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Effect of Organic and Inorganic Fertilizer Rates on Growth and Yield of Okra (*Abelmoschus esulentus* (L.) Moench) in Owerri.

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Abstract:
***Background**: Sustainable crop production demands the use of fertilizers because of loss of soil fertility. In the past, inorganic fertilizers were advocated for crop production to ameliorate low inherent fertility of soils in the tropics. Despite the effectiveness of these chemical fertilizers, their adoption and uses has been characterized by several problems such as inadequate supply or unavailability of fertilizers at the time of need, adulteration and high cost. The use of inorganic fertilizer alone has not been helpful under intensive agriculture, because it is often associated with reduced crop yield, soil acidity and nutrient imbalance. Worldwide, there is an increasing interest in organic manures as a means of compensating for the decrease in soil fertility. The need to reduce cost of fertilizing crops has revived the use of organic fertilizers. A combined use of organic and inorganic fertilizers has proved to be very effective.*
***Materials and Methods:** The experimental area measured 240m^2.The treatments consisted of three levels of NPK 20:10:10 fertilizer (0, 200, and 400kg/ha) and poultry manure (0, 6 and 9t/ha). The experiment was laid out in Randomized Complete Block Design (RCBD) with all the treatments arranged in all possible factorial combinations giving a total of 9 treatments replicated 3 times.*
***Results**: The application of organic and or inorganic fertilizer significantly (P<0.05) affected the growth and yield of Okra. NPK fertilizer did not significantly (P>0.05) differ from the control as to plant height at the rate of 200kg and 400 kg per hectare application. However, poultry manure rates at 6 and 9 tons per hectare gave significantly (P<0.05) taller plants from the control. The okra pod weight and number of pods were not significantly different from the control. Significant difference from the control was rather obtained from poultry manure application.*
***Conclusion:** Poultry manure alone applied at the rate of 6tons/ha would be enough to successfully grow okra in the study location to obtain very high yield. The best yield can be obtained through a combined use of 6tons/ha poultry manure and 400kg/ha NPK 20:10:10 fertilizer.*
***Key Word**: Organic; Inorganic; Fertilizer rates; Growth; Yield.*

I. Introduction

Okra (*Abelmoschus esulentus* (L.) Moench) is an important vegetable crop, widely cultivated and very important in the diet of Africans (Omotoso and Shittu, 2008). It is a member of the hibiscus family Malvaceae and has the typical floral characteristics of that family originating from Africa (National Research Council, 2006). Okra pods is a power house of valuable nutrients (Adetuyi *et al*., 2011) and an affordable source of protein, carbohydrate, minerals, vitamins and dietary fibre (Habtamu *et al*., 2014). Therefore, promoting the consumption of okra pods could provide cheap sources of nutrient that can improve the nutritional status and reduce the prevalence of malnutrition especially among resource constrained households and can also be used as a means of dietary diversification (Habtamu *et al*., 2015).

The use of inorganic fertilizer alone has not been helpful under intensive agriculture, because it is often associated with reduced crop yield, soil acidity and nutrient imbalance (Ojeniyi, 2000). In the past, inorganic fertilizers were advocated for crop production to ameliorate low inherent fertility of soils in the tropics. Despite the effectiveness of these chemical fertilizers, their adoption and uses has been characterized by several problems such as inadequate supply or unavailability of fertilizers at the time of need, adulteration and high cost (Adekiya and Agbede, 2009).

Also cultivation with persistent application of mineral fertilizers increase soil acidity and soil physical degradation which may reduce crop yield (Ojeniyi *et al*., 2007; Adeinyan and Ojeniyi, 2003).

Worldwide, there is an increasing interest in organic manures as a means of compensating for the decrease in soil fertility. The need to reduce cost of fertilizing crops has revived the use of organic fertilizers (Delate and Camberdella, 2014, Farhad *et al*., 2009)

Organic fertilizers are essential for the proper development of vegetables, flowers and fruits as they offer rapid growth with superior quality to all species. They have the nutrients and energy sources for soil micro-organisms (Silva *et al*., 2012). The suitability and usefulness of organic fertilizers has been attributed to high availability of NPK content (Waddington, 1998), which lead to increased microbial activity, thereby increasing the rate of organic material decomposition and nutrient release for plant uptake. They improve the physical properties of the soil as well (Nasef *et al*. 2004, Palada *et al*., 2004, Khaled and Shafei, 2005).

Organic fertilizers are often proposed as alternative to inorganic fertilizers, however, the traditional organic fertilizer cannot meet crop nutrient demand over large areas because of the limited qualities available, the high labour demand for processing and application. Most farmers in Africa fall within the two extreme of the organic to inorganic fertilizer continuum and use a combination of organic and inorganic input (Palm *et al.*, 1997).

The success of combined nutrient management depends on several factors including the availability and affordability of different types of inorganic fertilizers, the types and quality of organic materials available and the rate and proportion at which the two nutrient sources are combined (Palm *et al*., 1997).

Despite the numerous advantages of okra and the influence of fertilizers on its productivity and quality, there is a dearth of information on the integrated use of organic and inorganic fertilizers on the growth and pod yield of okra in Owerri Imo state. Therefore, the objective of this research was to determine the effect of the different rates of organic and inorganic fertilizers on the growth and pod yield of okra in Owerri.

II. Material and Methods

Description of study area: The study was carried out in 2020 at the Teaching and Research farm of Agricultural Technology Department, Federal Polytechnic Nekede Owerri Imo State, Southeastern Nigeria. The area lies between Latitude 5^0 21’ N and 50 25’ N and Longitude 70 03’ E and 70 15’ E. the area has an average annual rainfall range of 2000mm- 2250 and annual temperature range of 27^0 C- 30^0 C. The study location has two distinct seasons: the rainy season (April-October) and the dry season (November – March). There is usually a dry spell in between the peaks mostly in the month of August (August break). Recently, the current global warming with the attendant climate change has altered the weather pattern.

Source of seeds: Dwarf Clemson spineless variety of Okra were procured from Imo State Agricultural Development Programme.

Soil analysis: Composite soil samples were taken from 0-30cm depth prior to land preparation from the experimental site to determine the physico-chemical properties of the soil.

Treatment and Experimental design: The treatments consist of three levels of NPK 20:10:10 fertilizer (0, 200, and 400kg/ha) and poultry manure (0, 6 and 9t/ha). The experiment was laid out in Randomized Complete Block Design (RCBD) with all the treatments arranged in all possible factorial combinations giving a total of 9 treatments replicated 3 times.

Land Preparation and Plot Size: The experimental area measured $240m^2$. It was cleared of the existing bush and the trash packed off the farm site. Mapping of the site was followed by manual soil pulverization and making of beds. Each bed size measured 2m x 2m. The blocks were separated from each other by a 1m pathway, while the beds were separated by a 0.5m furrow for free passage and weeding.

Sowing: The seeds were sown at 3 seeds per hole at a spacing of 60cm x 60cm, they were thinned down to one seedling per stand at two weeks after sowing.

Fertilizer application: Poultry manure was applied seven days (1 week) at the various rates (0, 6 and 9t/ha) on each plot and incorporated into the soil before sowing. NPK 20:10:10 fertilizer was applied 2 weeks after sowing using the ring method at the various rates (0, 200, and 400kg/ha).

Weeding: weeding was done manually using hoe three times**.**
Data collection: data were collected on the following parameters;
Plant height was measured using a tape from the soil base to the tip of the plant at 3, 5 and 7 weeks after planting.
Leaf area was calculated as the product of the total length and breadth at the broadest point of the longest leaf on the plant (Musa and Usman, 2016). Leaf area = Lamina length × maximum width × K Where K = Correction factor 0.62.
Number of leaves were visually counted and recorded on selected plants.
The number of days to 50% flowering was counted and recorded.
The harvested pods were counted and weighed on per plot basis.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Fishers Least Significance Difference (F-LSD) at 5% level of probability using R desktop version 1.4.1717 (R Core Team, 2021).

III. Result

The physical and chemical parameters of the soil before the experiment was carried out (table 1). The result reveals that the soil is loamy sand, acidic in nature with low organic matter, nitrogen and phosphorus. It contains moderate potassium and low bulk density.

Table 1. Experimental soil characteristics.

Parameters	Values
Sand (%)	80.00
Silt (%)	6.00
Clay (%)	14.00
Textural Classification	Loamy Sand
Silt/Clay Ratio	0.43
Bulk Density (g/cm^3)	1.24
Porosity (%)	49.50
Moisture (%)	16.0
Sat. Hydraulic Conductivity (cm^3/s)	0.004
Chemical Parameters	
pH	4.50
Organic Carbon (g/kg)	8.53
Organic Matter (g/kg)	19.10

Total Nitrogen (g/kg)	1.04
Carbon/Nitrogen ratio	10.345
Available Phosphorus (mg/kg)	0.64
Exchangeable Potassium, (Cmol/kg)	10.13

The plant height of okra as affected by organic and inorganic manure rates is shown in table 2. At 3 weeks after planting, 400kg/ha application of NPK 20:10:10 fertilizer gave significantly taller plants ($p<0.05$) than 200kg/ha NPK 20:10:10 but was not statistically different from the 0kg/ha NPK 20:10:10 application. The 9 tons/ha poultry manure rate was significantly different ($p<0.05$) from both the 0 and 6 ton/ha poultry manure application rate. It produced the tallest okra plants affected by NPK and poultry manure.
At 5 weeks after planting, there was no observed significant difference ($p>0.05$) on the plant height of okra plants as influenced by NPK 20:10:10 application compared with the no application. The poultry manure application rate of 6 and 9 tons/ha were significantly different from the 0ton/ha poultry manure rate application. 7 weeks after planting followed the same trend as with the 5 weeks after planting.

Table 2. Effect of organic and inorganic manure rates on plant height of okra.

		Plant height(cm)		
	Treatment sources	3WAP	5WAP	7WAP
A	NPK 20:10:10 (kg/ha)			
	0	14.45ab	27.21a	34.22a
	200	13.23b	24.46a	31.82a
	400	15.16a	26.29a	33.81a
B	Poultry manure (ton/ha)			
	0	12.33c	20.49b	27.70b
	6	13.99b	29.55a	36.84a
	9	16.52a	27.92a	35.32a

According to Fishers LSD, means in the same column with the same letters are not significantly different ($p>0.05$).

The interaction of NPK and poultry manure rates on plant height of okra showed significant difference at 3 weeks after planting. NPK0 x PM9 was statistically similar ($p>0.05$) only to NPK400 x PM6 and NPK400 x PM9 but significantly different ($p<0.05$) from all others. At 5 weeks after planting, NPK400 x PM6 gave the tallest okra plants which was significantly different ($p<0.05$) from NPK200 x PM0, NPK0 x PM0 and NPK400 x PM0 but significantly not different ($p>0.05$) from others. 7 weeks after planting followed the same trend as observed at 5 weeks after planting (table 3).

Table 3. Interaction effect of organic and inorganic manure rates on plant height of okra

	Plant height interaction(cm)		
Treatment sources	3WAP	5WAP	7WAP
NPK0 x PM0	12.77d	23.55bc	30.99bc
NPK0 x PM6	12.77d	29.77ab	36.69ab
NPK0 x PM9	17.81a	28.33ab	34.99ab
NPK200 x PM0	11.55d	18.94c	25.30c
NPK200 x PM6	13.00cd	26.33ab	34.29ab
NPK200 x PM9	15.14bc	28.11ab	35.88ab
NPK400 x PM0	12.66d	19.00c	26.82c
NPK400 x PM6	16.22ab	32.55a	39.53a
NPK400 x PM9	16.60ab	27.33ab	35.08ab

According to Fishers LSD, means in the same column with the same letters are not significantly different ($p>0.05$).

The NPK fertilizer treatments did not have any significant effect ($p>0.05$) compared with the zero application on the number of leaves of okra at 3 weeks after planting, though the highest value (8.18) was obtained from NPK 400kg/ha application. The poultry manure rate of 9 tons/ha application was significantly different from 0ton/ha application rate. At 5 weeks after planting, the number of leaves were significantly not affected by the application of NPK fertilizer. 9tons/ha application of poultry manure significantly affected the number of leaves and was statistically different from 0 and 6tons/ha poultry manure application. At 8 weeks after planting, NPK application did not affect the number of leaves of okra statistically, but poultry manure application did. 9 tons/ha application was significantly different from 0ton/ha application (table 4).

Table 4. Effect of organic and inorganic manure rates on number of leaves of okra

		Number of leaves		
	Treatment sources	3WAP	5WAP	7WAP
A	NPK 20:10:10 (kg/ha)			
	0	7.81a	6.55a	8.61a
	200	7.55a	6.11a	7.99a

	400	8.18a	6.81a	8.76a
B	Poultry manure (ton/ha)			
	0	7.21b	5.81b	7.84b
	6	7.77ab	6.40b	8.35ab
	9	8.55a	7.25a	9.17a

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

The interaction of NPK fertilizer and poultry manure on the number of leaves of okra (table 5) at 3 weeks after planting shows that NPK200 x PM0 gave the lowest value which was significantly different (p<0.05) from all the other treatment combinations. At 5 weeks after planting, NPK200 x PM0 was significantly different (p<0.05) from all others with the lowest value of number of leaves. At 7 weeks after planting, the same trend of 5 weeks after planting was maintained.

Table 5. Interaction effect of organic and inorganic manure rates on number of leaves of okra

	Number of leaves interaction		
Treatment sources	3WAP	5WAP	7WAP
NPK0 x PM0	7.44ab	6.44ab	8.66ab
NPK0 x PM6	7.66ab	6.10bc	8.18bc
NPK0 x PM9	8.33a	7.11ab	9.00ab
NPK200 x PM0	6.55b	5.10c	6.88c
NPK200 x PM6	7.77ab	6.22bc	8.22abc
NPK200 x PM9	8.33a	6.99ab	8.88ab
NPK400 x PM0	7.66ab	5.88bc	7.99bc
NPK400 x PM6	7.88ab	6.88ab	8.66ab
NPK400 x PM9	8.99a	7.66a	9.62a

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

The effect of organic and inorganic manure rate on the leaf area of okra leaves at 3 weeks after planting shows that NPK had no significant effect (p>0.05) on the leaf area. The 400kg/ha application rate gave the highest value (123.96) but not significantly different from others. The poultry manure rates showed a significant difference. The 0ton/ha application was significantly (p<0.05) lower than all the manure rates. At 5 and 7 weeks after planting, the same trend was observed as seen in 3 weeks after planting (table 6).

Table 6. Effect of organic and inorganic manure rates on leaf area of okra

		Leaf area (cm^2)		
	Treatment sources	3WAP	5WAP	7WAP
A	NPK 20:10:10 (kg/ha)			
	0	111.85a	291.87a	301.91a
	200	97.48a	295.88a	307.01a
	400	123.96a	317.21a	328.32a
B	Poultry manure (ton/ha)			
	0	75.45b	214.26b	225.39b
	6	120.32a	330.90a	341.99a
	9	137.53a	359.81a	369.86a

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

At 3 weeks after planting, NPK200 x PM0 was significantly ($p<0.05$) lower than all the treatment interaction on leaf area. The same trend was followed at 5 and 7 weeks after planting. The highest value was observed in NPK400 x PM9 at 3 weeks after planting while at 5 and 7 weeks after planting it was observed in NPK200 x PM9 (table 7).

Table 7. Interaction effect of organic and inorganic manure rates on leaf area of okra

	Leaf area interaction (cm^2)		
Treatment sources	3WAP	5WAP	7WAP
NPK0 x PM0	79.70bc	227.73cd	237.54cd
NPK0 x PM6	112.74ab	286.62abcd	296.37abcd
NPK0 x PM9	143.10a	361.27ab	371.84ab
NPK200 x PM0	56.68c	174.67d	188.16d
NPK200 x PM6	107.96abc	304.38abcd	314.48abcd
NPK200 x PM9	127.80ab	408.61a	418.41a
NPK400 x PM0	89.96abc	240.38bcd	250.48bcd

NPK400 x PM6	140.24a	401.70a	415.13a
NPK400 x PM9	141.67a	309.55abc	319.35abc

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

Table 8 shows the effect of organic and inorganic manure rates on days to 50% flowering of okra. The various NPK rates did not affect the number of days to 50% flowering of okra statistically. The 6tons/ha poultry manure application was significantly different (p<0.05) from the 0ton/ha poultry manure application. It took 54.44 days for the 6tons/ha applied plants to flower while the 0ton/ha poultry manure applied plants took 58.11 days to flower.

Table 8. Effect of organic and inorganic manure rates on days to 50 % flowering of okra

		Days to 50% flowering
	Treatment sources	Number of days
A	NPK 20:10:10 (kg/ha)	
	0	46.44a
	200	46.77a
	400	45.33a
B	Poultry manure (ton/ha)	
	0	48.11a
	6	44.44b
	9	46.00ab

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

The interaction of the NPK X poultry manure had a significant effect on the number of days to 50% flowering of okra. NPK400 x PM6 was significantly different (p<0.05) from all the other treatment combinations. It gave the earliest significant number of days to 50% flowering (53.33days). All other treatment combinations were statistically not different in the number of days to 50% flowering (table 9).

Table 9. Interaction effect of organic and inorganic manure rates on days to 50 % flowering of okra

Days to 50% flowering interaction	
Treatment sources	Number of days
NPK0 x PM0	48.33a

NPK0 x PM6	45.00ab
NPK0 x PM9	46.00ab
NPK200 x PM0	48.33a
NPK200 x PM6	45.00ab
NPK200 x PM9	47.00ab
NPK400 x PM0	47.66a
NPK400 x PM6	43.33b
NPK400 x PM9	45.00ab

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

The pod weight /plot and per hectare as affected by NPK fertilizer did not show any significant effect (p>0.05) compared to the non-application. However, 400kg/ha rate of application gave the highest value of pod weight/plot (1397.40g) due to NPK application. The poultry manure rates had a significant (p<0.05) variation in the pod weight/plot and per hectare. The 0ton/ha poultry manure application rate was significantly different from the 6 and 9tons/ha manure application rate. The 6tons/ha rate gave the highest value of 1679.55g in pod weight/plot. The number of harvested pods per hectare as affected by NPK fertilizer application was not significantly different (p>0.05) from the control. Also, 400kg/ha NPK gave the highest obtained number of pods harvested per plot and per hectare. The poultry manure application had a significant difference in the number of pods harvested per plot and per hectare. The 0ton/ha poultry manure application had the significantly (p<0.05) lowest number of pods/plot and per hectare while the 6 tons/ha poultry manure gave the highest value of number of pods though not significantly different (p>0.05) from the 9ton/ha poultry manure rate (table 10).

Table 10. Effect of organic and inorganic manure rates on yield of okra

		Yield			
	Treatment sources	Pod wt/plot (g)	Pod wt/ha (Kg)	Number of pods/plot	Number of pods/ha
A	NPK 20:10:10 (kg/ha)				
	0	1249.02a	3122.56a	62.45a	156128.10a
	200	1296.94a	3242.35a	64.84a	162117.80a
	400	1397.40a	3493.51a	69.87a	174675.81a
B	Poultry manure (ton/ha)				
	0	853.30b	2133.27b	42.66b	106663.60b

6	1679.55a	4198.88a	83.97a	209944.40a
9	1410.50a	3526.27a	70.52a	176313.60a

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

The combined use of NPK fertilizer and poultry manure significantly affected the weight of harvested okra pods and number of pods harvested (table 11). NPK0 x PM0 gave significantly ($p<0.05$) lowest pod weight per plot and per hectare while the highest pod weight was obtained from NPK400 x PM6. The number of pods/plot and number of pods/hectare followed the same trend of pod weight. NPK400 x PM6 gave the highest number of pods and was significantly different from NPK0 x PM0.

Table 11. Interaction effect of organic and inorganic manure rates on yield of okra

	Yield interaction			
Treatment sources	Pod weight/plot (g)	Pod weight/ha (Kg)	Number of pods/plot	Number of pods/ha
NPK0 x PM0	739.58d	1848.95d	36.97d	92447.50d
NPK0 x PM6	1539.72ab	3849.30ab	76.98ab	192465.00ab
NPK0 x PM9	1467.77abc	3669.43abc	73.38abc	183471.70abc
NPK200x PM0	839.74cd	2099.35cd	41.98cd	104967.50cd
NPK200 x PM6	1687.89a	4219.73a	84.39a	210986.70a
NPK200 x PM9	1363.19abcd	3407.98abcd	68.15abcd	170399.20abcd
NPK400 x PM0	980.60bcd	2451.51bcd	49.03bcd	122572.80bcd
NPK400 x PM6	1811.05a	4527.63a	90.55a	226381.70a
NPK400 x PM9	1400.56abc	3501.40abc	70.02abc	175070.00abc

According to Fishers LSD, means in the same column with the same letters are not significantly different (p>0.05).

IV. Discussion

The result of this experiment shows that fertilizers strongly affected the productivity of okra in the study area. The application of NPK fertilizer at 400kg/ha gave taller plants when compared with the control. Poultry manure at the application rate of 9tons/ha gave plants results that are similar to the application of 400kg/ha NPK. Sanni, (2014) observed that okra plants treated with poultry manure produced the tallest plants at 3 and 6 weeks after planting and at flowering. This shows that poultry manure can be used as a better alternative to NPK fertilizers. The combination of poultry and NPK fertilizers also gave good results however, since they currently are not so cheap in the study region, either of them should be used.

The number of leaves of okra that received 400kg/ha NPK was more in number though not significantly different from the control. 9ton/ha poultry manure application gave okra plants with the highest number of leaves. A combination of 400kg/ha NPK and 9tons/ha poultry manure was found to be very great in terms of the number of leaves of okra plants applied. Alasiri (2002) reported that the nutrient use efficiency of okra crop is better with a mix of poultry manure and NPK fertilizer, nutrients seemed more readily available to okra plants with the mixes than the poultry manure or NPK fertilizer alone.

The best performance for okra in this research for the growth parameters accessed were observed in the plants that received 400kg/ha NPK, tons/ha poultry manure or a combination of 400kg/ha NPK and 9tons/ha poultry manure.

The use of poultry manure at the rate of 6tons/ha and 9tons/ha gave higher yields than the use of NPK fertilizers at 200kg/ha and 400kg/ha. The pod weights and the number of pods were greater in the poultry manure treated plants than the control and NPK fertilizer treated plants. A combined use of 400kg/ha NPK and 6 tons/ha poultry manure gave the highest yield value. This is similar to the findings of Akinmutimi and Amaechi, (2015) who reported that 10tons/ha of poultry manure gave the highest fruit performance, but it was closely followed by a combination of 10tons/ha poultry and 100kg/ha (NPK 15:15:15) fertilizer.

V. Conclusion

Organic and inorganic fertilizers used singly or in combination has a positive effect on the vegetative growth and yield of okra in the study area. This is so because soils in the study area are characterized by inherent low fertility. The choice of the type of fertilizer to use should be based on the assessment of the soil condition, cost of the fertilizer and its availability as at the time of need. However, for optimum yield and productivity which is the ultimate goal of every okra grower a combined use of 400kg/ha of NPK 20:10:10 and 6tons/ha poultry manure is recommended in the study area. A single use of 9 ton/ha poultry manure can also be adopted.

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