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EVALUATION OF SOIL CHEMICAL PROPERTIES, GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus*) AS INFLUENCED BY COMPOSTED POULTRY MANURE AND NPK (15:15:15) FERTILIZER

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ABSTRACT

Greenhouse and laboratory experiments were carried out to investigate the effects of organic manure (Poultry Manure) and NPK (15:15:15) fertilizer on soil chemical properties, growth and yield of okra (*Abelmoschus esculentus*) in Michael Okpara University of Agriculture, Umudike. Six treatments {T1-2.5tons/ha poultry manure, T2- 5tons/ha poultry manure, T3- 2.5tons/ha poultry manure + 100kg/ha NPK (15:15:15) fertilizer, T4- 5tons/ha poultry manure + 100kg/ha NPK (15:15:15) fertilizer, T5- 100kg/ha NPK (15:15:15) fertilizer, T6- Control (no fertilizer/poultry manure application)} were used. The treatments were replicated three times, and laid out in a completely randomized design (CRD). In the greenhouse, the experiment lasted for twelve weeks and data were collected on the following growth and yield parameters: plant height, number of leaves, stem girth, number of fruits and fruit weight at harvest. Results obtained indicated that growth and yield of okra were lowest in the control treatments, indicating that the organic manure used in the study (poultry manure) positively influenced the growth and yield of the okra. Poultry manure positively increased okra plant height by 199.3% and increased number of fruits of okra by 5.77% compared to the control treatments. Fresh fruit weight was also significantly ($p<0.05$) increased with the application of poultry manure compared to the control treatment; Fruit yield was highest in the T3 (5.77 tons per hectare)¸ followed by the treatment T2 (5.00 tons per hectare). Generally from the results, it could be concluded that T2 (5tons/ha poultry manure), T3 (2.5tons/ha poultry manure + 100kg/ha NPK (15:15:15) fertilizer) andT4 (5tons/ha poultry manure +100kg/ha NPK (15:15:15) fertilizer increased the growth and yield of okra when compared to other treatments. They were therefore recommended for farmers in the study area.

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Keywords: soil chemical properties, growth yield, okra, composted poultry manure, NPK (15:15:15) fertilizer

INTRODUCTION

Okra (*Abelmoschus esculentus*) is an important vegetable crop grown in West Africa¸ particularly in Nigeria¸ for its tender fresh pods which are rich in vitamins A B and C and other vital minerals particularly iodine (Lawal *et al*., 2012). The seeds contain 20-30% protein, 20-21% lipids, 6% ash and a good percentage of vitamin E.

Okra thrives naturally in the low land rainforest soils¸ high in moisture and temperature¸ but its yield had been reported to be very low (about 2 tons/ha) due to several factors which may include soil fertility status (Muoneke and Ashiegbu¸ 1997).

Organic matter decline in most soils is a major contributor to soil degradation processes. The soil fertility and productivity of most degraded soils are further reduced due to inadequate organic amendment and/or chemical fertilizer application by resource-poor farmers (Unagwu *et al*.¸ 2019b). in order to achieve a sustainable food production¸ proper use of soil resources must be accompanied with considerable management of soil properties by ensuring the physical¸ chemical and biological components of the soil are maintained (Unagwu *et al*.¸ 2019a).

To meet the growing need, organic amendment with added value is mandatory as an effective way to recycle and to improve soil nutrient and soil organic matter, buffer the soil and improve aggregate stability, reduce number of viable weed seeds and provide a balanced nutrient composition, stabilize organic matter and a slower release of soil nutrient for crop yield (Spaccini, and Piccolo 2017; Bernal *et al*., 2009).

The total amount of nutrients released from organic amendments for crop uptake depends on the value added, rate of application, characteristics of the waste such as toxic element content and the nutrient released pattern and the environmental condition (Aiyelaagbe, 2011). The extra benefits associated with value addition of organic material for soil improvement including extra crop yield, better crop quality, enhanced soil fertility and productivity (Gupta *et al*., 2004).

OBJECTIVES

1) To determine the effect of composted poultry manure and NPK (15:15:15) fertilizer on the growth and yield of okra (*Abelmoschus esculentus*)
2) To determine the effect of composted poultry manure and NPK (15:15:15) fertilizer on the soil chemical properties after harvest.

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MATERIALS AND METHODS

The Study Area

A greenhouse study was carried out in Michael Okpara University of Agriculture, Umudike. Umudike is located between Latitude 05^0, 29'N and Longitude 07^0, 33'E. The area falls within the tropical rainforest zone, having an altitude of 122m above sea level. The mean annual rainfall is 2200mm, distributed over nine to ten months in bimodal rainfall pattern; these are the early rains (April to July) and late rains (August to October) with five months dry season and short period in August popularly called "August break". The relative humidity varies from 84% to 87% while monthly minimum air temperature ranges from 20^0C to 24^0C and the monthly maximum air temperature ranges from 28^0C to 35^0C (NRCRI, 2016).

Soil Sampling and Sample Preparation

A composite soil sample was collected randomly from Michael Okpara University of Agriculture Umudike Abia state. The samples were collected at a depth of 0-15cm, air dried at room temperature and passed through 2 mm sieve mesh.

Treatments

The treatments comprised different rates of poultry manure and NPK (15:15:15) fertilizer which were sourced from the livestock unit of Michael Okpara University of Agriculture, Umudike and Umuahia town respectively.

Treatment Preparation

The poultry manure was collected and weighed after which it was allowed to decompose. After 90days the poultry manure was air dried, crushed, sieved and applied at their respective rates.

Greenhouse Experiment

Ten kilogram (10 kg) of soil was weighed into 6 plastic buckets representing each of the treatments, and replicated three times to give a total of 18 experimental units. The treatments were applied at the following rates:

T1- 2.5 tons/ha poultry manure

T2- 5 tons/ha poultry manure

T3- 2.5 tons poultry manure + 100 kg/ha NPK (15:15:15) fertilizer

T4- 5 tons poultry manure + 100 kg/ha NPK (15:15:15) fertilizer

T5- 100 kg/ha NPK (15:15:15) fertilizer.

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T6- Control (no fertilizer/poultry manure application)

Test Crop

Test crop was Okra (*Abelmoschus esculentus*) variety "lady finger" sourced from National Seeds Service, Umuahia, Abia state, Nigeria.

Agronomic Data

The following agronomic data were collected during the greenhouse experiment: plant height, number of leaves, stem girth, weight of fruit at harvest, number of fruit at harvest. The experiment lasted for 12weeks in the greenhouse.

Laboratory Analysis

The soil sample collected before treatment application and after harvest and was subjected to the following routine analysis:

Particle Size Distribution

This was determined using the Bouyoucos hydrometer method. 5% of a dispersing agent (calgon) sodium hexameta phosphate was used to separate sand, silt and clay particles bonded together for determination of their compositions (Bouyoucos, 1962).

Determination of exchangeable bases

Ca, Mg, K, Na were determined using NH_4OA_Cextractant method (Udo*et al*., 2009).

Organic Carbon

Organic Carbon was determined by Walkley and Black wet – oxidation method (Nelson and Sommers, 1982).

Soil pH

Soil pH was determined electrometrically using pH meter in a soil: liquid ratio of 1:2.5 (Thomas, 1996).

Available Phosphorous (Av.P).

Available phosphorus was extracted using Bray 2 solution as described by Bray and Kurtz (1945).

Total Nitrogen

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Total Nitrogen was determined by Micro Kjedahl digestion method (Bremmer and Mulvaney, 1982).

Effective Cation Exchange Capacity

This was calculated by the summation of exchangeable bases and the exchangeable acidity.

(Exchangeable Ca Mg Na K). Exchangeable acidity ($Al^{3+}$and H^{+}).

% Base Saturation was calculated using:

$$\frac{TEB}{ECEC} \times \frac{100}{1}$$

Where:

TEB = Total Exchangeable Bases

ECEC = Effective cation exchange capacity.

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) in a completely randomised design (CRD); Significant means were separated using Fishers least Significant Difference at a probability level of 5%.

RESULTS AND DISCUSSION

Some selected physical and chemical soil properties before treatment application

The pretreated soil analysis results used for the experiment are shown in Table 1. From the results obtained, the textural class of the soil used was sandy loam; the pH in H_2O (5.1) was strongly acidic according to Chude *et al*. (2005). Acidic soils potentially reduce plant growth, fix plant nutrient by increasing H^{+} and Al^{3+} ion toxicity and reducing availability of Ca, Mg and P. The soil was moderate in OC (1.24%) and OM (2.14%) according to the rating given by Charman and Roper (2000) (OC 1.00-1.80%; OM 1.70-3.00%). The total nitrogen was $0.11 g.kg^{1-}$ this value is less than the critical level given by Aduayi *et al.* (2002) $1.5 g.kg^{1-}$ in the tropical humid region. The value of available phosphorus was moderate ($15.3 mg.kg^{1-}$) as in the work of Holford and Cuilis (1985) (Av. P 10-17 mg. kg^{1-} moderate). The exchangeable cations were low: Ca- ($3.60 cmolkg^{-1}$) Mg- ($1.2 cmolkg^{-1}$) moderate, K- ($0.23 cmolkg^{-1}$) very low, Na- ($0.103 cmolkg^{-1}$) low, according to values given by Bruce and Rayment (1982).

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Table 1: Physical and Chemical properties of the soil before planting

Properties	Value
Sand (gkg^{-1})	658.00
Silt (gkg^{-1})	182.00
Clay (gkg^{-1})	160.00
Texture	Sandy Loam
pH (H_2O)	5.10
pH (KCl)	4.30
Av. P (mg/kg^{-1})	15.30
Total nitrogen (%)	0.11
Organic carbon (%)	1.24
Organic matter (%)	2.14
Calcium $cmolkg^{-1}$	3.60
Magnesium $cmolkg^{-1}$	1.20
Potassium $cmolkg^{-1}$	0.23
Sodium $cmolkg^{-1}$	0.10
Exchangeable acidity $cmolkg^{-1}$	1.38
Effective cation exchange capacity (cmolkg-1)	6.51
Base Saturation (%)	78.80

Mean Effect of Treatment on the Chemical Properties of Soil

The result on Table 2 shows mean effect of treatment on soil chemical properties. The values of soil pH ranged from 4.56-6.80 in water and 3.36-5.53 in salt. The result showed a significant ($p \leq 0.05$) increase in soil pH due to treatment application. The highest pH value was recorded in T4 (6.80) followed by T2 (6.43) while the lowest value was obtained on the control plot T6 (4.56). Soil pH in KCl followed the same trend, where T4 had the highest pH value (5.53) followed by T2 (5.36) while the T6 gave the lowest value (3.36). The result obtained on soil pH

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is in accordance with Duruigbo *et al*. (2007) who reported an increase in soil pH due to combined application of poultry manure and mineral fertilizer.

The available phosphorous (Av.P) ranged from 14.67-26.43mg/kg. There was a significant increase ($p \leq 0.05$) on Av.P value over the control. The highest value of Av.P was recorded on T5 (26.43mg/kg) followed by T4 (25.7mg/kg), While the lowest value of Av.P was obtained from T1 (14.97mg/kg). The increase in Av.P may be attributed to the increase in pH by the treatment. The result obtained on Av.P. was in agreement with Atkinson *et al.*, (2010); Barrow (2012); Xu *et al.* (2012) where they reported increase in phosphorous as a result of applying PM and NPK fertilizer.

The value of total nitrogen (TN) ranged from 0.428-0.105%. The result showed a significant ($P \leq 0.05$) increase with the application of treatments. The highest value of TN was recorded on the plot with T4 (0.428%) followed by T5 (0.353%). While the plot T6 gave the lowest value of TN (0.105%). The increase in TN recorded on T4 may be attributed to increase in nutrient reaction from combined application of poultry manure and NPK fertilizer. While the increase recorded on the plot with NPK fertilizer alone may be attributed to mineralization of the inorganic fertilizer added to the soil. The result was in accordance with the report of Bationo and Mokwunye (1991) where they observed an increase in nitrogen due to application of NPK and poultry manure.

The results of organic carbon (OC) and organic matter (OM) ranged from 0.75-2.01% (OC) and 1.29-4.23% OM. There was a significant ($P \leq 0.05$) increase on OC and OM values respectively. The highest value of OC and OM was recorded on T4 OC (2.01%) OM (4.23%) followed by T2 OC (1.95%) OM (3.36%) while the lowest value on OC and OM was obtained from T6 OC (0.75%) OM (1.29%). The increase in OC and OM may be attributed to the high content of stable carbon in the poultry manure (Bationo and Mokwunye. 1991).

The calcium (Ca) value ranged from 2.86-9.93 (Table 4.1). The result showed a significant ($P \leq 0.05$) increase in Ca value as a result of poultry manure and NPK fertilizer application. The highest value of Ca was recorded on T4, (9.93cmol/kg) followed by T3 (8.10 cmol/kg) while the lowest value was obtained from T6 (2.86cmol/kg) Mg, K, and Na followed the same trend where the highest value of Mg (4.76 cmol/kg) K (0.529cmol/kg) and Na (0.340 cmol.kg) were obtained from the T4. The results were significantly increase ($P \leq 0.05$) over T6 because of the combination of poultry manure and NPK fertilizer in T4.

The result obtained on Exchangeable H^+ and Al^{3+} showed a significant decrease ($P \leq 0.05$) on Exchangeable Acidity as a result of applying poultry manure and NPK fertilizer. The Exchangeable Acidity value ranged from 0.59-1.74cmol/kg, The highest value of Exchangeable Acidity was recorded on T6 Exchangeable Acidity (1.74cmol/kg), the lowest value of

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Exchangeable Acidity recorded on T4 Exchangeable Acidity (0.59cmol/kg). The increase in Exchangeable Acidity of the control may be attributed to the low organic matter content and low soil pH. While the decrease in Exchangeable Acidity observed on the plot treated with poultry manure 5t/ha may be attributed to release of Mg and Ca ions from the poultry manure which served as liming agents. The result of ECEC and BS range from (5.51-16.16 cmol/kg) and (68.40-96.32%) respectively, and the highest values of ECEC (16.16 cmo1/kg) BS (96.32%) were recorded on T4. The increase in most of the chemical properties of the soil as a result of applying poultry manure and NPK fertilizer was in agreement with Barrow (2012) who observed a similar increase in soil pH, Ca, Mg and CEC of soil after application of poultry manure and NPK fertilizer. Adekiya *et al*. (2020) also reported that organic manures and NPK fertilizer increased the soil organic matter¸ N¸ P¸ K¸ Ca and Mg when applied to okra.

Table 2: Effect of treatments on soil chemical properties after harvest

Trt	pH-H_2O	pH-KCl	Av.P	TN (%)	OC (%)	OM (%)	Ca	Mg	K	Na	EA	Al	ECEC	%BS
							→ Cmol/kg ←							
T1	5.73	4.70	19.97	0.21	1.65	2.85	5.33	2.03	0.28	0.18	0.96	0.34	8.79	89.08
T2	6.43	5.36	22.53	0.29	1.95	3.36	6.33	2.93	0.39	0.24	0.64	0.22	10.53	93.91
T3	6.10	5.06	23.07	0.33	1.63	2.81	8.10	3.46	0.38	0.24	0.85	0.28	13.04	93.45
T4	6.80	5.53	25.47	0.43	2.01	3.47	9.93	4.76	0.53	0.34	0.59	0.19	16.16	96.32
T5	5.46	4.33	26.43	0.35	0.95	1.64	5.00	1.66	0.44	0.31	1.22	0.42	8.64	85.80
T6	4.56	3.36	14.67	0.11	0.75	1.29	2.86	0.66	0.15	0.09	1.74	0.59	5.51	68.40
Mean	5.85	4.72	22.00	0.29	1.49	2.57	6.26	2.58	0.36	0.23	1.00	0.34	10.45	87.83
$LSD_{(0.05)}$	0.17	0.48	1.66	0.02	0.10	0.17	0.29	0.51	0.03	0.04	0.08	0.04	0.57	1.32
CV (%)	0.50	2.80	1.80	2.00	1.10	1.20	1.50	3.80	1.70	8.80	4.00	4.40	0.50	0.60
SE	0.028	0.133	0.231	0.005	0.017	0.029	0.090	0.090	0.006	0.020	0.039	0.015	0.056	0.539

Effect of Treatment on Plant Height of Okra

Table 3 shows the effect of treatment on the plant height of Okra. The result showed an increase in plant height ($p \leq 0.05$). At 3WAP, 6WAP, 9WAP and 12WAP. The highest value on plant height at 3WAP, was recorded at T3 (2.5tons/ha PM + 100kg/ha NPK) (33.3cm) followed by T4 (5tons/ha PM + 100kg/ha NPK) plant height (31.0cm) while the lowest value of plant height was recorded at T6 (control) plant height (23.0cm). At 6WAP, the highest value of plant height was recorded on T4 plant height (99.7cm) followed by T3 (78.4cm) while the least value at 6WAP was obtained on T6 (37.0cm). At 12WAP the plant height value ranged from 83.1-199.3 cm. The highest value was recorded on T4 (199.3cm) followed by T3 (156.8cm) while the lowest value was recorded on T6 (83.1cm). The increase in plant height may be as a result of poultry manure

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whose nutrients were gradually released to the plant from time to time ¸that resulted in T4 is having higher values.

Table 3: Effect of treatment on plant height (cm) of Okra

	Plant	Height	(cm)	
TREATMENT	3WAP	6WAP	9WAP	12WAP
T1 (2.5tons/ha poultry manure- PM)	28.7	41.5	70.7	100.3
T2 (5tons/ha poultry manure- PM)	31.0	60.9	102.7	121.8
T3 (2.5tons/ha PM + 100kg/ha NPK)	29.0	78.4	112.7	156.8
T4(5tons/ha PM + 100kg/ha NPK)	33.3	99.7	99.0	199.3
T5 (100kg/ha NPK 15:15:15 fertilizer)	28.0	57.7	91.7	115.4
T6 (control)	23.0	37.0	64.0	83.1
MEAN	28.8	62.5	90.1	129.4
$LSD_{(0.05)}$	NS	15.9	21.7	31.4
Coefficient of variation (CV %)	9.0	6.8	4.2	7.6

WAP- Weeks After Planting

Mean Effect of Treatments on Number of Leaves of Okra

Table 4shows the effect of treatment of the number of leaves of Okra. The result showed that number of leaves at 3WAP was not significantly ($p \geq 0.05$) increased when compared with the control and when compared with the other treatments. At 6WAP, the value obtained on number of leaves showed a significant increase ($p \leq 0.05$). The highest value was recorded on T4(10.0), followed by T3 (7.80) respectively while the lowest value was recorded on T6 (3.70). At 9WAP and 12WAP the result showed a significant ($p \leq 0.05$) increase on number of leaves. The highest value for 12WAP was obtained on T4 (21.40) followed by T3 (17.40) while the lowest was recorded on T6 (9.20). The increase in number of leaves may be attributed to nutrient build up in the soil orchestrated by the combined effect of poultry manure and NPK fertilizer in T3 and T4treatments. Ter *et al.* (2021) reported nutrient build up as a result of poultry manure application in combination with NPK fertilizer in the soil of Makurdi¸ Nigeria.

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Table 4: Effect of treatment on number of leaves of Okra

	Number	Of	leaves	
TREATMENT	3WAP	6WAP	9WAP	12WAP
T1 (2.5tons/ha poultry manure- PM)	2.90	4.20	8.10	11.10
T2 (5tons/ha poultry manure- PM)	3.10	6.10	11.40	13.00
T3 (2.5tons/ha PM + 100kg/ha NPK)	2.90	7.80	12.00	17.40
T4(5tons/ha PM + 100kg/ha NPK)	3.30	10.00	11.00	21.40
T5 (100kg/ha NPK 15:15:15 fertilizer)	2.80	5.80	10.20	12.80
T6 (control)	2.30	3.70	7.40	9.20
MEAN	2.90	6.30	10.00	14.20
$LSD_{(0.05)}$	NS	1.60	2.00	4.00
Coefficient of variation (CV %)	9.00	6.80	3.30	5.20

WAP- Weeks After Planting

Mean Effect of Treatment on stem girth of Okra

Table 5 shows the effect of treatment on the stem girth of okra. The result on stem girth ranged from 1.4-2.3cm at 3WAP and 1.8-2.7 at 6WAP having T4 and T3 as the highest girth of 2.3cm and 2.7 respectively and T6 as the lowest (1.4 and 1.8cm). The highest values of stem girth for 9WAP and 12WAP were recorded on T4 (5.0 and 6.6cm). The result in stem girth is an indication that the combination of Poultry manure and NPK fertilizer is likely to made better improvements.

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Table 5: Effect of the treatment on stem girth (cm) of Okra

TREATMENT	Stem girth (cm)			
	3WAP	6WAP	9WAP	12WAP
T1 (2.5tons/ha poultry manure- PM)	2.1	2.1	2.1	2.8
T2 (5tons/ha poultry manure- PM)	2.1	2.4	3.0	4.1
T3 (2.5tons/ha PM + 100kg/ha NPK)	2.3	2.5	3.9	5.2
T4(5tons/ha PM + 100kg/ha NPK)	2.2	2.7	5.0	6.6
T5 (100kg/ha NPK 15:15:15 fertilizer)	2.1	2.1	2.9	3.8
T6 (control)	1.4	1.8	1.9	2.5
MEAN	2.0	2.3	3.1	4.2
$LSD_{(0.05)}$	0.3	NS	0.8	1.1
Coefficient of variation (CV %)	4.6	3.8	6.8	6.8

WAP- Weeks After Planting

Effect of Treatment on fruit yield of Okra

The effect of treatment on the fruit yield of Okra shown in Table 6. It comprises the number of fruit per plant, weight of fruit per plant(kg) and the fruit yield per hectare. Counting on the number of fruits produced by a particular plant, T3gave the highest number. It gave the highest weight of okra fruit and produced more compared to other treatments in hectare and per plant bases. The yield was significantly ($P< 0.05$) higher than what was obtained in other treatments. The result is in line with the findings of Akinmutimi and Amaechi (2015) who reported a favourable yield of Okra when poultry manure was combined with NPK fertilizer as soil amendment in the study area.

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Table 6: Effect of treatment on Fruit yield characteristics of Okra

TREATMENT	No. of fruits Per plant	Fresh Fruit weight per plant(kg)	Fruit Yield (t/ha)
T1 (2.5tons/ha poultry manure- PM)	10.67	0.41	4.10
T2 (5tons/ha poultry manure- PM)	13.00	0.50	5.00
T3 (2.5tons/ha PM + 100kg/ha NPK)	15.00	0.58	5.77
T4(5tons/ha PM + 100kg/ha NPK)	11.17	0.43	4.29
T5 (100kg/ha NPK 15:15:15 fertilizer)	12.00	0.46	4.62
T6 (control)	6.00	0.23	2.31
MEAN	11.31	0.43	4.35
$LSD_{(0.05)}$	1.88	0.07	0.72
Coefficient of variation (CV %)	1.10	1.10	1.10

CONCLUSION AND RECOMMENDATION

With the performance of crops treated with the combination of 5t/ha poultry manure and NPK 15:15:15 fertilizer, there were significant improvements in the yield and growth of Okra with respect to height, stem girth, Leave number, fruit number and weight. It is therefore recommended that 5t/ha poultry manure, or combination of poultry manure with NPK 15:15:15 fertilizer be used by farmers in the study area for optimum growth and yield of Okra in farmlands pertaining to Umudike.

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