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Methods for overcoming dormancy in teak diaspores[1]

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ABSTRACT

Teak has one of the most valuable woods in the world. However, one of the main limitations to produce seedlings of this species is related to its slow and irregular germination. This study aimed to evaluate methods for overcoming dormancy in teak diaspores, as well as their influence on seedling quality. The experimental design was completely randomized, with six treatments and four replications, totaling 24 experimental units. The evaluated treatments were: control; immersion in water for 12 h and sun exposure for 12 h, a process that was repeated three times; mechanical scarification for 5 seconds, using an electric emery; oven treatment at 80 ºC, for 6 h; impact test on diaspores at the heights of 10 cm and 20 cm. The following parameters were evaluated: emergence percentage at 29 days after sowing; percentage of normal seedlings; emergence speed index; emergence relative frequency; seedling fresh and dry weight and seedling length. The use of oven heating at 80 ºC, for 6 h, is the most efficient method to overcome dormancy in teak diaspores. The methods used did not affect the seedlings quality.

KEYWORDS: *Tectona grandis* L. f.; mechanical scarification; seeds; seedlings.

RESUMO

Métodos de superação de dormência em diásporos de teca

Apesar de a teca possuir uma das madeiras mais valiosas do mundo, uma das principais limitações para a produção de mudas desta espécie é a germinação lenta e irregular. Objetivou-se avaliar métodos de superação da dormência em diásporos de teca e sua influência na qualidade das plântulas. O delineamento experimental adotado foi o inteiramente casualizado, com seis tratamentos e quatro repetições, totalizando 24 unidades experimentais. Os tratamentos avaliados foram os seguintes: testemunha; imersão em água por 12 h e exposição ao sol por 12 h, processo repetido três vezes; escarificação mecânica por 5 segundos com esmeril elétrico; estufa a 80 ºC por 6 h; teste de impacto sobre o diásporo à altura de 10 cm e 20 cm. Foram avaliados os parâmetros percentagem de emergência aos 29 dias após a semeadura; percentual de plântulas normais; índice de velocidade de emergência; frequência relativa de emergência; massa fresca e seca da plântula e comprimento da plântula. O aquecimento em estufa a 80 ºC, por 6 h, é o método mais eficiente para a superação de dormência em diásporos de teca. Os métodos utilizados não influenciaram na qualidade das plântulas.

PALAVRAS-CHAVE: *Tectona grandis* L. f.; escarificação mecânica; sementes; plântulas.

INTRODUCTION

The demand for wood, along with its intensive exploitation, has compromised native forests around the world, what evidences the need for researches that contribute to increase the wood production from commercial plantations (Silva et al. 2016). Furthermore, it is necessary an adequacy within environmental laws, with a reduction of native forest exploitation areas and consumer awareness (Rocha et al. 2014).

Currently, 7 % of the world's forests are planted and, in many cases, these forests consist of non-native species that were introduced because of their rapid growth, favorable wood properties, adaptability in different regions and other uses (Hurley et al. 2017).

In Brazil, silvicultural activities have become more important due to commitments to reduce greenhouse gases emission by reducing the exploitation of native forests and encouraging commercial plantations (IBA 2015), as well as studies with forest species of great commercial interest, such as teak (*Tectona grandis* L.).

Teak is a world-known species in the wood industry, and its use has called the attention of the

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forestry sector (Pelissari et al. 2013, Akram & Aftab 2016) due to its rapid growth, wood durability, natural resistance to the attack of fungi/insects and its economic value (Georgin et al. 2014, Silva et al. 2016). It has originated from the mixed deciduous forests of India, Myanmar, Thailand and Laos. Currently, this species is planted not only in Southeast Asia, but also throughout the tropical zone of the Americas, Africa and the Pacific (Trazzi et al. 2014).

Although the wood production is considered valuable (Georgin et al. 2014), one of the main limitations of teka is the slow and irregular germination of its seeds. Such lack of uniformity during germination, which is due to the mechanical dormancy imposed by the fruit (Ferreira et al. 2016), represents an emergence rate around 25-35 % in the field, varying 10-90 days (Rocha et al. 2011).

The teak diaspore, which is the plant dispersal unit, consisting of a seed or spore plus any additional tissues that assist dispersal, has the pericarp impermeable to water and protects the seeds. Furthermore, the endocarp and the mesocarp have a layer of palisade cells with thick walls that are externally covered by waxy cuticle, causing seed dormancy (Dias et al. 2009). Other limiting factors are the physiological immaturity of the seed and the presence of chemical inhibitors in the pericarp (Georgin et al. 2014).

The current procedures for overcoming dormancy in teak diaspores are characterized by low operational efficiency and less practicality, making it difficult to determine a suitable methodology for overcoming dormancy in this species (Ferreira et al. 2016).

This study aimed to test different methods for overcoming dormancy in teak diaspores, as well as evaluating their influence on seedling quality.

MATERIAL AND METHODS

The study was carried out in a laboratory and a greenhouse of the Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, in Araguatins, Tocantins state, Brazil (05º44'31"S and 48º19'01"W), in 2016. The diaspores were donated by a specialized company.

The diaspores that were visually damaged by pests and diseases, perforated or broken were excluded. Subsequently, the chosen diaspores were measured using a digital caliper, and those with a diameter of less than 10 mm and greater than 15 mm were excluded.

In order to promote disinfection, after the selection and classification processes, the diaspores were submerged in a 2 % sodium hypochlorite solution, for 4 minutes, followed by washing with distilled water (Dias et al. 2009). After disinfection, the diaspores were submitted to treatments, aiming at overcoming their dormancy. The room temperature was kept constant at 30 ºC and three fans were used to provide air circulation. The room temperature was monitored using an analogue thermometer.

The experimental design was completely randomized, with six treatments and four replications, totaling 24 experimental units. Each experimental unit consisted of 25 seeds. The treatments evaluated were as it follows: control (T1); immersion in water for 12 h and sun exposure for 12 h, a procedure that was repeated three times (T2); mechanical scarification for 5 seconds using an electric emery (T3); oven treatment at 80 ºC for 6 h (T4); test of impact on diaspores at the height of 10 cm (T5); and test of impact on diaspores at the height of 20 cm (T6).

For T2, the diaspores were placed in a cloth bag and kept in a plastic container filled with water, which was replaced every 6 h. During sun exposure, the diaspores were placed in a black plastic bag to intensify heating. For T3, an electric emery was used to remove the mesocarp at the exposure site, damaging the endocarp. Further care was taken not to damage the seeds. For T4, the diaspores were exposed to a temperature of 80 ºC, for 6 h, in a forced-air oven. For T5 and T6, a metal structure containing a base and an iron bar in the vertical position, coupled to a cylindrical structure that allowed the passage of a solid iron bar of 1.1 kg, was used (Figure 1). Such

Photo: Guilherme Octávio de Sousa Soares

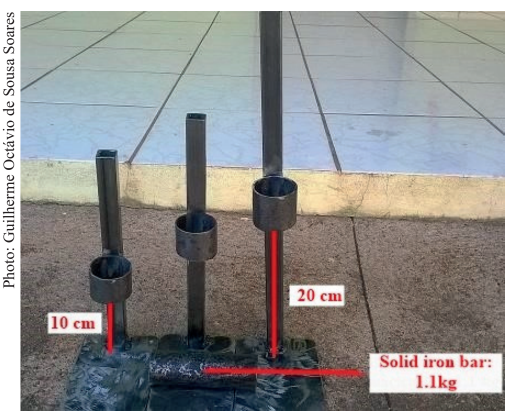

Figure 1. Metal structure used to impact the teak diaspores.

system was used to make that the iron structure could reach the lateral portion of the diaspore, causing an impact on the seed. For T5, the solid iron bar was released at a height of 10 cm from the base, while, for T6, the height was 20 cm.

After the application of pre-germination treatments, the diaspores were seeded at an average depth of 3 cm, in plastic trays with dimensions of 54 cm x 38 cm x 16 cm, containing washed sand. This experiment was carried out at the greenhouse. The volume of water added to the substrate was determined and maintained according to Brasil (2009).

The following parameters were evaluated: emergence percentage at 29 days after sowing, emergence speed index, percentage of normal seedlings, relative emergence frequency, seedling fresh and dry weight and seedling length.

The counts for the emergence percentage at 29 days after sowing was conducted when the cotyledons were stabilized. For the percentage of normal seedlings, seedlings that showed potential to continue their development and give rise to normal plants, without injuries caused by methods of overcoming dormancy, were chosen. The equation suggested by Maguire (1962) was used for the determination of the emergence speed index (ESI): ESI = (E1/N1) + (E2/N2) + ... + (En/Nn), where *E1*, *E2*, *En* are the number of normal emerged seedlings with epicotyl above the substrate computed in *n* counts, and *N1*, *N2*, *Nn* are the number of days after sowing for each count.

For the relative emergence frequency (%), the number of seeds that emerged per day until the last evaluation was counted (Labouriau & Valadares 1976).

After the emergence test, seedlings were removed from the trays and separated according to each treatment, for the evaluation of seedling quality at the laboratory.

The seedling length (cm) was obtained by measuring the seedling shoot with a ruler. For determining the fresh weight (g), whole seedlings (shoot and roots) were weighted in an analytical scale. After weighing, seedlings were placed in a forced-air oven at 80 ºC, for 24 h, for later dry weight (g) determination (Nakagawa 1999).

The data were submitted to analysis of variance and significance was measured by the F test ($p < 0.05$). The Tukey test was used at 5 %.

RESULTS AND DISCUSSION

The analysis of variance results indicated a significant effect ($p < 0.05$) among the dormancy methods for the variables emergence percentage at 29 days after sowing, emergence speed index and seedling dry weight. For the parameters percentage of normal seedlings, seedling fresh weight and seedling length, there was no significance, in terms of the applied treatments.

The treatment in which the diaspores were submitted to the temperature of 80 ºC for 6 h had the highest emergence percentage at 29 days (Table 1). The diaspore immersion in water for 12 h and sun exposure for 12 h was the second method that promoted the highest emergence rate. The other treatments were statistically similar.

A large part of the water content in the fruit endocarp, which is the diaspore layer with greater hardness, could be removed with the heating treatment, which consequently left the structure more fragile, especially in the frontier between the endocarp and the seed hilum, where the process of radicle emission begins.

Table 1. Emergence percentage at 29 days after sowing (E29), emergence speed index (ESI), percentage of normal seedlings (PNS), fresh weight (FW), dry weight (DW) and seedling length (SL) submitted to methods for overcoming dormancy.

Treatment	E29	ESI	PNS	FW	DW	SL
	%		%	g	g	cm
T1	06 c*	0.08 b	100 a	0.2462 a	0.0170 ab	07.577 a
T2	27 b	0.44 a	100 a	0.2852 a	0.0236 a	10.0475 a
T3	14 c	0.19 b	100 a	0.2645 a	0.0191 ab	09.5575 a
T4	44 a	0.63 a	100 a	0.2880 a	0.0231 ab	09.5650 a
T5	12 c	0.16 b	100 a	0.2697 a	0.0227 ab	10.0175 a
T6	06 c	0.08 b	100 a	0.1562 a	0.0112 b	04.7375 a

* Means followed by the same letter in the column do not differ from each other by the Tukey test at 5 %. Treatments: control (T1); immersion in water for 12 h and sun exposure for 12 h, being repeated three times (T2); mechanical scarification for 5 seconds using an electric emery (T3); oven treatment at 80 ºC for 6 h (T4); test of impact on diaspores at the heights of 10 cm (T5) and 20 cm (T6).

Vieira et al. (2009), when evaluating the heating of the diaspores at 80 ºC for 12 h, followed by immersion in water for 6 h, obtained a germination rate of 78 %, which was the best among the evaluated treatments. Ferreira et al. (2016), when also using the same treatment, but without water immersion, found an emergence percentage equivalent to 35 %. These authors attribute the best results to the use of heating, due to the fact that this process makes the diaspore walls less resistant, what favors the water imbibition and seedling emergence.

Pasa & Binsfeld (2012) evaluated the interaction between the heating and scarification factors to overcome dormancy in teak diaspores and found that the use of heating provided the best results in the germination rate of the diaspores, and that the treatments that went through scarification were the ones with the lowest germination rates. These results corroborate those found in the present study.

When evaluating the efficiency of different treatments for overcoming the dormancy of teak diaspores, Rocha et al. (2011) observed that there was a higher percentage of emergence in the seeds treated with sun heating, and also that the treatments that alternated temperatures had a better performance. The beneficial effect of this alternation may be related to both the physiological response of the seeds and the reduction in the mechanical resistance of the mesocarp that covers them.

The immersion of diaspores in water and the subsequent sun exposure may have weakened the endocarp, as well as the oven treatment at 80 ºC for 6 h, with less intensity. This process, together with the immersion of diaspores in water, facilitated the imbibition of the seed, allowing some advantages in the process for overcoming seed dormancy, in relation to the other treatments, being inferior only to the treatment with the exclusive use of the greenhouse.

Regarding the use of mechanical scarification with an electric emery, it was observed that, by damaging the mesocarp and part of the endocarp in only one place, there is no guarantee of a higher water absorption by the seed, because the seeds are inserted into distinct and resistant loci inside the seed, and, as soon as this layer breaks, the seed will not necessarily be more susceptible to water absorption.

Concerning the impact tests on diaspores (heights of 10 cm and 20 cm), there was no increase in the seed germination rate, which was statistically similar to the control treatment. These results corroborate the study conducted by Slator et al. (2013), who evaluated mechanical methods for overcoming dormancy in teak, and concluded that the low germination rate in seeds of this species is not caused by the physical impairment of the tegument.

The treatments that obtained the highest mean values for the emergence speed index were those that used the oven at 80 ºC for 6 h and immersion in water for 12 h and sun exposure for 12 h (0.63 and 0.44, respectively), since they possibly increased the permeability of the diaspore to the entrance of water, allowing the embryo to begin the germination process. The other treatments did not differ statistically, showing that these methods for overcoming dormancy in teak diaspores did not influence the teak emergence speed index.

A higher emergence speed may reflect in higher initial seedling growth rates, as well as higher growth rates during the crop cycle, since the seedlings can go through photosynthetic processes that allow a greater growth, in relation to other seedlings with lower emergence speed index values. This is due to the fact that, when the seed presents a superior emergence speed index, the seedling develops its roots and shoots faster, allowing a greater use of the natural resources and, consequently, a better development of the plant physiological processes (Guedes et al. 2015).

With the emergence speed index determination, the seed vigor and physiological quality can be measured, due to the fact that seeds that emerge with a higher speed are more vigorous (Oliveira et al. 2009, Santos & Paula 2009). None of the treatments damaged or influenced the formation of the seedlings essential structures.

Regarding the seedlings quality, as a function of the different treatments, the results showed a difference between the treatment with immersion in water for 12 h and sun exposure for 12 h, in relation to the impact test at 20 cm, when the variable analyzed was the seedlings dry mass (Table 1). The higher production of matter may be related to the germination rate, since the emergence speed index values of the treatment T2 were superior to the treatment T6, with a longer period of translocation of seed reserves to the newly emerged seedling.

The tested treatments for dormancy breaking of the teak diaspores did not influence the development of seedlings, when the evaluated variables were fresh

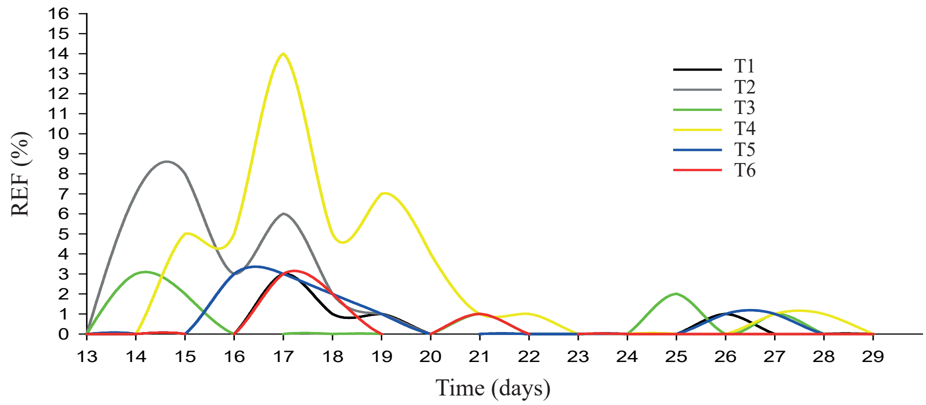

Figure 2. Relative emergence frequency (REF) of teak seedlings, as a function of dormancy overcoming methods. Treatments: control (T1); immersion in water for 12 h and sun exposure for 12 h, being repeated three times (T2); mechanical scarification for 5 seconds, using an electric emery (T3); oven treatment at 80 ºC for 6 h (T4); test of impact on diaspores at the heights of 10 cm (T5) and 20 cm (T6).

weight and length. This result shows that, when any of these methods are applied, plants will have a satisfactory fresh mass production capacity and length, if the embryo has enough energy reserves.

Oliveira et al. (2009) indicate that the most vigorous seeds are those with the highest fresh and dry weight and seedling length. According to the authors, these indexes are taken as indicators of seed vigor, when producing quality seedlings.

In a study on overcoming dormancy of teak diaspores, Ferreira et al. (2016) found better results for dry mass and length of teak seedlings when methods for overcoming dormancy were not used. These authors attribute these results to the larger amount of reserve material present in the seeds of the treatment without any dormancy overcoming method.

For relative emergence frequency (Figure 2), it was observed that the treatments T2 and T4 presented a greater germination uniformity, with a maximum percentage expressed between 14 and 22 days.

The treatment T2 presented its maximum germination potential (27 %) between 14 and 19 days, providing a better uniformity of seedlings, in relation to the other treatments. Dias et al. (2009), when evaluating methods for overcoming the dormancy of teak diaspores, found a greater amount of seedlings emerged between 40 and 50 days for all evaluated treatments. Rocha et al. (2011) observed a higher emergence frequency between 7 and 14 days for all evaluated treatments.

The control (T1) treatment, along with the treatments T5 and T6, in addition to presenting a low emergence rate, showed a lack of uniformity, regarding the relative emergence frequency values. A high fluctuation in the seedling emergence is undesirable, as it would produce non-uniform plants and would harm the plant stand.

By evaluating the influence of the physical impediment on the germination of teak seeds, Slator et al. (2013) observed that seeds which were inside the fruit had an emergence frequency varying from 4 to 16 days, whereas the seed extraction from within the fruit had a relative emergence frequency between 4 and 8 days. These authors attribute the mechanical impediment provided by the fruit as the cause of the emergence distribution of seedlings along the days after sowing.

CONCLUSIONS

1. The use of oven heating at 80 ºC, for 6 h, is the most efficient method to overcome dormancy;
2. The use of impact and mechanical grinding with an electric emery do not influence the dormancy breaking of teak seeds;
3. The methods for overcoming the dormancy of teak diaspores do not influence the seedlings quality.

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