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ASSESSMENT OF PALM OIL MILL EFFLUENT (POME) ON THE GROWTH AND YIELD OF AMARANTHUS (Amaranthus caudatus)

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ABSTRACT

A pot experiment was conducted to check the effect of Palm oil mill effluent (POME) on the growth and yield of Amaranthus caudatus at the Faculty of Agriculture, Kogi State University, Anyigba. There were four (4) treatments in the experiment -- $0m^3$/ha, $30m^3$/ha, $90m^3$/h and $110m^3$/ha. The treatments were replicated six (6) times. Amaranth seeds (variety NH536-1) were raised in the nursery for two weeks before they were transplanted into plastic buckets (containing 10 kilogram of soil) and observed for a period of six (6) weeks. Growth and yield parameters measured were plant height, number of leaves, stem girth, crown weight and total biomass. Data collected were analyzed using ANOVA, means were separated using Fishers Least Square Difference ($F\text{-}LSD_{0.05}$). Result shows that Palm Oil Mill Effluent (POME) had a significant effect on the plant height, yield of amaranth and plant nutrient uptake. At 6 WAT, number of leaves had no significant effect. Also, at 4 and 6 WAT, stem girth also had no significant effect. Significant differences were seen in the treatments, with T4 and T3 ($110m^3$/ha, $90m^3$/ha application rates) giving the highest in most of the growth and yield parameters tested. A significant response was also observed in the plant nutrient uptake (N, P and K). Plant nutrient uptake increased with increasing rates of POME. Therefore, application rates --$110m^3$/ha and $90m^3$/ha of POME can be recommended for optimum amaranth production in the study area.

Keywords: Palm oil mill effluent, Amaranthus caudatus, Pome

INTRODUCTION

Amaranth originated in America and is one of the oldest food crops in the world. With evidence of its cultivation reaching back as far as 6700BC. The genus Amaranth consists of nearly 60

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species, several of which are cultivated as vegetables, grain or ornamental plants while others are weeds. At present Amaranth is extensively grown as a green, leafy vegetable in many temperate and tropical regions the largest area ever grown was during the height of the Aztec civilization in Mexico during the 1400s. Meanwhile, Amaranth had spread around the world had become established for food use (the grain or leaves) in places such as Africa, India and Nepal (Ben-ErK, 2002).

The importance of Amaranth can be seen in its economic and nutritional value. Amaranth remain largely a crop of small producers, consumed largely in areas where those are produced. Farmers who grow Amaranth have marketed their crop in a number of ways. There are also a few middle-men who buy from the farmers and market it to the larger health food companies. Amaranth leaf is used as a steamed vegetable in soups and stows. One of the reasons, there has been recent interest in amaranth is because of its useful nutritional qualities. The grain has some protein (12% to 17%) and is high in lysine and amino acid that is low in other grain crops. The grain is high in fibre and low in Saturated fats, factor which contribute to its use by the health food market. It is an exceptionally rich source of Calcium, Iron and Vitamin A and Riboflavin a rich source of niacin and an above average source of protein (Jonathan Geoffrey, 2001).

Inorganic and organic fertilizers provide plants with the nutrients needed to grow healthy and strong. However, each contains different ingredient and supplies these nutrients in different ways. Organic fertilizers work over time to create a healthy growing environment, while inorganic fertilizer provides rapid nutrition (Rene Miller 2008). Organic fertilization is preferred over inorganic fertilization in one aspect, organic fertilizers are derived from naturally occurring substance, such as plant or animal by products and mineral rock. Whereas inorganic fertilizers are synthetically manufactured. Organic matter in organic fertilizer help to improve the water holding capacity of soil and also augments its structure, thus increasing its nutrient holding capacity as well. Another benefit of organic matter in organic fertilizer is that it encourages microbial activity which plays a crucial part in the breakdown of nutrients so that plants can use them (Nestaret al., 1998).Organic fertilizers are available in many forms, these include compost, manure, marine by product, mulch etc. Palm oil mill effluent (POME) is rich in organic material. As such it can be used as organic amendment to soil. Treated POME contain nutrients that can be used to improve soil fertility status. Ojeniyi (2000) reported that the most prominent constraint to Amaranth production in this part of the world is low native fertility of the soil. Treated POME is assayed at different rates in this study. It is important to know the application rate best suited for optimum production of Amaranth. This will help agriculturist to know the quality of using POME as a cheap organic fertilizer that may offer an alternative to the excessive application of chemical fertilizer. This will increase the understanding on the effect of POME on crop yield, especially on the growth and yield of Amaranth (NH536-1) species. Objectives of this study

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were to evaluate the effectiveness of POME on the growth, yield and to determine nutrients uptake by Amaranth (NH536-1) species.

MATERIALS AND METHOD

Experimental location

The project was a pot experiment carried out between June and September at the Faculty of Agriculture, Kogi State University, Anyigba during the cropping season of2015. The area is located on latitude 7^0 15'N – 7^0 29'N and longitude 7^0 11'E – 7^0 32'E. It is situated within the southern Guinea Savanna agro ecological zone of Nigeria. The dry season generally extends from November to March. Temperature shows variation throughout the year with average monthly temperature varying between 17^0C and 36^0C and rainfall of 1600mm (Amakhian*et al.,* 2010)

Nursery

A nursery bed size of 1m x1m was established near the experimental site on the 20th July, 2015. Seeds were mixed with sand and mulched with grasses. Four days after, upon emergence of the seedlings, the mulches were removed and a shade was raised to reduce the incidence of sun rays on the seedlings because there was a drought during that period of time. With watering cans, watering of the nursery beds was done every morning and evening.

Experimental treatments and designs

An Amaranth species (NH536-1) was used to assess the effect of treated palm oil mill effluent. The treated POME was applied to the soil at different rate; using a pot experiment during 2015 cropping season. Treatment one $(0m^3/ha = 0mlperpot)$ serve as control, Treatment two$(30m^3/ha = 50mlperpot)$, Treatment three $(90m^3/ha = 90mlperpot)$, Treatment four$(110m^3/ha = 130mlperpot)$. The four treatments were replicated six times each, using completely randomized design (CRD).

Preparation and Transplanting

Experimental pots were filled with 10kg of soil. After two (2) weeks, the seedlings on the nursery were transplanted to the pots (after 14 days in the nursery bed). Transplanting was carried out early in the morning. Amaranthus seedlings were transplanted from nursery bed into each pot at four plants per pot, later reduced to two plants per pot. The treatments were four levels of POME and control replicated six times, making a total of twenty four (24) pots.

Experimental materials

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The experimental materials for this research work include: pH meter, weighing balance, beakers, nylon, measuring cylinder, Plastic drum, Sieve (2mm), ruler, oven dry, envelope, thread, film cupboard, knife flame photometer, electrical heater and atomic absorption Spectrometer (AAS)

Sample collection

The soil samples were collected from undisturbed soil, beside the Faculty of Agriculture Laboratory complex from a road leading to the Faculty of Medicine, Kogi State University, Anyigba, Kogi State Nigeria. The soil sample obtained was air dried and sieved through 2mm sieve to remove stone, gravel and debris. 10kg of sieve soil was weighted into each pot (24) pots and 500g of sieved soil was put into a polythene bag, label and taken to laboratory for pre-cropping soil analysis.

Palm oil mill effluent (POME) was obtained from palm oil milling site aseptically into a drum and allowed to ferment for 20 days in an enclosed room to allow the decrease of phytotoxic compounds. Fermentation was conducted using 100 litter bowls with diameter 0.83m. The bowl was fed with raw POME, Urea was added to the POME to facilitate microbial activity and nitrogen mineralization. Temperature was maintained at 30^0C and $Ca(OH)_2$ was added to the POME(Onyia*et al.,* 2010). Noted these conditions to be favourable for nitrification process to take place. The content was stirred at least once a day to provide aeration. Initial chemical properties of POME have been taken previously to analysis to ascertain Nitrogen (N), Phosphorous (P), Potassium (K), content of the POME. After transplanting mulching was done to avoid or reduce loss of water due to transpiration and evaporation.

Data collection

Growth parameters were taken at 2,4,6 and 8 weeks after transplanting (WAT) plant height (cm) per plant, number of leaves per plant and plant stem girth (cm) per plant were taken to observe the rate of growth. After the plant had reached maturity stage, the plants were carefully uprooted, root were washed with water thoroughly, such that they were free of soil particle. The fresh weight of the plant and fresh weight of the crown were also taken to know the biomass of the plant and the fresh plant and crown were oven-dried at 70^0C for 24 hours and dry weight were also taken.

Soil data

Post- cropping soil samples were taken from the pots. The soil samples were air dried for five days under ambient temperature and sieved through 2mm sieve.

Particle size analysis

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Hydrometer method was employed to determine the particle size which involves the dispersion of the soil sample with sodium hexametaphosphate. The percentages of clay, silt and sand were determined according to Bouyoucus (1951).

Determination of pH

pH was determined using electronic method measured by pH meter as described by McLean (1982).

Determination of organic carbon

Organic carbon content determination was done by walkley-Black method. The method involved the oxidation of soil with dichromate and tetraoxosulphate (vi) (H_2SO_4). The residual dichloromate was titrated against ferrous sulphate. Organic matter was obtained by multiplying percent of soil organic carbon by a factor of 1.724 following the assumption that organic matter is composed of 58% content.

Determination of phosphorus

The available phosphorus in the soil and plant was determined by the (Bray and Kurtz, 1945) extraction procedure. Extracted phosphorus was read calorimetrically at a wavelength of 660µm after the development of molybdenum blue colour.

Determination of exchange cation (Ca, Mg, K, Na)

Cation exchange capacity (C.E.C) and exchangeable bases (K, Ca, Mg and Na) were determined after extracting the soil samples by ammonium acetate at pH 7.0. Exchangeable Ca and Mg in the extract were analyzed using atomic absorption spectrophotometer, while Na and K were analyzed by Flame Photometer (Thomas, 1982).

Determination of total nitrogen

The total Nitrogen content of the soil and plant tissue samples were determined using the stand macro kjeldhl method (Bremner and Mulvancy, 1982). Sample was digested with concentrated H_2SO_4.

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) as described by Gomez (Gomez, 1984) and means were separated using the least significant difference (LSD) at 5% level of significance (Steel and Torrie 1982).SPSS was used to analyze data generated.

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RESULTS AND DISCUSSIONS

Table 4.1: Physical and chemical soil characteristics of pre-cropping soil samples

Physico- chemical analysis	soil
pH in water	6.60
ECEC (Cmol/kg)	3.66
Organic carbon	1.45
Total nitrogen (%)	0.13
Available phosphorus (ppm)	3.08
Exchangeable cations_Sodium (Cmol/kg)	0.26
Magnesium (Cmol/kg)	0.36
Potassium (Cmol/kg)	0.43
Calcium (Cmol/kg)	2.21
Sand (%)	87.80
Silt (%)	5.40
Clay (%)	6.80
Textural class (USDA)	sandy loam

Pre-cropping soil and chemical properties

Physical and chemical analysis of the soil sample prior to planting is shown Table 4.1 above. The Nitrogen content of the soil samples is 0.13%. The soil falls below the low range of soil fertility class for Nigeria soils (Sobulo and Adepetu 1987; Adepetu 1990). The soil organic matter content is 0.025%, the result falls below the range of 0.05%-1.64% for Tropical soils (Birch and Friend, 1956). The available phosphorous concentration in the soil sample is 3.08ppm. The result falls below the range of soil fertility classes of Nigerian soils (Sobulo and Adepetu, 1987). The soil sample pH is 6.60 which indicate that the soil is slightly acidic. The low nutrient content of soil is very appropriate to test the influence of treated POME on soil and the textural class of the soil sample is Sandy loam.

Assessment of POME on Growth of Amaranth

Plant height of green amaranth is presented in table 4.2. POME application at the rates assayed had significant effect on the height of Amaranthus caudatus at ($P \leq 0.05$) for the second, fourth and sixth weeks after transplanting (WAT) in Table 4.2 below. At 2 WAT, 90m^3/ha showed the highest plant height (7.83) which is statistically different from other treatments while 0m^3/ha (control) showed the lowest mean plant height (5.20). Meanwhile, at the fourth WAT, 110m^3/ha also showed the highest plant height (18.83) which is statistically different from other treatments except 0m^3/ha followed by 30m^3/ha, 90m^3/ha and 0m^3/ha (control) with the lowest plant height (6.97). 6 WAT, T_4 gave the highest plant height (38.01) which is not statistically different from other treatments except 0m^3/ha (control).

Table 4.2: Assessment of POME on height of plant

Treatment	2 WAT	4 WAT	6 WAT
0m^3/ha (control)	5.20	6.97	24.63
30m^3/ha	6.43	16.94	32.75
90m^3/ha	7.83	16.19	31.23
110m^3/ha	6.62	18.83	38.01
LSD	1.71	3.26	4.08

WAT= Weeks after Transplanting; LSD= Least significant difference; NS= Not significant.

Number of leaves of plants

POME addition had significant difference on the number of leaves of amaranths at ($P \leq 0.05$) for second and fourth after transplanting (WAT) in Table 4.3 below. At 2 WAT, 90m^3/ha gave the highest number of leaves (6.50) which is not statistically different from 30m^3/ha and 110m^3/ha but there is a significant difference between 90m^3/ha and (5.25) control which gave the lowest number of leaves. However, at 4 WAT, 110m^3/ha gave the highest numbers of leaves (17.33)

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followed by 30 m^3/ha, 90 m^3/ha and 0 m^3/ha (control) with the lowest (10.83). Furthermore, at 6WAT, T4 and T3 respectively gave the highest number of leaves (27.7) which is not statistically different from other treatments.

Table 4.3: Assessment of POME on the Number of Leaves

Treatments	2WAT	4WAT	6WAT
0 m^3/ha (control)	5.25	10.83	21.50
30 m^3/ha	6.42	16.33	25.70
90 m^3/ha	6.50	14.83	27.70
110 m^3/ha	6.42	17.33	27.70
LSD	0.42	0.94	NS

WAT= Weeks after Transplanting; LSD= Least significant difference; NS= Not significant

Plant Stem girth

The application of POME had significant difference at the second WAT but had no significant difference at ($P \leq 0.05$) for 4 and 6 WAT in Table 4.4 below. At 2WAT, 30m3/ha gave the highest stem girth mean values (3.21cm) which is statistically different from other treatments. Followed by 110m^3/ha, 90m3/ha and 0 m^3/ha (control) with the lowest (0.64cm). Furthermore, at 4 WAT result showed that there was no significant different in stem girth of plants although 110m^3/ha had the highest while 0m^3/ha (control) had the lowest. Same trend was observed at 6 WAT for stem girth of plant.

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Table 4.4. Influence of POME on Stem Girth of Plant

Treatment	2WAT	4WAT	6WAT
0 m^3/ha (control)	0.64	1.13	3.46
30 m^3/ha	3.21	1.90	3.72
90 m^3/ha	1.28	1.58	3.72
110 m^3/ha	1.71	2.08	3.95
LSD	0.19	NS	NS

WAT= Weeks after Transplanting; LSD= Least significant difference; NS= Not significant

Crown weight of Plant

POME amendment had significant difference on the crown weight of Amaranthusat 5% level of significance (Table 4.5). However, control gave the lowest crown weight (0.52g) as compared to other treatment. The highest crown weight of green Amaranth was obtained from the application of T4 130ml/ha (2.35g) followed by T2 and T3 (1.64g) respectively.

Total biomass production of amaranth

Table 4.5 also showed the effect of POME on total biomass production of amaranths at ($p \leq 0.05$). Result shows a significant difference in treatments applied for total biomass production. 110m^3/ha gave the highest total biomass production (11.91g) while the 0m^3/ha gave the lowest (8.38g). Application of POME at 110m^3/ha can be considered best for total biomass production since it gave the highest yield.

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Table 4.5. POME application and its influence to yield of amaranth

Treatments	Crown weight (g) 6 WAT	Total biomass (g) 6 WAT
0 m^3/ha (control)	0.52	8.38
30 m^3/ha	1.64	10.51
90 m^3/ha	1.64	10.47
110 m^3/ha	2.35	11.91
LSD	0.64	0.21

LSD= Least significant difference; NS= Not significant; WAT= Weeks after Transplanting

Assessment of POME on plant nutrient uptake

Plant Nitrogen (N)

POME application had a significant influence in the uptake of nitrogen by Amaranths ($p \leq 0.05$). Although, T4 had the highest mean of (3.05) followed by 0 m^3/ha, 90 m^3/ha and 30 m^3/ha with lowest mean of (2.31)

Plant Phosphorus (P)

POME addition was significant at ($p \leq 0.05$) for plant phosphorus uptake. T3 had the highest mean of (2.09) which is statistically different from other treatments followed by T4, T2 and T1 had the lowest mean (0.80).

Plant Potassium (K)

The application of POME had a significant on Potassium uptake by plant at ($p \leq 0.05$). However, 110 m^3/ha had the highest mean (1.85) which is not statistically different followed by 90 m^3/ha, 30 m^3/ha and 0 m^3/ha with lowest mean (0.84)

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Table 4.6. Nutrient Composition of Amaranths plant treated with POME Fertilizer as analyzed at Harvest

Treatments	Nitrogen (%)	phosphorous (mg/kg)	potassium (mg/kg)
0 m^3/ha(control)	3.00	0.80	0.84
30 m^3/ha	2.31	1.41	1.45
90 m^3/ha	2.86	2.09	1.67
110 m^3/ha	3.05	1.64	1.85
LSD	0.19	0.35	0.21

LSD = Least Significant Difference; NS = Not Significant

Chemical properties of Post-cropping soil.

Results shows that there was a corresponding decrease with increase rates of POME in most of the chemical parameters tested with exceptions of potassium. The effect of treatment application on the post-harvest cropping soil chemical analysis presented in Table 4.7 below shows that the addition of POME had no significant effect increase on pH of the soil, organic carbon, total nitrogen, available phosphorus, calcium, magnesium, sodium, and Exchangeable acidity and CEC contest of soil. There was a significant difference in potassium at ($p \leq 0.05$) with increasing levels of POME, 110m^3/ha having the highest and the lowest recorded for 0m^3/ha.

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Table 4.7 Post-Cropping Soil Analysis

Physico-chemical analysis	Control	30	90	110	LSD
		←	m³/ha	→	
pH in water	6.52	6.34	6.36	6.40	NS
Organic carbon (%)	2.05	1.74	1.55	1.40	NS
Total Nitrogen (%)	0.18	0.14	0.13	0.13	NS
Available Phosphorous (mg/kg)	26.98	22.87	26.90	36.59	NS
Exchangeable acidity cmol/kg	3.53	3.00	2.67	2.41	NS
Calcium cmol/kg	2.54	2.58	2.52	2.41	NS
Magnesium cmol/kg	0.46	0.46	0.43	0.43	NS
Potassium cmol/kg	0.45	0.48	0.54	0.61	0.11
Sodium (cmol/kg)	0.41	0.36	0.32	0.39	NS
CEC (cmol/kg)	4.36	4.34	4.16	4.27	NS

LSD = Least Significant Difference; NS = Not Significant

DISCUSSION

The effect of treated POME on the growth, yield and nutrient uptake of *Amaranthus caudatus* was carried out in this study. The pre-cropping soil analysis shows that the soil used in the study was low in nutrient content which made the soil suitable for the study. This makes it possible to ascertain the response of the soil and amaranth to POME fertilizer application. At the second week after transplanting (2 WAT) 110m^3/ha was most effective for high plant height of the test crop used. Same was observed at six weeks after transplanting (6 WAT). This is in accordance with the work of Adeoluwa and Adeogun (2010) they reported better plant height in amaranth with the application of POME. In terms of more numbers of leaves, at two weeks after

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transplanting (2 WAT) treatment with 90m^3/ha was the most reliable to give more number of leaves while at six weeks after transplanting (even if the increase across the treatment was insignificant), treatment with 90m^3/ha gave the highest number of leaves. This indicates that amaranths responded best to treated POME application at 90m^3/ha. So, a farmer that is targeting more production of leaves might want to consider applying treated POME at this rate (90m^3/ha). Odiete *et al., (1999)*also reported increase in number of leaves of amaranth when treated with organic manure. For the production of wider stems treatment 30m^3/ha was most reliable at two weeks after transplanting (2 WAT), while at six weeks after transplanting (6 WAT) although the increase was insignificant, treatment with 110m^3/ha gave the highest stem girth.

Influences of treated POME at different levels were also tested to know how these can affect yield in amaranth production. At harvest, (6 WAT), 110m^3/ha performed best in terms of crown height. A farmer who wants better and more seeds in amaranth production could be advised to apply treated POME at110m^3/ha. The analysis of total biomass production with 110 m^3/ha being the best in terms of weight of amaranth biomass production.

Considering nutrient uptake of amaranth as influenced by application of treated POME, result showed that more nitrogen was taken up from soil at 110 m^3/ha with the least nitrogen content observed in 30 m^3/ha while phosphorous uptake was highest at 90 m^3/ha with 0 m^3/ha (control) having the lowest. Potassium uptake proved more effective at 110 m^3/ha when compared to 0 m^3/ha (control) which recorded the lowest potassium content.

CONCLUSION

From the results obtained in this present study, it was observed that application of treated POME positively influences the growth and yield of *Amaranthus caudatus.* Significant effects were seen in treatments with 110 m^3/ha and 90 m^3/ha application rates in most of the growth and yield parameters tested. Thus, application rates of 110 m^3/ha and 90 m^3/ha of treated POME should be considered for production of Amaranthin the study area.

RECOMMENDATION

It is therefore recommended that treated POME (at rates assayed) should be used to grow different crops in the study area to ascertain if there will be a significant effect in the growth and yield of these crops. Also, higher rates of treated POME application are recommended to know if there will be a declining effect on growth and yield of crops at rates higher than those used in this study.

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