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Study of the effect of five growing media used for the nursery production of *Bombax costatum* Pellegr. et Vuillet: A multipurpose tree in Côte d'Ivoire

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Abstract

Bombax costatum Pellegr. et Vuillet is a species frequently recommended for reforestation in West Africa. Mass production of vigorous seedlings of this species in nurseries is necessary for the reconstitution of colonies. The effect of five growing media on the growth parameters and dry matter production of *Bombax costatum* was studied in a completely randomised design. The Soil substrate was compared with a mixture of three (3) portions of Soil + one (1) portion of organic matter based on poultry droppings, rice straw compost, cocoa pod husks compost and wood chips compost, respectively. The growing media enriched with organic matter had pH values close to neutral and high levels of organic matter and nitrogen. The Soil + Poultry droppings substrate favored the production of plants with the highest values of stem height (87.84 cm; $p \leq 0.042$), collar diameter (13.72 mm; $p \leq 0.004$), number of leaves (19.34; $p \leq 0.025$) and total dry matter (20 $g.plant^{-1}$; $p \leq 0.036$). Since the quality of transplant affects plant establishment and initial growth, the substrate Soil + Poultry droppings must be recommended for the nursery production of *Bombax costatum*, followed by the substrates Soil + Rice straw and Soil + Cocoa pod husks compost.

Keywords: Nursery; *Bombax costatum*; Growing media; Vigorous seedlings

1. Introduction

Bombax costatum Pellegr. et Vuillet is an endemic West African species with multiple uses. The species is used for food, medicinal purposes and timber [1-4]. Indeed, the buds are used as vegetables by the local population. Its trunk is used to build houses and make furniture. The leaves and bark are used to treat a number of illnesses, including anaemia and dysentery [5]. *Bombax costatum* is a species whose low natural regeneration is partly due to the strong pressure exerted on its flowers by populations [6-8]. It is in fact an overexploited and deficient regeneration species [9, 10] that is not protected due to the lack of studies and data on its status [4]. However, according to predictions from the study of Coulibaly *et al*. [11], the species could prosper in the Sudano-Guinean and Sudanian zones of West Africa under the influence of rainfall and temperature over the coming decades. The species grows well in agrosystems, forests and savannahs [4]. It is recommended for reforestation programmes because of its status as a multi-purpose tree species and its endemism in West Africa. Indeed, its interest among local populations and the pressure exerted on the species make *Bombax costatum* a priority for conservation [12]. This is why it is necessary to promote the rapid production of seedlings on a large scale. Nursery work on the generative propagation of *Bombax costatum* has shown that the germination capacity of the seeds decreases over time, particularly from the eighth month after harvest, when the seeds are kept at a temperature below 28°C [13]. In addition, these authors showed that the quality of the growing media had a significant impact on the development of *Bombax costatum* seedlings; more specifically, they found that these seedlings developed better on substrates well supplied with phosphorus [14]. These results show the importance of the

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growing media for the development of this species. The growing medium is where the plant draws the nutrients it needs for its growth. The aim of this study is to assess the effect of five organic growing media on the growth of *Bombax costatum* in the nursery. In particular, growth will be assessed in terms of stem height, collar diameter, number of leaves and dry matter of seedlings compared with an absolute control.

2. Material and methods

2.1. Growing media constitution and chemical analysis

The growing media were made from composts, poultry droppings and topsoil. The composts were produced on the trial site from raw materials that are abundant in the study area. The raw materials used were rice straw, wood chips and cocoa pod husks. In Côte d'Ivoire, the rice straw and wood chips produced in large quantities are mostly burnt [15].These raw materials were composted in heaps. Three different composts have been made from these raw materials to obtain composts based on rice straw, wood chips and cocoa pod husk, respectively. Poultry droppings and composts were mixed individually with soil. One (1) portion of organic substrate was mixed with three (3) portions of topsoil to ensure the survival of seedlings in the nursery [16, 17]. The chemical composition of the growing media was determined. Chemical analysis of the growing media was carried out in the soil analysis laboratory of the Institut National Polytechnique Félix Houphouët-Boigny in Yamoussoukro. Total nitrogen was determined by the Kjeldahl method [18]. The pH was determined using a pH meter in a growing media/water suspension of 1/2.5. The available phosphorus content of the soil was determined by the Olsen 2 method [19] and the Ca, Mg and K contents of the soil were determined by the ammonium acetate saturation method at pH7 [20]; those of the organic growing media were determined by the dry method [21]. For the determination of Ca, Mg, K and trace elements (Fe, Mn, Zn), the samples were mineralised and the ions extracted by acid etching. The concentration of Ca, Mg, K and trace elements in solution was determined by atomic absorption spectrometry. The concentration of P was determined by spectrophotometry.

2.2. Plant material for trial in the nursery

The plant material consisted of *Bombax costatum* seeds harvested on 11 March 2023 in Pô, Burkina Faso. They were placed in hot water and soaked for 24 h, then removed and left in the open air for at least 30 min before sowing, in order to lift the dormancy.

2.3. Experimental design and monitoring of the trial

The trial in the nursery was carried out at the Jean Lorougnon Guédé University (6°54'34''N; 6°26'14''W), in west-central Côte d'Ivoire. It was set up on 13 January 2024 and monitored until the third month after sowing, during the long dry season. The average temperature recorded at the experimental site during the trial was 36°C. The seedlings were sown directly into 15 cm x 10 cm polyethylene bags. The bags were then placed in rows, out of direct sunlight, under a shade canopy, in a completely randomised design. The seedbeds were watered twice a day with an average of 0.66 litres of water per day. Manual weeding was carried out systematically.

2.4. Growth parameters

Growth parameters were determined at three months after sowing for all seedlings. Collar diameter was measured with a digital calliper to an accuracy of 0.2 mm. The seedlings height was measured using a tape measure. The number of leaves per plant was counted. The dry matter of roots, stems and leaves taken from 10 plants per treatment was measured using a digital balance with a capacity of 500 g and an accuracy of 0.01 g. Dry matter was assessed by weighing the seedling organs after rinsing and drying in an oven at 70°C.

2.5. Data analysis

The data were processed using STATISTICA 7.1 software. An analysis of variance was performed, the means were compared and the smallest significant difference was detected at 5%.

3. Results

3.1. Chemical characteristics of the soil

The soil used to prepare the growing media is acidic (pH = 5.2), with relatively low levels of organic matter (OM = 3.29%) and total nitrogen (N = 0.2%) (Table 1). The C/N ratio indicates a good capacity for decomposing organic matter (C/N = 9.6). It is desaturated, with a base saturation rate of 25%.

Table 1 Chemical characteristics of de growing media

pH	C (%)	Nt (%)	C/Nt	OM (%)	Av. P (ppm)	CEC (cmol.kg^{-1})	Ca2+ (cmol.kg^{-1})	Mg2+ (cmol.kg^{-1})	K+ (cmol.kg^{-1})	Na+ (cmol.kg^{-1})
5.2	1.91	0.2	9.6	3.29	34	12	1.31	1.08	0.26	0.39

The pH values of all the growing media based on organic matter were slightly acidic to neutral (6.4 ≤ pH ≤ 7.1). Their organic matter content was relatively high (OM ≥ 10%). The available phosphorus content of all growing media was low. They all had a C/N ratio of less than 15 (Table 2).

Table 2 Chemical characteristics of the organic growing

Substrats	pH	C (%)	OM (%)	Nt (%)	C/Nt	Av. P (ppm)	K (%)	Ca (%)	Mg (%)
Rice straw compost	6.8	17.41	30.01	1.26	13.82	0.76	0.83	0.93	0.23
Cocoa pod husk compost	6.5	18.77	32.36	1.48	12.68	5.96	1.28	2.25	0.29
Wood chips compost	6.5	19.76	34.07	1.68	11.76	5.71	3.30	2.16	0.31
Soil + Cocoa pod husk compost	6.4	6.04	10.41	0.42	14.38	1.17	0.75	0.62	0.36
Soil + Rice straw compost	7.1	6.45	11.12	0.64	10.08	2.16	0.68	1.16	0.26
Soil + Poultry droppings									

3.2. Seedling survival rate

Three months after sowing, the survival rate of *Bombax costatum* seedlings varied according to growing media. It was 45% for the Soil + Poultry droppings and Soil + Wood chips compost; 46.7% for the Soil + Cocoa pod husk compost; 48.3% for the Soil + Rice straw compost and 43.3% for the Soil.

3.3. Growth of aerial organs

The assessment of all the growth parameters revealed that *Bombax costatum* seedlings grew better on growing media enriched with organic matter (Table 3). The highest values for stem height (87.84 cm; p ≤ 0.042), collar diameter (13.72 mm; p ≤ 0.004) and number of leaves (19.34; p ≤ 0.025) of the seedlings were observed in the Soil + Poultry droppings substrate, followed by Soil + Rice straw compost and Soil + Cocoa pod husk compost. The lowest values of seedling collar diameter (6.92 mm; p ≤ 0.011) were measured on the Soil. In addition, the seedlings grew slowly in height and had the lowest number of leaves on that substrate and the Soil + Wood chips compost.

Table 3 Comparative growth of seedlings

Treatment	Stem height (cm)	Collar diameter (mm)	Number of leaves
Soil + Wood chips compost	54.81 ± 6.32^{a}	9.97 ± 0.98^{b}	13.69 ± 1.21^{ab}
Soil	43.07 ± 3.65^{a}	6.98 ± 0.54^{a}	12.45 ± 0.96^{a}
Soil + Rice straw compost	73.14 ± 4.86^{b}	10.00 ± 0.66^{b}	15.86 ± 0.87^{b}
Soil + Cocoa pods husk compost	70.25 ± 4.60^{b}	10.19 ± 0.68^{b}	15.93 ± 1.01^{b}
Soil + Poultry droppings	87.84 ± 5.13^{c}	13.72 ± 0.86^{c}	19.34 ± 1.16^{c}

3.4. Roots growth parameters

Mean root length and diameter were assessed (Table 4). Root lengths were statistically similar in all the growing media. The largest seedlings roots diameter were observed in the Soil + Poultry droppings substrate (13.64 mm; p = 0.004).

Table 4 Compared mean of root length and diameter of seedlings at three months after sowing

Treatment	Roots length (cm)	Root diameter (mm)
Soil + Wood chips compost	18.30 ± 5.79[a]	11.29 ± 3.57[ab]
Soil	21.95 ± 6.94$_a$	8.85 ± 2.80[a]
Soil + Rice straw compost	20.40 ± 6.45[a]	10.64 ± 3.36[ab]
Soil + Cocoa pod husks compost	20.60 ± 6.51[a]	12.00 ± 2.79[b]
Soil + Poultry droppings	20.30 ± 6.42[a]	13.64 ± 4.31[b]

3.5. Seedlings dry matter

The total dry matter of the *Bombax costatum* seedling and that of the leaves, stems and roots of this species were assessed separately (Table 5). Only root dry matter was statistically similar across all the growing media. The highest total dry matter was observed in seedlings grown on the Soil + poultry droppings (20 g.plant^{-1}; $p \leq 0.036$), followed by those on the Soil + Cocoa pod husk compost (12.77 g.plant^{-1}; $p = 0.019$). The Soil substrate had the lowest total dry matter value (7.22 g.plant^{-1}; $p \leq 0.030$). This growing medium also recorded the lowest leaf and stem dry matter values. The performance of the Soil + Poultry droppings was maintained for leaf (6.15 g.plant^{-1}; $p = 0.013$) and stem (10.55 g.plant^{-1}; $p = 0.001$) dry matter values.

Table 5 Dry matter (DM) of leaves, stems and roots of seedlings in the third month after sowing

Treatment	Total DM (g.plant^{-1})	Leaves DM (g.plant^{-1})	Stems DM (g.plant^{-1})	Roots DM (g.plant^{-1})
Soil + Wood chips compost	10.03 ± 3.17ab	3.22 ± 1.02ab	4.86 ± 1.54ab	1.95 ± 0.62a
Soil	7.22 ± 2.28a	2.72 ± 0.86a	3.09 ± 0.86a	1.40 ± 0.44a
Soil + Rice straw compost	11.32 ± 3.58b	4.05 ± 1.28ab	5.26 ± 1.66ab	2.01 ± 0.64a
Soil + Cocoa pod husks	12.77 ± 4.04bc	4.66 ± 1.47ab	5.68 ± 1.80ab	2.44 ± 0.77a
Soil + Poultry droppings	20.00 ± 6.32c	6.15 ± 1.94b	10.55 ± 3.34b	3.30 ± 1.04a

4. Discussion

4.1. Chemical characteristics of growing media and growth of aerial organs of seedlings

The addition of organic matter to the Soil substrate improved the nutrient content of the *Bombax costatum* seedbeds. Growing media enriched with organic matter resulted in better seedling survival rates. Indeed, the growing medium is the source of nutrients for the seedling's growth and development [22]. The quality of the seedlings is strongly influenced by the growing media [23]. The C/N ratios of the Soil and Soil + Rice straw compost indicate faster mineralisation of organic matter compared with the other substrates. However, the acidic pH and the low level of N in the Soil substrate limit mineral nutrition, particularly nitrogen. Nitrogen is a key component of the amino acids and nucleotides that form DNA and RNA, which are essential for cell division and plant growth. Nitrogen is also involved in photosynthesis through the production of chlorophyll [24]. Limiting soil N content slows seedling growth. This could explain the low level of development of *Bombax costatum* seedlings on the Soil compared with other substrates, even though the available P content of the Soil substrate is higher. According to Omoyemi and Olatunji [14], *Bombax costatum* seedlings develop better on growing media with a high phosphorus content. On the other hand, the relatively high N content of the Soil + Poultry droppings and Soil + Rice straw compost, combined with a C/N ratio indicating extensive decomposition of the organic matter, resulted in the highest values for the number of leaves, height and collar diameter of the seedlings. The best levels of these growth parameters obtained on the Soil + Poultry droppings substrate would be due to the high organic matter content compared with the other substrates, combined with a C/N ratio indicating relatively slow decomposition of the organic matter. The advantage of the characteristics of this substrate is the regular availability of nutrients for sustained seedling growth and the reduction of nutrient losses through leaching [25]. The positive effect of the Soil + Poultry droppings mixture on seedling growth in nurseries has been observed by several authors [26, 27]. Similarly, in the case of the Soil + Cocoa pod husks compost substrate, the regular availability of

nutrients through the relatively slow mineralisation of organic matter enabled good seedling growth to be observed compared with the Soil substrate.

4.2. Seedlings dry matter

Dry matter production is the result of the accumulation of assimilates from the photosynthesis activity. In fact, about 95% of the biomass of a plant are derived from the carbohydrates manufactured in the green parts by the process of photosynthesis and the remaining 5% come from mineral elements absorbed by the roots [28]. The total dry matter of the seedlings growing on the Soil + Poultry droppings, Soil + Cocoa pod husks compost and Soil + Rice straw compost reflects the level of aerial growth of the seedlings and the high level of fertility of these substrates. In addition, the high dry matter content of the *Bombax costatum* leaves grown on the Soil + Poultry droppings substrate was more favourable to the production of total dry matter by the seedlings. Indeed, Kannan & Paliwal [29] observed a significant positive correlation between dry matter production, leaf area, leaf dry weight of seedlings of *Peltophorum ferrugineum* and *Albizia lebbeck*. Since the quality of transplant affect plant establishment and initial growth [30], the substrate Soil + Poultry droppings must be first recommended for the nursery production of *Bombax costatum*, followed by the substrates Soil + Rice and Soil + Cocoa pod husks compost .

5. Conclusion

Bombax costatum is a multi-purpose species recommended in reforestation programmes and much appreciated by West African populations. Nursery production of good quality and vigorous *Bombax costatum* seedlings is necessary for successful reforestation. The use of growing media composed of three (3) portions of soil + one (1) portion of poultry droppings favoured the production of higher and larger seedlings with a high dry matter and a high number of leaves at three months after sowing. The characteristics of this growing medium show a very good ability to produce *Bombax costatum.* It can be recommended for mass production of *Bombax costatum* in nurseries.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have no relevant financial or non-financial interests to disclose. The authors have no competing interests to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article. No funding was received for conducting this study. There is no conflict of interest to declare

References

[1] Arbonnier M. Trees, shrubs and lianas in the dry zones of West Africa. CIRAD/MNHN/UICN ; 2000

[2] Mapongmetsem PM, Nduryang B and Fawa G. Contribution to knowledge of non-timber forest products in the Sudano-Sahelian zone of Cameroon. Kapseu C, Nzié W, Nso E, Silechi J and Gomo (eds). Biodiversity and global change from 21 to 23 July 2015 in Ngaoundéré. 2015; pp. 139-147.

[3] Tchingsabe O, Ngomeni AF, Mapongmetsem PM, Bekwake NA, Noutcheu R, Dibong SD, Tchatat M and Fawa G. Valorization of non-timber forest products in Mayo-Rey (North Cameroon). Journal of Applied Biosciences. 2017; 108: 10491-10499

[4] Zerbo I, Salako KV, Hounkpèvi A, Zozoda D, KakaïS RG, Thiombiano A. Ethnobotanical knowledge and conservation of *Bombax costatum* Pellegr. and Vuillet: an overexploited savanna tree species. Trees, Forests and People. 2022; Volume 10. https://doi.org/10.1016/j.tfp.2022.100356

[5] Zanh GG, Barima YSS, Kouakou KA & Sagne YC. Use of non-timber forest products by local communities in the Haut-Sassandra protected forest (west-central Côte d'Ivoire). International journal of Pure & applied Bioscience. 2016; 4(5): 212 -225.

[6] Ouédraogo A, Thiombiano A, Hahn-Hadjali K, Guinko S. Diagnosis of the State of Degradation of Stands of four Woody Species in the Sudanian Zone of Burkina Faso. 2006; 17:485-91

[7] Belem B, Boussim IJ, Bellefontaine R, Guinko S. 2008. Stimulation of suckering of *Bombax costatum* by root wounding in Burkina Faso. Bois For Trop. 2008; 295:71-9.

[8] Ouédraogo I, Nacoulma BMI, Ouédraogo O, Hahn K, Thiombiano A. Productivity and economic value of the *Bombax costatum* Pellegr. & Vuillet calyx in Burkina Faso's sudanian zone. Bois For Trop. 2014 ; 319: 31–41. https://doi.org/10.19182/ bft2014.319.a20550.

[9] Thiombiano A, Schmidt M, Da S, Karen H, Zizka G, Wittig R. Vascular plants: Flowering plants. In: Thiombiano, A., Kampmann, D. (Eds.), Biodiversity Atlas of West Africa. 2010; 2: 184–192.

[10] Oyen LPA. 2011. *Bombax costatum* Pellegr. & Vuillet. [On line] PROTA4U Fact Sheet. In: Brink, M, Achigan-Dako, EG (Eds.), PROTA (Plant Resources of Tropical Africa /Ressources végétales de l'Afrique tropicale). Netherlands, Wageningen. http://www. prota4u.org/search.asp. Accessed 2 August 2022.

[11] Coulibaly A, Avakoudjo HGG, Idohou R, Vodounnon EJ , Diallo S, Cherif M. Impact of climate change on the distribution of *Bombax costatum* Pellegr. & Vuillet in Mali, West Africa. Trees, Forests and People. 2023; Volume 11. https://doi.org/10.1016/j.tfp.2022.100359

[12] Sop TK, Oldeland J, Bognounou F, Schmiedel U, Thiombiano A. Ethnobotanical knowledge and valuation of woody plants species: a comparative analysis of three ethnic groups from the sub-Sahel of Burkina Faso. Environment, Development and Sustainability. 2012; 14 : 627-649. DOI : 10.1007/s10668-012- 9345-9

[13] Omoyemi O.M. & Olatunji A.I. Effects of provenances, storage temperature and duration on seed germination of *Bombax costatum* Pellegr & Vuillet. Journal of Forest and Environmental Science. 2021; 37(3): 235-242.

[14] Omoyemi O.M. & Olatunji A.I. Comparative influence of mycorrhiza and phosphorus on the growth of *Bombax costatum* Pellegr & Vuillet from different provenances. Ghana J. Sci . 2024; 65 (1)

[15] Irie LDV, Kouame KJ, Tape BSA. Artisanal production: Environmental and health consequences in the town of Bouaflé (Côte d'Ivoire). Geographical space and Moroccan society. 2024, https://doi.org/10.34874/imist.prsm/egsm/45557

[16] Djaha A, N'Da AA, Hala N, Edo K, N'guessan A. How to grow cashew trees in Côte d'Ivoire. Centre National de Recherche Scientifique. 2008; 4p

[17] Lazcano C, Arnold J, Tato A, Zaller JG, Domínguez J. Compost and vermicompost as nursery pot components: effects on tomato plant growth and morphology. Spanish Journal of Agricultural Research. 2009; 7(4): 944-951

[18] Bremner JM Organic nitrogen in soil. In: Bartholomew, WC Clark, FE eds. 1965; p. 93-149

[19] Pétard J. Analysis methods (Volume 1) : Soil analysis. ORSTOM, Nouméa, 1993

[20] Anderson JM and Ingram JSI. Tropical soil biology and fertility. A handbook of methods. 2nd ed. Wallingford, UK,1993

[21] De Saint Amand JD Determination of major mineral elements in plants: Methods applied in the foliar diagnostics laboratory at O.R.S.T.0.M : Paris ;1967

[22] M Samir, Rai R and Prasad B. Effect of organic manures on seed germination and seedling growth of khirn. Indian Forester. 2016; 142 (7): 666-669

[23] Fadila AB, Wijayanto N. The Giving Response of Compost Leaves of Gamal, Kaliandra, and Lamtoro on the Growth of Arrowroot Plants (*Maranta arundinacea*). The 4th International Conference on Tropical Silviculture. IOP Conf. Series: Earth and Environmental Science 012007. 2024; doi:10.1088/1755-1315/1315/1/012007

[24] Taiz, L. and Zeiger, E. Plant physiology. 4th Edition, Sinauer Associates, Inc., Sunderland; 2006

[25] Bhandari AL, Ladha JK, Pathak H, Padre AT, Dawe D, Gupta RK. Yield and soil and nutrient changes in a long-term rice-cowpea cropping system in semi-arid tropics. Plant Soil. 2002; 318:27-35.

[26] Han SH, An JY, Hwang J, Kim SB & Park BB. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (*Liriodendron tulipifera* Lin.) in a nursery system. Forest Science and Technology. 2016; 12(3): 137–143. https://doi.org/10.1080/21580103.2015.1135827

[27] Humnessa T, Asfaw Z, Derero A. Effect of Poultry Manure and its Biochar on Seedling Vigor of Selected Multipurpose Tree Species. J For Res. 2023; 12:335. DOI: 10.35248/2168-9776.23.12.335

[28] Cannell, MGR. Production and distribution of dry matter in trees of Coffea arabica L. in Kenya as affected by seasonal climatic differences and the presence of fruits. Annals of Applied Biology. 1971; 67: 99-120.

[29] Kannan D, Paliwal K. Dry matter production, chlorophyll, protein contents and foliar nutrient concentration in *Peltophorum ferrugineum* and *Albizia lebbeck* under nursery conditions. Forest Ecology and Management. 1992; 50(3–4): 265-273

[30] Grossnickle SC. Why seedlings survive: influence of plant attributes. New Forests. 2012; 43: 711-738. https://doi.org/10.1007/s11056-012-9336-6