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RESPONSE OF PALM OIL SLUDGE ON SEXUAL REPRODUCTIVE BIOLOGY AND ROOT DEVELOPMENT OF SOME CROPS IN SOUTHERN NIGERIA

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ABSTRACT
Experiment on the influence of different rates of palm oil sludge (0, 4000lit/ha, 8000lit/ha, and 12000lit/ha) application on flower initiation and root development of okra (Abelmoschus esculentus), maize (Zea mays L.) and cowpea (Vigna unguiculata (L.) Walp) were investigated in Port Harcourt, Nigeria. The result of the trial shows that there was significant (P<0.05) variation in the time of flowering for the crops as the treatment levels increases. The highest number of flower initiation for maize was obtained at 4000lit/ha application. At a higher level of application (12000lit/ha) the number of flowers decreased in all the crops studied hence the success of seed production was adversely affected. On root development, number of roots and length of roots decreased as the treatment levels increases from 4000lit/ha to 8000lit/ha and above in okra and maize. On cowpea root nodulation, there was significant (P<0.05) difference among the sludge levels. The nodules number increased from 22.3 to 63.0 per stand, with an increase in sludge rate from 4000lit/ha to 12000lit/ha. The number of flower initiation differs significantly at higher rate of sludge application. It is recommended to apply lower oil palm sludge rate (4000lit/ha) which enhances seed production of maize and okra and a higher rate (12000lit/ha) for root nodulation of cowpea.

Key-words: Palm oil sludge, Flowering, Root development, Okra, Cowpea, Maize

INTRODUCTION
Palm oil sludge is otherwise known as Palm Oil Mill Effluent (POME). It is brown slurry composed of 4-5% organic matter, 1% residual oil and 95% water with some organic nitrogen (Onyia *et al.*, 2001). They also reported that in Malaysia, Palm Oil and Rubber industries are sources of major polluting effluents and they contribute about 80% of the industrial pollution. Palm oil sludge could be a pollutant to the environment due to the offensive odour or as a contaminant resulting from the volumes it discharges to the environment. Palm oil sludge is one of the bi-products from the processing of oil palm fruits and they are discharged as wastes to arable land. This has been a continuous exercise among many palm oil processing industries over the years. However, there is paucity of information on its effects on root development and sexual reproductive system of crops in such areas where oil palm mill is sited. Oil palm is mainly grown in Southern part of Nigeria and palm oil mills are localized in those areas for the processing of oil palm fruits. These Palm oil mills are sited indiscriminately and its waste product (Palm oil sludge) is also indiscriminately discharged to arable land. Most of the food items being produced in Nigeria today are by smallholder farmers who practice land rotation (i.e bush fallow). This has been the practice in the yester-years, but as at today with a population of over 150 million people in Nigeria, this practice is gradually phased out so as to facilitate continuous cropping system to meet the increasing demand for food by the ever increasing human population.

In this study, okra (a vegetable crop), maize (a cereal crop) and cowpea (a leguminous crop) were selected in order to assess the effects of different rates of palm oil sludge application on the root development of these crops and their sexual reproductive biology (i.e

flower development) in Rivers State, Nigeria. The choice of these crops was attributed to their wide utilization and cropping in the areas of study. Maize (*Zea mays* L.) is the most widely distributed and the third most important cereals after wheat and rice. It is also the third most important cereal in Nigeria after sorghum and millet (Purseglove, 1972). Maize is principally used for human consumption and livestock feed. Okra, *Abelmoschus esculentus (L.)* Moench is a highly relished vegetable in many parts of Nigeria. The fruits are known to contain essential vitamins, minerals and proteins (Oyenuga, 1968). It is generally grown as a sole crop in home gardens or intercropped with other crops in large farms.

Cowpea is an annual herbaceous legume and can be grown with less rainfall and under more adverse conditions than the common beans (Onwume, 1988). The crop is cultivated for human food and for livestock feed. A higher level of palm oil sludge application up to 12,000 lit/ha reduced crop emergence, plant height and cob/grain yield of maize and okra (Orluchukwu and Ogburia, 2010). Isirimah *et.al.*,(1989) reported on the effect of crude oil on maize performance and soil chemical properties. They posited that crude oil treatment of soil at 1% and 2% adversely affected crop emergence, plant height, grain yield and dry production of maize.

In view of the increasing number of oil palm mills in the rural areas where the bulk of smallholder farmers reside and practice farming, there is the need to determine the effects of the palm oil sludge that is discharged indiscriminately and consistently to farm lands. The paucity of information on the effects of the palm oil sludge on the sexual reproductive biology (flowering habit), and root development of crops necessitated the trial.

METHODOLOGY

Experimental Site

The study was carried out in the Teaching and Research Farm of University of Port Harcourt, Nigeria. The University is on latitude $4^0$31' to 5^0N and longitude $6^0$41' to 7^0E, with an average temperature of 27^0C, relative humidity of 78% and average rainfall that ranges from 2500 – 4000mm (Nwankwo *et. al.*, 2010). Soil of the experimental plots was sampled and routine analysis was carried out. The rainfall pattern is essentially bimodal with peaks in June and September while in April and August there are periods of lower precipitation. The long rainy season is between August and October. The dry season lasts from November to March with occasional interruption by sporadic down pours. The soil at the site belonged to the great soil group – Typic Paleudult (Soil Survey Staff, USDA, 1975).

Treatments and Experimental Design

The experiment was conducted between the months of March – July, 2012. A plot size of 30m x 30m ($900m^2$) was used for the experiment. A complete randomized block design was used. The treatments were randomized with four replications. Each plot had six (6) rows, and each crop appeared in two rows per plot of 5m x 5m. The Palm oil sludge was analyzed chemically for N, P, K, Ca, Na and Mg before application. This was to determine the chemical composition of the palm oil sludge and the results obtained were recorded.

The Palm oil sludge (liquid waste) used for the study was obtained from the oil palm company (Risonpalm Limited) situated at Ubima Estate in Rivers State. The various doses of oil palm sludge used were 0, 10, 20 and 30 litres/plot of $25m^2$ (0, 4000, 8000, 12000 lit/ha). This was applied to the soil evenly using 10 litre watering can. Seeds of crops were sown at seven days after application of palm oil sludge. Data were collected on percentage germination, crop emergence, flowering (sexual reproduction) period, and root development. Crop emergence was taken seven days after sowing. This was done by counting the emerged seedlings per plot of treatment. The percentage seed germination or emergence was calculated using the formula:

$$\frac{number\ germinated}{number\ planted} x\ 10o$$

On flowering period, the time of flowering of each plant per treatment was observed and the number recorded, while data for root development or formation was done by uprooting each plant stand per plot of treatment. The number of roots and their length were measured and recorded. The number of nodules for cowpea was counted and recorded.

Data analysis

Data obtained were subjected to analysis of variance (ANOVA) test and differences between means were determined at 5% probability using Duncan Multiple Range Test (DMRT).

RESULTS

The oil palm sludge was analyzed to determine its nutrient content, and the result is shown in Table 1.

Table 1: Mineral composition of Palm oil sludge

Mineral contents	% chemical composition
N	1.91
P	0.32
K	3.86
Na	0.07
Mg	1.48
Ca	0.40

The effects of various levels of oil palm sludge on crop emergence, flower initiation and root formation are shown in Tables 2, 3 and 4, respectively.

Table 2: Impact of palm oil sludge on percentage emergence of test Crops

Sludge rates	Okra	Maize	Cowpea
Control	92 ± 0^{a}	92 ± 0^{a}	92 ± 0^{a}
4000lit/ha	90 ± 0^{b}	90 ± 0^{b}	90 ± 0^{b}
8000lit/ha	90 ± 0^{b}	90 ± 0^{b}	90 ± 0^{b}
12000lit/ha	88 ± 0^{b}	88 ± 0^{b}	88 ± 0^{b}

Means followed by the same letter do not differ significantly at $P<0.05$ according to Duncan's New Range Multiple Test (DMRT).

Table 3: Impact of palm oil sludge rates on flower initiation at 6 weeks after sowing (WAS)

Sludge Rates	Okra	Maize	Cowpea
0 lit/ha	6 ± 0.82^{a}	6.75 ± 0.5^{ab}	4.0 ± 0^{a}
4000lit/ha	7 ± 2.16^{b}	8.50 ± 5.8^{a}	4.0 ± 2.16^{a}
8000lit/ha	4 ± 1.41^{b}	7.75 ± 0.5^{b}	2.3 ± 1.5^{b}
12000lit/ha	0 ± 0^{c}	5.25 ± 0.5^{b}	2.0 ± 0.82^{c}

Means followed by the same letter do not differ significantly at P≤0.05 according to Duncan's New Range Multiple Test (DMRT).

Table 4: Impact of palm oil sludge rate on root development of crops and cowpea nodulation

Sludge Rates	**Okra**		**Maize**		**Cowpea**		
	No. of roots	Length of roots	No. of roots	Length of roots	No. of Nodules	No. of roots	Length of roots
Control	19.26 ± 0.96[b]	8.45± 0.42[b]	14.50 ± 0.96[b]	16.96±0.81[b]	28.25± 1.5[c]	39.25±1.71[c]	18.33±1.33[a]
4000lit/ha	22.0± 1.4[a]	10.75±1.19[a]	19.50 ± 1.90[b]	21.25±2.5[a]	22.25± 1.5[d]	30.0± 1.63[b]	9.45± 0.80[d]
8000lit/ha	17.0± 0.82[c]	7.25±1.10[b]	10.25 ± 1.30[d]	13.43±0.44[c]	50.25± 3.86[b]	35.0± 1.63[b]	15.18±0.77[b]
12000lit/ha	15.5± 0.58[c]	6.30±0.29[bc]	23.0± 1.80[a]	12.50±0.41[c]	63.0± 2.16[a]	41.0± 1.0[a]	14.0± 1.41[c]

Means followed by the same letter do not differ significantly at P≤0.05 according to Duncan's New Range Multiple Test (DMRT).

Palm oil sludge treatment at 8,000lit/ha and 12000lit/ha adversely affected the parameters studied. One crop emergence, treatment levels at 4000 lit/ha and 8000 lit/ha did not show any significant different (P>0.05) at 90% crop emergence, but the higher rate of 12000 lit/ha had a lower percentage crop emergence (88%), hence showed a significant difference (P<0.05) from other levels. The flowering periods of okra, maize and cowpea exhibited a significant variation at different levels of treatment especially as the treatment levels increases. The highest number of flower initiation for maize was obtained at 4000 lit/ha application. For cowpea, the flowering period was at 5 weeks after sowing (WAS) but the number of flowers differs significantly at higher rate of application (12000 lit/ha). Flowering in okra increased at 4000 lit/ha application of the sludge, but decreased as sludge application increased.

The results of palm oil sludge on root development of the crops and cowpea nodules are shown in Table 4. For cowpea root nodules there was a significant difference among the sludge levels. The nodules number increased from 22.4 - 63.0 per stand with an increase in sludge rate from 4000 – 12000 lit/ha. The highest length of roots was observed in the control plot while the highest sludge rate (12000 lit/ha) had the least root length of 14.0cm.

DISCUSSION

The low percentage of crop emergence due to high level of palm oil sludge application is attributable to poor aeration in soil. This was further confirmed by carrying out a separate experiment where the ungerminated seeds from the field were removed and sown with a more favorable moisture condition and 90% germination was observed. The low level of crop emergence on the high level of sludge treatment is associated with poor wettability and aeration (Strafford, 1973). As the palm oil sludge rate increases, the rate of flower initiation, which is the sexual reproduction of the crops, decreases. Pistillate flowers were considered because as in cassava, pistillate flowers determine the success of seed production (Kawano,

1980). Therefore, increase in palm oil sludge rate will lead to decrease in seed production in okra and maize. This will equally cause decrease in cowpea nodulation.

Number of roots and length of roots decreased as the treatment level increases in okra and maize. Similarly, Gundlach *et.al.,* (1981) indicated that where a spillage occurs within the mangrove system and both substrate root systems are oiled, defoliation and tree death occurs rapidly within months and where the mangrove is killed outright, numerous stress responses, on the trees as well as mangroves associated organisms may follow. At a treatment level of 4000 lit/ha roots development of the test crops was better compared to other levels of treatment. Better root formation will enhance anchorage of the plant in the soil and it will also withstand wind pressure, lodging effect of crop will be reduced, while poor root development of crop can cause easy lodging of crops resulting from wind effect.

CONCLUSION

The study has shown that palm oil sludge rate at 4000lit/ha will enhance the root development and higher number of flower development of the test crops (okra, maize , cowpea) while a higher rate of application will endanger or adversely affect root and flower development of crops. On cowpea nodulation, a significant difference exists in various rates of application as higher rate of sludge application enhances root nodulation. Therefore, farmers are advised to only cultivate on lands not heavily contaminated with palm oil sludge to avoid poor development of roots which will lead to easy lodge of crops, and reduction in flowering which subsequently affects seed production.

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