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Research Article

The Impact of Different Growth Media on Cocoa *(Theobroma cacao L.)* Seedling

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Abstract
Suitable growth medium is scarce, which constitutes a major challenge in cocoa seedling breeding across West Africa (e.g. Ghana). Information on efficient growth media would boost sustainable cocoa production. Complete Randomized Block Design using four treatments [i.e., River Sand + Sawdust (T_1), River Sand (T_2), Clay Soil (T_3) and Top Soil-Control (T_4)] with three trials was employed. River Sand and Sawdust (2:1) mixture recorded the greatest plant height (i.e., 23.46, 26.51 and 31.56cm) on day 30, 60 and 120, respectively. Significant differences ($P<0.05$) existed between the former and seedlings bred on Clay Soil. Top soil treated cocoa seedlings followed and River Sand ranked third. Seedlings treated on Clay Soil performed poorly for all the growth parameters. Significant differences ($P<0.05$) existed between the treatments for plant height and stem girth. River Sand and Sawdust (2:1) mixture could supplement Top Soil (control) in cases where the latter is scarce for healthy seedling production.

Keywords
aeration, cash crop, growth medium, soil amendment, vegetative growth

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1. Introduction

Cocoa (Theobroma cacao) is Ghana's chief export crop and most sought after cash crop. It is one of the most modelled commodities internationally [1] and attracts price premium globally due to its great fat content, which is above average, low levels of debris and adequate cocoa butter yields when processed [2]. However, the integral part of most horticultural production system is a growing medium. The substrates [i.e., the propagation media in which plants grow], which provide anchorage for the plant roots, air spaces to enhance aeration and retain sufficient available water are known as the growth media [3]. Growing media affect plant performance in bare roots and container nursery production [4]. The inherent nutrients and soil factor determine the productivity of crops [5]. Mostly, nursery or propagation media influence the emergence and growth of seedlings. Thus, suitable media that could enhance the vigour of seedlings is crucial [6] for continual cocoa production.

Nonetheless, there has been a decline in cocoa productivity over the years owing to over aged cocoa farms and the black pod disease. As a result, Government have intervened by rehabilitating the unproductive farms and replacing the diseased cocoa plants across the cocoa production zones with over 60 million hybrid cocoa seedlings tolerant to drought, diseases and of great yield [7]. Therefore, farmers need good cocoa seedlings for replanting their plantations. Yet, cocoa nurseries face a lot of challenges in cocoa growing areas of which, lack of suitable growth media for propagation of hybrid cocoa seedlings is a typical example. More so, Top Soil for nursery is usually conveyed from long distances to nursery sites and its scarcity hinders the attainment of the government and COCOBOD goals of raising healthy hybrid cocoa seedlings for effective and efficient distribution to farmers [8]. Fortunately, different growth media are available,

which are economical and could be suitable alternative to this already known Top Soil. Hence, this study sought to investigate the possibility of using different growth media in the propagation of healthy cocoa seedlings for sustainable production.

2. Materials and Methods

2.1 Study Area

The study was conducted within the nursery premises of the Cocoa Health and Extension Division Unit of COCOBOD, Nkrakwanta District (Latitude 7º 80' North and 7º 25' and Longitude 2º 35' West and 2º 48') 2.2 Experimental Design Complete Randomized Block Design using four treatments [i.e., River sand + Sawdust (T1), River sand (T2), Clay soil (T3) and Top soil-Control (T4)] with three replicates was engaged for this study. Nursery bags were initially perforated at the base with a perforator creating a 0.25 mm2 hole to facilitate drainage. Top Soil, which served as the control, River Sand, Clay Soil and Sawdust were, respectively sampled from an old dumping site, stream near the nursery, termite hill and sawmill. Specimens were sun-dried and sieved to a finer texture with the exception of Sawdust. River Sand and Sawdust (2:1) mixture were prepared. Polybags (17.5 × 25 cm^2) were arranged on thick polythene sheet to prevent the penetration of roots into the ground, from possible uptake of nutrients. For each treatment, 25 polybags were filled with respective medium. Hybrid cocoa pods were obtained from Bunsu Seed Production Unit of Ghana COCOBOD. Fresh cocoa beans were sown 2 seeds per polybag and thinning was carried out two weeks after germination. A shade net, which allowed about 40% sunlight through it was employed in this study and watering was done every three days. Liquid Foliar Fertilizer (Sidalco NPK - 10:10:10) (at a rate of 10 ml per 15 litres of water) was applied to the seedlings two weeks after germination with a knapsack sprayer. One insecticide treatment (60 ml Akatemaster 200 SL in 4.5l of water) was carried out on the third week using a knapsack sprayer so as to inhibit the growth of insect pests [9].

2.2 Data collection

Polybags from the middle of each block were selected and tagged for morphological data measurements. Leaf counts was conducted and stem diameter as well as plant height investigated, using thread and standard metre rule on day 30, 60 and 120, respectively [10].

2.3 Data Analysis

Data on seedling morphological growth was subjected to Analysis of Variance (ANOVA) and Fisher's Least Significant Difference (LSD) Test (at 95% confidence level) to compare their means using Statistical Package for the Social Sciences (SPSS).

3. Results

3.1 Plant height

River Sand and Sawdust (2:1) mixture recorded the greatest plant height (23.46 cm) for day 30 and Clay Soil recording the least (20.10 cm) relative to the Top Soil (control) (22.56 cm). There were no significant differences between the treatments [i.e., River Sand + Sawdust, River Sand and Top Soil (control)] except for the Clay Soil. For day 60, plant height was greatest for River Sand + Sawdust (31.26 cm) and Clay Soil recorded the least (22.51 cm) as compared to the control (26.31 cm). The differences between the treatments [i.e., River Sand + Sawdust (26.51 cm), River Sand (26.16 cm) and Top Soil (control) (26.31 cm)] for plant height were not significant. However, there were significant differences ($p<0.05$) between Clay Soil and the other three treatments. Close values were observed for River Sand + Sawdust, Top Soil and Rive Sand on day 120 and the differences were not significant. Clay Soil was significantly different ($P<0.05$) from the other treatments (Table 1).

Table 1. Effect of different growth media on height of cocoa seedlings

	Mean Plant Height (cm)		
Soil type	**30 Days**	**60 Days**	**120 Days**
River Sand + Sawdust (T_1)	23.46 ± 0.42^a	26.51 ± 0.97^a	31.26 ± 0.90^a
River sand (T_2)	22.04 ± 0.68^a	26.16 ± 0.92^a	29.54 ± 2.11^a
Clay (T_3)	20.10 ± 0.88^b	22.51 ± 1.15^b	23.19 ± 2.39^b
Top Soil (T_4)	22.56 ± 0.48^a	26.31 ± 0.64^a	30.36 ± 0.88^a

a, b: Means with different superscripts within a column are significantly different ($P<0.05$). ±: Standard error of mean.

3.2 Plant girth

Stem girth for River Sand + Sawdust was the greatest (1.46 cm) while the Clay Soil recorded the least (1.26 cm) in relation to the control (1.44 cm) on day 30. The differences were not significant for the three treatments (i.e., T_1, T_2 and T_4). However, significant differences ($P<0.05$) existed between T_3, T_1 and T_4. T_3 showed the least plant stem girth (1.34 cm) on day 60 and was statistically different ($P<0.05$) from T_1 and T_4. The greatest value was recorded for T_1. However, the differences were not significant for the three treatments (T_1, T_2 and T_4) on the 60th day. For day 120, stem girth (1.57 cm) was greatest for T_1 compared to the control (T_4). However, the difference was not significant (Table 2)

Table 2. Effect of different growth media on stem girth of cocoa seedlings

Mean Plant Stem Girth (cm)			
Soil Type	**30 Days**	**60 Days**	**120 Days**
River Sand + Sawdust (T_1)	1.46 ± 0.42^{a}	1.51 ± 0.64^{a}	1.57 ± 0.46^{a}
River sand (T_2)	1.34 ± 0.09^{a}	1.46 ± 0.43^{ab}	1.49 ± 0.46^{ab}
Clay (T_3)	1.26 ± 0.11^{b}	1.34 ± 0.68^{b}	1.37 ± 0.82^{b}
Top Soil (T_4)	1.44 ± 0.47^{a}	1.50 ± 0.37^{a}	1.54 ± 0.27^{a}

a, b: Means with different superscripts within a column are significantly different($P<0.05$). ±: Standard error of mean

4. Discussion

4.1 Effect of Different Growth Media on Plant Height

Selected growth media differed in both physical and chemical properties and so had varying influence on Plant Height. River Sand and Sawdust treated medium recorded the greatest (TABLE 1). This could be attributed to the availability of plant nutrients released from the sawdust serving as organic matter as well as the good aeration of the medium, aiding good water retention capacity. [11] opined that better plant height is attained in mixed amended media than in sole media. According to [12] a suitable growth medium plays four vital functions: Serving as a reservoir for plant nutrient, supplying available water to plants, providing gases to enhance aeration, which enable root to respire and retaining sufficient available water all together and acting as plant support-anchorage for the plants roots.

This current study conforms to [13] that sawdust treated tomato plant increased the vegetative growth of tomato plant compared to the control (i.e., without sawdust). Greater scores (23.46, 26.51 and 31.26 cm) recorded for the sawdust amended river sand throughout the study than the control (top soil) indicates that the use of soil amendment is beneficial to cocoa seedlings during nursery. [14] revealed that greater plant growth observed on organic amendment treated media could be ascribed to the fact that the materials release considerable amount of nutrients for plant use since their decomposition could enrich soil properties, which agrees with the present study. Low mean plant height observed for cocoa seedlings on clay soil could also be due to its high water holding capacity, poor aeration and low nutritional status leading to poor seedling growth. Composition of growth medium influences the quality of seedling [15] and might have been responsible for the poor observation under Clay Soil. There were no significant differences observed between the sawdust amended medium and top soil (control). However in terms of plant height, sawdust amended medium recorded greater values than the top soil treated cocoa seedlings. Top soil may not be the right choice for plants in pots or polybags. This could be due to the frequent watering of pot plants causing soil compaction, which leads to the formation of a tight and brick-like mass impeding growth performance [16] The incorporation of organic material into the soil offers a great advantage over the conventional top soil as this enhances adequate nutrient supply to seedlings, better root substrate relation and minimally pre-disposes the seedlings to soil borne pests and diseases [17]. [18] found considerable improvement in the germination of T. ivorensis when amended sawdust was resorted to as a growth medium.

Effect of organic materials applied to crop soil may not be apparent. However, its presence positively affects the immediate soil properties, and gradual release of nutrients into the soil. The gradual release of inherent nutrients in organic fertilizers could be responsible for the increase in crop yields from such plots in the subsequent years [19]. Sole river sand treated cocoa seedlings for plant height was not significantly different from Sawdust and River Sand mixture as well as the control. However, significant differences existed between sole River Sand and Clay Soil treated cocoa seedlings. This could be attributed to the former's good drainage capacity owing to bigger particle size. On day 30, the mean height for cocoa seedlings did not greatly differ as compared to those of day 60 and 120. This could be that plants take their nutrients from the cotyledons or rhizomes at their initial growth phase until the depletion of nutrients. Plants rely on their roots for up-take of nutrients from the growth medium following nutrient depletion. Erstwhile studies by [20], and [21] indicated that germination and seedling emergence are independent of soil nutrient status. However, they depend entirely on cotyledons attached to the seedling, which are rich in stored food reserves until the seedling becomes autotrophic and utilizes nutrients from the growth medium.

4.2 Effect of Different Growth Media on Plant Stem Girth

Growth medium could influence the quality of seedling emergence and growth. The River Sand amended with sawdust (2:1) recorded the greatest seedling stem girth (1.46 cm), which was statistically at par with the control (1.44 cm) on day 30. This may be attributed to the excellent water holding capacity of the medium, good aeration property and availability of plant nutrients in the medium, which facilitated photosynthetic activity (i.e., more reserved food) and, thus, increased seedling stem girth. This finding conforms to that of [22] which found Uapaca kirkiana planted on forest soil amended with sawdust (3:1) with the greatest root collar diameter. The efficacy of Sawdust amended River Sand has successfully been proven to be the best growth medium for the study. Clay treated cocoa seedlings recorded the least stem girth (1.26 cm), which was statistically different from River Sand and Sawdust mixture and the control (top soil). The lowest stem girth could be the

result of poor soil aeration, poor drainage of the clay soil, poor roots penetration and probably poor nutrients of the growth medium, which may have restricted growth during the first 30 days. The result for the sole River Sand treated cocoa seedlings was not significant. The low stem girth (1.34 cm) may be attributed to poor plant nutritional status of the growth medium and poor water holding capacity of the medium, which is in concurrence with previous findings of [8] indicating that good moisture content increases rate of photosynthesis, which is translated into plant growth. Though the control ranked the second greatest, no significant differences existed between the treatments (i.e., River sand + Sawdust, River Sand and Top Soil). However, significant difference existed between the control and the Clay Soil (Table 2).

Similar growth trend was observed on day 60. However, Clay treated cocoa seedlings growth rate (1.34 cm) was substantially retarded, which confirmed the depletion of plant nutrient in the medium and probably its poor aeration and compactness hindering seedling roots penetration. Nevertheless, River Sand amended with Sawdust recorded the greatest stem girth (1.51 cm) relative to the control and the sole River Sand. The sawdust amended River Sand may improve soil porosity, water holding capacity, pore of drainage, which supports vigorous growth due to availability of nutrients and aeration in the root zone of the seedlings. Significant differences existed for the Clay, River Sand + Sawdust as well as the Top Soil (control) treatments. .....On day 120, significant differences existed for Clay treated cocoa seedlings as well as two other treatments [i.e. River Sand + Sawdust and the control (Top Soil)]. Clay treatment recorded the least stem girth (1.37 cm) compared to other treatments. It could be the result of compactness of the medium owing to continuous watering of the seedlings. Watering of the seedlings in the polybags could also lead to poor aeration as the pores are tiny and deplete nutrients in the medium retarding growth. The sole River Sand treated cocoa recorded greater stem girth (1.49 cm) than sole Clay Soil. However, the differences were not significant. This conforms to [23], who stated that River Sand showed poor response to the growth of Dahlia pinnata. Close seedling stem girth (i.e., 1.57 and 1.54 cm) was, respectively recorded for River Sand + Sawdust and Top Soil (control). Cocoa seedlings in River Sand + Sawdust showed the highest growth response as compared to the control. Better growth performance of cocoa seedlings was observed for cocoa pod compost amended soil. Besides, substantial improvement in growth of cocoa seedlings in the nursery was achieved when organic soil amendment was employed [24]. According to [25] rice hulls mixed with top soil or river sand, increases humus content of the medium and enhances plant vigour. [26] suggested that an ideal potting medium should provide porosity to enhance good aeration, which offers better growth to plants. River Sand and Sawdust (2:1) mixture offered these conditions necessary for efficient growth of cocoa seedlings.

4.3 Effect of Different Growth Media on the number of plant leaves

Vegetative growth or the number of leaves generally depends on the nutrients absorbed from the substrate. The greatest number of leaves was recorded for River Sand +Sawdust (4.22) on day 30, and was significantly different from that of the Clay Soil (3.78) treated seedlings. The least value for Clay Soil could be attributed to compactness of the medium, which may restrict plant nutrient up take. Different trend was observed on day 60: Sole River Sand recorded the greatest (5.92). However; the differences were not significant between the treatments. More number of leaves on plants has positive correlation with the plant's vigour, which aids photosynthetic activities. Thus, more leaves tend to accelerate photosynthetic activity in plants. Greatest value (8.59) was recorded for River Sand + Sawdust (2:1) mixture on day 120. This may be due to the release of available plant nutrients and water for plant uptake. The findings of this study conform to [27], who noted substantial increase in pot Anthuriumc leaves count on coconut husk growth medium.

4.4 Conclusion and Recommendations

- River Sand and Sawdust (2:1) mixture positively influenced the growth performance of the cocoa seedlings based on plant height, stem girth and number of healthy leaves.
- River Sand and Clay Soil were ranked worst growth media because of their undesirable influence on growth performance.
- Though the control (Top Soil) was rated second best, its continual use as a candidate growth medium could threaten the environment (i.e., soil degradation, non-sustainable, non-renewable).
- Since good morphological development of seedling enhances better field establishment, the use of sawdust to amend growth medium could be a promising alternative for raising cocoa seedlings.
- In instances where topsoil is scarce, cocoa seedlings could be raised with River Sand and Sawdust (2:1) mixture.

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References

[1] A. Bulir, The Price Incentive to Smuggle and the Cocoa Supply in Ghana, 1998, 4518-9707.

[2] Anon, Agribusiness Ltd. "Study of the Cocoa Sector to Define Interventions on Behalf of Ghana's Smallholder with Particular Reference to the Framework of Mutual Obligations." Prepared for the Stablex 1992 and 1993 Allocation. 1997

[3] A.E. Einert, and E.C. Baker, Rice Hulls as a Growing Component for Cut Tulips, Journals of the American Society for Horticultural Science. 24(3), 1973, 2-5.

[4] H. Gajalakshmis, Phytochemical and Pharmacological Properties of (Annona muricata L.C.V.Elita), International Journal of Pharmacy and Pharmaceutical science, (4), 2012, 3-6.

[5] R. Chintala, L. M. McDonald, and W. B. Bryan, Effect of soil water and nutrients on productivity of Kentucky bluegrass systems in acidic soils. Journal of Plant Nutrition, 35, 2012, 288-303.

[6] A. E. Einert and Guldry, Media for Container grown Junipers. Journals of the American Society for Horticultural Science, 24(3), 1975, 5-8.

[7] M. O. Ogunlade, Seedling establishment under old cocoa plantation using neem fortified cocoa pod husk fertilizer at Ibadan and Owena, Ph.D. Thesis. University of Ibadan, Nigeria, 2008.

[8] P. D. E. T. Alvim and R. Alvim, Environmental requirements of cocoa with emphasis on response to shade and moisture: The incorporated Society of Planters, Proc. International conference on cocoa and coconuts. Kuala Lumpur, Malaysia; 1980, 93-111.

[9] S. Konlan, M. O. Opoku-Agyeman, K. Acheampong, K. Opoku-Ameyaw, G. J. Anim-Kwapong, and G. Addo, Evaluation of river sand as a medium for raising cocoa (Theobroma cacao L.) seedlings. American Journal of Agriculture and Forestry. 2 (4), 2014, 114-120.

[10] M. H. Afaf, Effect of NPK and Growing Media on Growth and Chemical Composition of Fishtail Palm (Caryota mitis Lour). Life Science Journal, 9(4), 2012, 3159-3168.

[11] C. A. Conover and R. T. Poole, Effect of soil compaction on physical properties of potting media and growth of Picea pubescens Liebm "Silver Tree". Journal of the American Society for Horticultural Science, 1981, 106:604-607.

[12] A. E. Einert, Performance of Rice Hulls Media for Pot Easter Lilies Under Three Forcing System. Journals of the American Society for Horticultural Science, 7(1), 1972, 60- 63.

[13] A. Katsuru, Effect of sawdust mulch on the growth and yield of tomato. Journal of American society for Horticultural science, 19, 1987, 589-597.

[14] W. B. Akanbi, Growth, nutrient uptake and yield of maize and okra as influenced by compost and nitrogen fertilizer under different cropping systems. Ph. D. Thesis, University of Ibadan, Nigeria, 2002, 233 pp

[15] S. B. Wilson, P. J. Stoffella and D. A. Graetz, Use of compost as a media amendment for containerized production of two subtropical perennials. J. Environ. Hortic, 19, 2001, 37-42.

[16] U. Tariq, S. Rehman, M. K. Aslam, A. Younis, M. Yaseen and M. Ahsan, Agricultural and municipal waste as potting media components for the growth and flowering of Dahlia hortensis Figaro. Turkey Journal of Botany, 36, 2012, 378-385.

[17] K. P. Baiyeri, Response of Musa species to macropropagation. II: The effects of genotype, initiation and weaning media on sucker growth and quality in the nursery. African Journal of Biotechnology, 4(3), 2005, 229-234.

[18] G. E. Omokhua, A. Ogu and B. A. Oyebade, Effects of different sowing media on germination and early seedling growth of Terminalia ivorensis (A.Chev.). International Journal of Scientific & Technology research, 4, 2015, 160-164.

[19] D. M. Miller and W. P. Miller, Land application of wastes, in M. E. Sumner (Ed.), Handbook of soil science (CRC Books 2000) 37.

[20] M., Diaz-Zorita, J. H. Grove and E. Perfect, Soil fragment size distribution and compactive effort effect on maize root seedling elongation in moist soil. Crop Science, 45, 2005, 1417-1426.

[21] A. A. C. Cernac, S. Hoffman-Benning and C. Benning, WRII is required for seed germination and seedling establishment1. Plant Physiology, 141, 2006, 745-757.

[22] J. Mhango. F. K. Akinnifesi, S. A. Mngomba and G. Sileshi, Effect of growing medium on early growth and survival of Uapaca kirkiana Muell Arg. Seedlings in Malawi. African Journal of Biotechnology, 72, 2008, 2200-2202

[23] K. Mehwish,. Effect of Different Growing Media on the Growth and Development of Dahlia (Dahlia pinnata) Under the Agro-climate Condition of Deraismail khan, Pakistan Journal of Biological Sciences 10 (23), 2007, 4140-4143.

[24] K., Ofori-Frimpong, A. A., Afrifa, A.Y. Akrofi, and J. E. Sarfo, Development of cocoa pod husk-based compost for nursing cocoa seedlings: Proceedings, 15th International Cocoa Research Conference, San Jose, Costa Rica, 2006, 1635-1644.

[25] J. M. Carlos,. Phsiological and Physio-chemical Characterization of Sour sop Fruit (Annona muricata L. C. V. Elita). Africa Journal of Medicinal Chemistry, 2012, 307-310.

[26] H. T. Hartmann, D. E. Kester, F. I. Davies and R. I. Genve, Hartmann and Kester's Plant Propagation, Principles and Practices, 7th edition. (Prentice-Hall of India Ltd. 2007) 880.

[27] S. Wuryaningsih, T. Sutater, and B. Tjia, The growth ornamental pot Anthurium andraeanumon coir dust growing media. J. Penelitian Pertanian, 18, 1999, 31-38.