Comunicata Scientiae
Horticultural Journal

ORIGINAL ARTICLE
published: 30 January 2025
https://doi.org/10.14295/CS.v16.4245

Morphology and initial development of Hancornia speciosa var speciosa in different substrates

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Abstract

The impact of commercial demand on fruits explored through extractivism requires sustainable production strategies. Among these strategies is seedling propagation for reforestation and/or commercial plantations. The substrate and its impact on the quantity and quality of propagated plants are critical aspects of seedling propagation. *Hancornia speciosa,* commonly known as mangabeira, is a native fruit species that has been primarily explored through extractivism; thus, the goal of this study was to assess the early development of *H. speciosa* var. *speciosa* seedlings in different substrates using morphophysiological parameters. The seeds were processed and sown in six different substrates (sand, sand + powder coconut coir, sand + vermiculite, commercial substrate, commercial substrate + powder coconut coir, vermiculite, commercial substrate + vermiculite). To evaluate seedling development, the parameters First Emergence Count, Emergence Percentage, Emergence Speed Index, Total Seedling Size, Shoot Height, Root Length, Stem Diameter, Number of Leaves, and Shoot and Root Dry Massa were used. The pure vermiculite substrate performed best across all parameters, followed by the commercial substrate + powder coconut coir and the commercial substrate. As a result, substrates containing pure vermiculite are recommended for the propagation of *H. speciosa* var. speciosa, whereas substrates containing higher concentrations of sand, 50 to 100%, have a negative impact on seedling development for this variety.

Keywords: germination, mangaba, propagation, seedling

Introduction

Tropical plants are a traditional resource of products for local communities. The process of exploring native plants in their natural habitat is referred to as plant extractivism, and fruits extracted from those environments are a direct source of food and income for local communities (Albuquerque, 2016).

However, increased fruit extraction to supply market demand can have a negative impact on seed dispersal and, consequently the survival of plants in their natural environment. Hence, sustainable practices are employed to ensure the regenerative capacity and safe exploitation of those species. Strategies include maintaining soil seed banks and propagating seedlings for forest regeneration or commercial plantations.

Mangaba (*Hancornia speciosa*), a tropical plant native to Brazil, is one of the plants mainly explored by extractivism (Ledo et al., 2015). This plant is found in diverse environments, such as the Cerrado, Caatinga, and Atlantic Forest biomes (Álvares-Carvalho et al., 2022; Collevatti et al., 2018). Among its conservation strategies, are the establishment of nature reserves and plants in fields of genebanks (Silva et al., 2021).

The fruits are the most important byproduct of the species (Mota et al., 2011). These are consumed both fresh or processed and are harvested in natural forests to supply the pulp, jam, and ice-cream industries. The mangaba fruits are appealing not only for their flavor but also for their nutrients and medicinal properties (Cardoso et al., 2014).

The mangaba fruits are produced in two annual harvests, yielding approximately 2000 tons per year of fruits in Brazil (IBGE, 2022). However, industry demand exceeds extraction capacity (Braga et al., 2021), while sustainable production strategies such as commercial plantations remain scarce (Nunes et al., 2022).

Received: 00 XXXXXXXXXX 2023
Accepted: 00 xxxxxxxxxxxxx2023

The domestication of *H. speciosa* is still in its early stages (Silva et al., 2019). This species propagates primarily through seeds (Dresch et al., 2016; Ledo et al., 2015), and despite its low soil nutrient requirements, the physical properties of the substrate influence the quantity and quality of propagated plants. Composed of organic and inorganic nutrient sources, the substrate should maintain a physical structure to retain moisture and provide nutrients for a successful seedling establishment (Silva et al., 2020).

In natural areas, *H. speciosa* is found in sandy, well-drained acidic soils, low in organic and inorganic nutrients (Ledo et al., 2015). Despite its tolerance to low-fertility soils, this species responds positively to higher nutrient availability (Rosa et al., 2005). Moreover, previous studies have observed greater emergence in substrates with a higher composition of inert porous material (Arrua et al., 2016).

Therefore, the objective of this research was to evaluate the early development of *Hancornia speciosa* seedlings using morphophysiological parameters in different substrates to support seedling production for conservation and/or commercial purposes.

Material and Methods

Ripe fruits were collected in March 2022 at the protected area Reserva Extrativista Mangabeiras Irmã Dulce dos Pobres (Decree 6.175/2020), an area of Atlantic Forest in the state of Sergipe, Brazil (**Figure 1**). Rype fruits are characterized by green to yellow exocarp with red spots of pigmentation.

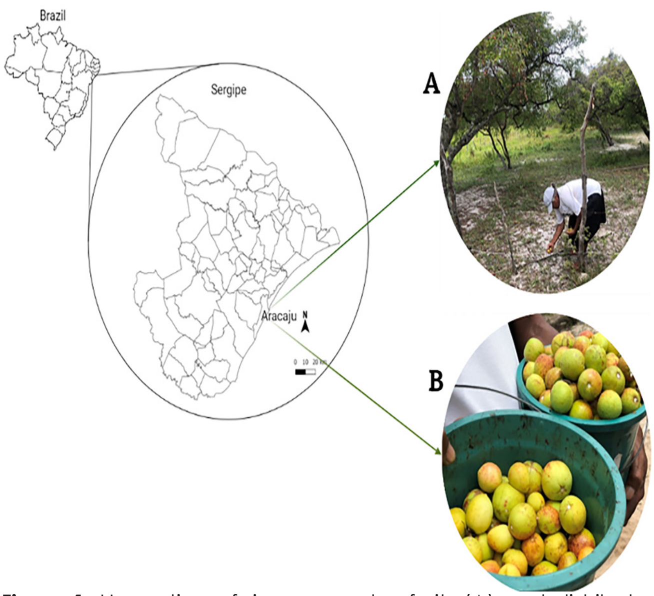

Figure 1. Harvesting of ripe mangaba fruits (A) and distributed in buckets (B) for use and commercialization. Aracaju, Sergipe, Brazil, 2022. Photos: Ana Veruska Cruz da Silva

The fruits were manually processed to obtain the seeds (**Figure 2**). Each fruit contains approximately 2 to 15 seeds (Ledo et al., 2015). And 24h after processing the fruits, the seeds were homogenized and sampled to grow in 6 types of substrates for evaluation (Table 1).

Figure 2. Manual processing of mangaba fruits to produce seedlings, using a sieve and running water to remove the pulp and obtain seeds. Aracaju, Sergipe, Brasil, 2022. Photos: Ana Veruska Cruz da Silva

Table 1. Substrates used for seed germination and growth of mangabeira seedlings. Aracaju, Sergipe, Brazil, 2022

Treatments	Components of the substrate (ratio 1:1)
T1	Sand
T2	Sand + powder coconut coir
T3	Sand + vermiculite
T4	Commercial substrate*
T5	Commercial substrate* + powder coconut coir
T6	Vermiculite

*Pine bark, ash, vermiculite, turf, wood sawdust.

The substrates were composed in a 1:1 proportion. The seeds were sown at 1 cm of depth in 80-cell plastic containers with daily irrigation. All experiments were conducted in a greenhouse (30 ± 3°C). The following parameters were evaluated:

First emergence count - corresponds to the accumulated percentage of normal plants, with values observed on the 30th day after the start of the experiment.

Emergence Percentage – the emergence test was conducted according to the recommendations of the Rules for Seed Analysis – RAS (Brasil, 2009). The test was conducted with four replicates of 25 seeds in standard size and shape. The evaluation began on the 30th day after seed sowing and the percentage of emergence was analyzed at the end of the experiments (60th day), adopting as emergence criteria the presence of cotyledons on the substrate with the consequent emergence of the hypocotyl.

Emergence Speed Index (ESI) - evaluated simultaneously with the emergency test, with daily counts at 8 AM, starting on the 30th day. This index was calculated according to the formula ESI = (E1/N1) + (E2/N2) + … + (En/Nn), where, ESI = emergence speed index, E = number of emerged normal seedlings at each count, and N = number of days from sowing to the n^{th} evaluation (Maguire, 1962).

After 60 days of seedling development, the following parameters were evaluated:

Total Seedling Size – the distance between the root and the apex of the plant was measured with a graduated ruler (cm);

Shoot height – the distance between the hypocotyl and the apex of the shoot was measured using a graduated ruler (cm);

Root length – the distance between the hypocotyl and the base of the root was measured using a graduated ruler (cm);

Stem diameter – measured using a digital caliper (SE® model 784EC, CA, USA), expressed in cm;

Number of leaves – determined by counting the number of leaves on each plant.

Shoot and root dry mass – obtained after drying in an oven at 80°C for 24 hours, then weighed on an analytical balance and the result expressed in grams (Nakagawa, 1999).

The experiment was conducted in a completely randomized design, with four replications of 25 seeds, totaling 100 seeds per treatment. The data obtained were submitted to previous analyses of homoscedasticity (Breusch-Pagan) and normality (Shapiro-Wilk) of the errors. An Analysis of Variance (ANOVA) was used, followed by a comparison of means using Tukey's test ($p < 0,05$), using R.

Results and Discussion

Substrates containing pure vermiculite (T6), or the commercial substrate and powder coconut coir (T5) had the highest results for seedling emergence at first count, followed by the pure commercial substrate (T4) (**Figure 3**A). The composition of these substrates includes vermiculite, as well as other components, such as pine bark, ash, turf, and wood sawdust (T5 and T4) that can contribute to the water/air ratio for oxygen diffusion and provide nutrients to seedlings. This parameter was lowest for substrates made of sand (T1), sand and powder coconut coir (T2), or sand and vermiculite (T3). We can infer those substrates composed of 50 to 100% of sand are not beneficial for early seedling development.

Studies in Mato Grosso, Mato Grosso do Sul, and Goiás, where Cerrado is the dominant biome, have revealed that the best seedling development occurs in local soils with naturally high fertility. For *H. speciosa* plants from Mato Grosso, the combination of local soil, sand, and bovine manure was beneficial for seedling development parameters such as height, stem diameter, number of leaves, and shoot mass (Gordin et al., 2016).

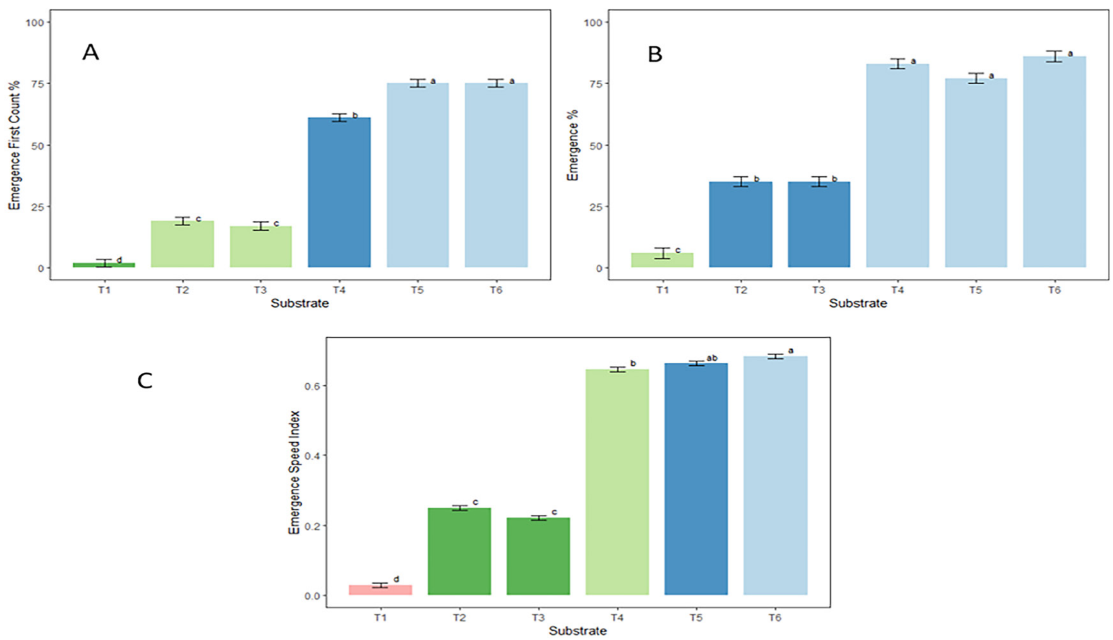

Figure 3. (A) Emergence First Count (%), (B) Emergence Percentage (%), and (C) Emergence Speed Index for mangabeira seedlings in cultivated different substrates (T1 = sand; T2 = sand + vermiculite (1:1); T3 = commercial substrate; T4 = commercial substrate; T5 = commercial substrate + powder coconut coir; T6 = vermiculite). Aracaju, Sergipe, Brazil, 2022.

The substrate composition allowed for nutrient availability and optimum water moisture retention. Substrates composed of pure commercial mixes have presented greater seedling shoot height and the number of leaves when compared to pure sand substrates in plants of Mato Grosso do Sul (Zuffo et al., 2019). While adding commercial substrate to local Cerrado soils did not promote seedling development (Silva et al., 2020). Additionally, another study using plants from Mato Grosso do Sul observed that substrates containing more than 30% bovine manure inhibit root growth and are not recommended for use with the species. A composition of 15 to 30% of manure was considered ideal for phytomass accumulation in *H. speciosa* (Machado et al., 2020). Other studies have found that substrates with a higher percentage of vermiculite promote seedling emergence, emphasizing the species' need for a porous substrate (Arrua et al., 2016) either by a higher composition of vermiculite (up to 100%) or sand (up to 15%) (Oliveira et al., 2018).

In the Cerrado region, *H. speciosa* var. *gardneri*, var. *cuyabensis* and var. *pubenscens* are common (Collevatti et al., 2018). However, our study focused on the growth of *H. speciosa* var. *speciosa*, a variety common to the coastland of the Atlantic Forest. It is noteworthy that *H. speciosa* var. *speciosa*, when cultivated in the Cerrado environment presents reduced growth compared to other varieties, emphasizing the differences within the species and its rusticity and adaptability to various edaphoclimatic conditions (Ganga et al., 2009).

The results for total seedling emergence at 60 days present a similar pattern, with the best results for treatments T6, T5, and T4 (Figure 3B; **Figure 4**). However, for the seedling emergence speed index, substrates T6 and T5 had better results (Figure 3C). In contrast, a study evaluating seedling development of *H. speciosa* from the Cerrado biome, found higher seed emergence (90%) and emergence speed index (1.1) for plants cultivated in the sand (Rodrigues et al., 2017), suggesting that there are varieties better adapted to this type of substrate composition.

Substrate T6 also showed the best results for seedling shoot height, total seedling size, stem diameter, number of leaves, and seedling dry mass (**Figures 5 and 6**). We observed greater initial seedling growth than previously reported for the species cultivated in sand, sand, and powder coconut coir (1:1) or sand and vermiculite (1:1) during greenhouse acclimatization (Freire et al., 2011). The seedlings in our study had shoot heights ranging from 4.5 to 6.7 cm (Figure 5A), whereas the previous report found plants ranging from 1.1 to 1.5 cm. For the number of leaves, we found seedlings with 5 to 6 leaves (Figure 6B), while the previous study had plants with 1 to 4 leaves.

Conversely, substrates T4 and T6 yielded the greatest results for root length. There was no statistically significant difference in seedling shoot/root ratio across all treatments (Figure 5). The high density of pure sand substrates (T1) can inhibit root development by limiting root penetration and growth. However, higher porosity substrates can benefit aeration and root development

A

B

Figure 4. (A) Mangabeira seedlings 30 days after sowing and (B) visual appearance of mangabeira seedlings 60 days after sowing. Photos: Ana Veruska Cruz da Silva. Aracaju, Sergipe, Brazil, 2022.

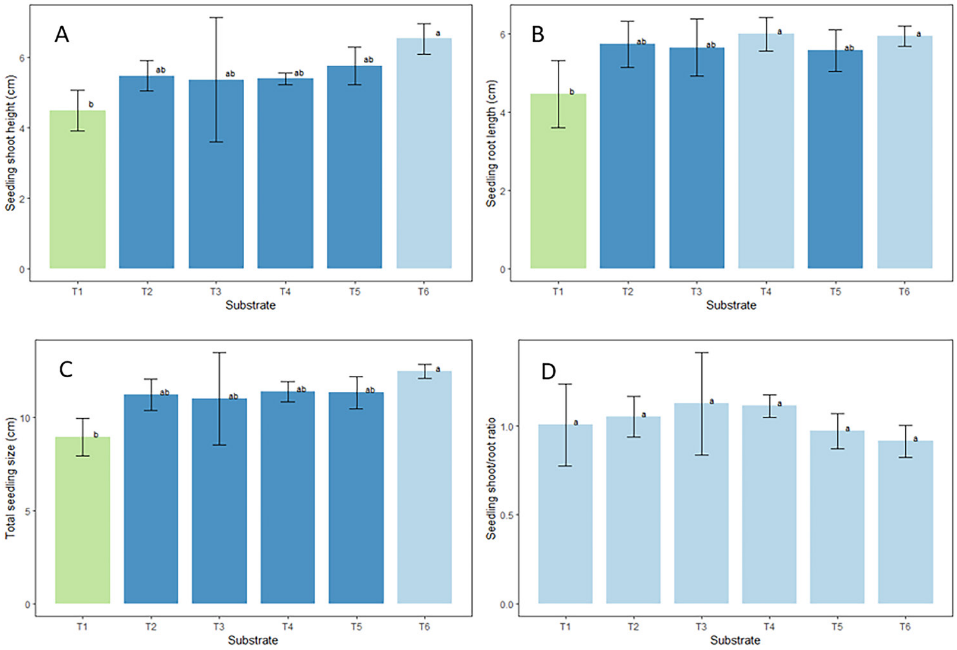

Figure 5. (A) Seedling Shoot Height (cm), (B) Seedling Root Length (cm), (C) Total Seedling Size, and (D) Seedling Shoot/Root ratio for mangabeira seedlings in cultivated different substrates (T1 = sand; T2 = sand + vermiculite (1:1); T3 = commercial substrate; T4 = commercial substrate; T5 = commercial substrate + powder coconut coir; T6 = vermiculite). Aracaju, Sergipe, Brazil, 2022

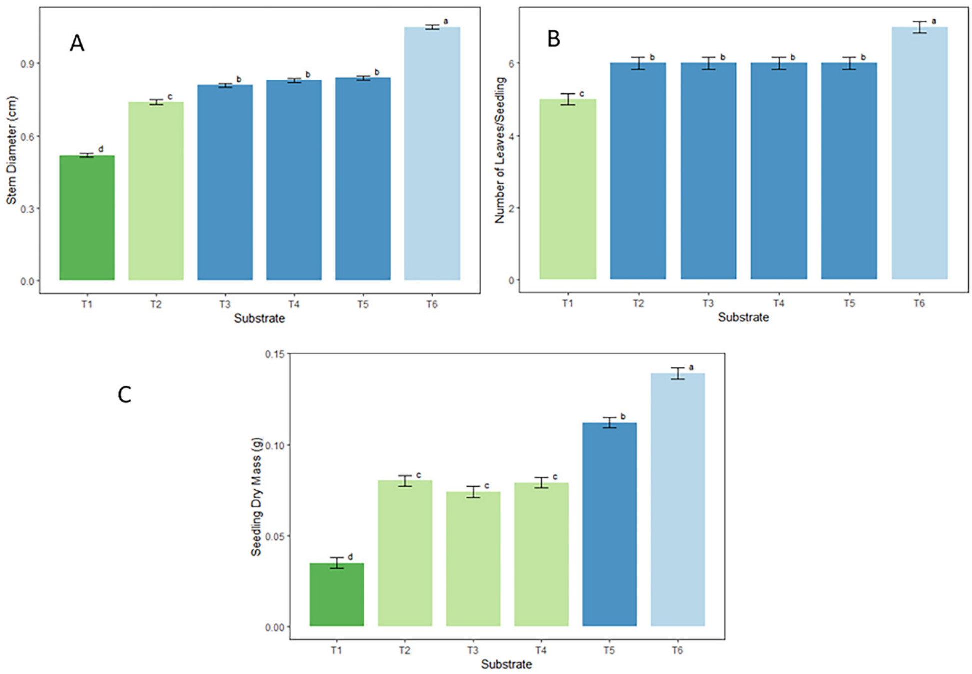

Figure 6. (A) Stem Diameter (cm), (B) Number of Leaves per Seedling, and (C) Seedling Dry Mass (g) for mangabeira seedlings in cultivated different substrates (T1 = sand; T2 = sand + vermiculite (1:1); T3 = commercial substrate; T4 = commercial substrate; T5 = commercial substrate + powder coconut coir; T6 = vermiculite). Aracaju, Sergipe, Brazil, 2022.

(Costa et al., 2017). In this regard, selecting the right substrate composition is critical for improved aeration, moisture retention, and nutrient availability. The development of the seedling root system is critical for plant nutrient absorption and assimilation, which is enhanced in *H. speciosa* by P, Ca, Mg, and S absorption (Rodrigues et al., 2017).

Another study found similar results to T1 for seedling development in the sand for shoot height, stem diameter, and the number of leaves, and yet higher results for root length and total seedling dry mass, with an average of 5.5 cm and 0,139g, respectively. Therefore, the plant development in phytomass found in the previous study reaches our highest values of root length and dry mass, despite using the substrate composition that yielded our lowest results. Plants grown in commercial substrate produced similar results to our study for shoot height, root length, and the number of leaves, though higher average results for total dry mass (Zuffo et al., 2019).

Considering that *H. speciosa* occurs in well-drained and porose soils, it is expected to observe a greater seedling development in vermiculite-rich substrates, as it is an inorganic compost capable of maintaining an even moisture supply in a well-drained porose substrate (Chatzistathis et al., 2021). However, plants sown in pure sand (T1) yielded the lowest results for all parameters. Despite its natural occurrence in poor sandy soils, studies have shown that higher nutrient availability benefits the initial development of *H. speciosa* seedlings (Ledo et al., 2015; ROSA et al., 2005). Therefore, we can infer that due to the low concentration of micronutrients in the sand and the higher concentrations of Fe, Mn, Zn, and Cu (Chatzistathis *et al.*, 2021)generally found in vermiculite, plants sown in this substrate (T6) the best development.

The natural occurrence of *H. speciosa* var. *speciosa* is in areas of well-drained low fertility sandy soils (Ledo et al., 2015). Despite this, some soil fertility is maintained by organic matter decomposition. Previous research found that combining sand and powder coconut coir (1:1) and sand and vermiculite (1:1) resulted in greater development parameters such as shoot growth, number of leaves, and number of nodes for seedlings derived from *in vitro* embryos when compared to pure sand (Freire et al., 2011), which is consistent with our findings.

Conclusions

Pure vermiculite substrate is recommended for the development of *Hancornia speciosa* var. *speciosa* seedlings in terms of emergence, vigor, and morphology. The use of higher concentrations of sand, 50 to 100%, has a negative impact on the variety's development.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.