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Influence of Cocoa Pod Husk Powder on the Performance of Black Benniseed under Basal Application Phosphorus Fertilizer in the Southern Guinea Savannah of Nigeria

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ABSTRACT

The experiment was conducted at the Teaching and Research Farms of Landmark University Omu-Aran, Kwara state in 2014 and 2015 planting seasons to evaluate the influence of cocoa pod husk powder on growth and seed yield of black benniseed (*Sesamum radiatum)* under basal application of phosphorus fertilizer in the southern guinea savanna of Nigeria. Treatment consisted of four rates of cocoa pod husk powder (0, 5, 10 and 15 tonnes ha^{-1}) in combination with basal application of phosphorus fertilizer (90 kg P_2O_5 ha^{-1}) and 200 kg ha^{-1} of NPK 15:15:15 fertilizer which represents the standard was applied. Phosphorus fertilizer (18% single superphosphate) was applied at planting at the rate of 90 kg P_2O_5 ha^{-1} to all the plots except NPK plots while cocoa pod husk powder was applied at the rate of 0, 5, 10 and 15 tonnes ha^{-1} based on treatments two weeks before planting. At two weeks after planting NPK 15:15:15 was applied to the assigned plots at the rate of 200 kg ha^{-1}. Treatments were arranged in Randomised Complete Block Design (RCBD), replicated four times. Parameters measured includes: - plant height, number of branches, number of leaves, biological yield, fresh vegetable yield, seed yield and harvest index. Data collected were subjected to analysis of variance using SAS procedure while LSD was used to separate the means at p<0.05 level of probability. Results showed that cocoa pod husk powder significantly increased all the evaluated parameters as the rates increases from control to 10 t CPHA ha^{-1} and it was comparable with 200 kg NPK 15:15:15 fertilizer (standard), further increase in the application of CPHA to 15 t ha^{-1} reduced the values for all the parameters. Application of 200 kg NPK 15:15:15fertilizer significantly increased all the parameters measured but the values are statistically similar with those of 10 t CPHA ha^{-1}. Therefore application of 10 t ha^{-1} and 90 kg of phosphorus fertilizer was considered best for black benniseed cultivation in the study area as it performed similar to application of NPK fertilizer and based on the fact that it is readily available and eco-friendly compared to NPK that is costly and may have adverse effect on the environment.

KEYWORDS: Basal phosphorus, Black benniseed, Cocoa pod husk powder, and Yield.

INTRODUCTION

Africa has a large reservoir of bio-diversity of edible vegetable species that plays important role in food security and balanced nutrition on one hand and on the other as an income for farmers in both rural and urban areas [27]. Among these vegetables is black benniseed (*Sesamum radiatum*) which is cultivated on a small scale since its bringing into cultivation is very recent. It is a member of the family pedaliaceae which occurs throughout tropical Africa, and it is often seen in the wild. It is propagated by seed and is one of the several neglected and underutilized leafy vegetables of the tropics despite its nutritional advantages. Young shoots are cut for use in soup; cooked leaves have a slimy texture. Black benniseed *(Sesamum radiatum)* is a perennial herb found in the Tropical areas of Africa [23].Vegetable sesame *(Sesamum radiatum)* is propagated by seeds drilled in or broadcast on a well-prepared seedbed. Seeds are at times first raised in a nursery and the seedlings are transplanted to the well-prepared seed beds [5]. The leaves are harvested 6-8 weeks from seedling emergence or establishment either by uprooting the entire plant or by repeated topping of plants that re-grow to yield harvestable branches. Nutritional analysis showed that most tropical greens are much richer than temperate types in protein, vitamins and minerals [21]. One of the local names of Black benniseed *(Sesamum radiatum)* in South-Western is Ewe atura which means leaves that bring relaxation and health to the body possibly because they relieve constipation and cure other ailments [20]. Black benniseed *(Sesamum radiatum)* is a nutraceutical traditional leafy vegetable. The leaves, seeds and oil serve as food especially in farming community in Nigeria [4].

Black benniseed *(Sesamum radiatum)* seeds have been shown to be estrogenic and /or anti estrogenic [12]. The seeds have been reported to have a crude protein content of 22.9%. It adds to the protein, vitamin and mineral contents of the predominantly starchy diet of the people of tropical Africa [22]; [21]. Its fatty acid composition is oleic acid 40%, Iinoleic acid 40%, palmitic acid 10% and stearic acid 7%. Nutritional composition of black benniseed *(Sesamum radiatum)* leaves per 100g edible portion is; water 85.5g, energy 118kj, protein 3.4g, fat 0.7g, carbohydrate 8.6g, fibre 2.4g, C 77mg, P 203mg and riboflavin 0.3mg. The leaves are also used for treating various stomach ailments. The decoction of the leaves is used for the treatment of catarrh, eye pains as well as bruises and erupted skins. The decoction of combined roots and leaves has been reported to have anti-viral and anti fungal activity [15].

Despite the huge nutritional benefits of black benniseed *(Sesamum radiatum)*, there is dearth of information with regards to its requirements for optimum productivity, especially in this part of the world where it is grown mainly by resource-poor farmers who have little knowledge on its potentials. Very little is known about Black benniseed *(Sesamum radiatum),* even in the scientific community and it falls into the group of so-called neglected and underutilized leafy vegetables of the tropics.

[19], observed that N content of most soil of Nigeria farmlands is low, making it the most limiting plant nutrient. [3] described soil fertility degradation as the second most serious constraint to food security in Africa. [16], [25], and [1] attributed the low marginal soil fertility to nutrient leaching, fast mineralization of organic matter, erosion of the top soil by intensive rainfall, bush burning, over grazing, clearing and continuous farming activity thus, severely reducing the soil productivity and results in low economic returns from farming activity. [17] attributed low productivity of tropical African soil to low nutrient holding capacities, high acidity, low organic matter, poor soil structure and low water-holding capacity. [6] posited that vegetable crop producers in the tropics are facing the problem of maintaining soil fertility as a result of unreliable rainfall, low level of fertilizer input and marginal soil fertility. This was due to the fact that vegetable crops are grown on farms that were intensively cropped, resulting in low yield [1].

Cocoa is one of the most important tropical crops [14]. West Africa contributes about 70% of the world's cocoa production. The crop significantly contributed to the economies of countries in this sub-region, as well as economies of many other countries in Central America and South East Asia. Nigeria is the fourth largest producer of cocoa in the world with an estimated production of 485,000 metric tons in 2006 [14]. Cocoa pod is known to be cheap in southwest Nigeria [13] and about 220,000 metric tones of dry cocoa pod husk were produced in Nigeria. Cocoa pod husk (CPH) manure contains Ca, P, K, and also sizeable amount of useful organic constituents [18].

The use of cocoa pod husk powder has been tested on some crops but there is little or no information on its use as fertilizer on black benniseed.

There have been few reports on the use of cocoa pod husk powder as organic amendments on some vegetables but no report of its use on black benniseed. Integrated application of agro wastes and mineral fertilizers have been found to increase productive capacity of the soil [7]; [11].

This study was therefore carried out to evaluate the influence of farm waste (cocoa pod husk powder) on growth, leaf and seed yield of black benniseed *(Sesamum radiatum)* under basal application of phosphorus fertilizer in view of its enormous benefits and potential role in improving the nutritional quality of man.

MATERIALS AND METHODS

Experiments were conducted in 2014 and 2015 planting seasons at the Teaching and Research Farm of Landmark University Omu-Aran, Kwara state (Latitude 8° 8' 0"N and Longitude 5° 6'0"E) located in the southern Guinea savannah zone of Nigeria. The location has an annual rainfall pattern which extends between the months of April and October with average annual rainfall of between 600mm-1500mm. The peak rainfall is in May-June and September-October while the dry season is between November and March.

Composite soil samples were collected during the cropping seasons to determine the physico-chemical properties of the soil.

The choice of land of the experimental sites were selected because they had been planted to various types of crops such as maize (*Zea mays* L.), guinea corn (*Sorghum bicolor* L. Moench), soybean (*Glycine max* L.), cowpea (*Vigna unguiculata*) and various leafy vegetables consecutively for more than five years without adequately replenishing the soil nutrients.

The experimental field of each of the experiments were ploughed once and harrowed twice to obtain a fine tilt after which it was marked into plots according to treatments. The size of each plot was 9 m^2 (3 x 3 m) while the net and the gross plot size used for the experiments were 144m^2 (9 m x 16 m) and 256 m^2 (16 m x 16 m) respectively. Seeds were sown directly by row drilling on the experimental plots and were thinned out two weeks after sowing to give a plant population of 133, 000 stands ha^{-1}.

Treatment consisted of four rates of cocoa pod husk powder (0, 5, 10 and 15 tonnes ha^{-1}) and NPK 15:15:15 arranged in Randomised Complete Block Design (RCBD), replicated four times.

Phosphorus fertilizer (18% single superphosphate) was applied at planting at the rate of 90 kg P_2O_5 ha^{-1} to all the plots except NPK plots while cocoa pod husk powder was applied at the rate of 0, 5, 10 and 15 tonnes ha^{-1} based on treatments two weeks before planting. At two weeks after planting NPK 15:15:15 was applied to the assigned plots at the rate of 200 kg ha^{-1}.

Pre-emergence application of Pendimethalin (500EC) at the rate of 2.5 kg a.i ha^{-1} was done immediately after seed sowing as a measure to control weeds. This was later supplemented by manual weeding at 6 and10 weeks after sowing. The following parameters were taken during the experiment, plant height, number of branches, number of leaves, leaf fresh weight, biological yield, seed yield and harvest index. Data collected were subjected to analysis of variance using SAS procedure while LSD was used to separate the means at $p<0.05$ level of probability.

RESULTS AND DISCUSSION

Pre-treatment soil physico-chemical analyses of the experimental sites for the periods of the study (Table 1) showed that the soils have the same values of sand, silt and clay. The soils were sandy loam in texture. The soils were high in sand and low in both silt and clay. The soils were acidic and low in organic matter, total N, available P and exchangeable K, Ca and Mg according to the critical levels of 3.0 % organic matter, 0.20 % N, 10.0 mg/kg available P, 0.16-0.20 cmol/kg for K, 2.0 cmol/kg for exchangeable Ca and 0.40 cmol/kg for exchangeable Mg recommended for crop production in ecological zones of Nigeria [2]. The soil will therefore be unable to sustain crop yield without the addition of external input. It was found that cocoa pod ash is high in K, Ca and Mg and low P and moderate in N (Table 2).

Table 1: Soil physical and chemical characteristics of the experimental sites at 0 – 15cmdepth

Soil properties	Values	
	2014	2015
Sand (%)	76	76
Silt (%)	13	13
Clay (%)	11	11
Textural class	Sandy loam	Sandy loam
pH (water)	5.25	5.36
Organic matter (%)	2.24	2.21
Total N (%)	0.16	0.14
Available P (mg/kg)	9.5	9.3
Exchangeable K (cmol/kg)	0.14	0.14
Exchangeable Ca (cmol/kg)	2.0	2.1
Exchangeable Mg (cmol/kg)	0.36	0.32

Table 2: Chemical composition of cocoa pod husk powder

pH (water)	O.C %	O.M %	N %	C:N	P %	Mg %	K %	Ca %
5.85	3.60	75.00	1.80	0.23	0.19	1.68	3.78	1.38

Vegetative parameters:

The influence of application of cocoa pod husk powder on the vegetative growth of black benniseed under basal application of phosphorus fertilizer in 2014 and 2015 planting seasons is as shown on Table 3. Application of NPK fertilizer produces taller plant height, number of branches and more number of leaves which was statistically similar with the application of 10 tonnes of cocoa pod powder. There was a significant effect of different rates of cocoa pod husk powder on growth parameters of sesamum ($p<0.05$) in both years. Varying rates of cocoa pod husk powder significantly increased vegetative parameter up to 10 tonnes ha^{-1}, further increase to 15 tonnes ha^{-1} significantly reduced the vegetative parameters. The control gave significantly lower values for plant height, number of branches and number of leaves.

Table 3: Effects of cocoa pod husk powder (CPHP) on the vegetative growth of black benniseed (*Sesamum radiatum*) under basal application of phosphorus fertilizer in 2014 and 2015 planting seasons.

Treatment	Plant height (cm)		Number of branches		Number of leaves	
	2014	2015	2014	2015	2014	2015
CPHP t ha^{-1}						
0	89.67	88.41	12	11	132	127
5	93.67	96.00	14	14	158	148
10	115.67	116.10	18	19	207	210
15	100.67	105.77	15	16	183	170
NPK	117.21	120.36	19	19	221	219
LSD $_{(0.05)}$	2.27	7.4	1.00	1.7	23.1	10.3

Yield and yield components:

Tables 4 and 5 shows the influence of cocoa pod powder on the yield and yield parameters of black benniseed under basal application of phosphorus fertilizer in 2014 and 2015 planting seasons. There were significant differences in fresh vegetable yield, biological yield, seed yield and harvest index of black benniseed at various application rates of cocoa pod powder in both years. Results revealed that yield and yield components increase with increasing rates of cocoa pod powder and the highest values were obtained with the application of 10 tonnes ha^{-1} which was statistically similar with the values obtained when NPK fertilizer was applied. The least values were obtained with the control (0 tonnes ha^{-1}).

Table 4: Effects of cocoa pod husk powder (CPHA) on yield parameters of black Benniseed (*Sesamum radiatum*) under basal application of phosphorus fertilizer in 2014 and 2015 planting seasons.

Treatment	Fresh vegetable yield (kg ha^{-1})		Biological yield (kg ha^{-1})	
	2014	2015	2014	2015
CPHP t ha^{-1}				
0	6,554.90	5,999.40	7,110.40	6,555.00
5	7,665.90	7,199.28	8,332.50	7,554.80
10	10,332.30	10,476.73	10,665.60	10,998.90
15	8,999.10	8,443.60	9,554.60	8,888.00
NPK	10,630.00	11, 302.55	10,960.54	11,275.10
LSD $_{(0.05)}$	433.29	1,288.76	377.74	333.30

Table 5: Effects of cocoa pod husk powder (CPHA) on seed yield and harvest index of black benniseed (*Sesamum radiatum*) under basal application of phosphorus fertilizer in 2014 and 2015 planting seasons.

Treatment	Seed yield (kg ha^{-1})		Harvest index	
	2014	2015	2014	2015
CPHP t ha^{-1}				
0	199.98	133.32	3.21	3.00
5	266.64	222.20	4.03	4.01
10	398.85	451.29	5.43	5.60
15	322.19	311.08	4.72	4.80
NPK	429.32	520.28	5.80	6.55
LSD $_{(0.05)}$	44.44	99.99	0.61	1.00

Discussion:

Analysis of cocoa pod powder showed that it contained N, P, K, Ca, and Mg. This is in line with the work of [8]. The height of plant is an important growth character directly linked with the productivity potential of plants. An optimum plant height has been claimed to be positively correlated with productivity of plants [24]. Nitrogen is a major nutritional element required for tissue differentiation and its role in increasing plant growth and development are well documented by various workers [10]. In this study, increase application of cocoa pod husk powder (10 t ha^{-1}) and application inorganic fertilizer (200 kg NPK ha^{-1}) resulted in significant increase in plant height. This could be due to availability of nitrogen with the application of the amendments, culminating in enhanced N uptake and hence faster growth. It could also be as a result of presence of calcium in the cocoa pod powder which function in the root and tip elongation making it to compete favorably with NPK fertilizer. The control (0 t ha^{-1} of cocoa pod husk powder) gave the least plant height which was significantly lower than other rates of cocoa pod husk powder. This could be that the native nitrogen in the soil was low and the basal application of phosphorus was not sufficient for the growth of black benniseed.

Changes in the number of leaves and number of branches affected the overall performance of plants as the leaves serve as photosynthetic organ of the plants [9]. Phosphorus fertilizer facilitates the production of more roots and increased number of branches. Results also revealed that number of leaves and number of branches per plant varied significantly with varying rates of cocoa pod husk powder and application of NPK fertilizer. Cocoa pod husk powder at 10 t ha^{-1} and NPK fertilizer at 200 kg ha^{-1} gave higher and statistically similar values for number of leaves and number of branches per plant while the least values for the parameters were obtained at 0 t ha^{-1} of cocoa pod husk powder. The increase in plant height, number of branches and number of leaves with the application of cocoa pod husk powder at 10 t ha^{-1} and NPK fertilizer at 200 kg ha^{-1} as observed in this study could be that both amendments supplied the plant with enough quantity of nutrient phosphorus in addition to the basal application of phosphorus fertilizer which facilitated increased rate of new cell formation.

Fresh vegetable and biological yield increased significantly when cocoa pod husk powder at 10 t ha^{-1} and NPK fertilizer at 200 kg ha^{-1} were applied. This could be as a result of increase plant height, more number of leaves and branches that was recorded.

Seed yield was also found to increase significantly with the application of 10 t ha^{-1} cocoa pod powder and 200 kg NPK ha^{-1}. This may be due to some of the functions of phosphorus fertilizer in stimulating seed production and its translocation into the fruiting areas of the plants. Similar result was documented by [26] who observed that some specific growth factors that have been associated with phosphorus are: stimulated root development, increased stalk and stem strength, improved flower formation and seed production, more uniform and earlier crop maturity, improvements in crop quality, and increased resistance to plant diseases.

Magnesium is known to be part of chlorophyll molecule that is essential in photosynthesis and large quantities of it are found in the seed. High values for all the parameter measured as a result of application of cocoa pod husk powder could be as a result of presence of magnesium in the amendment which assisted in the process of photosynthesis hence taller plants, more number of leaves and branches, increased fresh vegetable and biological yield and increased seed yield.

Generally, the control gave the least values for all the parameter tested. This signifies that basal application of phosphorus fertilizer alone (90 kg P_2O_5 ha^{-1}) will not be sufficient for the production of black benniseed. In the same vein, application of 15 t ha^{-1} of cocoa pod husk powder resulted in value reduction for all the parameters in the study area. This could be as a result of toxicity.

The reduction in all the parameters measured when 5 t ha^{-1} cocoa pod husk powder was applied could be that the soil is deficient in macro and micro nutrients and application of 5 t ha^{-1} cocoa pod husk powder could not sustain the production of black benniseed.

This study showed that cocoa pod husk powder which is apparently a waste product of cocoa and a farm waste could be used to increase availability of N, P, K, Ca, and Mg in soil and their uptake by black bennseed thereby leading to enhanced growth and yield performance of the plant.

Conclusion:

Application of 200 kg NPK 15:15:15 fertilizer significantly increased all the parameters measured but the values were statistically similar with those of 10 t CPHA ha^{-1}. The results of this study revealed that vegetative parameters, yield component and seed yield were all significantly increased with application of 10 t ha^{-1} of cocoa pod husk powder and it compared favorably with the application of 200 kg NPK ha^{-1}. Thus, application of 10 t ha-1 of cocoa pod husk powder was observed to be the best for black benniseed cultivation under basal (90 kg P_2O_5 ha^{-1}) application of phosphorus fertilizer in the study area.

Contribution to knowledge:

Cocoa pod husk ash powder could serve as organic fertilizer as it contains minerals like N, P, K, Ca and Mg in varying proportions while the applied in-organic fertilizer contains only NPK. Therefore attention can be shifted from the use of in-organic fertilizer which has detrimental effect on both health and the environment to the use of farm waste like cocoa pod husk powder

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