International Journal of Agriculture and Forestry 2012, 2(4): 138-144
DOI: 10.5923/j.ijaf.20120204.01

Evaluation of Agronomic Performance of Maize (*Zea mays L.*) under Different Rates of Poultry Manure Application in an Ultisol of Obubra, Cross River State, Nigeria

Agba Oliver Akongwubel[1], Ubi Benjamin Ewa[1,2,*], Abam Prince[1], Ogbechi Jude[3], Akeh Martins[3], Odey Simon[1], Ogar Nicholas[4]

[1]Dept. of Agronomy, Cross River University of Technology, Obubra Campus, Cross, River State, Nigeria
[2]Biotechnology Research & Development Centre, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria
[3]Dept. of Biological Science, Cross River University of Technology, Calabar Campus, Cross River State, Nigeria
[4]Dept. of Forestry and Wildlife Resources, Cross River University of Technology, Obubra Campus, Cross River State, Nigeria

Abstract Field studies were conducted at the Teaching and Research farm of the Cross River University of Technology, Obubra Campus, Nigeria, during the 2005 and 2006 cropping seasons to determine the agronomic performance of maize under different rates of poultry manure (PM) application. Ten rates of PM treatments consisting of 0, 4, 6, 8, 10, 12, 14, 16, 18, and 20 t/ha were used in this study. The treatments were laid out in a randomized complete block design with three replications. PM application significantly improved maize vegetative growth, biomass, yield components and grain yield. The use of 20 t/ha PM gave the highest maize plant height, stem diameter and number of leaves per plant; while the best 1000-seed weights of 273.5 and 270.7 g, as well as grain yields of 2.78 and 2.89 t/ha were obtained with the application of 18 t/ha PM in 2005 and 2006 cropping seasons, respectively. Moreover, all the evaluated traits were strongly positively correlated with each other ($P < 0.0001$). Our results indicated that while high rates of PM linearly improved growth attributes up to the highest rate of PM treatment (20 t/ ha), a dose of 18 t/ha applied two weeks before planting was best for maize production in the study area.

Keywords Agronomic Performance, Grain Yield, Growth Traits, Maize, Poultry Manure (PM)

1. Introduction

Maize (*Zea mays L.*) is the third most important cereal after wheat and rice[1]. The crop is commonly cultivated in the tropics and warm sub-tropics for food, livestock and industrial uses. In Nigeria, maize is an important food, fodder and industrial crop grown both commercially and at subsistence level[2]. Maize is used for the production of indigenous and commercial food products that are relished for their unique and distinctive flavours. It is eaten fresh or milled into flour and serves as a valuable ingredient for baby food, cookies, biscuits, ice cream, pancake mixes, livestock feed and a variety of traditional beverages[3,4].

Efforts aimed at obtaining high yield of maize would necessitate the augmentation of the nutrient status of the soil to meet the crop's requirements for optimum productivity and maintain soil fertility. Increasing the nutrient status of the soil may be achieved by boosting the soil nutrient content either with the use of inorganic fertilizers such as NPK or through the use of organic materials such as poultry manure, farm yard manure (FYM) or the use of compost. The maize crop requires an adequate supply of nutrients particularly nitrogen, phosphorus and potassium for optimum growth and yield. The most important micronutrients particularly in the savanna zone and under continuous cropping in the forest ecology are sulphur, zinc and magnesium [5]. Nitrogen, which is a major component of poultry manure, is associated with high photosynthetic activity, vigorous vegetative growth and a dark green coloration of the leaves[6,7]. At the other extreme, excessive supply of nitrogen may result in luxury consumption and the production of vegetative growth at the expense of high grain yield. Being a heavy feeder of nitrogen, adequate supply of nitrogen can be a limiting factor closely associated with its yield magnitude[8]. The optimum fertilizer requirement recommended for optimum yield of the maize crop in South-eastern Nigeria is 300 – 450 Kg/ha of NPK, though this study was limited to only few experimental locations[9-11]. Based on soil data, Ezeaku[10] reported a single dose application of NPK at rates of 493, 566, and 540 Kg/ha for optimum maize grain yield in three locations of South-eastern Nigeria, which was about 1.5 times higher

* Corresponding author:
ubi.benjamin@yahoo.com (Ubi, Benjamin Ewa)
Published online at http://journal.sapub.org/ijaf

than the recommended agronomic rate of 300 kg/ha NPK. The amount required of these nutrients particularly nitrogen depends on a number of factors including the previous vegetation cover/cropping history, crop variety grown, soil type, rainfall, organic matter content, CEC, tillage method and light intensity[12-14].

Studies conducted by various researchers[4,6,15-17] have shown that the application of fertilizer both from organic and inorganic sources significantly improves the growth and yield of maize. Thus, an integral use of both organic and inorganic fertilizer to ensure adequate supply of plant nutrients and sustain maximum crop yield and profitability has been advocated[18]. However, inorganic fertilizer is expensive and may be largely unaffordable and not available to the resource-poor farmers in Nigeria. On the other hand, organic manure such as poultry droppings is readily available as a cheap source of nitrogen for sustainable crop production. Organic fertilizer supplies the essential macro- and micro-nutrient elements to plants, as well as improves soil physico-chemical conditions for better maize growth and yield[19]. As earlier highlighted by Beckman[20], the application of poultry manure is expected to enhance soil productivity, increase the soil organic carbon content, soil flora and fauna, improve soil crumb structure and the nutrient status of the soil towards attaining sustainably high yields.

The role of organic manure in maintaining organic matter and raising the growth and yield of cereal crops had long been recognized in most agro-ecological zones[9,15,18]. Poultry manure (particularly from chicken) is the richest animal manure in N-P-K (1.1-0.8-0.5 %, respectively) relative to other organic manures such as cow, horse, steer, sheep, swine and rabbit manure[21]. The nutrient value in these manures varies greatly depending largely on the diet and age of the animals[21]. Enwezor *et al* [9] recommended the use of 20 tons per hectare of farm yard manure for the cultivation of maize in northern Nigeria.

Despite the economic importance of maize, large scale production is still low in Obubra, Cross River State, Nigeria. The yield is low and there is poor information on the nutrient requirements of the crop especially among the peasant farmers of the central and northern parts of Cross River State, Nigeria. The International Centre for Maize and Wheat Improvement (CIMMYT), Mexico, reported that maize yield in West Africa has virtually stagnated at about 1 tha^{-1} compared to the global average yield of 2.2-3.5 tha^{-1}[3]. Information is presently lacking on the alternative use of organic manure sources such as poultry droppings on the production of maize in Obubra, Cross River State. Therefore, this study was conducted to determine the appropriate rate of poultry manure application required for optimum maize production in Obubra agro-ecological zone.

2. Materials and Methods

2.1. Experimental Site and Plot Layout

Field studies were conducted during the 2005 and 2006 seasons at the Teaching and Research farm of the Department of Agronomy, Cross River University of Technology, Obubra Campus, Cross River State. The study area falls within the rainforest zone of South-South Nigeria and is located between Latitude 05^0 59N and longitude 08^0 16 E. Obubra has a mean annual rainfall of 2250 – 2500 mm [22]. The weather conditions during the growing season of this study in 2005 and 2006 is as shown in Table 1.

Table 1. Weather data at the experimental site during the 2005 and 2006 growing seasons

Month	Rainfall (mm)	No. of rain days	Relative humidity (%) 0600hrs	Relative humidity (%) 1800hrs	Temperature (°C) Min.	Temperature (°C) Max
A:2005						
April	126.3	8.1	81.2	68.4	24.1	32.5
May	217.5	12.3	82.7	73.6	20.3	28.7
June	445.2	17.1	86.3	76.1	19.8	27.4
July	561.4	23.4	87.3	78.5	19.5	24.3
August	311.4	18.3	85.5	72.3	19.3	24.1
Mean	332.35	15.84	84.6	73.78	20.8	27.4
B:2006						
April	138.3	14.5	87.2	66. 8	24.3	33.1
May	157.8	18.3	81.3	69.5	23.2	27.4
June	355.1	20.0	83.1	70.1	19.5	27.5
July	726.1	28.0	86.7	80.1	22.3	28.5
August	396.1	20.0	84.1	73.1	20.1	27.3
Mean	354.68	20.16	84.48	71.92	21.88	28.76

Table 2. Some physico-chemical properties of the soil at the experimental site determined at the start of the experiment in 2005 (top 0 – 20 cm)

Parameter	Value
Textural class	Loamy
Particle size (%)	
Course sand	13.5
Fine sand	65.2
Clay	4.6
Silt	17.2
pH(H_20)	5.57
pH(KCL)	5.03
Org. C (%)	0.72
Total N (%)	0.07
Total P (mg/kg)	6.1
Base saturation (%)	56.8
Organic matter (%)	1.32
Exchangeable cations (c mol / kg)	
K	0.11
Mg	1.9
Ca	2.7
Na	0.06
Al	1.4
H	2.2
CEC	8.35

Values were taken from bulked samples

The study was carried out during the rainy seasons of 2005 and 2006 under similar experimental conditions. Composite soil sample was collected in 2005 for laboratory analysis to determine the soil physical and chemical properties using standard laboratory methods (Table 2). The treatment was poultry manure (PM) from broiler chicken in deep litter system collected from a commercial farm at Obubra that was well-cured by being tied in bags for three (3) months and whose chemical composition is as shown in Table 3. The experimental design used was a randomized complete block design and the 10 different rates (treatments) of well-cured poultry manure at 0, 4, 6, 8, 10, 12, 14, 16, 18 and 20 tha^{-1} were randomly allocated to the experimental plots that were replicated three times. The experimental field was cleared and seed bed was well prepared by ploughing and harrowing in each season. The size of the plot per treatment was 4 x 5 meters (20 m^2) with 50 and 100 cm paths separating adjacent plots and blocks, respectively. A hybrid maize variety ("Oba super 1") obtained from the seed multiplication unit of the Agricultural Development Project (ADP), Ikom Zone, Cross River State was used as the test crop. The well-cured poultry manure was applied at two weeks before planting by broadcasting and completely worked into the soil. Three maize seeds were sown per hill and later thinned to one seedling/hill at a spacing of 75 x 30 cm on 20th April during the 2005 and 2006 cropping seasons giving a total of 88 plants / 20 m^2 plot and plant population of 44,000 plants per hectare. Weeding was done manually at 4, 8, and 12 WAP.

Table 3. Some chemical properties of the poultry manure used in the study

Nutrient	Content (%)	Reported range (%)[δ]
Magnesium	1.94	1.54 – 2.96
Calcium	6.79	1.2 – 4.40
Potassium	0.51	0.90 – 2.17
Nitrogen	1.35	2.17 – 3.50
Phosphorus	1.31	0.18 - 1.68
Organic carbon	50.45	26.30 – 40.70
Organic matter	20.13	45.40 – 70.20

Range reported by Quarcoo [28] from analysis of poultry manures from various farms

2.2. Measurement of Growth Characteristics

At four weeks after planting (4 WAP), 15 plants in the middle rows were randomly selected from each plot and tagged for the measurement of growth characteristics at 4, 8 and 16 weeks after planting (WAP) as follows:

2.2.1. Plant height (cm)

This was taken as the height of the maize plant measured to the nearest centimeter from the base to top at 4, 8 and 16 WAP. The mean height from the 10 randomly selected plants from the middle rows was taken as the score for each plot.

2.2.2. Stem diameter (mm)

This was taken as the diameter of the stem measured to the nearest millimeter at the base of the maize plant from 10 randomly selected plants from the middle rows per plot and used to compute the mean stem diameter score for each plot at 4, 8 and 16 WAP.

2.2.3. Number of leaves per plant

The number of leaves per plant was determined by counting and the data from 10 plants from the middle rows was used to compute the score for each plot at 4, 8 and 16 WAP.

2.2.4. Leaf area index (LAI)

In order to estimate LAI, the leaf area of 15 randomly selected plants from the middle rows was first measured with a leaf area meter. From the measured leaf area, LAI was determined based on the below relationship as proposed by Shortall and Liebhardt [23]:

$$LAI = Y \times N \times A_L \times (A_P)^{-1},$$

where, Y = Population of plants per plot

N = Average number of leaves per plant

A_L = Average area per leaf

A_P = Area of plot

2.2.5. Biomass (dry matter) yield per plant (g)

Biomass was determined by harvesting the leaf and stem materials at 8 and 16 WAP and oven-drying at 70^0C for 3 days. The mean of 5 randomly selected and destructively sampled plants from the middle rows was used as score for each plot.

2.3. Measurement of Yield Traits

The maize was harvested at maturity (i.e. at 16 weeks after planting) and the following pertinent yield data were taken:

2.3.1. Ear weight (g)

The fresh weight of the peeled ear measured to the nearest gram and the mean weight of ears from 10 randomly selected plants from the middle row was used to compute the score for each plot.

2.3.2. Ear length (cm)

The length of the peeled ear measured to the nearest centimeter and the mean weight of ears from 10 randomly selected middle row plants was used to compute the score for each plot

2.3.3. Diameter of ear (cm)

This was taken as the diameter of the peeled ear measured at the middle part of the ear to the nearest centimeter from ears harvested from 10 plants randomly selected from the middle rows of each plot and used to compute the mean ear diameter score for each plot.

2.3.4. Weight of 1000 seeds (g)

The weight of 1000 seeds (oven-dried to 13 – 14 % moisture content) weighed to the nearest gram was determined. Four replicate samples of 1000 seeds per ear were measured to obtain the mean weight per ear. The mean 1000 seed weight from the 10 randomly selected plants from the middle row was used to compute the score for each plot.

2.3.5. Grain yield per hectare (tha^{-1})

The total grain yield from all the 40 plants in the middle rows of each plot that were carefully harvested and threshed for full yield recovery was used to compute the grain yield (oven-dried at 13 – 14 % moisture content) in tons per hectare based on the plant population of 44,000 plants / hectare used in this study. This was estimated as per the relationship below:

$GY_{ha} = Y_p \times P_{ha}$

where, GY_{ha} = Grain yield per hectare

Y_p = Average grain yield per plant

P_{ha} = Plant population per hectare

2.4. Statistical Analysis

All the data collected were statistically analyzed using the analysis of variance (ANOVA) procedure described by Gomez and Gomez[24] for randomized complete block design (RCBD) experiments. Separation of treatment means for significant difference was done by using the Fisher least significant difference (F-LSD) procedure at 0.05 probability level[25].

3. Results

The results of this study showed that the application of different levels of poultry manure (PM) significantly improved the growth and yield of hybrid maize, "Oba super I". The performance of the maize during the 2005 and 2006 growing seasons was not statistically different in all the growth and yield traits evaluated. The calculated t-test values for comparisons of all the growth and yield data between the two seasons were largely less than the tabulated value of 2.03 (5 % prob. level at 18 df).

In both seasons, maize vegetative growth parameters assessed at 4 WAP showed that plant height, stem diameter, number of leaves per plant and LAI increased significantly with incremental rates of PM application (Table 4). At 0 t/ha level of PM application, the plant heights were 35 and 33 cm at 4 WAP during the 2005 and 2006 seasons, respectively (Table 4). Plant heights then respectively increased in 2005 and 2006 up to 152 and 168 cm at the highest PM rate of 20 t/ha (Table 4). Similarly, stem diameter, number of leaves / plant and LAI steadily increased in all plots treated with poultry manure application relative to the control, indicating that the PM treatment generally enhanced vigorous plant growth. However, there were no significant differences between the effects of 10 and 12 t/ha PM rate on stem diameter at 4 WAP during the 2005 growing season (Table 4). No significant differences were also observed in number of leaves / plant at PM rates of 6 - 8 t/ha and 14 – 16 t/ha in both seasons, as well as 18 – 20 t/ha during the 2005 growing season. LAI was also largely not significantly different from 6 – 12 t/ha and 16 – 20 t/ha in both seasons. Furthermore, the vegetative growth characteristics measured at 8 and 16 WAP in the two seasons were also significantly better in all plots receiving poultry manure application than the control treatment where PM was not applied (Table 5). The tallest plant heights of 275 and 281cm were obtained in plots treated with 20 t/ha of poultry manure in both 2005 and 2006, respectively. Generally, the application of poultry manure gave significant improvement in maize growth parameters. However, some levels of the PM treatment were not significantly different from each other in some of these vegetative parameters measured at 8 and 16 WAP (Table 5).

Table 4. Effect of Poultry manure on the growth parameters of maize at four (4) weeks after planting (4 WAP) in the 2005 and 2006 cropping seasons

Treatment (t/ha)	Plant height (cm)		Stem diameter (mm)		No. leaves per plant		Leaf area index (LAI)	
	2005	2006	2005	2006	2005	2006	2005	2006
0.0	35	33	5.1	5.2	3.1	3.0	2.2	2.3
4.0	53	55	8.3	8.9	4.2	4.4	3.2	3.3
6.0	64	66	10.2	9.8	5.1	5.7	3.5	3.6
8.0	68	70	10.5	10.7	5.1	5.7	3.6	3.8
10.0	73	74	11.9	11.2	5.5	5.8	3.7	3.9
12.0	80	82	11.8	11.7	6.4	6.3	3.8	4.1
14.0	86	88	12.6	13.8	6.7	6.7	4.0	4.1
16.0	91	104	18.5	19.4	6.7	6.8	4.7	4.8
18.0	111	112	21.3	22.3	7.1	7.1	4.8	4.9
20.0	152	163	25.4	26.2	7.1	7.3	4.8	4.9
Mean LSD	81.2	84.7	13.56	13.92	5.7	5.88	3.83	3.97
(0.05)	1.0	1.0	1.2	1.1	0.11	0.11	0.5	0.5

Biomass yield determined as leaf dry weight and stem dry weight at 8 and 16 WAP during the two seasons was also significantly better with increasing rates of PM application up to the highest treatment level of 20 t/ha (Table 6). However, some PM treatment rates were not significantly different from each other in biomass yield during the two growing seasons (Table 6). Although the use of poultry manure substantially promoted biomass yield, successive increases in manure rates from 4 – 8 t/ha did not produce any significant effects on leaf dry matter production at 8 and 16 WAP in both 2005 and 2006 cropping seasons, respectively. At 8 WAP, leaf dry weight significantly varied from 45.2 and 46.4 g at 0 t/ha (2005 and 2006 seasons, respectively) up to 89.4 and 88.5 g at 20 t/ha (2005 and 2006 seasons, respectively) with mean values of 69.28 g (2005 season) and 69.52 g (2006 season). At 16 WAP, the mean leaf dry weights were 192.08 g (in the 2005 season) and 193.26 g (in the 2006 season) with a range of 102.3 (at 0 t/ha) – 246.9 g (at 20 t/ha) in the 2005 season and 104.3 (0 t/ha) – 249.8 (20 t/ha) in the 2006 season. Similarly, stem dry weight at 8 and 16 WAP showed a significant increase with increasing levels of PM application (Table 6). Stem dry weight ranged significantly from 58.5 and 59.6 g (in 2005 and 2006 seasons, respectively) at 0 t/ha PM to 184.3 and 149.4 g (in 2005 and 2006 seasons, respectively) at 20 t/ha PM with a mean value of 111.7 g (in 2005 season) and 109.1g (in 2006 season) at 8 WAP. At 16 WAP, stem dry weight ranged significantly from 225.3 and 226.4 g (in the 2005 and 2006 seasons, respectively) to 359 g and 304.06 g (in the 2005 and 2006 seasons, respectively) with a mean value of 310.1 g (in the 2005 season) and 304.06 (in the 2006 season).

The percentage increment in stem dry weight from 8 to 16 WAP was relatively higher without PM application (74.04 and 73.68 % in the 2005 and 2006 seasons, respectively) than with PM application; e.g. at 20 t/ha PM, the percentage increment in stem dry weight from 8 to 16 WAP was 48.76 and 58.49 % in the 2005 and 2006 seasons, respectively. However, the percentage increment in leaf dry weight from 8 to 16 WAP was relatively higher with 20 t/ha treatment (63.79

and 64.57 %, in the 2005 and 2006growing seasons, respectively) than without PM treatment (55.8 and 55.51 %, in the 2005 and 2006 seasons, respectively). This probably suggests that the PM treatment enabled the maize plant to attain its maximum stem weight much earlier than the treatments with manure application, whereas the leaf biomass was rapidly accumulating with PM treatment for enhanced photosynthetic activity.

Table 5. Effect of Poultry Manure on the Growth Parameters of Maize at 8 and 16 weeks after planting in the 2005 and 2006 Cropping Seasons

Treatment (t/ha)	8 WAP						16 WAP					
	Plant height (cm)		Stem diameter (mm)		No. leaves per plant		Plant height (cm)		Stem diameter (mm)		No. leaves per plant	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
0.0	15	57	7.2	7.3	4.1	4.2	133	125	20.1	21.2	7.1	7.0
4.0	63	65	9.8	9.4	5.4	5.5	151	150	25.3	24.5	9.3	9.1
6.0	73	73	13.3	13.1	5.3	6.1	174	175	28.2	27.5	10.2	10.3
8.0	93	87	15.1	14.9	8.1	6.1	192	200	31.4	32.1	11.1	11.3
10.0	111	112	16.2	15.3	8.1	6.2	211	210	35.5	37.0	11.3	11.1
12.0	151	156	19.3	20.1	9.1	9.2	241	224	39.6	38.8	12.3	12.0
14.0	173	181	21.5	22.2	11.4	10.3	252	251	46.3	42.1	12.0	13.2
16.0	194	201	23.6	23.5	11.4	11.2	256	258	46.2	47.2	12.1	13.3
18.0	212	213	27.2	28.1	11.5	11.4	261	262	50.4	52.1	13.1	13.3
20.0	254	261	29.5	30.1	12.1	12.3	275	281	55.5	55.7	14.1	14.1
Mean	133.9	140.6	18.27	18.4	8.65	8.25	215	214	37.85	37.82	11.26	11.47
LSD (0.05)	3.0	2.0	2.11	2.21	0.03	0.02	4.0	4.0	6.1	5.2	0.31	0.32

Table 6. Effect of Poultry manure on biomass at 8 and 16 WAP during the 2005 and 2006 cropping seasons

	8 Weeks after planting				16 Weeks after planting			
	Leaf dry weight per plant (g)		Stem dry weight per plant (g)		Leaf dry weight per plant (g)		Stem dry weight per plant (g)	
	2005	2006	2005	2006	2005	2006	2005	2006
0.0	45.2	46.4	58.5	59.6	102.3	104.3	225.3	226.4
4.0	53.1	54.2	74.7	75.8	155.2	155.2	256.5	258.6
6.0	53.4	54.4	75.5	76.9	156.5	156.3	273.4	274.5
8.0	53.6	54.5	75.9	76.9	157.9	156.5	294.3	287.2
10.0	67.7	66.8	113.2	113.6	188.5	189.7	311.4	296.4
12.0	78.8	78.8	121.5	122.6	213.4	214.8	325.5	312.3
14.0	80.9	80.5	132.4	132.5	222.7	225.7	337.6	326.8
16.0	83.4	83.7	139.5	140.4	231.8	232.8	357.7	338.7
18.0	87.3	87.4	142.1	143.3	245.6	247.5	359.7	359.8
20.0	89.4	88.5	184.3	149.4	246.9	249.8	359.7	359.9
Mean	69.28	69.52	111.76	109.1	192.08	193.26	310.1	304.06
LSD (0.05)	2.3	2.5	5.31	5.4	5.5	5.7	7.5	7.8

Table 7. Effects of poultry manure on the yield parameters of maize in the 2005 and 2006 cropping seasons

Treatment (t/ha)	Mean ear weight (g)		Mean ear length (cm)		Mean ear diameter (cm)		1000-seed weight (g)		Grain yield (t/ha)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
0.0	116.2	114.5	10.1	10.2	8.2	7.9	138.5	139.7	0.28	0.27
4.0	145.7	146.8	11.3	11.1	9.4	9.2	154.6	156.3	0.49	0.70
6.0	172.3	171.2	11.8	11.6	10.2	10.1	168.3	166.9	0.77	0.76
8.0	204.5	206.3	12.4	12.2	10.8	10.7	181.4	183.2	0.87	0.85
10.0	231.8	230.9	13.2	13.1	11.4	11.3	195.2	193.6	0.92	0.93
12.0	252.3	251.3	13.6	13.6	11.4	11.4	211.5	212.4	1.01	1.11
14.0	258.7	258.1	14.3	14.2	12.5	12.5	237.4	239.3	1.46	1.51
16.0	263.4	264.2	15.1	15.0	13.4	13.3	251.1	250.5	2.61	2.38
18.0	271.9	270.9	16.4	16.2	14.3	14.2	273.5	270.7	2.78	2.89
20.0	305.5	299.3	17.2	17.0	15.4	15.4	255.6	256.7	2.18	2.26
Mean	222.23	221.35	13.54	13.42	11.7	11.6	206.71	206.93	1.337	1.366
LSD (0.05)	10.1	10.0	0.4	0.4	1.0	1.0	5.3	6.2	0.01	0.02

Table 8. Correlation values among the growth and yield traits measured in this study

Trait	LAI	PH	SD	NL_P	LDW	SDW	MEW	MEL	MED	1000-SW	GY_{ha}
LAI	1.000	0.925	0.944	0.953	0.942	0.940	0.930	0.942	0.953	0.938	0.913
PH		1.000	0.988	0.957	0.951	0.966	0.945	0.988	0.983	0.949	0.890
SD			1.000	0.952	0.940	0.959	0.931	0.993	0.993	0.958	0.932
NL_P				1.000	0.975	0.979	0.979	0.961	0.964	0.969	0.878
LDW					1.000	0.985	0.964	0.960	0.948	0.971	0.886
SDW						1.000	0.978	0.979	0.979	0.975	0.895
MEW							1.000	0.954	0.953	0.944	0.825
MEL								1.000	0.994	0.970	0.921
MED									1.000	0.961	0.916
1000-SW										1.000	0.949
GY_{ha}											1.000

Correlation values are based on pooled data from the treatments in the 2005 and 2006 seasons. All the traits are strongly correlated with each other at P < 0.00. LAI = leaf area index, PH = plant height, SD = stem diameter, NL_P = number of leaves per plant, LDW = leaf dry weight, SDW = stem dry weight, MEW = mean ear weight, MEL = mean ear length, MED = mean ear diameter, 1000-SW = 1000 seed weight, GYha = grain yield per hectare.

The results further indicated that poultry manure significantly enhanced maize yield in the two cropping seasons (Table 7). The use of poultry manure produced more vigorous maize plants having significantly bigger average ear weight, length and diameter than when poultry manure was not applied. The 1000-seed weight and maize grain yield per hectare increased significantly with each progressive increase in poultry manure rate and reached a threshold at 18 t/ha, beyond which there was a significant decline in seed weight and grain yield /ha as the PM rate increased. Thus, the highest maize grain yield of 2.78 and 2.89 t/ha and the 1000-seed weights of 273.5 and 270.7 g were obtained with the use of 18 tons/ha of poultry manure in 2005 and 2006 cropping seasons, respectively.

The result of correlation analysis of all the growth and yield traits is shown in Table 8. All the traits were very strongly correlated with each other (Prob. < 0.0001 at 8 df). The r-values ranged from 0.878 (correlation between number of leaves/plant and grain yield/ha) and 0.994 (correlation between mean ear length and mean ear diameter), suggesting that these traits are positively highly associated with each other.

4. Discussion

Maize growth and yield characteristics in 2005 and 2006 were significantly better with the use of poultry manure than the control where manure was not applied. There were no significant differences in the effect of the seasons on the performance of all the growth and yield attributes determined in this study. This lack of performance differences in all the growth and yield traits between the two growing seasons may likely be due to the fact that the same quality of poultry manure as well as similar field experimental conditions was used in both seasons. Furthermore, there were also no significant differences in the weather conditions during the 2005 and 2006 growing seasons. The calculated t-test values for the average rainfall (t = 0.8696), number of rain days (t = 0.242), average relative humidity (t = 0.628) and average temperature (t = 0.743) during the period of this study (April – August) was much less than the tabulated t-test value of 2.447 (6 df.) at 5 % probability level.

The observed significant performance in growth and yield parameters with the application of poultry manure could be attributed to the essential nutrient elements contained in the poultry manure that are associated with increased photosynthetic efficiency [6]. The greater number of leaves, plant height, stem diameter and LAI in maize occurred with higher rates of poultry manure of up to 20 tons/ha. This finding corroborates with the report of Okoruwa [4] who observed significant increases in LAI and dry matter accumulation in maize with successive increases in organic manure rates. This could be due to the ability of the organic manure to supply the nutrient elements necessary to promote more vigorous growth, improve meristematic and physiological activities in the plants, as well as improve the soil properties, thereby resulting in the synthesis of increased photo- assimilates that enhanced maize yielding ability. LAI and grain yield had been observed to be positively correlated as long as the value of LAI was below 5 [23]. In this study, the highest value of LAI (4.8 and 4.9 in the 2005 and 2006 growing seasons, respectively) was also reached at the PM rate of 18 t/ha (the peak point also for grain yield). A LAI of 4.4 had been reported for maize [26] and is close to the values observed in this study. Generally, all the traits were very strongly correlated with each other which suggest that, in the case of limited field resources, the performance evaluation of one or more of these traits may provide a reasonable index for the prediction of the probable performance of these other closely associated traits.

Biomass (leaf and stem dry weight) and yield components (ear weight, ear length, ear diameter and 1000-seed weight) were also significantly increased with application of poultry manure which resulted in an overall increase in grain yield per hectare. Ogbonna and Obi [27] reported similar results where increases in organic manure application resulted in high dry matter partitioning towards increased grain yield and higher harvest index. The poultry manure rate of 18.0 t/ha seemed most satisfactory in obtaining the best maize yield of 2.78 and 2.89 tons/ha in both cropping seasons. Beyond this level (18.0 t/ha PM), increases in PM application had no additional advantage on boosting maize grain yield under the Obubra growing conditions, i.e. the onset of luxury consumption of nitrogen and the production of vegetative growth at the expense of high grain yield occurred beyond a PM rate of 18 t/ha. Given the composition of the PM used in this study, 18 t/ha poultry manure is equivalent to 243 – 236 – 92 Kg NPK per hectare. The PM also contained sufficient amount of magnesium, which is among the most important micronutrients for maize particularly under the continuous cropping practice in this rainforest agro-ecology [5]. The quality of poultry droppings used in this study was seemingly low in nitrogen and organic matter compared with the reports of Quarcoo[28], which may probably be attributed to the poor quality of feed used in the commercial broiler farm, the type of the deep litter material used and possible volatilization losses during the 3-month curing period. In spite of the quality of the PM used with particular reference to nitrogen, the 18 t/ha level of PM application produced an appreciable maize grain yield of 2.84 t/ha (averaged over the two growing seasons) which is within the global average yield of 2.2-3.5 tha^{-1}[3]. The highest grain yield figure obtained in this study with 18 t/ha PM application is much higher than the average grain yield of 1 t/ha usually reported for West African farmers. Without the application of PM, the average maize grain yield from this study was 0.27 t/ha which is close to the yields generally obtained by peasant farmers who are not able to afford any fertilizer input in this agro-ecological zone.

5. Conclusions

From the above results, it could be concluded that yield advantages were gained by cultivating maize with poultry manure, albeit at high application rates. With the present high cost of mineral fertilizer, which is largely unaffordable and unavailable to the resource-poor peasant farmers, the yield potential by farmers in this study area can be successfully maximized with the application of 18.0 t/ha of poultry manure.

REFERENCES

[1] C. A. Jones, 1997, A survey of the variability in tissue nitrogen and phosphorus concentration in maize and grain sorghum, Field Crops Research 6,133-147.

[2] N. P. Eleweanya, M. I. Uguru, E. E. Enebong, and P. I. Okocha, 2005, Correlation and path coefficient analysis of grain yield related characters in maize (*Zea mays L*) under Umudike conditions of South Eastern Nigeria, Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension 1, 24-28.

[3] G. Olaoye and N. O. Adegbesen, 1991, Utilization and processing of maize. IITA Research Guide No. 35. Training Program, International Institute of Tropical Agriculture (IITA) 29p.

[4] E. A. Okoruwa, 1998, Effects of NPK fertilizer and Organic manure on the growth and yield of maize (*Zea mays L.*) Hybrid, Crop Sci. 22, 119-124.

[5] J. E. Iken and N. A. Amusa, 2004, Maize research and production in Nigeria, African Journal of Biotechnology 3 (6), 302-307.

[6] S. N. Dauda, F. A. Ajayi and E. N. Dor, 2008, Growth and yield of watermelon (*Citrullus lunatus*) as affected by poultry manure application, J. Agric. & Social Sci 4 (3), 121-124.

[7] L. W. John, D. B. James, L. T. Samuel and L. W. Warner, 2004, Soil fertility and fertilizers: An introduction to nutrient management, pp.106 -153, Pearson Education, India.

[8] H. A. Akintoye, E. O. Lucas and J. G. Kling, 1997, Effects of density of planting and time of N application on maize varieties in different agro-ecological zones of West Africa, Comm. Soil Sci. Plant Anal., 28, 116 -117.

[9] W. A. Enwezor, E. J. Udo, K. A. Ayotunde and J. A. Adepetu, 1995, Effects of Organic Fertilizer on the yield of maize, Field Crops Research*,* 65,132-136.

[10] P. I. Ezeaku, 2008, Optimum NPK fertilizer rates based on soil data for grain maize (Zea mays L.) production in some soils of south eastern Nigeria, Agricultural Journal, 3 (1), 36-41.

[11] M. I. Uguru and I. U. Obi, 1991, Optimum rates of NPK for hybrid maize production in the derived savanna zone of south eastern Nigeria, Nig. Agric. J., 25: 38-46.

[12] B. T. Kang, 1981, Nutrient requirement and fertilizer use for maize. In: Agronomy Training Manual for Agro-service Agronomist, NAFPP/IITA. Fed. Dept. Agric., Lagos, pp.405-416.

[13] U. R. Pal, 1991, Effect of source and rate of nitrogen and phosphorous nutrient uptake and apparent fertilizer nutrient recovery by maize in southern Nigeria guinea savanna. J. Agric. Sci. Tech. 1: 21 – 24.

[14] P. I. Ezeaku, 2001, Evaluation of legume crops as alternative source of fertilizer for maize production in Abakaliki, Southeastern Nigeria, J. Agrotech. Ext. 1, 1-9.

[15] A. A. Ano, 1991, Maize quality and utilization project, International Institute of Tropical Agriculture (Ibadan), 19p.

[16] I. U. Obi, 1989, Effect of time of planting on natural disease and pest infestation of late season maize in the Nsukka plains of Southern Nigeria, Maize Research Monograph 3, University of Nigeria Nsukka, 28p.

[17] S. A. Boateng, J. Zickermann and M. Kornahrens, 2006, Poultry manure effect on growth and yield of maize, West African J. Applied Ecology 9:1-18

[18] A. E. Eneji, A. A. Agboola and B. E. Ubi, 1997, Effect of farmyard manure and NPK fertilizer on growth and yield of maize + sweet potato intercrop in South-western Nigeria. Revista di Agricultura Subtropical e Tropicale **91(1)**: 63-78.

[19] K. K. Martin, K. K. Sankeran and Kerishnamoorthy, 1998, Maize growth and yield as influenced by organic waste nutrient. Exptal Agric. 23: 233 – 239.

[20] E. O. Beckman, 1973, Organic fertilization: vegetable farming luxury or necessity, Techn. Comm., *ISHA,* 29, 247.

[21] M. Hunt and J. Minnich, 1979, The Rodale guide to composting. Rodale Pr. (1st Edition) 350p.

[22] Cross River Agricultural Development Projec (CRADP), 1992, Report on Wetlands of Cross River State, Nigeria 15p.

[23] J. G. Shortall and W. C. Liebhardt 1975. Yield and growth of corn as affected by poultry manure. J. Environ. Qual. 4 (2): 186-191.

[24] K. A. Gomez and A. A. Gomez, A. A., 1984, Statistical procedures for agricultural research. 2nd ed. New York . John Wesley and Sons, 680p.

[25] I. U. Obi, 1986, Statistical methods of detecting differences between treatment means, SNAAP press limited, Enugu, Nigeria, 45p.

[26] N. Muleba, T. G. Hort and G. M. Paulsen, 1983, Physiological factors affecting maize yields under tropical and temperate conditions. Trop. Agric. 60: 3-10.

[27] P. E. Ogbonna and I. U. Obi, 2005, Effect of time of planting and poultry manure application on growth and yield of maize (Zea mays L) in a derived savannah Agro-ecology, Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension (2):133-38

[28] A. N. D. Quarcoo, 1996, Characterization and decomposition study of poultry manure. B.Sc. Project, University of Science and Technology, Kumasi, Ghana.