e-ISSN 2795-3248
p-ISSN 2795-3222

GPH INTERNATIONAL JOURNAL
Research in Biological Science
www.gphjournal.org || editor@gphjournal.org

Doi: https://doi.org/10.5281/zenodo.6778387 Vol. 05 Issue 01 Jan - 2022 Manuscript ID: #0540

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

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ABSTRACT

This study was carried out to assess the effect Palm Bunch Ash (PBA), at various levels (0, 2, 4t/ha) on soil Base Saturation and growth of Cucumis sativus *L. at the Teaching and Research Farm, Rivers State University, Port Harcourt. PBA, and Soil samples (0 – 15cm) before and after application, from the experimental plots were collected, and analyzed with standard methods for Physico-chemical properties and Base Saturation calculated. A total of 9 treatments were used with T0 (Control), T2 and T4, where T represents PBA as treatment, and the subscripts 0, 2 and 4 represent the 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, Port Harcourt were planted on each treatment plot of 2 x 2m at 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 Base Saturation increased ($p<0.05$) as the treatment level increased in the treated soil with the highest 65.96 of 4t/ha. Again, there was significant effect ($p<0.05$) on shoot height, as the PBA level increased in treated soil with the highest values 13.97 recorded in 2t/ha, and 48.13 and 77.90 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 amendment for acid soil neutralizer, Base Saturation booster, and nutrient buffer and supplier to the soil and ultimately to plants.*

KEYWORDS

Soil, Palm bunch ash, Soil Base Saturation, 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 soil environment, base saturation has an enormous influence on soil biogeochemical processes. It is the percentage of Cations Exchange Capacity possessed by bases such as Na^+, Mg^{2+}, K^+ and Ca^{2+}. Thus, the presence, and increase of the afore-mentioned cations lead to increase of Base Saturation. Soil Base Saturation is essential to plants, as studies revealed that, an 80% BS soil provides cations to plants more easily than 80% BS soil. Again, at pH of 5.5, most soils have 45 – 55% BS, while at pH 7, BS is more than 90%. This implies that BS increase as pH increase and is very important for plants nutrients uptake.

Nutrients are in addition to water basic requirements for plant growth and performance that are absorbed from the soil and air surrounding the plants. A well balanced nutrient supply has known to be crucial for all the crops in order to avoid excessive growth or mineral deficiency, since mineral elements affect plant physiology and, thereafter, also plant development (Bergmann, 2012). Soils do not only vary in the amounts and composition of mineral nutrients but also in the degree of the uptake availability by the roots. Base saturation can affect several chemical and biochemical processes occurring in the soil: precipitation - dissolution, adsorption - desorption, complexation - dissociation, and oxidation - reduction, which in progress control the mobility and plant-availability of nutrients (He *et al*., 2005).

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, 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 disposed and so 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).

In this study cucumber (*Cucumis sativus L*) was considered due to its ephemeral life span which accounts for more productivity within a short period of time, is very common in Rivers State especially in the cities and South-South in general. Also, the quality nutrient values of cucumber go beyond the provision of necessary vitamins, minerals, micronutrients and in a number of cases, protein. Therefore, increased cultivation and consumption of this vegetables; *Cucumis sativus L.* will be source of both micronutrients and bio-active compounds to address the problem of malnutrition. Therefore, the aim of the study is to investigate the effect of PBA as organic amendments on soil base saturation 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.

Experimental Design

An area of $90m^2$ (10 by 9m) was cleared and mapped out into 9 treatment plots of 2 by 2m. Thereafter, PBA- 0t, 2t, 4t/ha was applied to the treatment plots and replicated thrice with the experimental design of Randomized Complete Block Design (RCBD), the setup was allowed for two weeks for mineralization.

PBA and Soil Analysis

Palm Bunch Ash used for the study and soil of the experimental field at a depth of 0 – 15cm surface taken with hand auger were sub-sampled and analyzed with standard analytical methods to determine the chemical and physico-chemical properties respectively. These include: Soil texture, Moisture Content, pH, Base Saturation, Total Nitrogen, Organic Carbon, Phosphorus, Sulphur, Potassium, Calcium, Sodium, and Magnesium. Base Saturation was calculated by dividing the sum of the bases in meq/100g soil by the CEC.

Cultivation and Data collection on the Test Crop

Cucumber (*Cucumis sativus L*) seeds were planted two per hole of 9 holes at the spacing of 45 X 45cm, allowed to established, and later thinned to 1 per hole after emergence, and therefore a total number of 10,000 plants per hectare were planted. Height of Shoot (cm), and number of leaves of plants per Plot was obtained by measuring the perpendicular distance from the base to the apex of the plant, and simply counted the number of leaves, and the average calculated in each treatment plot and the average height within plot and between replicates (Akonye and Nwauzoma, 2003). This was done 3, 6, and 9 weeks after planting (WAP).

Statistical Analysis

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 Pair wise Comparisons among levels of treatment was used to separate the means.

RESULTS

The Chemical Properties of the unamend soil.

The analytical results of the physico-chemical properties of soil of the experimental plot, presented in Table 1 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 1: 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

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 2 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 2: 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)	7.909
Calcium (meq/100g)	24.407
Sodium (meq/100g)	0.414
Magnesium (meq/100g)	2.019

Effect of Palm Bunch Ash on Soil pH and Base Saturation

There was significant effect of PBA on soil Base Saturation as shown in Table 3 below, the highest value 65.96 $\pm$ 0.02^{d} was recorded in plots amended with 4t ha^{-1}, followed by 63.14 $\pm$ 0.02^{e} in the plots amended with 2t ha^{-1}, these values were higher than the control with 35.75 $\pm$ 0.02^{w}

Table 3: Effect of Palm Bunch Ash on Soil Base Saturation

Palm Bunch Ash	Treatment (t h^{-1})	Base Saturation
Control	0	35.75 $\pm$ 0.02^{w}
Amended	2	63.14 $\pm$ 0.02^{e}
Amended	4	65.96 $\pm$ 0.02^{d}

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 ± 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 $\pm$ 0.32^{r}, 31.57 $\pm$ 0.90^{m} and 61.37 $\pm$ 0.95^{p} respectively were all observed in 0t ha^{-1} (control).

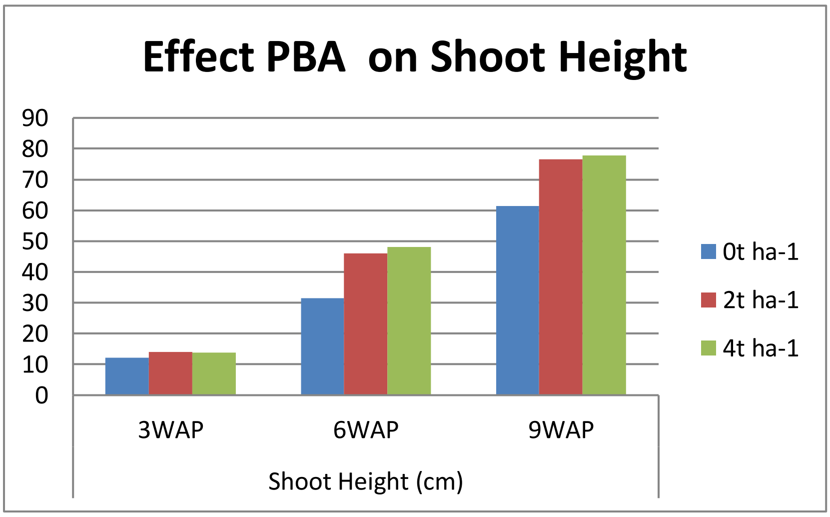

Fig.1: Effect of PBA on Shoot Height of Cucumber

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 below. 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 ± 1.53^{j-l}, 12.67 ± 0.58^{m-p} and 18.00 ± 1.00^{rs} respectively were observed in the 4t ha^{-1}, while the lowest values 5.00 $\pm$ 1.00^{l}, 9.33 $\pm$ 1.53^{p} and 15.00 $\pm$ 1.00^{s} respectively were all observed in 0t ha^{-1} the control.

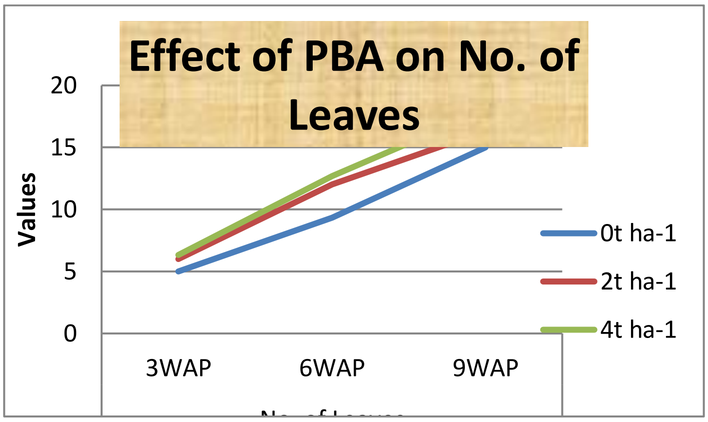

Fig.2: Effect of PBA on No of Leaves of Cucumber

DISCUSSION

The soil chemical status of the experimental plot relative to the palm bunch ash used for the experiment was low (See table 1 and 2). However, with the application of the palm bunch ash, Base Saturation in the treated soil analysis 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 Base saturation of the treated plots at 2t and 4t ha^{-1} were significantly higher than the control plot. This is because palm bunch ash contains the most common cations: Ca, K, Na and Mg found in the soil, which are higher than that of the untreated soil, hence created a neutralizing process, thereby raising the soil base saturation. Similar observations were made by Jaja & Nwauzoma (2015), Nnah *et al*. (2010), and Awodum *et al*., (2007) who noted that, palm bunch ash has pH above 7.0 and is alkaline, hence 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%; Jaja and Nwauzoma (2015) had similar values for pH, Ca and Mg as 8.8, 7.9 cmol/kg and 3.9cmol/kg respectively. 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 base saturaion, indicating that, both may be effective in ameliorating acidity in poorly buffered soils. Again, the characteristic increase in the Base Saturation due to application of PBA was is in accordance with the research works of many scholars who concluded organic amendment improve soil physical properties due to their mineral content which include calcium, magnesium, potassium and sodium. They increase base saturation which made the soil more productive when crops are planted, Busariet *et al*., (2009). Again, percentage Base saturation increases as soil pH increases. 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) as shown in figure 1. Similarly, the values for number of leaves per plant were significantly higher than the control, also as shown in figure 2. 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). Jaja & Nwauzoma (2015) also noted that palm bunch refused in their experiment has relative value of K, Ca and Mg, thus not only being a liming material but improved the soil fertility, which in turn influence the maize plant height. 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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