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Effects of palm oil mill effluent on some soil chemical properties and the growth of maize (*Zea mays* L.).

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ABSTRACT: A greenhouse study was conducted at the University of Benin, Benin City, Nigeria to evaluate the effect of palm oil mill effluent on some soil chemical properties and the growth of maize (*Zea mays* L.). The experiment was laid out in a completely randomised design with three replicates. Five rates of the effluent-0, 50, 100, 150 and 200g/2kg of soil were used. Results revealed that the effluent had effects on some of the soil chemical properties. Soil N, P, K, Mg, Ca, organic carbon, exchangeable acidity and Na increased with effluent application while soil pH and available P were reduced. The effluent did not influence the soil texture. The growth of maize and nutrients uptake were depressed in the treated soils compared to the control.

Key Words: Palm oil mill effluent, rate, soil, maize.

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is of domestic and industrial importance because of the oils obtained from it. The oils are the palm oil (obtained from the mesocarp of the fruit) and the palm kernel oil (obtained from the kernel). The sequence of processing of palm oil from oil palm include; reception of the bunches, sterilization, threshing, digestion/crushing, settling/purification, clarification, packaging, storage and distribution. The waste generated during these processes is known as the palm oil mill effluent. The waste is let out through the exit pipe into streams or land. Thillaimuithu (1978) observed that for every tonne of palm oil processed, two or three tonnes of palm oil mill effluent are generated. Thus, this may pose a disposal problem in large-scale production.

Studies on the use of industrial effluent as soil amendment has gained attention in recent times. The controlled application of various effluents has been reported to cause changes in soil properties. Yeow and Zin (1981) reported an improved water retention with rubber effluent. Increased soil pH, K, Ca, Mg and organic matter has been reported for soils with palm oil mill effluent (Poon, 1982; Lim and P'ng 1983; Lim *et al*., 1983); rubber effluent (Orhue *et al*., 2005); pharmaceutical effluent (Osaigbovo and Orhue, 2006). Soil treated with tannery effluent was observed by Karunyal *et al*., 1993 to be high in Mg, Mn, Fe, Na and K while cassava mill effluent increased the sodium content of the treated soil (Vieities and Brinkoli 1993; Ogboghodo *et al*., 2003).

Effluent also has effect on plants. Ogboghodo *et al*., (2003) observed a reduction in height, number of leaves and dry matter content in maize grown on soil amended with cassava mill effluent. Similarly pharmaceutical effluent was reported by Osaigbovo and Orhue, (2006) to depress plant height and number of leaves of maize. However, the growth as well as the chlorophyll content of maize plant was enhanced with brewery effluent (Orhue *et al*., 2005).
The objective of this study was to assess the effect of palm oil mill effluent on some soil chemical properties as well as the growth of maize (*Zea mays* L.).

Materials and Methods

The experiment was sited in the green house at the Faculty of Agriculture, University of Benin, Benin City, Nigeria. The palm oil mill effluent was obtained from Nigerian Institute for Oil Palm Research (NIFOR) in Edo

State, while the maize seeds were obtained from the Plant Breeding Unit of the Department of Crop Science, University of Benin, Benin City, Nigeria. The soil used was collected from top 15cm of an uncultivated field left to fallow for three years after several years of continuous cropping. The soil was bulked, mixed thoroughly and air-dried and then sieved to remove debris. Thereafter, 2kg of the composite soil was weighed and put into each of the polythene bags each measuring 23.5 X 25cm in size. The experiment was laid in a completely randomised design (CRD) with 3 replicates. Each replicate had 25 polythene bags with 5 polythene bags per treatment, making up a total of 75 bags.

The palm oil mill effluent was applied at the following rates 0 (control), 50, 100, 150 and 200g/2kg soil. The effluent applied was thoroughly mixed with the soil, watered with deionised water to field capacity and left for 2 week to allow for adequate mineralisation and equilibration before planting.

Four maize seeds were planted per polythene bag. Germination commenced 4-5 days after planting (DAP) and 100% germination was attained a week after planting (WAP). The plants were watered every other day with deionised water. The seedlings were thinned to one per polythene bag, two weeks after planting. Growth parameters were observed and measured every 2 weeks, starting from the second week after planting and was continued for 8 weeks. Thereafter, the plants were harvested, the above ground parts dried in the oven at 72^0C for 72 hours to a constant weight to determine the nutrient uptake using the method of Pal (1991).

The soil analysis was carried out before and after the experiment while the palm oil mill and plant analysis were carried out before and after the experiment respectively. The soil pH was determined in a 1:1 soil to water ratio using the glass electrode pH meter while the palm oil mill effluent pH was read directly. The soil particle size was determined using the hydrometer method of Bouyoucus (1951) as modified by Day (1965). The organic carbon content of both soil and effluent was determined by the chromic acid wet oxidation procedure described by the Jackson (1962). The nitrogen was determined by Microkjeldal method as described by Jackson (1962). Available phosphorous was extracted using Bray No 1 P solution (Bray and Kurtz, 1945) and the P in the extract was assayed colorimetrically by the molybdenum blue colour method of Murphy and Riley (1962). The exchangeable bases were extracted using IN neutral ammonium acetate solution. Calcium and magnesium content of the extract wee determined volumetrically by EDTA titration procedure (Black, 1965). The calcium, potassium and sodium determined by the flame photometry. Magnesium content was obtained by the difference. The exchangeable acidity was determined by the KCl extraction calculated as the sum of exchangeable bases and exchangeable acidity.

Results and Discussion

Properties of Oil Palm Effluent

The physico-chemical properties of the palm oil mill effluent (Table 1) showed that it contains nutrient elements such as N, P, K, Mg, Ca, Na and suspended particles. The high value of K in the effluent may be attributed to the routine application of muriate of potash fertilizer to the plant in order to boost yield. The effluent is acidic (pH 4.8), the BOD, COD, total solids are high and it is oily.

Table 1: Properties of palm oil mill effluent used in the experiment

PARAMETERS	RESULTS
pH	4.8
Organic C %	23
TOTAL N mg/l	1400
Available P mg/l	400
Potassium mg/l	1800
Magnesium mg/l	700
Calcium mg/l	439
Sodium mg/l	120
Biochemical Oxygen Demand (BOD)	2000
Chemical Oxygen Demand (COD)	4600
Total solids mg/l	3899
Total suspension solids mg/l	1000
Oil (%)	0.57

Table 2: Soil Chemical Properties before and after the experiment

	Particle Size Analysis								Exchangeable Base						
									← Cmol Kg g^{-1} →						
	Treatment grains)	Sand (%)	Silt (%)	Clay (%)	pH (H_2O) 1:1	Organic Carbon (%)	Total Nitrogen (%)	Available Phosphorus (%)	Ca	Mg	K	Na	Exchangeable Acidity	Fe_2O_3	Al_2O_3
Before effluent application		8.3	2	15	5.22	0.86	0.4	3.16	1.05	0.32	0.09	0.06	1.86	0.85	0.22
After	0	82	2	16	5.51	1.12	0.07	4.00	1.64	0.28	0.09	0.06	0.12	2.10	0.06
effluent	50	81	3	16	5.56	1.91	0.10	3.28	1.40	0.21	0.11	0.08	0.16	2.00	0.09
application	100	83	3	14	5.33	2.53	0.13	2.91	1.92	0.31	0.13	0.10	0.20	2.20	0.13
	150	82	4	14	5.20	3.62	0.18	2.37	2.24	0.38	0.13	0.12	0.24	2.83	0.15
	200	83	3	14	5.18	3.99	0.20	2.37	2.25	0.33	0.15	0.13	0.36	3.14	0.15

Effect of Oil Palm Effluent on Some Soil Physico-chemical Properties

The soil used in this study is an Ultisol as shown by its low percent base saturation (less 35%). The pH is acidic (5.22) and the particle analysis revealed that the soil is loamy sand (Table2). The soil particle size analysis revealed no changes in the soil texture with palm oil mill effluent. Similar results have been reported for brewery effluent (Orhue *et al.,* 2005) and pharmaceutical effluent (Osaigbovo and Orhue 2006).

The soil pH rose from 5.22 to 5.56 at 50g/kg effluent treatment. The pH however declined as the effluent application increased. The reduction in pH at higher application may be due to the presence of Fe and Al in the effluent. These trace elements have been reported to influence soil pH (Tisdale *et al.*, 1985). This result was however in agreement with the findings of Orhue *et al.*, (2005) and Osaigbovo and Orhue (2006) who observed a rise in soil pH with brewery and pharmaceutical effluents respectively. The organic carbon content rose from 0.86% to 3.99% in 200g effluent application. The increased organic matter content may be attributed to the presence of suspended and dissolved solids that are converted during microbial activities into organic carbon. This results collaborates with the reports of Poon (1982) using palm oil mill effluent, Orhue *et al.,* (2005) using rubber effluent and Osaigbovo and Orhue (2006) using pharmaceutical effluents. The total N increased progressively as the effluent application was increased. The highest value of N (0.20%) was obtained at 200g of effluent treatment. Vieities and Brinkoli (1993) and Ogboghodo *et al.,* (2003) reported an increase in soil nitrate with cassava mill effluent. The available P decreased with effluent application. The lowest value (2.73%) was obtained at 200g effluent treatment. The decrease in available P may be due to the decline in the soil pH. Tisdale *et al.*, (1985) reported pH as one of the factors affecting the availability of P to plants. The exchangeable Ca rose from 1.05Cmolkg^{-1} to 2.25 Cmolkg^{-1} in 200g effluent application. The increase in exchangeable Ca content even at a reduced pH may be due to the different buffering capacity of the soil at different levels of effluent application. Exchangeable Mg follows a similar trend with Ca. The highest value of Mg (0.38 Cmolkg^{-1}) was recorded in 150g effluent treatment, followed by 200g (0.31 Cmolkg^{-1}) effluent treatment. Exchangeable Mg then declined in 50g (0.21 Cmolkg^{-1}) effluent treatment. The exchangeable K rose from 0.09 Cmolkg^{-1} to 0.15 Cmolkg^{-1} in 200g effluent treatment. Increased K value have been reported for soils treated with rubber effluent (Orhue *et al.*, 2005), brewery effluent (Orhue *et al.*, 2005) and pharmaceutical effluent (Osaigbovo and Orhue, 2006). The Na content and exchangeable acidity rose from 0.06 Cmolkg^{-1} in control to 0.13 Cmolkg^{-1} in 200g effluent treatment and 0.12 Cmolkg^{-1} to 0.36 Cmolkg^{-1} respectively.

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

The results presented in Tables 3 – 6 showed that the maize grown in the control treatment was significantly (P>0.05) better in all the growth parameters measured. The trend was control>50g>100g>150g>200g effluent treatment. The fresh and oily nature of the effluent may have created anaerobic condition, which may have affected nutrient uptake and consequently depression of growth of maize in the treated soils.

Table 3: Effect of palm oil mill effluent on number of leaves in maize plant (*Zea mays* L.).

	Weeks after planting			
Treatment (g)	2	4	6	8
0	3.80^{a}	5.27^{a}	5.73^{a}	6.60^{a}
50	3.27^{b}	4.07^{b}	3.73^{b}	4.37^{b}
100	3.07^{b}	3.80^{b}	3.60^{bc}	4.20^{b}
150	3.00^{b}	2.87^{c}	2.60^{cd}	3.77^{bc}
200	3.00^{b}	2.73^{c}	2.33^{d}	2.80^{c}

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 4: Effect of palm oil mill effluent on plant height in maize plant (*Zea mays* L.).

	Weeks after planting			
Treatment (g)	2	4	6	8
0	8.77^{a}	12.10^{a}	19.99^{a}	23.77^{a}
50	5.60^{b}	7.15^{b}	10.27^{b}	12.28^{b}
100	4.99^{bc}	6.13^{bc}	8.99^{b}	11.64^{b}
150	4.55^{cd}	5.37^{c}	6.13^{c}	9.25^{bc}
200	3.79^{d}	4.13^{d}	5.23^{c}	6.44^{c}

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 5: Effect of palm oil mill effluent on leaf area (cm^2) in maize plant (*Zea mays* L.).

	Weeks after planting			
Treatment (g)	2	4	6	8
0	148.41^{a}	439.48^{a}	853.00^{a}	1232.80^{a}
50	68.15^{b}	157.12^{b}	203.90^{b}	324.60^{b}
100	51.29^{bc}	108.10^{c}	201.30^{b}	299.30^{b}
150	42.17^{bc}	59.24^{bd}	53.24^{c}	138.40^{b}
200	37.18^{c}	45.57^{d}	25.35^{c}	60.20^{b}

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 6: Effect of palm oil mill effluent on plant girth (cm^2) in maize plant (*Zea mays* L.).

	Weeks after planting			
Treatment (g)	2	4	6	8
0	1.55^{a}	2.02^{a}	2.87^{a}	3.33^{a}
50	1.21^{b}	1.39^{b}	1.83^{b}	2.10^{b}
100	1.14^{bc}	1.30^{b}	1.75^{b}	2.03^{b}
150	1.09^{bc}	1.20^{bc}	1.36^{c}	1.69^{bc}
200	1.03^{c}	1.10^{c}	1.30^{c}	1.36^{c}

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Effect of Palm Oil Mill Effluent on Nutrient Uptake

The results shown in Table 7 followed the same trend as that of growth. Control recorded the highest nutrient uptake, N (0.125Mgkg^{-1}), P (0.018 Mgkg^{-1}), K (0.127 Mgkg^{-1}), Ca (0.031 Mgkg^{-1}), Mg (0.007 Mgkg^{-1}) and Na (0.005 Mgkg^{-1}) while the lowest value was obtained in 200g effluent application, N (0.009 Mgkg^{-1}), P (0.006 Mgkg^{-1}), K (0.025 Mgkg^{-1}), Ca (0.010 Mgkg^{-1}), Mg (0.002 Mgkg^{-1}) and Na (0.001 Mgkg^{-1}). Nutrient uptake declined with increased effluent application. According to Orhue *et al.*, (2005) while citing Clinton and William, reported that certain factors such as temperature, aeration, plant age, concentration of competing ions, alteration of soil pH as well as nutrient interaction may influence variation in nutrient uptake. Furthermore, the reduced nutrient uptake in the presence of effluent could occur due to strong adsorption or degradation in the soil and that the extent of adsorption or degradation does not only depend on the properties of the effluent but also on the properties of the site, soil types, kind of soil organisms and climatic conditions (Drewes and Blume, 1977).

Table 7: Effect of palm oil mill effluent on nutrient uptake in maize plant (Zea mays . L)

	Nutrient Uptake (mg kg^{-1})					
Treatment (gram)	N	P	K	Ca	Mg	Na
0	0.125^{a}	0.018^{a}	0.127^{a}	0.031^{a}	0.007^{a}	0.005^{a}
50	0.114^{a}	0.011^{a}	0.081^{b}	0.024^{b}	0.006^{a}	0.003^{ab}
100	0.078^{b}	0.008^{b}	0.070^{b}	0.028^{a}	0.006^{a}	0.003^{ab}
150	0.022^{c}	0.006^{b}	0.033^{c}	0.012^{d}	0.004^{ab}	0.002^{ab}
200	0.009^{d}	0.006^{b}	0.025^{c}	0.010^{d}	0.002^{b}	0.001^{b}

Value with the same superscript in the column are not significantly different from one another at 5% level of probability.

Conclusion

The result of the trial showed that percentage organic carbon, total N, Ca, Mg, K, exchangeable acidity and Na content of the treated soil increased while pH and available P decreased. The uptake of N, P, K, Ca, Mg and Na reduced with increased effluent application. Also, results obtained from some agronomic characteristics measured showed that the control performed better than all other levels of effluent application throughout the period of the trial. Though, oil palm mill effluent contains nutrient that are necessary for the growth of maize, the effects of these nutrients was not reflected as indicated by the growth and nutrients uptake of the test crop.

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