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Morphology, biometry and quality of fruit, seeds, and seedlings of *Magonia pubescens*

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ABSTRACT: The goals of the research were to characterize and schematize the morphology and biometrics of fruits, seeds, seedling, as well as to evaluate the quality of the seeds and the early development of tingui (*Magonia pubescens*) saplings. For the characterization and morphological description, proportions, color, size, texture, number of seeds, consistency of tegmen, embryo, root, eophylls, etc., were observed. An accelerated aging test was used to assess seed quality (T0 – control group not subjected to rapid aging, T1 – 48 hours, and T2 – 96 hours), measuring germination and normal seedlings. At 63 days, the diameter and height of the aerial part of sapling developed in tubes of 180 and 280 cm^3 were measured. The tingui fruit is a capsule that is divided into locules and has longitudinal dehiscence. The seeds germinate in a hypogeal phanerocotyledonary and unipolar manner. Germination and complete seedling formation take place 4 and 22 days after seeding (d.a.s), respectively. The seeds were vigorous, and the 48-hour accelerated aging had a negative effect on *Magonia pubescens* seeds. At 63 d.a.s., there was no significant effect of tube volume on sapling production.

Keywords: Sapling production; Sapindaceae; Germination; Tingui.

Morfologia, biometria e qualidade de frutos, sementes, plântulas e mudas de *Magonia pubescens*

RESUMO: Os objetivos da pesquisa foram caracterizar e esquematizar a morfologia e biometria de frutos, sementes, plântulas, bem como avaliar a qualidade das sementes e o desenvolvimento inicial de mudas de tingui (*Magonia pubescens*). Para a caracterização e descrição morfológica, foram observados proporções, coloração, tamanho, textura, número de sementes, consistência de tégmen, embrião, raiz, eófilos, etc. Para avaliar a qualidade das sementes, foi utilizado o teste de envelhecimento acelerado (T0 – grupo controle não submetido ao envelhecimento rápido, T1 – 48 horas e T2 – 96 horas), medindo a germinação e plântulas normais. Aos 63 dias, foram mensurados o diâmetro e a altura da parte aérea da muda desenvolvida em tubetes de 180 e 280 cm^3. O fruto tingui é uma cápsula dividida em lóculos e apresenta deiscência longitudinal. As sementes germinam de forma hipógea fanerocotiledonar e unipolar. A germinação e a formação completa de mudas ocorrem 4 e 22 dias após a semeadura (d.a.s), respectivamente. As sementes eram vigorosas, e o envelhecimento acelerado de 48 horas teve um efeito negativo nas sementes de *Magonia pubescens*. Aos 63 d.a.s., não houve efeito significativo do volume do tubo na produção de mudas.

Palavras-chave: Produção de mudas; Sapindaceae; Germinação; Tingui.

Introduction

Brazil has one of the most diversified and exuberant floras on the globe due to its distinct plant structures and unique ecosystems. Of the 60,065 tree species identified in the entire planet as of 2017, 8,715 are found in the Brazilian territory, with 4,333 of these being endemic (Beech et al., 2017).

The Cerrado is considered the country's second largest biome, covering 21% of the national territory (Rocha et al., 2011), and contains a diverse range of species that can be used in food, medicine, crafts, wood supply, and forage (Faleiro et al., 2007). However, this biome has suffered from deforestation as a result of Brazil's rising agricultural development, as well as extractivism, resulting in the depletion of natural resources and the loss of native biodiversity, which has not yet been thoroughly studied (Macedo et al., 2009).

The identification of morphological characteristics of fruits and seeds, as well as the early stages of plant development (Cosmo et al., 2009), contributes to the understanding of the reproductive process, provides support for sapling production, and aids in the understanding of the natural regeneration process (Soares et al., 2013).

Lastly, research on seed quality helps preserve species, as it contributes to recognizing the viability and genetic diversity necessary for long-term conservation and ecological restoration projects (Pinã-Rodrigues et al., 2004; Figliolia, 2015). This includes, for example, germplasm banks, which play an important role as an alternative for maintaining biodiversity and supporting restoration efforts, as they house base collections for the conservation of broad plant genetic variability (Silva et al., 2012). They are fundamental for preventing the extinction of plant species, as well as allowing the multiplication and study of these materials (Silva et al., 2018).

Magonia pubescens A.St.-Hil., a Sapindaceae member of the family, is a typical arboreal species of the Cerrado biome, also known as tingui or timbó, with documented occurrences in the states of Rondônia, Tocantins, Ceará, Bahia, Piauí, Maranhão, Minas Gerais, Goiás, Mato Grosso, Mato Grosso (Brasil, 2020). It is suitable for planting in degraded and permanent preservation areas, as well as for the composition of gardens, squares, and narrow streets because it is resistant to poor soils (Souza Filho et al., 2011; Coelho et al., 2012; Jeromini et al., 2015).

Several research point to the application of Magonia pubescens bark extract in the control of Aedes aegypti stage 3 larvae (Silva et al., 2004), as well as in the slaughter of Nile tilapia, minimizing stress and extending fish quality during storage (Silva et al., 2004). (Miranda et al., 2016). Its seeds are used to make soap (Arruda et al., 2003; Silva et al., 2004; Saraiva et al., 2012), for medicinal purposes in traditional communities, and for personal hygiene in villages far from urban centers (Saraiva et al., 2012).

Given the possible applications of *Magonia pubescens* A.St.-Hil., it is critical to characterize its fruits, seeds, and basic stages of growth, as well as studies on seed germination potential. Thus, the purpose of this research was to characterize and schematize *Magonia pubescens* fruits, seeds, and seedlings, as well as to evaluate the quality of their seeds and saplings.

Material and Methods

The research was conducted at the Federal University of Recôncavo da Bahia's Seed Laboratory, which is located on the Cruz das Almas – BA campus. On a farm in the municipality of São João da Lagoa, northern Minas Gerais, Brazil, near coordinates 16°80' 03" S and 44° 40' 87" W, the fruits were collected from trees and stored in plastic bags, being evaluated immediately. Subsequently, the fruits were opened to remove and evaluate the seeds. With an elevation of 835 meters, the municipality has a hot and humid tropical climate (Am) according to the Koppen classification (DB-CITY, 2019).

Fruit and seed biometrics and morphology

The seeds (140 units) were examined for color, dimensions (length, width, and thickness), texture, shape, hilum and tegmen (external variables), embryo type, shape, size, embryo position, and the presence or absence of endosperm (internal variables).

The length was measured from the base to the apex and the width and thickness, in the midline. Color, type, length, width, texture, quantity of healthy seeds per fruit, and pericarp thickness were all analyzed in the fruits (140 units). The length was measured without the peduncle from the base to the apex. Width measurements were taken on the larger side's midline, and thickness measurements were taken on the smaller side's midline. A caliper with 0.1 mm precision was used to measure the length, width, and thickness of fruits and seeds.

The morphological description of the seedlings was conducted at various stages of development, and in addition to illustrations of the structures of the seeds and seedlings, the lengths of the primary root, hypocotyl, epicotyl, and the overall size of the seedling were described and measured using a millimeter ruler.

To observe the seedlings, four seeds were sown every two days in a greenhouse with 50% shading, in perforated polyethylene trays filled with commercial substrate Vivatto Plus®. When the first emerged seedlings emitted the second pair of expanded eophylls, seeding was complete.

A slight longitudinal cut in the wings section of the seed tegmen, without reaching the embryo, guaranteed seedling emergence uniformity.

The biometric data of seeds and fruits were statistically analyzed to determine the average number of seeds and their associated dimensions, minimum and maximum values, coefficient of variation, and standard deviation.

Seed quality

The seed quality was indirectly examined by vigor analysis, which used the accelerated aging test, which involves subjecting the seeds to high temperatures and moisture content. The experiment used a completely randomized design, with a control group (T0), two treatments (T1 - 48 hours and T2 - 96 hours), and 10 replications with 10 seeds each.

To apply the treatments, the seeds were placed on an aluminum screen in a Gerbox box holding 40 ml of distilled water, avoiding direct contact with the seeds. The seed boxes were stored in B.O.D. (Biochemical Oxigen Demand) without light exposure at a constant temperature of 45 °C for 48 hours (T1) and 96 hours (T2).

Following this period, the seeds were sanitized by immersing them in a solution of neutral detergent and water in the proportion of 200 ml of water to 10 drops of detergent for 10 minutes, followed by subsequent washings to eliminate residues.

For the germination test, the seeds were then placed between two sheets of Germitest® paper and dampened with a volume of distilled water corresponding to 2.5 times their dry weight (Brasil, 2009), forming rolls that were packaged in labeled plastic bags to maintain moisture. Following that, the bags containing the rolls were brought to the B.O.D. under constant photoperiod and 30°C temperature.

Germination percentage (% G) and Normal Seedlings (% PN), Germination Speed Index (IVG), and Average Germination Speed (VMG) were assessed after 10 days. The square root was used to convert the data. The Scott-Knott mean test was run with the R Studio software at a 5% probability of significance.

The moisture content of the seeds was 0), as well as the treatments T1 and T2, were examined using independent samples made up of two duplicates of ± 4.5g of seeds. The weight of a thousand seeds was calculated by repeating 10 times 100 seeds at random from the seed lot and calculating the result based on the sum of the samples (Brasil, 2009). determined using the oven drying method at 105 ±°C for 24 hours (Brasil, 2009). The control group.

Sapling quality

Four replications of eight sapling in two treatments (T1 - 180 cm^3 tube and T2 - 280 cm^3 tube) were used in a completely randomized design. The saplings were rated based on their height (cm) and diameter (mm). The data was subjected to analysis of variance, and the Tukey test was used to compare the means at a probability of 5%.

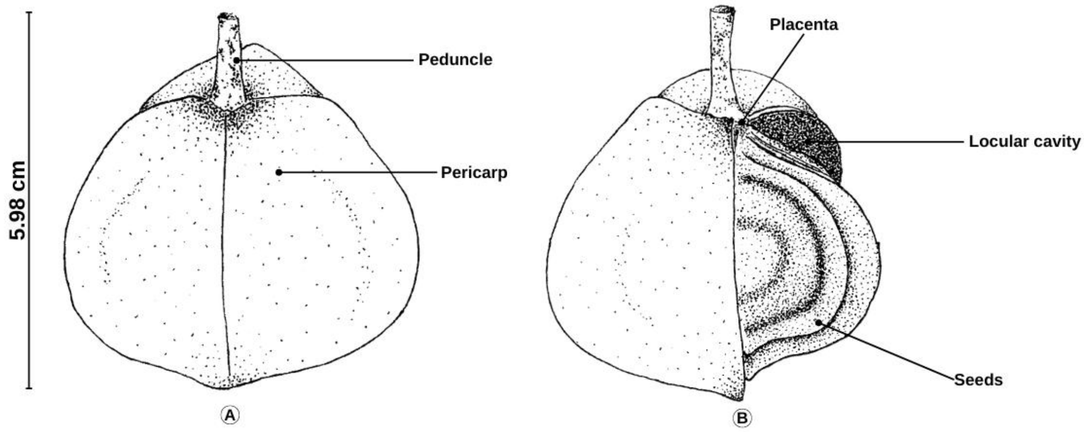
The first development of saplings was examined 63 days after seeding (d.a.s.) in polypropylene tubes, 180 cm3 (T1) and 280 cm3 (T2), filled with commercial substrate Vivatto Plus® and treated with NPK fertilizer at a substrate dosage of 8 g kg-1. In a greenhouse, the tubes were hanged from wooden benches and shaded by a 50 % shade screen. To better fit the seeds to the size of the containers, the winged part of the seeds were removed with scissors before seeding.

Results and Discussion

Morphology and biometry of fruit, seed, and seedling

The *Magonia pubescens* fruit has a trilocular shape, is woody, has a longitudinal dehiscence, is dark brown on the outside, has a rough powdery texture, is largely ovoid in shape, has a slightly triangular top view, and has rounded and slightly rough edges (Figure 1A). It is a loculicidal capsule with an ocher internal color that opens into three equal parts (Figure 1B). The pericarp is lignified (Figure 1A, B). According to Silva-Junior et al. (2008) and Fernandes et al. (2008), the peduncle, which was attached to the fruit and had a woody consistency, was brown in color.

Figure 1. Morphological characteristics of *Magonia pubescens* A.St.-Hil. Fruits, A – Closed ripe fruit, B – Open ripe fruit.
Figura 1. Características morfológicas de *Magonia pubescens* A.St.-Hil. Frutos, A – Fruto maduro fechado, B – Fruto maduro aberto.



Source: Authors; **Illustration:** Diego Souza.

The average length of the assessed fruit was 7.70 cm (Table 1), which is greater than the 5.96 cm found by Rocha et al. (2014), and the average shell thickness is 4.71 mm. In terms of width, the fruits ranged from 6.44 to 12.36 cm, matching only the minimum width found by Macedo et al. (2009), who examined fruits collected in the Cerrado region of Aquidauana-MS and measured them between 6.57 and 8.26 cm.

Table 1. Biometric determinations in a sample of 140 fruits of *Magonia pubescens* A.St.-Hil.

Tabela 1. Determinações biométricas em uma amostra de 140 frutos de *Magonia pubescens* A.St.-Hil.

Parameter	FL (cm)	FW (cm)	FT (cm)	PT (cm)	TNS	NH
Maximum	9.53	12.36	10.62	7.80	25	24
Minimum	5.31	6.44	6.33	2.94	7	5
Average	7.7	9.81	8.82	4.71	18	17.33
SEM	0.05	0.09	0.07	0.07	0.03	0.03
CV (%)	9.13	10.78	9.55	18.42	21.79	23.72
SD	0.88	1.06	1.08	0.87	0.39	0.41

Where: FL: Fruit length; FW: Fruit width; FT: Fruit thickness; PT: Pericarp thickness; TNS: Total number of seeds; NHS: Number of healthy seeds; SEM: Standard Error of the Mean; CV: Coefficient of variation; SD: Standard deviation.
Source: Authors**.**

The average total number of seeds per fruit was 18 seeds, with values ranging from 7 to 25 seeds, while Rocha *et al*. (2014) found that values for seeds ranged from 9 to 21, with an average of 14.94 seeds per fruit.

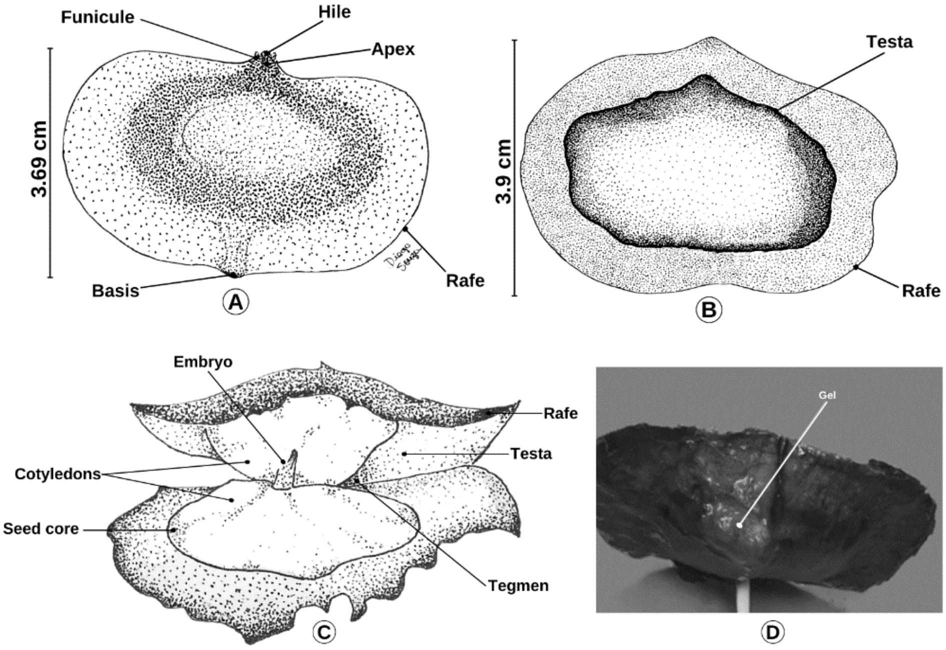
When only seeds that appeared healthy and well-developed were examined, an average of 17 seeds per fruit was observed.

Magonia pubescens seeds are winged, transverse oblong (Figure 2A), with color varying from light brown to reddish brown. The testa has a cartaceous and brittle appearance, with smooth undulations on the surface (Figures 2B and 2C).

Thin funiculus, lignified, fragile and barely perceptible to the naked eye. The raphe that surrounds the entire tegmen is fibrous, forming a slight undulation (Figures 2A, 2B and 2C). The apex is slightly convex and the base is invaginated (Figure 2A). The micropyle is inconspicuous, blending into the hilum, which is apical and easily visible at the apex of the seed (Figure 2A).

Figure 2. *Magonia pubescens* A.St.-Hil. A- Intact seed; B- Closed swollen seed; C- Swollen seed with open cotyledons and their internal structures; D - Swollen seed with emergence of gel Seed structure of *Magonia pubescens*.

Figura 2. *Magonia pubescens* A.St.-Hil. A- Semente intacta; B- Semente fechada e inchada; C- Semente inchada com cotilédones abertos e suas estruturas internas; D - Semente inchada com surgimento de gel Estrutura da semente de *Magonia pubescens*.



Source: Authors; **Ilustration:** Diego Souza.

The swollen seed (Figure 2B) showed an average gain of 0.21 mm in size, due to water absorption. Figure 2C illustrates the swollen seed with open cotyledons, and it is possible to observe the testa detached from the tegma.

In addition to its protective function, the tegmen's shape can aid in seed dissemination, as seen in *Magonia pubescens* (Teles *et al*., 2008), which has an anemochoric dispersion (Giotto *et al*., 2009). The seed coat, according to Labouriau (1973), is composed of approximately five layers organized in two mirrored juxtaposed sheets. One of the layers, the inner tegmen, covers only the cotyledons, and the second layer, from the outside to the inside, forms the gel when the seed is soaked in water (Figure 2D).

This gel is critical for seedling germination and survival because it can store water and transport it to the embryo when necessary (Teles *et al*., 2008). Thus, despite delaying germination by competing with the embryo for water, when the outer structure absorbs water and forms the gel, this evolutionary mechanism is advantageous in the natural conditions of the cerrado, because the embryo will have available water to initiate germination after this process (Labouriau, 1973).

In terms of biometrics, the seeds had average lengths, widths, and thicknesses of 4.84 cm, 8.10 cm, and 0.91 cm, respectively (Table 2).

As per Teles *et al*. (2008), the size of *Magonia pubescens* A.St.-Hil. seeds affect the percentage of germination, and the plant's initial development by representing the amount of reserve tissue and possibly physiologic maturity.

Table 2. Biometry of *Magonia pubescens* A.St.-Hil. seeds, sample of 140 seeds.

Tabela 2. Biometria de sementes de *Magonia pubescens* A.St.-Hil., amostra de 140 sementes.

Parameter	FL (cm)	FW (cm)	FT (cm)
Maximum	6.32	12.36	10.62
Minimum	3.72	5.47	0.39
Average	4.84	8.10	0.91
SEM	0.04	0.06	0.02
CV (%)	10.12	8.27	23.90
SD	0.49	0.67	0.22

Where: FL: Fruit length; FW: Fruit width; FT: Fruit thickness; PT: Pericarp thickness; TNS: Total number of seeds; NHS: Number of healthy seeds; SEM: Standard Error of the Mean; CV: Coefficient of variation; SD: Standard deviation.

Seed size refers to a physical characteristic determined by its weight, length, width, or thickness (Castro *et al*., 2006). This size impacts the establishment and dispersal of species, as it is linked to competition, predation, and spatial dispersal (Leishmann *et al*., 2000).

Larger seeds have fewer limitations in establishing themselves in small, distinct areas under natural conditions, which gives them more adaptive advantages (Lusk *et al.,* 2003). Smaller seeds, on the other hand, are more easily disseminated because they are produced in greater quantities, allowing them to explore areas where larger seeds have not arrived (Leishmann *et al*., 2000).

These circumstances result in the "Seedling Size Effect," which is a relationship between seed and seedling size directly related to initial establishment in the field (Leishmann et al., 2000). Seedlings are newly emerged young plants, resulting from the development of the embryo that germinated from the seed (Melo *et al*., 2004; Bareke, 2018).

Magonia pubescens has hypogean phanerocotyledon and unipolar germination, as well as a central cotyledonary axis. It was possible to see that the apical bud of this species

has a white base, a red apex, and is lanceolate and smooth. Arantes *et al*. (2017) observed similar characteristics. Emergence occurred four days after sowing, confirming radicle protrusion and growth (Figure 3C). The opening of the cotyledons and the development of the hypocotyl were observed after fourteen days (Figure 3H).

The root system developed rapidly in comparison to the aerial part, reaching the substrate's limit, corroborating the work of Lobo and Santana (2012).

The tegmen continued involving the cotyledons after the formation of the complete seedling, on the twenty-second day (Figure 3L).

The root system of the seedling is white, the primary root distribution is well-developed and curved, and the secondary root is short (Figure 3A-L). Secondary roots were observed developing below the stem as early as the eighth day after germination, and they were thin, twisted, and subdivided, with no regular distribution along the root axis (Figure 3E-L).

The stem, which is the transition zone between the hypocotyl and the radicle, is whitish in color and is easily identifiable by the naked eye due to its spherical shape and thickness compared to the root (Figure 3G-L).

The hypocotyl, which ranged in length from 0.5 to 1.0 cm, was short, smooth, and glabrous, with a cylindrical and curved shape and a color that changed from light green to dark green as the days progressed (Figure 3G-L).

The cotyledons, with a length between 1.5 and 2.0 cm, located at the base of the hypocotyl, were large, fleshy, globular, glabrous, rough, opposite, sessile to semi-sessile, with accumulation of reserves, entire limb, green in color and covered by the seed coat (Figure 3H).

On the twenty-second day, the epicotyl was elongated, green, glabrous or with small scales, located above the cotyledon insertion, cylindrical and straight, and measured between 3.5 and 6.5 cm in length (Figure 3H-L).

Significant development of the plumule was evident on day 16, when a basal plumule was observed, followed by four alternating leaf primordia arranged in a quadrant (Figure 3I-L). The Sapindaceae family's species are difficult to identify, and it is possible to rely on the observations of the fruits or leaves; thus, tree species such as the *Magonia pubescens* can be distinguished by leaf characteristics such as the number or margin of leaflets, as highlighted by Sprengel- Lima and Rezende (2013).

The leaf blades are oblong, foliaceous, and glabrous, with a bright green adaxial surface covered in whitish trichomes, and a smooth, opaque green abaxial surface. Base with rounded margins and smooth leaf margins with white trichomes, central pinnate veins, prominent and bulging veins, and secondary branched veins (Figure 3I-L). The petioles are green, smooth, striped, and the rachis are green with white trichomes (Figure 3J-L). According to Montoro (2008), the protophylls formed have the same morphology as the adult tree's leaves, with the only difference being their length.

Figure 3. A to L - Post-seminal development stages of *Magonia pubescens* A.St.-Hil. from 0 to 22 days after sowing. Tg = Tegmen; R = Raphe; Cf = Hood; H = Hilum; RP = Primary Root; RS = Secondary Root; C = Cotyledons; H = Hypocotyl; Co = Collect; Ep =Epicotyl; RS = Secondary Root; Eo = Eophyll.

Figura 3. A a L - Estágios de desenvolvimento pós-seminal de *Magonia pubescens* A.St.-Hil. de 0 a 22 dias após a semeadura. Tg = Tégmen; R = Rafe; Cf = Coifa; H = Hilo; RP = Raiz Primária; RS = Raiz Secundária; C = Cotilédones; H = Hipocótilo; Co = Coleto; Ep = Epicótilo; RS = Raiz Secundária; Eo = Eófilo.

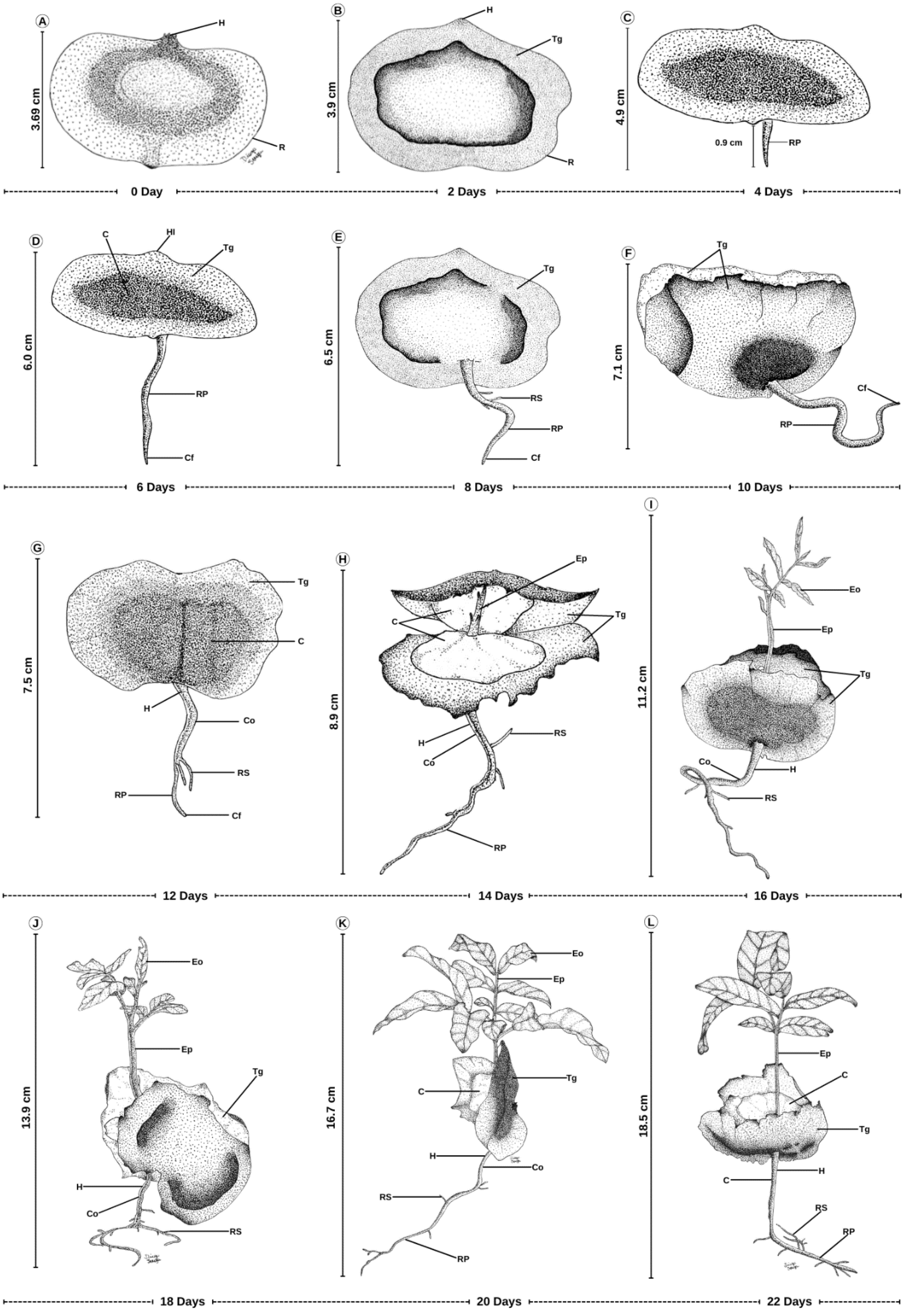


Illustration: Diego Souza.

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Seed quality

The weight of one thousand seeds in the current study was 1,904.37 g. Coelho *et al*. (2012) measured the weight of a thousand seeds from the Cuiabá-MT Cerrado at 2,711.48 g. Arantes *et al*. (2017) verified that after dividing the seeds into large and small seeds, the weights of thousand seeds were 3,143.3 g and 2,444.6 g, respectively, and had no significant effect on the germination rate.

The moisture content of *Magonia pubescens* seeds was 10.98% in the control group (T0), 11.84% after 48 hours (T2), and 13.32% after 96 hours (T2).

The moisture content of the *Magonia pubescens* seeds subjected to the accelerated aging test increased proportionally to the increase in exposure time. This occurred as a result of the seeds being exposed to high humidity levels in the environment during the accelerated aging process.

Moisture content is an important factor in seed conservation and viability maintenance during the storage process (Harrington, 1973). Souza Filho *et al.* (2011) found 10.8% moisture content of *Magonia pubescens* seeds during storage. Jeromini *et al.* (2015) found that a moisture content of 9% did not change during 90 days of storage, regardless of packaging.

According to the data in Table 3, seeds that were subjected to accelerated aging for 96 hours performed better in all variables tested. One of the explanations could be related to the gel's formation, which is an adaptive mechanism provided by the species. This period of time may have prevented the seeds from accelerating the degradation process.

Beside the findings of this study, Sales Guedes *et al.* (2009) found that accelerated aging at temperatures of 41 and 45ºC reduced the viability of *Erythrina velutina* Will seeds after 24 hours. Guedes, Alves, and Oliveira (2013) found that accelerated aging testing after 48 hours affected the germination rate of *Chorsia glaziovii* (O. Kuntze) seeds. However, these species do not exhibit gel formation, indicating that the presence of the gel can be a positive factor in the germination process when the seeds were exposed to high temperature and humidity for 96 hours, reducing the time between sowing and germination and reducing the possibility of attack by soil microorganisms.

The highest germination speed index (IVG) was observed in the 96-hour period, indicating that, even with statistically similar germination to the control, maintaining *Magonia pubescens* seeds for 96 hours in conditions of high relative humidity and temperature favors sapling production by promoting faster germination and reducing the permanence time of the seeds in adverse conditions.

Ferreira (2016) observed a slight increase in IVG values in *Aegiphila sellowiana* as the time of exposure of seeds to accelerated aging increased (24, 48, 72, and 96 hours), demonstrating that exposure to high temperature and moisture did not negatively influence the speed of seed germination.

The highest germination rate promotes the highest speed index (IVG) and, therefore, the highest average speed of germination (VMG). In general, seeds with high vigor germinate faster (Carvalho & Nakagawa, 2012).

The positive response of seeds to accelerated aging is uncommon in studies of forest species, highlighting the importance of these studies in understanding seed behavior.

Sapling quality

In the tubes, seedling emergence (100%) occurred 14 days after sowing. Giotto et al. (2009) studied germination, emergence, and growth of the same species and found similar results, in which seeds directly sown in the greenhouse also emerged after 14 days with a rate of 96%.

During the evaluation period, the tube volume had no significant effect on the quality of saplings. The height values for saplings produced in 280 and 180 cm^3 tubes ranged from 6.04 to 6.45 cm, respectively, while the diameter values for saplings produced in 180 and 280 cm^3 tubes ranged from 2.42 to 2.62 mm, respectively.

Giotto et al. (2009) evaluated the quality of Magonia pubescens saplings in black polyethylene bags measuring 15 x 25cm (capacity of approximately 1,000 cm^3 or 1L), finding height at 60 days ranging from 41.46±10.16cm to 51.25±14.48 and diameter ranging from 2.49±0.32a to 2.66±0.34a with no statistical difference between saplings grown in full sun or in a greenhouse, from direct seeding or germinated in the laboratory. Jeromini et al. (2015) found that saplings grown in 3-liter polyethylene bags in a greenhouse had higher values for height (13.50 cm) and diameter (3.58 mm) at 40 days post-emergence.

The significant difference in height observed by them and in this experiment could be attributed to the reduced volume of the tubes, which limits the supply of water and nutrients as well as space for the roots to grow.

Conclusion

The dehiscent capsule-type fruit of *Magonia pubescens* suggests a potentially favorable characteristic for its dispersal.

The hypogeal germination type, which occurs four days after sowing, with complete seedling formation 22 days later, demonstrates the capacity for accelerated establishment and recruitment within the population. This performance indicates a favorable possibility for high regeneration, making it suitable for forest restoration.

The volumes of the tubes used in seedling production did not show any effect, therefore the use of 180 cm^3 tubes is recommended as a cost reduction measure without compromising seedling quality.

The descriptions and illustrations of the created figures can assist in identifying the species, facilitating the visualization and identification of the structures and, consequently, expanding knowledge about the species.

Declaration of competing interests

The authors declare that we have no conflict of interest with the results of this manuscript.

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