Application of compost in mixed media improved oil palm nursery's secondary root structure thereby reducing the fertilizer requirement for growth

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Abstract. Although conventional inorganic fertilizers increased plant growth and productivity, their excessive use leads to wastage, run-offs and environmental pollution. In order to promote nutrient recycling and zero emission strategy in the palm oil industry, compost was produced from oil palm empty fruit bunch (EFB) and palm oil mill effluent (POME) anaerobic sludge. The main objective of this study is to determine the effect of compost in the mixed media on the growth and inorganic fertilizer requirement in the oil palm nursery. 100% soil as media with 100% inorganic fertilizer as control was compared with mixed media containing 50% compost in soil with inorganic fertilizer at 25%, 50%, 75% and 100% compositions and tested for plant growth and root structure. The results showed that the treatments with compost addition improved plant growth, compared to the control with 100% inorganic fertilizer which did not contain compost in the mixed medium. The improved plant growth corresponded directly to the enhanced secondary root structure, which probably resulted in more efficient absorption and uptake of nutrients by the plants. Furthermore, the plant growth and the secondary root structure in the mixed media with 50% inorganic fertilizer composition was not significantly different to the media with 75% and 100% inorganic fertilizer. Therefore it is suggested that the application of 50% compost in the mixed media enhanced the secondary root structure, resulting in reduced inorganic fertilizer requirement in the oil palm main nursery, without affecting the plant growth.

Keywords: compost, planting media, oil palm nursery

INTRODUCTION

Oil palm (*Elaeis guineensis*) is an important commercial agriculture crop which provides income and employment in the agricultural sector in the tropics. The waste and resources from the

non-oil streams in this industry are rich in nutrients which can generate additional economic value. The empty fruit bunch (EFB) and palm oil mill effluent (POME) anaerobic sludge are two

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raw materials that can be converted to organic fertilizer, which can improve soil fertility and conditions the soil in oil palm plantations. The prolonged cultivation of oil palm depleted the essential nutrients and soil cation exchange capacity (CEC). This can be alleviated by the application of organic fertilizer from EFB and POME anaerobic sludge (Ashraf *et al.*, 2017), which is an excellent nutrient-recycling strategy within the industry. The palm oil industry conventionally used topsoil in the media for the oil palm main nursery. Due to the limitation of good topsoil, application of inorganic fertilizers has been widely used which contributed to soil acidification, declined pH and low fertility of soil as media for oil palm nursery (Rosenani *et al.*, 2016). An alternative growth medium is desirable to produce high quality seedlings, particularly by enhancing plant growth and root structure. It has been proposed that EFB and POME anaerobic sludge can improve soil fertility by increasing the water holding capacity, total nitrogen content, available phosphorus content, CEC and microbial activity (Ramli *et al.*, 2016). In a previous study by Siregar *et al.* (2011), the growth in the main nursery with mixed media comprising of top soil and EFB compost was similar to topsoil with the normal fertilizer application. Rosenani *et al.* (2016) reported that the use of EFB in seedling planting nursery improved soil chemical properties and vegetative growth. In addition, Albrechts and Chandler (1993) reported that the level and form of the fertilizer applied affected the root and shoot morphology. The aim of this study is to determine the effect of compost from EFB and POME anaerobic sludge as a component in the mixed media on the growth and inorganic fertilizer requirement of oil palm main nursery plants.

MATERIALS AND METHODS

Treatments. The study was conducted in Ladang 10, Universiti Putra Malaysia with daily temperature variation of 24–33°C. Pressed-shredded EFB and POME anaerobic sludge obtained from Seri Hulu Langat palm Oil Mill and FELDA Trolak Palm Oil Mill, respectively, were composted at the Biorefinery Complex, Universiti

Putra Malaysia as reported by (Baharuddin *et al.*, 2009). Oil palm seeds, Dura x Psifera, were obtained from FELDA Agricultural Services Sdn. Bhd, Pusat Penyelidikan Tun Razak, Bandar Jengka, Pahang, Malaysia. Five polybag media were prepared with 100% Serdang series topsoil and compost (50% topsoil: 50% compost v/v) with different percentages of inorganic fertilizer, as shown in Table 1. The experiment was carried out in a randomized complete block design (RCBD) with four replications. The planting distance between each polybag in the block was 3 ft. x 3 ft. (triangle). One oil palm seed was sown in each polybag of 38 cm x 45 cm with equal volume per volume of media. The seedlings were watered twice a day by using the drip system and weeded manually. An inorganic fertilizer, NPK Yellow (15:15:6) was applied from week 1 (10 g/plant), week 2 (15 g/plant), weeks 3-5 (20 g/plant) and weeks 6-8 (30 g/plant), as used in conventional agricultural practise at the oil palm main nursery. Composite sample was taken from 10 seedlings per replication and 4 replications for every sampling. Table 1 showed treatment on this experiment, i.e. 100% soil with 100% inorganic fertilizer (Treatment 1) as control, 50% soil: 50% compost with 100% inorganic fertilizer (Treatment 2), 50% soil: 50% compost with 100% inorganic fertilizer (Treatment 3), 50% soil: 50% compost with 50% inorganic fertilizer (Treatment 4) and 50% soil: 50% compost with 25% inorganic fertilizer (Treatment 5).

Table 1. List of treatment used to treat oil palm seedling in this study.

Treatment	Percentage soil with inorganic fertilizer
T1	100% Soil With 100% Inorganic fertilizer
T2	50% Soil : 50% Compost With 100% Inorganic fertilizer
T3	50% Soil : 50% Compost With 75% Inorganic fertilizer
T4	50% Soil : 50% Compost With 50% Inorganic fertilizer
T5	50% Soil : 50% Compost With 25% Inorganic fertilizer

Compost production. The compost was produced as described by (Baharuddin *et al.*, 2009) with a mixed ratio of 1:1 pressed-shredded empty fruit bunch (EFB) and thickened palm oil mill

effluent anaerobic sludge, for a period of up to 40 days, to ensure its maturity.

Plant growth. The growth of the seedlings was monitored at three, six and eight months after transplanting by recording the girth size, plant height, frond number, frond length and dry weight. The greenness of the oil palm seedling leaves or the chlorophyll content was measured by using a SPAD 502 Chlorophyll meter. The planting media were sent to the laboratory to be analysed for their nutrient content at the beginning and at the end of the experiment. Leaf samples were harvested from frond number 3 for nutrient analysis at the end of the study by drying the sampled leaves. For biomass determination, the fronds and the girths were separated and dried at 70°C in an oven until constant weight.

Soil properties and nutrient content. Soil having weight of 20.00 g was placed into a plastic bottle. Distilled water was added into the bottle. The soil was shaken intermittently for one hour and left to stand overnight. The pH was calibrated by using buffers of pH 4.00 and pH 7.00. Basic exchangeable cations were extracted and determined by electrolyte solution in 0.01 M KCl. CEC was determined with ammonium acetate and the determination of ammonium ions in the soil was done using the colorimetric method. The total organic C content of the soil was determined by using the Walkley and Black titration method (Gelman *et al.*, 2012). The total N content of the soil was determined using alkaline phenol and hypochlorite. In order to measure the P content, the soil sample was first digested for 1 ¾ hours by using a Block Digester at 200°C and the analysis of P was then done using the Auto-Analyser. Determination of soil exchangeable cations (K, Ca, Mg, and Na) was done by using 1M ammonium acetate. The potassium, magnesium and calcium determinations were done on the AAS by pipetting 2 ml of the original solution and adding 20 ml of 825 ppm Strontium nitrate by using the Auto-Diluter 111. The sodium determination was done using the original solution and reading on the AAS (Sime Darby Research 2018).

Root analysis. The remaining soil adhering to the roots was removed by washing with water. The roots were separated according to their classes, namely the primary and the secondary roots. A digital calliper was used to measure the root diameter. The dry weights of the root samples were recorded after drying them in the oven at 70-80°C until constant weight (Rosenani *et al.*, 2016).

Statistical analysis. Data on the soil properties and nutrient depletion were subjected to analysis of variance (ANOVA) using the SAS Software Windows Version 9.4 (SAS, 2014). Tukey at $P \leq 0.05$ was used to test for significant difference between the treatments. The experiment was arranged in a Randomized Complete Block Design (RCBD) with five treatments and four replications.

RESULTS

Plant physical characteristics. Figure 1 shows the diagram of oil palm nursery stage comprising of the top part (leaves and rachis) and lower part (girth, primary root and secondary root). Figure 2 shows the plant growth after eight months under the different treatments. Table 2 shows the plant physical characteristic measurements taken after eight months. Table 2 shows plant height, girth size, chlorophyll content and frond length were significantly different on plant physical characteristic. The oil palm seedlings plant height in Treatments 2, 3, 4 and 5 planting media were significantly taller than the control seedlings in the main nursery. The biggest girth size belongs to Treatment 2 and the lowest Treatment 1. The frond lengths in Treatments 2, 3, 4 and 5 were longer and comparable with the oil palm seedlings at the main nursery in the control Treatment 1. The chlorophyll content was high in Treatment 2, followed by Treatment 3, Treatment 4, Treatment 5 and the lowest in Treatment 1. However, the frond production, and frond number of the leaflet readings taken at the end of the study did not show any significant difference in the values among the treatments tested.

Table 2. Oil palm main nursery plant characteristics under different treatments.

	Treatments	Plant height (cm)	Frond production	Girth Size (cm)	Chlorophyll content (SPAD unit)	Frond length (cm)	Frond number of leaflet (%)
T1	100% Soil With 100% Inorganic fertilizer	90.35±5.89b	17±0.66a	6.31±0.05b	52.49±7.75b	55.48±3.52b	24±1.25a
T2	50% Soil: 50% Compost With 100% Inorganic fertilizer	101.56±7.92ab	18±0.50a	7.62±0.56b	59.66±6.33a	64.30±6.23ab	26±2.63a
T3	50% Soil: 50% Compost With 75% Inorganic fertilizer	101.56±7.92ab	18±0.50a	7.62±0.56b	59.66±6.33a	64.30±6.23ab	26±2.63a
T4	50% Soil: 50% Compost With 50% Inorganic fertilizer	104.34±2.04a	17±0.23a	7.53±0.28b	57.89±5.73a	69.73±7.21ab	26±1.41a
T5	50% Soil: 50% Compost With 25% Inorganic fertilizer	104.42±7.37a	17±0.77a	7.50±0.53b	59.02±4.93a	63.60±4.67ab	27±0.58a

Note: Means with the same letter column are not significantly different at $p < 0.05$ according to Tukey ($n=4$).

Figure 1. Growth of main nursery seedling at 32th week at nursery stage. **Figure 2.** Growth of main nursery seedling at 8 months (32th week) at nursery stage (A) primary root (B).

Physicochemical characteristic of growth media.

Table 3 shows the result on macronutrient analysis on media. The pH and organic carbon are significantly different between before treatment and after treatment. The pH value before treatment in 100% soil was 4.15 and that of 50% soil: 50% compost was 4.5. After treatment, the pH values in Treatment 1 and Treatment 5 decreased, while treatment with mixed media 50% soil: 50% compost in Treatments 2, 3, and 4 showed stable values between 4.01-4.10. Organic carbon before treatment with 50% soil: 50% compost had a very high value compared to 100% soil. The CEC was not significantly different among treatments. Result on macronutrients N, total P, available P, K, Ca, Mg and Al are all significantly different at $p > 0.05$. The concentration of N in 50% soil: 50% compost was high compared to 100% soil. At the end of the experiment N content in all Treatments 1, 2, 3, 4, and 5 ranged from 0.06-0.18%. The same was observed in total P value in 50% soil: 50% compost. Total P in Treatments 2, 3, 4 and 5 are high compared to Treatment 1. Addition of compost to the media can maintain and increase the amount total of P. The result on available P has the same pattern with total P. However a different result was observed on K, with little change before and after treatment. Results on

micronutrient analysis of media, B, Zn, Mn, and Si showed significant differences between before and after treatment as shown in Table 4. Interestingly, results on B, Fe, Zn, and Mn showed treatment with 50% soil: 50% compost

gave the highest values, in contrast with 100% soil with the lowest values. After treatment, the results for B, Fe, Zn and Mn showed stable values in media with compost addition.

Table 3. Effects of compost as mixed media on macronutrient chemical characteristics of the main oil palm nursery.

Treatments		pH	Org C	CEC	N	Total P	Avail P	K	Ca	Mg	Al
		(%)	(%)	(cmol(+)/kg)	(%)			EXCH			
								cmol(+)/kg			
Before											
100% Soil		4.15±0.13b	1.31±0.10c	4.23±0.21a	0.15±0.15b	44.33±5.13e	10.50±1.91c	0.07±0.01a	1.30±0.12bc	0.17±0.01e	0.37±0.03b
50% Soil : 50% Compost		4.5±0.08a	7.59±0.12a	4.12±0.12a	0.38±0.01a	973.33±19.76a	27.50±2.08c	0.03±0.01b	2.13±0.02a	2.11±0.03a	0.65±0.01a
After											
T1	100% Soil With 100% Inorganic fertilizer	3.77±0.13c	1.20±0.13c	5.23±0.33a	0.06±0.01a	200.33±12.0d	64.00±17.32b	0.08±0.01a	1.66±0.26b	0.44±0.09de	0.20±0.02c
T2	50% Soil : 50% Compost With 100% Inorganic fertilizer	4.10±0.09b	4.23±1.12b	5.10±2.36a	0.18±0.05a	466.67±17.67bc	147.00±7.73a	0.06±0.03ab	1.27±0.17c	1.37±0.02b	0.35±0.02b
T3	50% Soil : 50% Compost With 75% Inorganic fertilizer	4.06±0.06b	5.12±0.85b	4.04±0.24a	0.18±0.03a	544.67±34.39b	151.75±2.06a	0.05±0.01ab	0.76±0.16d	1.00±0.36bc	0.31±0.06bc
T4	50% Soil : 50% Compost With 50% Inorganic fertilizer	4.01±0.08b	4.16±1.28b	4.62±1.38a	0.15±0.03a	544.67±34.12b	166.75±18.84a	0.05±0.02ab	0.42±0.08d	0.74±0.26cd	0.27±0.11bc
T5	50% Soil : 50% Compost With 25% Inorganic fertilizer	3.98±0.02bc	3.78±0.71b	4.68±1.43a	0.14±0.02a	396.33±9.01c	59.75±21.75b	0.06±0.01ab	0.66±0.10d	0.62±0.13cd	0.22±0.04c

Note: Means with the same letter column are not significantly different at $p < 0.05$ according to Tukey ($n=4$).

Table 4. Effect of compost as mixed media on macronutrient chemical characteristics by oil palm main nursery.

Treatments		B	Fe	Zn	Mn	Si
		mg/kg				
Before						
100% Soil		0.59±0.05c	338.15c	2.37±0.34b	1.22±0.07c	125.55±10.31a
50% Soil : 50% Compost		3.25±0.04a	455.46bc	27.85±7.05a	28.04±0.90c	0.23±0.02b
After						
T1	100% Soil With 100% Inorganic fertilizer	0.52±0.10c	581.35ab	1.68±0.06b	157.92±6.82a	3.91±0.22b
T2	50% Soil : 50% Compost With 100% Inorganic fertilizer	1.55±0.32b	517.95ab	1.98±0.07b	110.49±18.97b	5.68±0.76b
T3	50% Soil : 50% Compost With 75% Inorganic fertilizer	1.62±0.23b	577.95ab	2.00±0.06b	112.43±10.43b	4.42±0.76b
T4	50% Soil : 50% Compost With 50% Inorganic fertilizer	1.35±0.22b	589.56ab	1.91±0.05b	127.56±23.63ab	4.07±1.47b
T5	50% Soil : 50% Compost With 25% Inorganic fertilizer	1.5±0.15b	674.77a	1.93±0.04b	128.95±16.28ab	4.44±0.61b

Note: Means with the same letter column are not significantly different at $p < 0.05$ according to Tukey ($n=4$).

Dry weights of leaf, rachis, girth and root. The results presented in Table 5 showed that the dry weight of rachis was not significantly different among the treatments. The highest dry weight of leaves within all media mixed and the lowest on control know as Treatment 1, 100% soil with 100% inorganic fertilizer. Result on dry weight of girth size, total of shoot and total of root same trend with dry weight of leaves, with media mixed

got high dry weight. The total root showed that Treatment 5 had the best root followed by Treatment 4, Treatment 3 and Treatment 2, with the lowest in Treatment 1 (control). Figure 3 shows that the primary and secondary roots were significantly different in the main nursery of the oil palm. The primary and second roots of seedlings treated with 50% compost showed better results compared to the control.

Figure 3. Effects of compost application on (a) primary roots and (b) secondary/tertiary roots of seedlings in the main oil palm nursery. Bars with different lowercase letter differ significantly ($p < 0.05$).

Table 5. Effects of compost as mix media on dry weights of seedlings in the oil palm main nursery

	Treatments	Dry Weight of Leaves (g/plant)	Dry Weight of Rachis (g/plant)	Dry Weight of Girth (g/plant)	Total of Shoot (g/plant)	Total of Root (g/plant)	Root: Shoot
T1	100% Soil With 100% Inorganic fertilizer	177.27±4.50 b	133.43±22.6 4a	102.98±12.71b	310.70±24.1 6c	128.93±1.59 b	0.41±0.03a b
T2	50% Soil: 50% Compost With 100% Inorganic fertilizer	101.56±7.92a b	18±0.50a	7.62±0.56b	59.66±6.33a	64.30±6.23a b	26±2.63a
T3	50% Soil : 50% Compost With 100% Inorganic fertilizer	215.00±21.3 2a	163.34±12.7 1a	118.58±25.00a b	378.37±8.66a	136.56±4.86 b	0.36±0.02 b
T4	50% Soil: 50% Compost With 50% Inorganic fertilizer	104.34±2.04a	17±0.23a	7.53±0.28b	57.89±5.73a	69.73±7.21a b	26±1.41a
T5	50% Soil : 50% Compost With 75% Inorganic fertilizer	187.13±3.91a b	132.70±16.6 84a	117.46±8.60ab	319.83±16.0 0bc	134.57±5.95 b	0.42±0.04a b

Note: Means with the same letter column are not significantly different at $p < 0.05$ according to Tukey (n=4).

Foliar nutrients. The results presented in Table 6 showed that the foliar nutrients from the main nursery were only significantly different for N and P. The K, Ca, Mg, S, B, Cu, Fe, and Zn contents did not show any significant difference among all the planting media tested. It was postulated that the higher total N uptake in the leaf could be due to the supplementary nutrient content of the compost itself and the optimum C: N ratio (Robbins, 2013). The value for N was the highest in Treatment 2, followed by Treatments 3 and 4.

Cost of material. Table 7 shows the material cost for oil palm planting media at nursery stage. The highest cost was for 100% soil with 100% inorganic fertilizer (Treatment1) as control at RM6.04 per polybag, followed by 50% soil: 50 compost with 100% inorganic fertilizer at RM5.20 (Treatment 2). Treatment 3 with 50% soil: 50% compost with 75% inorganic fertilizer was RM4.64 per polybag while in Treatment 4 it was RM4.23. The lowest cost was in Treatment 5 at RM3.92 per polybag.

DISCUSSION

A suitable planting media will have a positive effect on the physical characteristics and

vegetative growth of oil palm seedling (Akb *et al.*, 2018). The dry weight of leaves, rachis and shoot to root ratio did not significantly differ among the treatments but the plant height, dry weight of girth and total of root significantly differed, indicating that the addition of composted agricultural waste significantly improved root growth. A similar phenomenon was reported by Al-Busaidi (2013). Nitrogen content has a strong correlation on leaf chlorophyll content, seedling height, root diameter and shoot morphology (Schlemmer *et al.*, 2013; Cuesta *et al.*, 2010; Andivia *et al.*, 2011; Olié *et al.*, 2009). N availability affected root elongation, root biomass, production and mortality (Kern *et al.*, 2004; Woolfolk and Friend, 2003). Primary root length is reduced by lowering nitrate application (Mounier *et al.*, 2014). Phosphorus (P) is essential for plant growth for root development, new shoot growth, flower development and for providing energy for the plant. P has mixed effect on root collar and plant height (Huda *et al.*, 2007). Starvation of phosphate stimulates lateral root growth, inhibit primary root and enhances root hair production (Shahzad and Amtmann, 2017). Efficient root management can help reduce the requirement of inorganic fertilizers (Shen *et al.*, 2013). From our results, even with the reduction in application to 50% compost with 50% soil : 50% inorganic fertilizer, there was 30% increase

in the total root biomass compared to 100% soil with 100% inorganic fertilizer. The diameters of the primary and secondary roots were significantly increased by using the mixed medium of T4 as 50% soil: 50% compost with 50% inorganic fertilizer as shown in Figure 1. This is supported by Zuraidah *et al.* (2015) who reported that the secondary root can penetrate the soil deeper to extract the nutrients on oil palm nursery. Root development on compost has better penetration because the soil mixed with compost had larger pores and less compaction compared to 100% soil as media (Celik *et al.*, 2010). This indicated that the root structure with compost could penetrate the soil deeper and absorb more nutrients as compared to the roots without compost. Lord and Betitis (2007) reported that oil palm seedlings raised plant height on compost with 75%, 50% and 25% of normal fertilizer regime had both widths and heights which were significantly greater than the soil at 100% of normal regime. Compost addition improved soil aeration and pore space. Compost application increased soil C content and also improved soil aggregation contributing to better crop growth (Rivenshield and Bassuk, 2007). These further highlighted the importance of compost in the growth medium to alleviate soil C content and to improve soil physical properties (Norizan *et al.*, 2016). Adding compost also improved the chemical properties of the growth medium as shown by various studies, which reported the ability of the compost to reduce soil acidity (Valarini *et al.*, 2009 and Giannakis *et al.*, 2014). Availability of nutrients depend on pH (Michael *et al.*, 2012). The C content of the medium increased significantly after treatment, treatment with 50% soil: 50% compost being 7.59% as compared to 100% soil at 1.31%. Abad *et al.* (2001) reported a similar pattern when compost was added to ornamental potted plant. Organic carbon for treatment in 100% soil with 100% inorganic fertiliser was 1.20%, compared to treatment in 50% soil : 50%

compost which had a higher organic content from 3.78%-5.12%, probably due to additional binding sites for exchangeable bases and decreased the availability of polycations like Fe^{2+} and Al^{3+} (Xu *et al.*, 2006). Thus, the addition of compost which is rich in negative functionalities could stabilize the pH value of the growth medium (Goh *et al.*, 1997). Besides, the high contents of alkaline elements (excess cations), particularly Ca and Mg which are present in the compost, could react with the free H^+ . This explained the liming effects of compost and the decarboxylation of organic anions during decomposition, improving the pH of the growth medium. Soil chemical characteristic is an important consideration in assessing the suitability of a soil for oil palm cultivation and the requirement for mineral fertilizers. Aluminum toxicity is recognized as a common concern in mineral soils at a low pH, but this is usually not a problem in organic-based mixed media (Xu *et al.*, 2006). This might be due to the depletion of the top soil in the old running nursery. At the end of experiment, both compost-based treatments by 50% soil: 50% compost with 75% inorganic fertilizer and by 50% soil: 50% compost with 50% inorganic fertilizer showed the highest values in total N compared to the other treatments, a reflection of the high N uptake by the leaves. Furthermore, compost could also supply the seedlings with additional N, P, Ca, Mg, and Zn, functioning as a source of nutrients and trace elements besides the inorganic fertilizers. Another mechanism could be that compost retained the nutrients in the growth medium by surface adsorption, thus increasing the nutrient recovery (Jouquet *et al.*, 2011). The cost of material was similar as reported by Mohammad (2014). The increasing production cost of seedlings is one of the main issues to a nursery operator. With the calculated cost of material and good performance of seedlings produced, the findings and results of this study can be used as a basis for commercial venture.

Table 6. Effects of compost as mix media on foliar nutrient in the main oil palm nursery.

Treatments		Total N	P	K	Ca	Mg	Cl	S	B	Cu	Fe	Zn
		(%)	EXCH cmol (+)/kg					mg/kg				
T1	100% Soil With 100% Inorganic fertilizer	2.71±0.1 2ab	0.17±0.01a b	0.90±0.0 3a	0.63±0.07a	0.26±0.0 3a	0.88±0.04a	0.13±0.0 1b	16.00±0.82 a	1.55±0.3 6a	96.11±3.15 a	19.32±0. 84a
T2	50% Soil : 50% Compost With 100% Inorganic fertilizer	2.88±0.0 6a	0.18±0.01a	1.00±0.0 8a	0.65±0.09a	0.28±0.0 2a	0.88±0.03a	0.14±0.0 1a	15.75±1.26 a	1.74±0.5 5a	97.81±7.80 a	20.11±1. 18a
T3	50% Soil : 50% Compost With 75% Inorganic fertilizer	2.84±0.1 2ab	0.17±0.01a b	0.91±0.0 2a	0.73±0.05a	0.25±0.0 1a	0.88±0.02a	0.14±0.0 1a	16.00±0.82 a	2.38±0.2 7a	101.93±3.7 6a	21.03±1. 05a
T4	50% Soil : 50% Compost With 50% Inorganic fertilizer	2.84±0.0 3ab	0.17±0.01a b	0.91±0.0 6a	0.72±0.04a	0.26±0.0 1a	0.88±0.01a	0.15±0.0 1a	15.50±1.00 a	2.34±0.3 2a	101.55±3.4 4a	21.26±0. 38a
T5	50% Soil : 50% Compost With 25% Inorganic fertilizer	2.67±0.0 3b	0.16±0.01b	0.91±0.0 4a	0.66±0.11a	0.24±0.0 1a	0.90±0.01a	0.14±0.0 1a	14.5±1.00a	2.22±0.4 1a	98.91±2.60 a	19.21±1. 41a

Note: Means with the same letter column are not significantly different at $p < 0.05$ according to Tukey.

Table 7. Material cost per polybag of planting media.

Treatment	Percentage soil with inorganic fertilizer	RM / Polybag
T1	100% Soil With 100% Inorganic fertilizer	RM6.04
T2	50% Soil : 50% Compost With 100% Inorganic fertilizer	RM5.20
T3	50% Soil : 50% Compost With 75% Inorganic fertilizer	RM4.64
T4	50% Soil : 50% Compost With 50% Inorganic fertilizer	RM4.23
T5	50% Soil : 50% Compost With 25% Inorganic fertilizer	RM3.92

Topsoil =RM160/ton, Compost =RM150/ton, NPK Blue = RM1300/ton and NPK Yellow = RM1200/ton.

CONCLUSION

The loss of nutrients from the oil palm nursery system, especially in the main nursery can be high if high inorganic fertilizer rates are applied and the best medium is used. Improvement in nutrient retention should be possible with adaptation of irrigation methods that supply water more efficiently and media as fertilizer and slow release nutrient sources. Replacement of inorganic fertilizer by 50% compost in the growth medium mixture in the main nursery was able to reduce the application of inorganic fertilizer by as much as 50%, resulting in overall cost reduction. The important finding in this study was that reduction of 50% inorganic fertilizer using 50% soil: 50% compost medium did not affect plant growth. Secondary and tertiary roots, which are important for the absorption of nutrients from the soil, were found to increase in all treatments with 50% soil: 50% compost, thus allowing for the reduction of inorganic fertilizer use. Further studies on the use of compost in the mixed growth medium should be done to ascertain the effects of the reduction of inorganic fertilizer on the soil microbial profile.

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