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Effect of Palm Oil Mill Effluent on the Growth of Maize (*Zea mays*)

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ABSTRACT

Background: Raw palm oil mill effluent is toxic effluent capable of posing serious threat to plants when discharged to the environment. In developing countries, the untreated effluent is often discharged to the surrounding land due to high cost associated with its treatment. The aim of the current study was to evaluate the impact of palm oil mill effluent treated with locally available material on the growth of maize.

Methods: The bunch ash obtained from local material by burning de-fruited oil palm bunch was used for the treatment. The experiment was consisted of eight treatments of concentrations of palm oil mill effluent *viz* 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0%. The treatment was carried out on potted maize plants with six replications. Four kilograms of soil was weighed into each pot. Six pots were labelled as control, with untreated palm oil mill effluent added to them. Eight other groups consisting of six pots each were treated with 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0% concentrations of the effluent. The maize seeds were planted one in each pot to avoid overcrowding. The pots were transferred to greenhouse and each pot was moistened daily with the specified concentration of the palm oil mill effluent. The growth rate, plant height and leaf length of the maize plants were thereafter determined.

Result: The 8.0% concentration of bunch ash in the effluent had the highest expected effect on all the parameters whereas the control gave the lowest expected effect. The effects increased as the concentration of bunch ash in the effluent increased, indicating that increased concentration of bunch ash recorded significant increase in growth rate, height and leaf length of maize. The analysis of variance for the obtained data showed that the effects of the different concentrations were significantly different. This study provides an alternative and cost effective method of ameliorating the toxicity of palm oil mill effluent to plants.

Key words: Bunch ash, Maize growth, Palm oil mill effluent, Pre-treatment.

INTRODUCTION

The production of palm oil is a great economic activity in areas where palm trees grow readily and the large production of palm oil in these areas necessitate the provision of palm oil mills. Palm oil mill effluent (POME) refers to the liquid waste or discharge from the final stage of palm oil production in the mills (Trisakti *et al.,* 2017). The effluent is a toxic industrial liquid waste capable of posing serious threat to the ecosystem including plants. The discharge of raw palm oil mill effluent on soil causes changes in soil structure, which in turn affect the arrangement of soil aggregates, thereby affecting the movement of microorganisms in the soil (Nwachukwu *et al.,* 2018). Apart from its effect on soil microorganisms, palm oil mill effluent causes deterioration of soil physicochemical properties and increases soil acidity (Chikwendu and Ogbonna, 2018). These changes make the soil which was previously fertile before exposure to the effluent pollution to lose its productive potential.

Researchers have expressed concern over the problems associated with the existing treatment technologies and processes for palm oil mill effluent (Paramitadevi and Rhamatullah, 2017). The methods are expensive and difficult to operate. In Nigeria and other developing countries, this problem causes operators of palm oil mills to discharge copious volumes of the effluent on the surrounding lands without treatment. The discharged effluent has serious negative effects on crops and other plants growing on the affected lands. Evidence of the effluent toxicity manifests in stunted growth, yellowing of leaves and low yield. Hence there is the need to seek alternative means of treating palm oil mill effluent that is cheap and easy to handle which will ameliorate its harmful effect on crops.

Keeping the above fact in view, the study was conducted to evaluate the impact of palm oil mill effluent treated with locally available material on the growth of maize.

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MATERIALS AND METHODS

Dried and de-fruited palm bunches used to prepare bunch ash were collected from palm oil mill located in Ohaji/ Egbema Local Government Area of Imo State, Nigeria. The bunch ash was obtained by burning 10 kg of dried and de-fruited oil palm bunches into ash in the presence of air. The ash sample formed was collected and stored in sterile container. The effluent was collected in five litre plastic containers from effluent storage tank. Certified seeds of maize were used for the experiment.

Physicochemical characterization of palm oil mill effluent and ash sample

The physicochemical characterization of the bunch ash involved the estimation of sulphate, carbonate, salinity, pH, nitrate and metals. The physicochemical analysis of both raw and treated palm oil mill effluent were carried out. Effluent sample to be analyzed for metals were preserved with 2% nitric acid.

These determinations were done using standard methods as suggested by American Public Health Association (Anonymous, 1995).

Treatments, treatment applications and procedure

The experiment was consisted of eight treatments of concentrations of palm oil mill effluent *viz.* 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0% obtained by treating 8 sets of 1000 mL of the effluent with 10 g, 20 g, 30 g, 40 g, 50 g, 60 g, 70 g and 80 g of bunch ash respectively. The treatment application was carried out on potted maize plants with six replications. Four kilograms of soil was weighed into each pot. Six pots were labelled as control with untreated palm oil mill effluent added to them. Eight other groups consisting of six pots each were treated with 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0% concentration of the effluent. The maize seeds were planted one in each pot to avoid overcrowding. The pots were transferred to greenhouse and each pot was moistened daily with the specified concentration of the palm oil mill effluent.

Determination of growth rate, plant height and leaf length

The growth rate was measured 21 days after sowing seeds in the pots. The meter rule was set at the base of the plant (ground level) and the heights were determined by measuring the plants from their base to the highest points. The values were written down in a chart with both the dates and the heights recorded. This activity was repeated at an interval of three days. The average daily growth rates were determined as suggested by Andrew (2018).

The plant height was measured with meter rule from the surface of the soil to the tip of the tallest leaf 28 days after sowing the seeds in the pots. A random sampling of five leaves per plant was chosen for measurement of leaf length. The values were added and divided by the number of measurements taken. The effects of the treatments were ascertained from the analysis of variance for the data obtained.

RESULTS AND DISCUSSION

Physicochemical properties of bunch ash and palm oil mill effluent

Table 1 shows the results of the physicochemical analysis of palm oil mill effluent and bunch ash.The results of the various determinations showed that the raw palm oil mill effluent had pH 4.8, oil and grease was 7200 mg/L, biological oxygen demand (BOD_5) was 29500 mg/L and chemical oxygen demand was 42200 mg/L. Effluent characterization using standard methods is widely accepted as an effective method of ascertaining the possible effect of a given industrial wastewater on the environment. Such analytical method often involves determining the physicochemical components of the effluent as carried out in this study. The high biological oxygen demand and oil and grease values as well as high acidity of the effluent are important, indicating that the effluent needed to be treated before it is discharged on the surrounding environment. This is in line with the findings of previous researchers that palm oil mill effluent characteristics were far above environmental health and safety guide

Table 1: Physicochemical characteristics of raw POME, treated POME and bunch ash.

Parameter	Raw POME (mg/L)	Treated POME(at 8.0 % w/v)	Bunch Ash (g/kg)
pH	4.83	8.6	10.01
TDS	715		
Chloride	<0.0016		
Salinity	<0.001		8000
DO	68		
Alkalinity	0.02		
Phosphate	29.74		
Sulphate	98.18	102	13.45
TSS	100	35	
Nitrate	0.174	4.32	4.29
TOC	269.84		
BOD_5	29,500	80	
Oil and Grease	7,200	142	
COD	42,200	102	
Iron	13.5		10.58
Copper	<0.01		2.56
Chromium	<0.01		
Calcium	17.00		64.48
Sodium	1.275		12.86
Magnesium	693	787	88.36
Zinc	0.07		6.49
Potassium	305	425	132.46
Lead	0.03		0.38
Carbonate			24.28
Bicarbonate			18.56
Cadmium			<0.002
Nickel			0.56
Barium			1.25

lines, which indicates unhealthy environmental conditions with potential negative consequences for the ecosystem (Verla *et al.,* 2014; Mosunmola and Olatunde, 2018).

The bunch ash had an alkaline pH and high potassium and magnesium contents. Other components of the bunch ash included sodium, iron, zinc, sulphate, nitrate and carbonates. Previous researchers (Eremrena and Mensah, 2017; Ugwuoha *et al.,* 2017) also have reported similar physicochemical components of bunch ash and recommended that empty fruit bunch ash could serve as a natural substance for improved crop production and bioremediation processes.

The biological oxygen demand (BOD_5), total suspended solids as well as chemical oxygen demand of the effluent were reduced after treatment. This observation agrees with previous reports that bunch ash could effectively be used to remove chemical oxygen demand and other physico-chemical parameters of palm oil mill effluent. Nur and Zudariana (2020) reported a significant reduction in chemical oxygen demand and total suspended solids when palm oil mill effluent was treated with bunch ash suggesting empty fruit bunch ash (EFBA) as a new cost effective substance for palm oil mill effluent treatment.

Effect of palm oil mill effluent on the growth rate, plant height and leaf length of maize

The different concentrations of bunch ash with palm oil mill effluent on growth rate, plant height and leaf length of maize yielded varying means effect. The 8.0% concentration had the highest expected effect on all the parameters whereas the control (untreated effluent) gave the least expected effect. The effects increased as the concentration of bunch ash in the effluent increased, indicating that increased concentration of bunch ash recorded significant increase in growth rate, plant height and leaf length. The 2.0%, 3.0%, 5.0%, 7.0% and 8.0% concentrations gave mean growth rates of 22.6 mm day^{-1}, 24.6 mm day^{-1}, 26.3 mm day^{-1}, 29.1 mm day^{-1} and 31.3 mmday^{-1} respectively (Table 2). The maize height and leaf length also increased as the concentration of bunch ash in the effluent increased. The untreated effluent gave reduced mean growth rate, plant height and leaf length. The analysis of variance (ANOVA) for growth rate, plant height and leaf length measurements show that the between groups (treatment effects) were significantly different, $p<0.005$ with the corresponding calculated f values of 5.038, 11.036 and 13.247 respectively.

This study recorded reduced growth of maize with untreated palm oil mill effluent as the control. The inhibitory effect of untreated palm oil mill effluent on crops after application to soil is established in scientific literature. Chibuike *et al.,* 2017 evaluated the growth of maize on palm oil mill effluent contaminated soil and observed that an increase in concentration of the raw effluent was associated with a decrease in the performance of the maize growth. This observation and the report of Oikeh *et al.,* 2014 that untreated palm oil mill effluent is detrimental to plant growth agree with the findings of this present study. It is, therefore, clear that the reduced growth recorded with the untreated effluent in this study was as a result of its toxicity to the crop. The toxic component of the effluent was not investigated because of limitation of fund.

It is evident from this study that bunch ash had an ameliorative effect on the toxicity of the effluent. Natural ameliorants have been reported to be effective in improving nutrient availability and crop yield (Triatmoko *et al.,* 2020; Lakshmi *et al.,* 2011). Palm bunch ash application has been recommended to farmers as a soil amendment tool for increased productivity (Ogbuehi, 2016). It is also recorded in this study that the treatment of palm oil mill effluent removed the acidity of the effluent which may affect nutrient availability to crops (Miller, 2016) and consequently reduce growth if the effluent is applied to soil without treatment. This also might be responsible for the positive effect recorded with the treated effluent. Moreover, it has been

Table 2: Effect of palm oil mill effluent treated with bunch ash on growth rate, height and leaf length of maize.

Treatments Bunch ash concentration	Growth rate (mm day^{-1})	Maize height (mm)	Leaf length (mm)
0.0%	15.6	138.6	94.8
1.0%	16.5	186.1	146.5
2.0%	22.6	247.1	205.8
3.0%	24.6	240.3	210.1
4.0%	22.3	248.3	197.8
5.0%	26.3	252.0	210.1
6.0%	22.3	226.6	193.3
7.0%	27.1	248.0	202.0
8.0%	31.3	266.8	230.0
SEM ±	1.66	13.51	13.83
F test (5%)	Sig	Sig	Sig
CD 5%	14.41	79.49	74.28

Note: All values represent mean of six replications.

reported that application of oil palm bunch refuse ash on soil significantly increased soil pH, soil phosphorus and exchangeable cations resulting in nutrient availability and improved yield (Adjei-Nsiah and Obeng, 2013). It is, therefore, not unlikely that the use of this natural substance in the treatment of palm oil mill effluent accounted for the reduced phytotoxicity of the effluent recorded in this study.

CONCLUSION

The use of bunch ash in the treatment of palm oil mill effluent significantly increased the height, growth rate and leaf length of maize whereas the untreated effluent had negative effect on the growth of the plant. Bunch ash is locally available and cheap to procure. This study, therefore, provides an alternative and cost effective method of ameliorating the toxicity of palm oil mill effluent to plants.

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