Nigerian Journal of Soil Science

journal homepage:www.soilsjournalnigeria.com

EFFECT OF COCOA POD HUSK BASED COMPOST ON THE GROWTH, NUTRIENT UPTAKE AND DRY MATTER YIELD OF ROSELLE

[1]Kayode, C.O., [2]Akande, M. O., [1]Adekunle, A. F., [1]Ogunleti D. A. and [3]Adeoye, G.O.

[1]*Federal College of Agriculture, Moor Plantation, Ibadan*
[2]*Institute of Agricultural Research and Training, Obafemi Awolowo University, Ibadan*
[3]*Department of Agronomy, University of Ibadan, Ibadan*
Corresponding author e-mail: bunmmykay@yahoo.com

ABSTRACT

A pot experiment was conducted at the Screen house of Federal College of Agriculture, Ibadan to investigate the effect of composts on the growth, nutrient uptake and dry matter yield of Roselle. Three types of compost were produced from cocoa pod husk (CPH), neem leaf (NL) and poultry manure (PM) namely CPH + NL + PM, CPH + NL and CPH + PM. There were fourteen treatments with three replications. The experimental design was Completely Randomized Design (CRD). The composts were applied at the rates of 0, 2.5, 5.0, 7.5 and 10 tons/ha. NPK 15-15-15 was applied at the rate of 300 kg/ha. The result obtained showed that there was significant treatment effects in all parameters considered. Plant heights and number of leaves ranged from 57.7 to 75.7cm and 11 to 19 respectively. Stem girth and leaf area ranged from 1.97 to 2.35cm and 194.89 to 280.02 cm^2 respectively. The highest shoot dry matter yield (15.75 g) and root dry matter yield (5.11 g) were obtained from the plant treated with 10 tons/ha CPH + NL + PM. Also the highest N uptake (74.87 g/pot) was obtained from the plant treated with 10 tons/ha CPH + NL + PM.

Keywords: Cocoa Pod Husk, Neem leaf, Poultry manure, Roselle, Dry matter partitioning.

INTRODUCTION

The red roselle (*Hibiscus sabdariffa* L.) is mainly cultivated in tropical and subtropical regions for its attractive edible calyces. It is known as Sobo in Nigeria. Apart from nutritional and health importance, roselle plays an important role in income generation and subsistence among rural farmers in developing countries. The different parts of roselle are the leaves, calyces and seeds and these have been used for different uses as vegetables, source of oils, refreshing drinks and food preserves (Pen-kong, 2002) and for medicinal and health purposes (Delgado-vargas *et al.*, 2000). The tender stems, leaves and calyces are used as vegetable in the preparation of soups and souces.

Compost is derived from biological conversion of organic materials into a soil-like fertilizer, it is a term that describes a managed process of organic matter decomposition and recomposition (Insam *et al*., 2002). It is an organic amendment that may be applied to the soil to supply macronutrient and micronutrients and their effects last longer than inorganic fertilizers because they are slow releasers (Gabrielle *et al.*, 2004; Tu *et al.*, 2006). Apart from its effect on nutrient release, compost is known to improve physical properties such as soil bulk density, water retention, infiltration and aeration.

Cocoa pod husk and its ash have not been adequately studied in plant nutrition. Ayeni *et al.* (2008), found that cocoa pod ash contained plant nutrients as N, P, K, Ca, Mg and micronutrients and is good for tomato production (Odedina *et al.*, 2003). About 800,000 tones of cocoa pod husk are generated annually in Nigeria and often wasted (Egunjobi, 1976). It is advised that the husk be burnt into ash as a method of farm sanitation and for the control of black pod disease. The husk left on the farm harbours the fungus *(Phytophtora palmivora)* which is the causal organism of black pod disease. Moyin Jesu (2003), after extensive literature search noted scarcity of report on use of cocoa pod husk in plant nutrition. Egunjobi (1976), found that ground cocoa husk applied to soil increased maize yield by 124%, and also increased uptake of P, K and Mg.

Because of low yield of roselle in Nigeria and the attendant low soil fertility, there is need to invigorate research into the use of organic wastes alone or combined with chemical fertilizers in roselle cultivation. Some of the organic wastes in forms of farm wastes and animal manures are commonly and cheaply available especially those of cocoa pod husk, neem leaf and poultry manure. Apart from high cost, the use of chemical fertilizer continuously cannot sustain crop production in the tropics (Madeley, 1990). Its continuous use depletes soil organic matter, degrades soil physical quality, cause nutrient imbalance and soil acidity thereby leading into reduction in crop yield. Research information is scarce on response of roselle to organic and chemical fertilizers in Nigeria soils. This study was carried out to evaluate comparative effect of cocoa pod husk based compost on the growth, nutrient uptake and dry matter yield of roselle.

MATERIALS AND METHODS

Compost making

The materials used for composting were Cocoa Pod Husk (CPH), Poultry Manure (PM) and Neem Leaf (NL). CPH was collected from Cocoa Research Institute of Nigeria, Ibadan. PM was collected from the poultry unit of Federal College of Agriculture, Ibadan while neem leaves were collected from one of the experimental plots of the Federal College Ibadan. The CPH was chopped to reduce the particle size. All the materials were analyzed before composting. Three types of compost were produced as follows:

CPH + NL + PM (30 kg CPH + 10 kg NL + 10 kg PM)
CPH + NL (30 kg CPH + 10 kg NL)
CPH + PM (30 kg CPH + kg PM)

The compost heap was watered at the beginning of the composting process and when the compost was turned fortnightly. The temperature of each of the compost was monitored everyday at the beginning of the composting process and at 3 days intervals for about 3 weeks. Thereafter, temperature measurement was done weekly until full compost maturity stage.

Screen house Experiment

Soil sample (0-15 cm) which is characterized by low nutrient status was collected from an experimental plot of Federal College of Agriculture, Ibadan. The soil was analyzed before compost application for major plant nutrients in the laboratory. Five kilogram (5 kg) of air-dried soil was weighed into plastic buckets. Each bucket was supplied with drainage holes and saucer. There were fourteen treatments replicated three times. The treatments consisted of control, CPH + PM + NL (2,5, 5.0, 7.5 and 10.0 tons/ha), CPH + PM

(2.5, 5.0, 7.5 and 10.0 tons/ha), CPH + NL (2.5, 5.0, 7.5 and 10.0 tons/ha) and NPK 15-15-15 (300 kg/ha).

Roselle seeds were obtained from the Industrial Crop Improvement Programme of Institute of Agricultural Research and Training, Ibadan and were planted two weeks after the application of compost. Four seeds of Roselle were planted and later thinned to two stands per pot at two weeks after planting. NPK was applied a week after crop emergence. The plants were watered regularly and observations were recorded on the effects of treatments for 10 weeks. Parameters measured were plant height, number of leaves, leaf area, dry matter yield and nutrient uptake of Roselle. The shoot was cut at ground level; the root was uprooted and washed. They were later packed in separate envelops and oven dried at 68^{o}C to a constant weight. Post-harvest soil samples were taken and analyzed.

Soil and Plant Analyses

Soil particle size distribution was determined by Bouyoucos hydrometer method. Soil pH was determined in distilled water at soil to water ratio 1:1 using electrometric method. Exchangeable bases (Na, Ca, Mg and K) extraction was done using 1N ammonium acetate pH 7.0 and determined using flame photometer. Available P was determined after Bray P-1 extraction and determined colorimetrically at 660nm after the development with molybdenum. Total N was determined by the kjedahl digestion method and soil organic carbon content was determined by dichromate oxidation procedure.

Chemical analysis of organic materials and plant tissue sample was carried out in the laboratory using standard procedures. The tissue samples were burnt to ash in a muffle furnace at a temperature of 550^{o}C. The nutrients in the ash were extracted using 0.1 N HCl and N, P and K were determined in the laboratory of Institute of Agricultural Research, Ibadan. Data were subjected to statistical analysis of variance (ANOVA) and means were separated by Duncan Multiple Range Test (SAS 2004).

RESULTS

Nutrient composition of the organic materials and matured compost

The concentration of major nutrients in the organic materials used for composting and matured compost is shown in Table 1. The materials differ in Nutrient composition. The N concentration in the materials is in the order of PM > NL > CPH (24.5, 21.6 and 11.8 g kg^{-1} respectively). Potassium concentration was in the order of CPH > NL > PM (36.7, 23.8 and 3.8 g kg^{-1} respectively). The N content of CPH which was low increased when composted with PM and NL. However, the compost that consisted the three materials had the highest N content of 23.3 g kg^{-1}. Generally, N in the compost ranged between 19.9 – 23.3 g kg$^{-1.}$ P ranged from 6.5 – 11.7 while K ranged from 10.4 – 14.6 g kg^{-1}.

Table 1: Nutrient content of the organic materials and compost

	N (g/kg)	P (g/kg)	K (g/kg)
Organic materials			
CPH	11.8	1.4	36.7
PM	24.5	21.5	3.8
NL	21.6	1.9	23.8
Compost			
CPH + PM + NL	23.3	11.7	14.6
CPH + PM	20.6	8.2	12.8
CPH + NL	19.9	6.5	10.4

Legend: CPH = Cocoa pod husk, PM = Poultry manure, NL = Neem leaf

Pre-planting soil properties

The chemical analysis of the soil used for the experiment presented in Table 2 showed that the textural class of the soil is sandy clay loam with a pH of 6.01 which indicates that the soil is slightly acidic. The organic matter, N, exchangeable bases and available P were low indicating that the soil was low in fertility. Therefore, there is need to apply fertilizer to the soil in order to boost its productivity.

Table 2: Physical and Chemical Properties of pre-cropping soil

Parameters	**Value**
pH (H_2O)	6.01
Exchangeable bases (cmolkg^{-1})	
Ca	1.23
Na	0.37
K	0.38
Mg	0.18
Ex. Acidity (H^+)	0.11
ECEC (cmolkg^{1})	2.27
Organiccarbon (gkg^{1})	2.80
Organicmatter (gkg^{1})	4.83
Total N (gkg^{-1})	3.00
Av. P (mgkg^{-1})	5.06
Silt (gkg^{-1})	105
Clay (gkg^{-1})	253
Sand (gkg^{-1})	642
Textural Class	Sandy clay loam

Effect of compost on growth of Roselle

The growth attributes of Roselle were significantly affected by the applied treatments. There is a corresponding increase in the growth of Roselle as the rate of fertilizer increases. The plant height varied from 57.7cm in non-fertilized plants to 75.7cm in plants that received 10 tons/ha CPH + PM + NL (Table 3). Also, significant increase in number of leaves, leaf area and stem girth was observed with fertilizer application when compared with the control. Plants treated with 10 tons/ha CPH + PM + NL gave the highest number of leaves which is significantly higher than the control but not significantly different from the plant treated with NPK fertilizer. The stem girth of plants treated with 10 tons/ha CPH + PM + NL was significantly higher than other treatments. Also, there is significant increase in the leaf area of treated plants compared to the untreated plants. This is in agreement with the findings of de Jesus (2001), that supply of adequate amount of nutrients in the right proportion could influence the leaf area development in many tropical crops.

Table 3: Effect of compost on growth of Roselle at 10 weeks after planting

Treatment	Rate (tons/ha)	Plant height (cm)	No of leaves	Stem girth (cm)	Leaf area (cm^2)
Control	0	57.7b	11.2c	1.97bc	194.89c
CPH+PM+NL	2.5	68.8ab	11.33c	2.17b	202.29c
CPH+PM+NL	5	71.7ab	15.67abc	2.02b	239.67ab
CPH+PM+NL	7.5	71.3ab	16.00abc	2.17b	247.67ab
CPH+PM+NL	10	75.7a	19.00a	2.35a	275.03a
CPH + PM	2.5	69.5b	12.33c	2.17b	231.41ab
CPH + PM	5	70.8b	12.67bc	2.00b	223.54ab
CPH + PM	7.5	71.6b	14.67abc	2.03b	237.88ab
CPH + NL	10	71.9b	14.33abc	2.15b	215.66ab
CPH + NL	2.5	69.83b	12.67bc	2.10b	182.65ab
CPH + NL	5	70.40b	11.67c	2.25ab	276.02a
CPH + NL	7.5	70.90b	13.33bc	2.28ab	270.03a
CPH + NL	10	71.70b	13.33bc	2.27ab	279.01a
NPK	300kg/a	71.80b	17.50ab	2.02b	267.60a

Means having the same letter(s) within a column are not significantly different at p<0.05 according to Duncan Multiple Range Test.

Effect of compost on dry matter yield and partitioning of Roselle

Application of different types of compost had significant effects on root, shoot, dry matter yield and partitioning of Roselle (Table 4). The highest shoot dry matter yield of 15.75 g/plant was obtained in the plants treated with CPH + PM + NL at 10 tons/ha which is significantly higher than the control and the plants treated with NPK. The lowest total dry matter of 6.54 g/plant was obtained from the control. Highest root dry matter was obtained from the plants treated with CPH + PM + NL at 10 tons/ha which is significantly higher than the control and NPK treated plants. The dry matter partitioning was more favoured with the application of 7.5 and 10 tons/ha CPH + PM + NL compost. Application of 2.5 tons/ha CPH + NL favoured the partitioning of dry matter to the root. The use of 2.5 tons/ha CPH + PM + NL and 2.5 tons/ha CPH + NL had the lowest dry matter of 75% partitioned to the shoot. The lowest dry matter partitioned to the root was obtained from plants treated with 7.5 tons/ha CPH + PM.

Table 4: Effect of treatment on dry matter yield and partitioning of Roselle

Treatment	Rate (tons/ha)	Shoot (g/plant)	Root (g/plant)	Total dry matter yield (g/plant)	Root/Shoot dry matter ratio
Control	0	6.54d	2.01c	8.55c	24:76
CPH+PM+L	2.5	8.44cd	2.62bc	11.06bcde	24:76
CPH+PM+L	5	8.01cd	2.48bc	10.49cde	24:76
CPH+PM+L	7.5	14.2a	3.49bc	17.69ab	20:80
CPH+PM+L	10	15.75a	5.11a	20.86a	24:76
CPH + PM	2.5	10.70abcd	3.56bc	14.26abcde	25:75
CPH + PM	5	12.79abc	3.41bc	16.20abc	21:79
CPH + PM	7.5	13.80ab	3.04bc	16.84abc	18:82
CPH + PM	10	14.89a	3.51bc	18.40ab	19:81
CPH + NL	2.5	7.16d	2.36bc	9.52de	25:75
CPH + NL	5	10.82abcd	2.63bc	13.45abcde	20:80
CP	7.5	11.40bcd	2.86bc	14.26abcde	20:80
CPH + NL	10	13.89ab	3.98ab	17.87ab	22:78
NPK	300kg/a	9.48bcd	2.67bc	12.15cde	22:78

Means having the same letter(s) within a column are not significantly different at p<0.05 according to Duncan Multiple Range Test.

Effect of compost on N, P and K uptake of Roselle

The N uptake of Roselle was significantly enhanced by use of 10 tons/ha CPH + PM + NL (Table 5). This is significantly higher than all the other treated plants and the control. The lowest N uptake (22.90 g/pot) was recorded in the plant treated with 2.5 tons/ha CPH + PM. The P uptake of Roselle was highest in the plants treated with 5.0 tons/ha CPH + PM + NL. This is significantly higher than the control and the plants treated with NPK but not significantly different from the plants treated with 7.5 and 10 tons/ha CPH + PM + NL. The K uptake was significantly enhanced by 5.0 tons/ha CPH + PM + NL and 10 tons/ha CPH + PM + NL than the control and other treatments.

Table 5: Effect of compost on N, P and K uptake of Roselle (g/pot)

Treatment	Rate (tons/ha)	N	P	K
Control	0	36.07cd	1.56d	30.67gh
CPH+PM+NL	2.5	38.59c	3.00bc	73.84b
CPH+PM+NL	5	31.57c	3.87a	76.68a
CPH+PM+NL	7.5	52.53b	3.53ab	74.47ab
CPH+PM+NL	10	74.87a	3.86a	74.62ab
CPH + PM	2.5	22.90g	2.93bc	30.73gh
CPH + PM	5	26.51f	3.46ab	38.13f
CPH + PM	7.5	36.12cd	3.85a	43.83e
CPH + PM	10	36.55c	2.34a	56.83c
CPH + NL	2.5	33.63d	1.58d	56.37c
CPH + NL	5	28.22ef	1.84d	33.10g
CPH + NL	7.5	30.25e	2.64c	54.20c
CPH + NL	10	39.10bc	1.64d	24.95i
NPK	300kg/a	28.24ef	2.37c	48.00d

Means having the same letter(s) within a column are not significantly different at $p<0.05$ according to Duncan Multiple Range Test.

Effect of compost on post-cropping soil chemical properties

Soil pH increased with the application of compost with values between 6.02 – 6.48 (Table 6) above the initial soil pH value of 6.01 (Table 2). The highest soil pH was recorded in the soil treated with 10 tons/ha CPH + PM +NL. This fertilizer significantly enhanced the soil pH better than NPK and control. The organic carbon content of the soil increased from the initial value of 2.8 g/kg (Table 2) to values of between 10.70-14.90 g/kg for CPH based compost (Table 6) compared to 9.0g/kg for control and 10.0 g/kg for NPK. There was an increase in N value from the initial value of 3.0 g/kg (Table 2). CPH + PM + NL at 10 tons/ha increased the soil N content to 15.2 g/kg. The CEC of the soil increased with the application of organic fertilizer.

Table 6: Effect of Compost on post-cropping Soil Chemical properties.

Treatment	Rate (tons/ha)	pH (H_2O)	OC (g/kg)	OM (g/kg)	Av. P (mg/kg)	Total N (g/kg)	Ex. K (cmo/kg)	Ex. Na (cmol/kg)	Ex. Ca (cmol/kg)	Ex. Mg (cmol/kg)	Ex Acidity (cmol/kg)	ECEC (cmol/k)
Control	0	6.12e	10.01ab	17.2b	2.20def	9.20def	0.44	0.27d	1.33e	0.33de	0.11	2.48e
CPH+PM+NL	2.5	6.22cde	10.7ab	18.4b	2.37def	10.3de	0.54	0.27d	1.51e	0.39de	0.10	2.81e
CPH+PM+NL	5	6.48a	11.3ab	19.7b	3.59abc	12.01c	0.49	0.28bcd	1.69e	0.26e	0.10	2.82e
CPH+PM+NL	7.5	6.45abc	11.2ab	22.2b	3.98ab	13.4b	0.60	0.34ab	3.25bcde	0.69cdc	0.10	5.25cde
CPH+PM+NL	10	6.60a	14.9a	25.9a	3.65ab	15.2a	0.62	0.39a	5.49a	2.38a	0.10	8.98a
CPH + PM	2.5	6.59a	10.01ab	17.2b	2.36def	10.3cde	0.53	0.37a	1.50e	0.37de	0.10	2.87e
CPH + PM	5	6.48a	11.60ab	20.0b	1.63f	12.2bc	0.64	0.37a	3.00cde	0.84cde	0.10	4.95de
CPH + PM	7.5	6.52a	12.52ab	21.7b	1.48f	13.0b	0.77	0.36ab	4.76abc	1.50abc	0.10	7.49abc
CPH + PM	10	6.58a	12.54ab	21.6b	1.49f	13.2b	0.76	0.39a	4.75abc	1.56abc	0.10	7.50abc
CPH + NL	2.5	6.04cde	11.7ab	20.3b	1.64f	12.1bc	0.65	0.37a	3.01cdc	0.86cde	0.11	5.00cde
CPH + NL	5	6.15bcd	12.4ab	21.6b	1.47f	12.2bc	0.69	0.37a	3.97abcd	1.20cdc	0.11	6.34abc
CPH + NL	7.5	6.03cde	12.5ab	21.6b	1.77f	13.0b	0.77	0.36ab	4.77abc	1.75abc	0.11	7.76abc
CPH + NL	10	6.47abc	12.70ab	21.8b	1.36f	10.2cde	0.87	0.37a	4.69abc	1.51abc	0.10	7.54abc
NPK	300kg//ha	6.11e	10.00ab	17.2b	2.75cdc	11.0bcd	0.42	0.27cd	2.59de	0.89cdc	0.11	4.28de

Means having the same letter(s) within a column are not significantly different at $p<0.05$ according to Duncan Multiple Range Test.

DISCUSSION

Fertilizer is one of the most important inputs contributing to crop production by increasing the productivity of the soil for plant growth and thus, improving the quantity and quality of the produce. Composting is a biological process that converts raw organic waste material into stable humus-like products; these organic products can be used as soil amendments without any negative enviromental impact. There are abundant numerous sources of organic materials which have been identified as valuable raw material suitable for producing fertilizers to meet deficient organic matter and essential nutrients requirement of these soils. In this study, the organic materials (cocoa pod husk, neem leaf and poultry manure) used varied in nutrients composition and after composting gave different composition of plant nutrients which is higher in plant nutrient than in the soil. The organic manure expectedly had high nitrogen content and so, was suitable for the study.

The soil used for the trial was sandy clay loam in texture and slightly acidic. The nitrogen content was very low. The base (Ca, Na, K, Mg) and CEC were also low. The phosphorus content was low. The exchangeable acidity and the base contents were generally low. These general low contents of the soil nutrients made the soil suitable for the study on response to fertilizer application. The growth of Roselle was significantly affected by the application of organic and inorganic fertilizer. Application of different levels of organic manure generally resulted in growths that are higher than the control. The organic material applied produced similar effects on average plant height, stem circumference and average leaf area. However, increasing the rates of application of the organic manure generally gave taller plants, with higher leaf area although the differences were not significant. The fertilized crops had a better growth as a result of higher nutrients availability, although, to varying levels. Enhancement of development of growth parameters of fertilized plants observed could be as a result of inadequate essential nutrients in the growth medium of the control pots. It has been asserted that cultivation of crop on soil with non limiting nutrients aid crop yield, growth and development thereby improving the crop nutritional components. However, dry matter accumulation was significantly affected by 10 tons/ha CPH + PM + NL. This is in agreement with the findings of Gyllapsy *et al.* (1993) and Akanbi *et al.* (2006), who reported on tomato and *Solanum macrocarpon* respectively. In these two reports, availability of essential nutrients (most especially N) in adequate quantity and form enhanced protoplasmic development and cell proliferation. These culminated in proper crop growth and development. Results from this study have shown that application of compost improved the growth and dry matter yield of roselle as well as chemical properties of the soil.

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