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ORIGINAL RESEARCH

Use of different organic fertilizers on soil fertility improvement, growth and head yield parameters of cabbage (*Brassica oleraceae* L)

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Abstract
Purpose Field experiment was carried out in Akure in the rainforest zone of Nigeria to determine the effect of poultry manure, wood ash and rice bran on the soil fertility improvement, growth and head yield of cabbage (*Brassica oleraceae* L) in 2011 and 2012 cropping seasons.
Methods The three organic fertilizer treatments were applied each at 6 t/ha with a reference treatment NPK 15-15-15 applied at 300 kg/ha and a control treatment arranged in a randomized complete block design with three replicates.
Results The results showed significant increases ($P < 0.05$) in the growth and head yield parameters of cabbage crop under the different organic fertilizers compared to the control treatment. The application of poultry manure resulted in the highest values of cabbage plant height, stem girth, leaf number, leaf area, head weight, head length and head girth followed by NPK 15-15-15, wood ash and rice bran, respectively. Cabbage head weight, head girth, head length, plant height, stem girth, leaf number and leaf area increased by 17, 18, 8,17, 19, 10 and 16 %, respectively, with application of poultry manure compared to NPK fertilizer. Also, these parameters increased by 23, 21, 13 29, 25, 17 and 45 % compared to the wood ash treatment. The highest values of soil pH, Ca and Mg were obtained under wood ash application, while the highest values of soil O.M and moderate values of soil P, K, Ca and Mg were obtained under poultry manure application. Moderate values of soil pH, K, Ca and low % N were also recorded under rice bran treatment. However, the highest K/Ca, K/Mg and P/Mg ratios of 93.1, 74.1 and 572.1, respectively, were obtained under NPK 15-15-15 fertilizer application compared to 2:1 K/Ca, 2:1 K/Mg and 16:1 P/Mg in rice bran treatment.
Conclusion The poultry manure applied at 6 t/ha gave the best results in improving soil fertility, growth and head yield of cabbage, and this was because of its balanced nutrient composition and the least C/N ratio.

Keywords Cabbage (*Brassica oleraceae*) · Head yield and growth parameters · Organic fertilizers and soil fertility improvement

Introduction

Cabbage is a leafy vegetable belonging to the Brassicaceae family which is originated from California. Hague (2006) cabbage is also an herbaceous biennial plant that produces "heads", and it has short stem upon which is crowned with a mass of green leaves (John 1997).

Cabbage is consumed raw or cooked with other vegetables; it contains 93 ml water, 15 g protein, 0.2 g fat, 4.0 g carbohydrate, 4 g calcium and 0.5 g iron/100 g sample (Moamogwe 1995). In addition, it has high medicinal value because of its rich content in vitamins C, E and K as well as its antioxidant components which suppressed cancerous cell growth (Tindall 2000). It is one important vegetable in healthy diets of people around the world.

In spite of the economic, nutritional and health importance of cabbage to the national development, its optimum production has not been achieved due to its difficult agronomic characteristics, decline in soil fertility, lack of

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techniques of growing the crop in both the nursery and field. However, efforts made to increase the soil fertility through the use of inorganic fertilizers are limited due to high cost of purchase and continuous use which destroyed soil properties (Moyin-Jesu 2008).

Besides, the climatic condition for growing cabbage in temperate region is between 20 and 25 °C and adaptation of the crop to Nigeria, especially south-west, is difficult because temperature is between 29 and 37 °C. In other parts of the country (Northern region), the temperature ranged between 36 and 41 °C except the Jos Plateau where temperature is about 24–27 °C.

Therefore, there is justification to adapt the cultivation of cabbage to the climatic condition in Nigeria, especially in south-west, as well as adopting the use of low-cost organic fertilizers for the crop cultivation. Kwari et al. (1991) found that the incorporation of grass cow dung into the soils in Borno state improved the cation exchange capacity of the soils. Solomon and Ogeh (1995) indicated that leguminous materials and rice husk supplied mainly N, P, K, Zn, Fe, Cu, Mn and B to the soil which NPK 15-15-15 fertilizer did not possess.

Ojeniyi et al. (2001) also reported that application of wood ash to the vegetable crops improved the yield of crops significantly and increased the soil nutrients such as N, P, K, Ca, Mg in a trial conducted in south-west Nigeria. Awodun (2007) also reported that sawdust applied to soil significantly increased soil and leaf N, P, K Ca and Mg contents and number of pods, pod weight, number of branches, number of leaves and grain yield of cowpea.

Moyin-Jesu (2013a) reported that the modified neem extracts (neem leaf + wood ash extracts) increased significantly the garden egg fruit weight, fruit length and fruit diameter by 42, 24 and 13 % compared to NPK 15-15-15 fertilizer. He also observed that continuous application of NPK 15-15-15 fertilizer decreased soil pH, Ca, Mg and O.M as well as having highest K/Ca, K/Mg and P/Mg ratio caused soil nutrient imbalance.

Moyin-Jesu and Ogochukwu (2014) also reported that poultry manure applied at 6 t/ha increased the soil N, P, K, Ca and Mg concentrations and growth parameters of coconut seedlings. He also reported that the organic materials applied (wood ash, rice bran and so firth) have beneficial residual effects on soil properties which are in line with growing concern of using environment friendly fertilizer.

Furthermore, Obi and Ofonduro (1997) and Moyin-Jesu (2007) also reported that problems associated with continuous use of chemical fertilizers included nutrient imbalance, increased soil acidity, degradation in soil physical properties and loss of organic matter. Hence, the tendency to supply all plant nutrients through chemical fertilizer should be reconsidered in the future because of the deleterious effect on soil productivity on a long-term basis.

Finally, Afshar et al. (2014) reported that soil organic amendments improved the seed yield and flavonolignan production of milk thistle (*Silyburn marianum* L, Gaertin) compared to chemical fertilizers. Critical review of literature revealed that there is scarcity of research report on the use of wood ash, rice bran and poultry manure in growing cabbage except the works of Moyin-Jesu and Odewande (2013b); Ijoyah and Sophie (2009) and Mohammed and Solaiman (2012) working on varietal trial of cabbage and tillage influence on cabbage yield.

The choice of wood ash, rice bran and poultry manure as source of organic materials in the research study was because of their availability and abundance in large quantities from the experimental location and its surrounding communities where majority of the farmers are predominantly cassava, rice growers with associated processing mills and poultry producers. Moyin-Jesu and Ojeniyi (2006) also reported that application of rice bran wood ash and spent grain significantly reduced soil bulk density and increased porosity. Hence, the use of wood ash and rice bran as organic amendments would also have strong beneficial improvement on soil physical properties and base saturation.

Purpose of the experiment

The following research questions would be answered for the experiment: (1) Is there any significant difference between applied organic fertilizers on growth and head yield parameters of cabbage? (2) Is there any significant difference between the applied organic fertilizers and post-cropping soil properties?

The objectives of the research were to determine the effect of wood ash, rice bran and poultry manure on the growth and yield parameters of cabbage and on post-cropping soil properties.

Materials and methods

Description of the study area

Field and nursery experiments were carried out at Akure in the rainforest zone of Nigeria in 2011 and were repeated in 2012 to validate the results. The soil of the experimental site is loamy sand, skeletal, kaolinitic, isohyperthermic Oxic paleustalf (Alfisol) Soil Survey Staff (1999). The annual rainfall of the area is between 1000 and 2060 mm and the annual temperature is between 29–37 °C as presented in Table 1.

Table 1 Monthly rainfail and temprature data for Akure in 2011 and 2012

Months	Rainfall (mm)		Temperature (0 °C)		Modified temp. (0 °C) of the environment under shade structure during the experiment (March–July)	
	2011	2012	2011	2012	2011	2012
January	1.90	–	33.70	36.30	–	–
February	41.10	34.80	36.10	35.60	–	–
March	127.10	40.00	35.00	37.10	22.10	22.60
April	230.00	81.80	29.10	32.20	23.10	23.40
May	222.30	156.60	30.30	29.30	22.80	22.60
June	162.00	195.80	32.20	31.20	22.50	22.30
July	169.00	423.00	29.10	29.20	22.30	22.00
August	169.00	682.90	31.40	30.10	22.90	22.70
September	378.00	240.90	30.70	32.30	–	–
October	141.90	111.60	33.10	31.10	–	–
November	51.30	93.20	33.60	35.30	–	–
December	–	–	32.70	34.60	–	–

Source: meteorological station Federal College of Agriculture, Akure

Pre-cropping soil sampling and analysis

Thirty core samples were collected from 0 to 15 cm depth, bulked together, air-dried, sieved with 2 mm and ready for routine analysis.

The soil pH (1:1 soil/water and 1:2 soil/0.01 M $Cacl_2$) was read on pH meter (Crockford and Nowel 1956), while organic matter was determined using wet oxidation method through chromic acid digestion (Walkley and Black 1934). 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).

Soil K, Ca, Mg and Na were extracted with 1 M NH_40AC pH7, and their contents K, Ca and Na were read on the flame photometer (Jackson 1958), while Mg content was determined using the atomic absorption spectrophotometer.

The soil nitrogen was determined using the micro-Kjeldahl method (Jackson 1964), while the micronutrients (Fe, Cu, Zn and Mn) were extracted with 0.1 M, HCl and read on atomic absorption spectrophotometer. Particle size analysis was carried out using hydrometer method (Bouycous 1951).

Table 2 shows the soil chemical composition before planting. The soil P 5.20 mg/kg is lower than 10 mg/kg P recommended for crop production in south-west Nigeria (Agboola and Corey 1973). The organic matter was also below 3 % critical level for crop production (Agboola and Corey 1973).

Soil N content was 0.08 % which is lower than 0.15 % N critical level for crops recommended by Sobulo and Osiname (1981). The exchangeable bases (K, Ca, Mg and Na) were below 0.20 mmol/kg recommended by Folorunso et al. (2000). The soil pH 5.82 showed that the soil is slightly acidic. The soil textural class is loamy sand.

Table 2 Soil properties before planting

Soil properties	Values
Soil pH (H_2O)	5.82
Soil pH (0.01 M $CaCl_2$)	5.34
Organic matter (%)	0.60
Nitrogen (%)	0.08
Available P (mg/kg)	5.20
Exchangeable bases	
K^+ (mmol/kg)	0.11
Ca^{2+} (mmol/kg)	0.13
Mg^{2+} (mmol/kg)	0.08
Na^{2+} (mmol/kg)	0.11
Exchangeable acidity	
H^+ (mmol/kg)	4.10
Al^{3+} (mmol/kg)	1.30
Micronutrients	
Fe (mg/kg)	8.30
Zn (mg/kg)	3.83
Cu (mg/kg)	2.20
Mn (mg/kg)	1.85
Particle size analysis	
Sand (%)	79.30
Silt (%)	14.70
Clay (%)	6.00

Sources and processing of organic fertilizers used for the experiments

Rice bran and wood ash were obtained from the large-scale processing unit of Federal College of Agriculture, Akure, which processed cassava tubers from 10,000 ha of cassava

farm and paddy rice from 5000 hectares of rice plantation, while the poultry manure was also obtained from the 10,000 poultry birds in the livestock unit of the same institution. NPK 15-15-15 was purchased from Agricultural Development Programme, while the imported cabbage seeds (Benelli cultivar) were purchased from a certified seed company Agro-Farm Enterprises, Akure.

The organic materials were processed, wood ash was sieved with 2 mm sieve to remove pebbles, while rice bran was partially composted for four weeks to reduce C/N ratio. Poultry manure was cured before application.

Chemical analysis of the organic materials used

Two grammes each of the processed forms of the organic materials was analysed. The N content was determined by the Kjeldahl method (Jackson 1964), while the determination of other nutrients such as P, K, Ca, Mg was done using the wet digestion method based on 25-5-5 ml of HNO_3-H_2SO_4-$HClO_4$ acids (AOAC 1970).

Table 3 shows the chemical analysis of the organic fertilizer used for the experiment. Wood ash had the highest values of K, Ca and Mg followed by poultry manure and rice bran, respectively. Rice bran had the least values of N, P, K, Ca and Mg and highest value of C/N ratio. Poultry manure also had the highest value of N, P and least C/N ratio compared to others.

Nursery establishment for cabbage seedlings

Land clearing and packing of debris were carried out followed by shade construction made of erected bamboo poles and top covered with moderate number of palm fronds. Twelve nursery beds with a size of 1 × 2 m^2 each were prepared. The cabbage seeds were sown on March manually into rows spaced at 30 cm apart, irrigated twice a day (morning and evening) to ensure good germination and establishment. Germination of the seeds occurred 8 days after planting and seedlings were nursed for 2 weeks before transplanting. The nursery establishment is important because directly sown seeds will not germinate; hence, the erection of shade structure in the experiment was to control the prevailing temperature of the environment for seeds germination.

Field experiment

The experimental site was cleared, ploughed, harrowed and divided into different plots. Each plot size was 4 × 4 m (16 m^2). There were three organic fertilizers treatments, namely poultry manure, wood ash and rice bran, applied at 6 t/ha with a reference treatment NPK 15-15-15 fertilizer applied at 300 kg/ha and a control treatment (no fertilizer). The experiment was arranged in a randomized complete block design and replicated three times. The choice of 6 t/ha for wood ash, rice bran and poultry manure in the experiment was based on the works of Folorunso (1999) and Moyin-Jesu (2008) which carried out extensive research on determination of soil critical levels for N, P, K, Ca and Mg using organic amendments such as rice bran, cocoa husk, poultry manure, wood ash and pig manure for vegetables. They reported that application of these organic fertilizer materials at 6 t/ha was the best critical level for optimum yield of crop in the study area.

The organic amendments were incorporated into the soil using hand trowel one week before transplanting the seedlings. Twenty-day-old seedlings were transplanted to the experimental plots at a spacing of 50 × 50 cm. After transplanting, irrigation was done every mornings and evenings until the rain was steady to allow full establishment.

A low-cost shade made of erected bamboo poles and the top covered with palm fronds was constructed over the transplanted cabbage seedlings to reduce partially direct impact of sun radiations and enhanced the prevailing environment of the site to favour sustainable cabbage production.

Weeding was done manually 10 days after transplanting and continued at 2 weeks interval until harvesting. Cabbage seedlings were sprayed with Avesthrin (Cypermethrin 10 EC) at 10 ml/litre of water at 3 weeks interval until 10 weeks after harvesting (WAT) to control leaf defoliating beetles and caterpillars. Growth parameters such as height, stem girth (cm), leaf area (cm^2) and number of leaves were measured starting from 15 days after transplanting (DAT) until 80 days after transplanting. The leaf area was estimated using the non-destructive and accurate method of Jamal et al. (2009) based on determination of individual leaf area using a predictive equation constructed from leaf length (L) and width (W) and their combination.

Table 3 Chemical analysis of the organic fertilizer used for the experiment

Treatments	N (%)	C (%)	C/N	P (mg/kg)	°K (%)	Ca (%)	Mg (%)
Poultry manure	4.32	30.00	6.93	385.00	9.70	3.30	4.10
Wood ash	1.53	18.00	11.76	86.00	23.02	9.40	8.52
Rice bran	0.60	14.00	23.33	56.00	7.93	0.12	1.80

Harvest of matured cabbage head started at 82 DAT and continued as they attain maturity in each experimental plot on treatment basis, and yield parameters such as cabbage head weight, cabbage head length and cabbage head girth were measured. In addition, it was observed that new shoots began to grow at the base of the harvested stem.

Soil analysis after harvesting cabbage

After harvesting, soil samples were taken from each plot using soil auger, bagged, air-dried and sieved for routine laboratory analysis. Soil pH, organic matter (O.M), N, P, K, Ca and Mg were determined as described for the pre-cropping soil analysis.

Statistical analysis

The average data of 2011 and 2012 cropping seasons on cabbage height, stem girth, leaf area, number of leaves, head weight, head girth and head length were analysed using ANOVA *F* test, and the treatment means were compared using Duncan multiple range test at 5 % level of significance (Gomez and Gomez (1984).

Results

Effect of organic fertilizers on the growth parameters of cabbage between 15 and 80 days after transplanting (DAT)

There were significant increases ($P < 0.05$) in the plant height, stem girth, number of leaves/plant and leaf area of cabbage under different organic fertilizer treatments compared to the control treatment (Table 4).

The highest values of cabbage plant height, stem girth, number of leaves and leaf area were obtained with poultry manure followed by NPK 15-15-15, wood ash and rice bran, respectively. The application of poultry manure treatment increased cabbage plant height, stem girth, leaf number/plant and leaf area by 17, 19, 10 and 16 % compared to NPK 15-15-15 fertilizer. The cabbage plant height, stem girth, number of leaves/plant and leaf area increased by 34, 26, 18 and 16 % with application of poultry manure compared to rice bran. The least values of growth parameters in cabbage were also obtained under the control treatment.

Effect of organic fertilizers on the head yield parameters of cabbage plant

There were significant increases ($P < 0.05$) in the head yield parameters (head weight t/ha, head girth and head length) of cabbage under different organic fertilizers compared to the control treatment (Table 5).

The highest values of cabbage head yield parameters were obtained with poultry manure followed by wood ash and rice bran, respectively. When compared to NPK 15-15-15, application of poultry manure also increased cabbage head weight, head girth and head length by 17, 18 and 8 %, respectively.

The application of poultry manure also increased cabbage head weight, head girth and head length by 23, 21 and 13 % compared to the wood ash treatment, respectively. The least values of cabbage yield parameters were obtained under the control treatment.

Soil chemical analysis after harvesting cabbage

Significant increases ($P < 0.05$) occurred in the soil N, P, K, Ca and Mg under different organic fertilizers compared to the control treatment (Table 6).

The soils which received NPK 15-15-15 fertilizer had the highest values of soil N, P, K, and the lowest contents of O.M, Ca and Mg. The highest values of soil organic matter (O.M) and moderate values of soil P, K, Ca and Mg

Table 4 Effect of different organic fertilizers on the growth parameters of cabbage plants

Treatments	Plant height (cm)			Stem girth (cm)			Leaf number			Leaf area (cm^2)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	4.00e	4.00e	4.00e	2.94e	2.70a	2.82e	4.64e	4.70e	4.67e	25.73e	26.11e	25.92e
NPK 15-15-15	10.53b	10.75b	10.64b	5.66b	5.30b	5.48b	8.10b	8.16b	8.13b	74.90b	73.60b	74.75b
Rice bran	8.50d	8.30d	8.40d	4.90d	5.18c	5.04d	7.46d	7.48d	7.47d	37.36d	36.20d	36.73d
Wood ash	8.70c	8.90c	8.80c	5.04c	5.14d	5.09c	7.50c	7.56c	7.53c	49.42c	48.30c	48.86c
Poultry manure	12.88a	12.40a	12.69a	6.84a	6.70a	6.77a	8.96a	9.10a	9.03a	88.88a	87.90a	88.39a

Treatment means within each group followed by the same letters are not significantly different from each other using Duncan multiple range test at 5 % level of significance

Table 5 Cabbage head yield parameters under different organic fertilizer treatments

Treatments	Head weight (t/ha)			Head girth (cm)			Head length (cm)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	0.90e	0.94e	0.92e	12.36e	12.30e	12.33e	9.10e	8.90e	9.0e
NPK 15-15-15	29.30b	28.90b	29.02b	31.80b	32.20b	32.00b	19.20b	18.30b	19.0b
Rice bran	22.60d	22.20d	22.40d	24.87d	24.57d	24.67d	16.80d	17.20d	17.00d
Wood ash	27.20c	27.40c	27.30c	29.90c	30.76c	30.33c	18.40c	17.60c	18.00c
Poultry manure	35.30a	34.90a	35.10a	38.56a	38.10a	38.33a	20.30a	20.70a	20.50a

Treatment means within each group followed by the same letters 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 harvesting cabbage

Treatment	Soil pH			O.M (%)			N (%)			P (mg/kg)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	5.30d	5.10e	5.20de	0.19e	0.21e	0.20e	0.029e	0.031e	0.03e	3.30e	3.10e	3.20e
NPK 15-15-15	5.12e	5.14d	5.13e	0.27d	0.23d	0.25de	0.39a	0.35a	0.37a	28.40a	28.80a	28.60a
Rice bran	7.16a	7.12a	7.14a	1.20b	1.22b	1.21b	0.25c	0.27c	0.26c	15.90c	15.52c	15.71c
Wood ash	6.60c	6.60c	6.62c	1.15c	1.11c	1.13c	0.15d	0.19d	0.17de	13.71d	13.53d	13.65d
Poultry manure	6.92b	7.06b	6.99b	2.30a	2.40a	2.53a	0.36b	0.34b	0.35b	25.55b	25.47b	25.51b

Treatment	Kmmol/kg			Ca (mmol/kg)			Mg (mmol/kg)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	0.03e	0.05e	0.04e	0.06d	0.04e	0.05d	0.032e	0.028e	0.03d
NPK 15-15-15	3.74b	6.68a	3.71a	0.03e	0.05d	0.04e	0.048d	0.052d	0.05e
Rice bran	3.90a	3.30b	3.10b	1.54a	1.52a	1.53c	1.28a	1.26a	1.27a
Wood ash	1.85d	1.53d	1.69d	0.93c	0.97c	0.95b	0.80c	0.86c	0.83c
Poultry manure	2.45c	2.65c	2.40c	1.24b	1.22b	1.23a	1.13b	1.11b	1.12b

Treatment means within each group followed by the same letters are not significantly different from each other using Duncan multiple range test at 5 % level of significance

were obtained with the application of poultry manure. The application of wood ash resulted in the highest values of soil pH, Ca and Mg compared to other treatments, while moderate values of soil pH, K, Ca and low % N were obtained with rice bran.

The soil N, P and K increased by 54, 53 and 55 % with application of NPK 15-15-15 compared to rice bran treatment. Also, it had higher K/Ca, K/Mg and P/Mg ratio of 93:1, 74:1 and 572:1 P/Mg, respectively, compared to 2:1 K/Ca, 2:1 K/Mg and 16:1 P/Mg in rice bran treatment.

The soil O.M, % N and P increased by 49, 26 and 39 %, respectively, with application of poultry manure compared to wood ash. However, soil pH, K, Ca and Mg were increased by 3, 30, 20 and 12 %, respectively, under wood ash treatment compared to poultry manure. The least values of soil pH, N, P, K, Ca and Mg nutrients were obtained under control treatment.

Discussion

The least values of soil, growth and head yield parameters (number of leaf, leaf area, stem height, head length, head girth and head weight) obtained under the control treatment compared to other treatments could be as a result of initial low soil nutrients status that often characterize continuous cultivation of land without fertilizer application. This finding was supported by Mohammed and Solaiman (2012) who worked on the efficacy of fertilizers on the growth and yield of cabbage and reported that nutrients supply was an important input for realizing higher cabbage yield. Hence, the application of fertilizers, especially organic fertilizers, enhanced both soil and crop productivity in the tropics.

The best cabbage head weight, head length, head girth, number of leaf, leaf area, stem girth and plant height obtained from the application of poultry manure could be

attributed to its balanced nutrient contents. The least value of C/N ratio of poultry manure also encouraged faster decomposition and quick release of nutrients for crop uptake and higher head yield parameters. This observation was supported by Ijoyah and Sophie (2009) who reported that the application of poultry manure increased cabbage yield. However, the head yield of 35.10 t/ha of cabbage obtained in this experiment was higher than 25.76 t/ha reported by Ijoyah and Sophie (2009). The prior processing and stacking of poultry manure enhanced quick decomposition and reduction in C/N ratio. This could be responsible for quick nutrient release and uptake by cabbage crop and hence higher cabbage head yield.

The increased soil pH obtained by the application of wood ash was attributed to its high K, Ca and Mg contents which served as base saturation agents and consequently increased soil buffering capacity (Moyin-Jesu and Ogochukwu 2014). The soil pH influenced nutrient availability and uptake as reported by Obatolu (1995) that oil palm bunch ash, wood ash and cocoa pod husk improved soil K, Ca and Mg nutrients and corrected soil acidity in an Alfisol under cultivation of coffee and corn.

The lower values of cabbage growth and head yield parameters under rice bran treatment compared to wood ash and poultry manure could be adduced to the fact that higher C/N ratio (23:3:1) of rice bran compared to poultry manure decelerated the residue decomposition rate and subsequently it had the least values of % N, P, K, Ca and Mg. The observation was supported by Moyin-Jesu (2007) who reported that the growth and yield performance of Okra were very low under the application of rice bran and sawdust. However, the processing of the organic fertilizer (rice bran) by composting was still responsible for reduction of C/N ratio and the results would have been extremely different, if the rice bran was not processed because of its high C/N ratio of 135:1. This was corroborated by Adebayo and Olayinka (1984) who used the unprocessed forms of oil palm bunch ash, sawdust and rice bran to grow maize; hence, prior processing of the organic fertilizers before application is important for good crop yield. Nevertheless, the inclusion of rice bran as source of fertilizer was important because it has been reported by Moyin-Jesu and Ojeniyi (2006) that rice bran, wood ash and spent grain were good in the reduction of soil bulk density and improved % porosity which are good soil fertility indicators (i.e. soil physical properties).

The application of NPK 15-15-15 fertilizer significantly increased the cabbage head yield and growth parameters more than that of rice bran, and this could be traced to the supply of readily available nutrients from the NPK fertilizer to the plant. This observation agreed with that of Makinde (2013) who reported that an increase in the readily available nitrate from the NPK fertilizer unlike the organic manure which must be mineralized before being utilized by crops. Moyin-Jesu (2013a) also reported that nitrogen increased the vegetative and yield performance of garden egg crop.

However, the high content of nitrogen in the NPK fertilizer and its continuous use might be responsible for excessive vegetative growth of cabbage and subsequently delayed maturity. This could explain the lower values of cabbage head yield and growth parameters compared to the poultry manure treatment. Also, Tong et al. (1997) reported higher rate of nitrate nitrogen leaching which polluted underground water particularly with the continuous use of chemical fertilizers compared to the organic fertilizers. Furthermore, Moyin-Jesu (2012) reported that the high K/Ca, K/Mg and P/Mg ratios would cause nutrient imbalance and made availability of nutrients such as K, Ca, and Mg difficult for both immediate and subsequent cropping of cabbage.

Conclusion

This experiment showed that the use of the various organic fertilizers (poultry manure, wood ash and rice bran) applied at 6 t/ha increased the growth, head yield of cabbage and soil N, P, K, Ca, Mg, pH and organic matter (O.M). It is recommended that poultry manure be applied at 6 t/ha for increased nutrient availability, growth and head yield of cabbage as well as enhancing sustainable cultivation of cabbage on commercial basis. The use of poultry manure would replace the application of large quantity of NPK 15-15-15 fertilizer.

The recommendation is important because the inorganic fertilizers are becoming very expensive to be purchased by small-scale and commercial farmers of cabbage. In addition, these organic fertilizers appear to have beneficial secondary effects on soil properties and ensuring environmental sustainability.

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