers at varying rates released nutrients for okra growth and yield. The fertilizers improved the soil's physical and chemical qualities, which increased okra growth and yield compared to the control treatment. Fertilizers may have improved okra growth and yield by increasing soil fertility due to low inorganic matter and total nitrogen concentration. The growth of leaves, branches, fruits, and fruit yield following fertilizer application showed the need for soil amendment. Organic chicken manure boosts cucumber output, growth, and yield (Idem et al., 2012).

The number of leaves and branches per plant increased significantly in this study. Both organic manure and artificial fertilizer supported okra growth and output. These results were supported by Ikeh et al. (2013) observed that organic and inorganic fertilizers boost okra growth and yield. Applying organic and inorganic fertilizers to okra may boost carbon utilization and assimilate synthesis. The significant response of okra parameters to fertilizers may indicate that the plant used the nutrient well in cell multiplication, amino acid synthesis, and energy creation, increasing photosynthesis. The sinks (pods and developing buds) received photosynthetic products. In agreement with Ikeh et al. (2013), okra responded significantly to fertilizer. Poultry manure (7.5 and 10 t/ha) treatments had significantly different growth parameters than inorganic fertilizer rates (100 and 200kg/ha NPK) and this may indicate that decomposing poultry manure increases macro and micronutrients and soil chemical properties. Okra grown on poultry manure outperformed mineral fertilizer in vegetative growth, yield, and yield components. Earlier studies reported that cucumber production of organic manure, specifically poultry manure, increased crop vegetative development more than other manures (Ikeh et al., 2012). However, Ikeh et al. (2023) reported that treatments with integrated fertilizers had lower soil pH, significantly higher total N, organic matter, and exchangeable bases at harvest for cassava yield in Utisol.

All fertilizer treatments outperformed the control in growth and yield, which could mean that all organic and inorganic fertilizer nutrients turned into okra's vegetative development, yield, and yield components. Higher doses of poultry manure may promote okra growth and output due to facile solubilization of released plant nutrients, improving soil nutritional status and water holding capacity. The results supported Ndaeyo et al. (2013) in waterleaf (*Talinum triangulare*) and Ikeh et al. (2013) in okra (*A. esculentus*) that organic manure application increased crop yield due to soil chemical properties and water holding capacity, which improved plant nutrient supply.

The result showed that the treatment cost of production and economic returns to management vary. Control had the lowest cost of production due to no fertilizer and its application, whereas 200kg/ha NPK had the greatest cost due to its high fertilizer cost compared to poultry manure treatments. The largest economic returns in 7.5t/ha Pm were due to better fruit yield and lower organic fertilizer costs.

## CONCLUSION

Based on research findings, fertilizer use enhanced okra growth and yield in Uyo, southeast Nigeria. Although the yield was not substantially different from the fruit yield obtained from the treatment of 7.5 t/h Pm, organic fertilizer at 10t/ha produced the maximum fruit yield. Okra producers were instructed to treat 7.5 t/ha of poultry manure for high okra yield and economic returns to management since this treatment offered the highest economic return to management.

## DISCLOSURE STATEMENT

The author declares no competing interests

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