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Impact of poultry manure on fruit yield and yield components of inland valley okra (*Albelmoschus esculentus* L.) in a forest – Savannah transition ecology of Nigeria

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ABSTRACT

A field experiment was conducted in an inland valley at the Federal University of Agriculture, Abeokuta, Nigeria in 2009 and 2010 to study the response of okra (*Abelmoschus esculentus*) to different rates of poultry manure. The poultry manure rates were 12.5, 25, 37.5 and 120 kgha^{-1} NPK (20-10-10) as check and no amendment as control. All these were arranged in Randomized Complete Block Design with five treatments and three replicates. Data collected on growth and yield parameters were analysed using general linear model and treatment means were separated using Duncan's Multiple Range Test. Application of poultry manure at 37.5 kgha^{-1} produced the tallest plant (58.1 cm) which was significantly different from the rest treatments, it was followed by 25 kgha^{-1} (55.3 cm) and 12.5 kgha^{-1} (52.5 cm) and shortest plants were observed in the control. NPK produced the largest leaf area (1.36 m^{2}plant^{-1}) compared to other treatments. Fruit length and number of fruit plant^{-1} were similar among plants treated with 25 and 37.5 kgha^{-1}. Similarly, fresh fruit weight was similar among the plants treated with 25 and 37.5 kgha^{-1} in the two years. It is therefore concluded that 25 kgha^{-1} of poultry manure may be adequate to meet the okra nutritional need in the partially depleted inland valley and can be produced twice using the residual moisture in dry season.

Keywords: *Abelmoschus esculentus*, fertilizer, fresh fruit weight, inland valley, poultry manure.

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INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) Moench, is an important vegetable crop natural to West Africa (Tindal, 1983) whose productivity could reach 7.74 ton/ha (Anonymous, 2004). The word okra is of Africa origin and called "*Lady's fingers*" in Igbo language of Nigeria (Olaniyi et al., 2010). It is a good source of vitamins, minerals, calories and amino acid found in seeds and compares favorably with those in poultry, eggs and soybean (Thompson, 1949; Schippers, 2000).

In spite of the potential of okra as a food security vegetable crop, yields are generally low in the tropics. A major cause of the low yields in this region is the growing population and the attendant pressure on land, resulting in more intensive agriculture and declining soil fertility.

Mbagwu and Ekwealor (1990) reported low organic matter, low reserves of essential plant nutrients and high soil acidity in the major agricultural lands of the region. They had earlier suggested the use of organic manure to improve the nutrient content and other soil physical characteristics in order to sustain yields.

Organic manure has variously been reported to improve the physical condition of soil and provides adequate amount of necessary nutrients for the soil productivity (Premsekhar and Rajashreee, 2009; Akande et al., 2010). Animal manure plays a vital role in soil fertility maintenance due to its intrinsic value as a soil amendment (Williams et al., 1993). The beneficial roles of manure in soil chemical properties have long been recognized. The capacity of manure to provide nutrients, especially, N, P and K is one of such benefits. It also increases in cation exchange capacity and pH (Ano and Agwu, 2005). Other important uses of poultry manure have been enumerated (Adeleye et al., 2010; Eifediyi and Remison, 2010).

Lowlands like flood plains and inland valleys have considerable potential for agricultural intensification and diversification. This is because double cropping is possible for many crops including fruit vegetables such as okra using residual moisture (Buri et al., 2011). The vast area of land which constitutes lowland in Nigeria is great and underutilized. A minor component is planted with leafy vegetables, sugar cane, rice and sometime for very early maize in forest ecology. However, poor management and the low fertility status are limiting factors for their effective utilization (Buri and Wakatsuki, 1996; Buri et al., 2010)

The use of inorganic chemical fertilizers is expensive and also hazardous to the soil environment. Chemical fertilizer could cause problems not only to the soil health but also to the human health and physical environment. Considering these facts, the present study was undertaken to determine the impact of poultry manure on yield and yield components of okra (*A. esculentus* L.) grown in inland valley which has been continuously cultivated with vegetables and dry season maize.

MATERIALS AND METHODS

Sampling area

The field experiment was carried out on an inland valley at the University of Agriculture Abeokuta (7°20′ N, 3°23′ E) Nigeria, during the dry season of 2009 and repeated in early wet season of 2010 which lasted for about six months. The area is transitional between forest and savannah ecologies of the tropics. There are two distinct seasons – the wet season, which extends from May to October and the dry season from November to last week in May in the year of this experiment. The mean annual rainfall is 1,113 mm. The mean monthly temperature varies from 22.94°C in August to 36.32°C in March. The relative humidity ranges from 75.52% in February to 88.15% in July.

Experimental design

The experiment was Randomized Complete Block Design (RCBD) with five treatments and three replicates. The treatments were three levels of poultry manure (12.5, 25 and 37.5 tha^{-1}) equivalent to 25, 50 and 75 kg N respectively, one level of NPK 20 – 10 – 10 fertilizer (120 $kgha^{-1}$) as check and the control without any amendment.

Soil samples were collected before the application of fertilizers for pre-experimental soil analysis using standard procedures. Planting was done twice within a circle of planting as the experiment was repeated during the dry season using the residual moisture. The poultry manure was also analyzed for nutrient content. Particle size analysis was carried out with hydrometer (Bouyoucos, 1962) using sodium hexa meta-phosphate as dispensing agent. Soil pH was determined in distilled water at a 1:1 (w/v) soil water:ratio. Exchangeable bases were extracted with neutral 1M NH_4OAC at a soil solution ratio of 1: 10 and measured by flame photometry. Magnesium was determined with an Atomic Absorption Spectrophotometer. Exchange acidity was by titration of 1 M KCl extract against 0.05 M NaOH to a pink end point using phenolphthalein as indicator (McLean, 1982).

The poultry manure was applied two weeks before planting to allow for mineralization. Okra seeds were planted at a placing of 30 × 30 cm at three seeds per hole which was later thinned to one per stand in a plot of 5 × 6 m^2, while the net plot was 8 m^2. Manual weeding was carried out at two and six weeks after germination. The experiment was repeated on the same plot in the following season. Five plants were randomly tagged from the net plot for collection of data on the growth parameters like plant height, stem girth and leaf area. Plants were selected for determination of yield component and yield parameters. Fruits harvesting was carried out at four days intervals as the fruit reached consumable size. Number of fruits was noted on each occasion and fresh pod weight was obtained to determine the yield. The vegetative parameters such as plant height, number of branches, root length were measured. Leaf area was determined using the method of Nichiporovich (1983). At harvest, plant were uprooted and partitioned into leaves, stem and roots. They were subsequently oven dried for 48 h at 60°C and weighed to determine their dry weights.

Data collected were analyzed using general linear model (SAS, 1999) and means were separated using Duncan's Multiple Range Test at 5% level of probability.

RESULTS

The initial soil physical chemical properties of the location used for the experiment and that of the poultry manure are shown in Table 1. The soil had pH values of 5.89 at the onset of the study. Organic carbon was 1.04%, total nitrogen was 0.08. Available phosphorus stayed at 12.15 mg kg^{-1} and exchangeable potassium was 0.13 mg kg^{-1}. Content of Ca, Mg, and Na were 0.67, 0.43 and 0.05 $mgkg^{-1}$, respectively. Trace element analysis also indicated the Zn, Cu and Fe from the location are from low to medium range. The soil was slightly acidic with low level of available nitrogen at the initial stage. Conversely, available P was on the high side. The acidic level and low nutrient status of the experimental location made it suitable for the trial.

Rate of poultry manure as well as NPK fertilizer significantly affected the plant height, stem girth and leaf area of okra plant in both years (Table 2). Application of 37.5 kg/ha poultry manure brought about the tallest plant which was significantly different from the rest treatments ($p < 0.5$); it was followed by 25 kg/ha while 12.5 kg/ha and NPK check were similar and above the control. The stem girth was similar among all the treatments but higher than the control whereas the leaf area was similar among the different rates of poultry and control but higher with NPK treatment.

Poultry manure rates at 37.5 kg/ha and NPK had similar and largest number of flowers in both years. Other treatments and control were similar whereas, pod girth was greater in 25 kg/ha and followed by 37.5 kg/ha. The other treatments were similar to control (Table 3).

Table 1. Soil physical and chemical properties of the location before the trial and manure analysis.

Parameter	Soil	Poultry manure
pH (H_2O)	5.89	6.11
Organic Carbon (%)	1.04	6.94
Total N (%)	0.08	6.48
Avail. P (mg/kg)	12.15	4.90
Exchangeable K (mg kg^{-1})	0.13	1.03
Exchangeable Ca (mg kg^{-1})	0.67	0.12
Exchangeable Mg (mg kg^{-1})	0.43	1.01
Exchangeable Na (mg kg^{-1})	0.05	0.25
ECEC (mg kg^{-1})	1.29	0.46
Trace elements (mg/kg)		
Mn	4.39	39.39
Zn	2.28	26.28
Cu	0.31	3.31
Fe	4.78	2.78
Sand gKg^{-1}	784	
Silt gKg^{-1}	164	
Clay gKg^{-1}	52	

Table 2. Effect of poultry manure on plant height, stem girth and leaf area of okra in 2009 and 2010.

Manure rates (tha^{-1})	Plant height (cm)	Stem girth (mm)	Leaf area (m^2 $plant^{-1}$)	Plant height (cm)	Stem girth (mm)	Leaf area (m^2 $plant^{-1}$)
Control	43.2^d	40.4^b	1.24^b	43.9^d	40.4^b	1.24^b
12.5	52.5^c	53.3^a	1.26^b	53.5^b	53.3^a	1.26^b
25	55.3^b	50.3^a	1.25^b	54.3^b	50.3^a	1.25^b
37.5	58.1^a	50.2^a	1.25^b	56.1^a	50.2^a	1.25^b
NPK (Check)	51.2^c	49.5^a	1.36^a	51.2^c	49.5^a	1.29^a

Values in the same column followed by the same letter are not significantly different from each other based on Duncan Multiple Range Test at $P \leq 0.05$.

Table 3. Effect of poultry manure on fruit length, pod girth and number of fruits of okra in 2009 and 2010.

Manure rates (tha^{-1})	Fruit length (cm)	Pod girth $plant^{-1}$	Number of fruit $plant^{-1}$	Fruit length (cm)	Pod girth $plant^{-1}$	Number of fruit $plant^{-1}$
Control	5.43^c	112^c	88^c	5.32^c	100^c	85^c
12.5	6.35^b	100^c	110^b	6.27^b	102^c	114^b
25	7.75^a	110^b	130^a	7.65^a	125^a	126^a
37.5	7.75^a	120^a	120^a	7.66^a	115^b	118^a
NPK (Check)	6.98^b	100^c	100^b	6.88^b	100^c	95^b

Values in the same column followed by the same letter are not significantly different from each other based on Duncan Multiple Range Test at $P \leq 0.05$.

The effect of rates of poultry manure on fruit length, pod girth and number of fruit is presented in Table 4. All the nutrient amended treatments had significantly higher values for all the yield parameters when compared with control. Fruits length was however similar among 25 and 37.5 kg/ha treatments but higher than NPK check which is also similar to 12 kg/ha in both years. Treatment with 25 and 37.5 kg/ha and 25 kg/ha produced the highest pod girth in 2009 and 2010 respectively while the other treatments were similar but higher than control. Similarly,

Table 4. Effect of poultry manure on fruit weight of okra in 2009 and 2010.

Manure rates (tha^{-1})	Fresh fruit weight (tha^{-1})	Fresh fruit weight (tha^{-1})
Control	1.55^{c}	1.45^{c}
12.5	2.77^{b}	2.47^{b}
25	3.18^{a}	2.98^{a}
37.5	3.85^{a}	3.45^{a}
NPK (Check)	2.26^{b}	2.46^{b}

Values in the same column followed by the same letter are not significantly different from each other based on Duncan Multiple Range Test at P ≤ 0.05.

Table 5. Effect of poultry manure on root, stem and leaf dry weight of okra in 2009 and 2010.

Manure rates (tha^{-1})	Root (g $plant^{-1}$)	Stem (g $plant^{-1}$)	Leaf (g $plant^{-1}$)	Root (g $plant^{-1}$)	Stem (g $plant^{-1}$)	Leaf (g $plant^{-1}$)
Control	12.34^{c}	23.40^{c}	8.22^{c}	12.2^{c}	28.43^{c}	8.13^{c}
12.5	13.23^{a}	28.97^{b}	12.34^{b}	15.5^{a}	33.30^{b}	1.38^{b}
25	14.54^{a}	30.56^{b}	12.45^{b}	15.3^{a}	34.24^{b}	11.46^{b}
37.5	14.34^{a}	45.20^{a}	12.35^{b}	15.1^{a}	46.93^{a}	12.53^{b}
NPK (Check)	14.45^{a}	44.35^{a}	14.31^{a}	15.2^{a}	47.52^{a}	14.06^{a}

Values in the same column followed by the same letter are not significantly different from each other based on Duncan Multiple Range Test at P ≤ 0.05.

control plots recorded the lowest number of fruits/plant in both years. Plot treated with 25 and 37.5 kg/ha recorded similar but higher values that those subjected to NPK and 12 kg/ha.

Table 5 shows the effect of the poultry manure rate on fresh fruit yield in 2009 and 2010. The observation is similar to what obtained in other parameters. Application of 25 and 37.5 kg/ha were consistent with higher and similar values for fresh fruit yield. This was followed by both 12 kg/ha and NPK check which were similar while the control recoded the least yield.

Poultry manure rate significantly affected the root, stem, and root dry weights of the okra plant in the two years (Table 5). Root dry weight was similar among all the manure treatments and NPK fertilizer but higher than the control plots in both years. Stem dry weight was higher in plots treated with NPK and 37.5 kg/ha followed by plant treated with 12.5 and 25 kg/ha while the control value remains the lowest in the two trials. The observation on leaf dry weight was different as plot treated with NPK produced the highest leaf dry weight while those treated with 12.5, 25 and 37.5 kg/ha produced similar but significantly higher values than the control.

DISCUSSION

Application of poultry manure greatly enhanced the performance of the okra plant as reflected in the various parameters measured. Soil amendment through fertilizer application is a very important activity in crop production because of its effect on yield and quality improvement. The low nutrient status of the inland valley resulting from continuous use made it suitable for this study. The P and N composition of the poultry manure was fairly appropriate (Landon 1984) while the trace elements were very low (Hsieh and Hsieh, 1990).

Several reports have been published on the desirability of organic manuring as an important input for crops including okra production (Adeleye et al. 2010; Sendurkumaran et al., 1998; Alasiri and Ogunkeye, 1999). Application of poultry manure at the rate above 12 kg/ha generally resulted into higher growth and eventual fresh fruit yield increase compared to control. This enhancement in many cases is comparable to or even higher than what obtained with inorganic fertilizer. This is similar to the results of Akande et al. (2003 and 2010) and Okwuagwu et al. (2003).

In this study, bigger, longer fruits and higher number of fruit obtained in 25 kg/ha poultry suggests the quantity as the optimum for this site. This is comparable to the recommendation of 20 kg/ha farm yard manure of Premsekhar and Rajashree (2009) in an upland trial. This is however contrary to recommendation of Morelock and Hall (1980) that 10 to 15 ton/ha of poultry manure be applied in winter (December) for spring (April) okra. The environment used by Morelock and Hall (1980) was temperate region and this may not be very applicable to the tropical environment used in this study. Whereas, the higher stem and leaf dry weights obtained with inorganic fertilizer suggested diversion of assimilates to vegetative than reproductive parts. This is similar to the report of Page (1996) that vegetable plants grown on plots receiving organic manure were always better than those receiving inorganic fertilizer.

In another study (Mitchell et al., 1978), it was reported that the application of poultry manure above optimum rates may result in accumulation of heavy metals in both soil and plant tissue with adverse effects on crop performance. In addition there may be a release of phototoxic quantities of NH_3, NO_3 and salts (Weil et al., 1979) which may adversely affect soil micro organism responsible for mineralization process. We did not collect information on these observation, but rather than reduction at 37.5 kg/ha, performance stability was noticed which further suggests 25 kg/ha as the optimum value required in this site.

Similarly, the better efficiency of organic manure has been attributed to availability of micronutrients which are needed for biosynthesis of important hormones, chlorophyll, coenzymes and general metabolic activities (Anburani and Manivannan, 2002; Nehra et al., 2001). It can similarly be attributed to improved physical and biological properties of the soil which resulted in better nutrient supply to the crop. Increased fruit weight and yield have been linked to solubilisation effect of plant nutrients in the poultry manure leading to improved uptake of essential nutrients (Sendurkumaran et al., 1998).

The yield advantages of the organic manure over inorganic fertilizer obtained in this experiment is ascribed to the probable effects of the poultry manures in improving the physical characteristics of the soil (Mbagwu and Ekwealor, 1990) and to their supply of the macro and trace element not contained in the inorganic fertilizer. Jaramillo et al. (1978) had shown the significant beneficial effects of the trace element Fe, Zn and B on okra fruit yield and all these are contained in organic manure.

It is generally recognized that the benefits of organic poultry manure are due to their ability not only to supply nutrient elements but also to improve the physical characteristics of the soil (Jackson et al., 1977; Weil et al., 1979; Mbagwu and Ekwealor, 1990). Due to inherent differences in their rate of physical and chemical characteristics, different poultry manure rates may differ in the degree of achieving the above benefits. This study showed that the potential values of the poultry manures for okra production varied according to manure rates with 25 ton/ha appearing to be the optimum.

Water holding capacity was not a major problem in the site being an inland valley, rather it was readily available. Inorganic fertilizer is subject to quick solubilisation and possibly, a large percentage may have been lost through volatilization and other means before plant could take it up. Whereas, poultry manure is slow in releasing nutrient; 25 to 30% of N is released in the first year (Premshikan and Rajashree, 2009) while P recovery is reported to be better for manure than from inorganic fertilizers as CO_2 released by decomposition improves its availability from soil (Gopalakrishnan, 2007). The use of lowland, flood plains and inland valley usually referred to as '*Akuro'* or '*Fadama'* in parts of Nigeria for vegetable production is a common practice particularly in the urban environment. This trial has given insight to nutrient management strategy that can be employed in okra farm.

Conclusion

The results obtained in this experiment indicated that poultry manure enhanced the growth characteristics, yield and yield attributes of okra than inorganic fertilizer. The growth characteristics, yield attributes as well as yield were significantly enhanced by the application of 25 kg/ha of poultry manure. It could therefore be concluded that acid soil of inland valleys could be corrected by poultry manure application. Application rate may be depended on the soil status which is also a function of intensiveness of cropping pattern and nutritional status of the soil.

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