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Potential of Palm Bunch Ash Application on the Growth and Yield of Okra (*Abelmoschus esculentus* (L.)

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ABSTRACT

An experiment to investigate the effect of Palm Bunch (PBA) Ash on the growth of okra was conducted at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri, during the cropping season of 2014. The experiment was laid out in a Randomized Complete Block Design with three replications 100g, 200g and 300g of PBA concentrations were used for the experiment while the no PBA (0g) represented the control. The various rates of PBA were incorporated into the soil two weeks prior to sowing, as one dose application. Data were collected on various parameters and recorded for analysis. Results showed that PBA application improved soil status and increased pH. In terms of germination, the PBA treated plots (100g PBA) gave the highest (74.79%) emergence compared to the control. In terms of plant growth and development, PBA treated plots showed great potentials with the highest plant height (33.250) stem girth (4.85cm), number of leaves (21.25), leaf area (229.89cm^2) and also in terms of plant aspects PBA plots recorded significantly different ($P<0.05$) values with the highest (0.579) relative growth rate. The highest dry weight of root and shoots (11.97g and 31.73g respectively were obtained from PBA plots, which was significant. It was concluded that PBA application at 100g rate was optimal for improving vegetative growth of okra and soil nutrient status, and that 300g rate was optimal for improving fruit yield of okra. It was recommended that small holder farmers should adopt PBA application as a soil amendment tool for increased productivity.

Keywords: *Palm Bunch Ash, Growth, Okra, and Yield.*

INTRODUCTION

In Nigeria, some of the constraints to okra production are unavailability of planting materials, poor handling and storability, pest and disease, soil degradation, and other environmental factors (Ibitoye and Attah, 2012). Most soils in the forest and humid tropical regions are acidic due to the high rainfall regime and intensity and associated leaching of nutrients (Awodun *et al.*, 2007). In the forest zone of Nigeria, this problem is being worsened by increasing soil fertility decline caused by continuous cropping as a result of population pressure (Ahn, 1993) and competition between food and tree crops for available land.

One option of improving soil fertility among small holder farmers without resorting to the use of mineral fertilizers is to use agricultural and agro-industrial residues as soil organic amendments (Adjei-Nsiah, 2012). This is because, besides the nutrients release to the crops, agro-industrial and agricultural residues also have positive residual effects on the soil chemical and physical properties.

In the south-eastern forest zone of Nigeria where there is intensive cultivation of oil palm, empty fruit bunch (EFB) of oil palm is one of the major waste products resulting from the processing of oil palm fresh fruit bunches (FFB). One ton of FFB when processed produces about 220kg of EFB which contains about 0.8% nitrogen (N), 0.1% phosphorus (P), 2.5% potassium (K) and 0.2% magnesium (Mg) on dry weight basis (Lim and Zahara, 2008). The EFB generated can be used as a fertilizer supplement, organic mulching material or composted into readily available organic manure for crop production.

In the large scale oil palm processing industrial estates, EFB are either incinerated in the mills as a means of getting rid of these waste as well as to provide energy for the boilers in FFB sterilization or used as organic mulch in the plantations.

However, the small scale mills which process about 80% of the total FFB produced in Nigeria (Odedina *et al., 2003*) burn the EFB as a means of disposing them off, resulting in heaps of ash dotted around small scale mills in the major oil palm producing areas in Nigeria (Adjei-Nsiah, 2012). According to Adjei-Nsiah (2012), there is currently no large-scale use for palm bunch ash in Nigeria, although it could be used for the manufacture of local soap due to its high potassium content. The burnt ashes produced as a result of the burning of the EFB constitute about 6.5% by weight of EFB and contain about 30%-40% K_2O (Lim and Zahara, 2008).

Studies carried out in parts of Africa shows that plant derived ash including those of wood and cocoa pod increased P, K, Mg, Ca status and pH of the soil and yield of *amaranthus*, tomato and pepper (Ojeniyi and Adejobi, 2002). Odedina *et al.* (2003) also reported of reduced acidity Awodun *et al.* (2007). Also found that PBA improved soil chemical properties by supplying organic matter. Palm bunch ash was also found to increase nutrient supply to cassava and increased the yield of cassava significantly (Ezekiel *et al.*, 2003).

Also information on the comparative response of different okr species to oil palm bunch ash is very scanty. The objective of this study was to investigate the potentials of oil palm bunch ash as source of organic manure in okra production.

MATERIALS AND METHODS

Location and Weather Condition

The field trial was conducted in 2014 cropping season at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State, Owerri. Owerri lies between the latitudes 5°10'N and 6°0'N and longitudes 6°35'E and 7°0'E within the south East rain forest agricultural zone of Nigeria. The rainfall distribution of the area is bimodal, with peaks in July and September with a two week break in August. The rainy season begins in March and lasts till October or early November. However, variations occur in rainfall amount from year to year. The area as reported by NIMET (2010) maintains an average annual rainfall of 2,500 mm, 27°C temperature and relative humidity of 85%.

Experimental Materials

An experimental plot of 19m X 17m was used for the study. Soil samples were collected randomly on site at depths ranging from 0-15cm, air dried and packaged for analysis to ascertain the physico-chemical status of the experimental site prior to the experiment. This was also done at the end of the experiment. Empty palm bunch (EPB) was collected from palm oil processing center at Ohaji Egbema. Okra seeds were collected from Imo ADP Owerri. Simple farm tools such as cutlass, hoe, rake, hand trowel were used. An electronic weighing balance (LT 502) and sieve mesh size of 0.3mm were used.

Preparation of Palm Bunch Ash (PBA).

The empty balm bunch collected form Ohaji/Egbema were gathered in an open space and set to burn in full supply of oxygen. It was allowed to burn completely to ash. The ash was collected in a wide metal tray and allowed to cool for 48 hours. The ash collected was sieved after 48 hours to get a fine particle of the PBA. Samples of the PBA were collected for analysis and the chemical composition was determined.

Treatments, Treatment Application and Procedure

Various rates (control 0.00g, 100g, 200g, and 300g) of the PBA will form the treatments levels. The treatment will be incorporated into the soil two weeks prior to sowing as one full dose application.

Experimental Design and Layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot measured 5m X 3m each, giving a total of 15 plots.

Table 1: Chemical Composition of the PBA

Parameters	pH (H_2O)	O.C	N	P	K	Ca	Mg	C/N
Status	8.50	10.4	1.76	1.12	1.34	4.31	3.01	10.5

Planting and Agronomic Practices

The okra seeds were sown two weeks after treatment application at a depth of 2-3cm with four seeds per hole. The inter and intra row spacing was 50cm X 30cm. Thinning was done 7days after emergence to reduce the plants to two seedlings per stand. Weeding was done regularly to keep the field weed free. The plant was monitored for possible emergence.

Data Collection

The experiment was monitored and data was collected on various parameters viz:

Agronomic Traits

Percentage Emergence (%): The percentage of seeds that emerged in each treatment plot was calculated using the formula below as applied by Bormann *et al.* (2002).

$$\frac{N_e}{N_p} \times 100$$

Where N_g = number of emerged seeds
N_p = number of seeds planted.

Plant Height (cm): 5 plants were selected randomly from each plot. The height of each of the five plants were measured with measuring tape and then averaged and recorded. This started at 2 weeks after planting and was repeated at 14 days interval.

Number of Leaves per Plant (cm): 5 plants were selected randomly from each plot. The visual count of leaves on the five plant were taken, averaged and recorded. This started at 2 weeks after planting and was repeated at 14 days interval.

Stem Girth (cm): 5 plants were randomly selected from each plot and their diameter was measured with the help of a measuring tape at 6cm point from the base of the plant and then averaged and recorded. This started at 2 weeks after planting and was repeated at 14 days interval.

Number of Pods per Plant: Number of pods in 5 randomly selected plants from each treatment was counted and then averaged per plot and recorded.

Fruits: Pods was taken and recorded for each plant per treatment.

Fruit Fresh Weight (g): Pods harvested from the five selected plants were bulked and weighed immediately after harvest and recorded.

Fresh Fruit Yield (kgha^{-1}): Yield of fresh pods was computed from the fresh weight of pods.

Root Dry Weight: Root dry weight was gotten using sensitive analytical weighing balance.

Physiological Traits

Net Assimilation Rate (NAR): this is a measure of the productive efficiency of the leaf surface of the crop, normally expressed in $g(crop)m^{-2}(leaf)d^{-1}$ (Liu *et al.*, 2004).

$$NAR = (w_2-w_1)\ (Log_e\ l_2 - Log_e\ l_1)/(t_2 - t_1)\ (l_2 - l_1)$$

Where,

L	=	*plant leaf area*
W_1	=	*crop dry weight at first harvest*
W_2	=	*crop dry weight at second harvest*
t_1	=	*days to first harvest*
t_2	=	*days to second harvest*
Log_e	=	*Natural logarithm*

Leaf Area/Plant: Leaf area of okro was calculated using a general formula for leaf area calculation as proposed by Pederson and Laverne, (2003).

Leaf area index (LAI): Leaf area index (LAI) was computed by using the formula given by Watson (1974).

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

RESULTS

Soil Physical and Chemical Status

The pH value of the experimental site before treatment application was 5.22 with organic carbon (OC) content of 1.43 and total nitrogen (TN) of 0.15%. The available phosphorus was at 2.14ppm while the exchangeable cations (K^+, Ca^{2+}, Mg^{2+}) were at 1.29, 1.80 and 1.10 meq/100gsoil respectively (Table 2). The aluminum ion (Al^{3+}) was at 0.40meg/100gsoil with cation exchange capacity of 3.64meq/100gsoil. The sand, silt and clay levels were 80.81%, 2.01% and 17.18% respectively (Table 2).

After treatment application, the control plot yielded a sand percentage of 82.40% with 4.10% silt and 13.50% clay with pH level of 5.22 while the organic carbon content stood at 1.45% and the Total Nitrogen content was 0.14% with available phosphorus of 2.15ppm and the exchangeable cations levels were 0.87, 3.37 and 2.17 meq/100gsoil for potassium, calcium and magnesium respectively (Table 2). The Al^{3+} in the control was at 0.42 meq/100gsoil with CEC of 3.63meq/100gsoil.

In the 100g PBA treated plots, the sand, silt and clay status were 80.83%, 4.00% and 15.17% respectively with pH value of 5.76 and organic carbon of 1.68% with total nitrogen of 0.18% while the available phosphorus remained at 3.51ppm. The exchangeable potassium, calcium and magnesium recorded the following values of 2.33, 4.37 and 2.80 meq/100gsoil respectively (Table 2). The Al^{3+} level was 0.61 meq/100gsoil and CEC of 3.71meq/100gsoil (Table 2).

Looking from the 200g PBA treated plots, the sand silt and clay level were recorded as 81.64%, 3.19% and 15.17% respectively.

Showing a pH value of 6.87 with CEC of 3.51 while the Al^{3+} level was at 2.10 meq/100gsoil (Table 2). The organic carbon content remained at 1.60% with total Nitrogen of 0.17% and available phosphorus of 2.05ppm the exchangeable potassium, calcium and magnesium recorded the following values of 1.32, 4.31 and 2.37 meq/100gsoil respectively (Table 2).

From the 300g PBA plots, the sand level was 80.82% while the silt and clay level were at 2.00% and 16.18% respectively (Table 2). The pH from this treatment plot remained at 6.93 with CEC of 3.53meq/100gsoil and Al^{3+} of 2.06 meq/100gsoil. Total Nitrogen of 0.16% and organic carbon of 1.55% were recorded, showing available phosphorus level of 3.23ppm while the exchangeable potassium, calcium and magnesium were recorded as 1.79, 4.34 and 2.48meq/100gsoil respectively (Table 2).

Table 2: Soil Physico-chemical properties before and after the Experiment

Soil Properties		Before Status	After Control	100g PBA	200g PBA	300g PBA
Sand (%)		80.81	82.40	80.83	81.64	80.82
Silt (%)	meq/100gsoil	2.01	4.10	4.00	3.19	2.00
Clay (%)		17.18	13.50	15.17	15.17	16.18
pH (H_2O)		5.22	5.22	5.76	6.87	6.93
Organic carbon (%)		1.43	1.45	1.68	1.60	1.55
Total Nitrogen (%)		0.15	0.14	0.18	0.178	0.16
Available Phosphorus (ppm)		2.14	2.15	3.51	2.05	3.23
Available potassium		1.29	0.87	2.33	1.32	1.79
Available calcium		1.80	3.37	4.37	4.31	4.34
Available magnesium		1.10	2.17	2.80	2.37	2.48
Aluminum ion (Al^{3+})		0.40	0.42	0.61	2.01	2.06
Cation exchange capacity		3.64	3.63	3.71	3.51	3.53

Seed Emergence (%)

The highest (74.79%) mean seed emergence was recorded from the 100g palm bunch ash (PBA) treated plots. And the second (70.60%) mean seed emergence was recorded from the 300g PBA treated plots while the lowest (45.63%) mean seed emergence was recorded from the control plot (Table 3).

Table 3: Seed Emergence of Okra as Influenced by PBA

Treatments	Seed Emergence (%)
Control	45.63^{d}
100g PBA	74.79^{a}
200g PBA	53.88^{c}
300g PBA	70.60^{b}
LSD	1.08

Means with the same letter(s) superscript are not significantly different at P<0.05.

Plant Height (cm)

At 2 weeks after plant (WAP), the highest (5.52cm) mean plant height was recorded from the 300g PBA treated plots which however did not show significant difference (P<0.05) from the lowest (4.52cm) mean plant height recorded from the control plots (Table 4) 200g PBA treated plots recorded the highest (11.50cm) mean plant height at 4WAP which did not show significant difference from the lowest (8.82cm) mean plant height recorded from the control plots (Table 4). At 6WAP, the highest (15.70cm) mean plant height recorded from the 200g PBA treated plots showed significant difference (P<0.05) from the lowest (10.30cm) mean plant height recorded from the control plot (Table 4).

At 8WAP, the 100g PBA treated plots recorded the highest (20.17cm) mean plant height which showed significant difference (P<0.05) from the lowest (15.11cm) mean plant height obtained from the control plots. At 10WAP, the 100g PBA treated plots also recorded the highest (47.70cm) mean plant height which was significantly different (P<0.05) from the lowest (18.25cm) mean plant height recorded from the control plots (Table 4).

Table 4: Plant Height of Okra as Influenced by PBA

	Mean Plant Height (cm)				
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	4.52^{a}	8.82^{a}	10.30^{b}	15.11^{b}	18.25^{c}
100g PBA	5.02^{a}	10.70^{a}	13.22^{ab}	20.17^{a}	47.70^{a}
200g PBA	4.97^{a}	11.50^{a}	15.70^{a}	18.31^{ab}	33.25^{b}
300g PBA	5.52^{a}	10.02^{a}	13.37^{ab}	16.22^{b}	27.37^{bc}
LSD	1.73	3.07	3.72	3.49	9.72

Means with the same letter(s) superscript are not significantly different at P<0.05.

Stem Girth (cm)

Okra stems in the 100g PBA treated plots record the highest (0.42cm) mean girth which was not significantly different (P<0.05) from the other treated plots while 200g PBA treated plots recorded the lowest (0.35cm) mean stem girth. At 4WAP, the 200g PBA treated plots recorded the highest (1.37cm) mean stem girth which was significantly different (P<0.05) from the other treated plots while the control plots recorded the lowest (0.87cm) mean stem girth (Table 5). At 6WAP, 100PBA treated plots recorded the highest (1.75cm) mean stem girth which showed significant difference (P<0.05) from the lowest (1.02cm) mean stem girth recorded from the control plots (Table 5). At 8WAP, the highest (2.67cm) mean stem girth was recorded from the 100g PBA treated plots which was statistically at par with the 1.92cm mean stem girth recorded from the 200g PBA treated plots, while the control plots recorded the lowest (1.02cm) mean stem girth which was significantly different (P<0.05) from the highest mean stem girth (Table 5). At 10WAP, the 200g PBA treated plots recorded the highest (4.85cm) mean stem girth which showed significant difference (P<0.05) from the lowest (3.47cm) mean stem girth recorded from the 300g PBA treated Plots (Table 5).

Table 5: Stem Girth of Okra as affected by PBA

	Mean Stem Girth (cm)				
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	0.37^{a}	0.87^{b}	1.02^{b}	1.02^{b}	3.92^{ab}
100g PBA	0.42^{a}	1.15^{ab}	1.75^{a}	2.67^{a}	4.82^{a}
200g PBA	0.35^{a}	1.37^{a}	1.57^{a}	1.92^{ab}	4.85^{a}
300g PBA	0.37^{a}	0.95^{ab}	1.70^{a}	1.62^{b}	3.47^{b}
LSD	0.16	0.42	0.53	1.04	1.10

Means with the same letter(s) superscript are not significantly different at P<0.05.

Number of Leaves Per Plant

The highest (3.50) mean number of leaves at 2WAP, was recorded from the 100g PBA treated plots which did not show significant difference from the 3.25 mean number of leaves recorded from the other plots. At 4WAP, 200g PBA treated, plots recorded the highest (7.00) mean number of leaves which showed significant difference (P<0.05) from the lowest (5.25) mean number of leaves recorded from the control plots. Similarly, at 10WAP, the control plot recorded the lowest (11.00) mean number of leaves which however did not differ significantly (P<0.05) from the highest (21.25) mean number of leaves recorded from the 40g PBA treated plots (Table 6).

Table 6: Number of Leaves of Okra as affected by PBA

Mean Number of Leaves Plant					
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	3.25^{a}	5.75^{b}	4.25^{c}	5.25^{b}	11.00^{a}
100g PBA	3.50^{a}	5.75^{b}	6.75^{a}	11.50^{a}	21.25^{a}
200g PBA	3.25^{a}	7.00^{a}	4.50^{bc}	7.75^{ab}	16.50^{a}
300g PBA	3.25^{a}	5.25^{b}	6.50^{ab}	8.75^{ab}	16.25^{a}
LSD	0.93	1.13	2.13	4.36	10.35

Means with the same letter(s) superscript are not significantly different at P<0.05.

Leaf Area (cm^2)

The highest ($5.00cm^2$) mean leaf area at 2WAP, was recorded from the 100g PBA treated plots which was statistically at par with the mean leaf area recorded from other treated plots however, it showed significant difference (P<0.05) from the lowest ($1.64cm^2$) mean leaf area which was recorded from the control plots (Table 7). At 4WAP, the highest ($54.75cm^2$) mean leaf area was obtained from the 200g PBA treated plots and it was significantly different (P<0.05) from other plots except the plots that received 100g PBA treatment which gave $40.82cm^2$ mean leaf area. However, the control plots recorded the lowest ($20.13cm^2$) significant mean leaf area (Table 7). At 6WAP, the plots that received 100g PBA gave the highest ($80.57cm^2$) mean leaf area which did not show significant difference (P<0.05) from the other treated plot. While the control plots recorded the lowest ($47.35cm^2$) mean leaf area at 6WAP. The plot that were treated with 100g PBA recorded the highest ($149.60cm^2$) mean leaf area at 8WAP. This mean showed significant difference (P<0.05) from the lowest ($63.06cm^2$) mean leaf area recorded from the control plots. At 10WAP, similarly, 100g PBA treated plots recorded the highest ($229.89cm^2$) significantly different (P<0.05) mean leaf area while the control plots recorded the lowest ($159.36cm^2$) mean leaf area (Table 7).

Table 7: Leaf Area of Okra as affected by PBA

Mean Leaf Area (cm^2)					
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	1.64^{b}	20.13^{b}	47.35^{a}	63.06^{b}	159.36^{b}
100g PBA	5.00^{a}	40.82^{ab}	80.57^{a}	149.60^{a}	229.89^{a}
200g PBA	3.31^{ab}	54.75^{a}	76.48^{a}	99.20^{ab}	220.51^{a}
300g PBA	4.07^{a}	29.48^{b}	58.32^{a}	92.20^{ab}	182.18^{ab}
LSD	2.89	22.95	41.59	58.70	57.80

Means with the same letter(s) superscript are not significantly different at P<0.05.

Leaf Area Index

The leaf area index at 2WAP was highest (8.160) from the control plots which was significantly different from the lowest (0.060) recorded from the 300g PBA, a similar tread was recorded at 8WAP, with the control plots recording the highest (0.189) mean leaf area index which was significantly different (P<0.05) from the lowest (0.113) mean leaf area index recorded from the 300g PBA treated plots (Table 8). There was no significant difference (P<0.05) recorded at 4, 6 and 10WAP from the mean leaf area index recorded (Table 8).

Table 8: Leaf Area Index as influenced by PBA

Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	0.160^{a}	0.192^{a}	0.262^{a}	0.189^{a}	0.085^{a}
100g PBA	0.101^{ab}	0.146^{a}	0.484^{a}	0.125^{ab}	0.063^{a}
200g PBA	0.114^{ab}	0.149^{a}	0.291^{a}	0.118^{a}	0.062^{a}
300g PBA	0.060^{b}	0.130^{a}	0.162^{a}	0.113^{b}	0.064^{a}
LSD	0.078	0.086	0.602	0.068	0.030

Means with the same letter(s) superscript are not significantly different at P<0.05.

Net Assimilation Rate (NAR)

At 2WAP, 8WAP and 10WAP, there was no significant recorded in the mean net assimilation rate of okra plants in the various treatment plots. However, at 4WAP, the plots that received the 300g PBA showed the lowest ($0.004gm^2$(leaf day^{-1}) mean net assimilation rate (NAR) which was significantly different (P<0.05) from the highest (0.021…) mean NAR recorded from the control. And at 6WAP, the 300g PBA treated plots recorded the highest (0.005…) mean NAR which differed significantly (P<0.05) from the lowest (0.001…) mean NAR recorded from the control (Table 9).

Table 9: Net Assimilation Rate as Influenced by PBA

Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	0.001^{a}	0.021^{a}	0.001^{b}	0.003^{a}	0.047^{a}
100g PBA	0.013^{a}	0.007^{ab}	0.002^{ab}	0.013^{a}	0.021^{a}
200g PBA	0.048^{a}	0.013^{ab}	0.002^{ab}	0.002^{a}	0.033^{a}
300g PBA	0.018^{a}	0.004^{b}	0.005^{a}	0.003^{a}	0.015^{a}
LSD	0.060	0.014	0.003	0.010	0.053

Means with the same letter(s) superscript are not significantly different at P<0.05.

Relation Growth Rate (RGR)

The highest (0.091) mean RGR at 2WAP was recorded from the 100g PBA treated plots and this showed significant difference (P<0.05) from the lowest (0.030) mean RGR recorded from the control plots. At 4WAP, 200g PBA treated plots recorded the highest (0.745) mean RGR. This was significantly different (P<0.05) from the lowest (0.066) mean RGR obtained from the 300g PBA treated plots (Table 10). At 6WAP, the plots that received 300g PBA treatment recorded the highest (0.232) mean RGR which is not differ significantly (P<0.05) from the lowest (0.034) mean RGR recorded from the control plots (Table 10). At 8WAP, the 100g PBA recorded the highest (0.513) mean RGR which was significantly different (P<0.05) from the lowest (0.227) mean RGR (Table 10). At 10WAP, the means recorded from the various treatments did not show significant difference (P<0.05). However, the 200g PBA traded plots recorded the highest (0.579) while the lowest (0.323) mean RGR was recorded from the 100g PBA treated plot (Table 10).

Table 10: Relative Growth Rate as Influenced by PBA

	Mean Relative Growth Rate				
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	0.030^{c}	0.118^{ab}	0.034^{a}	0.255^{b}	0.327^{a}
100g PBA	0.091^{a}	0.311^{ab}	0.232^{a}	0.513^{a}	0.323^{a}
200g PBA	0.057^{bc}	0.745^{a}	0.191^{a}	0.227^{b}	0.579^{a}
300g PBA	0.065^{ab}	0.066^{b}	0.323^{a}	0.271^{b}	0.525^{a}
LSD	0.028	0.664	0.349	0.211	0.455

Means with the same letter(s) superscript are not significantly different at P<0.05.

Root Dry Weight (g)

At 2WAP, the highest (0.017g) mean root dry weight was recorded from the 100g PBA treated plot was significantly different (P<0.05) from the control plots. At 4WAP the 200g PBA treated plots recorded the highest (0.192g) mean rot dry weight which differed significant (P<0.05) from the other treated plots. While the lowest (0.069g) mean root dry weight was recorded from the control plots.

At 8WAP, the plots that received the 100g PBA and the highest (3.390g) mean root dry weight showing significant difference (P<0.05) from the lowest (0.114g) mean root dry weight. However, at 6WAP and 10WAP, there was no significant difference (P<0.05) observed from the means recorded (Table 11).

Table 11: Root Dry Weight as Influenced by PBA

	Mean Leaf Area (cm^2)				
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	0.008^{b}	0.069^{b}	6.518^{a}	0.114^{b}	1.609^{a}
100g PBA	0.017^{a}	0.107^{ab}	0.091^{a}	3.390^{a}	11.990^{a}
200g PBA	0.012^{ab}	0.192^{a}	0.103^{a}	0.867^{b}	11.217^{a}
300g PBA	0.014^{ab}	0.072^{b}	0.198^{a}	0.312^{b}	3.466^{a}
LSD	0.006	0.098	10.390	2.398	11.503

Means with the same letter(s) superscript are not significantly different at P<0.05.

Shoot Dry Weight (g)

At 2WAP and 6WAP, the mean shoot weights recorded did not show significant difference (P<0.05). However, at 4WAP, the 200g PBA treated plots recorded the highest (1.32g) mean shoot dry weight which showed significant difference (P<0.05) from the lowest (0.30g) which was recorded from the control (Table 12). At 8WAP, 100g PBA treated plot recorded the highest (8.84g) mean shoot dry weight which was significantly different (P<0.05) from the lowest (0.87g) mean shoot dry weight recorded from the control. At 10WAP, 100g PBA treated plots also recorded the highest (31.73g) mean shoot dry weight which differed significantly from the lowest (3.8g) mean shoot dry weight recorded from the control plots (Table 12).

Table 12: Shoot Dry Weight as Influenced by PBA

	Mean Shoot Dry Weigh (g)				
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**	**10WAP**
Control	0.04^{a}	0.30^{b}	0.21^{a}	0.87^{b}	3.81^{b}
100g PBA	0.24^{a}	0.69^{ab}	0.91^{a}	8.84^{a}	31.73^{a}
200g PBA	0.21^{a}	1.32^{a}	0.58^{a}	1.70^{b}	26.24^{a}
300g PBA	0.24^{a}	0.44^{b}	1.23^{a}	1.76^{b}	11.43^{ab}
LSD	0.22	0.68	1.07	5.59	20.50

Means with the same letter(s) superscript are not significantly different at P<0.05.

Yield and Yield Components

The highest (13.65g) mean first weight of okra was recorded from the 300g PBA treated plots which showed significant difference (P<0.05) from the other treated plots. However, the lowest (7.51g) mean fruit weight of okra was recorded from the control plots (Table 13).

The highest (4.75) mean number of orka fruits was recorded from the 200g PBA treated plots which was significant different (P<0.05) from other plots except the 100g PBA treated plots which recorded 4.25g. However, the lowest (1.25g) mean number of fruits was recorded from the control plots (Table 13).

The highest (34348.00kg/ha) mean okra fruit yield was recorded from the 300g PBA treated plots which was statistically at par with the 2806400kg/ha mean yield recorded from the 100g PBA treated plots. The lowest (18782.00kg/ha) mean fruit yield of okra was recorded from the control plots (Table 13).

Table 13: Yield and Yield Components as Influenced by PBA

Treatments	Mean number of fruits	Mean fruit weight (g)	Mean fruit yield (kg/ha)
Control	1.25^{b}	7.51$_{c}$	18782.00^{c}
100g PBA	4.25^{a}	11.22^{b}	28064.00^{ab}
200g PBA	4.75^{a}	8.73^{c}	22471.00^{bc}
300g PBA	2.50^{b}	13.65^{a}	34.348.00^{a}

Means with the same letter(s) superscript are not significantly different at P<0.05.

DISCUSSION

Results from this study showed that application of Palm Bunch Ash (PBA) significantly influenced the emergence of okra plant. When compared with the control. However, it was observed that the potential of the PBA to improve germination reduced with increase in the concentration of the PBA. As 100g PBA concentration recorded the highest emergence percentage. This observation can be attributed to the liming effect of the PBA, which have increased the pH of the soil above the optimal level in the 200g and 300g treated plots. The findings in this current study is in conformity with the reports of Agbede (2013) who reported that application of palm bunch ash increased the pH of soil in a ginger trial.

It was also observed that PBA application improved the okra plant growth in terms of height and stem enlargement compared to the control plots. As observed in the seed emergence, the 100g PBA resulted to taller stands of okra compared to the other concentrations especially at 10WAP. This further confirms that PBA at a concentration as low as 100g can improve soil status which in turns improves plant growth and development. This is in line with the reports of Adjei-Nsiah (2012), who worked on the effects of different rates of PBA application on maize; he stated that greater effects of PBA were recorded from lower concentration. The production of leaves per okra plant was also observed to be greater in PBA treated plots. The leave production also decreased as the concentration of PBA increased. In addition to the above stated reason of the soil pH to be a contributing factor to this observation, it can be also be said that some unexplainable interaction between the soil and plant root can be responsible for the physiological reactions observed. Also according to Awodun *et al.* (2007), in ability of okra plants in the higher (200g and 300g) concentration plots to perform as well as those in the lower (100g) concentration could be attributed to the inhibitory effect of excessive potash on plant nutrient release which was observed in their maize trial.

The above observations were further confirmed in the leaf area recorded by each plant in the control and or the treatment plots. While the plants in the untreated (control) plots recorded lower leaf area, the plants in the treated plots recorded greater leaf area. The leaf area was also observed to decrease with increase in the concentration of PBA application. This observation of decrease in the number of leaves produced and subsequent leaf area recorded reveals that although Nitrogen which was available in a reasonable quantity in the soil may not have been easily absorbed by the plants which resulted in the above observation. This inhibition of Nitrogen and or other nutrients could be evident in the Net Assimilation rates of the plants as recorded in the results. This situation is usually encountered in an aluminum toxic soil (Ojeniyi and Adejobi, 2002). Taking stand from the above premise, the pH level may not be solely responsible for the poor performance in the higher concentration plots but also high level of aluminum (Al^{3+}) could also be inhibitory to the assimilation potential of the plant and or available of nutrient to the plant.

The increase in Net Assimilation Rate (NAR), Relative Growth Rate (RGR) and Leaf Area Index (LAI) observed in PBA plots could be attributed to increase uptake of nutrient by the okra plants leading to enhanced carbohydrate synthesis and assimilation which might have resulted in increase cell elongation, cell division and enlargement

Palm Bunch Ash application also influenced yield and dry matter accumulation okra plant. It was observed that the dry shoot and root weight was greater in the PBA treated plots with greater weights coming from the 100g PBA plots. This showed that nutrient conversion was improved with application of PBA. This resulted to greater number of fruits and greater fruit weights recorded from the treated plots.

However, the higher rate of nutrient conversion and higher leaf area recorded in the treated plots can explain why greater yields were recorded from the treated plots. According to Datta and Naug (1968), photosynthesis is a function of leaf broadness quantity. Therefore the greater number of leaves and leaf area recorded from the treated plots resulted to greater sites for photosynthesis which resulted to greater nutrient conversion in the plants and as such greater dry matter and fruit yield. This agreed with work of Adu-Dapaah et al (1994) who found that shoot and root dry matter of maize increased with increasing application of ash of cocoa pod husk.

CONCLUSION

The study showed that the PBA application was able to improve vegetative growth and increase yield in okra. The results also suggest that PBA can be used as an amendment material to amend pH of highly acidic soils as well as a nutrient supplement in soils with leached nutrients. Application of PBA contributed to the improvement of soil chemical properties of acid soil used in the study by increasing the soil pH. The study suggests that peasant farmers in the oil palm growing area of SouthEastern Agro-Ecological Zone of Nigeria where there is abundant quantity of PBA scattered around oil palm plantations and processing mills should be encouraged to apply the use of PBA a soil conditioner for improved food productivity.

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