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Influence of Empty Oil Palm Bunch Ash on Vegetative Growth and Control of Leaf Blight Disease of Cocoyam [*Colocasia esculenta* (L.) Schott.] Caused by *Phytophthora colocasiae*

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Field experiments were done to determine the effect of oil palm bunch ash on vegetative growth and control of leaf blight disease of cocoyam [*Colocasia esculenta* (L.) Schott.] caused by *Phytophthora colocasiae* in a degraded ultisol of humid forest/derived Savanna zone of Southeastern, Nigeria. The experiment consisted of four rates of empty oil palm bunch ash (EOPBA) namely 0 t ha^{-1}, 1 t ha^{-1}, 2 t ha^{-1} and 3 t ha^{-1} laid out in a randomized complete block design (RCBD) and replicated three times. Soil samples were collected from the topsoil at a depth of 0 to 20 cm before application of EOPBA. Samples of EOPBA were analyzed to determine the chemical constituent of the ash applied to the soil. The result revealed that the application of EOPBA gave a non-significant ($p > 0.05$) effect on percentage emergency of cocoyam at 30 days after planting, the number of leaves at 30, 60 and 120 days after planting except at 90 days after planting which had a significant effect, leave area index at 30, 90 and 120 DAP was non-significant ($p > 0.05$) except at 60 DAP were a significant effect was observed and cocoyam leaf blight

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incidence and severity were non-significant ($p > 0.05$) at 90 and 120 days after planting respectively. The use of EOPBA as a soil amendment and for the control of cocoyam leaf blight diseases caused by *Phytophthora colocasiae* revealed that it has the potentials of promoting vegetative growth of cocoyam [*Colocasia esculenta* (L.) Schott.] grown in a degraded ultisol. This study also revealed that EOPBA does not have any significant effect ($p > 0.05$) in the control of cocoyam leaf blight incidence and severity. Application of 2 t ha^{-1} was found to be an optimal dose in the enhancement of cocoyam vegetative growth (leaf area index, number of leaves, stem girth and plant height respectively).

Keywords: Cocoyam; empty oil palm bunch; Phytophthora colocasiae; leaf blight disease.

1. INTRODUCTION

Despite, the socio-cultural and economic importance of Cocoyam [*Colocasia esculenta* (L.) Schott.] in achieving food security, nutritional enhancement, income generation, youth and women empowerment for national development, its production is low due to poor agronomic practices, poor soil fertility conditions, pests and diseases especially leaf blight caused by *Phytophthora colocasiae* [1,2,3]. Leaf blight is a highly infectious fungal plant disease that is characterized by the formation of large brown lesions on the leaves of infected taro plants.[1] Lesions are the result of oomycetes leaching nutrients out of the leaves via haustoria to create white powdery rings of sporangia [4] This pathogen grows best in high humidity and high rainfall environment offering the pathogen means of dispersal via rain splash as well as a warm humid environment that favors hyphal growth across the infected plant [5]. [6] found that blight epidemics occur when night and day temperatures ranged between 20 - 22°C and 25 - 28°C, respectively, with a relative humidity of 65% during the day and 100% at night and accompanied by overcast rainy weather. Under such conditions, *Colocasia* leaves could be damaged by blight disease in 5-7 days. Disease outbreak could occur when the temperature and relative humidity conditions are optimum for 6 - 8 hours for three consecutive days with light rain or dew in the morning. Minimum temperature and relative humidity had a significant positive correlation with disease severity. The occasional sunlight with intermittent rain is more favourable for disease severity compared to prolonged cloudy weather with rainfall.

Taro Leaf Blight causes a reduction in yield of taro. Reductions in corn yield of 25 - 50% have been reported in various locations across the Pacific. Losses of 25 - 35% of corm yield have been recorded in the Philippines while in some extreme cases, losses of 95% have been recorded in various cultivars across Hawaii. [7] found that the infected leaves collapse within 20 days of unfurling compared to 40 days in healthy leaves. They have also found 30 - 40% loss in tuber yield when the attack was recorded on 40 – 70 days old crop. Leaf blight adversely affects dry matter production through the destruction of leaf area as expressed in terms of disease severity. A decrease in crop growth, in turn, reduces tuber yield. Out of 128 representative fields of *Colocasia* tested during the 1988 monsoon season, 94% of fields were infected by leaf blight with 78.38% of fields having more than 80% incidence. During 1989, out of 164 *Colocasia* fields, 92% showed blight infection with 81.75% of fields showing more than 80% incidence.

Several methods for the management of leaf blight of taro have been recommended such as the use of tolerant cultivars, bio-control method, use of fungicides, shifting of planting time, quarantine measures, cultural practices tailoring down to fertilizer such as organic and inorganic fertilizers. Early planting of cocoyam (April - June) has been reported in order to control leaf blight and improve growth and yield in the field [1]. [2,5] Chemical control of *P. colocasiae* has offered some relief in the form of preventative sprays containing copper, manganese, and zinc.

Oil palm (*Elaeis guineensis*), a dominant and important food and cash crop of south-south Nigeria generates a huge waste in form of palm bunch refuse during oil processing. Similarly, about 75% of farmers in the zone also keep some livestock, predominantly, small ruminants and birds such as goats, sheep and poultry [8] which generate organic wastes that could be a problem of the environment if not controlled. The disposal of these forms of agricultural waste is becoming problematic for communities and villages in which such productions occur. On the other hand, organic wastes of this nature have recently been used directly or in processed forms, as cheap and abundant biological resources for the bioremediation of degraded soils for crop production [9,10]. Palm bunch ash (PBA) and poultry manure (PM) have been used extensively to improve soil fertility for crop production [11,12]. [13,14] observed that organic manure improves the chemical and physical properties of the soil for enhanced crop production. These manure resources apart from a large number of nutrient elements contained have high liming ability that when incorporated into the soil neutralize soil acidity, enhances aggregation of soil particles and rate of organic matter decomposition [15], thereby increasing crop yields. Since these wastes contain a substantial amount of plant nutrients, they become very useful organic fertilizers for soil fertility improvement to enhance crop production. The use of oil palm bunch ash at different rates for improvement of soil fertility and structure, higher yield, and good crop growth and disease management has not been given full attention in Nigeria in contrast to chemical fertilizer, which apart from high yield output, it makes crops easily prone to pests and disease infection, poor storage quality, destruction of soil structure and induce leaching [16]. Palm bunch ash has been used as a source of organic fertilizer in many developed Nations. The proper use of palm bunch ash is essential for crop growth and soil resources rejuvenation [17].

Cocoyam belongs to a group of crop called tubers [5]. Root and tubers are the major carbohydrate staples in most countries of West Africa. In Nigeria, it is estimated that 31 million tons of root and tubers such as cassava, yam, sweet potatoes and cocoyam are produced annually [18]. Cocoyam occurs in different varieties, but the major and commonly grown cultivars are *Colocasia esculenta* (Taro) and *Xanthosoma sagittifolium* (Tannia). It is also cultivated for human nutrition, cash crop and as animal feed [19].

The aim of this study is to determine the effect of oil palm bunch ash on vegetative growth and control of leaf blight disease of cocoyam [*Colocasia esculenta* (L.) Schott.] caused by *Phytophthora colocasiae* in a degraded ultisol of humid forest/derived Savanna zone of Southeastern, Nigeria

2. MATERIALS AND METHODS

2.1 Description of the Experimental Site

The study was carried out in the experimental field of the Department of Agricultural Technology, Enugu State Polytechnic, Iwollo. Iwollo is situated on longitude 06°16'North and latitude 07°16'East. It has a mean annual rainfall of 1700 mm - 1800 mm. The soil of the study area is heavy clay loam ultisol.

2.2 Materials

The materials that were used for the experiment were empty oil palm bunch ash (EOPBA) and Cocoyam taro cultivar "Nachi". The cormel of this cultivar was sourced from Nsukka market, Enugu state. Nigeria. Empty oil palm bunch wastes were collected from an oil palm mill station at Iwollo, after removing of oil palm fruits from the oil palm fruit bunch. The collected wastes were packed and taken to an open drying lot at Enugu State Polytechnic, Iwollo. Empty oil palm bunch wastes were spread and dried under the sun in the month of March - April 2015. The dried wastes were collected, heaped and burnt into ashes. The ashes were analyzed and used for soil amendment in the study.

2.3 Experimental Design and Field Operations

The experiment consisted of four rates of EOPBA namely 0 t ha^{-1}, 1 t ha^{-1}, 2 t ha^{-1} and 3 t ha^{-1} laid out in a randomized complete block design (RCBD) and replicated three times. The trial field was manually cleared, ploughed, harrowed and heaped made with a hoe. A total land area measuring 8 m x 11 m (88 m^2) was used. The land area was divided into three blocks (column: north-south direction), and each was sub-divided into four plots (rows: east-west direction) making a total of twelve plots. Plots measuring 2 m x 2 m (4 m^2) were separated by 1 m x 1 m pathway between and within plots. Cocoyam cormels of the average weight of 25 - 35 g per cormels were sowed at a spacing of 0.5 m x 0.5 m intra x inter row. The planting depth was 5 - 8 cm. Weeding was done manually with hoe. Three plants at the centre row were sampled during data collection. EOPBA was applied two weeks before planting to the plots using the trial rates respectively.

2.4 Soil Sample Collection and Analyses

Soil samples were collected from the topsoil at a depth of o to 20 cm before application of EOPBA. Three representative soil samples were randomly collected per plot and bulked together to form a composite soil sample per plot. A total of twelve composite soil samples were collected.

Samples were air dried, ground and passed through a sieve of 2 mm standard mesh size. The soil pH was determined with a pH meter using 1:2.5 soil to water ratio and 1: 2.5 soil to 0.1 N KCl (potassium chloride) suspension according to [20]. Organic carbon was determined using the Walkley and Black wet digestion method [21]. Soil organic matter content was obtained by multiplying the value of organic carbon by 1.724 (Van Bemmeler factor). Total nitrogen was determined by the micro-kjeldahl procedure [20]. Available phosphorus was extracted with Bray II extractant as described by [22] and determined colorimeterically using ascorbic acid method [23]. Exchangeable potassium was extracted using 1 N ammonium acetate (NH_4OAC) solution and determined by the flame emission spectroscopy as outlined by [24]. Aluminum and Hydrogen content (exchangeable acidity) were determined by titrimetric method after extraction with 1.0 N KCl [25]. The cation exchange capacity was determined by NH_4OAC displacement method [26]. Calcium and magnesium were determined by the complexio-meteric titration method as described by [27]. Particle size distribution analysis was done by the hydrometer method [28] and the corresponding textural class determined from the United States Department of Agriculture Soil Textural Triangle. Base saturation was determined by the method outlined by [20].

2.5 Analyses of Empty Oil Palm Bunch Ash (EOPBA)

Samples of EOPBA were analyzed to determine the chemical constituent of the ash applied to the soil. pH was determined with a pH meter using 1:2.5 ash to water ratio according to [20]. Organic carbon was determined using the Walkley and Black wet digestion method [21]. Soil organic matter content was obtained by multiplying the value of organic carbon by 1.724 (Van Bemmeler factor). Total nitrogen was determined by the micro-kjeldahl procedure [20]. Available phosphorus was extracted with Bray II extractant as described by [22] and determined colorimeterically using ascorbic acid method [23]. Exchangeable potassium was extracted using 1 N ammonium acetate (NH_4OAC) solution and determined by the flame emission spectroscopy as outlined by [24]. Calcium, sodium and magnesium were determined by the complexiometeric titration method as described by [27].

2.6 Data Collection

Emergency percentage was determined by counting the number of emerged cormels per plot over the total number of cormels planted multiplied by 100 at 30 days after planting, plant height was obtained by measuring the plant height of the individual sampled stand from the ground base to the topmost growing tip with a meter rule and recorded in centimeter, number of leaves per stand was determined by visual counting of the number of leaves in individual tagged stands per plot at 30, 60, 90 and 120 days after planting (DAP), Leaf area index per plant was determined at 30, 60, 90 and 120 DAP as total leaf area per plant divided by the feeding area available for the plant (inter row spacing multiplied by intra row spacing of each plant), stem girth was determined at 30, 60, 90 and 120 DAP at 5 cm above the soil level using vernier caliper. Disease incidence was determined as the number of infected plants over total number of plants multiplied by 100 and Disease severity was determined as the number of leaves infected over the total number of leaves multiplied by 100 and later estimated (Table 1) on 0 - 5 point (0 - 4) disease severity scale as postulated by [29].

2.7 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) as outlined [30]. Significant means were separated using Fishers least significant difference (F-LSD) at 5% probability level. Statistical analysis was executed using GENSTAT Release 7.2DE Discovery Edition 3, [31]statistical software.

Table 1. Estimation scale of disease severity

Scale	Severity range (%)	Interpretation
0	< 1	No infection
1	1 - 25	Low infection
2	26 -50	Moderate infection
3	51 - 75	High infection
4	> 76	Very high infection

3. RESULTS AND DISCUSSION

The data shown in Table 2 indicates that the soil of the study area before the application of EOPBA was acidic (pH 5.80 and 5.30 in water and potassium chloride respectively). The soil textural class was loamy sand which contained 70.70% total sand%, 12.08% clay and 17.22% silt. The organic carbon content was found to be

2.00%, organic matter content was 3.45% and total nitrogen contents were 0.15%. The exchangeable base [sodium 2.84 cmol kg^{-1}, potassium 0.36 c mol kg^{-1}, calcium 2.78 c mol kg^{-1} and magnesium 2.62 c mol kg^{-1}. Available phosphorus (Bray 11) was found to be 7.9 c mol kg^{-1}. This preliminary investigation showed that the organic carbon, organic matter, nitrogen and available phosphorus were very low [32] benchmark for tropical soils. The results depict a soil that is poor, degraded and of low fertility status. This is typical with the general conditions of soils of the eastern Nigeria which are highly acidic and poor in fertility nutrients status [33], and requires soil amendment due to high rainfall, leaching, soil and air temperature and continuous cropping with inorganic fertilizers. [34,35] reported low soil pH, organic matter content and exchangeable bases in Southeastern Nigeria.

Furthermore, the chemical composition of the EOPBA (Table 3) reveals that the pH (KCl) was 8.81 and contains organic matter content (1.81%), total nitrogen contents (0.19%), sodium (0.06 c mol kg^{-1}), potassium (33.50 c mol kg^{-1}), calcium (9.32 c mol kg^{-1}), magnesium (4.22 c mol kg^{-1}) and phosphorus (12.00 c mol kg^{-1}). It has been seen that ash material contains solely exchangeable cations, which are known to increase soil pH [33] which is a very remarkable characteristics of organic manures in general. This confirms their high nutrient contents and also supports the findings that organic materials have the ability to increase the soil pH [36].

The result presented in Table 4 shows that there was non-significant ($p > 0.05$) on percentage emergency of cocoyam at 30 days after planting. There were equal values of percentage emergency (100%), respectively in all the treatments. This might be due to the slow and low release of nutrients by EOPBA. This result agrees with the report made by [37] who reported that the recommended rate of 15 - 20 t ha^{-1} compost for leafy and fruit vegetable has a non-significant effect on days to sprouting and emergency under good climatic and soil conditions.

The result shown in Table 5 reveals a non-significant ($p > 0.05$) effect of EOPBA on the number of leaves at 30, 60 and 120 days after planting except at 90 days after planting which had a significant effect. At 30 DAP, the application of 1 t ha^{-1} produced the highest number of leaves per plant (3.89) than the other rates. The addition of 3 t ha^{-1} consistently recorded the highest number of leaves per plant at 60 DAP (5.22), 90 DAP (12.89) AND 120 DAP (20.20) when compared with the other rates. Soils which received no EOPBA rate (control) produced the lowest number of leaves per plant across the sampling periods. These low values may be due to no application of palm bunch ash which is essential for plant tissue growth and development. Application of EOPDA improve soil pH [38], thereby improving the release and availability of plant nutrients to the crops [39]. The increasing rate of palm bunch ash promotes vegetative traits like plant height, number of leaves, branches etc. EOPBA contains essential nutrient element associated with high photosynthesis activities and thereby promoting roots and vegetative growth [40]. It also enhances soil aeration, soil structure water retention and improves soil pH. [41] had confirmed that ash obtained from plant source was effective as limiting material and source of nutrient for different crops. The increase in growth cocoyam in this study also could be attributed to improved microbial activities in the plots treated with EOPBA, thus supplying the limiting and lacking the nutrient, organic matter and the attendant increase in available N, P, K, Ca, Mg, and another beneficial nutrient.

Also, there was a non-significant ($p > 0.05$) effect of EOPBA rates on the leave area index at 30, 90 and 120 DAP except at 60 DAP were a significant effect was observed (Table 5). Soils which were amended with 1 t ha^{-1} at 30 DAP produced the highest (1.27) leaves area index, while the lest was observed in cocoyam plots fertilized with 2 t ha^{-1} (0.76). However at 60 days after planting, the application of 2 t ha^{-1} recorded the highest (2.94) leave area index, while the least (1.86) was obtained in plots amended with 3 t ha^{-1}. At 90 and 120 DAP, the application of 3 t ha^{-1} and 2 t ha^{-1} produced the highest (10.10 and 17.5 respectively) than the other rates. The lest leaves area index (5.55 and 11.8) were recorded on soils treated with 1 t ha^{-1} and 0 t ha^{-1} respectively. However, increasing rate of EOPBA leads to improvement in the leave area index of cocoyam at later growth stage due to slow release and long lasting effect of nutrient released by EOPBA application. This result agrees with [42] who stated that the application of palm bunch ash increased leave area index than plots which received no application of EOPBA.

Table 2. Initial soil characteristics before application of empty oil palm bunch ash (EOPBA)

Parameters	Values
Particle size distribution (%)	
Total sand	70.70
Clay	12.08
Silt	17.22
Textural class	Loamy sand
pH (water)	5.80
pH (KCl)	5.30
Organic carbon (%)	2.00
Organic matter	3.45
Total nitrogen (%)	0.15
Available phosphorus (c mol kg^{-1})	7.9
Exchangeable bases (c mol kg^{-1})	
Calcium	2.78
Magnesium	2.62
Potassium	0.36
Sodium	2.84

The results presented in Table 6 shows that there was a non-significant ($p > 0.05$) effect of EOPBA on plant height and stem girth at 30, 60, 90 and 20 DAP. At 30 DAP cocoyam grown on soils treated with 1 t $ha^{-1,}$ EOPBA were taller (27.56 cm) than the other cocoyam grown on plots with were fertilized with the other rates of EOPBA. The lowest cocoyam height (23.49 cm) was observed in plots amended with 3 t ha^{-1} at 30 days after planting. Moreover, at 60, 90 and 120 days after planting, the highest cocoyam height (67.4 cm, 103.3 cm and 99. 0 cm) were recorded by 2 t ha^{-1} respectively, while the lest (59.5 cm, 82.8 cm and 74.5 cm) was observed in plots which received no application of EOPBA rates at 60, 90 and 120 DAP respectively.

More so, at 30 DAP, the addition of 1 t ha^{-1} to the soil gave the highest the stem girth (9.04 cm), and the least(7.99 cm) was recorded on plots fertilized with 3 t ha^{-1}. At 60, 90 and 120 days after planting, soils amended with 1 t ha^{-1}, 2 t ha^{-1} and 3 t ha^{-1} EOPBA had the highest stem girth (20.94 cm), (52.80 cm) and (58.10 cm) thus, showing an increase in stem girth with an increase in the level of EOPBA. The least stem girth (20.23 cm), (38.8 cm) and (52.0cm) were consistently maintained in plots which received 0 t ha^{-1} at 60, 90 and 120 DAP respectively (Table 6).

Table 3. Chemical composition of empty oil palm bunch ash (EOPBA)

Parameters	Values
pH (KCl)	8.81
Organic matter (%)	1.81
Nitrogen (%)	0.19
Phosphorus (c mol kg^{-1})	12.00
Calcium (c mol kg^{-1})	9.32
Magnesium (c mol kg^{-1})	4.22
Potassium (c mol kg^{-1})	33.50
Sodium (c mol kg^{-1})	0.06

Table 4. Effect of empty oil palm bunch ash on percentage emergency at 30 days after planting

Rates	Values
0 t ha^{-1}	100
1 t ha^{-1}	100
2 t ha^{-1}	100
3 t ha^{-1}	100
$LSD_{(0.05)}$	NS

NS- non-significant at 0.05 probability level

The data in Table 7 indicates that there was a non-significant ($p > 0.05$) effects of EOPBA rate on cocoyam leaf blight incidence and severity at 90 and 120 days after planting respectively. Cocoyam sowed on plots in which all the EOPBA rates were added expressed 100% leaf blight incidence at 90 and 120 DAP respectively. EOPBA is not a good soil amendment in the control of cocoyam leaf blight incidence. Furthermore (Table 7), at 90 days after planting, cocoyam leaf blight were less servere (3.33) on

Table 5. Effect of empty oil palm bunch ash on number of leaves and leaf area index per plant at 30, 60, 90 and 120 days after planting

Rates	Number of leaves per stand				Leaf area index per plant			
	30	60	90	120	30	60	90	120
	Days after planting							
0 t ha^{-1}	3.44	4.33	6.89	14.69	1.20	2.40	7.03	11.80
1 t ha^{-1}	3.89	4.35	7.89	18.89	1.27	2.40	5.55	13.80
2 t ha^{-1}	3.78	4.56	10.22	18.89	0.76	2.94	9.12	17.50
3 t ha^{-1}	3.67	5.22	12.89	20.20	0.80	1.86	10.10	14.80
$LSD_{(0.05)}$	NS	NS	0.01	NS	NS	0.63	NS	NS

$LSD_{(0.05)}$ – Least significant difference at 0.05 probability level, NS - non- significant at 0.05 probability level

Table 6. Effect of empty oil palm bunch ash on plant height (cm) and stem girth per plant (cm) at 30, 60, 90 and 120 days after planting

Rates	Plant height				Stem girth			
	30	60	90	120	30	60	90	120
	Days after planting							
0 t ha^{-1}	26.52	59.50	82.80	74.50	8.89	20.23	38.80	52.00
1 t ha^{-1}	27.56	66.10	92.60	85.50	9.04	20.94	44.10	54.20
2 t ha^{-1}	26.56	67.40	103.30	99.00	8.92	20.37	42.80	54.60
3 t ha^{-1}	23.49	61.00	87.00	77.20	7.99	20.30	42.90	58.10
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS

NS - non- significant at 0.05 probability level

Table 7. Effect of empty oil palm bunch ash on taro leaf blight incidence (%) and severity at 90 and 120 days after planting

Rates	Disease incidence		Disease severity	
	90	120	90	120
	Days after planting			
0 t ha^{-1}	100	100	3.33	4.33
1 t ha^{-1}	100	100	3.33	4.33
2 t ha^{-1}	100	100	3.67	4.00
3 t ha^{-1}	100	100	3.33	4.00
$LSD_{(0.05)}$	NS	NS	NS	NS

NS - non- significant at 0.05 probability level

plots treated with 0 t ha^{-1}, 1 t ha^{-1} and 3 t ha^{-1}, respectively than plots which received 2 t ha^{-1} (3.67). At 120 days after planting, cocoyam leaf blight severity was suppressed in plots with received 2 t ha^{-1} and 3 t ha^{-1} EOPBA respectively. Highest cocoyam leaf blight severity was observed in plots amended with 0 t ha^{-1}, 1 t ha^{-1} EOPBA respectively. This outcome suggests that amending the soil with EOPBA does not have any significant effect in the control of cocoyam leaf blight incidence and severity in a degraded acid ultisol in Iwollo Enugu South east Nigeria. These findings disagree with [43] and other earlier reporters who reported the use of 15 – 20 t ha^{-1} compost as a soil amendment is useful in the management of leafy and fruit vegetable diseases in the Tropics.

4. CONCLUSION

Empty oil Palm bunch ash (EOPBA) is generally considered as a waste product during oil processing. However, the use of this by-product as a soil amendment and for the control of cocoyam leaf blight diseases caused by *Phytophthora colocasiae* revealed that it has the potentials of promoting vegetative growth of cocoyam [*Colocasia esculenta* (L.) Schott.] grown in a degraded ultisol. This study also revealed that EOPBA does not have any significant effect (p > 0.05) in the control of cocoyam leaf blight incidence and severity. Application of 2 t ha^{-1} was found to be an optimal dose in the enhancement of cocoyam vegetative growth (leaf area index, number of leaves, stem girth and plant height respectively). The use of EOPBA could be a cheap alternative source of organic fertilizer for the cultivation of cocoyam in Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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