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EFFECT OF PALM BUNCH ASH ON SOIL PH AND GROWTH OF CUCUMBER *(CUCUMIS SATIVUS L)*

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ABSTRACT

A field experiment to assess the effect Palm Bunch Ash (PBA), at various levels (0, 2, 4t/ha) on the pH of soil and growth of Cucumis sativus at the Teaching and Research Farm, Rivers State University, Port Harcourt, was conducted. Soil samples (0 – 15cm) before and after application, from the experimental plots were collected, and analyzed with standard methods for pH and nutrients. Also, Palm Bunch Ash (PBA) sub-sampled, and analyzed with standard methods for pH used for the experiment. A total of 9 treatments were used with A_0 (Control), A_2 and A_4, where A represents PBA, and the subscripts 0, 2 and 4 represent the treatment levels. The experiment was a 1x3 factorial in Randomized Complete Block Design (RCBD) with 3 replicates. 18 seeds of cucumber (2 per hole) from NSPRI, Rumueme, Port Harcourt were planted on each treatment plot of 2 x 2m at a plant spacing of 45 × 45cm. Thereafter, it was thinned to one (1) per hole after emergence. This implies that, there were a total number of 10,000 plants per hectare. Growth parameters include shoot height (cm), 3, 6 and 9WAP, and Number of leaves, 3, 6 and 9WAP. Data generated from field were subjected to one-way ANOVA test using the Minitab package and the means were separated using Tukey's Honest Significant Difference at 95% probability. The results revealed that pH increased ($p<0.05$) as the amendment level increased in the treated soil with the highest 6.00 of 4t/ha. Also, there was significant effect ($p<0.05$) on growth, as the PBA level increased in the treated soil with the highest values 13.97cm recorded in 2t/ha, and 48.13cm and 77.90cm recorded in 4t/ha for 3, 6, and 9WAP. Similarly, for number of leaves, the highest values were recorded in 4t/ha, also for 3, 6, and 9WAP. Hence, PBA is recommended as good amendments for acid soil neutralizer and nutrient buffer and supplier to the soil and ultimately to plants.

KEYWORDS

Soil, Palm bunch ash, Soil pH, Nutrient, Growth, Cucumber.

INTRODUCTION

The soil is the critical element of life support systems because it delivers several ecosystem goods and services such as carbon storage, water regulation, soil fertility, and food production, which have effects on human well-being (FAO, 2015; FAO & ITPS, 2015; Jones *et al*, 2013). And so, the ecosystem functions of soil have an intense relationship with soil biogeochemical processes, which are linkages between biological, chemical and geological processes (Dahlgren, 2006). However, humid tropical soils are usually acidic with low (pH, cation exchange capacity, base saturation, organic matter) and consequently low nutrient reserve as evident in the works of Ikpe *et al*., (2003b), Onwugbuta-Enyi & Kpekot (2018). Nutrient uptake by plant is the product of the nutrient availability in the soil, soil pH condition and species of the plant. This assertion is supported by Havlin *et al*., (2014) that, "the net effect of crop growth on soil activity depends on plant species, the proportion of NH_4^+ and NO_3^- uptake, total biomass production or yield quantity of plant material harvest, and quantity of NO_3^- leached.

In the natural environment, the pH of the soil has an enormous influence on soil biogeochemical processes. Soil pH is, therefore, described as the "master soil variable" that, influences myriads of soil biological, chemical, and physical properties and processes that affect plant growth and biomass yield (Minasny *et al*., 2016). Soil pH is compared to the temperature of a patient during medical diagnoses because it readily gives a hint of the soil condition and the expected direction of many soil processes. For instance, soil pH is controlled by the leaching of basic cations such as Ca, Mg, K, and Na far beyond their release from weathered minerals, leaving H^+ and Al^{3+} ions to dominant exchangeable cations; the dissolution of CO_2 in soil water producing carbonic acid, which dissociates and releases H^+ ions; humic residues from the humification of soil organic matter, which produces high density carboxyl and phenolic groups that dissociate to release H^+ ions; nitrification of NH_4^+ to NO_3^- produces H^+ ions; removal of N in plant and animal products; and inputs from acid rain and N uptake by plants (White, 2006).

Plant growth and development largely depend on the combination and concentration of mineral nutrients available in the soil, but often face significant challenges in obtaining an adequate supply of these nutrients to meet the demands of basic cellular processes due to their relative immobility. The nutrients may not be available in certain soils, or may be present in forms that the plants cannot use. Soil properties like water content, pH, and compaction may exacerbate these problems. Plants are known to show different responses to different specific nutrient deficiencies and the responses can vary between species. The most common changes are inhibition of primary root growth (often associated with P deficiency), and increase in lateral root growth and density (often associated with N, P, Fe, and S deficiency).

A deficiency of any one of them may result in decreased plant productivity and/or fertility. It can have a significant impact on agriculture, resulting in reduced crop yield or reduced plant quality. Nutrient deficiency can also lead to reduced overall biodiversity since plants serve as the producers that support most food webs. Changes in the climate and atmosphere can have serious effects on plants, including changes in the availability of certain nutrients. In a world of continual global climate change, it is important to understand the strategies that plants have evolved to allow them to cope with some of these obstacles.

Also, in a related development to ensure sustainable nutrient availability in the soil, man has been recycling generated degradable wastes into the soil as sources of plant nutrients. For instance, in man's effort to produce more food and raise the standard of living, there is an increase in both the agricultural and agro-industrial activities thereby releasing, in most cases, garbage (solid wastes) into the environment. In this study, the considered waste is Empty Palm Bunches incinerated into Palm Bunch Ash (PBA). Empty Palm Bunches are the fruitless bunches which are considered as wastes. It is generated at about 850t/ha on yearly basis in oil palm plantations in Nigeria. (Ojeniyi *et al*., 2010). The untreated solid wastes like (EPB) recklessly dumped in compounds of buildings, roadsides, and riverbanks and along beaches form unsightly heaps and health hazards as many animal pests and vectors of diseases live and breed there. It also disturbs the delicate balance of ecosystem making the non-living environment undesirable or unfit for life; threatening the health and existence of living organisms including man. Therefore, with the high cost of inorganic fertilizers and the seemingly difficulty accessibility, there is the need to shift to organic fertilizers as soil amendment which are cheap and readily available as wastes. Application of organic fertilizers in the form of ash to young maize plants had significantly increased the yield of maize (Odiete *et al*., 2005).

Plant nutrition-based research activities are indispensable in meeting food security needs in the 21st century. One of the high priority objectives of plant-nutrition research will be ensuring a long-term sustainable nutrient management system for crop production, and developing more efficient mineral nutrient uptake by crop plants and improving intra and intercellular use of nutrients without detrimentally affecting the environment. Soil amendments are important in the lives of soils and plants, and when recycled into useable forms, it has similar benefits as inorganic fertilizers. This study brings to light the fact that the use of soil amendments improves soil textures and chemistry while minimizing the impact on the environment as some soil amendments are more affordable, manageable, and economical for farmers in developing countries while others are expensive. In this study a fruit vegetable cucumber (*Cucumis sativus*) was considered as test crops because of their quality nutrient values which go beyond the provision of necessary vitamins, minerals, micronutrients and in a number of cases, protein. Therefore, increased consumption of this vegetables; *Cucumis sativus* will be source of both micronutrients and bio-active compounds to address the problem of malnutrition. Secondly, because of the ephemeral life span which accounts for more productivity within a short period of time, *Cucumis sativus* comes handy and is very common in Rivers State especially in the cities and South-South in general. Therefore, the aim of the study is to investigate the effect of PBA as organic amendments on soil pH and growth of Cucumber (*Cucumis sativus L*).

Materials and Methods

Study Area

The study was conducted in the Rivers State University Teaching and Research Farm, Port Harcourt, located at Latitude 4^0 79^1N, and Longitude 6^0 98^1E, with a fairly uniform mean of daily temperature usually above 27°C but rarely exceeds 32°C, and is always under serious cultivation for students' research experiments but allowed to fallow for about some years.

Experimental Design

An area of $90m^2$ (10 by 9m) was cleared and mapped out as the experimental field with a perimeter path of 2m, and was further divided into 9 treatment plots of 2 by 2m. There were three treatment levels of PBA- 0, 2, 4t/ha, and replicated thrice with the experimental design of Randomized Complete Block Design (RCBD). The soil of the treatment plot was well tilled manually and the application of amendment was done after tillage, and allowed for two weeks to enhance stabilization and mineralization before planting. Thereafter, the seeds of cucumber were planted, weeding done at intervals from 2WAP (Weeks After Planting) manually with hoe and rogueing where necessary.

Soil and PBA Analysis

Earlier, palm bunch ash (PBA), and soil samples were taken from the experimental field at a depth of 0 – 15cm surface with hand auger and analyzed with standard analytical methods to determine physic-chemical properties: pH, Moisture Content, Total Nitrogen, Organic Carbon, Phosphorus, Sulphur, Potassium, Calcium, Sodium, and Magnesium. The pH of the soil and Palm Bunch Ash was determined by the Electrode pH Meter in both distilled water (1:2.5) and 1M KCl (1:1).

Collection and Cultivation of Plant Material

Cucumber (*Cucumis sativus L*) seeds from Nigerian Stored Products Research Institute (NSPRI), Port Harcourt were planted two per hole of 9 holes at the spacing of 45 X 45cm, this implies that 18 seeds were planted per plot, allowed to germinate, and later thinned to 1 per hole after emergence, and therefore a total number of 10,000 plants per hectare were planted.

Data Collection and Statistical Analysis

Height of Shoot (cm) of plants per Plot was obtained by measuring from the ground level to the top or apex of the plant in each treatment plot and the average height within plot and between replicates were calculated and expressed in cm (Akonye and Nwauzoma, 2003). Similarly, the numbers of leaves on the plant for which the height was considered were simply counted, and the average calculated within plot and between replicates, and the values were recorded. This was done three weeks after planting (3WAP), six weeks after planting (6WAP), and nine weeks after planting (9WAP). Data generated from the analyses of unamend soil, PBA, the amended soil before planting and from the growth parameters of the test crop were subjected to statistical analysis using Minitab statistical package version 20. One-way Analysis of variance (ANOVA) was used to test the effects of the PBA on the pre and post application soil chemical properties and growth. Where the effects were significant, Tukey's Honest Significant Test with 95% Simultaneous Confidence Intervals, All Pairwise Comparisons among levels of treatment was used to separate the means.

RESULTS

Chemical Composition Palm Bunch Ash used for the experiment

The result of laboratory analysis for the determination of the chemical composition of this Palm Bunch Ash used as soil amendment is presented in Table 1 below. It revealed that moisture content is 7.06% and pH value 10.7. It contains nitrogen 4.41 mg/kg, organic carbon 45.20%, phosphorus 0.19 mg/kg, sulphur 0.98 mg/kg, potassium 7.91 meq/100g, calcium 24.41 meq/100g, sodium 0.41 meq/100g and magnesium 2.02 meq/100g.

TABLE 1: Chemical Composition Palm Bunch Ash used for the experiment

Chemical Properties	Values
Moisture Content (%)	7.06
pH	10.7
Total Nitrogen (mg/kg)	4.41
Organic Carbon (%)	45.20
Phosphorus (mg/kg)	0.19
Sulphur (mg/kg)	0.98
Potassium (meq/100g)	7.91
Calcium (meq/100g)	24.41
Sodium (meq/100g)	0.41
Magnesium (meq/100g)	2.02

Determination of Soil Physico-Chemical Properties of the Experimental Plot (unamend soil)

The analytical results of the physico-chemical properties of soil of the experimental plot, presented in Table 2 below showed that, the texture of unamend soil is sandy-clay with sand having highest percentage value of 75.7%, clay with 13.1% and silt 11.2%. It also showed that the soil is acidic with pH value of 5.7, low in nitrogen and sulphur with 0.15 and <0.01 mg/kg respectively. Also, Total Organic Carbon (TOC) of 1.26%, calcium and magnesium has equal value of 0.09meq/100g, while Potassium and Sodium have 0.03 and 0.04meq/100g respectively. The result also revealed that, Cation Exchange Capacity has the value 0.25meq/100g, while iron has the highest value 1.4mg/kg among the micro-nutrients with both cobalt and molybdenum as the least with <0.01mg/kg. Again, Nickel, Zinc and copper have 0.04, 0.06 and 0.17mg/kg respectively.

TABLE 2: The Chemical Properties of the unamend soil.

Chemical Properties	Values
pH	5.7
Electrical Conductivity (µs/cm)	44.3
Total Organic Carbon (%)	1.26
Total Nitrogen (mg/kg)	0.15
Available Phosphorus (mg/kg)	2.14
Sulphur (mg/kg)	<0.01
Acidity (mg/kg)	6.8
Base Saturation (%)	72.9

Calcium (meq/100g)	0.09
Magnesium (meq/100g)	0.09
Potassium (meq/100g)	0.03
Sodium (meq/100g)	0.04
Cation Exchange Capacity (meq/100g)	0.25

Effect of Palm Bunch Ash on Soil pH

There was significant effect of PBA on soil pH as shown in Table 3 below, the highest value 6.00 ± 0.05^{gh} was recorded in plots amended with 4t ha^{-1}, followed by 5.72 ± 0.05^{jk} in the plots amended with 2t ha^{-1}, these values were higher than the control with 5.70 ± 0.05^{jk}.

Table 3: Effect of Palm Bunch Ash on Soil pH

Palm Bunch Ash	Treatment (t h^{-1})	pH
Control	0	5.70 ± 0.05^{jk}
Amended	2	5.72 ± 0.05^{jk}
Amended	4	6.00 ± 0.05^{gh}

Mean values with the same superscript (letter) on the same column are significantly not different at 0.05 level of Probability

Effect of Palm Bunch Ash on Shoot Height (cm) for 3, 6 and 9WAP

Result of Shoot Height 3, 6 and 9WAP with respect to the treatment effect is presented in Figure 1 below. There was significant difference in shoot height of cucumber between the treatments at $p<0.05$. In 3, 6 and 9WAP, the highest values $13.97 \pm 0.21^{p-r}$, 48.13 ± 0.85^{i} and 77.90 ± 0.87^{o} were all observed in plots with 4t ha^{-1}, while the lowest values 12.13 ± 0.32^{r}, 31.57 ± 0.90^{m} and 61.37 ± 0.95^{p} respectively were all observed in 0t ha^{-1} (control).

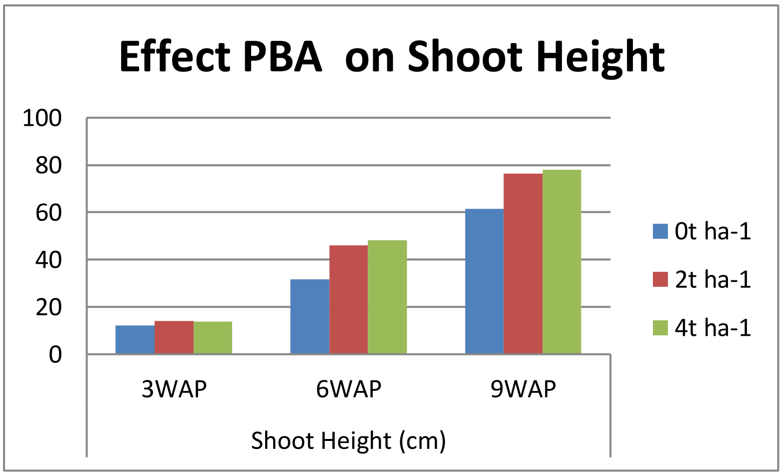

Fig.1: Effect of PBA on Shoot Height of Cucumber

Effect of Palm Bunch Ash on Number of Leaves for 3, 6 and 9WAP

Result of Number of Leaves 3, 6 and 9WAP in response to the treatments effect is presented in Figure 2. There was significant difference in number of leaves of cucumber between the treatments at $p<0.05$. In the 3, 6 and 9 WAP, the highest values $6.33 \pm 1.53^{j-l}$, $12.67 \pm 0.58^{m-p}$ and 18.00 ± 1.00^{rs} respectively were observed in the 4t ha^{-1}, while the lowest values 5.00 ± 1.00^{l}, 9.33 ± 1.53^{p} and 15.00 ± 1.00^{s} respectively were all observed in 0t ha^{-1} the control.

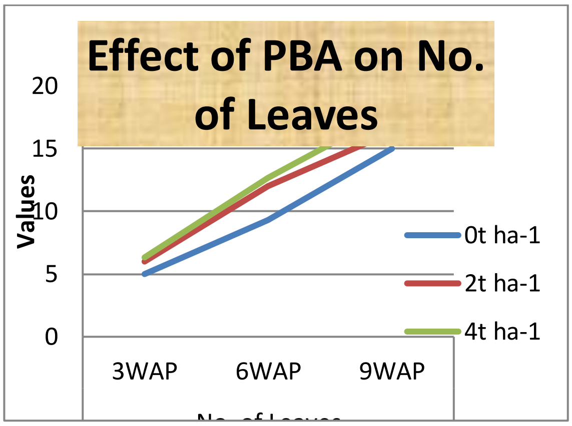

Fig.2: Effect of PBA on No of Leaves of Cucumber

DISCUSSION

The soil chemical status of the experimental plot relative to the palm bunch ash used for the experiment was low (Table 1 and 2). However, with the application of the palm bunch ash, the pH in the treated soil indicated that the values were significantly higher than in the untreated soils (control) in response to the palm bunch ash as organic amendments (See table 3). The pH of the treated plots at 2t and 4t ha^{-1} were significantly higher than the control plot. This is because the pH of palm bunch ash was higher than that of the untreated soil, hence created a neutralizing process. Also the values of the cations: Ca, K, Na and Mg in palm bunch ash were higher than the untreated soil. Similar observations were made by Nnah *et al*. (2010), and Awodum *et al*., (2007) who noted that, palm bunch ash is also a liming material. Also Busariet *et al*., (2009) agreed that improvement in soil physical properties is due to application of organic amendment. Akinrinde and Obigbesan (2000) also gave constituent analysis of oil palm bunch ash with the pH value of 8.8; N = 1.6%; P = 0.13%; K = 29.8%; Ca = 7.95% and Mg = 3.92%. Teoh *et al.*, (1986) further equates oil palm bunch ash to limestone. They concluded that equal rates of oil palm bunch ash and limestone application produce the same increase in top soil pH, indicating that, both may be effective in ameliorating acidity in poorly buffered soils. From the foregoing, it implies that oil palm bunch ash improved soil physical properties and is a potential supplier of major nutrients to the soil and plants, and it is also a liming material or a soil buffer.

Palm bunch ash also increased performance of cucumber (Figure 1 and 2). The values for height of shoots for 2t, and 4t ha^{-1}, were higher than 0t ha^{-1} (control). Similarly, the values for number of leaves per plant were significantly higher than the control. PBA increased soil nutrients like N, P, K, and Mg which in turn enhance nutrient release to the plants for growth and development. This also corroborate to the assertion of Ojeniyi *et al.*, 2007; that organic manures reduce bulk density and increase soil moisture content which enhance root growth, nutrient uptake and yield. Busari *et al.*, 2009 also added that the aggregate stability of the soil makes it more productive. Manure supplies nutrients for crops but also organic matter thus improving soil fertility (Goss *et al.*, 2013). To this end PBA as organic waste turned manure, not only improve soil fertility but also becomes source of vital nutrients to the plants, which influenced the shoot height and number of leaves of cucumber. Again, multiple benefits derive from the use of organic waste as fertilizer, for instance an increase in organic C content and microbial activity (Scotti *et al.*, 2015), a greater concentration of plant nutrients like N, P K and Mg, and a root reinforcement (Donn *et al.*, 2014). In all, the overall increase of the soil nutrients and improvement is attributable to the gradual release of nutrient from palm bunch ash as organic manure.

CONCLUSION

The study has shown that organic amendment such as Palm Bunch Ash has the potential to neutralize the acidity of sandy-clay soil on which the experiment was sited. That palm bunch Ash contains major plant nutrients such as potassium, magnesium, calcium and phosphorus which are deficient in sandy-clay soils. Soil physico-chemical properties improved with increase in Palm Bunch Ash (organic amendment) application rates. Palm Bunch Ash is strongly recommended as organic amendment to farmers in the south-south part of Nigeria for remediation of the soil and supply of plant nutrients, as they are readily available, cheap and environment friendly, as well for proper and adequate disposal, and turning wastes to wealth.

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