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Research Article
Combined Effect of Oil Palm Bunch Ash and NPK Fertilizer on Pod Yield and Yield Components of Okra in Port Harcourt

[1]Kpekot Anthony Kpekot , [2]George Nnabugwu Anaero-Nweke, [1]Julia Obaraemi Tariah , [1]Chimankpa Wosa Worlu, [1]Fortune Nyekalurum Chinenye Okogbule, [1]Samuel Sunday Agbagwa, [3]Tamuno-Boma Odinga-Israel and [1]Emylia Tamunodiari Jaja

[1]Department of Plant Science and Biotechnology, Faculty of Science, Rivers State University, Nigeria
[2]Department of Animal and Environmental Biology, Faculty of Science, Rivers State University, Nigeria
[3]Department of Biochemistry, Faculty of Science, Rivers State University, Nigeria

Abstract

Background and Objective: Soil infertility has posed a great challenge in the agricultural sector. In a situation of poor soil fertility and limited financial resources, locally available materials with the potential for soil enrichment become necessary. Hence this study evaluated the use of palm bunch ash as soil amendment. The objective of the study was to examine the combined effect of oil palm bunch ash and NPK fertilizer on the yield and yield components of okra (*Abelmoschus esculentus*) in Port Harcourt. **Materials and Methods:** The 4 seeds were planted per hole and thinned to two after emergence at 60×30 cm spacing. The combined effect of various levels of oil palm bunch ash OPBA-P_x (0, 2, 4. 6 ton/ha) as a soil amendment and NPK-Ny (0, 200, 400 kg/ha) on the yield of okra at the Teaching and Research Farm, RSU, Port Harcourt during rainy (June-September) and dry (January-April) seasons were assessed. Data collected on yield parameters (Number of plants/plot, pods/plot, pods/plant/plot and total dry matter of pods/plot) were subjected to a two-way ANOVA and the means were compared with DMRT. **Results:** The oil palm bunch contains major nutrients needed by plants and has a pH value of 10.90, meaning that it is highly basic. Hence neutralized acidic soil and released nutrients to the crop. There were more harvested pods in the dry season than in the rainy season. The values ranged between 0.00 for P_0N_0 (Control) and P_0N_2 treatments and 49.00 for P_4N_2 treatment in the rainy season. Similarly, in dry season the values ranged between 4.33 for P_0N_2 and 166.33 for P_4N_2 treatments. **Conclusion:** The study strongly suggest that alternative soil amendments using oil palm bunch ash (OPBA), an agricultural waste, is cheap, readily available, easy and convenient to apply and environment-friendly replacement for conventional and expensive chemical fertilizer, NPK.

Key words: Soil amendment, soil fertility management, yield, oil palm bunch ash, okra

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Corresponding Author: Tamuno-Boma Odinga-Israel, Department of Biochemistry, Faculty of Science, Rivers State University, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The yield of any crop is dependent on the availability and quality of the environmental resources. According to Mochida *et al.*[1], "crop growth and production depend on the interaction of biological systems-which is the plant or more often a population of plants and the physical environment in which they grow". Soil is one of the most valuable natural and environmental resources of a nation and in agricultural production. More importantly, it is most often deficient in essential plant nutrients after a few years of cropping. Hence, to make it more productive, organic manures and chemical fertilizers are excellent soil amendment materials because they alter the chemical and physical properties of the soil[2]. However, effective global fertilizer management practices necessitate a thorough understanding of soil conditions and the nutrient needs of the crops being planted.

Fertilizer application is the most widely used method for enhancing soil fertility among farmers and is just as crucial as improved seeds, disease and pest management and water availability for achieving optimal crop yields. This highlights the significance of fertilizer use in crop production, especially in impoverished, degraded soil and low-input agricultural systems. The arable soil of South-Eastern Nigeria are mostly sandy, acid ultisols with low organic matter and nutrients and as such unproductive without adequate soil amendments[3]. Regrettably, most soil in South-Eastern Nigeria and some parts of the humid tropics like the Niger Delta (Port Harcourt) are acidic because of their parent material, high and intense rainfall that leads to erosion and nutrient leaching, the impact of acid rain and, importantly, soil pollution resulting from harmful industrial activities such as oil spills, etc. For a rain-fed farming system and oil-polluted soil like that of the Niger Delta region and a good crop yield, the most important factor is the fertilizer, besides seed viability and available moisture. However, in many African countries, fertilizers are imported at a very expensive rate and the price is neither decreasing nor fluctuating rather it is on the increase. Hence, in a situation of limited financial resources, locally available materials like oil palm bunch ash with the potential of soil enrichment become necessary.

Oil palm bunch ash (OPBA) is the residue of the fruitless bunch of the palm that is burnt. Oil palm bunch ash has been observed to be alkaline and contains relatively high values of potassium, calcium and magnesium but low values of nitrogen and phosphorus[4]. Therefore, low cost amendments like oil palm bunch ash can serve as soil buffers, nutrient suppliers and a replacement for chemical fertilizers. Also, the increase in soil pH under oil palm bunch ash application compared to other treatments is traceable to its high K, Ca and Mg contents and could be effective liming materials that have been reported to influence nutrient uptake and availability. Therefore, alternative sources of soil amendments are needed that are useful, cheap, readily available, easy and convenient to apply and environment friendly.

Okra (*Abelmoschus esculentus* L. Moench.) known in many Anglophone countries as lady's fingers or gumbo is a flowering plant in the family Malvaceae. The plant is cultivated in the tropical, subtropical and warm temperate regions of the world. However, it does best in warm climatic conditions with abundant sunshine and well-distributed rainfall between 1500-3000 mm per annum. Its soil requirement is sandy loam with a high content of organic matter and adequate release of nutrients plus the soil pH requirement of 5-6.5[5]. Okra outside its nutritional values has seeds when pressed; produces greenish-yellow edible oil, with a pleasant smell and taste and is high in unsaturated fats such as oleic acid and linoleic acid[6]. Oil yields from okra crops are high, at 794 kg/ha, the yield was exceeded only by that of sunflower oil[7].

In this study, oil palm bunch ash (OPBA) is on trial and could be one or such soil amendments. Hence, the objective of the study was to examine the combined effect of oil palm bunch ash and NPK fertilizer on the yield and yield components of okra (*Abelmoschus esculentus*) in Port Harcourt.

MATERIALS AND METHODS

Study duration: This study was carried out between June and September, 2012 for raining season and between January and April, 2013 for the dry season.

Study area description: The experiment was conducted in the Teaching and Research Farm of the Rivers State University, Port Harcourt, Nigeria. The experimental plot slopes gently and is covered with secondary vegetation of annual and perennial grasses like *Panicum maximum* and *Chromolaena odorata* etc. The climate of the area is influenced by the North-East Trade Wind and South-West Trade Wind for the dry and rainy seasons, respectively. The area is characterized by high rainfall in the rainy season and heavy sunshine in the dry season. It has a frequent average rainfall of 2384 to 2500 mm per annum and a fairly uniform mean daily temperature usually above 27°C but rarely exceeding 32°C.

Study design: The 50 dry pods of okra were obtained. Also, 8 kg of NPK were obtained, both from Songhai Farm. Then, 15 kg of palm bunch ash was used. All samples were obtained from Songhai Farm (Rivers State Government Development Initiative), Bunu Tai, Rivers State. The seeds were subjected to a simple viability test by pouring them into a water-filled bowl. The floating seeds were discarded while the ones that soil samples were taken from three cores (spots) at random from the experimental site at a depth of 0-15 cm with an auger, mixed thoroughly, air-dried and ground to pass through a 2 mm sieve and sub-sampled-composite sample and were analyzed with standard analytical methods for the physicochemical properties. Also, empty palm bunch was obtained and burnt to ashes under atmospheric conditions. The ash was sieved to remove impurities. The fine ash was thereafter sub-sampled and NPK was used for the experiment. The pH, nitrogen, phosphorus, calcium, magnesium and potassium were analyzed using standard analytical methods.

Land preparation, mapping and experimental plot layout: The parcel of land was cleared manually by cutting, removing stumps and dried grasses packed away. An area of 336 m^2 (24 by 14 m) of the cleared parcel was mapped out as the experimental plot with a perimeter path of 2 m. The main plot was partitioned into 21 treatment plots of 2 by 2 m (4 m^2), where the various levels of the application of amendment (OPBA), fertilizer NPK) and planting was done. These plots were arranged in 3 replicates of 7 plots per replicate. The spacing between one replicate and the other was 2 m and between the treatment plots was 1 m. The soil of the individual treatment plot was tilled and the edge ridged to prevent run-off water and nutrients from one plot entering into another. The application of ash and fertilizer to the various treatment plots was done and allowed for a period of 1 week to stabilize before planting. Thereafter, 4 seeds were planted per hole at a plant spacing of 40×40 cm, which were thinned to 2 per hole after emergence and there were a total number of 125,000 plants per hectare.

Experimental treatments and design: There were four treatment levels of OPBA: 0, 2, 4 and 6 ton/ha and three treatment levels of N'PK: 0, 200 and 400 kg/ha giving a total combination of 7 treatments; P_0N_0 (0 ton/ha+0 kg/ha), P_2N_2 (2 ton/ha+200 kg/ha), P_2N_4 (2 ton/ha+400 kg ha), P_4N_2 (4 ton/ ha+200 kg/ha), P_4N_4 (4 ton/ha+400 kg/ha), P_6N_2 (6 ton/ha+200 kg/ha) and P_6N_4 (6 ton /ha+400 kg/ha). The experimental design of this work was Randomized Complete Block Design (RCBD).

Cultural practices: After emergence, weeding was done once a month manually with hoe and rogueing where necessary. Bitter leaf (*Vernonia amygdalina*) extract was used to spray on the leaves and stems against caterpillar and lady beetles' attacks. The extract application was done once a month during the dry season, but twice a month during the rainy season.

Data collection: The data were collated from yield parameters which include; total number of plants per plot: Where number of plants per plot where counted and recorded; Number of fruits (pods) per plot: Where selective harvesting method was employed i.e., only the sizable and mature pods plot was carefully harvested with a knife and counted every 2 days for 2 weeks, the summation of all the fruits harvested per treatment plot and average between replicates gave the total number of pods (fruits) per treatment; Average number of pods per plant: It was obtained by calculating the ratio of the total number of pods per plot to the total number of plants that produced fruits (pods) per plot and the average between replicate gave the number of pods (fruits) per plant per treatment and Okro dry matter (ton/ha): After the fresh sizable mature pods were harvested, weight recorded, the same pods were oven-dried at 60°C (to avoid charring) to constant weight. The sum of the 2 weeks of recorded dry weights gave the dry matter.

Statistical analysis: The IBM SPSS version 25 was the statistical tool used and the instrument Analysis of Variance (ANOVA) was used to test the effects of OPBA and NPK fertilizer on the okro yield, where the effects were significant, Duncan's New Multiple Range Test (DNMRT) was also used to separate the means. The significance level was considered at $p<0.05$.

RESULTS

The combined effect of oil palm bunch ash and NPK fertilizer on the yield parameters, during the rainy and dry seasons were presented in Table 1 to 4.

Number of plants per plot: Table 1 shows the value of the number of plants per plot during rainy and dry seasons. A significant difference at $p<0.05$ probability level was observed between treatments in both seasons. During the rainy season, the values ranged between 0.00 for P_0N_0 control plot and 27.33 for P_6N_2 plot. During the dry season, the values were between 5.00 for P_0N_0 and P_0N_4 and 68.67 for P_4N_2 plots.

Number of pods per plot: The values of the number of pods in relation to the treatments in the plots during rainy and dry seasons were presented in Table 2. There was a significant difference $p<0.05$ in both seasons. However, the values ranged between 0.00 for P_0N_0 control and 49.00 for P_4N_2 treatments during the rainy season. Similarly, during dry season the values ranged between 5.67 for P_0N_0 and 166.33 for P_4N_2 treatments.

Table 1: Combined effect of oil palm bunch ash and NPK on number of okra per plot during rainy and dry seasons

	Number of plants/plot	
Parameter/Treatment	Rainy season	Dry season
P_0N_0	0.00[a]	5.00[a]
P_2N_2	9.33[ab]	58.33[b]
P_2N_4	20.67[bc]	54.00[b]
P_4N_2	18.00[bc]	68.67[b]
P_4N_4	19.67[bc]	63.33[b]
P_6N_2	27.33[cd]	62.00[b]
P_6N_4	20.00[bc]	48.67[b]

Values with the same superscript on the same column are significantly not different at 0.05 level of probability and the 0.00 values observed for P_0N_0, during the rainy season in this table show that all the plants died before harvest

Table 2: Combined effect of oil palm bunch ash and NPK on number of pods per plot during rainy and dry seasons

	Number of pods/plot	
Parameter/Treatment	Rainy season	Dry season
P_0N_0	0.00[a]	5.67[a]
P_2N_2	26.33[cd]	139.33[bc]
P_2N_4	30.00[cd]	149.33[bc]
P_4N_2	49.00[d]	166.33[c]
P_4N_4	41.67[cd]	160.67[bc]
P_6N_2	41.33[cd]	164.33[c]
P_6N_4	46.67[cd]	126.00[b]

Values with the same superscript on the same column are not significantly different at a 0.05 level of probability and the 0.00 values observed for P_0N_0, during the rainy season in this table show that all the plants died before harvest

Table 3: Combined effect of oil palm bunch ash and NPK on average number of pods per plant per plot during rainy and dry seasons

	Average number of pods/plant	
Parameter/Treatment	Rainy season	Dry season
P_0N_0	0.00[a]	0.37[a]
P_2N_2	3.67[c]	2.47[b]
P_2N_4	2.07[abc]	2.80[b]
P_4N_2	3.23[bc]	2.43[b]
P_4N_4	2.97[bc]	2.57[b]
P_6N_2	1.47[ab]	2.97[b]
P_6N_4	2.43[bc]	2.57[b]

Values with the same superscript on the same column are not significantly different at a 0.05 level of probability and the 0.00 values observed for P_0N_0, during rainy season in this table show that all the plants died before harvest

Table 4: Combined effect of oil palm bunch ash and NPK on total dry matter of pods per plot during rainy and dry seasons

	Total dry matter of pods/plot	
Parameter/Treatment	Rainy season	Dry season
P_0N_0	0.00[a]	4.42[a]
P_2N_2	106.22[ab]	386.63[b]
P_2N_4	54.31[ab]	445.51[b]
P_4N_2	140.07[b]	446.51[b]
P_4N_4	60.44[ab]	448.50[b]
P_6N_2	133.08[b]	401.99[b]
P_6N_4	150.96[b]	377.76[b]

Values with the same superscript on the same column are not significantly different at a 0.05 level of probability and the 0.00 values observed for P_0N_0, during the rainy season in this table show that all the plants died before harvest

Average number of pods per plant: The results were shown in Table 3 for the rainy and dry seasons. There were significant differences $p<0.05$ in both seasons. However, during the rainy season, the highest value of 3.67 was observed in P_2N_2 treatment while the lowest value of 1.47 was observed in P_6N_2. Similarly, during dry season, the highest value of 2.97 for P_6N_2 treatment was observed while the lowest value observed was 0.37 for P_0N_0 (control) plot.

Total dry matter of pods per plot: The values of the total dry matter of pods per plot in grams in relation to the plot treatments were presented in Table 4 for rainy and dry seasons. There was no significant difference of $p>0.05$ in the rainy season but there was a significant difference of $p<0.05$ in the dry season. During the rainy season, the values ranged between 54.31 g for P_2N_4 plot and 150.96 g for P_6N_4 plot. Also, during dry season the values ranged between 4.42 g for P_0N_0 and 448.50 for P_4N_4 treatment.

DISCUSSION

The use of organic matter or by-products as soil amendments in agricultural production exemplifies a strategy for converting waste to resources. This has been a long-time practice but users are shifting focus to beneficial reuse for both economic and environmental reasons. This is evident in the work of Taj *et al*.[8], who determined that poultry manure resulted in improved yields for maize and cassava. They found that while higher application rates of manure, either alone or combined with chemical fertilizers, may be optimal, a rate of 10 ton/ha of poultry manure is recommended as an economical optimum for sustainable crop production on the degraded Ultisol in Umudike, Southern Nigeria. The effect of oil palm bunch ash and NPK fertilizer on okra yield as shown in the number of plants per plot in both seasons confirmed the supply of additional nutrients from the ash and the NPK fertilizer (Table 1). Though there were significant differences in both seasons, the yield during the dry season was far higher than during rainy season. This could be attributed to the optimum moisture level that was available to the crops. There was no significant leaching and surface erosion of the nutrients may have been prevalent during rainy season. Consequently, the uptake of nutrients from the amendments also affected other yield components like the number of pods per plot, number of pods per plant and total dry matter (Table 2 to 4).

Also, there were more pods in the dry season than during rainy season. This is attributed to the uptake of more nutrients that are supportive of growth and development of crops. This result was similar to the report of Romdhane *et al.*[9] that the highest maize grain yield of 1.97 ton/ha was in 200 kg/ha NPK 15-15-15 plus 2 ton/ha wood ash mixture compared with other treatments which showed a high yield obtainable when wood ash alone or in combination with inorganic fertilizer was used to improve soil fertility for increased crop production[10-12]. This result also recorded the highest yield in the plots treated with ash application from 2 to 6 ton/ha sole or combined with NPK fertilizer, which agreed with the report of Ibanga *et al.*[13], that oil palm bunch ash at 4 ton/ha significantly increased the yield of maize and its nutrients.

Other reasons that may be responsible for the better yield in the dry season than in the rainy season could be attributed to insolation and photoperiodism. It is evident that solar radiation which reaches the earth's surface in considerable amounts is the major source of energy and is the root of physical and chemical processes and events that take place in nature - either organic or otherwise[1]. Insolation is the amount of incoming solar radiation received by an exposed surface and varies with the season. Thus, the dry season corresponds to the period of higher sun angle when radiant energy is concentrated into a smaller area thereby causing a hotter surface temperature and triggering various photochemical reactions like photosynthesis in plants. The reason could also be that okra plants were favorably exposed to sunnier days whose rays were not intercepted by clouds. These two factors may have influenced the various physiological processes which included the formation of chlorophyll, assimilation or carbon, good differentiation of plant tissues, etc., which were translated to better yield during dry season.

CONCLUSION

The results obtained from this experiment have shown that oil palm bunch ash contains major plant nutrients such as potassium, magnesium, calcium and phosphorus which are deficient in coastal plain sand and, thus, have the potential to neutralize the acidity of coastal plain sands on which the experiment was sited. Also, soil chemical properties improved with the increase in oil palm bunch ash and NPK application rate. Therefore, okra yield and yield components significantly increased due to the application of soil amendment in the dry season more than the rainy season.

Oil palm bunch ash is strongly recommended as a soil amendment and should be recommended to farmers in the South-Eastern part of Nigeria for the production of okra as it is readily available, cheap and environmentally friendly, as the soil is acidic in reaction and devoid of basic cations.

SIGNIFICANCE STATEMENT

Crop growth and production depend on the plant and the environment in which it grows. Due to insufficient or total lack of arable land space for agriculture, the available spaces are over-exploited leading to soil infertility. Most of the soils in South-Eastern Nigeria are characterized by low inherent fertility, strongly weathered, acid in reaction and fragile. For better output, restoration of soil fertility through the application of cheap and locally sourced organic soil amendment is expedient. This study suggested an evidence-based alternative soil amendment using oil palm bunch ash (OPBA) which is an agricultural waste. It is economical, readily available, easy and convenient to apply and an environment-friendly replacement for conventional and expensive chemical fertilizer, NPK.

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