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Full Length Research Paper

Raising oil palm seedlings using sole and amended green-gro compost

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ABSTRACT

The use of quality growth medium enhances oil palm growth and development. The continuous use of soil has become environmentally unsustainable. Compost has been found to have the potential to replace not only soil but also fertilizer in the nursery. The use of sole green-gro a composted medium and green-gro amended with three inorganic fertilizer formulations in the oil palm nursery were investigated. Butt development, number of fronds per seedling, seedling height, dry weight of seedlings and leaf nutrient concentration of the seedlings were measured. The growth performance of oil palm seedlings planted in sole green-gro (control) compared well with seedlings planted in any of the amended green-gro. Assessment of dry matter production of the seedlings showed that sole green-gro and G-Niphomag produced higher dry weight than G-Polyfeed and G-PolyMag. The measured leaf nutrients showed varying levels of optimality for the various treatments. Green-gro and G-Niphomag has the prospect for use as growth medium to raise oil palm seedlings in the nursery.

Keywords: Growth medium, Nursery, Oil palm seedlings, G-Polyfeed, G-PolyMag.

Abbreviations

Niphomag: Combination of nitrogen, phosphorous, potassium and magnesium fertilizers in a ratio of 1:1:1:2; **Polyfeed:** Combination of nitrogen, phosphorous, potassium fertilizers in a ratio of 1:1:1; **PolyMag:** Combination of nitrogen, phosphorous, potassium and magnesium fertilizers in a ratio of 1:1:1:1; **G-Niphomag:** Green-gro amended with Niphomag; **G-Polyfeed:** Green-gro amended with Niphomag; **G-PolyMag:** Green-gro amended with PolyMag

INTRODUCTION

The soil has traditionally been used as growth medium to raise seedlings in the oil palm nursery. This practice involving the winning of soil from productive areas is used to fill nursery bags. Annually between 3000 - 3500 tons of soil is needed to raise oil palm seedlings in the CSIR-OPRI nursery. This practice of winning soil is not an environmentally sustainable option as it depletes and destroys the area from which it is collected. Additionally, it is increasingly becoming scares to come by adequate quantities of fertile soil for nursery operations. When available, its fertility will have to be boosted with the application of appropriate levels of either organic or inorganic fertilizer.

Current studies are focussing on plant growth media that are organic, appropriate, less expensive and readily available and conserve the environment. The beneficial effects of organic materials such as compost in raising seedlings have well been documented by several researchers (Hartz *et al.,* 1996, García-Gómez *et al.,* 2002, and Akanbi *et al.,* 2005). Its influence on the physical properties, exchange and buffering capacities of the soil and as a rich source of nutrients for plants has been observed (Hutabarat *et al.,* 2006). Studies by Hamdan et al. (1998) showed that nutrients from 60 tons/hectare/year of empty fruit bunch were sufficient to support oil palm growth. Similarly, compost application at the rate of 5kg and 7.5kg to oil palm seedlings was observed to give similar responds as inorganic fertilizer (Siregar *et al.,* 2002). Studies in Nigeria by Aisueni and Omoti (2001) found that the application of compost without any inorganic fertilizer increased dry matter content of oil palm seedlings by 71%.

Commercial production of organic growth media for raising seedlings is receiving attention in Ghana. Green-gro composted from shredded coconut husk, cocoa pod husk, chicken litter, palm kernel shells, soil and marketed by Green-Gro Ltd (Takoradi, Ghana) is proposed for use in the oil palm nursery. The product aims at reducing the use soil and the frequency of fertilizer application in the nursery. However, seedling damage and slow growth rate have been reported from the use of compost as growth medium. Studies by Troeh and Thompson (2006) show that some organic materials have slow nutrient release characteristics and this makes nutrients release from them difficult to predict (Domburg *et al.,* 2000). Some researchers have therefore suggested the combination of composts with sufficient fertilizer application to meet crop requirements (Sikora and Enkiri, 1999 and Cakmak, 2002).

According to Cakmak (2002); Singh and Kalloo (2000) good nutrient management may be achieved by the combination of mineral fertilizers with organic materials. Although compost has been studied as soil substitutes, there is no information concerning the use of green-gro growth medium in combination with inorganic fertilizer in the oil palm nursery. Finding a compost-fertilizer combination, that is environmentally sustainable, inexpensive, nutrient-rich and produces oil palm seedlings at a minimum cost, is of utmost research and commercial importance.

This work investigates the effects of a green-gro as growth medium and different fertilizer formulation on growth, development and dry matter yield of oil palm seedlings. This information is critical in recommending the use of the medium for nursery operation.

MATERIALS AND METHODS

The study was carried out at Okyinso near Kade. The area falls within the semi deciduous forest zone of Ghana with mean annual rainfall of 1500mm.

Pre-nursery

Mini polybags (black) of dimensions 10 cm x 19 cm lay flat and perforated at the lower third of the bags to enhance drainage of excess water were filled with soil from the Kokofu series (Ferric Plinthic Acrisol FAO/UNESCO) (Asiamah and Senayah, 1991). Germinated oil palm seed nuts of *Dura* x *Pisifera* (D x P) were sown singly in the black polybags for four months in the pre-nursery.

Main nursery

Maxi polybags (black) of dimension 35.6 cm x 45.7 cm lay flat was also filled with 10kg of green-gro and arranged in triangular planting design of distance 70 x 70cm. Each plot containing 30 maxi poly bags were arranged in a randomized complete block design with three replicates. At four month, the seedlings from the pre-nursery were transplanted into the maxi bags to expose them to prevailing environmental conditions. Green-gro was amended with no fertilizer, 30g of Niphomag, 30g of Polyfeed and 30g PolyMag. Treatment were as follows:

T_1 = G-Niphomag
T_2 = G-Polyfeed
T_3 = G-PolyMag
T_4 = No fertilizer (Control)

Growth measurement

Growth responses were measured on butt development of seedlings, number of leaves per seedling and seedling height on 10 central seedlings randomly selected and tagged in each treatment. Butt development was assessed by measuring the butt diameter of the seedlings with a vernier caliper at the widest point in two different directions. The value of the diameter was converted to circumference using a formula of πD (i.e 3.14 multiplied by the obtained diameter (D) value). Number of leaves was obtained by counting the number of leaves fully opened on a seedling monthly. Destructive method was used to estimate the dry matter production in the frond, butt and root at the end of the 12^{th} month. Dry weight of the seedling parts were recorded after oven drying at 70^oC constant weight. The 3^{rd} frond from the centre spear (Hartley, 1988) of the seedlings was harvested at 6, 9 and 12 months of growth, dried in an oven at 70^oC weighed and ground. The samples were then digested and nutrient (N, P, K, Ca, Mg) content determined.

Chemical properties of medium used

Characterization of green-gro was carried out for pH (1:2.5) using digital pH meter, organic carbon content using the Walkley-Black wet oxidation method (Walkley-Black, 1934). Total nitrogen by the Kjeldahl procedure, exchangeable cations by displacing all exchangeable cations with NH_4^+ in 1*N* NH_4OAC at pH 7. Potassium was estimated by flame photometry while calcium and magnesium were estimated by (0.01*M* EDTA) titration solution. Available phosphorus (P) and potassium (K) was extracted with Bray-1 (Bray and Kurtz, 1945) solution. All data were subjected to analysis of variance (ANOVA) using GENSTAT statistical package. Differences were considered statistically significant at $p<0.05$.

RESULTS

Number of fronds per seedling

This parameter did not significantly vary at $p<0.05$ within the treatments irrespective of the inorganic fertilizer used (Table 2).

Table 1. Chemical properties of media used.

Parameters	Green-gro
pH (1:2 H_2O)	7.2
Organic C (%)	2.4
Total N	0.22
Available P (mg/kg)	34.2
Available K (mg/kg)	102.0
Exchangeable cation (cmol/kg)	
Ca	11.0
Mg	4.3
K	0.44
Exchangeable acidity (cmol/kg)	0.05

Table 2. Effects of green-gro amended medium on number of fronds per seedling

Treatments	Months after treatment application					
	4	5	6	7	8	9
G-Niphomag	5	6	6	7	8	9
G-Polyfeed	5	6	7	7	7	9
G-PolyMag	5	6	6	7	7	8
Control	5	6	7	7	8	9
Lsd	0.5	0.6	1.2	1.0	1.5	1.3
C.V	7.6	4.2	5.1	5.3	5.2	3.0

* **T_1** = G-**Niphomag** **T_2 = G-Polyfeed**
T_3 = G-PolyMag **T_4 = No fertilizer (Control)**

N.S = Not significant at $p<0.05$

Seedling height

Although the seedlings varied in height, significant difference ($p<0.05$) in response to the fertilizer amendment was not observed between the 6th and 12th months (Fig. 1)

Butt development

Responses among the treatments in term of butt development were significantly lower ($p<0.05$) in G-PolyMag treated seedlings on the 5th and 7th month (Fig. 2). However, there were no differences of significance among the treatments on the 6th, 8th – 11th month. G-PolyMag treated seedlings recorded significantly lower butt development on the 12th month compared with G-Niphomag and control.

Seedling dry weight

Significant variation in terms of mean dry weight of fronds, butt and root existed among the treatments (Fig. 3) Similarly, differences arising from the total dry weight for G-Polyfeed, G-PolyMag and/or G-Niphomag, control were significant ($p<0.05$).

Seedlings leaf nutrient

Von Uexkull and Fairhurst (1991) gave the optimum ranges of leaf nutrient levels of oil palm as 2.6 -3.0%, 0.16 – 0.25%, 1.10 – 1.80%, 0.30 – 0.70% and 0.50 – 0.70% for N, P, K, Mg and Ca respectively. N levels were in excess of the critical range with the exception of T4 on the 6th month, P and Mg levels were optimum whiles Ca and K levels were deficient throughout the sampling period for all the treatments (Table 3).

DISCUSSION

A good growth medium need to have sufficient plant nutrient to promote seedling growth and development (Hartmann and Kester, 1990). Composted organic materials have been observed to contain appreciable level of plant nutrients and have the potential to replace not only the soil but also fertilizer at the nursery (Abner

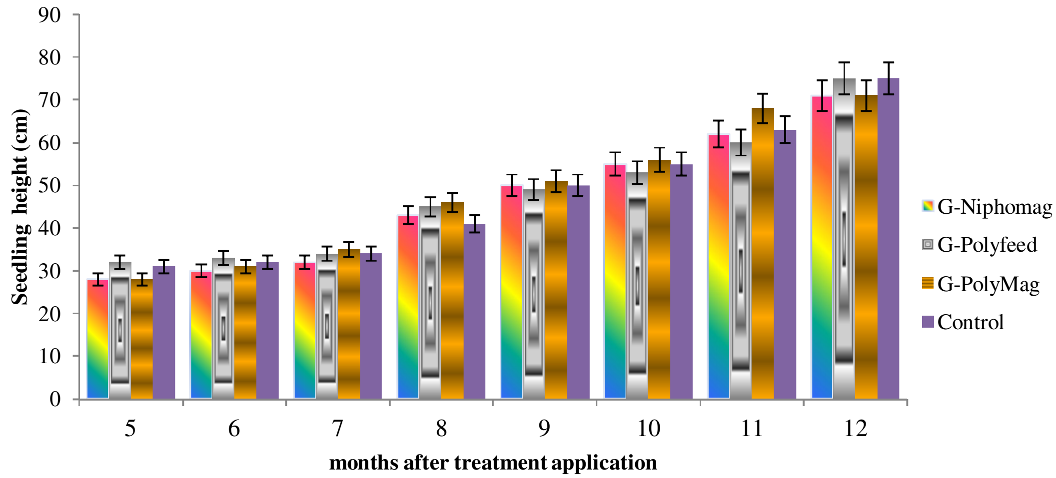

Fig 1. Effect of green-gro amended medium on seedling height

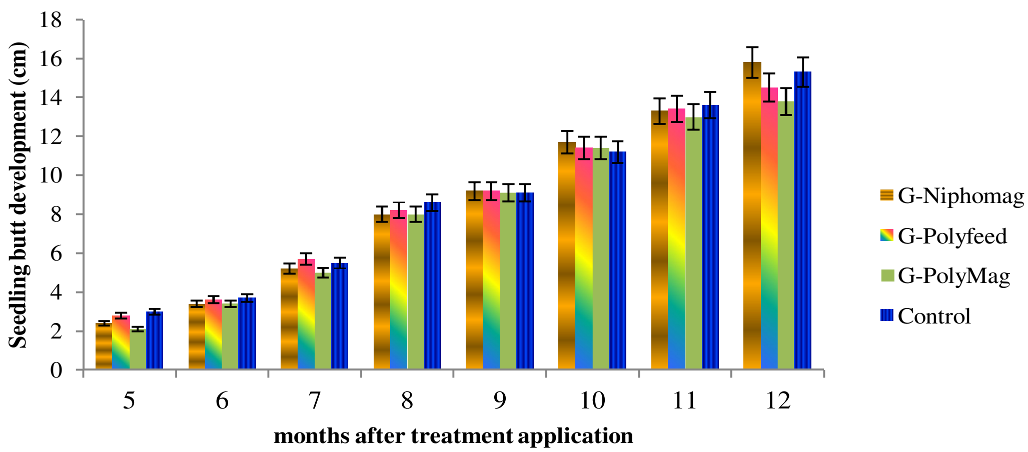

Fig 2. Effect of green-gro amended medium on butt development

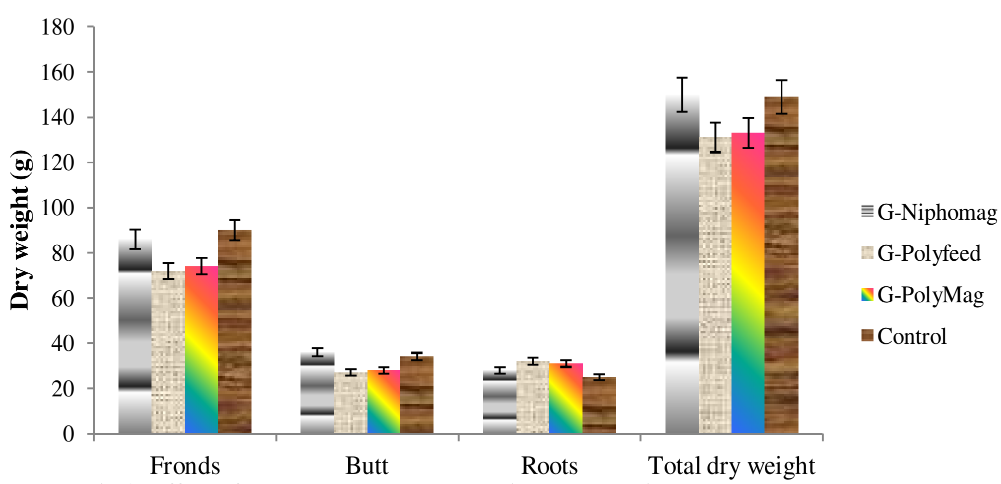

Fig 3. Effect of green-gro amended medium on seedling dry matter production

Table 3. Effect of green-gro amended medium on leaf nutrient of seedlings

Treatment			6th month		
	N	P	K	Mg	Ca
			(%)		
G-Niphomag	3.53	0.24	0.71	0.74	0.19
G-Polyfeed	3.27	0.24	0.80	0.70	0.18
G-PolyMag	3.31	0.24	0.77	0.62	0.16
Control	2.35	0.30	0.78	0.68	0.25
Lsd	0.49	0.10	0.17	0.09	0.10
C.V	2.6	2.5	8.9	10.9	9.7
			9th month		
G-Niphomag	3.89	0.24	0.73	0.67	0.19
G-Polyfeed	3.34	0.24	0.77	0.53	0.20
G-PolyMag	3.57	0.23	0.71	0.68	0.19
Control	2.82	0.27	0.73	0.61	0.19
Lsd	0.09	0.03	0.07	0.09	0.09
C.V	4.1	5.3	6.8	4.6	3.8
			12th month		
G-Niphomag	4.15	0.22	0.91	0.58	0.14
G-Polyfeed	4.11	0.19	0.89	0.52	0.12
G-PolyMag	3.92	0.19	0.85	0.59	0.12
Control	3.49	0.22	0.92	0.48	0.15
Lsd	0.44	0.04	0.12	0.05	0.06
C.V	2.1	3.1	3.7	7.6	6.5

and Foster, 2006). At all stages of development, growth pattern in both the amended and sole green-gro were similar in the number of fronds per seedling irrespective of the inorganic fertilizer added (Table 2). According to Siregar *et al.,* (2002) compost used to raise oil palm seedlings has been observed to give similar responds as inorganic fertilizer. Therefore harnessing its full benefit is of research and commercial importance. This study also observed similar growth pattern in treatments that received inorganic fertilizer (G-Niphomag, G-Polyfeed and G-PolyMag) and the sole use of green-gro (control) medium in terms of seedling height from the 6th -12th month (Fig. 1). Combining green-gro with any of the inorganic fertilizers did not elicit significant seedling height increases *($p<0.05$)* in G-Niphomag, G-Polyfeed and G-PolyMag, in comparison to the control. Similarly butt development among the treatments showed no significant differences on the 6th, 8th – 11th month. This observation could be indicative of the readily release of nutrients from the green-gro medium. In one study by Rees *et al.* (1993) similar growth observation was noted in using composted materials as a supply of plant nutrients.

Nitrogen an integral component of many compounds essential for plant growth processes including chlorophyll (Brady and Weil, 2000) was high in the leaf samples of both the amended and sole green-gro, contrary to observations made by Domburg *et al.,* (2000); Cakmak (2002); Troeh and Thompson (2006) that organic materials have slow nutrient release characteristics and needed to be boosted with sufficient fertilizer to meet crop requirements. This could account for the similarities in the number of frond produced per seedling. This observation confirms the assertion by Goulding *et al.* (2001) that there is substantial release of nitrogen from organic medium, offsetting the need to provide inorganic fertilizers. Satisfactory level of plant nutrients from the chemical analysis of the green-gro medium (Table 1) affirms the observation that organic material can be used as growth media with very good results (Bugbee and Frink, 1989; Piamonti et al., 1997 and Garcia-Gomez et al., 2002).

The high levels of nitrogen, in leaf samples (Table 3) above the Von Uexkull and Fairhurst (1991) optimum range for oil palm in both the amended and non amended green-gro medium, supports the findings of Abbasi *et al.* (2003) who showed that composted growth medium was an important source of plant nutrients and it made an important contribution to the N demand of growing crops. Similarly, compost was also critical in supplying plant nutrients in the absence of inorganic fertilizer (Rees *et al.,* 1993).

Leaf nutrient concentration in the seedlings did not change significantly *($p< 0.05$)* among the treatments. Based on Fairhurst and Mutert (1999) leaf nutrient levels for oil palm under 6 years, nitrogen (N) was in excess of the critical range, phosphorous (P) and magnesium (Mg) were optimum. This can be adduced to the high nutrient content in the compost fertilizer mixture. However deficient levels of calcium (Ca) and potassium (K) were observed. Bah and Zaharah (2004) observed similarly low levels of Ca and K in oil palm leaves. They partly attributed this observation to the antagonistic effects between K and Ca combined with Mg in the plants and explained that the absorption of these elements by the roots depended on their relative concentrations in the growth medium. Deficient levels of K observed in the study agreed with the findings of Fairhurst and Mutert (1999) that high levels of N when K was low might result in a K deficiency because the increased seedling growth required more K. This study observed optimum levels of P. According to Iglesias-jimenez and Alvarez (1993) compost was effective in diminishing the fixation process by providing equivalent amount of liable-P, which significantly increased P concentration of plant tissue. Hue et al. (1994) also reported similar findings and attributed it to the release of P during the decay process and the organic anions released by the compost.

Total dry matter production varied in response to the inorganic fertilizer application (Fig 3). Oil palm seedlings in green-gro treated with G-Polyfeed and G-PolyMag produced significantly lower total dry matter compared to G-Niphomag. The similar total dry matter observed between G-Niphomag treated seedlings and control is in line with Lawson et al., (1995) who observed increase in dry matter production of soybean plants treated with compost. This is in agreement with Aisueni and Omoti (2001) who found that the application of compost without any inorganic fertilizer increased dry matter content of oil palm seedlings. Contrarily, no significant increase $(p<0.05)$ was observed between the control and G-Niphomag treated seedlings. This observation is in line with the findings of Siregar *et al.* (2002) who reported that compost use under oil palm seedlings gave similar responds as those that received inorganic fertilizer.

CONCLUSION

Use of sole green-gro (control) produced similar growth patterns as compared to the amended green-gro with G-Niphomag, G-Polyfeed or G-Polymag. Similar leaf nutrient levels were observed in all the treatments. The use of G-Polyfeed and G-PolyMag did not elicit an additive response in dry matter production over the control. G-Niphomag and Green-gro (control) satisfactorily promoted the growth and development of oil palm seedlings in the nursery and has the prospect for use as growth medium to replace soil in raising oil palm seedlings in the nursery.

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