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ORIGINAL RESEARCH ARTICLE

Effect of sole and combined application of cocoa pod husk ash and cocoa pod husk powder on growth and yield of radish (*Raphanus sativus*)

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ABSTRACT

This study was carried out at the Teaching and Research Farm of Landmark University, Omu-Aran. Treatments consisted of 3 levels of cocoa pod husk ash (0, 2 and 4 tonnes CPHA ha^{-1}), 3 levels of cocoa pod husk powder (0, 2 and 4 tonnes CPHP ha^{-1}), NPK and the control. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated four times. The following parameters were taken plant height, number of leaves (at 2, 3, and 4 weeks after sowing), total plant weight, root weight, leaf weight, roots girth and roots length. Data collected were subjected to Analysis of Variance (ANOVA) Using S.A.S, 2000. Treatment means were compared using Duncan Multiple Range Test (DMRT) at 0.05 level of probability. Results showed that chemical analysis of cocoa pod ash and powder contained plant nutrients as N, P, K, Ca, Mg and some other micronutrients in varying proportions. Application of CPHA 4 + CPHP 2 gave higher values for all the vegetative parameters. The implication of this study is that high level of cocoa pod husk powder in combination with high level of cocoa pod husk ash is detrimental to radish cultivation. In the same vein, the nutrition of radish was incomplete when NPK fertilizer was applied. It can therefore be recommended that the use of combined application of cocoa pod ash and cocoa pod powder at CPHA4 + CPHP2 was sufficient for the cultivation of radish (*Raphanus sativus*) in the study area as it compete favorably with application of NPK fertilizer.

Keywords: Radish; Cocoa Pod Ash; Cocoa Pod Powder; Growth and Yield

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1. Introduction

Radish (*Raphanus sativus*) is an edible root vegetable of the Brassicaceae family. It is a crop grown for its swollen tap-roots which can be globular, tapering or cylindrical. It is a fast maturing and easy to grow vegetable. It is grown for its young tender tuberous root which is consumed either cooked or raw.

Radish roots vary in size, shape and other external characters as well as the length depending on cultivars. They can grow more than 60 cm long, but they tend to become tough and fibrous when more than 30 cm long.

An investigation was carried out to evaluate the potentials of cocoa pod husk ash (CPHA) as fertilizer and liming materials on nutrient uptake and growth performance of cocoa (*Theobroma cacao*) seedlings in the nursery.

The results showed that the cocoa pod husk ash increased significantly ($P < 0.05$) the plant height, stem diameter, number of leaves, leaf area, number of branches, root and shoot lengths, root and shoot fresh weights, root and shoot dry weights, N, P, K, Ca, Mg of soil and leaf,

soil pH and organic matter contents of cocoa seedlings relative to the control treatment[1].

In tropical countries, high cost, scarcity, nutrient imbalance and soil acidity are problems associated with the use of mineral fertilizer while bulkiness, low nutrient quality and late mineralization were the bottleneck to the sole use of organic manures for crop production. In their studies, they confirmed that combined application of organic manures gave superior effects in terms of balanced plant nutrition and improved soil fertility[2,3]. Other advantages of using combined application of organic and inorganic fertilizers, is that, it reduces the need for mineral fertilizer and aids time of mineralization of nutrients from organic manures.

The loss of soil nutrients due to continuous cropping reduces the soil organic matter, thereby causing a reduction in the yield of crop. Therefore, there is a need for adequate soil amendment or fertilization, to achieve optimum growth and yield of the crop planted to ensure the availability of food for the ever-growing population[4].

Moyin Jesu[5], after extensive literature search, noted scarcity of report on use of cocoa husk in plant nutrition.

Cocoa pod is known to be cheap in southwest Nigeria. About 800,000 tons of cocoa pod husks are generated annually in Nigeria and often wasted[6]. Cocoa pod husk and its ash have not been adequately studied in plant nutrition. Ayeni *et al*.[7] found that cocoa pod ash contained plant nutrients as N, P, K Ca, Mg and micronutrients and is good for tomato production[8].

The objective of the study was to: determine the combined and sole effect of cocoa pod husk ash and cocoa pod husk powder on the growth, root yield and nutritional composition of radish *(Raphanus sativus)*.

2. Materials and methods

The experiment was conducted during the 2017 cropping season at the Teaching and Research Farm, Landmark University, Omu-Aran, Kwara State (Latitude 8.9°N and Longitude 50°61′E of the equator.) to study the effect of organic materials (cocoa pod ash and cocoa pod powder) and in-organic fertilizers on the growth and yield of radish (*Raphanus sativus*). It has annual rainfall pattern which extends between the months of April and October and it ranges between 600 mm–1,500 mm, with peak rain in May–June and September–October, while the dry season is between November and March.

2.1 Sources of materials

Cocoa pod husk (CPH) were collected from cocoa farmers in Edidi, Kwara state, sun dried and divided into two. One part was burnt into ash while the second parts was milled into powder and were kept inside separate bags.

2.2 Treatment and experimental design

Treatment consisted of 3 levels of cocoa pod husk ash (0, 2 and 4 tonnes CPHA ha^{-1}), 3 levels of cocoa pod husk powder (0, 2 and 4 tonnes CPHP ha^{-1}), NPK fertilizer and the control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three-times replicated.

2.3 Land preparation and planting

The land was ploughed once and harrowed twice to give a fine tilt. After which beds were made into 2 m × 2 m with an alley of 0.5 m between each bed and between each replicate.

2.4 Seed sowing

Radish seeds were sown on 13th of October 2015, at an intra and inter row spacing of 30 cm × 30 cm. Two seeds were sown per hole and were thinned to one plant per stand two weeks after sowing.

2.5 Application of amendments

Cocoa pod ash and powder were incorporated into the soil two weeks before planting to give room for mineralisation while N.P.K 20:10:10 fertilizer was applied to radish plant 2 weeks after sowing (WAS) by side placement 8 cm away from the base of the plant.

2.6 Weeding

Weeding was done at 2 and 4 WAS by hand picking all emerged weeds.

2.7 Harvesting

Radish roots were harvested 6 WAS by hand pulling the roots from the ground. Time of harvesting depends on the purpose for which it is being planted. If radish is planted for seed, harvesting will be delayed till flowering.

2.8 Observation and data collection

The following vegetative parameters plant height (cm), number of leaves and stem girth (cm) were collected at 2, 3 and 4 weeks after sowing while total plant weight (g), leaf weight (g), root weight (g), root girth (cm), root length (cm) were collected at harvest.

2.9 Statistical analysis

Data collected were subjected to Analysis of Variance (ANOVA) Using S.A.S, 2000.

Treatment means were compared using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

Table 1. Soil physical and chemical property prior planting (0–15cm)

Parameter	Value
Sand (%)	76.12
Silt (%)	12
Clay (%)	11.88
Textural class	Sandy loam
pH (H_2O) 1:1	5.25
Total nitrogen	0.16
Organic carbon	1.88
Organic matter	3.24
Exchangeable bases	
K (cmol/kg)	0.23
Na (cmol/kg)	0.66
Ca (cmol/kg)	3.97
Mg (cmol/kg)	1.32
Al + H (cmol/kg)	0.07
ECEC (cmol/kg)	6.25
Available phosphorus (mg/kg)	21.12

3. Results

3.1 Initial soil properties

The pre-planting soil analysis is as shown on **Table 1**. The pH of the soil was strongly acidic, the Nitrogen content of the soil was very low, the available phosphorus was high, and the exchangeable K was at moderate while the exchangeable Na, Ca, and Mg were all suitable. The organic carbon and organic matter are adequate. The soil is high in sand with relatively low values in both silt and clay; hence the textural class Sandy loam.

3.2 Nutrient composition of cocoa pod ash and cocoa pod powder (%)

The result of the analysis of cocoa pod ash revealed that Nitrogen is low in the ash and at a moderate level in the powder, the available Phosphorus was low in the powder and moderate in the ash, and the exchangeable K, Ca and Mg were higher in the ash than in the powder.

3.3 Effect of cocoa pod ash and cocoa pod powder on plant height of radish

The effect of cocoa pod ash and cocoa pod powder on plant height of radish is as shown on **Table 2**. The ANOVA test show significant effect of the treatments on plant height at 2, 3 and 4 weeks after sowing (WAS). Across all weeks after sowing, the values obtained at application of CPHA 4 + CPHP 2 was significantly higher than other treatments values but statistically similar with the values obtained at application of CPHA 2 + CPHP 2, CPHA 2 + CPHP 4 and CPHA 4 + CPHP 0 at 3 WAS. At 2 and 4 WAS, application of CPHA 0 + CPHP 0, CPHA 0 + CPHP 2, CPHA 0 + CPHP 4 and CPHA 2 + CPHP 0 gave statistically similar values. At all weeks after sowing control gave the least values for plant height.

3.4 Effect of cocoa pod ash and cocoa pod powder on number of leaves of radish

The effect of cocoa pod ash and cocoa pod powder on number of leaves of radish is as shown on **Table 2**. At all sampling periods, increasing levels of both treatments from CPHA 0 + CPHP 0 to CPHA 4 + CPHP 2 resulted in increasing number of leaves with CPHA 4 + CPHP 2, having a significantly a greater number of leaves. Application of CPHA + CPHP 4 resulted in reduced number of leaves. Number of leaves obtained at application of NPK was statistically lower when compared with the values obtained at application of CPHA 4 + CPHP 2. At all sampling periods, control gave a statistically reduced number of leaves which was only similar to the values obtained when CPHA 4 +

CPHP 4 was applied at 4 WAS.

Table 2. Effect of cocoa pod ash and cocoa pod powder on plant height and number of leaves of radish (Raphanus sativus)

Treatments (t ha^{-1})	Plant height (cm)			Number of leaves		
	2 WAS	3 WAS	4 WAS	2 WAS	3 WAS	4 WAS
CPHA 0 + CPHP 0	3.77c	4.83d	5.50f	3.23d	4.00d	5.00e
CPHA 0 + CPHP 2	4.53c	9.73bc	11.40d	4.00c	5.00bc	6.00d
CPHA 0 + CPHP 4	4.53c	9.83bc	12.07d	4.00c	5.10bc	6.07d
CPHA 2 + CPHP 0	4.37c	10.10b	11.33d	4.33d	5.20bc	6.63c
CPHA 2 + CPHP 2	5.67b	11.87ab	13.77c	4.60ab	5.43b	6.83bc
CPHA 2 + CPHP 4	6.40b	12.70ab	15.77b	4.67ab	5.50b	7.00b
CPHA 4 + CPHP 0	6.17b	12.50ab	15.70b	4.43abc	5.50b	7.10b
CPHA 4 + CPHP 2	7.80a	13.80a	21.93a	4.87a	7.57a	8.83a
CPHA 4 + CPHP 4	3.83c	7.27cd	9.13e	4.40b	4.83c	5.00e
NPK	3.73c	7.43c	9.13e	4.40bc	5.50b	7.00b

Note: Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

Table 3. Effect of cocoa pod ash and cocoa pod powder on Total biomass, leaf weight, and root weight of radish (Raphanus sativus)

Treatments	Total biomass	Leaf weight	Root weight
CPHA 0 + CPHP 0	55.00d	11.20f	43.79d
CPHA 0 + CPHP 2	143.00b	21.11d	121.89ab
CPHA 0 + CPHP 4	144.00b	21.53d	121.47ab
CPHA 2 + CPHP 0	143.00b	20.80d	122.20ab
CPHA 2 + CPHP 2	146.77ab	25.49c	121.28ab
CPHA 2 + CPHP 4	150.00ab	27.67b	116.67b
CPHA 4 + CPHP 0	149.41ab	27.65b	121.76ab
CPHA 4 + CPHP 2	156.27a	32.93a	128.00a
CPHA 4 + CPHP 4	113.33c	18.74e	94.80c
NPK	118.33c	18.30e	100.03c

Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

3.5 Effect of cocoa pod ash and cocoa pod powder on total biomass, leaf weight and root weight of radish

The effect of cocoa pod ash and cocoa pod powder on total biomass, leaf weight and root weight of radish is as shown on **Table 3**. Relative to the control which gave the least values for total biomass, leaf weight and root weight, application of other treatments resulted in varying increase in the values of the parameters. Application of CPHA 4 + CPHP 2 gave higher values for the parameters although statistically similar with values obtained at application of some treatments. The values obtained when NPK and CPHA 4 + CPHP 4 was applied were statistically similar.

4. Discussion

Chemical analysis of cocoa pod ash and powder revealed that they contained plant nutrients as N, P, K, Ca, Mg and some other micronutrients. This is in line with the work of Odedina *et al.*[8], Ayeni *et al.*[7], and Adu-Dapaah *et al.*[9], that cocoa pod ash contains plant nutrients.

Manhas and Gill[10] found that increment of application of organic manure increased the growth, dry matter accumulation, yield and quality of plant. This study revealed that varying levels of cocoa pod husk ash (CPHA) and cocoa pod husk powder (CPHP) increased vegetative parameters of radish. This could be as a result of the cumulative and complementary effect of both treatments which makes the nutrients available to the plants. It could also be as a result of low fertility status of the native soil. Similar study was by Ayeni[3], and Odedina *et al.*[8] who found that cocoa pod ash increased soil organic matter, N, P, K, Ca, and Mg hence increase in plant vegetative growth.

Application of CPHA 4 + CPHP 2 gave higher values for all the vegetative parameters. The presence of nitrogen in both amendments in addition to the soil nitrogen could be adequate which may be responsible for the increase in vegetative parameters.

Magnesium (Mg) is present in the two

amendments in varying amounts and it is known to be present in chlorophyll and essential for photosynthesis. This could also be responsible for increased vegetative parameters.

Several researchers have revealed that organic manuring increases the vegetative growth and biomass production effectively[12,13].

Calcium functions in root tip and shoot developments. Total biomass, leaf weight and root weight were also found to increase with application of CPHA 4 + CPHP 2. This could be attributed to presence of adequate quantity of calcium that is present in both amendments. Increased in the parameters could also be as a result of high requirement of calcium by the plant which aided in plant root tip and elongation.

Reduction in the values for all the parameters when NPK fertilizer was applied could be that all the nutrients' requirements for the plant were not present in the inorganic fertilizer. In the same vein, application of CPHA 4 + CPHP 4 reduced the values for all the parameters. This may be attributed to over application of the amendments resulting in soil acidity which makes some of the nutrients to be unavailable to the plants.

5. Conclusion

The implication of this study is that high level of cocoa pod husk powder in combination with high level of cocoa pod husk ash is detrimental to radish cultivation. In the same vein, the nutrition of radish was incomplete when NPK fertilizer was applied. It can therefore be recommended that the use of combined application of cocoa pod ash and cocoa pod powder at CPHA 4 + CPHP 2 was sufficient for the cultivation of radish (Raphanus sativus) in the study area. This is because combined application of CPHA 4 + CPHP 2 competes favorably with application of NPK fertilizer.

Conflict of interest

The authors declared no conflict of interest.

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