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# Growth, Dry Matter Yield and Nutrient Uptake of Oil Palm Seedlings (*Elaies guineensis* Jacq.) as Affected by Different Soil Ammendments

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## Abstract

The use of quality growth medium can enhance growth and development of oil palm seedlings as the continual use of soil alone in oil palm nursery operations is becoming environmentally unsustainable. Organic materials such as biochar and compost have been found not only to reduce the amount of top soil used in the nursery but also have the potential to provide adequate nutrients for oil palm seedling growth. The aim of this study was to evaluate different growing media (soil only, soil amended with rice husk biochar (RHB) and compost (CO); at different ratios (1:1), (1:1:1), (1:1:2) and (1:2:1). The effect of type of growing media on the physico-chemical properties were monitored. In addition, the vegetative growth parameters, dry weight of seedlings and plant nutrient uptake of the seedlings were measured. Water holding capacity of the media increased with an increase in compost while increasing the RHB did not reflect any direct pattern in the water holding capacity of the growing medium. Generally, organic materials (biochar, compost) based growth media treatments recorded higher and significant differences in the parameters monitored compared to the treatment that did not receive any organic amendments. The soil+RHB +CO, 1:1:2 growth media recorded the highest vegetative growth and nutrient uptake compared to the control (Soil only).

**Keywords:** Rice husk biochar; Compost; Vegetative growth; Nutrient uptake

## Introduction

Annually over 3000-3500 tons of soil is needed to raise oil palm seedlings in Ghana, a practice which is environmentally unsustainable as it degrades the area from which soil is collected [1]. Another constraint of raising oil palm seedlings in polybags that are fully filled with soil is that it is so heavy that most farmers transport seedlings without to the fields for planting. This practice destroys several roots and affect early field establishment and growth thus defeating partly the objectives of raising the planting material in polybags. Growing media is a key material to produce high quality, oil palm seedlings. Many Various media formulations have been developed from waste materials and successfully introduced to the nursery industries. These include lightweight bio-waste resources, which are cheaper, more porous, and renewable than natural soil or peat [2,3] pointed out that palm growth in the nursery is poor when subsoil was used for poly bag filling. Among the organic residues, carbonated rice husk (biochar and dewatered fecal sludge compost) are promising materials that could be introduced to container media for the production of quality seedlings, since vigorous growth is needed to withstand the vagaries of the weather and as well as field pest and diseases resistance [4]. The structure of the planting media must be soft, porous enough and also provide anchorage and support for the palms [5]. This is because palm seedlings growth characteristic is strongly dependent on the correct functioning of the root system. The difference in physical and chemical properties of planting media which reflects the variation in physical and biomass allocation of oil palm seedlings can be used to classify the suitability of a planting media in relation to the needs of the vegetative growth. Efforts to increase the soil nutrient status through the use of inorganic fertilizers are accompanied by high cost, scarcity at farmer's level and probable degradation of soil by continuous use [6]. Hashim et al. [7] found that light weight potting media such as peat/polystyrene, dried affluent/polystyrene, coir dust/polystyrene and soil/polystyrene are suitable in the nursery for raising oil palm seedlings. Meanwhile, study by Quah [8] indicated that palm kernel shells (PKS)+coco peat mixed at 6:1 ratio by weight is a suitable light weight planting medium for oil palm nursery. Apart from the high nutrient content and light-structure of planting media the optimum water holding capacity, pH, CEC, better aeration and organic matter also are the dominant factors considered when choosing materials as planting media [4]. Thus, the purpose of this study was to determine the most suitable planting media and their effect on the oil palm seedling growth in line with standard management practice.

## Materials and Methods

The study was carried out at the University of Ghana Agricultural Research Centre (ARC), Okumaning-Kade, in the Kwaebribirim district, (6°05'N; 0°05'W), and 175 km from Accra. It is located in the moist semi-deciduous vegetation zone in the Eastern Region of Ghana. The study area has a bimodal rainfall pattern with an annual rainfall of 1678 mm recorded in 2011. Rainfall within the growing period (August, 2015-March, 2016) was 574.8 mm. Temperature ranged between 29.9°C-33.3°C and relative humidity between 63.6-92.3.

Six different soil amended growth media which included 100%soil(M1), soil+RHB+compost(1:2:1)(M2), soil+RHB +compost(1:1:1)(M3), soil+RHB+compost(1:1:2) (M4), soil+RHB

(1:1) (M5) and soil+compost (1:1) (M6). All planting media were filled into 30 cm × 35 cm black polybags on v/v ratio. For the control, soil alone without any fertilizer treatment was used. Top soil used was taken at a depth of 0-10 cm, air-dried and sieved through 5 mm mesh size to remove all plant debris, soil clogs and stones in order to obtain a fine tilth. All other media combinations in their respective ratios were thoroughly mixed. Germinated nuts procured from Oil Palm Research Institute (OPRI) were planted on the 16 August 2013 in polybags filled with the different growth media. The polybags with growth media watered and water left to settle for 24 hours before seedlets were planted in the middle of each polybag. Polybags were transferred to the nursery site, mounted on bamboo platforms to avoid root- soil contact with the in situ soil with pots spaced 20 cm apart.

The seedlings stayed at the nursery for seven months and were watered two times a week at 0.8 litres of water/seedling to ensure optimum moisture levels are maintained. Polybags were hand weeded regularly to prevent weeds from serving as host to pests and also competing with the seedlings for nutrients. Ground weeds were also controlled with a non-selective herbicide Kalach at 150 mls/15 litres of water. The treatments were arranged in a randomized complete block design with three replications where each plot contained twelve seedlings. The growth of seedlings were monitored for seven months after planting by recording the vegetative growth including girth size , chlorophyll, plant height, and total leaf area. The soil amended growth media were sent to laboratory to analyse the physical and chemical contents at the beginning of the experiment. Leaf samples were harvested for nutrient analysis at the end of the study. For biomass allocation, the upper shoot and lower shoots were separated and dried at 70ºC in an oven until constant weight was obtained. Plant nutrient uptake from each growth media was also determined at the end of the study using the equation;
DMY × NUT.CONC/100

| Media | Bulk density g/cm³ | Water holding capacity (%) | pH | E.C (dS/m) | N (%) | P (%) | K (%) |
|---|---|---|---|---|---|---|---|
| M1 | 0.98 | 35.00 | 5.8 | 0.24 | 0.89 | 0.05 | 0.34 |
| M2 | 0.63 | 83.60 | 7.3 | 3.00 | 0.78 | 0.05 | 1.14 |
| M3 | 0.66 | 89.80 | 7.0 | 1.50 | 1.55 | 0.80 | 0.13 |
| M4 | 0.67 | 91.70 | 7.1 | 2.50 | 2.26 | 0.89 | 1.63 |
| M5 | 0.64 | 84.00 | 6.8 | 1.20 | 0.53 | 0.05 | 0.19 |
| M6 | 0.78 | 81.70 | 7.2 | 1.90 | 1.23 | 0.72 | 0.14 |

**Table 1:** Some physical and chemical characteristics of the growing media.

## Data analysis

The data collected was subjected to the analysis of variance using Genstat 12th edition statistical package. LSD at p ≥ 0.05.

# Results and Discussion

The bulk density (0.98 g cm$^{-3}$) of the top soil was, significantly higher than that of the organic material-based growing media (Table 1). The application of rice husk biochar was more effective in reducing bulk density of the growing media than the compost, thus the bulk density of soil+50% compost (M6), was significantly higher than any treatment containing RHB (M2, M3, M4 and M5) which is consistent with the findings that a 10% biochar amendment significantly decreased bulk density of the soil [9]. Compost application generally influences soil structure in a beneficial way by lowering soil density due to the admixture of low density organic matter into the mineral soil fraction. This positive effect has been detected in most cases and it is typically associated with an increase in porosity because of the interactions between organic and inorganic fractions [10].

The water holding of the various growing media was the highest in M4 (91.7%) and the lowest in the soil only treatment (35.0%), suggesting that organic materials significantly increased the Water holding capacity of the growing medium. Water holding capacity of the media increased with an increase in compost while increasing the RHB did not reflect a direct pattern in the water holding capacity of the growing medium. Increasing the compost fraction in the growing medium increased (Table 1), while increasing the RHB fraction did not reflect a direct effect pattern in the water holding capacity of the growing medium (Table 1) his observation is contrary to Grigatti et al. [11] who reported that for water holding capacity generally decrease with increase in compost percent.

Results of the initial growth media content showed that the soil was generally low in N, P, and K (Table 1). The soil pH was slightly acidic with low EC. Nutrient analysis of soil amended growth media is shown in Table 1. N, P, K contents were high with pH above neutral. This consequently makes the compost appropriate to supply nutrients for plant growth due to its ability to enhance soil pH and improve buffering capacity [7,12].

## Plant growth indicators

The mean seedling height was significantly affected by the type of growth media used. Growth media M2 (TS+CRH+CO, 1:2:1), M3 (TS +CRH+CO, 1:1:1), M4 (TS+CRH+CO, 1:1:2), M5 (TS+CRH, 1:1), and M6 (TS+CO, 1:1) increased seedling height significantly compared to the control M1 (TS only). As at the seventh month, average plant height in M4 was 36.5% higher than in M1. The order of mean seedling height decreased as follows M4>M5>M2>M6>M3>M1 (Table 2). The results showed that mean butt diameter of treatments M2, M3, M4, M5, M6 were highly significant (p ≥ 0.05) compared to M1 treatment. The highest girth was recorded in M5, M4 and M2 (32.2, 30.9 and 28.4 respectively). The order of mean bole diameter also decreased as follows M5>M4>M2>M6>M3>M1 (Table 2). The addition of organic material (CRH, COMP or combinations) induced greater leaf area than the soil only treatment. The M4 treatment induced the highest total leaf area, and was 1.5 fold higher than that of the soil only treatment. The different combination of the growth media, soil/CRH/COMP treatments also affected the total leaf area, as M4 was greater than M2 and M3 by 9% and 30% respectively. Similarly, M4 was greater than M5 and M6 by 4% and 17% respectively. The application of CRH to the soil (M5) induced 13% greater leaf area than that of application of Compost (M6) (Table 2). Type of growth media used significantly affected the total dry weight at seven months. The highest total dry weight of M4 (40.03 g/plant) was 1.18 fold greater than the dry weight of soil only (18.38 g/plant). Similarly, the total dry weight of M4 was 62% greater than M3, indicating that the composition of the growth medium is significant in contributing to total dry matter production of oil palm seedling. The total dry weight of M4 was greater than M2, M5 and M6 by 24%, 4% and 27% respectively (Table 2).

The reason for the increased growth in the organic based growth media could be due to the higher nutrient uptake as a result of low bulk density, suitable pH, adequate water holding capacity that promoted the absorption and translocation of nutrients to the shoot. These plant nutrients promoted larger leaf area, high chlorophyll content and taller plants that generated greater photosynthetic area, and produced the high shoot and total plant dry weights, compared to the soil only treatment. Similar findings were recorded by Kumah [13] who observed significant increase in leaf area, plant height, shoot and root dry weights and total dry matter production of plantain sucker as a result of low bulk density, increased water holding capacity and a pH range of 6.8, when biochar and compost were added to the growth media. Similarly, Burke et al. [14] reported a significant increase in leaf area, stem dry matter; and fruit dry matter of cotton when biochar was applied. Biochar improved soil nutrient holding capacity and replenishment. Soil incorporation of biochar reinstates Carbon (C), nitrogen (N) and a variety of plant nutrients that are extracted from the soil upon the removal of biomass [15,16].

| TRTS | Plant height (cm) | Bole diameter (mm) | Leaf area (cm$^2$) | Total plant dry weight(g) |
|---|---|---|---|---|
| M1 | 42.2 | 22.4 | 175.7 | 18.36 |
| M2 | 54.5 | 28.4 | 407.5 | 32.29 |
| M3 | 47.4 | 24.9 | 341 | 24.77 |
| M4 | 57.6 | 30.9 | 444.6 | 40.03 |
| M5 | 55.8 | 32.2 | 427.4 | 38.54 |
| M6 | 49.8 | 26.8 | 379 | 31.54 |
| LSD (P ≥ 0.05) | 0.62 | 0.21 | 2.57 | 0.38 |

**Table 2:** Effects of different soil amended growth media on the vegetative growth of seedlings.

### Plant nutrient uptake

The total N uptake by oil palm seedling was influenced by the type of growing medium and was the highest in M4 and the lowest in the SOIL only medium (Table 3). The highest N accumulated was recorded in M4 (1.29 gN/plant) and was significantly greater than M2 and M3 by 27% and 70% respectively. The addition of biochar to the soil treatment (M5) accumulated 16% greater N than application of compost (M6) and the difference was significant. The highest P uptake was observed in treatment M4 (0.15 gP/plant) and was 1.5 fold greater and significantly different from that accumulated by the soil only treatment (0.06 gP/plant). There was no significant difference in the P accumulated between M2 and M4, however P accumulated by M5 (addition of biochar only) was 8.4% greater than M6 (addition of compost only). Similarly, treatment M4 accumulated 15% and 36% greater P than M2 and M3 respectively (Table 3) The highest K accumulation was observed in M4 and was significantly different from the soil only treatment (M1) which recorded the lowest among the treatments. The combination of the different fractions in the growing medium affected the K accumulation as M4 accumulated 27% and 59% greater K than M2 and M3 respectively. The K accumulated by adding compost to the growing medium (M6) was greater than applying biochar only (M5) by 8% and the difference was significant (Table 3). This result suggests that the organic material provided adequate nutrients in synchrony to meet the plant nutrient requirement. This supports earlier reports by Cox et al. [17] that biochar application enhanced nutrient availability and acts as a 'slow release' fertilizer.

| Media | N g/plant | P g/plant | K g/plant | Ca g/plant | Mg g/plant |
|---|---|---|---|---|---|
| M1 | 0.70 | 0.06 | 0.28 | 0.02 | 0.07 |
| M2 | 1.01 | 0.13 | 0.55 | 0.03 | 0.19 |
| M3 | 0.76 | 0.11 | 0.44 | 0.03 | 0.17 |
| M4 | 1.29 | 0.15 | 0.70 | 0.04 | 0.24 |
| M5 | 1.18 | 0.13 | 0.56 | 0.04 | 0.18 |
| M6 | 1.02 | 0.12 | 0.61 | 0.04 | 0.18 |
| LSD (p ≥ 0.05) | 0.07 | 0.02 | 0.04 | NS | 0.02 |

**Table 3:** Effects of different soil amended growth media on the nutrient uptake of seedlings.

## Conclusion

In general, Organic materials in different combinations with Kokofu soil series (top soil) significantly affected the physico-chemical properties of the growing media compared to the control (soil only). In terms of seedlings growth, planting media M4 and showed good performance for all variables measured compared to the control. Seedlings nutrient uptake analysis showed higher nutrient uptake of N, P and K contents when grown in M4 compared to the control.

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## References

1. Danso F, Adu C, Opoku A, Danso I, Anim Okyere S, et al. (2013) Raising oil palm seedlings using sole and amended green-gro compost. International Research Journal of Agricultural Science and Soil Science 3: 362-368.
2. Ingelmo F, Canet R, Ibanez MA, Garcia PJ (1998) Use of MSW compost, dried sewage sludge and other wastes as partial substitutes for peat and soil. Bioresource Technology 63: 123-129.
3. Gillbanks AR (2003) Standard agronomic procedures and practices. Chapter in Oil Palm.
4. Khan MM, Khan MA, Mazhar A, Muhammad J, Ali JMA, et al. (2006) Evaluation of potting media for the production of rough lemon nursery stock. Pak J Bot 38: 623-629.
5. Asiah A, Mohd Razi I, Mohd Khanif Y, Marziah M, Shaharuddin M (2004) Physical and chemical properties of coconut coir dust and oil palm empty fruit bunch and the growth of hybrid heat tolerant cauliflower plant. Pertanika J Trap Agric Sci 27: 121-133.
6. Folorunso OO (1999) Use of plant residues for improving soil fertility and the yield of okra (Abelmuschus esculentum) and amaranthus (Amaranthus viridis). PhD Thesis, Federal Univ of Tech, Akure, pp: 1-3.
7. Hashim MT, Yeow KH, Poon YC (1987) Recent Development in Nursery Practice- Potting Media. In Proceedings of the 1987 International Palm Oil/Palm Oil Conferences. Progress and Prospects, Conference 1-Agriculture, Palm Oil Res Inst, Malaysia, Kuala Lumpur, pp: 369-371.

8. Quah YT (1995) Palm kernel shells (PKS) and Cocopeat as light weight planing medium in oil palm nursery. AAR News October 1995, Internal Circulation, p: 6.
9. Zavalloni C, Alberti G, Biasiol S, Vedove GD, Fornasier F, et al. (2011) Microbial mineralization of biochar and wheat straw mixture in soil: A short-term study. Appl Soil Ecol 50: 45–51.
10. Amlinger F, Peyr S, Geszti J, Dreher P, Karlheinz W, et al. (2007) Beneficial effects of compost application on fertility and productivity of soils. Literature Study, Federal Ministry for Agriculture and Forestry, Environment and Water Management, Austria.
11. Grigatti M, Giorgioni ME, Clavatta C (2007) Compost-based growing media: Influence on growth and nutrient use of bedding plants. Bioresource Technology 98: 3526-3534.
12. Ouedraogo E, Mando A, Zombre NP (2001) Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. Agriculture Ecosystems & Environment 84: 259-266.
13. Kumah HK (2012) Effect of type of initiation and growing media on growth and nutrient uptake of plantain (Musa aab) at the nursery stage. Mphil thesis submitted to School of Research and Graduate Studies. Crop Science Department, College of Agriculture, University of Ghana, Legon, pp: 38-41.
14. Burke JM, Longer DE, Oosterhuis DM, Kawakami EM, Loka DA (2014) The Effect of biochar source on cotton seedling growth and development and association with conventional fertilizers. International Journal Plant and Soil Science 3: 996-1008.
15. Laird DA (2008) The charcoal vision: a win–win–win scenario for simultaneously producing bioenergy, permanently sequestering carbon, while improving soil and water quality. Agronomy Journal 100: 178-181.
16. Mullen CA, Boateng AA, Goldberg NM, Lima IM, Laird DA, et al. (2010) Bio-oil and biochar production from corn cobs and stover by fast pyrolysis. Biomass and Bioenergy 34: 67-74.
17. Cox J, Downie A, Jenkins A, Hickey M, Lines-Kelly R, et al. (2012) Biochar in horticulture: Prospects for the use of biochar in Australian horticulture. HAL report.