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Soil Properties, Leaf Nutrient Composition and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) as Affected by Broiler Litter and NPK 15:15: 15 Fertilizers in Ekiti State, Nigeria

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Abstract: The effect of Broiler litter and NPK 15-15-15 fertilizers on soil properties, growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) were investigated at the Teaching and Research Farm, University of Ado-Ekiti and a farmer's field at Omuo Ekiti (Southern guinea savannah soil), Nigeria. The treatments consisted of 0, 2, 4 MT ha^{-1} Broiler litter (Poultry manure) and 150 kg ha^{-1} NPK 15-15-15 fertilizer. The results indicated a significant increase in growth parameters in those plants planted in NPK 15-15-15 fertilized plot than poultry manure plot. However, growth parameters (plant height, stem girth and number of leaves) were increased significantly ($p<0.05$) as manure rates increased. Poultry manure at 4 MT ha^{-1} gave significant increase in fruit yield of okra in both location leading to 20.1 and 14.6% increase, respectively for Ado-Ekiti and Omuo Ekiti over the unfertilized plot (control). Leaf nutrient content was also increase with increasing rates of poultry manure.

Key words: Broiler litter, yield components, leaf nutrient, growth, NPK fertilizer

INTRODUCTION

Abelmoschus esculentus (L.) okra is a widely cultivated vegetable and can be found in almost every market all over Africa Schippers (2000). The nutritional constituents of okra include calcium, protein, oil and carbohydrates; others are iron, magnesium and phosphorus. Most okra is eaten in cooked or processed form. Young fruits may be eaten raw. The oil in the seed could be as high as in poultry eggs and soybean (Akinfasoye and Nwanguma, 2005).

Okra production is very low in many developing countries. Most farmers rely mainly on innate fertility of the soil and in addition invest considerable amount of money so as to achieve a reasonable yield of okra. Optimum production of okra requires intensive management practices that conserve and manage soil and nutrients needed for maintaining soil and water quality.

Soil productivity and fertility can be maintained by the use of soil amendments in form of fertilizers (Anonymous, 2005). Poultry manure contains high percentage of nitrogen and phosphorus for the healthy growth of plants (Ewulo, 2005). Corrale *et al*. (1990) noted the yield advantages accruing from the application of inorganic fertilizers but cautioned on the negative influence of their cost and availability resulting in the popularity of organic materials (including chicken manure) as means of supplementing native soil fertility in tropical areas. Chicken manure improves soil structure, water holding capacity, aeration and drainage (Cooke, 1980) besides containing high levels of N, P and K (Singh and Balasubramanian, 1980; Adediran and Banjoko, 2003). Nevertheless Agboola *et al*. (1982) observed that combined use of organic and inorganic fertilizers is the best means of augmenting available nutrient contents of tropical soils.

Nitrogen is said to be the motor of plant growth (IFA/FAO, 2000) Organic matter is the ultimate determinant of the soil fertility in most tropical soils and this account for its use, the fertility of soil

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could be sustained with the addition of poultry manure (Ikpe and Powel, 2002). NPK fertilizer has been reported to give a yield increase in okra (Babatola, 2006). Generally, fertilizer recommendation for most of the vegetables growth in Nigeria is between 50-100 kg N ha^{-1}, 20-60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} (Babatola *et al*., 2002). Also, intensive research studies had been carried out on the effect of fertilizer on crops (Adebayo and Adoun, 2002; Akanbi *et al*., 2002; Alasiri *et al*., 1998).This study was carried out to examine the effectiveness of Broiler litter and NPK 15:15:15 fertilizer application on soil properties, growth and yield of okra.

MATERIALS AND METHODS

The study was conducted at the Teaching and Research Farm, University of Ado-Ekiti between July and October 2005 and a farmer's field at Omuo-Ekiti, (southern guinea savannah). Ado Ekiti is located on latitude 7° 31' N and longitude 5° 49' E. The two locations have a bimodal rainfall of 1250 to 1460 mm with mean annual rainfall of 1367 mm and average number of rainy days of about 112 per annum. Temperature is almost uniform throughout the year 23-32°C with little deviation from mean annual of 27°C. February and March are the hottest month with mean temperature of 28 and 27°C, respectively. The mean total sunshine hour is about 2000 hours with mean annual radiation of about 130 kcal cm^{-3} $year^{-1}$. The area falls within the high forest zone where the rich tropical forests once thrived. Both locations have a tropical humid climate with distinct wet and dry seasons. The wet season is from late March to October with little dry season in August.

Field trials were conducted between July and October, 2005 at the Teaching and Research Farm, University of Ado-Ekiti and a farmer's field at Omuo-Ekiti, (southern guinea savannah). The size of the plot used was 12× 8 m. This was divided into three blocks (replicates) each measuring 4×2.5 m. The trial was a split plot design with experimental location as the main plot factor while sub-plot consisted of the fertilizer treatments. NPK 15:15:15 fertilizer was applied at 150 kg ha^{-1} NPK and poultry manure (Broiler litter) at the rate of 0. 2 and 4 MT ha^{-1}. The four treatments were randomized completely within each block separately using the random digit of number and were replicated three times to give a total of twelve experimental field plots. Before sowing, the seeds were soaked in water to determine its viability through floating method. Three seeds of okra variety LD 88 (Nihort) were planted on the field at spacing of 50×30 cm which was latter thin to one per stand after two weeks of sowing of okra seed. Weeding commenced at two weeks after sowing of okra seed and subsequent weeding was carried out as at when due. Chemical spraying with hypermetricin was carried out to control some insect pests that affect the leaves of okra plant.

Prior to planting soil samples from the two experimental locations were collected air-dried in the laboratory, ground and sieved through a 2 mm sieve. Particle-size distribution was determined by the hydrometer method (Bouyoucos, 1951). Soil pH was measured using the pH meter at 1:1 soil to water ratio. The percentage organic carbon was determined by the Walkey Black wet oxidation method (Walkley and Black, 1934) while percent total nitrogen (N) was determined by the micro-kjeldahl technique (Jakson, 1962) The present organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724.. Available P was extracted by the Bray/method and determined colorimetrically (Bray and Kurtz, 1945). Exchangeable bases were displaced by NH_4^+ from neutral/NH_4OAC solution as describe by Jackson (1958). Calcium (Ca) and Magnesium (Mg) were determined by the atomic absorption spectrophotometer (AAS) and potassium (K) and sodium (Na) were determined by flame emission photometry. Cation Exchange Capacity (CEC) was determined by the neutral/NH_4OAC saturation method. Base saturation was calculated with reference to the NH_4OAC-CEC. Exchangeable acidity was extracted with IMKCL and determined by titration with NaOH solution.

Eight plants each per plot were selected for determination of growth and yield parameters. Successive harvesting was done four days interval as fruits reached marketable size. Number of fruits was counted on each occasion and fresh pod weight obtained to determine yield.

The vegetative parameters assessed included plant height, number of branches, root length, leaves area. At final harvest, the okra plants were uprooted, partitioned into leaves, stem and roots and were measured. Each of these part were oven-dried in brown envelope for 48 h at 60°C. Measurements of dry weight were taken of stem, leaves and roots. Subsequently, nutrient uptake of each of the nutrient elements by the test crop were determined after grinding the dried plant samples and wet digesting with a mixture of 25 mL of HNO_3, 5 mL of H_2SO_4 and 5 mL of $HClO_4$.

All statistical analyses were performed using the Statistical Analysis System (SAS, 1985).

RESULTS AND DISCUSSION

Physical Properties of the Soil

The soil from the two sites are loamy in texture (Table 1), Sand is the dominant fine earth fraction ranges from 71-82 and 72-75% for Ado-Ekiti and Omuo-Ekiti, respectively (less than 2 mm portion) which accounted for greater than 70% of the textural quality indicating high porous soil profile with low water holding capacity and high vulnerability to surface run-off. Silt and Clay content ranges from 12-24.7 and 5.5-12%, respectively. Clay plays a marked increase in the subsurface (Bt) horizons. In Ado-Ekiti soil, the clay content is below the critical level showing soil with weak structural stability and high erosive index (Hurges, 1983). This characteristics distinguishes these soils from most other sandy soils of southwestern Nigeria, which are mostly characterized by low silt (<10-15%) content (Shittu and Fasina, 2004; Fasina, 2002). The high content of silt reflects the fact that the soils were formed from coarse colluvial materials (Hill wash). This tends to suggest that erosion is a marked pedogenic process in this area.

Soil Chemical Characteristics

The soil pH measured in water ranges from 6.38-6.63 from the two locations, indicating a slightly acidic reaction. The value of the organic carbon (C) at the surface horizon (0-15) is of medium class (1.04 %). At Omuo Ekiti, the organic carbon both at Ap and Bt horizons are very high indicating that the soil is high in organic matter content (Table 2).

Table 1: Physical analysis of the soils at the experimental locations

Locations	Horizon designation	Depth (cm)	Sand	Silt	Clay	Textural class
			----------------	(%)	----------------	
Ado-Ekiti	Ap	0-15	71.0	24.7	4.3	LS
	Bt	15-30	82.4	12.0	5.5	
Omuo-Ekiti	Ap	0-15	72.0	18.0	10.0	SL
	Bt	15-30	75.0	13.0	12.0	

Table 2: Chemical properties of the soils of the experimental locations

Locations	Depth (cm)	pH (H_2O)	Org.C	N (%)	Av. P ($mg\ kg^{-1}$)	K	Ca	Mg	Na
						----------------	($cmol\ kg^{-1}$)	----------------	
Ado-Ekiti	0-15	6.41	1.04	0.71	6.85	0.11	1.40	1.19	0.13
	15-30	6.38	1.36	0.66	5.78	0.13	1.32	1.10	0.15
Omuo-Ekiti	0-15	6.50	2.92	1.30	6.33	0.25	0.41	0.08	0.15
	15-30	6.63	2.16	1.30	6.30	0.30	0.44	0.08	0.14
Mean		6.48	1.88	1.00	6.32	0.44	0.89	0.61	0.14

Table 3: Chemical composition of Broiler litter used on dry weight basis (DWB)

Properties	Values
Organic carbon (%)	18.10
Total N (%)	2.31
P (ppm)	1.02
K (cmol kg^{-1})	1.22
Ca (cmol kg^{-1})	0.20
Mg (cmol kg^{-1})	0.61
Na (cmol kg^{-1})	0.07
C:N	7.00

Table 4: Effect of poultry manure and NPK fertilizer on fresh weight and dry matter accumulation of okra

	Fresh weight (g $plant^{-1}$)			Dry weight (g $plant^{-1}$)			
Treatments	Leaf	Root	Stem	Leaf	Root	Stem	Fruit
Ado-Ekiti							
0 MT ha^{-1} PM	60.50b	10.69a	21.04c	8.63a	2.23b	3.39c	21.21c
2 MT ha^{-1} PM	63.18b	12.07a	21.59c	11.03a	3.28a	9.72b	24.10b
4 MT ha^{-1} PM	67.47a	16.21a	38.20a	14.15a	4.32a	14.92a	26.63a
150 kg ha^{-1} NPK	66.93a	15.29a	25.02b	12.31a	4.43a	10.75b	24.11b
Omuo-Ekiti							
0 MT ha^{-1} PM	54.40c	10.70a	16.32d	7.65d	2.14a	3.01d	23.34b
2 MT ha^{-1} PM	64.81b	10.32a	19.04c	12.42b	3.10a	9.42c	25.12b
4 MT ha^{-1} PM	69.21a	13.20a	23.07a	15.03a	3.81a	13.54a	27.14a
150 kg ha^{-1} NPK	66.32b	12.16a	21.72b	10.31c	2.41a	11.71b	26.58b

Mean with the same letter(s) in each column for each location are not significantly different ($p<0.05$) by DMRT. PM = Poultry Manure (Broiler litter)

The N contents of the soil at Ap and Bt horizons of Ado-Ekiti are also high with all the values ranges between (0.66-0.77%) which is far above 0.15 % critical levels recommended for Southwestern Nigerian Soils (Sobulo and Osiname, 1981; Agboola *et al*., 1982). The P content is below the recommended critical level of 8.51 mg kg^{-1} soil (Agboola *et al*., 1982). The N content of Omuo Soils is also high at both horizons while the P contents at both horizons are critically low with all the values below 8.5 mg kg^{-1} recommendation indicating serious deficiency problem. The exchangeable K at Ado-Ekiti ranges from 0.11-0.13 cmol kg^{-1} soil. These values are rated as low (< 0.16 cmol kg^{-1}) (Sobulo and Osiname, 1981. While at Omuo Ekiti soil, K content is moderate ranges between 0.25-0.30 cmol kg^{-1} in the two horizons. The value of exchangeable Ca at Ado-Ekiti soils range from 1.32-1.40 cmol kg^{-1}. These values are considered high when compared with Omuo Ekiti soil which is quite low. However, the high exchangeable Ca in the soil suppresses Boron uptake by plants as reported by (Osiname, 2000) thereby resulting into distortion of leaves and stunted roots (Anonymous, 2004). The high value of Ca is indicative of low pH, a condition that is unsuitable for most plant growth (Veldkamp, 1992). The use of fertilizer containing Ca would to some extent remedy the associated acidity problem. Exchangeable Mg is very high in Ado-Ekiti soils while it is low in Omuo soils. Thus, Mg is likely to constitute constraint to agricultural productivity in the soil (Table 2). Table 3 describes the chemical composition of Broiler litter used on dry weight basis.

Effect of Broiler Litter and NPK 15:15:15 on Okra Growth, Yield and Leaf Nutrient Composition

The effect of fertilizer application on Plant height, stem girth and number of leaves are shown in Fig. 1-3 for both locations. Broiler litter and NPK significantly increased the leaf and stem fresh weight of okra at both locations (Table 4), higher fresh weight was recorded for 4 MT ha^{-1} Broiler litter. The effect of treatments on root fresh weight was not significant while on leaf and root fresh weight was significant. The effects of Broiler litter and NPK fertilizers on leaf dry matter accumulations was not significant in Ado-Ekiti but w ere significant in Omuo. Greater plant dry weight was recorded for

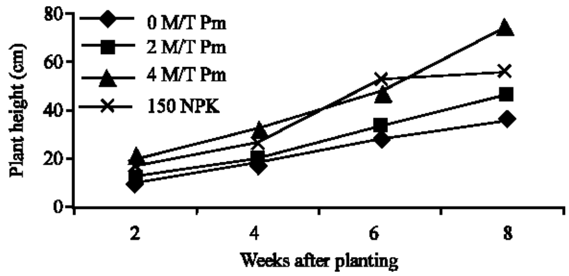

Fig. 1a: Effect of poultry manure and NPK fertilizer on plant height of Okra at Omuo Ekiti

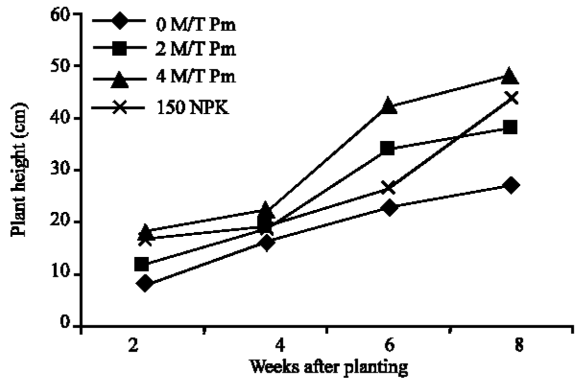

Fig. 1b: Effect of poultry manure and NPK 15-15-15 on plant height of Ado-Ekiti

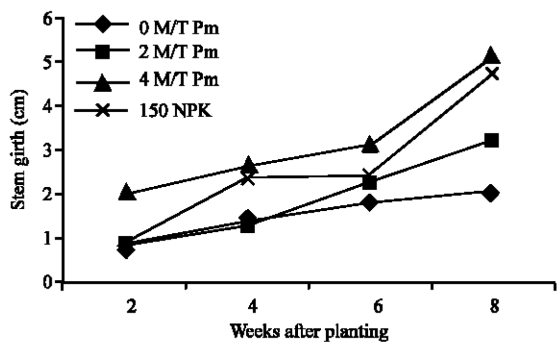

Fig. 2a: Effect of poultry manure and NPK fertilizer on stem girth of Okra at Omuo Ekiti

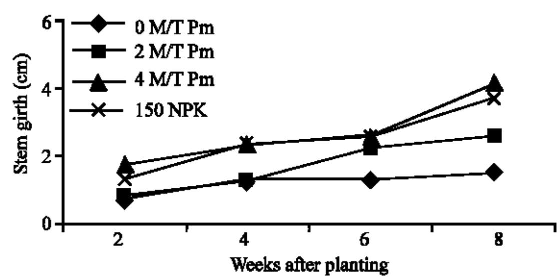

Fig. 2b: Effect of poultry manure and NPK 15-15-15 fertilizer on stem girth of Ado-Ekiti

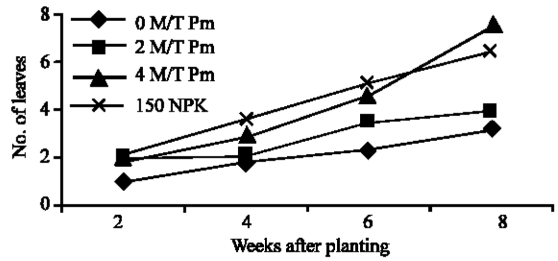

Fig. 3a: Effect of poultry manure and NPK fertilizer on No. leaves of Okra at Omuo Ekiti

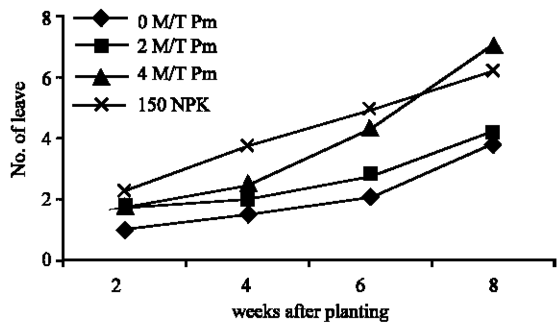

Fig. 3b: Effect of poultry manure and NPK 15-15-15 fertilizer on No. of leaves of okra at Ado-Ekiti

Table 5: Effect of poultry manure and NPK fertilizer on yield and yield components of okra

Treatments	Pod length plant^{-1} (cm)	Pod girth plant^{-1} (cm)	No. of pod plant^{-1}	Pod weight plant^{-1} (g)
Ado-Ekiti				
0 MT ha^{-1} PM	5.53c	6.88c	1.12c	40.96c
2 Mtha^{-1} PM	6.63b	8.66a	2.36c	46.83b
4 MT ha^{-1} PM	7.76a	10.00a	6.15a	58.96a
150 kg ha^{-1} NPK	7.34a	8.60b	3.76b	47.78b
Omuo-Ekiti				
0 MT ha^{-1} PM	6.21c	6.70c	4.20c	52.06c
2 Mtha^{-1} PM	6.94c	9.30b	5.26c	56.42c
4 MT ha^{-1} PM	8.12a	10.21a	8.31a	70.56a
150 kg ha^{-1} NPK	7.60b	9.86b	6.75b	63.91b

Mean with the same letter(s) in each column for each location are not significantly different ($p<0.05$) by DMRT

4 MT ha^{-1} of Broiler litter as against 150 kg ha^{-1} NPK in both stem and fruit weight per plant. There were significant increases in fresh and dry weights of the plants with increasing poultry manure treatments except in root fresh and dry weight Kim *et al.* (1997) obtained increases in dry matter yield from the amendment of soil with cattle manure compost mixed with rice husk/sawdust.

The effects of poultry manure treatments on number of pods/plant were significant for both locations (Table 5). Increasing levels of manure significantly increase pods/plant. Also, the pods produced by 4 MT ha^{-1} were weightier hence the higher number of pods/plant at that rate. When compared with unfertilized plants, both the poultry manure and NPK fertilizer gave significant ($p<0.05$) higher yield. In both locations 4 MT ha^{-1} poultry manure gave the highest yield.

The plant nutrient composition as affected by the application of NPK 15-15-15 fertilizer and or poultry manure is shown in Table 6. Irrespective of the fertilizer source, those plants that were fertilized performed better than unfertilized plants. The NPK 15-15-15 fertilizer and or poultry manure increased nutrient composition over the control.

Table 6: Effect of poultry manure and NPK 15: 15: 15 on nutrient uptake of okra

Treatments	N	P	K	Ca	Mg	Na
	(%)					
0 MT ha^{-1} PM	0.90	1.35	1.36	2.10	0.30	0.70
2 MT ha^{-1} PM	1.27	2.25	2.40	2.90	0.40	1.20
4 MT ha^{-1} PM	1.38	3.40	3.61	3.30	0.60	1.10
150 kg ha^{-1} NPK	1.65	4.60	5.10	5.20	0.50	1.40

Leaf nutrient composition tends to increased with increasing level of poultry manure. Comparative analysis of poultry manure (Broiler litter) in it uptake indicated that poultry manure compete well with NPK 15-15-15 fertilizer. The robust look of plants in poultry manure plots is indicative of the induced C:N ratio.

Addition of Broiler litter has produced better and healthier growth and thereby improved significantly the growth, yield and nutrient contents of okra. Broilers litter at the rate of 4 MT ha^{-1}gave significant higher yield.

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