Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) Under the Influence of Different Organic Fertilizers

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Abstract: **The desire for organic food products by consumers is on the increase due to its health benefits despite the higher cost of such food products. Therefore at the Teaching and Research Farm of the Ekiti State University, Ado Ekiti, Nigeria, a field experiment was conducted to investigate the effect of five organic fertilizers; Moringa compost (MC), *Tithonia* compost (TC), fresh moringa leaf (FM), poultry manure (PM), and fresh *Tithonia* leaf (FT) on the growth and yield of okra in a randomized complete block design in five replications. Data on growth and yield parameters collected were subjected to analysis of variance and treatment means separated using Turkey post-hoc test at 5% level of probability.. Although MC and PM gave a higher number of leaves (5.3), plant height (22.6 and 21.9 cm), and stem girth (2.8 and 2.9 cm), they did not differ significantly from other treatments. PM produced higher leaf area (173.9 cm^2) which did not differ significantly from 162.3 cm^2 for MC. MC produced 1.3 number of flowers which was significantly higher than 0.9, 0.84, 0.8, 0.72, for PM, FT, FM and control respectively. Although MC produced higher number of fruit $plant^{-1}$ (1.8), PM gave the higher okra fruit weight $fruit^{-1}$ (0.19 kg) and fruit yield (1.20 t ha^{-1}). The five organic fertilizers used for okra production in this study produced significantly higher fruit yield than the control. However, MC and PM are recommended due to the significant increase in growth and yield components.**

Keywords: **Organic fertilizers, Okra, Growth, Yield, Moringa.**

I. INTRODUCTION

Okra (*Abelmoschus esculentus (*L.) Moench) is a vital fruit vegetable found in the tropical and subtropical regions of the world (Senjobi *et al*. 2013). In Nigeria, where it is produced mainly for its young leaves and green pods by peasant farmers, in-home gardens or in mix-cropping with cereal. Okra ranked third to tomato and pepper (Ibeawuchi, 2007). The pods contain a mucilaginous substance used to thicken soups and stews, and as plasma replacement or blood volume expander (Onunkun, 2012). The young leaves and fruits are boiled or fried and eaten as a vegetable or in a soup. The high intake of okra tends to reduce the risk of several chronic diseases such as atherosclerosis and cancer (Ohr, 2004. The okra seeds contain about 20% protein similar to the amino acid composition of soybean protein and 20% oil similar in fatty acid composition to cottonseed oil (Siemonsma and Hamon, 2002). The flowers can be beautiful and sometimes used in decorating the room (Schippers, 2000).

The decline in okra production in Nigeria attributed to continuous use of inorganic fertilizer which increases the soil acidity, thereby affecting the microbiological property of the soil (Onunkun, 2012) adversely. However, Akande *et al.* (2003) reported that the application of organic manure ameliorates the acidic condition of soil which improve crop production.Organic manure which ranges from fresh/dried plant materials to animal's litters and agricultural by-products (Green, 2015) has helped to override the challenges of inorganic fertilizer to which many crops have responded positively especially with composted organic materials (Gordon *et al*., 1993; Ibeawuchi *et al*.,2006).Organic manure increases soil nitrogen, phosphorus and potassium and sustained soil fertility through minimizing leaching with improved soil structure (Kwayep et al., Omotoso *et al*., 2018).

Poultry manure is rich in organic matter, improves the physical properties of the soil (Ayeni, 2011), and supplies more nutrients compare to other organic manures in okra production (Fagwalawa and Yahaya, 2016; Afe and Oluleye, 2017; Khandaker *et al*., 2017; Omotoso *et al*., 2018).*Tithonia diversifolia* is an annual weed found proliferating along the road and abandoned farmland in Nigeria, used successfully to improve soil fertility (Ayeni *et al*., 1997;Opala *et al*., 2015). *Tithonia diversifolia* leaf found to improved growth and yield of okra (Ademiluyi, 2012;Olowokere and Odulate, 2019). Olabode et al. (2007) reported that okra yield was 43% higher in the soil treated with *Tithonia diversifolia* leaf than the untreated soil. *Moringa oleifera* famously called miracle tree due to its potentials in human health and as plant growth hormone (Fahey, 2005; Fuglie, 2008), has been a good source of organic fertilizer in okra production (Aluko *et al*., 2017; Aluko and Olajide, 2020). These organic fertilizers improved the growth and yield of okra as it competes favourably with inorganic fertilizers (Aluko *et al*., 2017; Jonah *et al*., 2017)

Nowadays, the health consciousness of individuals has ensued in the preference of organic food to conventional food products. Despite the higher cost of organic food to conventional food products, human health and safety were a critical factor of preference as reported by Yiridoe (2005) on consumer perceptions and preference towards organic food. Therefore, this work was conceptualized to study the effects

of different locally available and economically sustainable organic fertilizers on the growth and yield of Okra in Ado-Ekiti, Nigeria.

II. MATERIALS AND METHODS

Study Area

The experiment was conducted at the Teaching and Research Farm of the Ekiti State University, Ado-Ekiti, Nigeria, during the rainy season of 2018. Ado-Ekiti is in the forest ecological zone that experience a tropical climate with distinct rainy and the dry season from March to October and November to February respectively.

Compost preparation

Fresh *Moringa oleifera* and *Tithonia diversifolia* leaves were collected and composted separately with sawdust in 1:1 ratio. Constant temperature and weight indicated the readiness of the compost for usage.

Experimental Plot

The experimental plot was cleared, ploughed, and harrowed, and divided into 2 x 2m subplots for each treatment infive replications. Surface soil samples (0 – 15 cm) collected randomly at the experimental plot were air-dried, sieved and analyzed for soil physical and chemical properties using the procedure described by Udo et al. (2009).

Poultry manure, fresh *Tithoni*a *diversifolia* leaves, Fresh *Moringa oleifera* at 10 t ha^{-1} were applied two weeks before planting. At the same time, the *Moringa* and *Tithonia* composts at 10 t ha^{-1} were applied one week after sowing (WAS). The okra seeds (variety Nihort 47-7) was sowed at two seeds $hill^{-1}$ at 60 x 30 cm spacing and later thinned to one seedling $hill^{-1}$ one WAS.

Data collection

Three randomly sampled okra plants to which data on plant height, stem girth, leaf area, and the number of flowers were collected weekly from two WAS. The number of fruit $plant^{-1}$,fruit length, fruit breadth and fruit weight of sampled okra plants were collected at harvest, which was observed every five days interval.

Statistical analysis

All data collected were subjected to the generalized model of Statistical package for social science (SPSS) for the analysis of variance (ANOVA), and treatment means separated using Turkey post-hoc test at 5% level of probability.

III. RESULTS

Characteristic of the Soil Used

Table 1 shows the physical and chemical properties of the soil used for the study. The soil used was loamy sand which contains 845.60 g kg^{-1} sand, 71.00 g kg^{-1} silt and 83.40 g kg^{-1} clay as shown from soil particle analyze with a pH of 5.5. The soil contains 0.70 g kg^{-1} organic matter, 1.21 g kg^{-1} total nitrogen, and 0.58 mg kg^{-1} available phosphorus. The effective cation exchangeable capacity was 2.27 with 0.50, 0.60, 0.56, and 0.51 cmol kg^{-1} exchangeable K, C, Mg, and Na, respectively.

Table 1: The Physical and chemical properties of soil used for the study

SOIL CHEMICAL PROPERTIES	VALUES
Ph	5.5
Organic carbon (g kg^{-1})	0.70
Organic matter (g kg^{-1})	1.21
Total nitrogen (g kg^{-1})	0.58
Available Phosphorus (mg kg^{-1})	0.60
Exchangeable bases (cmol kg^{-1})	
Potassium	0.50
Calcium	0.60
Magnesium	0.56
Sodium	0.51
Exchangeable Acidity	0.30
Effective Cation Exchangeable Capacity (ECEC)	2.47
Sand (g kg^{-1})	845.60
Silt (g kg^{-1})	71.00
Clay (g kg^{-1})	83.40
Textural class	Loamy sand

Effect of Some Organic Fertilizers on Some Growth Parameters of Okra

Table 2 shows the effects of moringa compost (MC), tithonia compost (TC), fresh moringa leaf (FM), poultry manure (PM), fresh tithonia leaf (FT), and control (C) on some growth parameters of okra. The average number of leaves (4.90) produced by plants at 2 WAS with the application of MC and TC was not significantly higher than 4.64, 4.80, 4.50, and 4.06 produced for FM, PM, FT, and C respectively. At 3 WAS, PM produced the higher number of leaves (5.30) which did not differ significantly from 5.24, 4.90, 4.80, 4.70, and 4.06 for MC, TC, FM, FT, and C respectively.

The number of leaves $plant^{-1}$ decline at 4 WAS with FM producing the higher number of leaves (4.70) which did not differ significantly from the number of leaves produced by other organic fertilizer examined. The application of MC and PM produced a higher average number of leaves $plant^{-1}$ (5.30) at 5 WAS which did not differ significantly from 5.20, 5.00,5.02, and 4.50 for TC, FM, FT, and C respectively. The leaf area (26.90 cm^2) produced by PM at 2 WAS did not differ significantly from 26.10, 21.70, 24.20, 21.60, and 20.80cm^2 for MC, TC, FM, FT, and C respectively. However, at 3 and 4 WAS, MC produced leaf areas (77.40 and 93.40 cm^2) which were significantly different ($P < 0.05$) from the values for other treatments applied. However, at 5 WAS PM produced leaf area (173.90 cm^2) which was significantly higher than

162.30, 150.60, 152.40, 145.50, and 131.10 cm^2 for MC, TC, FM, FT, and C respectively.

The leaf areas produced by the organic fertilizers used were significantly different from the control at $P < 0.05$. The application of organic fertilizers produced okra plants with significantly higher plant height than the control. At 2 WAS, okra plants treated with FT produced higher plant height of 8.60 cm which did not differ significantly from 8.40, 7.48, 8.10, 8.20 cm for MC, TC, FM, and PM respectively but significantly higher than 6.38 cm for the control. FM produced higher plant height of 11.90 and 16.40 cm at 3 and 4 WAS which did not differ from the values of other organic fertilizer examined.

The application of MC produced the higher stem girth (1.20 cm) at 2 WAS, which did not differ significantly from other treatments. At 3 WAS, the five organic fertilizers used produced similar stem girth (1.80 cm), which was significantly higher than 1.20 cm for the control. The stem girth of 2.04 cm produced at 4 WAS with MC treated okra plants was not significantly higher than 2.00 and 1.80 cm for TC and PM, and FM and FT respectively. However, at 5 WAS PM produced higher stem girth (2.90 cm) which was not significantly different from 2.80, 2.50, 2.40, and 2.20 cm for MC, TC, FM, and FT respectively. The application of the five organic fertilizers used on okra plants produced plant height and stem girth, which was significantly different from the control at $P < 0.05$.

Table 2: Effect of some organic fertilizers on some growth parameters of okra

Treatment	Week After Sowing			
	2	3	4	5
	Number of leaves			
MC	4.90^a	5.24^a	4.60^a	5.30^a
TC	4.90^a	4.90^a	4.60^a	5.20^a
FM	4.64^a	4.80^a	4.50^a	5.00^a
PM	4.80^a	5.30^a	4.40^a	5.30^a
FT	4.50^a	4.70^a	4.70^a	5.02^a
C	4.06^a	4.06^a	4.50^a	4.50^a
	Leaf area (cm^2)			
MC	26.10^a	77.40^a	93.40^a	162.30^{ab}
TC	21.70^a	67.90^b	80.30^b	150.60^b
FM	24.20^a	62.60^b	79.10^b	152.40^b
PM	26.90^a	67.90^b	85.26^{ab}	173.90^a
FT	21.60^a	61.30^b	71.80^b	145.50^b
C	20.80^a	46.20^c	61.20^c	131.10^c
	Plant height (cm)			
MC	8.40^a	11.60^a	16.30^a	22.60^a
TC	7.48^a	11.20^a	13.90^a	19.40^a
FM	8.10^a	11.90^a	16.40^a	21.30^a
PM	8.20^a	11.70^a	15.80^a	21.90^a
FT	8.60^a	11.30^a	15.80^a	21.80^a
C	6.28^b	9.30^b	10.10^b	14.40^b
	Stem girth (cm)			
MC	1.20^a	1.80^a	2.04^a	2.80^a
TC	1.00^a	1.80^a	2.00^a	2.50^a
FM	1.00^a	1.80^a	1.80^a	2.40^a
PM	1.10^a	1.80^a	2.00^a	2.90^a
FT	1.00^a	1.80^a	1.80^a	2.20^a
C	0.70^a	1.20^b	1.40^b	1.70^b

Notes: Means with the same letters are not significantly different at 5% probability Turkey Post-hoc test.

Moringa Compost (MC), Tithonia Compost (TC), Fresh Moringa (FM), Poultry Manure (PM), FreshTtithonia (FT), Control (C)

Effect of some organic fertilizers on flowers production of okra

Table 3 shows the effect of some organic fertilizers on the number of flowers of the okra plant. The PM produced higher number of flowers (1.60), which did not differ significantly from 1.10, 1.30, 1.50, 1.40, and 1.30 for MC, TC, FM, FT, and C respectively. However, at 5 WAS, MC produced 1.30 number of flowers, which was significantly higher than 0.72, 0.90, 0.84, and 0.80 for TC, FM, FT, and C respectively.

Table 3: Effects of Some Organic Fertilizer on Number of Flowers of Okra

Treatments	Weeks After Sowing	
	4	5
MC	1.10^a	1.30^{ab}
TC	1.30^a	0.72^b
FM	1.50^a	0.72^b
PM	1.60^a	0.90^b
FT	1.40^a	0.84^b
C	1.30^a	0.80^a

Notes: Means with the same letters are not significantly different at 5% probability Turkey Post-hoc test

Moringa Compost (MC), Tithonia Compost (TC), Fresh Moringa (FM), Poultry Manure (PM), Fresh Tithonia (FT), Control (C)

Effect of some organic fertilizers on yield and yield components of okra

The effect of some organic fertilizers used on yield and yield components is shown in Table 4. The yield and yield components produced by the application of MC, TC, FM, PM, and FT produced were significantly higher than the control. The okra fruit length of 5.70 cm produced by the application of MC, TC, PM, and FT did not differ from 5.50 cm for FM. The MC produced okra fruit diameter (6.50 cm), which was similar to 6.00, 6.20, 6.30, and 6.10 cm for TC, FM, PM, and FT respectively. The application of MC produced larger

average okra fruit size of 0.19 kg, followed by PM with 0.17 kg.

Although MC produced larger okra fruits, PM gave the higher average yield (1.20 t ha^{-1}) which did not differ from 1.10 t ha^{-1} for MC but differed significantly from values obtained for other treatments. The TC produced fruit yield of 0.93 t ha^{-1} followed by FM (0.86 t ha^{-1}) and FT (0.79 t ha^{-1}) which were significantly higher than 0.44 t ha^{-1} for control.

Table 4: Effect of Some Organic Fertilizers on Yield and Yield Components of Okra

Treatments	Fruit length (cm)	Fruit diameter (cm)	Number of fruit	Fruit weight (kg)	Yield (t ha^{-1})
MC	5.70[a]	6.50[a]	1.80 [a]	0.18[a]	1.10[a]
TC	5.70[a]	6.00[a]	1.60[b]	0.17[a]	0.93[b]
FM	5.50[a]	6.20[a]	1.60[a]	0.14[a]	0.86[b]
PM	5.70[a]	6.30[a]	1.70[a]	0.19[a]	1.20[a]
FT	5.70[a]	6.10[a]	1.50[a]	0.15[a]	0.79[b]
C	3.00[b]	3.10[a]	0.90[b]	0.10[b]	0.44[c]

Notes: Means with the same letters are not significantly different at 5% probability Turkey Post-hoc test

Moringa Compost (MC), Tithonia Compost (TC), Fresh Moringa (FM), Poultry Manure (PM), Fresh Tithonia (FT), Control (C)

IV. DISCUSSIONS

The soil used for the study required no liming as it was slightly acidic. The total N and available P contents were below the critical level established for crop production in Nigeria (Adepetu et al., 2014). The total N and available P values of 0.58 g kg^{-1} and 0.60 mg kg^{-1} were lower compared to the critical level of 1.1 g kg^{-1} for N and 10 mg kg^{-1} for P. The exchangeable K value was medium-high (0.50 cmol kg^{-1}) compared to the critical value of 0.20 cmol kg^{-1}. The soil, therefore, required amendment for effect okra production as Arapitsas (2008) had reported weak growth and yield responses of crops in unfertilized soil.

The results from the study show the positive response of okra to the different organic fertilizers used. The applications of the organic fertilizers increase the okra growth and yield significantly compared to the control which received no amendment. The results agree with Akande et al. (2010) and Olujobi and Ayodele (2013) that plant extract residues as organic fertilizers improved the quality of plant and can compete favourably with inorganic fertilizers. The applications of poultry manure, *Moringa oleifera* and *Tithonia diversifolia* as a soil amendment has increases the chances of alternative sources of nutrients to boost okra production. All the organic fertilizers trials are capable of enhancing growth and yield of okra.

There was no significant difference in the growth and yield components except at fruit yield in which PM and MC produced higher values compared to other organic fertilizers used. The results indicated that these plant parts could be manipulated into various forms of used either as compost or as fresh parts. Early works on poultry manures, moringa and tithonia showed that these plants were effective organic fertilizer for okra production (Ademiluyi, 2012; Aluko *et al*., 2017, Omotoso *et al*., 2017; Olowokere and Odulate, 2019).

Moringa oleifera leaf is a source of green manure (Fuglie, 2008), and it used has green manure for okra production has been established (Aluko *et al*., 2017). The use of *Moringa oleifera* leaf as compost in this study gave a significant increase in growth and yield of okra compared to its usage as fresh green manure. The same trend was observed with *Tithonia diversifolia* leaf compost. Compost materials on okra gave higher growth and yield in agreement with earlier finding by Olowokere and Odulate(2019).

The compost competes favourably with poultry manure as the yields show no significant difference.

V. CONCLUSION

This study showed that poultry manure, *Moringa oleifera leaf, Tithonia diversifolia leaf, and their* compost as organic fertilizer enhanced the growth and yield of okra. The results obtained showed MC and PM, displaying a significant increase in growth and yield and can thus be adopted for okra production.

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