Impact of Poultry Manure and NPK Fertilizer on Soil Chemistry and Okra (Abelmoschus Esculentus L. Moenh) Growth in Akure, Southwest Nigeria.

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Abstract

The experiment was conducted at the Akure rainforest zone of Nigeria to study the effects of sole and combined applications of poultry manure (PM) and NPK fertilizer (NPK) at reduced rates on soil and plant nutrients composition and performance of okra. Trials were conducted at the Federal University of Technology, Akure (FUTA) Southwest Nigeria. Treatments included a control, 300kg/ha 20-10-10 Nitrogen Phosphorus Potassium Fertilizer (NPK), Poultry Manure (PM) at 20t/ha and combinations of NPK and PM at ratios 3:1, 2:2 and 1:3. The test soil was acidic, deficient in Phosphorus (P). NPK and PM significantly increased plant height and stem girth with combined applications at reduced levels given highest values. The 225kg/ha NPK +5t/ha PM gave highest value, 150kg/ha NPK +10t/ha PM gave highest number of fruits. It increased mean number of fruits by 22% followed by 75kg/ha NPK +15t/ha PM. Also the PM and 75kg/ha NPK + 15t/ha PM significantly increased fruit weight at the second harvest. The PM and combinations of PM and NPK significantly increased fruit girth at the second harvest. The PM increased soil N, P, K, Ca, Mg and pH, NPK increased soil P, K. It was 75kg/ha NPK +15t/ha PM that constantly increased soil nutrients. The NPK, PM or their combinations increased leaf N significantly although 150kg/ha NPK +10t/ha PM and 75kg/ha NPK +15t/ha PM more constantly increased leaf nutrients.

Keywords: Poultry Manure, NPK fertilizer, Soil chemical properties, Okra, Plant yield

I. Introduction

Okra (Abelmoschus esculentus L. Moenh) is an important vegetable crop belonging to the family Malvaceae. It is widely cultivated in tropical, subtropical, and warm temperate regions of the word particularly Africa, Asia and part of America. Okra

is believed to have originated in Africa and one of the numerous vegetable crops cultivated in Nigeria. All parts of the okra plant are useful. Its leaves and tender shoots which are equally rich in nutrients can be cooked and eaten, dietary fiber and seed protein balanced in lysine and tryptophan amino acids it provide to diet. The crop is commonly grown for its immature green pods, which are consumed as vegetables and used in soups, stews, and various traditional dishes (Singh and Nigam, 2023). Okra requires a moderate rainfall of 80 – 100 cm which is well distributed to produce its young edible fruits over a relatively long period. An average temperature of 20°C to 30°C is considered optimum for growth, flowering and fruiting. Most soils in southern Nigeria and in parts of the humid tropics are acidic due to the nature of their parent material, high rainfall regime and intensity with associated leaching of nutrients, decomposition of soil organic matter and weathering.

A number of studies has shown that okra yield is markedly limited by low soil fertility, hence response to application of N,P and K fertilizers and organic fertilzers (Bello et al, 2023; Adekiya et,al, 2020; Gugudi and abdulmalik 2015) have been reported. However there are limitation to the use of inorganic fertilizers such as high cost, scarcity, loss of organic matter, soil physical degradation and inadequate supply of nutrients and soil acidity (Penuelas et al, 2023; Ojeniyi,2012), which was found to reduce uptake of nutrients in okra (Onwu et.al, 2026;Law-Ogbomo 2013). Farmers increasingly resort to the use of organic fertilizers in okra production because they improve soil nutrient content (Okole et al, 2025: Adekiya et al, 2020) which is hampered by its low quality. Hence there is need to step up research into combined use of organic and inorganic fertilizers in okra production .Integrated plant nutrition is recommended for sustainable crop production in the tropics (Musa et.al, 2024;Ojeniyi, 2012).

This work carried out on acidic alfisols of southwest Nigeria, investigated the effect of combined applications of poultry manure and NPK fertilizer on the performance of okra, soil and plant nutrients composition. Despite the nutritional value of okra, its optimum yields (2-3t/ha) and quality have not been attained in tropical countries partly because of continued decline in soil fertility. Hence there is need to study combined use of organic and inorganic fertilizers for enhancing growth, yield and nutrient composition of okra. The use of poultry manure in

promoting organic farming and in enhancing soil fertility has profound implications on the agricultural production as well socio- economic factors of people living in the rural areas in the developing world. Poultry manure has frequently been found to increase the yields of pastures and crops including vegetables. Unlike inorganic fertilizers, organic fertilizers are cheap, easy to come by, always safe to use, not poisonous to crops and environmentally friendly but must be applied in large quantities to the crop because the nutrient concentration is very low compared with inorganic fertilizer. This would definitely result in high transportation cost of manure materials.

The objectives of this study are:
(a)To investigate the effects of combined application of poultry manure and NPK 20-10-10 fertilizer treatment on soil chemical properties and plant nutrient composition and performance of okra.

(b)To determine the suitable rate of poultry manure and NPK 20-10-10 application for optimum yield of okra in the study area.

II. Materials and Method

The experiment was conducted Federal University of Technology Akure (FUTA) Research farm,Southwest Nigeria. Akure lie between latitude 7^{o} 30^{l}N and Longitude 3^{o} 52^{l}E in the tropical rainforest belt. From April to July. Annual average minimum and maximum temperatures are 24.80 C and 28.10 C respectively. The relative humidity is about 75%. The soils is classified as a alfisols.

The experiment was conducted to study the effects of combined application of poultry manure (PM) and NPK 20-10-10 fertilizer on soil chemical properties and okra (lady's finger) performance. Six treatments were applied to soil grown to okra (Abelmoschus esculentus L. Moench) seedlings.
The treatments were namely;
T1 = Control (no PM, no NPK)
T2 = 300kg/ha NPK 20-10-10
T3= 20t/ha poultry manure
T4 = 225kg/ha NPK + 5t/ha PM

T5 = 150kg/ha NPK + 10t/ha PM
T6 = 75kg/ha NPK + 15t/ha PM

The six treatments were replicated three times on manually cleared land using Randomized Complete Block Design (RCBD). Each of the plots was 2x3m and seedlings were established at 0.6m by 0.6m. Three seeds were planted per hole and later thinned to one 7days after planting. Air-dried poultry manure was broadcast a week before planting. The NPK 20-10-10 fertilizer was applied by ring method a week after thinning; weeding was manually done twice after fertilizer application.

Growth and yield data
Parameters such as plant height with the use of ruler in centimeter (cm), stem girth with the use of vernier caliper in centimeter (cm) and number of leaves were taken weekly and yield parameters such as pod length, pod diameter and weight were determined weekly on harvested fruits as from 60 days after planting using 5 plants per plot.

Soil Chemical Analysis
Surface (0-15 cm) soil samples collected by an auger over each site in the first experiment were bulked for routine chemical analysis (Faithful, 2002; Paramesh et.al.,2023). Samples were also collected for each treatment plot 60 days after planting. Samples were air-dried and 2mm sieved. Total N was determined by the kjedahl method, available P by Bray-1 extraction followed by Molybdenum blue colorimetry, exchangeable K, Ca and Mg were extracted by ammonium acetate. The K was determined on a flame photometer and Ca and Mg by atomic absorption spectrophotometer. Organic matter was determined by using wet dichromate method. Soil pH in water suspension at 1:1 soil solution ratio was determined using pH meter.

Plant and poultry manure analysis
Leaf samples collected in each treatment plot at 60 days after planting were oven-dried for 24 hours at 70^{o} C and ground in a kliley-mill. Leaf N was determined by the micro- kjeldahl digestion method. Samples were ashed at 500^{o}C for 6 hours in a furnace and extracted using nitric- perchloric acid mixture for determination of P, K, Ca and Mg. The available P was determined using vanadomolybdate

colorimetry method, K by flame photometer, and Ca and Mg by EDTA titration (AOAC, 1997).

Statistical Analysis

Data were subjected to analysis of variance to determine the effects of treatments on the parameters measured. Duncan Multiple Range Test was employed to compare the treatment means.

III. RESULTS

Initial Soil Analysis

The test soil was adequate in N, K and Ca it was also adequate in OM but deficient in available Phosphorus.(Table 1). The adequacy levels of nutrients in the ecological zones of Nigeria were submitted as 3% OM, 0.01-0.15% total N, 20mg/kg available P, and exchangeable K 0.16-0.20 cmol/kg (Akinrinde and Obigbesan, 2000). The test soil was quite acidic. Considering the attributes of the soil, it required application of organic and inorganic fertilizers.

Table 1 also shows that poultry manure was clearly higher in N, K, Ca and OM compared with soil. Similar observation was made by Law-Ogbomo et al. (2013). The relatively high nutrient contents of the manure compared with soil implies that it is composed of nutrients which can be released into the soil after degradation and mineralization (Law – Ogbomo et al, 2013).

Table 1: Chemical Properties of test soil and poultry manure (PM)

Properties	Soil sample	PM
Total N%	0.08	4.48
Available P mg/kg	6.46	2.20
K^+ cmol /kg	0.29	3.20
Ca cmol /kg	2.60	7.63
Mg cmol/kg	2.84	1.96
pH H_20	4.17	-
O.M%	3.43	7.20

Effect of the treatments on plant height

The effects of treatments on plant height were not significant at 3, 4, 5, 6, 7 and 8 weeks after planting (WAP). For example the values at 8 WAP were 31.6, 34.5, 32.1, 30.0, 28.3 and 32.6 cm for the control, NPK, PM20t/ha, 225kg/ha NPK + 5t/ha PM, 150kg/ha NPK + 10t/ha PM and 75kg/ha NPK + 15t/ha PM (Table 2).

Table 2. Effects of treatments on the plant height of okra (cm)

TREATMENTS	WEEKS AFTER PLANTING					
	3	4	5	6	7	8
Control	10.31	14.70	19.28	21.55	20.40	31.63
NPKF 300Kg/ha	9.35	15.05	22.10	27.0	28.10	34.56
P.M 20t/ha	11.41	16.03	21.17	24.9	24.53	32.13
225kg/ha NPKF + 5t/ha PM	10.97	15.80	19.70	20.80	20.53	30.06
150kg/ha NPKF + 10t/ha PM	10.07	14.78	20.10	23.50	24.66	28.33
75kg/haNPKF+15 t/ha PM	11.77	17.33	22.19	22.83	22.50	32.60

Means in a column followed by the same alphabet are not significantly different (P=0.05) as indicated by Duncans Multiple Range
Test.

Effects of treatments on number of leaves

The numbers of leaves given by the control, fertilizer and manure treatments were not significantly different except at 8WAP. The values were 21.8, 16.4, 22.0, 22.9, 18.2 and 19.1 respectively for the control, NPK, PM, 225kg/ha NPK + 5t/ha PM, 150kg/ha NPK + 10t/ha PM and 75kg/ha NPK + 15t/ha PM. The NPK had the least values. (Table 3). Manure and fertilizer significantly increased the number of leaves and their combined applications and NPK gave similar values of number of leaves.

Table 3. Effects of treatments on number of okra leaves per plant (cm)

	WEEKS AFTER PLANTING					
TREATMENTS	3	4	5	6	7	8
Control	5.73a	5.47a	7.13a	14.47a	18.13a	21.80ab
NPKF 300Kg/ha	5.93a	6.63a	10.28a	14.53a	15.53a	16.40b
P.M 20t/ha	6.13a	5.93a	7.87a	13.73a	17.53a	22.0ab
225kg/ha NPKF + 5t/ha PM	5.87a	5.40a	7.60a	15.47a	18.33a	22.93a
150kg/ha NPKF + 10t/ha PM	6.0a	6.67a	9.13a	13.07a	15.07a	18.20ab
75kg/ha NPKF + 15t/ha PM	6.0a	5.93a	8.67a	13.80a	16.60a	19.13ab

Means in a column followed by the same alphabet are not significantly different

(P=0.05) as indicated by Duncan's Multiple Range Test.

Effect of treatments on stem girth

Stem girth (first experiment)

The manure and NPK increased the stem girth of okra at site 1 especially as from 4WAP but the effects were not significant (Table 4)., the effects were significant relative to the control. The highest value was given by 225kg/ha NPK + 5t/ha PM at 4, 5, 6, 7 and 8 WAP.

Table 4. Effects of treatments on the Stem girth of okra (cm)

TREATMENTS	WEEKS AFTER PLANTING					
	3	4	5	6	7	8
Control	0.35	0.57	1.05	1.22	1.44	1.60
NPKF 300Kg/ha	0.35	0.64	1.24	1.50	1.63	1.79
P.M 20t/ha	0.37	0.69	1.22	1.41	1.60	1.77
225kg/ha NPKF + 5t/ha PM	0.39	0.67	1.25	1.47	1.51	1.81
150kg/ha NPKF + 10t/ha PM	0.30	0.62	1.22	1.28	1.47	1.73

75kg/ha NPKF + 15t/ha PM	0.37	0.67	1.26	1.43	1.59	1.72

Means in a column followed by the same alphabet are not significantly different

(P=0.05) as indicated by Duncan's Multiple Range Test.

Yield parameters

Effect of treatments on number of fruits

150kg/ha NPK + 10t/ha PM gave the highest number of fruits which was significantly higher compared with the control (Tables 5). Therefore it is the 150kg/ha NPK + 10t/ha PM that is recommendable. Relative to the control, it increased the mean number of fruits by 22%, followed by 75kg/ha NPK + 15t/ha PM which increased it by 14%.

Table 5. Effects of poultry manure (PM) and NPK 20-10-10 on number of okra fruits per plant

TREATMENTS	Number of harvests			
	1	2	3	4
Control	1.34ab	1.61ab	1.76a	2.59ab
NPKF 300kg/ha	1.44a	1.17ab	1.47a	1.89b
P.M 20t/ha	0.71b	1.56ab	2.03a	2.55ab
225kg/ha NPKF + 5t/ha PM	0.88ab	0.71b	1.89a	1.94ab
150kg/ha NPKF + 10t/ha PM	1.00ab	1.76a	1.89a	2.13ab
75kg/ha NPK F+ 15t/ha PM	1.17ab	1.46ab	1.79a	2.67a

Means in a column followed by the same alphabet are not significantly different

(P=0.05) as indicated by Duncan's Multiple Range Test.

Fruit weight

NPK, PM and their combinations did not increase fruit weight significantly at the first, third and fourth harvests (Table 6). However the PM and 150kg/ha NPK +10t/ha PM significantly increased fruit weight at the second harvest.

Table 6. Effects of poultry manure (PM) and NPK 20-10-10 on fruit weight of okra (g)

TREATMENTS	Number of harvest			
	1	2	3	4
Control	8.43a	6.98ab	10.26a	9.65a
NPKF 300kg/ha	10.73a	9.15ab	5.66a	10.40a
P.M 20t/ha	0.00	12.07a	11.99a	9.93a
225kg/ha NPKF + 5t/ha PM	1.38a	0.00	11.41a	7.08a
150kg/ha NPKF + 10t/ha PM	14.39a	9.27ab	9.94a	10.39a
75kg/ha NPKF + 15t/ha PM	9.72a	10.76a	6.47a	11.79a

Means in a column followed by the same alphabet are not significantly different

(P=0.05) as indicated by Duncan's Multiple Range Test.

Fruit length

NPK, PM and combinations of their reduced rates did not increase fruit length at the third and fourth harvests (Table 7) and the PM alone significantly increased fruit length

Table 7. Effects of poultry manure (PM) and NPK 20-10-10 on fruit length of okra (cm)

TREATMENTS	Number of harvest			
	1	2	3	4
Control	3.78a	2.92ab	4.13	4.13
NPKF 300kg/ha	3.43ab	3.12ab	2.60	3.66
P.M 20t/ha	0.00	4.34a	4.23	3.86
225kg/ha NPKF + 5t/ha PM	0.83ab	0.00	4.26	4.26
150kg/ha NPKF + 10t/ha PM	2.17ab	3.11ab	3.55	3.56
75kg/ha NPKF + 15t/ha PM	2.98ab	3.23ab	2.63	2.63

Means in a column followed by the same alphabet are not significantly different

(P=0.05) as indicated by Duncan's Multiple Range Test

Fruit Girth

NPK, PM and their combinations did not affect fruit girth at the third and fourth harvests (Table 8). However NPK increased fruit girth significantly at the first harvest , and there were significant increases by PM and the combinations of PM and NPKF in the case of the second harvest. The PM alone significantly increased fruit girth at the second harvest. Combinations of the two materials (150kg/ha NPK + 10t/ha and 75kg/ha NPK + 15t/ha PM) significantly increased fruit girth at the second harvest).

Table 8. Effects of poultry manure (PM) and NPK 20-10-10 on fruit girth of okra (cm)

TREATMENTS	Number of harvest			
	1	2	3	4
Control	2.08ab	1.50ab	2.39	2.27
NPKF 300kg/ha	2.43a	1.70ab	1.48	2.47

P.M 20t/ha	0.00	2.53a	2.51	2.34
225kg/ha NPKF + 5t/ha PM	0.57ab	0.00	2.42	2.05
150kg/ha NPKF + 10t/ha PM	1.37ab	2.23a	2.47	2.39
75kg/ha NPKF + 15t/ha PM	1.73ab	2.48a	1.58	2.42

Means in a column followed by the same alphabet are not significantly different

(P=0.05) as indicated by Duncan's Multiple Range Test.

Effect of treatments on soil chemical composition

Tables 9 show values of soil chemical composition. At the end of experiment it was 75kg/ha NPK + 15t/ha PM that consistently increased soil nutrient level such as N, P, K, Ca and OM. It also increased soil pH significantly. It was followed by 150kg/ha NPK + 10t/ha PM. The NPK fertilizer increased soil P, K, Mg indicating that it increased soil acidity. The PM alone increased soil P, Ca, Mg and OM Treatments involving combination of NPK and PM at reduced levels consistently increased soil available P, K, Ca and OM but it was 75kg/ha NPK + 15t/ha PM that increased N.

Table 9. Soil nutrient composition as affected by NPK fertilizer (NPKF) and poultry manure (PM)

Treatments	N%	Pmg/kg	K cmol/kg	Ca cmol/kg	Mg cmol/kg	p H	O.M %
Control	0.43c	15.6f	0.36c	2.10e	1.10b	4.28b	1.65e
NPKF 300kg/ha	0.98 b	72.2a	0.39b	1.90f	2.20a	4.14e	1.65e
P.M 20t/ha	0.41c	18.74e	0.34d	3.50b	1.20b	4.44a	2.77a
225kg NPKF + 5t/ha PM	0.42c	22.24c	0.39b	3.10d	0.50d	4.16 d	2.51c

150kg NPKF + 10t/ha PM	0.50c	29.94b	0.37c	3.30c	0.30e	4.20c	2.21 d
75kg NPKF + 15t/ha PM	2.02a	22.09d	0.42a	3.70a	0.80c	4.20c	2.54b

Means in a column followed by the same alphabet are not significantly different
(P=0.05) as indicated by Duncan's Multiple Range Test.

Effect of treatment on leaf nutrients composition

Tables 10 contain data on leaf nutrient composition of okra as affected by manure and NPK, sole NPK, PM, or combined significantly increased leaf N and increased Mg and P. The five treatments increased leaf N significantly relative to the control. The increase in K is not significant. The PM alone increased leaf N, P, K and Mg. Combinations of 150kg/ha NPK + 10t/ha PM and 75kg/ha NPK + 15t/ha PM more consistently increased leaf nutrients as far as N, P, Ca and Mg were concerned.

Table 10. Okra leaf nutrients composition as affected by NPK fertilizer (NPKF) and poultry manure (PM)

TREATMENTS	N%	P%	K%	Ca%	Mg%
Control	2.16e	0.40c	7.5b	0.23d	0.31e
NPKF 300kg/ha	3.05c	0.40d	7.5b	0.21e	1.05a
P.M 20t/ha	3.08b	0.49a	8.0a	0.14f	0.76b
225kg NPKF + 5t/ha PM	2.80d	0.44d	7.5c	0.25b	0.24f
150kg NPKF + 10t/ha PM	3.14a	0.44b	7.4c	0.28a	0.36c
75kg NPKF + 15t/ha PM	3.12a	0.45b	7.5c	0.24c	0.33d

Means in a column followed by the same alphabet are not significantly different (P=0.05) as indicated by Duncan's Multiple Range Test.

IV. Discussion

Increased growth and pod count of okra recorded for NPK and PM are attributable to increased soil nutrient levels which led to increased uptake of nutrients. It could be seen that the two materials increased the availability of N, P and K in soil. Thus the manure had liming effect on soil. The combined application of the materials ensured increased availability of N, P, K, Ca, Mg in soil and OM and, pH. It ensured balanced soil nutrition compared with NPK alone. This should have enhanced the yield of okra compared with sole use of NPK . Also, increased availability of N, P and K in soil and increased release of nutrients from the manure due to the presence of mineral fertilizer should have also contributed to better performance of okra under integrated application of the two materials. The liming effect of PM is important considering the findings of Aduayi (1981) who observed reduced nutrient uptake by okra with increased soil acidity.

The highest values of number of fruits recorded for 150kg/ha NPK + 10t/ha PM and 75kg/ha NPK + 15t/ha PM is consistent with the highest values of leaf N recorded for the treatments. Alasiri (2001) observed that N fertilizer significantly enhanced the growth of okra. Also, Gupta (1981) and Kaltung et al. (1996) reported significant enhancement of plant height of okra with N fertilizer.

The NPK enhanced Mg.These findings could be due to enhancement of mineralization of organic nutrients from soil organic matter which released the base elements.

The PM alone increased soil N, Ca, Mg and OM. This confirms the liming effect of manure and its being a natural source of nutrients. These effects could have led to the increase in growth parameters of okra such as plant height, number of leaves and stem girth as from fifth week after application of manure when it should have been decomposed and mineralized to release nutrients into soil (Amusan and Ojeniyi, 2011). The release of base elements such as K, Ca and Mg led to increased soil pH and reduction of soil acidity which aided uptake of nutrients.

It could be seen that leaf N increased with rate of organic manure. This confirms organic matter as a major source of N (Amusan and Ojeniyi, 2011). Manure and N fertilizer are major factors controlling uptake of N by plant, the N being the nutrient most limiting for plant performance, especially growth. Hence both leaf N and fruit count of okra tended to increase with increasing rate of PM from 5 to 15t/ha irrespective of NPK rate. Therefore the manure appeared to dictate yield rather than NPK. This could be attributed to other advantages of manure such as improvement in soil physical properties and biotic life, water conservation and moderation of soil temperature. The manure also has a mulching effect on soil being an organic matter.

This work supports the findings of Ojeniyi (2012) in his review work that organomineral fertilizers gave similar or higher crop yield compared with recommended NPK fertilizer and also improved nutritional quality. Aside from its liming effect, they have synergistic or complementary effect on nutrient supply. Ojeniyi (2012) reported that integrated application of organic and inorganic fertilizers would ensure build-up of soil productivity and quality on long term basis. The reduction in quantities of either component would reduce cost of production, fertilization will be reduced and plant nutrition balanced which are expected to enhance crop growth, yield and quality as shown in the present work. This is supported by reports by Adeniyan and Ojeniyi (2003), Sangotoye et.al,(2024).,Umeh et al (2024) and Adewale et.a l(2024). The combination of 150kg/ha NPK fertilizer and 4t/ha PM was recommended. Integrated plant nutrition will also assist in enviromental sanitation by utilization of farm wastes. It combines the attributes of organic manure and chemical fertilizer.

V. Conclusion and Recommendation

The experiment was conducted in Akure, southwest Nigeria to determine the effects of sole and combined applications of NPK fertilizer (20-10-10) NPK and poultry manure (PM) on growth, fruit yield, soil and plant nutrient composition of okra. There was a control, NPK at 300kg/ha, PM at 20t/ha and their combinations at reduced rates of 3:1, 2:2 and 1:3 respectively. The test soils were acidic and either medium or deficient in available P and marginal in organic matter. Combined applications of NPK and OM enhanced crop growth and fruit count than NPK or PM alone and increased soil and plant N, P, K, Ca and Mg.

Combination of 150kg/ha NPK + 10t/ha PM gave highest fruit count which was 22% higher compared with the control. The NPK fertilizer reduced soil pH.

It was concluded that requirement for NPK fertilizer in okra production can be reduced by fifty percent when combined with 10t/ha poultry manure. Yield, plant and soil nutrients composition were increased by combined application of the materials and soil acidity reduced. The combination 150kg/ha NPK + 10t/ha PM is thus recommended for okra production.

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