Evaluation of Palm Oil Mill Effluent (POME) Impact on Soil Chemical Properties and Weed Cover in Awka–Rain Forest Zone of Nigeria

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ABSTRACT

A factorial experiment fitted into a randomized complete block design was used to test the impact of POME on some soil chemical parameters and weed cover at the Nnamdi Azikiwe University Awka Teaching and Research Farm. POME levels of 8000l/ha,6000l/ha,4000l/ha and 0l/h(control) were applied on the plots after which three cultivars of cowpea were planted(Dan Kano, Bornu local and Sokoto local). During the course of the work, increasing the level of POME application increased the soil pH. At 8000l/ha the soil was slightly alkaline (9.5) and (8.1) during wet and dry seasons respectively.Exchangeable bases like calcium and potassium also increased with increase in POME rates. But there was a slight decrease in total nitrogen and C/N ratio in both seasons with increase in POME rates.On weed infestation,the control plots had the largest weed score(3.5) and weed weight (670.45g/m^2) in rainy season while 8000l/ha plots had the least weed score(2.0) and weed weight (170.73g/m^2) also in rainy season. This work showed that POME,an organic waste can be effectively and safely applied on farm lands at rate of up to 8000l/ha especially if cowpea is to be planted notably Sokoto local which gave the highest yields (0.3 and 0.24t/ha)in rainy and dry seasons respectively.

Keywords: *Cowpeacultivars, POME, Weed score/weight, Lit/ha, C/N ratio, Exchangeable bases.*

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Highlights of this paper

- Combination of organic amendment such as POME with soil chemical properties and weed management.
- Use of Palm Oil Effluent (POME) to improve soil chemical properties such as organic carbon, available phosphorus, soil pH and exchangeable bases like calcium, magnesium and potassium.
- Use of organic amendment such as palm oil effluent in a specified quantity can tackle weeds on cowpea cultivars such as Dan Kano, Borno local and Sokoto local.

1. INTRODUCTION

Oil Palm tree *(Elaeis guineensis)* is a tropical forest palm native to West Africa. Grown in plantations it produces 3–8times more oil from a given area than any other tropical or temperate oil crop [1]. Vegetable oils can be extracted from both the fruitmesocarp (crude palm oil) and the seed (palm-kernel oil). Most crude palm oil is used in foods. In contrast, most palm-kernel oil is used in various non-edible products, such as detergents, cosmetics, plastics, surfactants, herbicides, as well as a broad range of other industrial and agricultural chemicals [2].

Processing oil palm into palm oil produces large amounts of liquid waste, around 55% to 67% of the total fresh fruit bunches processed [3]. This fresh waste is in the form of a colloidal suspension consisting of94-95% water, 0.7-1%oil and 4-5%total solids including floating solids of 2-4%. Raw or unprocessed palm oil mill effluent (POME) has a high Biochemical Oxygen Demand (BOD) value around 25,000mgL^{-1}or more [2] hence the POME produced by palm oil companies must be processed in order to have no negative impact on humans or the environment.

The palm oil industry is a major agro based enterprise in Nigeria especially in the southern part of the country where palm oil trees are found both in the wild and plantations [4]. These effluent streams are normally disposed of in drainage channels or stored in evaporation ponds or worse still discharged in arable lands to possibly avert the cost of treatment [5].

This practice is predominant in developing countries where effluent discharge standards are not strictly adhered to. It has been observed that most of the POME produced by the small-scale traditional operators undergoes little or no treatment and is usually discharged into the surrounding environment.Weeds damage crops by competing for light, water and nutrients. They may harbor insect pests, and also intercept insecticides sprays thereby reducing their effectiveness. Generally Crops suffer from weeds particularly when they are in the early stages. Weeding should be done by the second week after germination, although this depends on the type of crop, weeds present and how well the land was prepared. Pre-emergence herbicides are used before planting or crops emergence while selective post emergence herbicides are used when the crops have fully grown.The purchase and application of herbicides is costly in-terms of material and human involvements.Most herbicides also pollute the environment and underground water bodies.

Cowpea Vignaunguiculata, (L) walpis a grain legume of the family Fabaceae.It is one of the most popular and important crops in the tropics [6].It is basically grown in the third world for its cheap source of dietary protein and a supplement for meat. It maybe consume at various stages of its development; green leaves, greenpods, green peas, dry grains and the straw are excellent animal feed [7].Itsoptimumyieldshave,however,notbeenrealizeddueto pests, diseases and weed infestations and other limiting factors.This research, therefore, aimed at studying the general impact of POME on soil physic-chemical properties like pH,cation exchange capacity, total organic carbon and total nitrogen and how these changed properties affect weed cover and performance of cowpea.

2. MATERIALS AND METHOD

2.1. Experimental Materials

Cowpea cultivars used were: Dan Kano (A1) ,Bornu local (A2) and Sokoto local (A3) .They were sourced from Michael Okpara Federal University of Agriculture ,Umudike , Nigeria. The palm oil mill effluent (POME) was sourced from an oil mill in Elele in Ikwerre Local Government Area of Rivers State,Nigeria.The four levels of the POME applications were termed factor as followed 4000lit/ha (B1),6000lit/ha(B2),8000lit/ha(B3) and Control 0lit/ha(B4).The twelve treatments combinations used were A1B1,A1B2,A1B3 and A1B4,A2B1,A2B2,A2B3 and A2B4,A3B1,A3B2,A3B3 and A3B4.The treatment combinations were randomized within each block and replicated three times.

2.2. Experimental Design

A 3×4 factorial arrangement that was fitted into randomized complete block design (RCBD) was used for the experiment. Data collected were subjected to analysis of variance and significant means separated by least significant difference (LSD).

2.3. Cultural Practices

Land clearing for dry season planting was done on November26th,2017 while that for 2018 rainy season was done on April 6th. POME was applied seven days before planting in the different seasons to allow percolation before planting. Planting was done manually at 25cm × 30cm.

2.4. Data Collection

Soil samples were collected from 0 to 15 cm depth in all the 12 subplots and composited for analysis before POME application.Composite soil samples were also collected and analyzed towards the end of the experiment.

Analysis of chemical properties of soil samples: These assays were carried out after the soil samples have been air-dried, after which they were sieved in a 2 mm mesh and the samples leached and the leachate used in the assays.

The soil pH was determined electrometrically using EL model 720 PH meter.Exchangeable cations (Ca, K, Na and Mg) were determined according to the methods described by Agbenin [8]. A flame photometer (FP 640) was used in this assay.Cation exchange capacity: This was determined according to the method described by Agbenin [8]. Percentage carbon and organic matter analysis was done using a modified method of Landis, et al. [9]. Available phosphorus in the soil was determined using the Trough method as described by Landis, et al. [9].

Weed count was taken at 6 WAP, the weight per treatment taken to determine the response to POME levels.This was done for every squaremeter(m^2). Weed score was used: 1=3.0, 2=2.5, 3 = 2.0,4 =1.5 and 5=1.After the final harvest, drying, threshing and winnowing. The final grain yield at 14% moisture content was determined for each plot using weighing balance.

3. RESULTS

Table-1. Effect of POME on soil pH and total nitrogen(%).

	Soil pH				Total Nitrogen(%)			
	Wet season		Dry season		Wet season		Dry season	
POME level	Before	After	Before	After	Before	After	Before	After
Control	6.9	6.9	6.7	6.8	0.39	0.38	0.42	0.43
4000lit/ha	6.9	7.5	6.7	7.2	0.39	0.28	0.42	0.35
6000lit/ha	6.9	7.8	6.7	7.4	0.39	0.26	0.42	0.35
8000lit/ha	6.9	9.5	6.7	8.1	0.39	0.28	0.42	0.36

Soil pH values obtained at 1:25 soil/water showed that increasing POME rates increased soil pH and reduced soil acidity Table 1. At 8000l/ha, the soil was slightly alkaline (9.5 and 8.1) in wet and dry seasons respectively.The table also showed that increasing POME rates also slightly decreased available Nitrogen, for example at 6000l/ha POME rate total nitrogen before and after application in dry season was(0.42 and 0.35)and in rainy season was (0.39 and 0.26) Table 1.

Table-2. Effect of POME on available phosphorus(%) and organic carbon(%).

	Available Phosphorus(%)				Organic Carbon(%)			
	Wet season		Dry season		Wet season		Dry season	
POME level	Before	After	Before	After	Before	After	Before	After
Control	0.70	0.70	0.78	0.78	0.56	0.56	0.60	0.60
4000lit/ha	0.70	0.72	0.78	0.76	0.56	0.54	0.60	0.58
6000lit/ha	0.70	0.75	0.78	0.75	0.56	0.50	0.60	0.50
8000lit/ha	0.70	0.76	0.78	0.68	0.56	0.52	0.60	0.53

There was an increase in available phosphorus with increase in POME level during wet season whereas the trend changed during dry season Table 2. There was a general slight decrease of organic carbon with increase in POME levels in both seasons although not significant.

Table-3. Effect of POME on carbon/nitrogen (C/N) ratio.

POME level	Wet season		Dry season	
	Before application	After application	Before application	After application
Control	0.56:0.39	0.56:0:38	0.42: 0.60	0.38:0.51
4000lit/ha	0.56:0.39	0.54:0.28	0.42: 0.60	0.38.0.51
6000lit/ha	0.56:0.39	0.50:0.26	0.42: 0.60	0.35:50
8000lit/ha	0.56:0.39	0,52:0.28	0.42: 0.60	0.36:0.53

Both wet and dry seasons recorded decreased C/N ratio as POME rates increased Table 3.

Table-4. Effect of POME on exchangeable cations(meg/100g soil).

	Potassium (K)				Calcium (Ca)				Magnesium (Mg)			
	Wet season		Dry season		Wet season		Dry season		Wet season		Dry season	
POME levels (lit/ha)	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
0	0.27	0.28	0.38	0.38	0.02	0.25	0.03	0.03	0.10	0.10	0.05	0.05
4000	0.27	0.33	0.38	0.40	0.02	0.03	0.03	0.03	0.10	0.12	0.05	0.50
6000	0.27	0.35	0.38	0.40	0.02	0.03	0.03	0.02	0.10	0.13	0.05	0.05
8000	0.27	0.40	0.38	0.43	0.02	0.23	0.03	0.03	0.10	0.12	0.05	0.63

Table-5. Impact of oil palm sludge levels on weed species incidence during wet season planting.

Oil Palm sludge level	Weed species	Sub class	% Abundance	Weed score
Control	Panicummaximum jacq.	Monocot	50.0	
	Asphiliaafricana, sidaacuta			
	Calapogoniummucunoids	Dicot	30.0	
		Dicot	12.0	
		Monocot	8.0	3.5
4000lit/ha	Panicium maximum jacq	Monocot	48.0	
	Asphiliaafricana			
	Sidaacuta	Dicot	38.0	3.0
		Dicot	8.0	
	Calapogonium mucunoids	Monocot	6.0	
	Panicum maximum jacq			
		Monocot	40.0	
6000 lit/ ha	Asphiliaafricana	Dicot	50.0	
	Sidaacuta	Dicot	6.0	2.5
	Calapogonium mucunoids	Monocot	4.0	
8000 lit/ ha	Panicum maximum jacq	Monocot	35.0	
	Asphiliaafricana			
	Sidaacuta	Dicot	28.0	
		Dicot	4.0	2.0

Table-6. Impact of oil palm sludge levels on weed species incidence during dry season planting.

Oil Palm sludge level	Weed species	Sub class	%Abundance	Weed score
Control	Panicummaximum jacq.	Monocot	46.0	
	Asphiliaafricana	Dicot	30.0	
	Sidaacuta	Dicot	28.0	3.0
4000lit/ha	Panicium maximum jacq	Monocot	40.0	
	Sidaacuta	Dicot	30.0	
	Asphiliaafricana	Dicot	25.0	2.5
6000 lit/ ha	Panicium maximum jacq	Monocot	35.0	
	Sidaacuta	Dicot	25.0	2.5
	Asphiliaafricana	Dicot	20.0	
8000 lit/ ha	Panicum maximum jacq	Monocot	30.0	
	Sidaacuta	Dicot	15.0	
	Asphiliaafricana	Dicot	10.0	1.5

Table-7. The effect of POME levels on fresh weight of weeds at 6 WAP (g^{-ha}).

Oil Palm Sludge level (lit/ha)	Fresh weed weight (g/m^2) during wet season	Fresh Weed weight (g/m^2) during dry season
Control	670.45	520.30
4000	540.56	460.40
6000	392.62	300.50
8000	170.73	110.52
LSD	2.60	1.82

During both seasons, potassium increased with increase in POME rates ,Calcium also recorded such increase but Magnesium level did not vary much despite season or POME level Table 4.

Weeding was done at 6WAP and the result showed that the dominant weed in the plots was *Panicummaximum*(50%) on control plot Table 5. The highest weed score during the wet was recorded in control plot(3.5) while the least weed score was recorded in the 8000l/ha plot(2.0).

There was slight decrease in weed score during the dry season.The weed score trend was also the same as in wet season Table 6. The control plot had the highest weed score(3.0),4000l/ha and 6000l/ha POME applied plots had the same score(2.5),while 8000l/ha plots had the least score(1.5).The weed incidence decreased with increase in POME application rate.

POME application significantly affected weed incidence and populations Table 7. The highest weed weight(670.45g/ha) was recorded in control plot during the wet season while the least came from 8000l/ha POME plot(170.73g/ha).The same trend was followed in the dry season,the control plot recorded(520.30g/ha) while the least weight came from 8000l/ha POME plots(110.52g/ha).

Table-8. Effect of POME on cowpea yield components.

	Number of pods/seeds						Dry matter yield (t/ha)					
	Wet season			Dry season			Wet season			Dry season		
POME levels (lit/ha)	Dan Kano	Bornu local	Sokoto local	Dan Kano	Bornu local	Sokoto local	Dan Kano	Bornu local	Sokoto local	Dan Kano	Bornu local	Sokoto local
0	13	18	23	11	14	19	0.17	0.26	0.24	0.14	0.15	0.15
4000	13	18	23	12	15	18	0.15	0.24	0.24	0.18	0.18	0.18
6000	14	19	23	17	16	19	0.23	0.27	0.26	0.24	0.22	0.23
8000	14	18	25	12	17	20	0.25	0.25	0.30	0.16	0.25	0.24

LSD	0.50	0.26	0.15	0.12

The different levels of POME significantly affected the different cowpea seeds per pod and over all yield per hectare. During the wet season,Sokoto local had the highest number of seeds per pod(25) on 8000l/ha plot and on all other levels of treatments including control.The least was recorded on Dan Kano Table 8. The trend was also the same in dry season.On dry matter yield per hectare,Sokoto local also had the highest yield(0.30t/ha) on 8000l/ha plot in the wet season.Dan Kano recorded the least yield (0.14t/ha) on control plot during the dry season period.

4. DISCUSSION

The pH of the soil increased with increase in POME levels,plots that received 8000l/ha were even slightly alkaline in both wet and dry seasons Table 1. It has been reported that when raw POME is discharged the pH is acidic but tends towards alkalinity as biodegradation takes place [10]. Soil acidity (pH) is one of the principal factors affecting nutrient availability to plants. Therefore, the availability of plant nutrients in soils is affected by the acidity of the soil. When POME decomposes in the soil, it adds and also increases nutrients availability of the soil [11].

The slight increase of available Phosphorus and Exchangeable Cations with POME application was also attributed to the release of useful POME nutrients like phosphorus [12] and calcium by soil bacteria during POME decomposition. (Lim,1987).This must have contributed to the high dry matter wet season yield (0.30t/ha) of Sokoto Local on 8000l/ha POME plot. The slight decrease in soil total Nitrogen and organic carbon with increase in POME application was contrary to the findings of Amelia, et al. [13] and Hazelton and Murphy [14] sincethereis always an increase in atmospheric nitrogen fixation during oil decomposition phase by soil bacteria in both seasons.

The rate of weed infestation decreased with increase in the rate of POME application. POME contains unrecovered palm oil which forms a thick soil cover which prevents enough sun light to penetrate soil surface thereby smothering the weeds especially the low growing ones.It also displaced air from the soil pores there by creating anaerobic condition and reduced root hairs absorption abilities [15].

5. CONCLUSION

This work showed that POME, an organic waste can be effectively be applied on farm land at up to 8000l/ha to reduce weed infestation, improve soil stability and soil chemical properties especially for cowpea (Sokoto local) cultivation.

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