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Influence of NPK Fertilizer and Poultry Manure on the Growth of Okra (*Abelmoschus esculentus* L. Moench) in Northern Sudan Savanna Region of Nigeria

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Abstract*— *Field trials were conducted during the 2018 rainy season at the Federal University Dutsin-Ma Teaching and Research Farm, Badole. The aim of the work was to evaluate the influence of different levels of NPK fertilizer (0, 40, 80 kg ha^{-1}) and poultry manure (0, 4, 8 tons' ha^{-1}) on the growth of okra. The trial was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The application of 4 and 8 tons' ha^{-1} of poultry manure showed significant difference on the number of plant per plot at 4 and 6WAS. While the application of NKP 15:15:15 at all level were statistically at par on the number of plant per plot. The application of poultry manure and NPK 15:15:15 showed significant difference among the treatment to plant height, number of leaves, leaves area, stem girth at various weeks of data collection. The increase in the level of poultry manure and NPK 15:15:15 fertilizer showed the significant effects on number plant, number of leave per plant, leave area, plant height, stem girth. And some of parameters were statistically at far by varied level of factors and time. Okra variety Clemson spineless significantly gave taller plants and increase in the plant organs. Both NPK fertilizer and poultry manure were found to play a significant role in increasing the growth of okra plant.

***Keywords*— Growth, influence, NPK fertilizer, okra, poultry manure.**

I. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop widely grown primarily for its soft immature fruits or pods and the third most important fruit vegetable crop after tomato in Nigeria. The pods contain a glutinous, sticky substance that is used to thicken soups and stews. They are boiled or fried and eaten as vegetable. They can also be cut into pieces, dried and/or powdered and stored for use in soups during the dry season when fresh okra fruits are scarce. Despite its nutritional value, its optimum yield (2-3t/ha) in the tropical countries is low partly because of continuous decline in soil fertility (Abdul-El-kader et al., 2010). With the results obtained from this study, it is revealed that increasing rate of poultry manure application have profound effect on the overall performances of okra plant. The poultry manure at the rate of 20t/ha was found to affect the growth and yield of okra positively in the assessed parameters and adapted to the nature of soil the environment study. The manure is cheap and easily assessable in the study area unlike the synthetic fertilizer. It is therefore, advisable

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to use this rate for the production of okra in the agro-ecological area.

Ibrahim et al. (2002) reported that NPK fertilizer increases soil fertility and yield of okra. However, NPK fertilizer is very expensive and therefore increases cost of production. It is also not environmentally friendly. Alternative sources of fertilizer are therefore sought to increase yield of okra. Olaniye et al. (2005) reported that manure applied in correct proportion not just improves soil porosity but it also contributes to good plants growth, development and yield. According to Emeberi et al. (1992), Poultry manure contains high amount of nutrients especially nitrogen that are easily taken up by plants for fast growth however, Oshunsanya (2011) reported that manure application should be limited to amount needed to make a difference between crop needs and the existing soil fertility levels, any manure application more or less will result into defect in production, However, there is lack of information on the recommended level of poultry manure required for economical production of Okra in the study area. It is based on this and lack of information on use of appropriate level of poultry manure on okra production to farmers in the area that this experiment was carried out to study the effect of different levels of poultry manure on the performance of Okra in Ikorodu Agro-ecological zone of Lagos, Nigeria.

Use of inorganic fertilizers can improve crop yields and soil pH, total nutrient content, and nutrient availability, but its use is limited due to scarcity, high cost, nutrient imbalance and soil acidity. Use of organic manures as a means of maintaining and increasing soil fertility has been advocated (Smil, 2000). Animal manures, when efficiently and effectively used, ensure sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields. Manures are usually applied at higher rates, relative to inorganic fertilizers. When applied at high rates, they give residual effects on the growth and yield of succeeding crops (Makinde et al., 2001) Improvements of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocating use of organic materials (Prabhu et al., 2003). Organic manures improve soil fertility by activating soil microbial biomass (Ayuso et al., 1996). Application of manures sustains cropping system through better nutrient recycling (Emeberi et al., 1992). Manures provide a source of all necessary macro- and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil.

Mixing organic and inorganic fertilizers may be a sound soil fertility management strategy in many countries. Apart from enhancing crop yields, the practice has a greater beneficial residual effect that can be derived from use of either organic or inorganic fertilizers applied alone. Makinde et al. (2001) reported that maize (*Zea mays* L.) yields obtained from application of a combination of synthetic fertilizer and manure improved yield over that from manure alone. Akande et al. (2003) reported that combined use of ground rock phosphate applied together with poultry manure significantly improved growth and yield of Okra (*Abelmoschus esculentus*) compared to application of each material separately. Akanbi et al. (2005) reported that the combined application of 4 $Mt \cdot ha^{-1}$ of maize straw compost and N mineral fertilizer at 30 $kg \cdot ha^{-1}$ improved plant growth and gave higher tomato (*Lycopersicum esculentum* L.) yields than other combinations. *Gliricidia sepium* (Jacq) Kunth is a common tropical legume tree, usually planted as a wind break and to trap atmospheric nitrogen to recycle into the soil as well as to generate biomass for feeding livestock. It is commonly used in alley farming systems in Africa. This study was conducted to determine effects of poultry manure, *Gliricidia* leaves and NPK 20-10-10 applied individually, and in combination, on growth and yield of okra and on soil nutrient dynamic

The combination of organic materials with reduced NPK fertilizer rates produced plants that were similar to unmixed NPK fertilizer. This indicated that the high dose of organic manures can be reduced by half and mixed with a reduced rate of NPK fertilizers as reported by Akande et al. (2003). The nutrient use efficiency of crops is better with a mix of manure and inorganic fertilizer. Nutrients seemed more available to okra plants with the mixes than the organic materials alone. The OBF-NPK mix supported okra growth better than NPK alone. Fertilization gave significantly higher fruit yields.

Application of a mix of organic materials and inorganic fertilizers can be used to sustain okra in the tropics. A similar trend of response had been earlier observed with other crops such as: maize (Makinde et al., 2001); with sorghum-*Sorghum bicolor* L (Prabhu et al., 2003) and with rice - *Oryza sativa* L (Senjobi et al., 2010). It appears N from *Gliricidia* leaves was more readily available to the plants than N from poultry manure and OBF. Lowered K content as a result of some treatments may be due to complexes formed

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with native soil K which causes the release of nitrogen in the NPK fertilizer. Application of organic materials increased soil Ph. This confirms findings of Akande et al. (2003) that application of organic materials could ameliorate slightly acidic tropical soil to improve crop production. *Gliricidia* leaves will require combination with NPK to release nitrogen to the soil. Application of organic materials increased soil available P, showing the potentials of the organic materials as source of P to the soil.

Application of organic based fertilizer, poultry manure, *Gliricidia* leaves and inorganic fertilizer enhanced plant growth and development when compared to untreated controls. Organic manures can be used to provide nutrition to okra and attain yields that generally are comparable to that obtained with mixtures of organic and mineral fertilizer. A comparable level of productivity can be achieved with a lowered level of mineral fertilizer combined with manures. The amount of manure required for optimum production can reduce the inorganic fertilizer requirement for okra

Production constraints of okra in Nigeria have been attributed to low input supply system, where green fruit yields, in most instances, have been relatively low (Ibrahim and Hamma, 2012). Even in cases where high yield cultivars have been grown, the inherently low fertility status of the soils, coupled with inadequate application of fertilizers, remain the principal limiting factors to okra production, especially in the savannah regions of Nigeria. As a result of this constrains, yields of 2 to 3 tones ha-1 of green fruits have been reported. The scarcity of inorganic manure associated with high cost, has created a lot of problems in arable crop production in Nigeria. In the past, farm yard manure has been used to improve and supplement soil nutrients (Adeleye *et al.,* 2010), but the advent of inorganic manure has reduced the use of organic manure by farmers as a source of plant nutrients and soil improvement because of its relative ease of application and quick results. A lot of these organic manures lie as wastes in rural and urban centers. They are occasionally dumped around farmstead and sawmills. Periodically, they are burnt while others remain on the ground surface, causing problem of environmental pollution and health hazards. Many farmers in Nigeria rely on these inorganic manure, hence, their productivity has not been so much profitable especially when these inorganic sources are neither readily available nor affordable (Ogunwale, 2003).

Most soils in the tropics especially in Dutsin-Ma are low in nutrients which are necessary for plant growth and development. Therefore, it is necessary to supplement the amount of nutrients present in the soil with inorganic or organic fertilizers or both to meet up crop requirement and increase yield of okra. Continuous application of mineral fertilizer only in tropics without supplementing with organic manure is associated with reduced crop yield, increased soil acidity and nutrient imbalance in soil. Therefore, a combination of organic materials and mineral fertilizers is important for management of these soils for high yield and quality harvest of okra (Akande *et al.*, 2003). Donahue et al. (1990) reported that NPK fertilizer increases soil fertility and yield of okra. However, NPK fertilizer is very expensive and therefore increases cost of production. It is also not environmentally friendly. Alternative sources of fertilizer are therefore sought to increase yield of okra. Therefore, this research work was aimed to evaluate the influence of poultry manure and NPK (15:15:15) fertilizer on the growth of okra plant.

II. MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Federal University Teaching and Research Farm Badole, Dutsin-Ma, Katsina State. Dutsin-Ma is located at longitude $07^0$27'41.7" E, latitude $12^0$23'52.1" N and altitude of 499 m, in the Sudan savanna ecological zone of Nigeria. The area lies within savanna zone of Nigeria and experience rainfall basically within the months of April and September. In the rare cases the rainfall can extended to early or mid-October. This experiment was started during rainy season in the month of June and completed during rainy season in the month of September.

Cropping History of the Site

The crops that are usually cultivated at the experimental sites are; maize (*Zea mays*), sorghum (*Sorghum bicolor*), millet as cereals, cowpea, bambaranut (*Cajanus cajan*) groundnut, okra, tomato, celosia, onion, pepper etc.

Source of Planting Material

The seed of okra used for this experiment was obtained from premier seed company, Zaria road Funtua, Katsina State, Nigeria, the variety used was Clemson spineless. It is an early maturity variety that matures at a period between 45-55 days from sowing.

Treatment and Experimental Design

The experiment consisted of nine (6) treatments and control in three replications. The treatments included 3 levels of poultry manure (0, 4, and 8 tons/ha) and 3 levels of NPK

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fertilizer (0, 40, and 80 kg/ha) which were laid out in a Complete Randomized Block Design (CRBD) and replicated three times. The experimental plot consisted of four rows 75cm inter row spacing and 30cm intra row spacing, the gross plot size is 4 m^2

Cultural Practices

The seed of Clemson spineless green okra was directly sown using dibbling method, two seeds were sown per hole at a depth of 1-5cm-2.0cm. Thinning was done at two weeks after sowing (WAS) to maintain plant population and density in the experiment. One plant was left per stand. The tagging of stand was done for easy collection of data, in which three plant were tagged in each plot. Weeding was done using hand picking and using of local hoe in controlled of weeds. During the experiment, chemicals were used for the control of pest in the site. The chemicals used are such Mixcrop and Marshel with active ingredient of lambda-Cyhalothrin 2.5 applied at dosage of 0.7/ha at the time when the okra was affected with pests at the economical level. Fertilizer application was done on treatment basis. The harvesting was done at interval (4-5 days) when the tender fruit of okra is edible. The first harvest was done at 63 days after planting.

Data Collection

The growth parameters were measured periodically at 2, 4 and 6 weeks after sowing (WAS) while the yield and yield parameters were measured at the harvest.

Fifty Percent Germination (50%)

The germination percentage was calculated at 4 days after sowing, in which the number of plant germinated were counted and the average was calculated for each and every one of the plot.

Plant Height (cm)

Plant height was measured using a graduated meter rule, measuring from the base to the growing tip of the plant. Three randomly plants were selected in each net plot and measured, their means height was recorded.

Number of Leaves per Plant

The number of leaves per plant was obtained by counting the number of leaves from the three tagged plants, the average number of leaves was calculated and recorded per plant.

Number of Branches per Plant

The number of branches per plant was obtained by counting the number of branches from the three randomized tagged plants for each net plot. The average number of branches was recorded per plant.

Leaf Area per Plant (cm^2)

The leave area was measured using a graduated meter rule, measuring from the base of the leaf tip point as leaf length and the wider area of a leaf was measured as the leaf width.

Stem Girth

The stem girth was measured using digital venire caliper. The three randomized tagged plant of the net plot were measured for each and every plot and then average was obtained and recorded.

Statistical Analysis

Data collected from the observation in the experimental site were subjected to statistical analysis of variance (ANOVA) and using of SAS package version 9.0 of the statistical analysis (SAS institute 2002). The differences among treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955). The effects were considered statistically at 5% level of probability.

III. RESULTS AND DISCUSSION

Effect and Interaction of Poultry Manure and NPK Fertilizer on the Growth of Okra

Days to 50% Germination and Number of Plant per Plot

Table 1 showed the result of the days to 50% germination and number of plant per plot at 2, 4 and 6WAS. Application of poultry manure had significant effect on the days to 50% germination. Application of poultry manure at 0-ton ha^{-1} attained 50% germination in significantly shorter days than application of 8 tons' ha^{-1}, but was at par with application of 4 tons' ha^{-1}.

Application of poultry manure was also significant on number of plant per plot at all the periods observed, except at 4WAS which was not significant. The application of poultry manure at 8tons ha^{-1} produced significantly the highest number of plant per plot but was however statistically similar to application of 0 tons' ha^{-1} and 4 tons' ha^{-1} at 2 and 6WAS respectively.

However, application of NPK fertilizer was not significant on the days to 50% germination of okra and number of plant per plot at all the rates applied. The interaction of poultry manure and NPK 15:15:15 fertilizer was also not significant on the days to 50% germination and on number of plant per plot at 2, 4 and 6WAS.

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Table 1: Influence of poultry manure and NPK fertilizer on days to 50% germination and number of plant per plot of okra at 2, 4 and 6WAS

TREATMENT	50%germination	Numbers of plant per plot		
		2WAS	4WAS	6WAS
PM tons ha^{-1}				
0 tons ha^{-1}	5.22^{a}	21.89^{ab}	20. 56	20.56^{b}
4 tons ha^{-1}	4.67^{ab}	20.89^{b}	20. 89	21.22^{ab}
8 tons ha^{-1}	4.33^{b}	22.44^{a}	21.78	21.78^{a}
SE±	0.22	0.39	0.43	0.35
NPK 15:15:15kg ha^{-1}				
0 kg ha^{-1}	4.33	21.67	20.78	21.22
40 kg ha^{-1}	5.00	21.78	21.22	21.33
80 kg ha^{-1}	4.89	21.78	21.22	21.00
SE±	0.22	0.39	0.43	0.35
INTERACTION				
PM*NPK	NS	NS	NS	NS

NS: Not significant, S: Significant, WAS: Weeks after Sowing, SE±: Standard Error. The means followed by the unlike letter(s) within the same column and treatment are significant at 5% level of probability using Duncan's multiple rate test (DMRT)

Plant Height and Number of Leaves

Table 2 presents the effect of poultry manure and rates of NPK fertilizer on plant height and number of leaves per plant of okra. Application of poultry manure had significant effect on plant height and number of leaves per plant at all the sampling period except at 2WAS where number of leaves per plant was not significant at the rates of application. Application of 8tons ha^{-1} of poultry manure produced the tallest plants and more number of leaves but was statistically similar to application of 4tons ha^{-1} at 4 and 6WAS.

Application of NPK 15:15:15 fertilizer was not significant at 2WAS and at 2 and 4WAS on plant height and number of leaves per plant respectively. However, application of 40 kg ha^{-1} produced significantly taller plants than the control but was also significantly equal to the application of 80 kg ha^{-1} plant height at 4 and 6WAS and number of leaves per plant at 6WAS. The shortest plant height and lowest number of leaves were obtained at the control treatment for all the sampling periods on both application of poultry manure and NPK fertilizer.

The interaction between poultry manure and NPK 15:15:15 fertilizer was not significant on plant height and number of leaves per plant of okra.

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Table 2: Influence of poultry manure and NPK (15:15:15) fertilizer on plant height and number of leaves of okra plant at 2, 4, and 6 WAS

TREATMENT	Plant Height			Number of Leaves		
	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS
PM tons ha^{-1}						
0 tons ha^{-1}	7.24^{c}	9.79^{b}	34.21^{b}	5.22	7.44^{b}	9.0^{b}
4 tons ha^{-1}	8.14^{b}	21.78^{a}	42.12^{a}	5.44	8.00^{a}	9. 89^{ab}
8 tons ha^{-1}	9.79^{a}	23.06^{a}	45.06^{a}	5.67	7.89^{a}	10.11^{a}
SE±	0.22	0.49	1.14	0.17	0.13	0.34
NPK (15:15:15kg ha^{-1})						
0 kg ha^{-1}	8.18	18.66^{b}	35.11^{b}	5.56	7.78	8.89^{b}
40 kg ha^{-1}	8.37	21.08^{a}	41.58^{a}	5.44	7.89	9.67^{ab}
80 kg ha^{-1}	8.63	22.42^{a}	44.70^{a}	5.33	7.67	10.44^{a}
SE±	0.22	0.49	1.14	0.17	0.13	0.34
INTERACTION						
PM*NPK	NS	NS	NS	NS	NS	NS

NS: Not significant, S: Significant, WAS: Weeks after Sowing, SE±: Standard Error. The means followed by the same letter (s) within the same column and treatment are significant the at 5% level of probability using Duncan's multiple rate test (DMRT)

Leaf Area and Stem Diameter (Stem Girth)

Application of poultry manure had significant effect on leaf area and stem girth of okra (Table 3). Application of 8 tons' ha^{-1} and 80 kg ha^{-1} produced significantly wider leaf area and stem girth of okra plant than other rates of application, but was however at par with application of 4tons ha^{-1} of leaf area at 4WAS. Application of NPK fertilizer also showed significant difference in all the treatments except at 2WAS in both leaf area and stem girth were they were insignificant (Table 3). Application of 40kg ha^{-1} produced significantly the largest leaf area and stem girth of okra, but was however statistically similar to the application of 80kg ha^{-1}. The control treatments produced the least leaf area and stem girth in the application of poultry manure and NPK fertilizer.

There was no significant difference in the interaction between poultry manure and NPK fertilizer on okra in this experiment. The interaction of the application of 4ton ha^{-1} of poultry manure and that of 80kg ha^{-1} NPK fertilizer produced the thickest stem diameter (Table 4).

Table 3: Influence of poultry manure and NPK (15:15:15) fertilizer on leaf area and stem diameter of okra plant at 2, 4, and 6WAS

TREATMENT	Leaf Area			Stem Diameter		
	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS
PM tons ha^{-1}						
0 tons ha^{-1}	34.45c	143.74^{b}	230.15^{c}	4.07^{c}	6.72^{c}	20.65^{c}
4 tons ha^{-1}	38.38^{b}	209.44^{a}	308.53^{b}	4.48^{b}	8.49^{b}	21.62^{b}

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8 tons ha^{-1}	44.42^{a}	230.85^{a}	407.88^{a}	4.88^{a}	9.56^{a}	22.58^{a}
SE±	0.64	9.55	14.09	0.09	0.30	0.19
NPK (15:15:15kg ha^{-1})						
0 kg ha^{-1}	39.87	133.20^{b}	247.25^{b}	4.43	7.36^{b}	20.59^{b}
40 kg ha^{-1}	37.98	213.79^{a}	335.11^{a}	4.54	8.28^{a}	21.94^{a}
80 kg ha^{-1}	39.39	237.04^{a}	364.21^{a}	4.46	9.13^{a}	22.32^{a}
SE±	0.64	9.55	14.09	0.09	0.30	0.19
INTERACTION						
PM*NPK	NS	NS	NS	NS	NS	NS

NS: Not significant, S: Significant, WAS: Weeks after Sowing, SE±: Standard Error. The means followed by the same letter (s) within the same column and treatment are significant the at 5% level of probability using Duncan's multiple rate test (DMRT)

Table 4: Interaction between poultry manure and NPK fertilizer on Stem Diameter

	NPK (kg^{-ha})		
TREATMENTS	0	40	80
PM (tons ha^{-1})			
0ton	20.95^{e}	21.51^{e}	22.84^{e}
4tons	22.95^{e}	28.01^{d}	34.36^{a}
8tons	27.60^{d}	32.64^{b}	31.39^{c}
SE±	0.34		

IV. DISCUSSION

Effect of Poultry Manure on the Growth of Okra Plant

The significant increase in plant height and number of leaves per plant as a result of the application of poultry manure may be attributed to the beneficial role of manure in enhancing soil nitrogen, phosphorus, potassium and other essential nutrients which in turn improved growth and development of the plants during the trials. The positive effect of poultry manure on these growth attributes could also be due to the contribution made by the manure to fertility status of the soils, as the soils were low in organic carbon content. The manure when decomposed increased both macro and micro-nutrients as well as enhances physico-chemical properties of the soil. This could have led to its high vegetative growth. (Akanbi et al., 2005), poultry manure has been reported to contain a relative high nitrogen content that supported more of vegetative growth in crops. Dademel et al. (2004) reported that the nitrogen content in both organic fertilizers has been known to enhance leaf production, seed formation and root formation, this will lead to higher metabolic activities and consequently higher fresh fruit yield in okra. Okra growing on poultry manure performed better in terms of plant height, number of leaves, leaf area and stem diameter. This shows that poultry manure was readily available and in the suitable balance for easy absorption by the plant roots, thus, enhance the morphological growth of the plant. And also this is supported with the findings of Ibrahim et al. (2002) in okra production in which they reported that, organic manure especially poultry manure could increase plant height and branches of crops. Increase in the poultry manure rate has a significant effect on the vegetative growth of the plant.

Effect of NPK Fertilizer on the Growth of Okra Plant

Okra plants responded with significant increase with increase in NPK application, this could be because most vegetable crops require NPK fertilizer of about 40-60 N, 20-40 P and 20-40 K (kg ha^{-1}) for optimum growth and yield

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development, however, where these nutrients are insufficient or inadequate, application of the deficient elements through fertilization are well encouraged and recommended under different agromatic conditions which can be manipulated to maximized production from a unit land area. Therefore, the increase in growth with increase in NPK fertilizer. Babatola and Olaniyi (1999) also support the fact that increase in NPK leads to increase in vegetative growth of onion.

The significant response of growth components such as number of leaves per plant, and leaf area of the trials could be attributed to the role of applied NPK to the plants during the trials, which were essential in plant growth and development. This is supported by the findings of Musa et al. (2017) and Smith et al. (2001) who reported that the use of NPK under good environmental conditions significantly influenced the growth of okra and cowpea. The crop requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield. Another study had shown that the application of N and or NPK led to significant increase in the growth of okra (Katung et al.1996). Growth characters such as plant height, shoot fresh weight, number of leaves per plant, number of primary branches per plants are maximized either at 60 or 90 kg N ha-1 at early stage of growth.

V. CONCLUSION

The application of 80 kg ha^{-1} NPK fertilizer significantly influenced the growth of okra plant. Poultry manure fertilization at the rates of 4 and 8 t ha^{-1} exerted significant influences on the growth of okra. However, application of 8 t ha^{-1} of poultry manure seems to be more appropriate for the production of okra in Sudan savanna ecological zone of Nigeria. Poultry manure must have made available its embedded nutrients through mineralization, created conducive environment for soil microbial activity and exerted great influence on soil physical, chemical and biological properties for enhanced okra growth. More so, application of both poultry manure and NPK fertilizer at 50% NPK + 50 % poultry manure proved to be the most influential in producing good growth performance in okra.

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