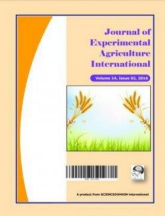

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Impact of Different Organic Fertilizers Application on Soil Fertility Improvement, Growth and Fruit Yield Parameters of Pineapple (*Ananas comosus* L)

Emmanuel Ibukunoluwa Moyin-Jesu[1*]

[1]Department of Agronomy, Federal college of agriculture, Akure, Ondo State, Nigeria.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Field experiment were carried out in Akure in the rainforest zone of Nigeria to determine the efficacy of wood ash, pig, poultry and cattle manures on the soil fertility improvement, growth and fruit yield parameters of pineapple (*Ananas comosus* L) between 2008 and 2011 cropping seasons.The four organic fertilizer treatments were applied each at 6t/ha with a reference treatment NPK 15-15-15 fertilizer applied at 300 kg/ha and a control treatment, replicated four times and arranged in a randomized complete block design. The results showed significant increases ($P<0.05$) in the soil, growth and fruit yield parameters of pineapple crop under the different organic fertilizers applied compared to the control. The highest values of pineapple fruit weight, fruit length, fruit diameter, "D" leaf length, leaf area, plant height and number of propagules were obtained with the application of poultry manure followed by pig manure, wood ash, cattle manure and NPK 15-15-15 respectively. Pineapple fruit weight, fruit length, fruit diameter, "D" leaf length, leaf area, plant girth, plant height and number of leaf propagules increased by 30%, 29, 8.7, 31, 15.4, 21, 30% and 20% respectively with the application of poultry manure compared to NPK fertilizer. Generally, the yield parameters of pineapple were higher in values in the second year of harvest than the first year under different organic fertilizer treatment compared to NPK fertilizer. The highest values of soil organic matter (0.M) and moderate values of soil P, K, Ca and Mg were obtained under wood ash treatment

**Corresponding author: E-mail: moyinjesu2004@yahoo.com;*

application. Moderate values of soil pH, K, Ca, Mg and N were also recorded under pig and cattle manures. Nevertheless, the highest K/Mg, K/Ca and P/Mg ratios of 61:1, 49:1 and 640:1 respectively were obtained under NPK 15-15-15 fertilizer application compared to 2:1 K/Mg, 2:1 K/Ca and 23:1 P/Mg in the cattle manure treatment. The poultry manure applied at 6t/ha produced the best results in improving soil fertility, growth and fruit yield parameters of pineapple and this was because of its balanced macro and micro nutrients contents and the very low C/N ratio.

Keywords: Pineapple (Ananas comosus); fruit and growth parameters; organic fertilizers and soil fertility improvement.

1. INTRODUCTION

Pineapple (*Ananas Comosus* L) is an important commercial tropical fruit which belongs to the family Bromeliceae and originated from Latin America. [1] It is also ranked as the most important tropical fruit in the world after banana and citrus which is consumed in either fresh or in juice forms but it is highly perishable and seasonal. [2] The main world pineapple producing countries are Thailand, Philippines, Brazil and China with almost 50% contribution of the total output while the remaining ones are from Kenya, Nigeria, India, Indonesia, Costa-Rica, Uganda and Ghana. [3]

[4] reported that mature pineapple fruit contains 14% sugar, crude fibre, carbohydrate, Vitamins A and B, Citric and malic acids, bromelin an enzyme which helped in food digestion and vitamin C. [5] also explained that one healthy ripe pineapple fruit supplied 16.2% of daily requirement for vitamin C which is the body primary water soluble anti-oxidant against free radicals that attacked and damaged normal cells as well as helping to form collagen in bones, cartilages, muscles and absorption of iron.

In addition, pineapple fruit has a lot of industrial uses because many food items such as syrup, squash, alcohol, vinegar, jelly marmalade and jams are derived from it, as well as source of livestock feed after juice extraction [6] and [3] In Africa, pineapple production is increasing in Nigeria, Kenya, Uganda and Ghana because of the commercial value of the crop as source of income, raw materials for fruit juice canned industries and as an export crop for foreign exchange earnings [7]. Nigeria accounted for 1.4million metric tonnes of pineapple fruits in 2011 which is 7% of the world production. [8]. Therefore, there is a great potential for pineapple crop to solve problem of food security, generates jobs through industrial development and improves the health benefits of the people.

In spite of the above mentioned economic, nutritional and industrial benefits of pineapple, its maximum yield has not been attained in Nigeria because of continuous cultivation of the crop on the same piece of land without fertilizer application which has led to rapid decline in soil fertility. Other problems responsible for low pineapple production included poor agronomic knowledge, vagaries of climate and poor value chains development [9].

Concerted efforts aimed at improving the yield of pineapple and enhanced the soil fertility using inorganic fertilizers are limited by the high cost of purchase and increasing soil acidity on continuous use. [10]. Furthermore, [11,12] had also reported that major problems accompanying continuous application of inorganic or chemical fertilizers were increased soils acidity, loss of organic matter, nutrient imbalance and antagonism, and degradation of soil physical properties. Hence, the choice of using inorganic fertilizers to supply all the essential plant nutrients should be re-considered seriously both immediate or in the future because of the deleterious effects on sustainable soil productivity. Therefore, there is justification for adoption of using low cost organic fertilizers which are sustainable, cheaper and enhanced soil fertility [13] reported that application of sawdust to soils increased significantly the leaf and soil N, P, K, Ca and Mg contents, number of branches, pods population, pod weight and grain yield of cowpea.

[14] reported that application of poultry manure rice bran, spent grain and wood ash improved considerably the yield of Okra, improved soil N, P, K, Ca and Mg concentrations and growth parameters of coconut seedlings while [15] also reported that the wood ash applied to the vegetable crops increased significantly the yield and soil nutrients (N, P, K, Ca and Mg).

[16] further reported that the application of organic fertilizer such as wood ash cocoa husk and poultry manure significantly improved the nutrient balance sheet for coffee seedlings and maize in an alfisol in South West Nigeria while

[17] also reported that application of poultry, pig manures and wood ash improved the soil fertility and yield of cabbage under controlled atmosphere in Akure, South West Nigeria

Critical review of literature revealed that there is a paucity of research report on the use of poultry, pig, cattle manures and wood ash in growing pineapple as well as improving soil fertility except the works of [18,19,20] on the use of NPK 15-15-15 and Nitrogen (Urea) fertilizers to grow pineapple.

The choice of wood ash, pig, cattle manures and wood ash as source of organic materials in the research study was due to their availability and abundance in large quantities from the study area and the surrounding communities where majority of the farmers are majorly cassava growers with associated processing mills, poultry, pig and cattle producers. [21] Had also reported that application of wood ash, poultry, pig manures and their amendments significantly reduced soil bulk density, improved the yield of Okra and increased soil N, P, K, Ca and Mg.

Therefore the use of wood ash, pig, poultry and cattle manures as organic amendments would contribute significantly on the yield of crops, soil physical properties and chemical composition (N, P, K, Ca and Mg).

1.1 Purpose of the Experiment

These underlying research questions would be answered for the experiment (i) Is there any significant difference between the applied organic fertilizers on growth and fruit yield parameters of pineapple? (ii) Is there any significant different between the applied organic fertilizers and post-cropping soil properties?

The objectives of this research were to determine the effects of poultry, pig, cattle manures and wood ash on the growth, yield parameters of pineapple and on post cropping soil properties.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Field experiments were carried out at Akure, in the rainforest zone of Nigeria between 2008 and 2011. The Soil of the experimental site is loamy sand, skeletal, kaolinitic, isohyperthermic oxic paleustalf (Alfisol). Soil Survey Staff (1999) [22]. The annual temperature of the area is between 29-37ºC while the annual rainfall is between 1000 and 2060 mm [17].

2.2 Pre-cropping Soil Sampling and Analysis

Thirty (30) core soil samples were randomly collected from 0 to 15cm depth, using soil urger, bulked together, air-dried, sieved with 2mm and ready for routine analysis.

Soil P was extracted by Bray P1 extractant and the extract was developed on Murphy blue colouration and determined on a spectronic 20 at 882 um [23]. The soil organic matter was determined using wet oxidation method through chronic acid digestion [24] the soil pH (1:1 soil/ water) and (1:2 soil/0.01M $CaCl_2$ suspension) was determined on a pH meter [25] while the percent nitrogen was determined by the micro-Kjeldahl method [26].

The soil K, Ca, Mg and Na were extracted with 1M $NH_40ACpH7$, and their contents K, Ca and Na were determined on the flame photometer [27] while Mg content was determined using atomic absorption spectrophotometer.

The soil micronutrients (Zn, Cu, Mn and Fe) were extracted with 0.1M HCl and read on atomic absorption spectrophotometer while the particle size analyss was determined using hydrometer method [28].

Table 1 shows the soil fertility composition before planting. The soil pH 5.8 showed that the soil is slightly acidic. The soil organic matter was below 3% critical level recommended for crop production [29] The soil available in P 5.30mg/kg content is lower than 10 mg/kg P for crop production in South West Nigeria [29] while the soil exchangeable bases (K, Ca, Mg and Na) were below 0.20mmol/kg critical level in the study area [30]. The soil N content of 0.081% was lower than 0.15% N critical level for crops as recommended by [31]. The soil textural class is loamy sand comprising of 78.30% sand, 15.20% silt and 6.50% clay respectively.

2.3 Sources and Processing of the Organic Fertilizers Used for the Pineapple Experiment

The poultry, pig and cattle manures were obtained from the 10,000 poultry birds, 500 pigs and 500 heads of cattle in the livestock unit of Federal College of Agriculture, Akure while wood ash was obtained from the large-scale processing unit of the same institution which

processed cassava tubers from 10,000 hectares of cassava farm.

Table 1. Pre-cropping soil analysis for pineapple

Soil Parameters	Values
Soil pH (H_20)	5.80
Soil pH (2:1$CaCl_2$0.1M)	5.40
Soil Organic matter (%)	0.76
Nitrogen	0.08
Available P	5.30
Exchangeable bases	
K^+ (mmo1/kg)	0.16
Ca^{2+} (mmo1/kg)	0.08
Mg (mmo1/kg)	0.10
Na (mmo1/kg)	0.11
Micronutrients	
Fe (mg/kg)	8.20
Zn "	3.80
Cu "	2.23
Mn "	1.87
Particle size analysis	
% Sand	78.30
% Silt	15.20
% Clay	6.50

The NPK 15-15-15 fertilizer as purchased from Ondo State Input supply Agency Akure while the pineapple suckers (Sweet cayenne var L) were purchased from the National Horticultural Research Institute Ibadan, Oyo State Nigeria.

The wood ash was sieved with 2mm sieve to remove pebbles while the manures were cured to remove the weed seeds and enhanced quick release of nutrients. The curing technology of the manure has helped to reduce ammonia gas emission, prevent weed seed germination as well as enhancing mineralization and consequently the reduction of C/N ratio.

2.4 Chemical Analysis of the Organic Fertilizers Used

Two (2) grammes each of the processed organic fertilizers was analysed. The determination of nutrients such as, K, Ca, Mg and P was done using the wet digestion method of 25-5-5ml HNO_3-H_2SO_4-$HClO_4$ acids [32] while soil N content was determined by the Kjedahl method [26].

Table 2 presents the chemical composition of the organic fertilizers used. Poultry manure had the highest values of N, P and the least C/N ratio followed by pig manure. The wood ash also had the highest values of K, Ca, Mg, C/N ratio and least values of N and P compared to others. The cattle manure also had relatively moderate amount of %P, K, Ca, Mg and N suitable for crop production.

2.5 Field Experiment

The experimental site was cleared, parked off the debris, ploughed, harrowed and marked out into plots. Each plot size was 4m x 4m each ($16m^2$). There were four organic fertilizer treatments such as poultry, pig, cattle manures and wood ash applied at 6t/ha with a reference treatment NPK 15-15-15 fertilizer applied at 300kg/ha a control treatment (no fertilizer). The experiment was arranged in a randomized complete block design and replicated four times.

The choice of poultry, pig, cattle manures and wood ash application at 6t/ha for the experiment was based on the works of [10,33] which carried out an in depth research on soil critical levels for N, P, K, Ca and Mg using organic amendments for growing vegetables in the study area.

The organic amendments were incorporated into the soil using hand trowel one week (seven days) before planting the pineapple suckers. The pineapple suckers (Sweet cayenne cv L) variety were planted each into the different plots at a spacing of 30 x 60 x 90cm giving a total of 43,500 plants/hectare in April 2008. Spraying of Avesthrin (10 EC Cypermethrin) against leaf beetles was done at four weeks after planting and continued at three weeks until twelve weeks after planting.

Weeding operations started at three weeks after planting and continued at four weeks interval until harvest. In-addition, at four (4) weeks after planting, growth parameters such as pineapple sucker "D" leaf length, number of leaf propagules, girth, plant height and leaf area were taken and continued at 7 days interval until 24 weeks after planting. The leaf area was estimated using allometric relationship determining the length and width of "D" leaf as described by [34] The "D" leaf is the longest central leaf.

The pineapple suckers started bearing inflorescence between 11 and 12 months (44 – 48 weeks) after planting and the first matured pineapple fruits were harvested at 15 months (60weeks) after planting. The harvest continued every week (7 days) interval depending on the extent of fruit ripening on treatment basis. The harvested pineapple fruits were measured for fruit weight (t/ha), fruit diameter and fruit length respectively.

Table 2. Chemical Composition of the organic fertilizers

Treatments	%C	%N	C/N ratio	P (mg/kg)	% K	%Ca	%Mg	Fe mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg
Poultry Manure	30.0	4.33	6.93	385.00	9.72	3.20	4.11	37.85	1.66	0.15	1.26
Pig Manure	27.0	3.72	7.25	312.00	14.45	3.10	4.8	34.0	1.62	0.17	1.30
Cattle Manure	20.00	2.52	7.93	169.00	9.94	2.90	4.5	35.5	1.60	0.13	1.13
Wood ash	18.0	1.53	11.76	86.00	23.02	9.40	8.52	65.51	11.92	0.66	1.83

In the following cropping year, 2010/2011, pineapple fruits were harvested on treatment plot basis and measured for fruit length, weight and diameter respectively as the 2nd harvest.

2.6 Post Cropping Analysis of Soils after Harvesting of Pineapple

At 16 months (64 weeks) after harvesting the first crop, soil samples were collected from each treatment plot (0-15 cm) air – dried, sieved with 2mm and analysed for soil pH, O.M, N, P, K, Ca and Mg as described earlier under pre cropping soil analysis. [The soil samples were also taken at end of second harvest of pineapple fruits from each treatment and analysed for the above mentioned nutrients]

2.7 Statistical Analysis

All the data collected on the soil growth and fruit yield parameters of pineapple were subjected to Analysis of variance F-test and their means were separated using Duncan Multiple Range Test at 5% level of significance [35].

3. RESULTS

3.1 Effect of Organic Fertilizers Applied on the Growth Parameters of Pineapple Crop between 2 – 24 Weeks after Planting

There were significant increases ($P<0.05$) in the "D" leaf length, leaf area, plant height, girth and number of leaf propagules of pineapple under different organic fertilizers treatments compared to the control treatment (Table 3). The highest values of pineapple "D" leaf length, plant height, girth, number of leaf propagules and leaf area were obtained with the application of poultry manure followed by pig manure, wood ash, cattle manure and NPK 15-15-15 fertilizers.

Poultry manure treatment increased pineapple "D" leaf length, leaf area, plant girth, plant height and number of leaf propagules by 31%, 15.4%, 21%, 30% and 20% compared to NPK 15-15-15. When compared with wood ash, pig manure also increased the "D" leaf length, plant girth and number of leaf propagules by 9% and 4% respectively except in leaf area and number of leaf propagules where wood ash increased the values by 5% and 3% more than pig manure.

The cattle manure treatment application increased moderately the values of growth parameters in pineapple while the least values of these growth parameters were obtained under the control treatment where there was no fertilizer application.

3.2 Effect of Different Organic Fertilizers Applied on the Yield Parameters of Pineapple between Two Harvest Periods

There were significant increases ($P<0.05$) in the fruit weight, fruit length and fruit diameter of pineapple under different organic fertilizer treatments compared to the control treatment (Table 4).

Table 3. Effect of different organic fertilizers applied on the growth parameters of pineapple crop between 4 – 24 weeks after planting

Treatments	Plant height	"D" leaf length (cm)	Leaf area (cm^2)	Plant girth (cm)	Leaf population
Control	15.00a	14.14a	60.23a	4.03a	15.20a
NPK 15-15-15	54.50b	51.70b	124.87b	9.57d	31.30b
Poultry manure	77.60f	75.00f	147.58e	12.10f	39.14f
Pig manure	67.40e	65.90e	133.82c	11.08e	36.25d
Cattle manure	60.20c	58.78c	124.46b	10.68b	32.34c
Wood ash	62.30d	60.00d	138.10d	10.67bc	38.20e

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 of significance

The highest values of pineapple fruit weight, length and diameter were obtained with the application of poultry manure followed by pig, cattle manures, wood ash and NPK15-15-15 fertilizers. Generally, the yield parameters of pineapple were higher in values in the second year of harvest than the first year under the different organic fertilizer treatments. However, it was observed that the values of pineapple fruit yields parameters obtained with the application of NPK 15-15-15 fertilizer decreased slightly in the 2nd year of harvest compared to the first year.

When compared with NPK 15-15-15 in the first harvest, application of poultry manure increased pineapple fruit weight, fruit length and fruit diameter by 30%, 29% and 8.7% respectively. However, in the second year harvest, the values of these parameters increased by 44%, 40% and 25% respectively.

Pig manure application also increased the fruit weight, length and diameter by 10%, 10% and 11% compared wood ash. However, it was observed that there was a significant performance in the wood ash application in the second year harvest because the values of pineapple yield parameters particularly fruit weight and diameter were higher than the cattle manure. The least values of pineapple yield parameters were obtained under the control treatment where no fertilizer was applied.

3.3 Soil Chemical Analysis after Harvesting Pineapple Fruits (16 Months after Planting Suckers)

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

The soils treated with NPK 15-15-15 had the highest values of soil N, P, K and leas contents of soil pH and O.M. The soil N, P, K contents increased by 33, 26 and 36% with application of NPK 15-15-15 compared to cattle manure but it had higher ratios of K/Mg, P/Mg and K/Ca 61:1, 640:1 and 49:1 respectively compared to 2:1 K/Mg, 2:11 P/Mg and 2:1 K/Ca in cattle dung treatment.

Table 4. Effect of different organic fertilizers applied on the yield parameters of pineapple between 2008/2009 and 2010/2011 cropping seasons

Year	Treatments	Fruit weight (t/ha)	Fruit Length (cm)	Fruit Diameter (cm)
2008/2009	Control	47.55a	9.00a	13.0a
First harvest	NPK 15-15-15	88.30b	13.50b	34.70b
	Poultry manure	126.15f	19.00e	38.00f
	Pig manure	113.10e	17.50d	36.00d
	Cattle manure	95.70d	15.00c	35.10c
	Wood ash	91.35c	15.50c	36.20de
2010/ 2011	Control	44.42a	8.10a	11.70a
Second harvest	NPK 15-15-15	87.00b	15.00b	41.50b
	Poultry manure	156.60f	25.00f	55.40f
	Pig manure	130.50e	18.00c	48.50e
	Cattle manure	117.45c	20.00e	43.10c
	Wood ash	126.15d	19.50d	47.60d

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

Table 5. Effect of different organic fertilizers on the soil chemical composition after first harvest of pineapple fruits

Treatments	Soil properties						
	% N	P (mg/kg)	K mmol/kg	Ca mmol/kg	Mg mmol/kg	pH	O.M %
Control	0.03a	3.70a	0.04a	0.03a	0.02a	5.30ab	0.22a
NPK 15-15-15	0.46f	25.60f	2.45d	0.05ab	0.04ab	5.10a	0.18a
Poultry manure	0.37e	23.47e	2.55e	0.94e	0.83e	6.94e	2.35f
Pig manure	0.33d	20.40d	1.83c	0.80c	0.70c	6.76cd	1.89e
Cattle manure	0.29c	19.53c	1.57b	0.84cd	0.74cd	6.60c	1.70d
Wood ash	0.20b	15.51b	2.67f	1.05f	1.12f	7.14f	1.35c

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

Table 6. Effect of different organic fertilizers on the soil chemical composition after second harvest of pineapple fruits

Treatments	Soil properties						
	% N	P (mg/kg)	K mmol/kg	Ca mmol/kg	Mg mmol/kg	pH	O.M %
Control	0.02a	0.59a	0.028a	0.02a	0.014a	5.00ab	0.15a
NPK 15-15-15	0.32f	17.92f	1.72d	0.035a	0.03ab	4.90a	0.13a
Poultry manure	0.260e	16.43e	1.79de	0.665e	0.58e	6.95e	1.65e
Pig manure	0.23d	14.28cd	1.28c	0.56b	0.49c	6.78d	1.32d
Cattle manure	0.20c	13.67c	1.00b	0.59cd	0.52d	6.60c	1.19c
Wood ash	0.14b	10.86b	1.87f	0.74f	0.78f	7.20f	0.95b

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

The soils treated with application of poultry manure also produced the highest values of organic matter and moderate values of soil Ca, Mg, K and P. The soil O.M, P and N increased by 43, 34 and 46% with application of poultry manure compared to wood ash treatment.

The highest values of soil pH, K, Ca, Mg were obtained with application of wood ash compared to poultry, pig, cattle and NPK 15-15-15 fertilizer respectively. The soil K,Ca, Mg and pH increased by 31.5, 24, 38 and 5% compared to pig manure treatment.

The control treatment which received no application of fertilizers had the least values of soil pH, O.M, N, P, K, Ca and Mg. The same trend of performances were noticed in the soil properties after second harvest of pineapple (Table 6). The residual effects of these nutrients would be useful for subsequent cropping.

4. DISCUSSION

The highest values of pineapple fruit weight, length, diameter, D leaf length, leaf area, plant girth, plant height and number of propagules obtained with the application of poultry manure could be traced to its balanced nutrients composition of having the best values of % N, P, Fe and moderate K, Ca, Mg and C/N values which encouraged quick decomposition and release of essential nutrients to pineapple for uptake. This also reflected in the soil chemical composition after harvesting.

[36,37] also reported that Nitrogen increased vegetative and yield parameters of crops. This observation was also supported by [20] who worked on application of different levels of N fertilizer on pineapple and reported significant increase effect of N on the growth and yield of pineapple.

[38] reported that pineapple had high requirement for nitrogen (N) potassium (K) and Iron (Fe). This could explain why poultry manure had the highest values of pineapple growth and yield parameters in the experiment.

The absence of N in either organic or inorganic farms usually resulted in low productivity with the associated symptoms of nitrogen deficiency.

The pineapple fruits yield weight per hectare obtained in this experiment using poultry manure were far higher than the 94.61tha^{-1} obtained by [18], 34.65 tha^{-1} [39] and 87.2 tha^{-1} [38] respectively.

The observation that pineapple yield parameters were higher in the second harvest than the first harvest under poultry, pig and cattle manures was supported by [20] who worked on pineapple. This could be due to the least C/N ratios of poultry, pig and cattle manures which would encourage decomposition, quick release and uptake of essential nutrients by crops, there by utilizing the nutrients in the subsequent cropping seasons.

In-addition, the better nutrient composition of pig and cattle manures added to the soils also reflected in the improvement of soil N, P, K, Ca and Mg which subsequently increased growth and yield of pineapple.

The application of woodash to soils increased soil pH and this was attributed to its having highest values of K, Ca and Mg which subsequently increased soil buffering capacity as observed by [14] The soil pH also influenced nutrient availability and uptake of nutrients as observed by [16] Interestingly, the wood ash treatment had the highest soil pH after harvest.

The highest values of K, Ca and Mg could be responsible for better values of pineapple yield weight than the cattle manure. The observation was supported by [38] who reported that potassium was essential for increased pineapple yield, fruit size, total soluble salts and vitamin C. They further explained that potassium was important in enhancing flowering, fruit maturity and yield of pineapple when applied in adequate quantities.

Besides, [10] reported the importance of Mg in enhancing photosynthetic power of plants while Ca is important for roots development.

[21] also reported that wood ash, rice bran and spent grain were efficient in the reduction of soil bulk and improvement of % porosity which are important indicators of soil fertility particularly the soil physical properties improvement.

The application of NPK 15-15-15 fertilizer also increased significantly the pineapple fruit yield and growth parameters and this could be due to its supply of readily available nutrients such as N, P and K from the fertilizers. This was necessary because of faster mineralization process in NPK 15-15-15 fertilizer than organic fertilizers which must first undergo mineralization before utilization by crops. NPK fertilized soils are low in Ca and Mg.

There was a slight decrease in the pineapple yield parameters in the second harvest under the NPK 15-15-15 fertilizer treatment application and this might be due to the high K/Ca, K/Mg and P/Mg ratios which caused nutrient imbalance and made difficult the availability of nutrients K, Ca and Mg for both immediate and subsequent cropping of pineapple compared to the poultry, pig and cattle manures with low K/Ca, K/Mg and P/Mg ratios.

The decline in soil pH under NPK fertilized plots could trigger soil acidity and affected the nutrients uptake, O.M and subsequently reduced the growth and yield parameters of pineapple. In-addition, the high nitrogen amount in NPK 15-15-15 fertilized plots and its continuous application could trigger excessive growth and delayed maturity of pineapple yield. Furthermore, there could be pollution of underground water bodies with nitrate nitrogen leached downwards as reported by [40].

The least values of soil, fruit yield and growth parameters such as D leaf length, leaf area, plant height, number of propagules, fruit weight, length and diameter obtained under the control treatment where no fertilizer was applied compared to other treatments could be traced to the initial low soil nutrients composition which was as a result of continuous cultivation of land without fertilizer application. This finding was supported by [41] who worked on the effectiveness of fertilizers on the growth and yield maize/popcorn intercropped and reported that crops with no fertilizer application had the least yield and growth parameters. Furthermore, [38] reported that the absence of N and other nutrients in soils grown to pineapple always had characteristic symptoms of yellowish leaf colouration for N, purple leaf colour for P, and marginal leaf burn for K deficiency.

Therefore, deficiencies in N, P, K, Ca and Mg can be balanced out by the use of poultry, pig, cattle manures and wood ash hence, their choice for growing pineapple in this experiment.

However, the farmers are advised to process the cattle before application to crops to avoid weed seeds emergence which can trigger weed infestation and could reduce the yield of crops and cause other problems of controlling weeds emanating on the field.

This research is very important because there is an increasing consumer demand for organically produced fruits. The high nutrients composition in pineapple fruits such as Vit C, A and minerals would reduce drastically the amount expended by consumers in buying artificial synthetic drugs. This observation was emphasised by [3] who analysed the nutritional and medicinal benefits of pineapple.

The major explanation of the exceptional performance of pineapple growth and fruit yield parameters with the application of poultry manure treatment was that it had higher % N contents and lesser C/N ratio of 7.93 compared to wood ash C/N ratio 11.93. The high C/N ratio makes it difficult for decomposition of the wood ash and subsequent release of nutrients quickly to pineapple. If wood ash had not been processed as done in the experiment, its C/N ratio would be very high and thereby made decomposition and release of nutrients to pineapple very difficult.

5. RECOMMENDATIONS AND CONCLUSION

The experiment clearly showed that the use of the different organic fertilizers such as pig, poultry, cattle manures and wood ash applied at 6t/ha increased significantly the growth, fruit yield parameters of pineapple and soil pH, organic matter, N, P, K, Ca and Mg. Therefore, it is recommended that poultry manure should be applied at 6t/ha to increase availability of essential soils nutrients, growth and fruit yield parameters pineapple which would go a long way in enhancing sustainable production of pineapple on commercial basis. Besides, the use of poultry manure would substitute for application of huge quantity of NPK 15-15-15 fertilizer.

This recommendation is very essential because the purchase of inorganic fertilizers by both small scale and commercial farmers of pineapple is becoming very expensive. Also, the beneficial secondary effects of these organic fertilizers on soil properties and ensuring environmental sustainability should be considered.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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