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EFFECT OF NPK Mg BIOCHAR. COMPOST AND OIL-PALM WASTE IN PRE-NURSERY OIL-PALM SEEDLING PRODUCTION

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ABSTRACT

The effectiveness of organic fertilizer materials (decomposed Empty Fruit Bunch, EFB: Sunflower Compost, SFC; Palm-Oil Mill-Effluent, POME, Palm Kernel Cake, PKC and Biochar) for the production of oil-palm seedlings at the pre-nursery (four-month stage) were evaluated, using NPK Mg 12:12:17:2 as reference. In an initial pot experiment (employing 2 kg soil samples per 2.5 x 25 cm^2 polythene bag), reference fertilizer was applied at 0, 6, 12, 18 and 24 g/pot (in three equal doses) to determine the optimum rate needed for the application of EFB, SFC, POME, PKC and Biochar by the polynomial regression ($y = a + b_1x + b_2x^2$) analysis. In the two experiments, treatments were replicated three times in randomized complete block design. Plant height, stem girth, leaf area and number of leaves were measured at 4, 8, 12 and 16 weeks after planting (WAP). The amounts of biomass produced (a plant vigor indicator) were also determined after 16 weeks of growth. Oil-palm seedlings responded optimally to NPK Mg at 8 g/pot while significant ($p \leq 0.05$) differences in treatment means were observed at 12 and 16 WAP. Results further indicated that 10, 11, 13, 17 and 52 g/pot of EFB, SFC, POME, PKC and Biochar were the respective amounts required to supply optimum nutrition to the seedlings. The seedlings treated with SFC, EFB, POME and PKC performed better (with respect to plant height, stem girth, leaf area, number of leaves and dry biomass weight) than NPK Mg 12:12:17:1, Biochar and Control (untreated) plants. It was evident that the organic fertilizer materials could be used for the production of pre-nursery oil-palm seedlings instead of the usually expensive, inorganic NPK Mg 12:12:17:2 fertilizer.

Keyword: pre-nursery, oil-palm seedlings, fertilizer treatment.

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INTRODUCTION

The oil palm nursery can be handled in two stages – the pre-nursery and the main nursery. Seeds are first planted in pre-nursery polythene bags (2.5 x 25 m^2 size) for 3-4 months and then moved to the main nursery for 8-9 months. The pre-nursery permits a more intensive care of the seedlings (watering, removal of weeds, control of diseases and pests as well as easy screening) than in the main nursery.

In Nigeria, the use of inorganic fertilizers is currently limited by scarcity, rising cost, low quality and unavailability during periods of peak demand. The alternative to the use of these inorganic fertilizers is to explore the potentials of organic sources. Wastes from oil palm production (palm oil mill effluent, palm kernel cake and empty fruit bunch) contain organic matter with high amounts of macro and micro-nutrients besides helping in improving soil physical properties (Akhatar and Malik, 2000). Hence, wastes from oil palm also help to restore both organic matter content and the soil structure (Kashmanian *et al.,* 1990). Bacteria present in city compost also help in fixing atmospheric N and making P available to the plant (Bharan *et al.*, 2007). Biochar has been specifically noted to be capable of lowering soil activities, improving soil quality and acting as long term fertilizer (Lehman, 2007).

Organic fertilizers are of various types and they have generally been underexploited. In Nigeria, the use of different organic fertilizers to enhance oil palm seedling performance is still at its infancy; thus necessitating the evaluation of the potential of decomposed Empty Fruit Bunch (EFB), Palm Oil Mill Effluent (POME), Palm Kernel Cake (PKC), sunflower Compost (SFC) and Biochar on the growth and biomass production of oil palm seedlings. Therefore, this research work sought to determine the optimum application rate of NPKMg on the performance of oil palm seedlings at the pre-nursery stage. A comparative study of the effects of the different inorganic and organic fertilizer sources on the growth and dry matter accumulation of oil palm seedlings was also conducted at the pre-nursery stage.

MATERIALS AND METHODS

This study was conducted at the main station of the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Edo State. The soils at NIFOR main station fall within the subdivision of acid sands (Vine, 1956).

The soil was thoroughly air dried, crushed and passed through a 2 mm sieve to remove debris and large stones. The sieved soil was bagged in black polythene bags of 2.5 cm wide and 25 cm depth before planting sprouted seeds. Six bags were arranged per treatment in randomized complete block design. The study was carried out in two phases. Phase 1 involved the use of inorganic fertilizer NPKMg (12:12:17:2) at 0, 6, 12, 18 and 24g/2kg soil. These were applied in three equal doses at 0, 4, and 8 weeks after planting. The optimum N fertilizer rate derived from the use of inorganic fertilizer was used as basis for the calculation of the amount (in grams) of the various organic fertilizers used for the phase 2 of the study. The five organic fertilizers (mixed with the soil in each polythene bag before planting) were decomposed Empty Fruit Bunch (EFB), Palm Oil Mill Effluent (POME), Palm Kernel Cake (PKC), Sunflower Compost (SFC) and Biochar at 10, 13, 17, 11 and 52gN/2kg soil, respectively. These were compared with NPKMg (12:12:17:2) and control (without fertilizer application) in the phase 2 of the experiment. Weeding was first carried out at 2 weeks after planting and thereafter at 3 weeks interval. Measurements were taken in respect of plant height, stem girth, number of leaves and leaf area at 4, 8, 12 and 16 weeks after planting. Plant height was measured with the aid of a meter rule. Leaf area was determined by summing up the product of the length and the broadest width of each leaf. Destructive sampling was done at 16 weeks after planting to estimate the fresh and dry biomass yields. Dry matter yield was obtained by oven drying the harvested plants for 48 hours at 85^{o}C. Total N was determined by micro-kjeldahl method and available-P by the Bray-1 method (Bray and Kurtz, 1945).

The exchangeable-K was extracted by ammonium acetate and determined by flame photometer. Similarly, the hydrometer method was used for dispersing the soil into sand (2.00-0.05 mm), silt (0.05-0.002 mm) and clay (<0.002 mm) fractions. Data collected were subjected to analysis of variance (ANOVA) as described by (Steel and Torrie, 1984).

RESULTS

The pH (1:1 H_2O) value for the soil used in this study was 5.5, which indicates that it is slightly acidic while its textural class was Sand (Table 1). Total nitrogen and organic carbon contents were low but moderately deficient in available phosphorus. The nutrient composition of the organic fertilizers tested in phase 2 of the study is shown in Table 2.

Table 1: Physical and Chemical Characteristics of the soil before planting

Parameter	Value
pH (1:1 H_2O)	5.5
Organic carbon (gkg^{-1})	0.32
Total Nitrogen (gkg^{-1})	0.03
Available-P ($mg\ kg^{-1}$)	9.7
Exchangeable cations ($cmol\ kg^{-1}$)	
Ca	10.7
Mg	2.5
K	2.7
Mechanical analysis (gkg^{-1})	
Sand	939
Silt	35
Clay	26
Textural class	Sand soil

Table 2: Nutrient composition of organic fertilizer materials

Parameter	BIOCHAR	POME	PKC	EFB	SFC
N (g/kg)	1.87	7.20	5.69	7.62	8.69
P (g/kg)	0.70	6.10	3.80	5.01	3.30
K (cmol/kg)	0.42	1.46	3.20	3.64	5.46
Mg (cmol/kg)	0.07	0.63	0.60	0.63	0.24

EFB = decomposed Empty Fruit Bunch, POME = Palm Oil Mill Effluent, PKC = Palm Kernel Cake, SFC = Sunflower Compost.

Effects of NPK Mg 12:12:17:2 Fertilizer Application Levels on the Growth of Oil-Palm Seedlings

The effects of the various application levels of NPK Mg 12:12:17:2 on the growth of pre-nursery seedlings are provided in Table 3 and 4. The treatments had no effect on growth of the seedlings at 4 and 8 WAP. Response was however observed at 12 and 16 WAP.

At 12 weeks, seedlings treated with 6g or 12g/2kg soil, gave the highest leaf area (Table 3). There was a decline in leaf area associated with further increases in fertilizer application to 18 and 24g. the values of the leaf area of seedlings supplied with 18g or 24g of the inorganic fertilizer were not significantly different from those of the control. Application at 12g per seedling produced the tallest plants followed by 6g; the effect being significantly (p>0.05) higher than the applications at the other levels. The untreated and 24g NPKMg-treated seedlings were the shortest. Production of seedlings with highest number of leaves and larger stem girth were associated with the application of 6g and 12g of the fertilizer per seedling. The respective values were significantly greater than those obtained with the application of 18g or 24g as well as for the untreated seedlings. Production of leaves was similar for both 18g and 24g NPKMg application levels.

After 16 weeks of growth, oil-palm seedlings that received 6g or 12g NPKMg were the tallest and were not significantly different. Significant differences, however, occurred in plant height among seedlings treated with 18g and 24g as well as the untreated seedlings (Table 4). The effects of 18g and 24g application levels resulted in dwarfing (height reduction). Seedlings treated with 12g NPKMg had the highest leaf area followed by those with 6g while those supplied with either 18g or 24g as well as those without fertilizer treatment were significantly lower. The largest stem girth was recorded on seedlings treated with 6g, which had similar girth with those that received 12g of the inorganic fertilizer. Numbers of leaves were more among seedlings treated with 12g, 6g and control. The lowest numbers of leaves were produced by seedlings treated with 18 and 24g.

Table 3: Effects of NPKMg (12:12:17:2) fertilizer application rates on the growth of oil-palm seedlings at 12 weeks after planting

NPKMg (12:12:17:2) (g/2kg Soil)	Stem Girth (cm)	Plant Height (cm)	Leaf Area (cm^2)	Number of Leaves
0	1.99c	14.58c	69.6b	3.25b
6	2.23a	16.39a	88.1a	3.75a
12	2.08b	16.50a	73.2ab	3.38b
18	1.96c	15.70b	66.6b	3.13c
24	1.91c	13.93d	62.9b	3.13c
LSD ($p \leq 0.05$)	0.19	0.12	17.5	0.15

* Treatment means followed by similar letters are not significantly different at $p \leq 0.05$.

Table 4: Effects of inorganic fertilizer application rates on the growth of oil palm seedlings at 16 weeks after planting

NPKMg (12:12:17:2) (g/2kg Soil)	Stem Girth (cm)	Plant Height (cm)	Leaf Area (cm^2)	Number of Leaves
0	3.08	19.55b	137.2b	4.50a
6	3.23	21.73a	191.6a	4.50a
12	2.98	21.35a	194.0a	4.50a
18	2.84	18.98c	139.2b	4.25b
24	2.60	17.20d	111.4b	4.00c
LSD ($p \leq 0.05$)	0.27	0.40	50.2	0.25

* Treatment means followed by similar letters are not significantly different at $p \leq 0.05$.

NPKMg (12:12:17:2) fertilizer application rates (x) in relation to growth parameters (v) of 16-week old pre-nursery oil-palm seedlings

The regressing equations (polynomial/ quadratic model) relating NPKMg (12:12:17:2) fertilizer application rates to each of the oil-palm seedling growth parameters (plant height, number of leaves, leaf area and stem girth) at 16 WAP are summarized in Table 5. The correlation coefficients (r = 0.74 – 0.76) were high in respect of leaf area and plant height, implying that either of these two growth attributes of the crop could be employed for predicting its fertilizer requirement in the acid sand used in this study.

Thus, the prediction equations were used to determine the optimum fertilizer rate for subsequent application of various organic fertilizer materials to permit maximum growth of the oil palm seedlings in the phase 2 of this study.

The optimum fertilizer rate was estimated to be 8 p/pot while leaf area was observed least with the supply of 24 g/pot.

Table 5: Regression equations and correlation coefficients relating NPKMg (12:12:17:2) fertilizer application rates (x) to each of the growth parameters (y) of 16-week old pre-nursery oil-palm seedlings

Growth parameters	Regression equation	r^2	r
Stem girth	$y=0.0013x^2+0.0101x+3.1136$	0.3513	0.59
Leaf area	$y-0.4459x^2+8.9174x+144.6$	0.5799	0.76
Number of leaves	$y=0.0015x^2+0.0149x+4.4929$	0.0919	0.30
Plant height	$y=0.0196x^2+0.3473x+19.836$	0.5474	0.74

*r significant at p≤0.05
**r significant at p≤0.01

Effects of various organic fertilizer sources on growth of oil-palm seedlings

Responses to the various organic fertilizer treatments were observed at 12 and 16 weeks after planting. At 12 weeks, the effects of SFC and EFB were highest and similar on all growth parameters (Table 6). Empty fruit bunch-treated seedlings had the highest leaf area that is insignificantly different from those of the SFC-treated seedlings. Palm oil mill effluent and PKC-treated seedlings also had similar leaf area while NPKMg-treated seedlings had higher leaf area than control and Biochar-treated seedlings. Differences were also observed on height with SFC and EFB producing the tallest seedlings compared to the other treatments except those of EFB-and POME-treated seedlings with similar heights. The effect of NPKMg on seedling height was greater than those of Biochar and control. Sunflower compost-treated seedlings produced more leaves than the other treatments while similar results were obtained in respect of EFB, POME, PKC and NPKMg treated seedlings. The control and Biochar treatment had the least production of leaves. Similar trend occurred as regards stem girth, except that seedlings treated to NPKMg, Biochar as well as those untreated (control) were similar in girth.

At 16 weeks after planting, SFC-treated seedlings produced more leaves compared to the other treatments, followed by EFB, POME and PKC, which produced statistically the same numbers. Seedlings treated with SFC or EFB produced the highest leaf area with no significant difference among them (Table 6). The seedlings supplied NPKMg fertilizer had higher leaf area than control and Biochar-treated ones. Seedlings that were treated with compost made from sunflower (SFC) were the tallest followed by EFB-, PKC- and POME-treated seedlings which were statistically the same. NPKMg treatment produced significantly taller seedlings than control and Biochar-treated ones. Number of leaves was significantly affected by fertilizer treatment, those treated with SFC, EFB, POME and PKC produced more leaves, while NPKMg, Biochar and untreated seedling were the similar but the lowest. The effects of the fertilizer treatments on stem girth were similar with those on number of leaves.

Table 6: Effects of various organic fertilizer sources on stem girth, leaf area, number of leaves, and plant height of oil palm seedlings at 12 and 16 weeks after planting.

Fertilizer Sources	Stem Girth (cm)	Plant Height (cm)	Leaf Area (cm^2)	Number of Leaves
		12 WAP		
SF	2.7a	29.2a	163.8ab	4.3a
EFB	3.0a	27.8ab	183.0a	3.7a
POME	2.8a	25.1b	106.4c	3.7a
PKC	2.7a	13.6e	20.7e	3.2b
NPKMg	2.3b	13.0e	20.3e	2.9b
Biochar	2.2b	13.6e	20.7e	3.2b
Control	2.1b	13.0e	20.3e	2.9b
LSD (P≤0.05)	0.5	3.5	35.1	0.4
		16 WAP		
SF EFB	5.7a	43.2a	617.5a	6.3a
POME	5.1a	36.0b	582.7ab	6.0a
PKC	5.2a	35.3b	494.3ab	5.7a
NPKMg	5.0a	32.7b	427.6b	5.7a
Biochar	4.1b	25.5c	216.6c	4.3bc
Control	3.1c	19.2d	37.6d	4.3c
	2.7c	18.9d	35.9d	3.7c
LSD (P≤0.05)	0.9	1.90	177.3	1.2

* Treatment means followed by similar letters are not significantly different at p≤0.05.

Fresh and dry weights of seedlings were similar with EFB and SFC treatment, but significantly higher than with the other treatments, except for PKC with higher fresh weight (Table 7).

Table 7: Effects of organic fertilizer sources on biomass yield of oil-palm seedling at 16 weeks after planting

Fertilizer sources	Fresh weight (g/pot)	Dry weight (g/pot)
Control	6.67c	4.73c
NPKMg (12:12:17:2)	12.86b	6.57b
POME	11.57b	5.80b
EFB	17.26a	7.71a
SFC	17.40a	8.03a
PKC	17.90a	8.03a
Biochar	7.53c	4.70c
LSD (P≤0.05)	2.61	0.92

* Treatment means followed by similar letters are not significantly different at p≤0.05

DISCUSSION

The effectiveness of various application levels of NPKMg (12:12:17:2) on the growth parameters of pre-nursery seedlings were compared. Treatment had no effect on growth of seedlings at 4 and 8 weeks after planting and this could be due to the nourishment from endosperm [Corley, 1976].

The best growth was observed among seedlings treated with 6 and 12g/2kg soil (Table 3 and 4). Application at this rate could have enhanced the release of N, P, K and Mg at sufficiency levels. Results obtained from the prediction equations (using quadratic model) gave 8g/2kg soils as being the optimum rate.

This is lower than the previous recommendation rate of 14g per plant at 2-4 months after planting [Gray, 1966]. Similarly, Ugbah and Utulu (2005) observed the rate to be 28 - 42g for nursery seedlings,

The better performance of SFC and EFB over the other organic fertilizers source could be attributed to the respective high N content. Nitrogen is the most important nutrient during vegetative growth stage in the nursery. This is consistent with the findings of Omueti *et al.* (2006) that compost is of value in agriculture for improving the structure and moisture retention properties of the soil and for supplying plant nutrient. During the composting process, organic wastes are decomposed, plants nutrient are mineralized into plants-available forms, and pathogens are destroyed [Parr et al., 1994]. Application of compost improves the development of root systems, increases the diversity of roots fungal flora, promotes the growth of plants, reduces the incidence of soil-borne diseases, and depresses the propagation of pathogens [Nitta, 1994].
The enhancement of growth by SCF and EFB at low rates of 10 and 11 g N /pot, respectively can be associated with the high N contents, while others could not enhance growth even at higher rates (POME at 13g, PKC at 17g and Biochar at 52g N/pot).

The performance of POME and PKC on the growth parameters can be related to their moderately high contents of nutrients (N and other micro nutrients) as reported by Akhtar and Malik (2000). Biochar was observed to have supported the lowest growth compared with the other organic fertilizer sources probably because of its very low N content. This is in line with the claim by Abramas (1995) that biochar contains high P, K, Ca and no N. It is difficults to compliment its function. This is in line with the view expressed by Abramas (1995) that Biochar enhances nutrient retention capacity, thereby reducing total fertilizer requirement and environmental damage associated with fertilizer use. The results obtained by Glacier *et al.,* (2002) indicated that its application in forest soils along with synthetic or natural fertilizer increased bio-availability and plant uptake of phosphorus and reduced nutrient leaching losses (Lehman, 20907).

High fresh weight of PKC-treated seedlings recorded in this study could be due to the high fibre content (16%) and high phosphorus to calcium ratio, as well as high iron and zinc contents (Tang, 2001).

CONCLUSIONS

In this study, optimum NPKMg (12:12:17:2) fertilizer application rate for pre-nursery oil palm seedlings was 8g/2kg soil, applied in three-split doses from eight weeks after planting.

Sunflower compost (SFC), decomposed empty fruit bunch EFB), palm oil mill effluent (POME) and palm kernel cake (PKC) proved to be potential substitutes for the relatively expensive, conventional inorganic fertilizer source (NPKMg 12:12:17:2) on the acid sand alfisol. The fertilizer sources were effective in the order: SFC > EFB = POME = PKC > NPK Mg > BIOCHAR = CONTROL. For the production of pre-nursery seedlings with high vigor (identified with high biomass yield), application of SFC, EFB, POME, PKC at 10, 11, 13 and 17g N/2kg soil, respectively would be sufficient.

The results of this initial investigation with pre-nursery seedlings give credence to previous assertions that organic wastes from oil palm could be re-used as fertilizer in large scale production. Further results being collated from on-going research efforts at our Institute of Oil-palm Research (NIFOR) in Benin and Department of Agronomy, University of Ibadan, Nigeria on the combined use of Biochar and other natural or synthetic fertilizer are encouraging and would be the subject for another communication.

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