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Effect of Poultry Manure on Growth and Yield of Maize (*Zea mays Var Praecox*) in Jalingo, Taraba State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author JOS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author YAG managed the analyses of the study. Author MB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of the experiment was to investigate the influence of poultry manure on the performance of maize (*Zea mays Var Praecox*).
Study Design: A randomized complete block design (RCBD) with 4 replications a randomized complete block design (RCBD) with 4 replications
Place and Duration of the Study: Field trials were established at the Nukkai Irrigation Teaching and Research Farm of the Crop Science Department, Taraba State College of Agriculture, Jalingo during the 2014 and 2015 cropping seasons.
Methodology: The trial consisted of five treatments namely, 0, 1, 1.5, 2.0 and 2.5 tonnes/ha of poultry manure worked into the soil and watered for one week before planting of maize. Soil samples randomly taken at 0 – 30 cm depth and poultry manure samples were analyzed using standard laboratory procedures to determine the physico-chemical characteristics of the soil and manure nutrient content.

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Results: The results obtained showed the soil was highly acidic (pH 4.52) with a sandy clay loam structure with nutrient contents below critical levels (Organic carbon 1.4%, total N 0.14%, available P 9.18 mg/kg, and exchangeable K, Ca, Mg and ECEC of 0.24, 0.58, 0.51 and 1.53 cmol/kg, respectively). Results also showed that poultry manure at 2.5 tones/ha produced tallest plants (124.8/130.2 cm) with largest stem girth (12.5/12.8 cm), bearing more cobs/plant (2.7/2.6) and highest grain yield of 3,050 and 3,058 kg/ha in 2014 and 2015, respectively at P = 0.05.
Conclusion: This indicates that 2.5 tones of poultry manure and above per hectare could be adequate for good growth and yield of maize and is recommended for farmers in Jalingo area.

Keywords: Growth and yield; pop corn; poultry manure; savanna area.

1. INTRODUCTION

Maize used as popcorn (*Zea mays Var. praeax*) is one of the seven groups or types of maize (*Zea mays, Poaceae* [1] grown in a wide range of agroecologies in monoculture or mixed cropping systems. It is the oldest type of corn that has been cultivated for several thousands of years dating as far back as 3600 BC [2]. Popcorn is grown for its tasty seeds that expands from the kernel and puffs up when heated [3].

The crop has become a popular snack cherished by both adults and children due to its crunchy and tasty feel when eaten. Popcorn is naturally high in dietary fibre and antioxidants, low in calories and fat, and free of sugar and sodium. This has made it an attractive food for people placed on low fat diet which is beneficial for the health of the heart and cholesterol levels, prevention of cancers as well as in the maintenance of overall good heath and optimal weight [4]. Introduced into Africa by the Portuguese traders in the 16th century, maize has become the most important staple food crop for more than 1.2 billion people in SSA and Latin America [5]. It accounts for 30−50% of low-income household expenditures in Eastern and Southern Africa. In Africa as a continent 95 % of the maize output is consumed as human food, compared countries that use most of its maize as animal feed [6]. Maize produces more biomass than other cereals and is largely cultivated for fodder and silage to feed the ruminant livestock. It is also an important raw material as feedstock for green energy and ethanol production in developing countries [7,8,9].

Nigeria is listed as the 15th most important world producer of maize [10] and the second highest in Africa after South Africa [11] with a total production of about 7.2 million metric tonnes in 2016 [8]. Maize is fast transforming into an industrial crop and has become an essential raw material for many agro-based industries in Nigeria and other parts of the [10,11,12,13]. The transformation of maize into a cash crop has escalated the demand for the crop. This has created a wide gap between demand and supply arising from the predominantly low maize yield which fluctuates around 1 - 2 tonnes per hectare in traditional farmers [14] compared to high yield of about 8.6 tonnes/ha obtained with good crop management in advanced agriculture [15,16]. Maize production in Nigeria is carried out mainly in the savanna agro-ecology of the country where agro-climatic conditions and reduced incidence of pests/diseases favour the growth of the crop [17]. However, maize cultivation in the savannas is faced with several production constraints which limit productivity among which poor soil fertility and other soil-related constraints arising from high cropping intensity are often considered most critical maize yield limiting factors in the region [17-19].

Maize is a heavy feeder particularly in terms of mineral N but savanna soils are low in plant nutrients and the crop cannot be grown without the application of some form of mineral and/or organic inputs [20]. Farmers' fields are frequently characterized by several interacting biotic and abiotic stresses which can cause severe yield losses [21,22]. Agronomic best practices such as organic soil fertility management can enhance crop tolerance to such stresses as well as provide a sustainable strategy in restoring or sustaining soil fertility under intensive cropping systems [23,24]. The trial was therefore initiated to develop a recommendation on the use of poultry manure in organic maize production in the Guinea – Sudan Savanna transition zone of Nigeria.

2. MATERIALS AND METHODS

The trial was conducted in 2014 and 2015 cropping seasons at the Nukkai Irrigation Teaching and Research Farm of Crop Science

Department of the Taraba State College of Agriculture, Jalingo (Latitude 80° 50" N and Longitude 11° 50" E). The trial consisted of five treatments namely, 0, 1, 1.5, 2.0 and 2.5 tonnes/ha of poultry manure sourced from the college poultry farm. Pop corn was sourced from open market in Jalingo. Land clearing and seedbed preparation were carried out manually. Unit plot dimensions were 2 m x 3 m (6 m^2) each separated by 1 m wide pathways. Soil samples were randomly taken from the gross plot using soil auger from the depth of 0 – 30 cm and analyzed using standard laboratory procedures [25] to determine the physico-chemical characteristics of the soil at the pre-planting stage. Poultry manure was also analyzed in the laboratory to show its nutrient content. The manure was uniformly spread on the relevant plots and worked into the soil and watered for one week before planting of maize. Two maize seeds were planted per hole 2-3 cm deep at 75 cm x 25 cm and later thinned to one plant per stand at 2 weeks after planting (WAP). Weeding was done manually using hand hoe at 3 and 6 WAP to keep plots weed-free during the experiment.

Data were collected on plant height, stem girth, days to 50% tassling, number of cobs/plant, cob weight/plant, 100-seed weight and grain yield/ha. Harvesting was done when the maize was fully matured and dehusked cobs were well sun-dried before threshing manually. Data collected were subjected to analysis of variance (ANOVA) technique and significant means were compared using least significant difference (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Soil Characteristics at the Experimental Site

The physical and chemical properties of thee soil at the experimental site are shown in Table 1 The relative proportions of sand, silt and clay contents in the soil indicated sandy clay loam texture of the soil. The texture of soils has critical agronomic importance as it influences the aeration and determines the irrigation potential of the soil.

The soil exhibited strongly acidic reaction and such soils frequently require liming to raise the pH to about 6.2 – 6.5, a mildly acidic range required by most vegetable, tree and arable crops [26]. High soil acidity suppresses the activity of rhizobium bacteria with a consequent effect on nitrogen (N) fixation by legumes. Also Mn, Fe and P are easily 'fixed' in insoluble complexes and are commonly unavailable to plants on acid soils. Liming of the soils at the experimental area could improve their productivity. The nutrient profile of the soil was also low. Organic carbon and total N were low and typical of sandy soils under continuous cropping. Exchangeable K, Ca Mg and cation exchange capacity of the soil were all below the critical levels, requiring a sustainable approach such as organic manure application to restore and maintain the fertility of the soil as a vital prerequisite for increasing productivity. Poultry manure usually contains adequate levels of nutrients and organic matter (Table 2) and their regular use on farmland improves and sustains the quality of soil in the long-run. The soil productive capacity is largely influenced by its organic matter content which is important for nutrient supply, water holding capacity, cation exchange capacity, and soil structure as well as energy source to drive biological and chemical processes in the soil and enhances soil biological activity [27,28].

Table 1. Physico-chemical properties of the soil at the site before planting (0 – 30 cm depth)

Soil parameter	Value
P^H (H_20)	4.52
Org. C (%)	1.40
Total N (%)	0.14
Available P (mg/kg)	9.18
Exchangeable cations (cmol/kg)	
K	0.24
Ca	0.58
Mg	0.51
Na	0.03
(Al + H)	0.53
ECEC	1.53
Base saturation (%)	68.0
Particle size distribution (%)	
Sand	62.5
Silt	10.3
Clay	27.2
Texture	Sandy clay loam

3.2 Effect of Poultry Manure on Vegetative Growth and Yield of Maize

The application of poultry manure significantly ($p \leq 0.05$) influenced the growth of maize Plant height and stem girth increased with increasing

rates of manure applied (Table 3). Tallest plants with thickest stems were found in plots amended with 2.5 tonnes of poultry manure per hectare. These plants were followed by those nourished with 2.0, 1.5 and 1.0 tonnes of the manure per hectare, while unfertilized plants were shortest with thin stems at all sampling periods in both cropping seasons. The best growth exhibited by plants in plots fertilized by the highest poultry manure rate was probably due to adequate supply and availability of nutrients which obviously stimulated rapid crop growth in such plots. This observation is consistent with the report of IFA [29]) and that of Tisdale and Nelson [30] in which good plant growth was similarly attributed to adequate nutrient supply in poultry manure plots particularly Nitrogen and phosphorus which promoted crop performance.

The grain yield and yield components of maize were all influenced by poultry manure except days to 50% flowering which was similar in all plants though lower values were recorded for plants in plots treated with 2.5 tonnes/ha of poultry manure (Table 4). The number of cobs produced per plant increased significantly with incremental rate poultry manure rates and maximized in plants fertilized with the highest manure rate in 2014 but in 2015, control plants and those fertilized with 1.0 t of the nutrient produced similar number of cobs per plant.

Table 2. Some chemical properties of poultry manure used in the experiment

Parameter	Value
N (%)	2.42
NH_4^+ (%)	0.14
P_2O_5 (%)	1.26
K_2O (%)	1.70
Ca (%)	3.62
Mg (%)	2.17
Mn (%)	0.04
Org. C (%)	36.20
Organic matter	62.10
C/N ratio	14.50
eC (ms/cm)	5.50
P^H (H_2O, 1:10)	7.20

Cob weight and seed weight also increased as the poultry manure rates were increased and maximized in maximum poultry manure plots, while control plants had lowest values of these parameters. Highest cob weight difference between the control plants and those fertilized with the highest poultry manure rate was 2.6 kg/plot in 2014 and 2.8 kg/plot in 2015, while seed weight difference of 4.2 g was obtained for the same plants in both years.

Table 3. Plant height (cm) and stem girth (cm) of maize as affected by application of poultry manure

Poultry manure rates (t/ha)	Plant height (cm)				Stem girth (cm)	
	2014		2015		2014	2015
	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP
Control	72.8	82.3	73.0	82.8	7.3	7.9
1.0	82.5	98.0	83.5	98.0	8.5	8.6
1.5	92.3	101.2	93.0	101.8	10.3	10.5
2.0	94.3	120.0	94.7	120.3	11.5	11.8
2.5	96.2	123.9	96.8	124.8	12.2	12.5
$LSD_{(0.05)}$	1.7	1.9	1.8	0.9	0.2	0.2

Table 4. Influence of poultry manure on grain yield and yield components of maize in Jalingo (2014 and 2016)

Poultry manure	Days to 50% tassling		No. of cobs Per plant		Cob weight Per plot (kg)		100-grain yield (g)		Grain yield (kg/ha)	
rates (t/ha)	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	60.6	60.5	1.5	1.6	2.3	2.3	20.1	20.2	1933	1931
1.0	60.5	60.4	1.8	1.7	3.6	3.8	22.5	23.4	2143	2147
1.5	59.6	59.7	2.1	2.0	4.3	4.4	23.8	24.2	2253	2259
2.0	59.2	59.4	2.4	2.4	4.5	4.7	24.2	24.4	2382	2386
2.5	59.0	59.1	2.7	2.6	4.9	5.1	24.3	24.4	3050	3058
$LSD_{(0.05)}$	ns	ns	0.1	0.1	0.1	0.1	0.2	0.3	24.5	25.3

Grain yield also varied among the different rates of poultry manure applied and like cob weight, grain yield increased with each increase in the rate applied and maximized in plots incorporated with 2.5 tonnes of poultry manure per hectare, while the lowest grain yield was obtained in control plots in both years. Grain yield increments over the control by applying 1, 1.5, 2.0, and 2.5 tonnes of poultry manure per hectare were 212 kg/ha (10.98%), 322 kg/ha (16.68%), 451 kg/ha (23.36%) and 1'119 kg/ha (57.95%) in 2014, while in 2015, yield increases obtained in the corresponding treatments were 214, 324, 453 and 1,123 kg/ha representing 11.07, 16.74, 23.44 and 58.04%, respectively. This indicates that 2.5 tones of poultry manure and above per hectare could be adequate for good growth and yield of pop corn in Jalingo area.

4. CONCLUSION

Growth and grain yield of maize were improved by poultry manure application and the best crop performance was obtained in plots incorporated with the nutrient at 2.5 t/ha which could be adjudged to be optimum for sustainable productivity of maize in the experimental area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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