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Productivity of okra (*Abelmoschus esculentus* L. Moench) as Influence by NPK Fertilizer and poultry manure in Northern Sudan Savanna Region of Nigeria

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Abstract**—** *The aim of this research work was to evaluate the effect of different levels of NPK fertilizer (0, 40, 80 kg ha^{-1}) and poultry manure (0, 4, 8 tons' ha^{-1}) on the productivity of okra plant. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. From the result of the experiment, it was shown that there was significant difference in days to 50% flowering by application 0-ton ha^{-1} of both NPK and poultry manure. The application of poultry manure and NPK 15:15:15 showed significant difference among the treatments to fruit length, fruit diameter, fruit yield in kgha^{-1} and weight of fruit in kgha^{-1} 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 fruit length, fruit diameter, fruit yield ha^{-1}, and weight of fruit in kgha^{-1}. Some of the parameters were statistically at far by varied level of factors and time. Okra variety Clemson spineless significantly gave taller plants, longer fruits and fewer days to 50 % flowering. Both poultry manure and NPK fertilizer were found to be sufficient to increase the yield of okra plant.*

Keywords**— Influence, NPK fertilizer, okra, poultry manure, productivity.**

I. INTRODUCTION

Okra (*Abelmoschus esculentus L*. Moench) belongs to family malvaceae with 2n=8x=72 or 144 and is polyploidy in nature. There are 30 species under genus *Abelmoschus* in the old world and four in the new world. Out of them *Abelmoschus esculentus* is the only species known to be cultivated extensively as commercial vegetable. Being it is self-pollinated crop, occurrence out crossing to an extent of 20 percent by insects has made an often cross - pollinated crop.

Being native of tropical Africa, it is widely cultivated in Nigeria. Okra is valued for its delicious tender fruits. It is the best source of iodine and calcium. Okra accounts for 60 percent of export of fresh vegetables excluding potato, onion and garlic (Ibrahim et al., 2002). Okra is cultivated for its green non - fibrous fruits or pods containing round seeds. The fruits are harvested when immature and eaten as a

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vegetable. Okra fruit can be cooked in a variety of ways. The roots and stems of okra are used for clarification of sugarcane juice from which sugar or brown sugar is prepared (Olaniyi et al., 2005). Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Mature fruits and stems containing crude fiber are used in the paper industry. Extracts from the seeds of the okra is an alternative source for edible oil. The greenish yellow edible oil has a pleasant taste and odour, and is high in unsaturated fats such as oleic acid and linoleic acid. Okra provides an important source of vitamins, calcium, potassium and other minerals which are often lacking in the diet in developing countries (Olaniyi et al., 2005).

Widely grown, distributed and consumed either fresh or in dried form. The crop is an annual vegetable, grown from seed and is widely cultivated in the tropics for its fruits used as vegetables. In Africa, there is great diversification of okra with the most important production regions in Ghana, Burkina-Faso and Nigeria (Raemaekers, 2001). Okra is grown in all types of soils, thriving best in moist friable well manured soil. The production and economics importance of okra in Nigeria has rapidly increased in recent years and the seasonal supply of this vegetable to a large extent determines how much of it is being consumed by the majority of the people. The total world production of okra is estimated at 6 million metric tons per year and production in West and Central Africa is estimated at 500,000 – 600,000 metric tons annually based on available consumption data (Singh et al., 2004). The West and Central Africa region accounts for more than 75% of okra produced in Africa, but the average productivity in this region low (2.5 t/ha) compared to East (6.2 t/ha) and North Africa (8.8 t/ha). Nigeria is the largest producer (1,039,000t/ha) followed by Cote d' Ivoire, Ghana and others (Singh et al., 2004).

Okra is a good source of vitamin A, B and C including minerals especially iodine and amino acids found in the seeds; which competes favorable with those in poultry, eggs and soybean (Senjobi et al., 2000). The stem is useful as fiber, while the leaves are considered good cattle feed and are sometimes consumed by man. Smith et al. (2001), reported that okra contain about 20% edible oil and protein, while its mucilage is utilized for medicinal purposes. Composition per 100 g of edible portion of okra contains, Calories 35.0 mg, Calcium 66.0 mg, Moisture 89.6 g, Iron 0.35 mg, Carbohydrates 6.4 g, Potassium 103.0 mg, Protein 1.9 g, Magnesium 53.0 mg, Fat 0.2 g, Copper 0.19 mg, Fibre 1.2 g, Riboflavin 0.01 mg, Minerals 0.7g, Thiamine 0.07 mg, Phosphorus 56.0 mg, Nictonic acid 0.06 mg, Sodium 6.9 mg, Vitamin C 13.10 mg, Sulphur 30.0 mg and Oxalic acid 8.0 mg (Ibrahimet al.,2002). Okra is said to be very useful against genito - urinary disorders, spermatorrhoea and chronic dysentery. Its medicinal value has also been reported in curing ulcers and relief from hemorrhoids.

The improvement of soil fertility through the application of fertilizers has become an essential factor that enables the world to feed billions of people (Abdul-Elkader et al., 2010). Organic manure is a compound fertilizer that contains one or more kinds of organic matter and the ingredient may be animal or vegetable matter or a composed. Poultry manure has a fairly high nutrient composition when compared with other animal sources such as goats, pigs, and cattle manures (Akanbiet al.,2005). Poultry manure is widely recognized as soil conditioner for raising soil PH and exchangeable bases levels. Inorganic fertilizer (referred to as synthetic fertilizer), is manufactured artificially and contains minerals or synthetic chemicals typically made up from petroleum or natural gas including phosphorus, potassium and other trace elements often mined from the earth. The proper use of inorganic fertilizers can improve crop yield, soil PH, total nutrient content and nutrient availability to plants (Akandeet al.,2003).

Fertilizer is one of the most important inputs contributing to crop production because it increases productivity and improves yield quantity and quality. The general low ambient soil nutrient content made the soil suitable for study of responses to fertilizer. Application of organic materials generally resulted in growth which compared favorably with NPK fertilizer alone. Soil productivity maintenance is a major constraint of tropical agriculture. Crop cultivation is usually moved between fields to utilize only fertile soils for some years without use of fertilizers. However, this cannot be sustained to meet increased demand of an increasing population. Tropical soils are adversely affected by sub-optimal soil fertility and erosion, causing deterioration of the nutrient status and changes in soil organism populations (Akandeet al.,2003).

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,

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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 (Adeleye*et al.,* 2010). They are occasionally dumped around farmstead and sawmills (Ogunwale, 2003). The aim of this research work was to evaluate the effects of NPK 15:15:15 and poultry manure on the yield of okra.

II. MATERIALS AND METHODS

Experimental Site

The experiment was carried out at 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 499m, 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.

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.

Determination of soil and poultry manure nutritional status

Soil samples were collected randomly from the experimental sites at a depth of 0-30 cm using soil auger. Routine soil analysis was carried out to determine particle size distribution by hydrometer method (Adeosun, 2000). Soil pH, using pH meter as described by Walkley-Black (1934) total N was determined using Kjeldhal method as described by Bremner and Malvaney (1982). Available P was determined by Bray 1 test. Exchangeable bases (Ca, Mg, k and Na) were extracted with IN Ammonium (NH_4OAC), Ca and Mg were determined using absorption spectrophotometer while K and Na was determined using flame photometer.

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 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

Seed Sowing

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

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.

Fertilizer Application

Fertilizer application was done on treatment basis.

Weeding

Manual hoe weeding was carried out at 2 and 4 weeks after sowing

Pest and Disease Control

Insect pest observed on the field were treated accordingly. This was carried out from pre-flowering to flowering and pod formation stages at weekly interval using karate 5 EC and Judo (lambda cyhalothrin 2.5% EC) in 15 ml of water using knapsack sprayer.

Harvesting

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.

Observation and Data Collection

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The yield and yield parameters were measured at the time of harvesting.

Number of fruit per plant

All the harvested fruit of the randomized three tagged net plot plant was counted and divided by the number of the tagged plant i.e. three and the average was obtained and recorded

Number of fruit per plot

All the harvested fruits were counted from each net plot and recorded.

Fruit yield per hectare

The fruit yield per hectare was determined at harvest. The harvested fruits from net plot were weighted. The total weight per plot was expressed in kilogram per hectare and recorded.

Statistical data 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. 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 Yield of Okra

Days to 50% Flowering, Fruit Length, Diameter, Yield and Weight

Application of poultry manure was significant on the days to 50% flowering day, fruit length, diameter and yield of okra plant (Table 1). However, application of poultry manure was not significant in the fruit weight of okra plant (Table 1). Application of 8tons ha^{-1} produced significantly more fruit length, diameter and yield of okra plant than other application rates while application of 0 tons' ha^{-1} produced the least. Application of no poultry manure and NPK fertilizer attained 50% flowering on lesser number of days than other application rates. However, application of 80kg ha^{-1} of NPK fertilizer produced significantly more fruit length, diameter and weight of okra. Application of 40kg ha^{-1} NPK was statistically similar to that of the application of 80kg ha^{-1} with the control producing the least yield of okra.

Interaction between poultry manure and NPK fertilizer showed significant difference in the days to 50% flowering, fruit diameter and fruit weight. The interaction was however not significant in fruit length and fruit yield of okra plant.

The interaction effect between poultry manure and NPK fertilizer on days to 50% germination was significant, with plots treated with zero treatment producing more 50% flower (Table 2). However, the interaction between 8tons ha^{-1} of poultry manure and 80kg ha^{-1} NPK fertilizer also produced significantly heavier okra fruits than other interactions (Table 3).

Table 1: Influence of poultry manure and NPK (15:15:15) fertilizer on days to 50% flowering, fruits length, fruits diameter, fruit yield per hectare, and fruits weight per hectare of okra plant

TREATMENT	50% FLOWERING	FRUIT LENGTH	FRUIT DIAMETER	FRUIT YIELD/HA	FRUIT WEIGH(kg/HA)
PM tons ha^{-1}					
0 tons ha^{-1}	21.22^{a}	12.10^{c}	21.77^{c}	96370.00^{c}	122148
4 tons ha^{-1}	19.78^{b}	14.29^{b}	27.45^{b}	106148.00^{b}	2077.00
8 tons ha^{-1}	19.33^{c}	15.43^{a}	31.53^{a}	122148.00^{a}	3525.90
SE±	0.09	0.13	0.19	3074.06	287.81
NPK					
(15:15:15kg ha^{-1})					
0 kg ha^{-1}	21.00^{a}	12.97^{c}	23.83^{c}	95037.00^{b}	929.20^{c}

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40 kg ha^{-1}	19.78^{b}	13.98^{b}	27.38^{b}	111777.00^{a}	1847.70^{b}
80 kg ha^{-1}	19.56^{b}	14.88^{a}	29.53^{a}	117852.00^{a}	3423.60^{a}
SE±	0.09	0.13	0.19	3074.06	287.81
INTERACTION					
PM*NPK	**	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 at 5% level of probability using Duncan's multiple rate test (DMRT)

Table 2: Interaction between poultry manure and NPK fertilizer for days to 50% flowering.

	NPK (kgha^{-1})		
TREATMENTS	0	40	80
Poultry Manure (t ha^{-1})			
0ton	22.00^{a}	21.00^{b}	20.67^{b}
4tons	21.00^{b}	19.33^{d}	19.00^{d}
8tons	20.00^{c}	19.00^{d}	19.00^{d}
SE±	0.15		

Table 3: Interaction effect weight in kg/ha of okra fruits

	NPK (kgha^{-1})		
TREATMENTS	0	40	80
PM (tons ha^{-1})			
0ton	430.4c	604.1c	758.1c
4tons	965.2c	1850.4bc	3415.3b
8tons	1392.0c	3088.5b	6097.3a
SE±	0.3		

Discussion

Effect of Poultry Manure on the Productivity of Okra Plant

An increase in the number of fruits 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 the increase in yield attributes could also be due to the contribution made by the manure to increase the 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. Dademelet al. (2004) reported that the nitrogen content in both organic fertilizers has been known to enhance flowering, seed formation and root formation, this will lead to higher metabolic activities and consequently higher fresh fruit yield in okra.

Yield components such as number of fruits per plant, fruit diameter, and fruit yield were significantly influenced by the

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application of poultry manure. This could be attributed to the fact that vegetative growth had been favored more if poultry manure was applied at higher dosage. Coupled with the high N content in the soils that could favor vegetative growth at the expense of reproductive growth, thus lead to the not significant response in the yield components. It could either be there were some nutrients already present in the soil or the plant need were satisfied with that quantity of nutrients present in the soil. This would have apportioned more of the plant photosynthetic to more of growth and yield characters as well as pod development. While to the peculiar to high nitrogen application present in the poultry manure which might bring nutrient in-balance and antagonism that could result in the lower yield observed in the present investigation. Application of high rate of manure or manure with high N content has been reported to cause reduction in fruits yield (Adekiya and Agbede, 2009). The reason for increase in yield could also be attributed to the solubilization effect of the major essential nutrients with addition of poultry manure thereby resulting to increased uptake of N P and K (Sonkuwaret al., 1997). The not significant response in fruit weight (kg ha^{-1}) to poultry manure experienced in the field experiment could be as a result of water logging experienced in some of the plots during the trial due to the soil topography, physical and biological properties which made it difficult for the plants to respire and utilize the nutrient available in the soil for its growth and development, thus caused reduction in yield. This could also be as a result of leaching, which made difficulty in the absorption and utilization of the nutrients that can be used for good yield and development, which may go beyond the root zone of the okra plant.

Effect of NPK Fertilizer on the Productivity of Okra Plant

An 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 yield 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.

An increase in response to yield components such as number of fruits per plant, and fruit weight per hectare 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 Smith et al.(2001) who reported that the use of NPK under good environmental conditions significantly influenced the fruit yield of okra. The crop requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield. This also agrees with the findings of Adediran and Banjoko (2003) and Musa et al. (2020) which showed the application of these nutrients (N, P and K) is important for enhanced fruit number and yield of okra. Another study shown that, the application of N and or NPK led to significant increase in the yield of okra (Katunget al., 1996).

The significant response recorded by okra on yield components such as number of fruits per plant and fruit yield (kg ha-1) to the application of NPK fertilizer up to 80 kg ha^{-1}, could be attributed to the significant role play by NPK in the improvement of soil fertility, nutrient uptake and enhancement of crop yields. This is supported by the findings of Smith et al.(2001) who reported that the use of NPK under good environmental conditions significantly influenced the fruit yield of okra. The crop requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield. This also agrees with the findings of Adediran and Banjoko. (2003) which showed the application of these nutrients (N, P and K) is important for enhanced fruit number and yield of okra. Another study has shown that the application of N and or NPK led to significant increase in the yield of okra and cowpea (Katunget al.,1996; Musa et al., 2017; Musa et al., 2020).

Effect of the combination of poultry manure and NPK fertilizer on the productivity of okra

The interactions between poultry manure and NPK fertilizer was significant on the number of fruits per plant and ability to adapt to the environmental conditions.High weight of fruit was obtained when 80 kg NPK ha^{-1} was applied in combination with 8 t ha^{-1} poultry manure than the rest of the treatments. This is in agreement with the findings of a research in which application of 50% NPK + 50 % poultry manure proved most effective in ensuring good performance in terms of fresh yield of lady's finger in valley soils of Chittangon, Bangladesh, and also reported that nutrients seemed more available to okra plants with mixes than the organic material alone (Akandeet al., 2003). The nutrient use efficiency of crops tends to be better with mix of manure and

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inorganic fertilizers. Nutrients seemed more available to okra plant with the mixes than the organic materials alone, a similar trend of response had been earlier observed with other crops such as maize and sorghum bichlor L. (Ayusoet al. 1996; Makindeet al. 2001; Nehra et al 2001).

IV. CONCLUSION

Application of 80 kg ha^{-1} NPK fertilizer had significantly influenced the productivity of okra plant. Poultry manure fertilization at the rates of 4 and 8 t ha^{-1} exerted significant influence on the productivity 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. Moreover, application of both poultry manure and NPK fertilizer at 50% NPK + 50 % poultry manure proved to be the most effective in ensuring good performance of good weight of okra fruits plant.

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