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Efficacy of Palm Bunch Ash on the Growth Performance and Mineral Nutrient Composition of *Phaseolus vulgaris* L. Grown in Diesel Oil Polluted Soil

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Authors' contributions

This work was carried out in collaboration between both authors. Author POE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SIM managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

This study was designed to investigate the efficacy of palm bunch ash on the growth and nutrient composition of *Phaseolus vulgaris* affected by diesel oil pollution of soil. The model chosen for this study was the growth and nutrient composition of *Phaseolus vulgaris*. The Study was undertaken at the University of Port Harcourt Botanic garden. The polluted treatments were obtained by mixing thoroughly 100 ml of diesel oil with 2kg of loamy soil, while 0 ml (unpolluted soil) was used as control. Amelioration treatments were carried out by adding organic supplements (palm bunch ash) at the rate of 0.5, 1.0, 1.5 and 2.0 kg to the 100 ml level of diesel oil polluted soil. The experimental works were undertaken in polythene bags. The growth parameters examined were: Plant height, leaf number, root length and shoot/root ratio. While the nutrient composition examined were:

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Calcium, potassium, magnesium, phosphorus, nitrogen, sodium, zinc, iron and copper. This study showed that there were significant increase (P = 0.05**)** in plant height, root length and leaf number with increase in the level of palm bunch ash. Similarly, the calcium, magnesium, potassium, iron, sodium and calcium contents of *P. vulgaris* showed significant increase (P = 0.05) with levels of palm bunch ash. Therefore, palm bunch ash is an effective organic supplement for remediation of diesel oil polluted soil.

Keywords: Palm bunch ash; amelioration; growth; mineral nutrient; diesel oil.

1. INTRODUCTION

Palm bunch refuse is the solid waste generated during the processing of oil palm fruits. Palm bunch refuse ash is obtained by burning the solid waste (palm bunch refuse), which is generated in the processing process [1]. Palm bunch refuse ash is alkaline and contains relatively high potassium, calcium, magnesium, but low values of organic matter, nitrogen and phosphorus [2]. Palm bunch refuse ash is an effective fertilizer and liming material for increasing soil fertility, pH and nutrient uptake because of its rich content in nitrogen, phosphorus, potassium, calcium and magnesium [3]. According to [4], the effect of palm bunch ash on crops is due to the fact that it constitutes some vital mineral elements needed by plants for growth and development. Palm bunch ash contributes varying amount of calcium, phosphorus, potassium and magnesium which affect the yield of crop [4].

Increasing petroleum exploration has led to wide spread contamination of agricultural lands [5]. In Nigeria, most of the terrestrial ecosystem and shore lines in oil producing communities are important agricultural lands under continuous cultivation. Crude oil pollution usually results in the damage of soil, microorganisms and plants [6]. Oil pollution increases soil organic carbon and reduces soil nitrates and phosphorus, thus imposing a condition that impairs oil degradation in the soil [7].

Contamination by diesel fuel can kill plant roots, and this prevents the plants from taking up water and other nutrients. It can also disrupt plant and water relationship in soil [8]. Petroleum derived diesel consists of 75% saturated hydrocarbons primarily paraffin and 25% aromatic hydrocarbons. Regardless of the complexity, diesel fuel can be degraded by a number of soil microorganisms. Diesel fuel is toxic to plants at relatively low concentrations. At levels below this toxic level, the developments of plants grown in diesel fuel contaminated soil differs greatly from plants grown in normal soil conditions [6].

The use of organic supplements such as palm bunch ash to remediate petroleum oil pollution is one of the viable cost effective methods of soil recovery [3]. A need exists to understand the interactions between oil pollution and environmental variables in order to effect remediation. The success of any remediation is dependent upon the environmental context, such as local geology, mineralogy, soil condition, nutrient levels, pH, texture and structure, temperature and precipitation [9].

This study therefore, is aimed at investigating the potential of using palm bunch ash to remediate diesel oil polluted soil using *Phaseolus vulgaris* as the test crop.

2. MATERIALS AND METHODS

The matured seeds of *P. vulgaris* were collected from Akwa Ibom State Agricultural Development Project (AKADEP). The obtained seeds were pretreated by picking out infected seeds. The viable ones were used for the research. The diesel oil was sourced from Mobil petroleum oil filling station in Uyo. Loamy soil was obtained from the University of Port- Harcourt botanic garden. Palm bunch ash was sourced from local farmers in Uyo, Akwa Ibom State. The Physico-chemical properties of palm bunch ash were analyzed using standard procedures [10].

2 kg of the loamy soil was weighed using a weighing balance. Polluted soil were obtained by mixing thoroughly 2 kg of loamy soil with 100 ml of diesel oil and left undisturbed for one week. 0ml (unpolluted soil) was used as control. The amelioration treatments were carried out by adding organic supplements at the rate of 0.5, 1.0, 1.5, 2.0 kg to the 100 ml level of diesel oil polluted soils. The soil samples with or without organic nutrient were left undisturbed for another four weeks before being placed in perforated polythene bags (18 x 36 cm).The period was supposed to be enough to facilitate loosening of the oil constituent completely [11]. The importance of the holes in the bottom was to enhance proper drainage [12].

The seeds were sterilized with approximately 0.01% mercuric chloride solution for 30 seconds, thoroughly washed several times with distilled water and air dried. During treatment floating seeds or those that had bubbles were discarded, while the remaining good ones were used for the research. Three seeds of *P. vulgaris* were sown directly in each polythene bag containing the various level of organic supplement-palm bunch ash mixed with 2 kg loamy soil. After germination the seeds were thinned down to one. Each level of treatment was replicated three times using randomized complete block design. The experimental works were maintained under light condition, the plant watered as need arises and allowed to grow for two months in order to determine the growth and yield performances.

The following growth and biochemical parameters were analyzed: plant height (cm), Leaf number, root length (cm), shoot/root ratio, pH, available phosphorus, total Nitrogen and heavy metals.

The shoot length (plant height) was measured with a metre tape in centimetres from the soil surface to the plant apex. The plant were uprooted from each bucket and weighed immediately on a weighing balance, model PN 163 to avoid moisture loss. This was done to obtain the fresh weights. To get the dry weights, the plants were taken to the laboratory, oven-dried at 80℃ for 24 hours to get rid of moisture and ensure constant weight. It was then weighed on a PN 163 model weighing balance. The leaves of the test crop were rinsed with distilled water and dried. The dried plant materials of each sample were macerated into powdered form using pestle and mortar. The powder was sieved through a 0.2 mm wire mesh to obtain fine powder. Each sample of the powdered materials was kept in small bottles for analysis. The contents of the mineral elements (Calcium (Ca), Magnesium (Mg), Phosphorus (P), Potassium (K), Zinc (Zn), Copper (Cu), Iron (Fe), Manganese (Mn), and Lead (Pb) were determined using AA-7000 atomic absorption spectrophotometer.

All data collected were subjected to statistical analysis such as Analysis of variance (ANOVA) and standard error means. Duncan's New Multiple range test was employed to separate means.

3. RESULTS AND DISCUSSION

The pH of the diesel oil and elemental components are presented in Table 1.

Table 1. Physicochemical Properties of experimental diesel oil (mg/kg)

Parameters	Values
pH	6.10
Pb(mg/kg)	6.0
Ni (mg/kg)	2.6
Cu (mg/kg)	10.30
Zn (mg/kg)	178.15
Fe (mg/kg)	851.6

The high pH (9.60) value of palm bunch ash shows it is an alkaline medium. This result corresponds with the physicochemical analysis conducted by [2]. A moisture content of 42% was recorded. The micronutrients recorded a high value of potassium (50.24), while calcium (8.22) and magnesium (6.24) as well as sodium were lower than the potassium content of the palm bunch ash. Similarly, the micronutrients contents of the palm bunch ash showed the following with a decreasing trend; iron (1.12), zinc (1.02), copper (0.86) and manganese (0.72). The micronutrients were all expressed in parts per million as shown in Table 2. Palm bunch ash has been reported to contain rich nutrients such as nitrogen, phosphorous, potassium, calcium and magnesium. Thus, the alkaline properties and rich nutrient contents of the palm bunch ash used in this study could be a better source of remediation practice in diesel oil polluted soil with an acidic pH and nutrient depleted characteristics [3].

Table 2. Physico-chemical Properties of palm bunch ash

Properties	Values
pH	9.60
Moisture content (%)	42
Potassium (ppm)	50.24
Calcium (ppm)	8.22
Magnesium (ppm)	6.24
Sodium (ppm)	6.42
Zinc (ppm)	1.02
Iron (ppm)	1.12
Copper (ppm)	0.86
Manganese (ppm)	0.72

There were significant (P=0.05) increase in plant height of *P. vulgaris* with increase in the concentration of palm bunch ash in diesel oil amended soils. These increases were not higher than the value obtained from the control treatment. However, the values recorded in amended soil were higher than those of diesel oil polluted soil (Fig. 1). The leaf number of *P. vulgaris* increased (P=0.05) significantly with increase in the concentration of palm bunch ash in diesel oil amended soil. Although, these increases were comparatively lower than the control treatment, but higher than pollution treatment. The highest value for leaf number were recorded at 2.0 kg (20.33) treatment level and lower value (17.33) at 0.5 kg treatment level against the control 0.0 kg treatment level with a leaf number of (24.33) (Fig. 1). There were significant (p=0.05) increase in root length of *P. vulgaris* with increase in the level of palm bunch ash. Increased oil polluted soil value recorded for the control was higher than the values for all other treatments (Fig. 1). The value of shoots/roots ratio for the control treatment was comparatively higher than the value obtained from pollution treatment amended with various level of palm bunch ash.

P. vulgaris showed certain considerable tolerance in diesel oil polluted soil (pollution treatment) by surviving to the end of the study. Although, there were reduction in plant height, root length, leaf number and shoot/root ratio compared to the control and diesel oil polluted soil amended treatments. The reduction in growth of *P. vulgaris* in diesel oil pollution treatment could be as a result of depression of growth of leguminous plants usually observed in high soil acidity as evidenced in petroleum oil polluted soils [13].

In diesel oil polluted soil amended with palm bunch ash. The calcium, magnesium, phosphorus, nitrogen and sodium contents of *P. vulgaris* plants increased with increase in the level of palm bunch ash. The values recorded for the control treatments were comparatively higher than the value recorded for other treatments. Values for magnesium, phosphorus, sodium and nitrogen were statistically (P=0.05) significant, while those of calcium were not significant (Table 3). Conversely, the calcium content of *P. vulgaris* grown in diesel oil amended soil increased with increase in the level of palm bunch ash. The values recorded here were not statistically (P=0.05) significant. Similarly, the zinc, iron and copper contents of *P. vulgaris* increased with increase in the level of palm bunch ash in diesel oil amended soils. Comparatively, these values were not higher than those of the control treatment. Values recorded for iron and copper showed statistical significance, while those of zinc were not significant (Table 3).

The enhanced plant growth in diesel oil polluted soil supplemented with palm bunch ash as observed in this study may be attributed to the important role played by the organic supplement in supplying the readily available plant minerals and in providing favorable condition for microbial activity as well as providing better soil conditions [14].

Palm bunch ash has been reported to contain high amount of calcium, potassium and magnesium with a considerable proportion of organic matter, nitrogen and phosphorus [2] as shown in this study.

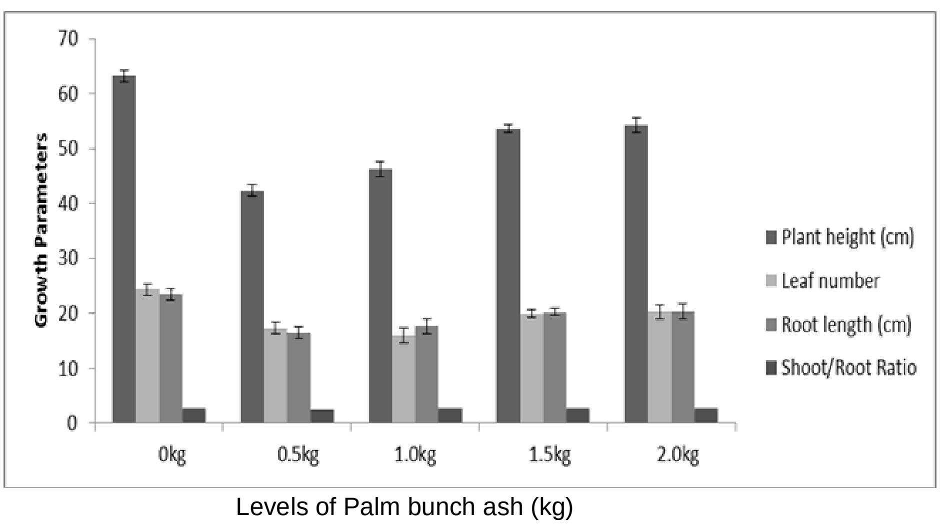

Fig. 1. The plant height (cm), leaf number, root length (cm) and shoot/root ratio of *Phaseolus vulgaris* at different levels of palm bunch ash treatment

Table 3. Nutrient content of *P. vulgaris* grown in diesel oil polluted soil amended with palm bunch ash

	Nutrient Element (mg/100 g)								
Treatment (kg)	**Ca**	**K**	**Mg**	**P**	**N**	**Na**	**Zn**	**Fe**	**Cu**
0	1.37±0.30	1.34±0.16	3.13±0.36	10.94±1.21	4.44±1.3 5	5.37±1.82	0.20±0.06	2.12±1.20	0.63±0.02
0.5	0.86±0.10	1.17±0.16	1.07±0.33	7.70±1.30	2.04±0. 63	4.93±1.22	0.08±0.01	0.72±0.06	0.47±0.61
1.0	0.93±0.06	1.28±0.32	1.08±0.41	8.68±0.07	2.3±1.24	5.27±1.54	0.09±0.04	0.94±0.05	0.05±0.03
1.5	1.06±0.43	0.83±0.02	2.64±1.20	9.68±0.19	3.02±1. 68	5.58±1.20	0.12±0.04	1.34±0.02	0.52±0.04
2.0	1.29±0.21	0.79±0.22	2.95±1.30	10.38±1.27	3.36±1 .77	5.89±1.28	0.17±0.06	1.87±0.16	0.06±0.01

Mean ± standard error

The enhanced nutrient uptake of *P. vulgaris* in diesel oil polluted soil amended with palm bunch ash could be attributed to the effectiveness of palm bunch ash as a liming material in raising the pH of the polluted soil to enhance nutrient availability. Soil nutrients status to increased due to the application of palm bunch ash as a result of improved pH of the soil and increased microbial activities leading to the production of organic matter and nutrient availability [2].

4. CONCLUSION

Palm bunch ash proves effective as a liming material for increasing soil fertility in petroleum polluted soil, as evidenced in this study. It has been shown in this study to be effective for the improvement of growth and mineral nutrient status of *P. vulgaris* plant grown in diesel oil polluted soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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