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COATING OF *PLATHYMENIA RETICULATA* BENTH SEEDS WITH DIFFERENT MATERIALS

REVESTIMENTO DE SEMENTES DE *PLATHYMENIA RETICULATA* BENTH COM DIFERENTES MATERIAIS

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ABSTRACT
Plathymenia reticulata Benth, popularly known as 'vinhático', is a tree species with potential for the production of high-quality timber that is used in luxury furniture and construction. Seed coating ensures an adequate stand, vigorous plants, delayed onset of epidemics, and increased yield. The present study was carried out to investigate different types of seed-coating materials and their effects on the physical and physiological characteristics of *Plathymenia reticulata* Benth and define the best coating material. The coatings were made with sand, silicate, limestone, sand + silicate, sand + limestone and uncoated seeds as a control. The experiment was set up as a completely randomized design with six treatments tested in four replicates with 50 seeds each. Sand + limestone coating reduced GSI and ESI but did not influence the seedling germination or emergence rates. The best material for coating *Plathymenia reticulata* Benth was the sand + limestone mixture.
KEYWORDS: *Plathymenia reticulata* Benth; Vigor; Germination

RESUMO
Plathymenia reticulata Benth, popularmente conhecida como 'vinhático', é uma espécie arbórea com potencial para a produção de madeira de alta qualidade, utilizada em móveis e construção de luxo. O recobrimento das sementes garante um estande adequado, plantas vigorosas, início tardio de epidemias e aumento da produtividade. O presente estudo foi realizado para investigar diferentes tipos de materiais de revestimento de sementes e seus efeitos nas características físicas e fisiológicas de Plathymenia reticulata Benth e definir o melhor material de revestimento. Os revestimentos foram feitos com areia, silicato, calcário, areia + silicato, areia + calcário e sementes não revestidas como testemunha. O experimento foi realizado em delineamento inteiramente casualizado com seis tratamentos testados em quatro repetições com 50 sementes cada. O recobrimento com areia + calcário reduziu o IVG e o IVE, mas não influenciou na germinação das mudas ou nas taxas de emergência. O melhor material para o revestimento de Plathymenia reticulata Benth foi a mistura areia + calcário.
PALAVRAS-CHAVE: *Plathymenia reticulata* Benth; Vigor; Germinação

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INTRODUCTION

Plathymenia reticulata Benth, popularly known as vineyard or field vineyard, is a tree species, deciduous, heliophyte, selective xerophyte. It is a Brazilian species, typical of the Atlantic Forest and the Cerrado. *P. reticulata* is a source of high quality wood often used in sophisticated carpentry, and is useful in restoring deforested areas, contributing to an economical and sustainable economy (DELLA TORRE et al., 2011), in addition to being a species indicated for use in the recovery of degraded areas (BRAGA et al., 2007).

However, the rate of emergence of vinhatic seeds is low due to the impermeability of the tegument, which slows down the emergence process, and for this reason the seedling production is carried out via the seed, however some factors hinder the continuous production of seeds, thus justifying studies aimed at optimizing techniques for the production of seedlings of this species. And one of the main factors that decrease or hinder the production of seeds of this species is the lack of definition of the ideal time to harvest the seeds and the point of maturity of the fruit that is compatible with the maturity of the seeds (SOUZA and LORENZI, 2008), thus justifying studies aimed at optimizing techniques for the production of seedlings of this species.

Obtaining forest seedlings in high quantity and quality is one of the most important steps for the establishment of good forest stands. Along with physical, sanitary, and physiological characteristics, the genetic quality of the seed directly influences the plant's ability to attain its maximum productive potential (JULIATTI, 2010). One of the techniques that can be used to produce seedlings in quantity and quality throughout the year in the most diverse species is the treatment of seeds, which is a cheap insurance. The treatment of seeds is a low-cost insurance, and, given the agronomic and environmental advantages of seed technologies, they should be increasingly enhanced and used in all crops (MENTEN, 2010).

In this scenario, seed coating emerged as a technique to improve the performance of seeds through the application of layers of materials that can contribute to their development, e.g.: macronutrients, micronutrients, hormones, fungicides, insecticides, and many other products. According to Menten (2010), seed coating ensures an adequate stand, vigorous plants, delayed onset of epidemics, and increased yield, in addition to providing benefits in the medium and long terms. The right choice of the coating type can contribute to the economy of production activities, savings of inputs, and generation of higher yields and better-quality products. Additionally, it may even lower the costs incurred in the process and increase revenues, balancing the production system.

On these basis, the present study proposes to examine different coating materials and their effects on the physical and physiological characteristics of *Plathymenia reticulata* Benth seeds and define the best coating material for the species.

MATERIAL AND METHODS

The experimental procedures were performed in a laboratory and in a green house. Seeds of *Plathymenia reticulata* Benth provided by Caiçara Comércio de Sementes Ltd. were used in the experiment. The seeds underwent an initial treatment that consisted of wing removal and screening for uniformity (in which they were manually separated into viable and shriveled or malformed seeds). After this step, the seeds were mechanically scarified using 36-grit iron sandpaper to overcome dormancy.

Sand, calcium silicate, and dolomitic limestone were used as filler materials to coat the seeds. A PVA-based glue was used as the adhesive solution, which was diluted in water heated at 70 ºC at the ratio of 1:1 (v/v), as recommended by Mendonça et al. (2007).

Six coating treatments were tested, namely: T1 - Sand; T2 - Silicate; T3 - Limestone; T4 - Sand + Silicate; T5 - Sand + Limestone; and T6 - uncoated seeds. The proportion between filler material and seeds was 3:1 (p/p). Accordingly, 150 g of filler material was used for each 50 g of seeds. This amount of filler material was divided into twelve portions, and each layer was composed of two 12.5-g portions of material.

The coating process was performed in a bench-top seed-coating machine (N-10, Newpack). The equipment consists of a stainless-steel drum; spraying nozzle for the application of the adhesive material, which is activated by compressed air at 4-bar pressure; and a hot-air blower for drying the seeds with temperature regulator and timer, which regulates the spraying and blowing time. During the coating procedure, the following settings were used: drum speed: 40 rpm; adhesive solution spraying time: 1 s, with a 1-min interval between each spraying; hot-air blower temperature: 40 ºC; blowing time: 1 min. (XAVIER et al, 2016).

Seeds were placed inside the drum of the coating machine along with a portion of filler material (sand, silicate, or limestone, according to the treatment). Next, the adhesive solution was sprayed twice, at 1-min intervals, and then another portion of the filler material was deposited in the drum, followed by another spraying of adhesive solution. Subsequently, the hot-air blower was activated for 1 min. This process corresponded to one layer of coating. Six layers were added for the complete coating of the seeds.

After coating, the seeds were evaluated for the following physical and physiological characteristics:

Water content: determined by drying 4.5 ± 0.5 g of seeds in a forced-air oven at 105 ± 3 ºC for 24 h (Brasil, 2009), with two replicates. Results were expressed in percentage terms (wet basis).

1000-seed weight: determined in eight replicates of 100 seeds, which were weighed on a precision scale (0.0001 g). Results were expressed as the average weight of a thousand seeds (grams) (Brasil, 2009).

Germination test: performed in four replicates with 50 seeds each, which were seeded on germination paper rolls previously moistened with an amount of water corresponding to 2.5 times the weight of the paper. Next, the paper rolls with the seeds were transferred to a germination chamber (BOD type) at a constant temperature of 25 ºC. Evaluations were carried out at 10 and 16 days, in which the number of normal, abnormal, infested, and ungerminated seedlings was counted, adopting the criteria established in Rules for Seed Testing (Brasil, 2009).

Germination speed index (GSI): determined along with the germination test, but at every two days, from seeding to the end of the test. The index was calculated using the formula proposed by Maguire (1962).

Fresh matter (FM): after the ten best seedlings were measured, they were weighed on a precision scale to determine the fresh matter values.

Dry matter (DM): after measuring and weighing, the seedlings were packed in paper bags and dried in a forced-air oven at 60 ºC for 72 h. Subsequently, they were weighed on a precision scale to obtain the dry matter values (Brasil, 2009).

Emergence in greenhouse (E): determined in four replicates, in which 50 seeds were seeded in plastic trays containing washed sand, corresponding to each of the treatments with the filler materials. Trays were kept in a greenhouse and the normal emerged seedlings were counted on the 16th day after seeding (Brasil, 2009).

Emergence speed index (ESI): determined along with the evaluation of seedling emergence in the greenhouse, at every two days, from seeding to the 16th day after seeding, following Maguire (1962).

Shoot and root lengths: measured after 60 days in the greenhouse. The plants were washed and cut, and shoots and roots were separated at the neck of the seedling. These were then measured separately with a millimeter-graduated ruler, using 10 seedlings per replicate.

Fresh and dry matter of shoots and roots: after the shoot and root lengths were measured, these fractions were weighed on an analytical scale to obtain the fresh matter values. Both were then placed in paper bags separately and dried in a forced-air oven at 60 ºC for 72 h. Next, they were weighed on an analytical scale to obtain the dry matter values.

Statistical analysis

The experiments undertaken in the laboratory and in the greenhouse were conducted as completely randomized design with four treatments, which were tested in four replicates with 50 seeds each. The obtained data were subjected to analysis of variance and means were compared by Tukey's test at the 5% probability level, using ASSISTAT software (SILVA & AZEVEDO, 2009).

RESULTS AND DISCUSSIONS

The 1000-seed weight analysis revealed that the coated seeds were 5.25 to 8.95 g heavier than the uncoated group (Table 1). The treatments in which sand, silicate, and limestone were used separately provided higher weight gains than the sand + silicate and sand + limestone coatings.

Table 1. 1000-seed weight (g) and increase in weight gained with coating (g) of *Plathymenia reticulata* Benth seeds according to the coating treatment

Treatment	1000-seed weight (g)	Increase gained with coating (g)
Control	11.37 b	0.00
Sand	18.77 a	7.40
Silicate	20.32 a	8.95
Limestone	18.41 a	7.04
Sand + Silicate	16.62 a	5.25
Sand + Limestone	17.17 a	5.80

Means followed by common letters do not differ according to Duncan's test at the 5% probability level.

The heavier weight of coated seeds facilitates aerial seeding in areas of difficult access, since, despite their adequate size, *Plathymenia reticulata* Benth seeds may disperse easily, which can be lessened by coating them. Moreover, coating can also alter and standardize the seed color, which ranges from brown to red and complicates their identification during seeding. With the change in color, they will become more visible, making it easier to monitor the seeding procedure.

These distinct increases in weight are due to the different types and textures of materials used and also to their arrangement in the coating process. Coatings with only one type of material can better adhere to the seed, resulting in a more homogeneous and consequently heavier layer.

In spite of the significant differences, the lower adherence of the treatments with two types of material to the seed surface was due to the different particle sizes, considering that sand has larger granules than limestone and silicate, in addition to a finer texture. This difference in particle size prevents homogeneous adherence to the seeds, resulting in a more heterogeneous and less heavy coating.

Accumulation of coating materials on the seeds is a consequence of their adherence to their surface. Coating allows for a significant increase in the amount of inert material on the seeds, thereby increasing their size and weight. However, it proportionally reduces the number of seeds per kilogram.

These results corroborate the results found by Sousa et al. (2016), in which studying the coating with fungicide and different doses of fertilizer in vineyard seeds attributes the formation of the different sizes of pellets due to the different types of texture of the materials used and also to their availability in the coating process.

Regarding the water content, although water is added to the coating, the data show that the coated seeds (Figure 1) had a lower water content compared to the uncoated seeds, which happens due to the drying that is done during the process of coating and at the end of it, causing the water that was added to be lost, in addition to also decreasing the amount of water in the seed itself, as the values of the water content of the coated seeds are lower than the seeds without coating.

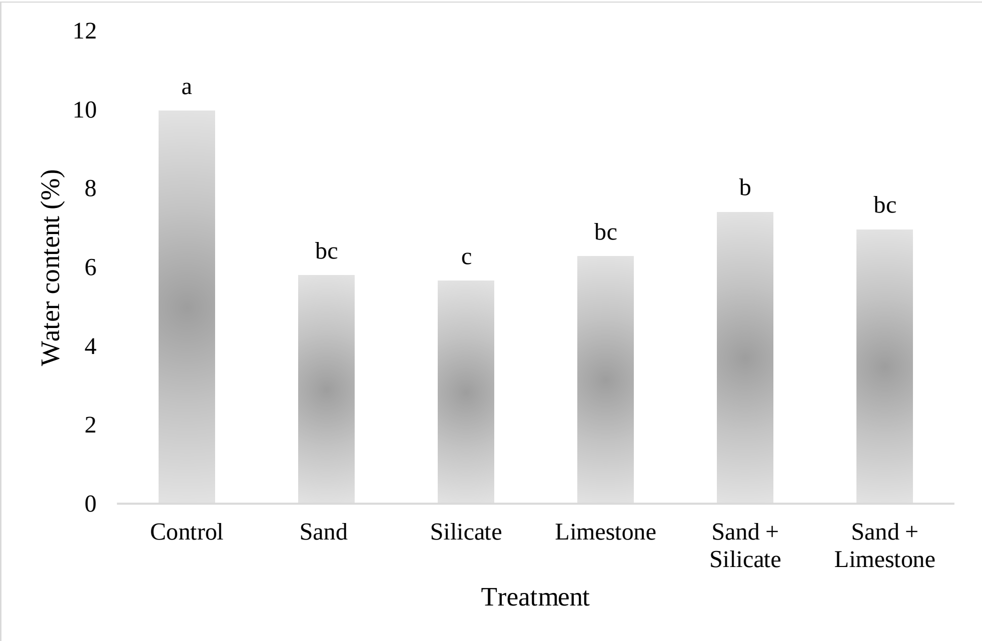

Figure 1. Water content in *Plathymenia reticulata* Benth seeds according to the coating treatment.

The fact that the water content is lower in the coated seeds indicates that the drying temperature of the pellets at 40 ° C was efficient and that the materials did not retain moisture, this lower water content in the coated seeds emphasizes that the material used does not retain this moisture, as the added water is lost more easily, and this lower water content in the coated seeds facilitates their storage due to less moisture retention, without compromising the physiological attributes of the seed or even accelerating the deterioration after the process due to moisture present in the coating.

According to studies by Conceição and Vieira (2009), observed lower water contents in coated corn seeds in comparison with their uncoated counterparts. Those authors attributed this finding to the lower water content in the coating layer despite the unchanged water content within the seeds. Ultimately, the water content of the coated seeds as a whole is reduced. Derré et al. (2016) investigated imbibing and seeding depth in uncoated and coated seeds of forage plants and observed that the former showed a higher water content than the coated seeds, regardless of the cultivar.

Silva et al. (2017) working with styling seeds Campo Grande covered with different layers of sand found that the treatments without covering had a higher water content, because as the covering of the seeds occurs there is a weight gain without water gain, even with the sprinkling of cementitious material that has water in its composition. They also found that the coating reduced the water content of the seeds, with a gradual reduction in the water content of the covered seeds, showing that there is a relationship between the number of layers and the water content of the seeds.

The results of first germination count (FGC), germination rate (G), abnormal seedlings, and infested seedlings (Table 2). There was a significant difference between the treatments for FGC and in the final germination count (G). Considering FGC, the control, sand, and sand + limestone treatments were not surpassed by any other. The coating with silicate exclusively provided the lowest FGC value, despite the lack of significant differences between it and the limestone and sand + silicate treatments. As regards G, the sand, sand + silicate, and sand + limestone treatments showed excellent results, which may be related to the larger particle size of sand, which led to a greater coating porosity, facilitating the entry of water into the seed, and, consequently, germination.

Table 2. First germination count (FGC) at 10 days, germination rate (G), abnormal seedlings (AS), and infested seedlings (IS) at 16 days in *Plathymenia reticulata* Benth seeds according to the coating treatment

Treatment	FGC (%)	G (%)	AS (%)	IS (%)
Control	82.5 a	79.5 a	4.0 ab	9.5 a
Sand	87.0 a	84.0 a	5.0 ab	9.0 a
Silicate	61.5 b	69.5 b	7.0 a	11.5 a
Limestone	70.5 ab	67.5 b	7.0 a	10.5 a
Sand + Silicate	79.0 ab	79.0 a	3.0 ab	10.5 a
Sand + Limestone	83.0 a	83. a	2.5 b	9.0 a
CV (%)	10.49	7.34	56.3	36.21

Means followed by common letters do not differ according to Duncan's test at the 5% probability level.

The seeds silicate- and limestone-coated showed the lowest germination values. These minerals have a finer texture, leading to the formation of denser coating, which reduces the imbibing speed of the seeds coated with them. For this reason, there was a delay and a reduction in germination speed. This can be verified in the seeds coated with silicate only, whose integument took longer to open, releasing yellowish seedlings. The seeds coated with sand and sand + limestone germinated statistically equally to the control and sand + silicate groups, but reached 4.5 and 3.5% higher germination rates. During the experiment, it was visually observed that the sand-coated seeds had greater ease releasing the radicle, exhibiting a similar behavior to the uncoated seeds.

According to studies by Vieira and Simonetti (2014), the coating of soybean seeds with insecticides did not cause interference in germination, since the coating made by them had only one layer of insecticide, which does not hinder germination as long as in adequate doses, different of the present study that tested six layers of coating.

In the studies of Vieira & Simonetti (2014), the coating of soybean seeds with insecticides did not interfere with their germination. While Caldeira et al. (2016) claimed that the material used in the pelletizing process can contribute as a physical barrier to the emission of the primary root, causing delay in germination speed, and this delay was also observed in the present study. Brites et al. (2011) concluded that coating delayed or reduced germination in coated seeds of tropical forages, which was due to the barrier imposed on the seeds by the coating layer. Santos et al. (2010) studied 14 coating types and also observed that seed coating leads to a reduction in the germination and emergence speeds of *Urochloa brizantha* cv. Marandu seedlings, irrespective of the coating type.

No significant difference was detected for the percentages of abnormal seedlings and infested seedlings, according to the statistical analysis. However, the treatments with silicate and limestone led to the greatest tendency to fungal incidence, which was most likely because they slowed seed germination. Despite the lack of significant statistical differences, the sand + limestone treatment showed the lowest tendency of occurrence of abnormal seedlings, which was also lower than that observed in the uncoated group.

The seeds coated with silicate exclusively exhibited the worst result for percentage of ungerminated seeds. Despite the elevated coefficient of variation, the said treatment was significantly higher and achieved a 107% higher value than control. This result may be related to the higher density of silicate, which made the coating a physical impediment to the germination process. During the tests, it was observed that the seeds were imbibed; however, several seeds did not germinate in the test period (Table 3).

Table 3. Percentage of ungerminated seeds (UGS) and germination speed index (GSI), fresh matter production (FM), and dry matter production (DM) of seedlings from *Plathymenia reticulata* Benth seeds according to the coating treatment

Treatment	UGS (%)	GSI	FM (g)	DM (g)
Control	7.0 bc	0.247 a	1.96 a	0.12 a
Sand	2.0 c	0.232 a	1.82 b	0.12 a
Silicate	14.5 a	0.125 d	1.32 d	0.12 a
Limestone	3.5 bc	0.165 c	1.63 c	0.13 a
Sand + Silicate	9.5 ab	0.167 c	1.64 c	0.13 a
Sand + Limestone	7.0 bc	0.205 b	1.94 ab	0.10 a
CV (%)	57.52	9.37	5.14	16.76

Means followed by common letters do not differ according to Duncan's test at the 5% probability level.

Control treatment and for the treatment with sand coating exhibited the best results for GSI. The good germination results of the sand-coated seeds were due to the ease of air and water movement inside the coating structure, which was provided by the sand. The coating treatments with silicate and limestone, which formed a heavier layer according to 1000-seed weight, led to worse performance in terms of GSI, reaching almost half the GSI of that shown by the uncoated seeds.

Xavier & Vieira (2018) studied seeds of perennial soybean and reported that the coated seeds took longer to germinate or release seedlings (emergence) than their coated counterparts.

According to Bomfim et al. (2016), unenclosed ("naked") seeds of quinoa (*Chenopodium quinoa*) have a higher GSI than pelleted seeds when tested in laboratory, but there are no differences between these treatments in greenhouse conditions.

Ferreira et al. (2015) also observed that the coating of *Brachiaria hybrid* cv. Mulato II reduced germination rates, emergence rates, and ESI. Caldeira et al. (2016) stated that the material employed in pelleting can act as a physical barrier against the emission of the primary root, reducing the germination speed. The coating materials influenced seedling FM production (Table 3). For this variable, the sand + limestone treatment was statistically equal to control, which provided the highest values, suggesting that sand + limestone was the best coating for FM production. Silicate was the treatment that provided the lowest seedling FM production. This treatment delayed germination and led to a high percentage of ungerminated seeds and also one of the lowest GSI. Together, these factors contributed to a lower seedling FM production.

According to Dode et al. (2012), plants with larger fresh and dry matter production than others of the same species indicate good seed physiological quality and are considered more vigorous.

In the current experiment, seedling DM was influenced by the different coating materials, which shows that the treatments did not compromise seedling growth. Coating significantly interfered with seedling emergence (E) (Table 4). The limestone-coated seeds were the only ones whose E values were lower than those obtained with control treatment. The other treatments, in turn, provided satisfactory emergence. The coating materials did not affect GSI in relation to control. This finding is extremely interesting and agrees with the reports of Xavier et al. (2015), who studied seeds of Stylosanthes cv. Campo Grande.

Table 4. Emergence rate (E) at 16 days, emergence speed index (ESI), shoot fresh matter (SFM), shoot dry matter (SDM), root fresh matter (RFM), and root dry matter (RDM), of seedlings from *Plathymenia reticulata* Benth seeds according to the coating treatment[1]

Treatment	E (%)	ESI	SFM (g)	SDM (g)	RFM (g)	RDM (g)
Control	85.0 a	0.12 ab	2.23 a	0.79 a	1.35 cd	0.48 a
Sand	81.5 ab	0.10 b	2.44 a	0.79 a	1.12 d	0.28 c
Silicate	75.5 ab	0.09 b	2.45 a	0.77 a	1.74 bc	0.36 bc
Limestone	72.0 b	0.10 b	2.54 a	0.82 a	1.51 cd	0.34 bc
Sand + Silicate	76.0 ab	0.10 b	2.25 a	0.72 a	2.05 a	0.40 ab
Sand + Limestone	77.5 ab	0.10 b	2.56 a	0.82 a	2.24 ab	0.37 bc
CV (%)	8.28	9.15	9.59	9.28	15.45	16.7

Means followed by common letters do not differ according to Duncan's test at the 5% probability level.
[1] Measured in greenhouse conditions.

Shoot FM and DM did not differ significantly (Table 4), but the sand + limestone coating provided a 15% higher fresh matter in the seedlings compared with control treatment. However, the treatments yielded different results for root FM and DM. The seedlings originated from sand + limestone-coated seeds reached a 66% higher root FM than those produced from uncoated seeds. The seeds coated with sand + silicate also stood out for this trait. Control treatment, in turn, was not surpassed by any other in terms of root DM.

As reported by Tavares et al. (2012), rice seeds coated with dolomitic limestone produced seedlings with larger FM production than those coated with other materials. Bianchi et al. (2016)

studied the germination of coated and uncoated seeds of *Panicum maximum* cv. Tanzania under water-deficient conditions and concluded that seed coating does not influence GSI, shoot DM, or root DM. Throughout the experiment, the sand + limestone treatment provided optimum results for all analyzed variables, showing that this filler mixture is suitable for the coating of *Plathymenia reticulata* Benth seeds.

The overall analysis of the obtained data revealed that not all combinations tested in this experiment were successful, warranting further studies on the influence of coating on the quality of *Plathymenia reticulata* Benth seeds.

CONCLUSIONS

The coated seeds had a lower water content than the uncoated seeds. Silicate coating provided the highest 1000-seed weight, reduced germination rate and germination speed index, and increased the percentage of ungerminated seeds. Sand + limestone coating reduced germination speed index but did not affect germination rate or seedling emergence rate. Seedlings produced from seeds coated with sand + limestone showed a 14.8% higher fresh matter content than control seedlings. The best coating material for *Plathymenia reticulata* Benth seeds was the sand + limestone mixture.

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