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Efficacy of Different Organic Fertilizers on Soil Fertility Improvement, Growth and Fruit Parameters of Cucumber (*cucumis sativus L*)

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ABSTRACT

The efficacy of different organic fertilizer such as poultry pig manure oil palm bunch ash and wood ash on the soil fertility improvement, growth and fruit yield parameters of cucumber (cucumber sativus L) was studied at Akure in the rainforest zone of Nigeria between 2011 and 2012 cropping seasons.

Four organic fertilizer treatments were used such as poultry, pig manures, wood ash and oil palm bunch ash applied at 6t/ha with a reference treatment NPK 15-15-15 applied at 300kg/ha and a control treatment (no fertilizer application) replicated three times and arranged in a randomized complete block design

The result showed that there were significant increases ($P< 0.05$) in the cucumber growth parameter (vine length vine girth, leaf area and leaf number), fruit yield parameter (fruit weight, diameter and leaf number) under the different organic fertilizer and NPK 15-15-15 compared to control treatment. NPK 15-15-15 fertilizer had the highest values of cucumber vine length, vine girth, leaf area and leaf number followed by poultry manure, wood ash and oil palm bunch ash treatments respectively. NPK 15-15-15 fertilizer increased vine length, vine girth, leaf area and leaf number by 14.7%, 22.16%, 6.6% and 6.64% respectively compared to poultry manure

For the yield parameters, poultry manure treatment had the highest values of fruit length, fruit diameter and fruit weight of cucumber followed by pig manure, NPK15-15-15, wood ash and oil palm bunch ash treatments respectively. Poultry manure increased the fruit length, fruit diameter and fruit weight by 47% ,5.4% and 26.74% respectively compared to pig manure. When compared with NPK 15-15-15 fertilizer, poultry manure also increased the fruit length, diameter and fruit weight by 52.9%, 24.4% and 12.8% respectively.

In term of soil fertility improvement, poultry manure treatment had the highest values of soil organic matter (O.M), P and moderate values of K, Ca and Mg compared to other treatments while wood ash and oil palm bunch ash had the highest values of soil pH, K, Ca and Mg. the NPK 15-15-15 fertilizer treatment had the highest value of soil N, K and least values of soil O.M, Ca and Mg. However, NPK 15-15-15 had higher K/Ca, K/Mg and P/Mg ratio values of 130:1, 78:1 and 656:1 signifying high nutrient imbalance and would affect the uptake of these nutrients compared to 2:1 K/Ca, 2:1 K/Mg and 35:1 P/Mg ratio in pig manure.

The excellent performance of poultry manure applied at 6t/ha in improving soil, growth and producing the highest fruit yield parameters of cucumber was due to its balanced nutrient composition which other treatments did not possess.

KEYWORDS: Cucumber (cucumus sativus L), growth, fruit yield parameters, organic fertilizers and soil fertility improvement.

INTRODUCTION

Cucumber (cucumis sativus L) is an important crop belonging to the family cucurbitaceae (Efediyi and Remison 2010)[1] and it is fourth most important vegetable after tomato, cabbage and onion. Cucumber is a crop grown for its edible fruits which are eaten while still immature, either fresh or cooked and supplies vitamins, minerals and anti-oxidant to the body. Jitendra et al (2013)[2].

Inspite of the economic and health importance of cucumber crop, its optimum yield has not been attained in Nigeria partially because of poor germination of seeds sown directly, poor nursery establishment practices and climatic vagaries but the problem is further compounded because there is decreasing soil fertility arising from continuous cultivation on the same piece of land yearly without fertilizer application. Further efforts being made to increase the soil fertility through the use of inorganic fertilizers are limited by high cost of purchase and deterioration of soil properties on continuous use (Moyin-Jesu 2007)[3]. Therefore, there is an urgent need to look for alternative source of locally produced organic fertilizers which are cheap and sustainable.

Except the works of Eifediyi and Remison (2010)[1], Adenawoola and Adejoro (2005)[4] who worked on the growth and yield of five varieties of cucumber and jute respectively, there were scarcity of research reports on the use of poultry manure, pig manure and wood ash to grow cucumber in the field, hence, there is a strong justification to use these organic fertilizers for the sustainable cultivation of cucumber.

The objectives of this research study are:

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i. To determine the effect of different organic fertilizers such as poultry, pig and wood ash on the growth and fruit yield of cucumber.
ii. To determine the effect of these organic fertilizers on the soil chemical composition after harvesting.

MATERIALS AND METHODS

The experiment was carried out at Akure in the rainforest zone of Nigeria in 2011 and was repeated in 2012 to validate the results. The soil is sandy loam, skeletal, kaolinitic, isohyperthermic oxic paleustalf (Alfisol). Soil survey staff (1999)[5]. The annual rainfall is between 1100-1500mm while the annual temperature is between 9-32ºC.

Soil sampling and analysis before planting

Core soil samples were collected from 0-15cm depth on the site, bulked together, air-dried, sieved with 2mm sieve and ready for routine laboratory analysis.

The soil pH (1:1 soil/water) and (1:2 soil/0.01M $CaCl_2$ was read on pH meter (Crockford and Nowell, 1956)[6] while organic matter was determined using wet oxidation method through chromic acid digestion (Walkley and Black, 1934)[7]. Soil P was extracted by Bray P1 extractant and the extract was developed on Murphy blue colouration and determined on a spectronic 20 (Murphy and Riley, 1962)[8].

The soil K, Ca, Mg and Na were extracted with 1 M NH_4OAC pH7 and their contents K, Ca and Na were read on the flame photometer (Jackson, 1958)[9] while Mg content was determined using the atomic absorption spectrophotometer.

The %N was determined using the microkjedahl method (Jackson, 1964)[10] while the micronutrients were extracted with 0.1M HCl and read on atomic absorption spectrophotometer. Soil bulk density was determined using core method (Ojeniyi, 1985)[11] while particle size analysis was done using hydrometer method. Bouycous (1951)[12].

Sources and processing of organic fertilizers used for the field experiment

The poultry and pig manures were obtained from the livestock section while the wood ash and oil palm bunch were also collected from the crop processing unit of Federal College of Agriculture, Akure. The poultry and pig manure were air-dried and stacked under a shade to allow quick mineralization while oil palm bunch ash, wood ash were sieved with 2mm sieve to remove pebbles, wood and charcoal remnants.

NPK 15-15-15 fertilizer was purchased from Agricultural Input Supply Agency, Akure, Ondo State while the cucumber seeds were purchased from Nigeria Institute of Horticultural Research, Ibadan, Nigeria.

Chemical analysis of the organic materials used

Two grammes each of the processed forms of organic materials were analyzed. The N content was determined by the kjedahl method (Jackson, 1964)[10] while the determination of P, K, Ca, Mg was done using the wet digestion method based on 25-5-5ml of HNO_3-H_2SO_4 acids (AOAC, 1970)[13].

Nursery establishment for cucumber seedlings

A shade was constructed and the land was cleared of debris and packed. Ten nursery beds with a size of 1m x 2m each was prepared. The cucumber seeds were sown through drilling at 30cm spacing between March and April, watered both morning and evening. Germination of the seeds started six days after planting and continued growing until two weeks after germination before transplanted to the field. The nursery establishment is important because direct sowing of seeds on the field will not germinate.

Field Experiment

The site was cleared, ploughed, harrowed and divided into different plots. The size of each plot is 4m x 4m ($16m^2$). There were four organic fertilizer treatments such as poultry manure, pig manure, wood ash and oil palm bunch ash applied at 6t/ha with a reference treatment NPK 15-15-15 fertilizer applied at 300kg/ha and a control treatment (no fertilizer nor manure), replicated three times and arranged in a randomized complete block design.

The treatments were incorporated into the soil using a hand trowel and allowed to decompose for one week before transplanting germinated seedlings of cucumber (Royal Ashley variety) at a spacing of 1m x 1m, watered immediately and continued every morning and evening until the rain was steady which is meant to allow full establishment.

Staking was done to allow the vines to be held uprightly for better exposure to sunlight. This is because cucumber is a sun loving plant (photoperiodic in nature). Weeding was done manually starting from two weeks after transplanting and continued at 2 weeks interval until harvesting. Avesthrin (10 EC Cypermethrin) at 10ml per 10L of water was sprayed to control pests starting from two weeks after transplanting.

In each plot, six plants were sampled for data collection on growth parameters such as vine length, vine girth and leaf area starting from two weeks after transplanting and continued weekly till the sixth week after transplanting. The inflorescence started from the fifth to the seventh week.

At eight week after transplanting, harvesting of matured fruits started and were measured for fruit diameter (cm), fruit length and fruit weight (kg). The harvesting continued at three days interval until senescence and the gestation period was between 2 ½ - 3 months.

Soil analysis after harvesting

After harvesting, soil samples were taken from each treatment plot using soil auger, bagged, air-dried and sieved with 2mm sieve for routine analysis of soil pH, N, P, K, Ca and Mg.

Statistical analysis

All the data collected on the growth and fruit parameters (vine length, leaf area, vine girth, fruit length, fruit diameter and fruit weight) were subjected to statistical analysis using the ANOVA F-test and their means were separated using Duncan Multiple Range Test at 5% level. Gomez and Gomez (1984)[14].

RESULT

Soil chemical composition before planting cucumber

Table 1 presents the chemical composition of soils before planting cucumber (cucumis sativus L). The soil P (mg/kg) is 5.33 mg/kg which is far lower than 10mg/kg P recommended for crop production in South Western Nigeria (Agboola and Corey, 1973)[15].

The soil pH value was 5.83 (1:1 soil/H_2O suspension) which showed that soil is slightly acidic. The percent organic matter was 0.66% which is below 3% critical level for crop production in South Western Nigeria (Agboola and Corey 1973)[15].

The percent Nitrogen was 0.09 which is much lower than the 0.15%N critical level for crops. Sobulo and Osiname (1981)[16]. The exchangeable bases (K, Ca, Mg and Na) were below 0.2mmol/kg recommended by Folorunso et al (2000)[17]. The soil textural class is sandy loam and the soil bulk density is 1.58mgm^{-3}.

Chemical analysis of the organic fertilizer materials

The analysis of nutrient composition of organic fertilizer materials were presented in Table 2. Wood ash had the highest values of K, Ca, Mg followed by oil palm bunch ash, poultry and pig manures respectively. Poultry manure had higher values of N, P, K, Ca and Mg than pig manure with least C/N ratio value.

Effect of organic fertilizers on the growth parameter of cucumber

The growth parameters of cucumber (vine length, vine girth, leaf area and leaf number) increased significantly ($P<0.05$) under different organic fertilizers compared to the control treatment (Table 3).

NPK 15-15-15 fertilizers had the highest values of cucumber vine length, vine girth, leaf area and leaf number followed by poultry manure, pig manure, wood ash and oil palm bunch ash treatments respectively. NPK 15-15-15 fertilizer increased significantly vine girth, leaf area, leaf number and vine length by 14.7%, 22.16%, 6.6% and 0.5% respectively compared to poultry manure treatment.

Among the organic fertilizers, poultry manure treatment increased cucumber vine length, vine girth, leaf area and leaf number by 28.2%, 34.5%, 11.71% and 26.48% compared to the wood ash treatment. The control treatment had the least values of cucumber growth parameters.

Effects of organic fertilizers on the fruit yield parameters of cucumber under different organic fertilizers

Significant increases ($P<0.05$) occurred in the fruit yield parameters of cucumber (fruit length, fruit diameter and fruit weight) under different organic fertilizers compared to control treatment (Table 4).

Poultry manure had the highest values of fruit length, fruit diameter and fruit weight of cucumber followed by pig manure, NPK 15-15-15, wood ash and oil palm bunch ash treatments respectively. For example, poultry manure increased the fruit length, fruit diameter and fruit weight by 47%, 5.4% and 26.74% respectively compared to pig manure. It also increased the same parameters by 59.6%, 17.77% and 36.9% compared to wood ash.

When compared with NPK 15-15-15 fertilizer treatment, poultry manure increased the fruit length, diameter and fruit weight by 52.9%, 24.4% and 12.8% respectively. The control treatment had the least values of all fruit yield parameters of cucumber.

Soil chemical composition after harvesting cucumber

There were significant increases ($P<0.05$) in the soil N, P, K, Ca and Mg under different organic fertilizers compared to the control treatment. (Table 5).

NPK 15-15-15 fertilizer had the highest values of N and K compared to other treatments. It also had least values of organic matter (O.M), Ca and Mg implying high K/Ca, K/Mg and P/Mg ratios. For instance, NPK 15-15-15 fertilizer increased the soil N and K by 28% and 39% compared to pig manure. However, it had higher K/Ca, K/Mg and P/Mg ratio values of 130:1, 78:1 and 656:1 compared to 2:1 K/Ca, 2:1 K/Mg and 35.1 P/Mg in pig manure.

Poultry manure had the highest values of soil organic matter (O.M), P and moderate values of K, Ca and Mg compared to other treatments. Also, wood ash and oil palm bunch ash had the highest values of soil pH, K, Ca and Mg.

Poultry manure increased soil O.M and P by 30% and 46% compared to wood ash while wood ash increased soil K, Ca and Mg by 20%, 20.3% and 14% respectively compared to poultry manure. The control treatment had the least values of soil pH, N, P, K, Ca and Mg nutrients.

DISCUSSION

The control treatment had the least values of soil nutrients, growth and yield parameters of cucumber when compared to other treatments and this could be due to continuous growing of crops on the same piece of land which led to soil nutrients depletion and the resultant low soil fertility status. This finding was also supported by Ojeniyi and Moyin-Jesu (2006)[18] who reported low yield and sharp decline in soil nutrients (N, P, K, Ca, Mg), pH and O.M after five years of continuous cropping for Okra (Abelmoschus esculentum L) in the rainforest area of Nigeria without fertilizer application.

Thee excellent performance of poultry manure treatment in increasing the values of vine length, vine girth, leaf area, leaf number, fruit length, fruit diameter and fruit weight of cucumber compared to wood ash, pig manure, oil palm bunch ash and NPK 15-15-15 could be traced to its balanced nutrient contents particularly it had the highest value of Nitrogen, least C/N ratio and moderate values of P, K, Ca and Mg which enhanced faster decomposition and release of nutrients to increase the soil nutrients, organic matter and subsequently, improved the uptake of water and nutrients for higher yield productivity. Moyin-Jesu (2014)[19] also reported that Nitrogen is responsible for good vegetative growth and yield of crops as well as serving as a contributory factor to organic matter build up. This could be responsible for the highest fruit yield parameters under the poultry manure treatment.

The fruit yield of cucumber obtained (40,300kg/ha or 40,03t/ha) was far higher than 37,254kg/ha or 37.25t/ha obtained by Eifediyi and Remison (2010) and 27.84t/ha obtained by Jitendra et al (2013)[2].

The decrease in yield of cucumber fruits under NPK 15-15-15 could be explained by the fact that application of NPK 15-15-15 led to higher K/Ca, K/Mg and P/Mg ratio, which made difficult the availability of nutrients such as K/Ca and Mg nutrients in the soil for crop uptake and this observation was similar to Ndor et al (2013)[20] and Moyin-Jesu (2013)[21] who reported nutrient imbalance in chemical based fertilizers on fluted pumpkin and Gordon egg.

The very high Nitrogen content in NPK 15-15-15 encouraged excessive vegetative growth such as vine length, vine girth and leaf number but delayed fruit formation and yield of cucumber, hence the lower values of fruit length and diameter. The observation was similar to the work of Aduayi (1980)[22] who reported the effect of ammonium sulphate in increasing soil acidity, reduces K, Ca, Mg, organic matter and micronutrients uptake by Okra (Abelmoschus esculentum L).

The drastic reduction of organic matter by NPK 15-15-15 could also affect nutrient supplies to cucumber, hence, its lower yield compared to poultry and pig manures as observed by Moyin-Jesu (2013)[21].

The increase in soil pH under wood ash and oil palm bunch ash compared to other treatments was attributed to their high K, Ca and Mg contents which can serve as liming materials (Gordon, 1988)[23] unlike the NPK 15-15-15 fertilizer which on continuous use decreased soil pH.

The soil pH had been reported to influence nutrient uptake and availability. Obatolu (1995)[24] also reported that oil palm bunch, wood ash and cocoa pod husk improved K, Ca and Mg nutrients as well as correcting soil acidity in an alfisol grown to coffee and maize.

In term of nutritional status, the consumption of cucumber by human beings would supply more of vitamin A, C and B6, minerals, anti-oxidant for body growth, building up blood and immune systems and reduction in growth of cancerous cells as noted by Vogtamnn et al (1993)[25]. The implication is that farmers and other consumers in the cucumber value chain would spend less amount of money in purchasing drugs containing protein, minerals, vitamins and anti-oxidants to cure themselves of diseases as well as living healthy life.

Therefore, the people would become stronger in term of health status, food security and productivity to national income of their respective countries, thereby meeting the attainment of food security and sound health under the Millennium Development Goal of United Nations by 2015.

CONCLUSIONS AND RECOMMENDATION

The use of organic fertilizers such as poultry, pig manure, oil palm bunch ash and wood ash applied at 6t/ha increased the growth and fruit yield parameters and soil N, P, K, Ca, Mg, pH and organic matter.

It is recommended that poultry manure applied at 6t/ha was the most effective fertilizer material for improving the nutrient availability, growth, yield as well as ensuring sustainable cultivation of cucumber on commercial basis and it could replace the application of 300kg/ha NPK 15-15-15.

The recommendation is important because of the fact that inorganic fertilizers are becoming very expensive to purchase by small holding and commercial farmers of cucumber. Besides, these organic fertilizers appear to have beneficial secondary benefits on soil properties as well as ensuring environmental sustainability and preservation.

Table 1: Soil analysis before planting cucumber

Soil Parameter	Values
Soil pH (1;1 H_20)	5.83
Soil pH (1:2 soil/0.01M $CaCl_2$)	5.60
Organic matter (%)	0.66
Nitrogen (%)	0.09
Available P (mg/kg)	5.33
Exchangeable bases	
K^+(mmol/kg)	0.14
Ca^{2+}(mm0l/kg)	0.13
Mg^{2+}(mmol/kg)	0.08
Na^+ (mmol/kg)	0.10
Exchangeable acidity	
H^+ (mmol/kg)	4.16
Al^{3+}(mmol/kg)	1.40
Micronutrients	
Fe (mg/kg)	8.30
Zn $^{2+}$(mg/kg)	3.60
Cu^{2+} (mg/kg)	1.70
Mn^{2+}(mg/kg)	1.98
Textural analysis	
% sand	79.50
% silt	14.70
% clay	5.80
Bulk density (mgm^{-3})	1.58

Table 2: Chemical analysis of the organic fertilizers used

Organic fertilizers	%N	%C	C/N ratio	P mg/kg	K %	Ca %	Mg %
Poultry manure	4.32	30.0	6.93	385.0	9.70	3.30	4.10
Pig manure	3.72	27.0	7.25	312.0	14.45	3.10	4.8
Oil palm bunch ash	1.49	16.0	10.74	69.00	21.04	3.52	6.25
Wood ash	1.53	18.0	11.76	86.00	23.02	9.40	8.52

Table 3: The growth parameters of cucumber under different organic fertilizers (3-6 weeks after transplanting)

Treatments	Vine length (cm)	Vine girth (cm)	Leaf area (cm^2)	Average leaf number
Control	28.25a	1.23a	6.00a	9.6a
NPK 15-15-15	129.00de	3.40f	14.26f	27.10f
Poultry Manure	128.33d	2.90e	11.10e	25.3e
Pig Manure	105.44d	2.00d	10.05cd	20.0d
Wood ash	92.10c	1.90bc	9.80c	18.6c
Oil palm bunch ash	90.06b	1.85b	9.05b	17.1b

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

Table 4: The yield parameters of cucumber under different organic fertilizers

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit weight kg/ha
Control	7.90a	1.40a	422.2a
NPK 15-15-15	16.30d	3.40bc	19,000d
Poultry Manure	18.70c	4.5f	40.300f
Pig Manure	13.70c	3.8de	21,200e
Wood ash	11.80b	3.7dc	16,300c
Oil palm bunch ash	11.12b	3.3b	15,600b

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

Table 5: The soil chemical composition after harvesting cucumber

Treatments	Soil pH	O.M%	N%	P (mg/kg)	K (mmol/kg)	Ca (mmol/kg)	Mg (mmol/kg)
Control	5.30ab	0.33ab	0.04a	3.5a	0.05a	0.06ab	0.07ab
NPK 15-15-15	5.20a	0.29a	0.38f	32.80d	3.91f	0.03a	0.05a
Poultry Manure	6.60d	172f	0.34e	38.12e	2.60c	1.26cd	1.10d
Pig Manure	6.40e	1.38e	0.27d	23.52c	2.40b	1.23c	0.74c
Wood ash	7.02e	1.21cd	0.24c	20.70b	3.25d	1.58e	1.28e
Oil palm bunch ash	7.03ef	1.19c	0.21b	20.35b	3.40e	1.68f	1.50f

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

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