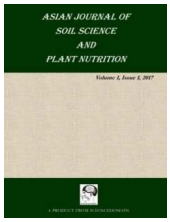

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# Effect of Time and Rate of Application of Poultry Manure on the Growth and Yield of Okra (*Abelmoschus esculentus* (L) Moench) in the Cross River Rain Forest Area, Nigeria

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author JDN designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Author JOS managed the analyses of the study. Author EDO managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** The aim of the experiment was to evaluate the effects of time and rate of application of poultry manure (PM) on the performance of an early maturity okra (*Abelmoschus esculentus* (L.) Moench) variety 'Clemson spineless *VGTH-014K*.
**Study Design:** The experimental design was the randomized complete block design (RCBD) with three replications.
**Place and Duration of the Study:** The field experiment was conducted the University of Calabar Teaching and Research Farm from June to September, 2016.
**Methodology:** The treatments consisted of 5 and 10 PM t/ha incorporated each into the soil at 1 and 2 weeks before planting, at planting, 2 weeks after planting, and zero poultry manure (0 t PM /ha) served as the control to give a total of 9 experimental units.
**Results:** The results obtained indicated that application of poultry manure at different times significantly ($P \leq 0.05$) influenced the vegetative and fruit yield parameters okra evaluated.

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Statistically, 10 t of PM/ha had the best effect on okra performance irrespective of the time of application. However, early application at two weeks before planting produced the tallest plants (39.70 cm), highest number of leaves (22.67) and branches (9.67) per plant and highest leaf area index value (44.96). Also the highest fresh (1.43 t/ha) and dry pod yield (0.55 t/ha) as well as highest dry seed yield of 308 kg/ha were obtained in this treatment.
**Conclusion:** PM rates incorporated before planting were more effective than the corresponding rates applied at other periods. The optimum performance of okra was obtained at 10 t PM/ha and could be recommended for enhanced productivity of the crop in the study area.

*Keywords: Food security; humid areas; poultry manure; time of application; VGTH-014K.*

## 1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) also known as ladies's fingers, is an annual herbaceous vegetable cultivated throughout the tropical, sub-tropical and warm temperate regions of the world [1,2]. It is considered one of the most versatile crops with multiple health benefits [3] and high industrial potential for high quality edible oil [4] and biofuel production [5,6]. The crop is valued for its nutritious edible green seed pods which produce a mucilaginous 'drawing' mash much cherished for soup [7]. Okra is usually grown in compound gardens and smallholder plots in Nigeria and is commonly found in almost all Nigerian markets throughout the year [8].

The demand for okra in the country is usually high especially in the dry season when most local leafy vegetables are in short supply. But the output is frequently far from satisfying the demand resulting in the high cost of the crop commonly experienced especially in urban centers. The low productivity of okra and other vegetables in Nigeria has been attributed to several factors including soil constraints such as poor fertility, soil acidity and nutrients imbalances [9, 10], posing a serious threat to food security in countries experiencing rapid population expansion such as Nigeria.

Chemical fertilizers are frequently used to rejuvenate and maintain soil fertility to boost farm productivity but long-term reliance on synthetic fertilizers jeopardizes the environment leading to unsustainable crop production [11]. Also the extent to which chemical farming can be depended on to increase farm output is constrained by the high cost and untimely availability of the right type of inorganic fertilizers as well as lack of technical skills and limited financial capacity of traditional farmers who dominate crop agriculture in Nigeria for their livelihood to purchase the fertilizers [12].

Organic agriculture which avoids or largely excludes the use agrochemicals offers a sustainable alternative farming system to minimize the evils of chemical farming. Organic soil fertility management utilizes the application of compost, manures, green manure and other organic amendments to replenish soil nutrients and enhance crop performance [13,14].

Animal manures are an excellent source of organic matter and soil nutrients and the utilization of organic manures in soil fertility management is an integral part of sustainable agriculture [15]. Organic matter in soil improves moisture and nutrient retention and soil physical properties [16]. Adding compost to garden soils improves soil structure, increases the population of beneficial microbes, increases soil moisture retention, reduces nutrient loss, boosts pH and can suppress certain diseases [17]. Organically fertilized crops have been shown to exhibit high resistance and tolerance to both biotic and abiotic stresses, and are also more nutritious and more palatable with longer shelf-life than those produced with synthetic inputs [17].

The quantity and time of applying manures are of critical importance in crop production. When properly applied, manures can be valuable resources for crop production [18]. The fertility quality of manures varies widely and the quantity to be applied depends on the nutrient content of the material. The okra plant has a sensitive balance between the vegetative growth and pod production. Too much nitrogen from excess manures can reduce the yield and quality of many vegetables. Application of manures like any fertilizer, can lead to nutrient leaching and pollution of groundwater and streams [17]. To maximize the economic and fertilizer value of organic manures, their application should match the nutrient needs of the crops. The objective of this trial was to determine the optimum rate and appropriate time of application of poultry manure for enhanced okra productivity in Calabar rainforest ecology.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The experiment was carried out at the Teaching and Research Farm of the Department of Crop Science University of Calabar, Calabar Metropolis located in the Cross River rainforest area between latitudes of 4° 45'30'' and 5° 08' 30'' N and longitudes 8° 11' 21'' and 8° 27' 00''with altitude o 32 m above sea level. The area receives an average annual rainfall of 2500 mm. The lengthy rainy season spanning nine months lasts from March/April to October/November with bimodal distribution in July and September. The mean maximum and minimum temperatures are 23 and 32℃ respectively, while the relative humidity ranges from 78% in the dry season to 92% in the rainy season [19,20].

### 2.2 Seedbed Preparation

The land was cleared manually with machete, fine tilled and seed beds of 3 m x 3 m made with the aid of a spade.

### 2.3 Treatments and Experimental Design

The experimental treatments tested were 2 x 3 factorial combinations of 5 and 10 t of poultry manure (PM)/ha and three periods of applications: at planting, two weeks before planting (WBP) and two weeks after planting (WAP), while zero poultry manure served as a control treatment. This gave seven treatments laid out in a randomized complete block design (RCBD) with three replications to give a total of 21 experimental units or plots.

### 2.4 Planting

Planting was done on 3rd of June 2016. The seeds of the Clemson spineless early okra variety 'VGTH-014K' (premier brand seeds) soaked in were warm water overnight and air-dried before planting to hasten germination .Three seeds were planted per hole at a depth of 2 – 3 cm and spaced 45 cm x 45 cm. Two weeks after emergence, the plants were thinned to one plant/stand giving 44 plants/plot (49,382 plants/ha) out of which the 8 plants in the net plot were used as sample plants.

### 2.5 Maintenance of Experimental Plots

Weeding was done manually at three weeks after planting using a hand-held hoe. Cross bunds were constructed and plot edges raised to control runoff and erosion within the gross experimental plot.

### 2.6 Harvesting

Harvesting of fresh fruits commenced 5 weeks after planting (WAP) and was done every 2 days up to 9 WAP after which the fruits were allowed to mature fully and dry on the plants to obtain the seed yield. The fully grown immature fruits were cut off neatly using a sharp razor. No pod was allowed to overmature in order not to reduce the harvest duration and future yield. The cumulative fresh fruit yield was determined at the end of fresh fruit harvest. The dry pods were harvested, weighed and shelled to determine the seed yield.

### 2.7 Data Collection and Analysis

Data on vegetative growth were collected at 5 WAP while the fruit yield parameters were taken on the sample plants during each harvest. The leaf area of each plant in the net plot was determined by graphical method. The area obtained was multiplied by the total number of leaves and this gave the total leaf area per plant. The leaf area index was then calculated by dividing the total leaf area per plot by the area of the plot.

Data collected were subjected to analysis of variance (ANOVA) and significant means were compared using Duncan New Multiple Range Test (DNMRT) at 5% probability level.

## 3. RESULTS AND DISCUSSION

### 3.1 Okra Plant Growth Parameters

The vegetative growth parameters of okra varied significantly ($P$ = .05) among the various treatments tested. Irrespective of the time of application before planting, poultry manure at 10 t/ha produced tallest plants, followed by those in plots applied with the same rate of manure at 2 WAP, and then 5 t/ha PM at 2 WBP, 5 t/ha PM at 1 WBP, while plants treated with PM at 5 t/ha at planting and at 2 WAP had similar plant height and shortest plants were in control plots (Table 1). Plant height ranged from 38.92 cm to 39.4 cm in plants that received the highest PM rate whereas at 5 t PM/ha, plant height ranged from 31.53 cm to 36.4 cm.

Leaf production and the number of branches followed the trend and were higher in all treated plants that received 10 t PM/ha than those fertilized with 5 t PM/ha, irrespective of the time of manure application.

The plant canopy coverage represented by the leaf area index (LAI) was also highest at 10 t PM/ha, followed by 5 t PM/ha applied at 2 WAP, 5 t PM/ha applied at other times while lowest LAI values were obtained in control plots.

Among the treatments, application of 10 t PM/ha two weeks before planting was most effective on okra growth compared to other treatments. Okra plants in this treatment grew more rapidly and were taller by 3.27 – 8.17 cm and 11.5 cm than those treated with 5 t PM/ha at any time and those in the control plots respectively. The tallest plants also produced the 10.34 – 12.67, 3.34 – 4.67 and 23.39 – 27.96 more leaves, branches and higher LAI values respectively than 5 t PM/ha and zero PM.

### 3.2 Okra Yield and Fruit Yield Parameters

The results on okra pod yield and yield attributes indicated that poultry manure applied at either 5 t/ha or 10 t/ha irrespective of the time of application significantly ($P$ = .05) increased the yield parameters assessed. Poultry manure at 10 t/ha applied 2 WBP recorded the highest fresh pod yield which did not vary from the yield obtained when the manure rate was applied at other times, followed by 5 t PM/ha applied before or at planting and 5 t PM/ha applied 2 WAP, while the least yield was obtained in the control plots (Table 2).

Analysis of the various treatments with respect to fresh pod yield performance indicated higher increase in the fresh pod and seed yield at 10 t PM/ha than at 5 t PM/ha compared to the yield obtained in control plots. However, application of 5 t PM/ha two weeks earlier before planting increased okra the fresh pod yield by 0.34 t/ha (33%) which reduced to 0.31 t/ha (30%), 0.28 t/ha (27%), and 0.25 t/ha (24%) by delaying application to one week before planting, at planting and 2 WAP, respectively. Similarly, by applying 10 t PM/ha at 2 WBP, the yield increment obtained above the control was 0.39 t/ha (38%) which also reduced to 0.36 t /ha or 35% when application of the nutrient was done late at 2 WAP.

The dry pod and seed yield trends followed the same fresh pod yield scenario and were also significantly (P = 0.05) highest at 10 t PM/ha applied 2 WBP which were also similar in the same treatment irrespective of the time of incorporation into the soil. Compared to the control, seed yield increase in plots that received 5 t PM/ha was highest (68.5 kg/ha or 38%) at 2 WBP and lowest (35.5 kg/ha or 17%) at 2 WAP, while the seed yield increase obtained at 10 t PM/ha was highest (99.2 kg/ha or 48%) and lowest (78.0 kg/ha or 37%) in treatments fertilized at 2 WBP and 2 WAP, respectively.

The performance of okra was better in plots that received poultry manure early before planting compared with other treatments. The manure rates that were applied earlier were more effective than the same rates applied late. Early application of poultry manure compared to late application appeared to have increased morphological growth parameters and yield of okra. This could be explained by the fact that a time frame is needed for mineralization and release of nutrients from the poultry manure. Thus, timing of fertilizer application to synchronize with an active nutrient absorption by plant is important critical in nutrient management. Okra growth was more enhanced leading to increased leaf production, branches and leaf area index due to early application of poultry manure. Increased foliage development reflected in increased LAI could have increased the net photo assimilate production and thus increase in yield of fresh pods and seed obtained in plots nourished earlier with at 10t/ha. Application of poultry manure at or after planting did not enhance the growth of the crop as when it was applied two weeks earlier.

Enhanced productivity of other crops such as turmeric due to early application of poultry manure has been reported by Mittra [21] elsewhere. Similarly, Uwah and Ogbonna [22] working with pig manure, reported increased fresh pod weight of okra in the research area. The result obtained in this present work was also in agreement with the finding of Ekwu and Nwokwu [23] in which they reported higher yield response of okra crop in organic manure plots attributed to better supply of nutrient to the plant. Thus, the application of poultry manure at 10 t/ha two weeks prior to planting appeared to have optimized vegetative growth and pod yield of okra in Calabar humid forest ecology.

It was also observed that the higher manure rate had higher effect on the parameters assessed than the lower rate. The best performance of okra observed in plots amended with the higher manure rate could be attributed to possible favourable physical conditions and more nutrients released in such plots This underscores the importance of timely application of adequate quantities of organic manures to enhance their fertilizer efficiency.

**Table 1. Growth parameters of okra as influenced by the time and rate of application of poultry manure at 5 WAP**

| Treatment | Plant height per plant | Number of leaves per plant | Number of branches per plant | Leaf area index |
|---|---|---|---|---|
| No poultry manure(control) | 28.20d | 11.92b | 5.00b | 17.00d |
| poultry manure at 5t/ha applied 2 weeks before planting | 36.43b | 12.33b | 5.33b | 24.22c |
| Poultry manure at 5t/ha applied 1 week before planting | 32.67c | 11.98b | 5.00b | 21.20cd |
| Poultry manure at 5t/ha applied at planting | 31.90cd | 12.33b | 5.67b | 21.57cd |
| Poultry manure at 5t/ha applied 2 weeks after planting | 31.53cd | 10.00b | 6.33b | 19.12cd |
| Poultry manure at 10t/ha applied 2 weeks before planting | 39.70a | 22.67a | 9.67a | 44.96a |
| Poultry manure at 10/ha applied 1 week before planting | 39.60a | 22.20a | 9.53a | 44.92a |
| Poultry manure at 10t/ha applied at planting | 39.40a | 21.98a | 9.38a | 44.47a |
| Poultry manure at 10t/ha applied 2 weeks after planting | 38.92ab | 21.96a | 9.33a | 44.44a |

*Means within a column followed by the same letter of alphabet are not significantly different from one another based on Duncan's New multiple range test (DNMRT) at 5% level of probability*

**Table 2. Fruit yield and yield parameters of okra as influenced by time and rate of application of poultry manure**

| Treatment | Fresh pod yield (t/ha) | Dry pod Yield (t/ha) | Seed yield (kg/ha) |
|---|---|---|---|
| No poultry manure(control) | 1.04d | 0.26c | 208.8e |
| Poultry manure at 5t/ha applied 2 weeks before planting. | 1.38b | 0.40b | 277.3c |
| Poultry manure at 5t/ha applied at planting. | 1.32b | 0.38b | 272.7c |
| Poultry manure at 5t/ha applied 2 weeks after planting. | 1.29c | 0.38b | 244.3d |
| Poultry manure at 10t/ha applied 2 weeks before planting. | 1.43a | 0.55a | 308.0a |
| Poultry manure at 10t/ha applied at planting. | 1.40a | 0.54a | 290.6b |
| Poultry manure at 10t/ha applied 2 weeks after planting | 1.40a | 0.50a | 286.8b |

*Means within a column followed by the same letter are not significantly different from one another based on Duncan's New Multiple Range Test (DNMRT) at 5% probability level*

## 4. CONCLUSION

Poultry manure improved the growth and pod yield of okra when applied early prior to planting. Poultry manure at 10 t/ha applied 2 WBP recorded the highest fresh pod yield of 1.43 t/ha. Timely application of poultry manure at this rate could be more effective for enhanced productivity of okra in the study area.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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