Journal of Agriculture, Biotechnology & Ecology, 2(3), 313-321, 2009
ISSN: 2006-3938

Growth and Yield of Maize (*Zea mays L.*) on an Acidic Coastal Plain Soil Fertilized with Compost and Inorganic Fertilizers

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ABSTRACT

Our objective was to assess the effect of compost and other fertilizer types on the growth and yield of maize on a coastal plain soil. The experimental soil was an Ultisol inherently low in organic matter, clay and essential nutrients. We evaluated five treatments arranged into a randomized complete block design with three replications: no-fertilizer (control), NPK 15-15-15 (400 kg/ha), organo-mineral fertilizer (3 t/ha), compost (20 t ha^{-1}) and liquid fertilizer (Ag-zime) at 5 litres/ha. The results showed significant ($p < 0.05$) differences among treatments with NPK 15-15-15 producing the tallest plants (181.96 cm) with the biggest stem girth (6.69 cm). Organo-mineral fertilizer had plants with the largest leaf area (784.07cm^2) and cob circumference (13.96 cm). Maize grain yields on plots with no-fertilizer (1.01 t ha^{-1}) and liquid fertilizer (1.02 t ha^{-1}) were significantly ($p < 0.05$) lower than those in plots fertilized with NPK 15-15-15 (1.68 t ha^{-1}) and organo-mineral fertilizer (1.80 t ha^{-1}) but similar to those in plots amended with compost (1.26 t ha^{-1}). Our results suggested that a combined application of compost and mineral fertilizer would better improve the grain yield of maize in an acidic Ultisols with high precipitation than single use of other fertilizer sources.

INTRODUCTION

Maize is known to provide nutrients to humans and animals and also serves as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food and fuel. Increases in production of grains has now become extremely urgent, to reduce the grain deficit facing most developing countries, especially during periods of global food crisis as recoded this year. One of the ways by which such a deficit can be eliminated is by rapid expansion of maize production by small-scale farmers.

A major constraint to extensive production of maize in the coastal plain soils of Nigeria is the low level of inherent fertility. Yet, most herbaceous annual crops are very sensitive to deficiency of nutrients such as N, P and K. The deficiency of N and K are common in acid sandy soils, while that of P is common on acid clayey or volcanic ash soils (Udoh et. al, 2005). Due to the porous nature of the coastal soils, their low pH, and organic matter and clay contents as well as high rainfall, the application of inorganic fertilizers is accompanied by a high rate of leaching losses even when they are properly incorporated into the soil (Agboola, 1998).

To ameliorate these problems, earlier research works with some crops involved the use of either chemical fertilizer or fresh organic manures alone or a combination of both (e.g. Eneji et al., 1995; 2003). A report by Agboola (1998) showed that the combined application of mineral fertilizer and fresh organic manures increased the growth and yield of many food crops. The growth and yield of cassava (*Manihot esculenta*) was much higher with the application of an organo-mineral fertilizer (compost mixed with inorganic fertilizer) than with either compost or chemical fertilizer alone (John et. al., 2006). According to Sobulo and Aduayi (1990), the future of agriculture in the tropics will depend on the development of organic based fertilizers which will provide the required nutrients as well as improve the organic matter content of the soil. Our objective was to determine the effects of compost, inorganic and liquid fertilizers alone, and a combination of compost and inorganic fertilizer, on the growth and yield of maize on the acidic coastal plain sands of southeastern Nigeria.

MATERIALS AND METHODS

Field studies were carried out at the University of Uyo Teaching and Research Farm, Use-offot, Uyo, Nigeria, during the early planting season of 2007, to access the effect of different fertilizer types on the growth and yield of maize. Uyo lies within the humid tropical rainforest zone of South-eastern Nigeria. It has an annual rainfall of about 2000 to 3000 mm. It is situated between latitude 5.17 and 5.27 °N and longitude 7.27 and 7.58 °E (UCCDA,

1998). Annual temperature average is about 28 °C. The fertilizer treatments were No fertilizer (control); NPK (15-15-15) at 400 kg ha^{-1}; organo-mineral fertilizer at 3,000 kg ha^{-1}; compost at 20,000 kg ha^{-1} and liquid fertilizer (Agzime) at 5 liters ha^{-1}. The compost was made from a mixture of poultry manure, cow dung and ash. Each of these fertilizer treatments was applied 3 weeks after sowing. The experimental plots were laid out in a randomized complete block design (RCBD) with three replications.

Soil sampling and analysis

A composite soil sample representing the experimental site was collected at the soil depths of 0-15 and 15-30 cm, labeled, air-dried, crushed and sieved through a 2 mm mesh for physico-chemical analysis. Organic carbon was determined using Walkley-Black method as described in Nelson and Sommers (1982). Total nitrogen was determined by macro-kjedahl procedures (Jackson, 1962). Available phosphorus was extracted using Bray P-1 method (Bray and Kurtz, 1945) and P in the extract measured colorimetrically according to Murphy and Riley (1962). Exchangeable acidity was extracted with IN KCl and determined by titration. Soil pH was determined in a 1:2 soil/water ratio using a digital pH meter. Exchangeable bases were extracted with IN NH_4OAc; Ca^{2+} and Mg^{2+} in the extract were determined by EDTA titration while K^+ and Na^+ were measured with the flame analyzer. Particle size distribution was determined by the hydrometer method of Bouyoucos (1962).

Cultural practices

The experimental site which had been under continuous cultivation for over thirty years was cleared manually using a matchet. Three seeds of the local variety of maize (*Uwep)* were sown per hole at the spacing of 0.75 m within and between rows. Thinning was carried out 14 days after emergence. At 3 weeks after sowing (WAS), the different solid fertilizers were applied in a ring and the liquid fertilizer by spraying on each maize stand. Weeding was done manually using a hoe at 3 WAS. The cobs were picked at full maturity, 90 days after sowing.

Growth and yield parameters

At three weekly intervals, plant height was measured using a measuring tape. The number of leaves per plant was determined by counting the number of functional leaves; leaf area was determined by measuring the length and breadth of the leaf of maize plant. Stem girth was measured using a measuring tape round the maize stem. The number of cobs was counted for each plant and the circumference of sampled cobs measured with a measuring tape. We determined the grain weight by weighing 100 grains per treatment. Data collected were subjected to an analysis of variance (ANOVA)

and means were compared using the least significant difference (LSD) at the 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The experimental soil was generally low in essential nutrients, pH, base saturation, cation exchange capacity, organic matter and clay content (Table 1). The synergetic effect of both compost and mineral N fertilizer greatly enhanced the yield and yield components of maize. The applied composts possibly provided cation exchange sites for the efficient use of the applied nitrogen fertilizer.

Table 1: Chemical and physical properties of the experimental soil used for the planting of maize.

Property	Soil depth (cm)	
	0 – 15	15 – 30
Particle size:		
Sand (g kg $^{-1}$)	858.1	823.0
Silt (g kg $^{-1}$)	94.0	88.4
Clay (g kg $^{-1}$)	48.0	89.0
pH	4.7	4.8
Organic matter (g kg $^{-1}$)	28.2	24.2
Total nitrogen (g kg $^{-1}$)	1.20	1.50
Available Phosphorus (mg kg $^{-1}$)	106.7	113.3
Exchangeable cation:		
Calcium (cmol kg^{-1})	1.60	1.80
Sodium (cmol kg^{-1})	0.07	0.08
Potassium (cmol kg^{-1})	0.12	0.09
Magnesium (cmol kg^{-1})	1.80	1.50
Exchangeable acidity:		
Al^{3+}	3.38	2.68
Effective cation exchange cap.		
Base saturation (%)	35.90	36.80
Bulk density (g cm^3)	1.40	1.50

Maize plants fertilized with NPK 15-15-15 and organo-mineral fertilizer produced significantly ($P<0.05$) taller plants than those in control (soil only) and Ag-zime (liquid fertilizer) fertilized plots (Figure 1). Similar observations were made for the stem girth of the maize plant. Obviously, the low soil fertility status of the control soil characterized by low water and

nutrient holding capacities due to the high sand fraction negatively affected growth. This also explains the ineffectiveness of the liquid inorganic fertilizer for maize growth. The number of maize leaves varied little but the stem girth and leaf area were significantly ($P<0.05$) different among the various fertilizer types. A larger leaf area was observed in plots that received organo-mineral fertilizer and NPK 15-15-15. These observations were consistent with the reports of Agboola (1998) who attributed this to the synergistic effect of combining organic and inorganic fertilizers.

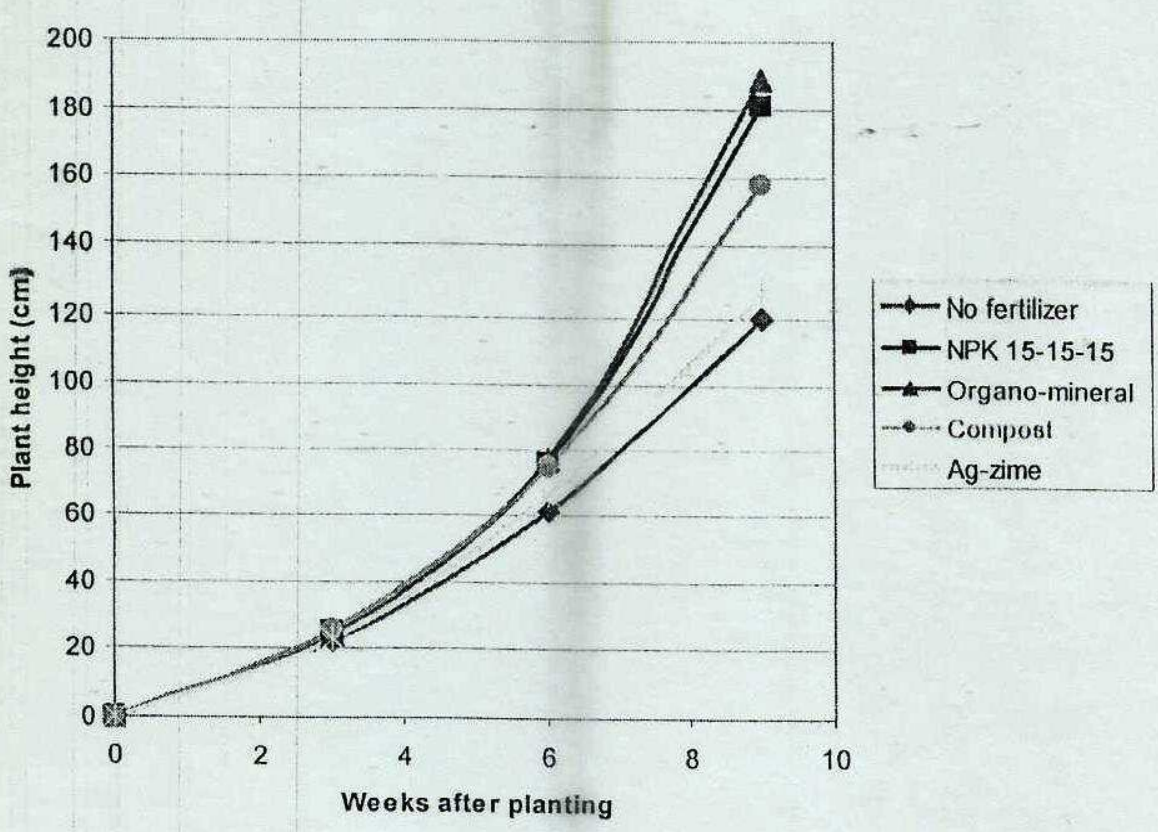

Fig. 1: Height (cm) of maize plants under different fertilizer types.

Maize yield and yield components were better in the organo-mineral plots than other fertilizer plots (Table 2). This manifested in the significant differences among the various fertilizer treatments in the stem girth and leaf area at 9 weeks after sowing. These parameters did well with application of organo-mineral fertilizer than the control (soil only) and other fertilizer treatments. An earlier report (Agboola and Odeyemi,1972) showed that use of organic manure in combination with inorganic fertilizer enhanced the establishment of the maize crop due to nutrient release from the inorganic component while mineralization of the organic manure promoted yield

components that develop later in the season. Other researchers (Kwakye, 1980; Jones 1973) also made similar observations.

Maize grain yield in the plot that received NPK 15-15-15 was not much different from that in plots fertilized with organo-mineral fertilizer (Figure 2). However, some of the cobs from NPK fertilized plot were poorly or partially filled and others were without any grains. Maize cobs from organo-mineral fertilizer plots though smaller in size than those of the NPK fertilized plots were completely filled. This difference in cob filling was presumably due to the general deficiency of micronutrients in the soil which was not met by the inorganic fertilizer (NPK 15-15-15) but were supplied in the organo-mineral fertilizer through the incorporation of compost in its formulation.

Table 2: Mean number of leaves, stem girth and leaf area of maize as influenced by the different fertilizer types.

	Weeks after sowing		
Fertilizer type	3	6	9
Number of leaves			
No fertilizer	6.70	8.43	10.33
NPK 15-15-15	6.50	9.43	11.33
Organo-mineral	7.07	9.33	11.40
Compost	6.87	9.37	10.96
Ag-zime	6.87	8.20	10.97
LSD (P<0.05)	NS	NS	NS
Stem girth (cm)			
No fertilizer	1.93	4.57	4.69
NPK 15-15-15	2.07	5.28	6.69
Organo-mineral	2.30	5.40	6.62
Compost	2.43	5.47	5.57
Ag-zime	2.17	4.72	4.83
LSD (P<0.05)	NS	NS	0.46
Leaf area (cm^2)			
No fertilizer	90.54	364.40	439.35
NPK 15-15-15	95.85	419.32	751.50
Organo-mineral	106.93	348.13	784.07
Compost	117.32	467.68	651.01
Ag-zime	127.85	367.23	467.24
LSD (P<0.05)	NS	NS	128.84

NS = Not significant

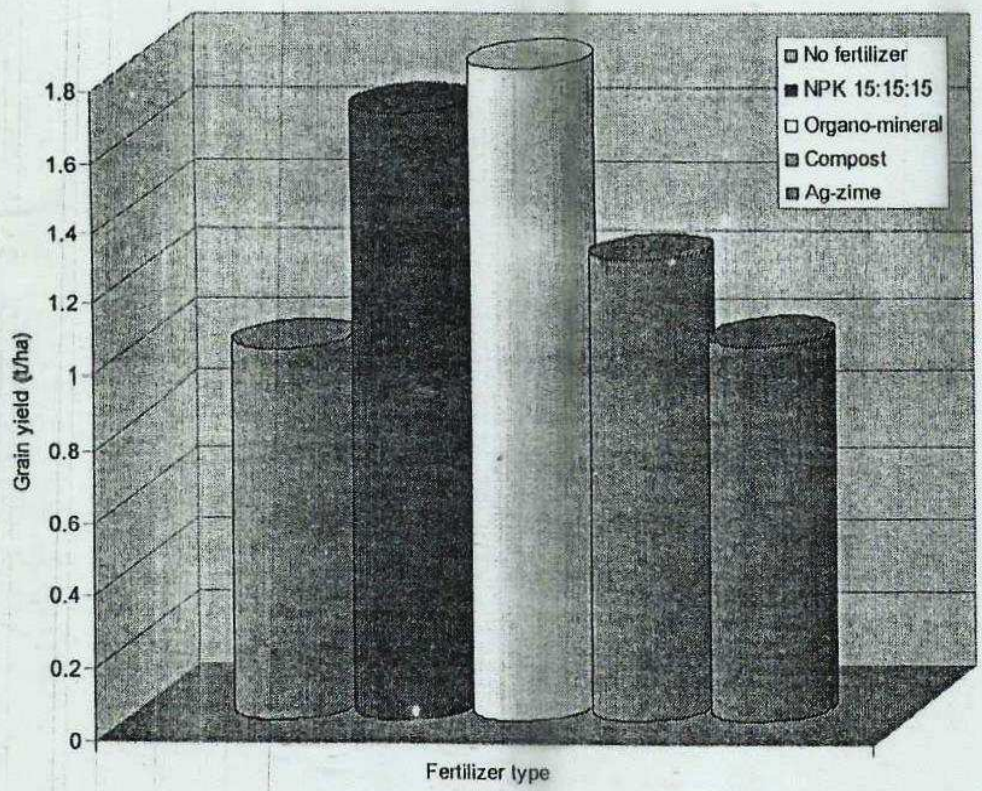

Fig. 2: Maize grain yield as influenced by application of different fertilizer types.

The fertilizer treatments had no significant effects on the number of cobs per plant, length of maize cob, weight of undehusked maize cobs and fresh grain weight (Table 3). However, there were marked differences in the circumference of the maize cobs and dry weight of grains. As a result, the grain yield from plots fertilized with NPK 15-15-15, organo-mineral fertilizer and compost were higher than those fertilized with Ag-zime and no-fertilizer.

CONLUSION

The application of compost to maize growing on an acidic coastal plain soil resulted in little improvements on crop growth and yield because of the low inherent contents of primary (N, P and K), secondary and micro nutrients in both the soil and compost tested. However, use of an organic-based fertilizer such as the organo-mineral fertilizer produced a synergy that was significantly favourable to the growth and yield of maize. As the current

prices of inorganic fertilizer keep increasing in Nigeria, peasant farmers have been unable to afford its use. Therefore, the development of an organic-based low input fertilizer technology for soil fertility maintenance would be a more viable alternative.

Table 3: Mean yield components of maize as influenced by the application of different fertilizer types.

Fertilizer types	No. of cobs/ stand	Circumference of cobs (cm)	Weight of undehusked cob (g)	Length of cob (cm)	Weight of grain (g)	Weight of 100 grains (g)
No fertilizer	1.07	12.65	149.33	110.00	14.71	26.75
NPK15-15-15	1.05	13.67	218.78	153.33	15.58	29.18
Organo-mineral	1.07	13.96	231.33	160.70	17.37	31.59
Compost	1.00	13.69	200.00	146.67	16.52	28.11
Ag-zime	1.00	12.75	170.22	129.00	15.84	26.99
LSD (P<0.05)	NS	1.09	NS	NS	NS	NS

NS = Not significant

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