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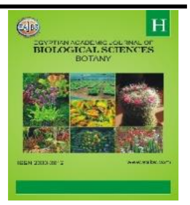

The Growth and Yield of Okra (*Abelmoschus esculentus* L.) Under the Application of some Organic Fertilizers

Matthew Aluko[1*]; Seye O. Olufemi[2] and Zainab B. Ajofoyinbo[1]

[1]Department of Crop, Horticulture and Landscape Design, Ekiti State University, Ado-Ekiti, Nigeria.

[2]Department of Sustainable Agriculture and Food Security, Royal Agricultural University, Stroud Road Cirencester, GL7 6JS.

*E. Mail: matthew.aluko@eksu.edu.ng

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ABSTRACT

A pot experiment to evaluate the effects of some organic fertilizers on the growth and yield of two okra (*Abelmoschus esculentus* L.) varieties (Maha F1 and Royal stunning2) was conducted at the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria. The organic fertilizers tested include Poultry manure (PM), Siam weed leaves (SWL), *Moringa oleifera* leaves (MOL), and Humic acid (HA). The experimental pots were laid out in a completely randomized design (CRD) and were replicated thrice. Data were collected on the plant height, number of leaves, leaf area, stem girth, yield, and yield components, which were subject to analysis of variance. Royal stunning2 produced more leaves than Mama F1, with MOL producing the highest number of leaves (20.25), while Maha F1 are taller than Royal stunning2, with PM producing the tallest plant (31.50 cm). HA produced the highest number of fresh pods/plant (11.03), while MOL gave the highest fresh pod weight (16.63g) in Maha F1. Meanwhile, in Royal stunning2, SWL produced the highest number of fresh pods/plant (11.00) and fresh pod weight/plant (16.31g). SWL gave the highest moisture content (76.20%) in Maha F1, while MOL gave the highest carbohydrate (17.07%), and HA gave the highest fat (1.43%) and ash (0.79%) contents. Meanwhile, in Royal stunning2, HA had the highest moisture content (76.11%), while MOL had the carbohydrate (16.42%) and ash (0.80%) content. All the treatments gave a better performance than the control. However, SWL and MOL are recommended due to their better yield performance and fruit quality.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) of the family Malvaceae plays a significant role in the agricultural economies of many countries, particularly in West Africa, India, and the southern United States, where it has become a common part of the diet (Swamy, 2023). In Nigeria okra is cultivated both as a subsistence crop and for commercial purposes and serve as primary source of employment (Anyaoha *et al*., 2023). India is the leading producer, accounting for approximately 70% of the world's total production followed by Nigeria which is the largest producer of okra in Africa with approximately 1.8 million metric tons annually (FAO, 2023). The global demand for okra has been rising due to its nutritional benefits and versatility in culinary applications. Okra has been reported as an easily available, low-cost vegetable crop with various nutritional values and potential health

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benefits (Elkhalifa *et al*., 2021). It is rich in minerals and vitamins and also contains bioactive compounds like flavonoids, tannins, and polyphenols (Gemede *et al.*, 2018). They are characterized by a mucilaginous texture, which can be reduced through various cooking methods (Nwachukwu and Uka, 2018). Moreover, okra cultivation can contribute to sustainable agriculture by improving soil health through its deep root system and potential use in crop rotation (Mabhaudhi *et al*., 2017).

As the global population continues to rise, the demand for increased food production has led to a heavy reliance on synthetic fertilizers to boost crop yields. However, the overuse of these chemical inputs has had detrimental effects on the environment, including soil degradation, water pollution, and a decline in biodiversity (Guo *et al.*, 2020). In response to these concerns, there has been a growing interest in the use of organic fertilizers as a more sustainable alternative for maintaining soil health and improving crop productivity. Organic fertilizers, derived from plant or animal materials, offer numerous benefits over their synthetic counterparts (Sao, 2024). Not only do they provide essential nutrients for plant growth, but they also improve soil structure, water-holding capacity, and microbial activity (Joshi *et al.*, 2021). One of the main advantages of organic fertilizers is their ability to improve soil health in the long term (Dinkinah, 2024). Unlike synthetic fertilizers, which can lead to soil acidification and nutrient imbalances, organic fertilizers gradually release nutrients over time, promoting the growth of beneficial soil organisms and enhancing the fertility of the soil (Guo *et al.*, 2020). A study by Joshi *et al.* (2021) found that the application of organic fertilizers, such as compost and green fertilizer, increased the abundance and diversity of soil microorganisms, which in turn improved soil aggregation and nutrient cycling.

Despite these benefits, the adoption of organic fertilizers has been hindered by several challenges, including the availability of raw materials, the time-consuming nature of composting, and the lack of awareness among farmers about their advantages (Yadav *et al.*, 2020). To overcome these barriers, governments and research institutions have been promoting the use of organic fertilizers through policy incentives, extension services, and the development of innovative technologies, such as on-farm composting systems and microbial inoculants (Lal *et al.*, 2019). This study therefore aimed at improving the yields and fruit quality of okra from different organic fertilizers.

MATERIALS AND METHODS

Experimental Site:

The experiment was conducted at the Teaching and Research Farm (T&S) of Ekiti State University, Ado-Ekiti, Ekiti State, during the 2024 cropping season (March - June). Ekiti State occupies a land mass of approximately 6,6028 km^2. The geographical coordinates of Ado-Ekiti, the capital city of Ekiti State in Nigeria, are approximately 7.6233°N and 5.2209°E. Ekiti State is predominantly an agricultural area whose main cash crops are cocoa, timbers, oil palm and kola nuts. The region experiences a tropical climate with two main seasons, i.e. the rainy season and the dry season, suitable to investigate the effect of moringa leaf, siam weed leaf, poultry manure and humic acid on the growth and yield of okra (*Abelmoschus esculentus* L.)

Soil Sample Analysis:

Soil sample was taken for routine analysis of the physical and chemical properties using Udo *et al.* (2009). The physical parameters indicated that the soil is a loamy sand containing 82.80% sand, 8.44% silt and 8.76% clay with 6.70 pH. The soil contains 2.47% organic matter, 0.12% N and 28.92 g/kg available P. The contents of exchangeable cation K, Ca, Mg and Na were 0.26, 4.80, 2.50 and 0.02 cmol/kg respectively with 0.80 cmol/kg exchanged acidity.

Treatments and Design of Experiment:

Top soil samples were randomly collected from the T&S, mixed, sieved (2mm meshed sieve), and budged into pots of 10 kg per pot, laid in a completely randomized design (CRD) in three replicates to minimized bias in the homogeneous units (pot experiment). The treatments include *Moringa oleifera* leaves (MOL), Siam weed leaves (*Chromolaena odorata*) (SWL), poultry manure (PM) and humic acid (HA) fertilizer. The MOL and SWL were collected, air-dried, milled and mixed thoroughly with soils in the designated pots at 10 tons/ha two weeks before okra seed sowing (WBS). The PM obtained from the poultry farm at T&S was collected, allowed to be cured and mixed with soil in the designated pots at 10 tons/ha two WBS. Also, HA purchased at a farm shop as Grand Humus Plus (Rising Era Dynast, NICERT and FPA) contained Humic acid (92.0%), K as K_2O (7%), Organic matter (91.12%), pH (10.07) and 100% water solubility was applied at the recommended rate (1g/pot) one week after sowing (WAS). There were also designated pots for control (soils in pots without treatment). The two varieties of okra seeds, Maha F1 and Royal Stunning2, from a farm shop were sown into each separate treatment, designated pots with two seeds per pot and thinned into one seedling/pot one WAS. Watering was done via watering can at intervals to keep the soil moist, and hand weeding was undertaken on any weed site in any pot.

Studies Characteristics:

Data on the growth and yield parameters were collected for each treatment on each okra variety (three replicates) totaling 15 samplings per variety. The growth parameters were collected from the second WAS while at harvest (eight WAS) were collected at three days interval for three weeks. The number of leaves were taken by counting the leaves on each okra plant. The plant height (stem) was measured in centimeters from the base of the plant to the tip using measuring tape while the stem girth was measured using a Vannier caliper. The number of pods per plant was taken by counting while pod weight per plant was taken using a sensitive weighing balance. The pod length and breadth for each pod per plant were taken using Vannier caliper.

Statistical Analysis:

All data collected were subjected to analysis of variance (ANOVA) using the IBM SPSS Statistics version 23 model, and means were separated using Duncan's Multiple Range Test (DMRT) 5% probability.

RESULTS

Effects of Organic Fertilizers on Growth Parameters:

The applications of organic fertilizers produced significantly higher leaves in okra plants than in the control (Table 1). In the Maha F1 okra variety, plants treated with PM and SWL had significantly the highest plant height (15.03) at the eighth WAS, which HA followed. At two WAS, there was no significant difference in the number of leaves by all the treatments except the control. The SWL, MOL and HA produced a significantly higher number of leaves than PM at the fourth WAS. However, at the sixth WAS, PM produced the number of leaves (12.03), which was significantly higher than that of other treatments. The Royal stunning2 variety produces more leaves than the Maha F1 variety. At eighth WAS, in Royal stunning 2, ML produces plants with a more significant number of leaves (20.25) per plant than all other treatments used. The least number of leaves produced at eighth WAS in Royal stunning2 (18.00) by SW, and HA is higher than the highest produced in Mafa F1 by SW and PM (15.03). The control produced the least number of leaves in both varieties. Although MOL and HA produced the highest number of leaves at the fourth WAS in the Maha F1 variety, Royal stunning2 produced more leaves than Mafa F1 at the eighth WAS in all the treatments.

Table 1: Response of Maha F1 and Royal stunning2 okra varieties on number of leaves to the application of some organic fertilizers.

Treatments	**Weeks after sowing**			
	2	4	6	8
Maha F1				
Siam weed leaf	4.05b	7.05a	9.03d	15.03d
Moringa oleifera leaf	4.03b	7.03a	9.03d	13.13f
Poultry manure	4.05b	6.03b	12.03a	15.03d
Humic acid	4.05b	7.03a	10.03c	14.03e
Control	2.05c	4.05d	6.03f	10.03h
Royal stunning 2				
Siam weed leaf	4.00b	5.38c	11.00b	18.00c
Moringa oleifera leaf	5.00a	6.13b	12.05a	20.25a
Poultry manure	5.00a	6.00b	12.13a	19.00b
Humic acid	4.05b	6.00b	12.13a	18.00c
Control	2.00c	3.60d	7.00e	11.00g

Mean values in the same column with the same letter (s) are not significantly different ($p<0.05$)

Table 2, shows the response of the okra varieties on plant height to some organic fertilizers' application. The application of PM maintained the plants with the highest plant height throughout the study. PM produced the highest plant height in Maha F1, from 11.50 cm at two WAS to 31.50 cm at eight WAS, which differed significantly from other treatments in both varieties. The treatments produced higher plant height at eight WAS in Mafa F1 than Royal stunning2 except for ML.

Table 2: Response of Maha F1 and Royal stunning2 okra varieties on plant height (cm) to the application of some organic fertilizers.

Treatments	**Week after Sowing**			
	2	4	6	8
Maha F1				
Siam weed leaf	9.50b	14.00c	22.00b	31.20b
Moringa oleifera leaf	9.00c	15.30b	21.50c	29.00c
Poultry manure	11.50a	17.00a	25.00a	31.50a
Humic acid	9.00c	12.00f	19.00f	27.00f
Control	7.00f	11.00g	18.60g	22.50h
Royal stunning 2				
Siam weed leaf	8.30d	13.00e	21.00d	29.00c
Moringa oleifera leaf	9.50b	13.00e	19.60e	8.00d
Poultry manure	7.20e	13.00e	21.00d	7.40e
Humic acid	7.00f	13.30d	22.00b	28.10d
Control	6.50g	11.00g	17.00h	25.30g

Mean values in the same column with the same letter (s) are not significantly different ($p<0.05$)

The application of SWL produced plants with the highest stem girths in both varieties, with Royal stunning2 having a significant stem girth of 4.20 cm at the eighth WAS

(Table 3). SWL maintained plants with the highest stem girths during the study in both varieties. However, the stem girth of plants by MOL in Royal stunning2 (3.50 cm) is higher than the highest stem girth of 3.40 cm by SWL and not significant. At the eighth WAS, the control produced the thinnest plants in both varieties, with the least in Royal stunning (2.20 cm).

Table 3: Response of Maha F1 and Royal stunning2 okra varieties on stem girth (cm) to the application of some organic fertilizers.

Treatments	**Weeks after sowing**			
	2	**4**	**6**	8
Maha F1				
Siam weed leaf	0.80a	2.50a	3.10c	3.40b
Moringa oleifera leaf	0.60bc	2.00cd	2.60de	2.80d
Poultry manure	0.70ab	1.90d	2.50e	2.70d
Humic acid	0.60bc	1.60e	2.50e	2.70d
Control	0.50c	1.50e	2.17f	2.50e
Royal stunning 2				
Siam weed leaf	0.80a	2.40ab	4.10a	4.20a
Moringa oleifera leaf	0.50c	2.10c	3.30b	3.50b
Poultry manure	0.50c	2.30b	2.60de	3.10c
Humic acid	0.60bc	2.00cd	2.70d	3.10c
Control	0.50d	1.50e	2.10f	2.20f

Mean values in the same column with the same letter (s) are not significantly different ($p<0.05$).

The leaf area was significantly low in HA in Royal stunning2 at two WAS (5.24 cm^2), which eventually increased to give the highest leaf area (54.31 cm^2) at the eighth WAS (Table 4). In Maha F1, the PM produced the highest leaf area from the second WAS (16.11 cm^2) to the eighth WAS (53.11 cm^2). In comparison, PM produced plants with the highest leaf area till the sixth WAS in the Maha F1 variety. But on the eighth WAS, HA gave the highest leaf area (54.31 cm^2), followed by PM (54.28 cm^2) in Rayal stunning2.

Table 4: Response of Maha F1 and Royal stunning2 okra varieties on leaf area (cm^2) to the application of some organic fertilizers.

Treatments	Weeks after sowing			
	2	4	6	8
Maha F1				
Siam weed leaf	10.20b	21.14b	34.21d	45.63f
Moringa oleifera leaf	6.32e	15.24g	26.31g	35.13h
Poultry manure	16.11a	33.12a	43.21a	53.11c
Humic acid	6.34e	14.21h	32.28f	43.24g
Control	5.21g	11.20j	18.32i	33.21i
Royal stunning 2				
Siam weed leaf	7.81c	20.11c	34.21d	52.41d
Moringa oleifera leaf	7.37d	18.31d	33.24e	49.24e
Poultry manure	5.94f	16.11f	38.11b	54.28b
Humic acid	5.24g	17.61e	37.21c	54.31a
Control	5.01h	13.32i	21.41h	27.15j

Mean values in the same column with the same letter (s) are not significantly different($p<0.05$) (DMRT).

Effects of Organic Fertilizers On Yield And Yield Component:

Results in Table 5, shows the yield and yield components of Maha F1 and Royal stunning2 okra varieties in response to some organic fertilizers. HA produced plants with the highest number of fresh pods/plants in Maha F1 (11.03), while SWL gave the highest number of fruits/plants in the Royal stunning2 variety. Despite the low number of fruits/plant (8.00) by MOL, it produced the highest average fruit weight/plant (16.63g) in Maha F1, which was not significantly different from 16.31g from 11.00 number of fresh pods/plant in Royal stunning variety by SWL. MOL produced the highest average fresh pod length (12.12 cm) and diameter (7.70 cm) in Maha F1.

Table 5: Effects of different organic fertilizers on yield and yield components of Maha F1 and Royal stunning2 okra varieties

Treatments	**Number of fresh pods/plant**	**Average Fresh pod weight/plant (g)**	**Average fresh pod length (cm)**	**Average fresh pod diameter (cm)**
Maha F1				
Siam weed leaf	10.00b	14.07b	10.20e	5.83e
Moringa oleifera leaf	8.00c	16.63a	12.12a	7.70a
Poultry manure	7.04d	11.21d	9.58f	5.41f
Humic acid	11.03a	14.64b	10.31d	6.12d
Royal stunning2				
Siam weed leaf	11.00a	16.31a	10.70c	6.81c
Moringa oleifera leaf	10.00b	14.12b	8.21h	5.81e
Poultry manure	10.00b	12.70c	9.50g	5.41f
Humic acid	8.00c	10.85d	10.91b	7.17b
Control	7.00d	9.65e	6.51j	5.31g

Mean values in the same column with the same letter (s) are not significantly different ($p<0.05$).

Effects of Organic Fertilizer On Fruit Quality:

The fruit quality through proximate analysis is shown in Table 6. SWL produced fresh pods with the highest moisture content (76.20%) and the least crude fibre (2.91%) in the Mafa F1 variety. However, SWL gave the highest crude protein content (3.35%) in the Royal stunning2 variety. HA produced fresh pods with the highest crude fat content (1.43%) in Maha F1, while MOL gave the highest crude ash content (0.80%) in Rayal stunning2, which did not differ from 0.79% by HA in Maha F1. MOL produced fresh pods with the highest crude carbohydrate content (17.07%) in Mafa F1. The response of the varieties tested to the treatments on fruit nutrient quality did not follow a regular pattern, as indicated by the results obtained.

Table 6: Effects of different organic fertilizers on fruit quality of Maha F1 and Royal stunning2 okra varieties through proximate analysis.

Treatments	Moisture (%)	Fat (%)	Ash (%)	Protein (%)	Crude Fibre (%)	Carbohydrate (%)
Maha F1						
Siam weed leaf	76.20a	1.37bc	0.78ab	3.14e	2.91e	15.80f
Moringa oleifera leaf	75.19f	1.42ab	0.70de	3.16de	3.08bc	17.07a
Poultry manure	75.24f	1.42ab	0.73cd	3.29b	3.14ab	16.68b
Humic acid	75.40e	1.43a	0.79a	3.20cd	2.94de	16.51c
Control	74.85g	1.31d	0.67e	3.04f	3.02cd	15.59h
Royal stunning2						
Siam weed leaf	76.05b	1.39abc	0.70de	3.35a	3.01cd	15.76fg
Moringa oleifera leaf	75.71d	1.42ab	0.80a	3.14e	3.06c	16.42cd
Poultry manure	75.82c	1.40abc	0.69de	3.22c	3.18a	15.92e
Humic acid	76.11ab	1.36cd	0.75bc	3.04f	3.14ab	16.34d
Control	74.62h	1.32d	0.68e	3.00f	2.94de	15.60g

Mean values in the same column with the same letter (s) are not significantly different($p<0.05$).

DISCUSSION

The study carried out on the soil used indicated a textural class of loamy sand which is suitable for vegetable production. However, the level of some nutrient elements especially N is below the critical of 1.1% N required for arable crop production in Nigeria (FMANR, 1990; Adepetu *et al*., 2014). The results of the study showed that SWL, MOL, PM and HA are truly integral to improving the growth and yield of okra. The gradual release of organic fertilizers ensured a continuous nutrient supply throughout the growing season (Souza *et al.*, 2018). Aluko et al. (2020) have observed that composting plant leaves, including fresh moringa leaves, increase the growth and yield of okra, to which the results from this study agree.

The results of this study agreed with the earlier works of Nawaz and George (2004), Ibe *et al*. (2008), Abdul Azeez et al. (2018), Nantachit *et al.* (2020) and Smith and Onamadi (2021) that SWL as mulch and compost improved okra performance by adding organic matter and nutrients, particularly nitrogen, to improving soil fertility through decomposition.

Anwar *et al.* (2020) and Mashamaite *et al.* (2022) observed that moringa leaves and their extract improves soil fertility and are an effective supplement synthetic fertilizer for crop production. Therefore, the results from the study in which MOL showed a significant increase in okra yield and fruit quality agreed with the work of Kekong and Ibrahim (2023) and Nurseha *et al*. (2023). Conversely, humic acid performed relatively well compared to other treatments used.

It gave significant fruit yield and quality in support of Aluko and Alabi (2023) and Canellas *et al.'s* (2015) findings.

CONCLUSION

This study shows that all the treatments used performed better, indicating a potential nutrient material to increase okra production. The *Moringa oleifera* and siam weed leaves emerged as top choices for consistent and high-performance results. However, further studies are required to investigate the optimum rate and specific stages of application to optimize growth and yield. This approach not only enhances productivity but also improves the nutritional quality of the okra, contributing to sustainable and effective agricultural practices.

DECLARATIONS:

Ethical Approval: Ethical considerations are not necessary as no plant, animal or human subjects were recruited for the current study.

Conflict of interest: The authors declare no conflict of interest.

Authors Contributions: I hereby verify that all authors mentioned on the title page have made substantial contributions to the conception and design of the study, have thoroughly reviewed the manuscript, confirm the accuracy and authenticity of the data and its interpretation, and consent to its submission.

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