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Scarification and doses of Acadian®, Stimulate® and *Trichoderma* spp. promote dormancy overcoming in *Hymenaea courbaril* L. seeds?

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ABSTRACT: The present study establishes the following research problem: Can different concentrations of Acadian®, Stimulate®, and *Trichoderma* spp. be effective in promoting the emergence and vigor of *Hymenaea courbaril* seedlings with or without mechanical scarification? The experimental design used was completely randomized, in a 4 x 3 x 2 factorial scheme, corresponding to four concentrations (0, 5.0, 10.0, and 15.0 $mL.L^{-1}$), three hormones (Acadian®, Stimulate® and *Trichoderma* spp.), with and without mechanical scarification, with four replicates, each of which consisting of 25 seeds. Acadian® at a concentration of 5.0 $mL.L^{-1}$ in scarified seeds of *H. courbaril* leads to a greater increase in the percentage of emergence and percentage of normal seedlings. Stimulate® at concentrations of 10.0 and 15.0 $mL.L^{-1}$ is efficient in obtaining more than 85% emergence seedlings with seeds subjected to mechanical scarification. *Trichoderma* spp. from 9.0 $mL.L^{-1}$ does not favor gains in the percentage of normal seedlings of *Hymenaea courbaril* grown from seeds with and without mechanical scarification. The dose of maximum technical efficiency (DMTE) of the bioregulator Acadian® is 8.50 $mL.L^{-1}$ and, in scarified seeds of *H. courbaril*, it increases the percentage of seedling emergence.

Index terms: *Ascophyllum nodosum*, bioregulators, mechanical scarification.

RESUMO: O presente estudo estabelece o seguinte problema de pesquisa: Sementes com e sem escarificação mecânica sob diferentes concentrações de Acadian®, Stimulate® e *Trichoderma* ssp. podem ser eficazes na promoção de emergência e vigor de plântulas de *Hymenaea courbaril*? O delineamento experimental utilizado foi o inteiramente casualizado, em esquema fatorial 4 x 3 x 2, sendo as concentrações (0; 5,0; 10,0; e 15,0 $mL.L^{-1}$), três hormônios (Acadian®, Stimulate® e *Trichoderma* ssp.) e com e sem escarificação mecânica, com quatro repetições, sendo cada uma delas composta de 25 sementes. O Acadian® na concentração de 5,0 $mL.L^{-1}$ em sementes escarificadas de *H. courbaril*, exibe maior incremento no percentual de emergência e bem como na porcentagem de plântulas normais. O Stimulate® nas concentrações de 10,0 e 15,0 $mL.L^{-1}$ é eficiente na obtenção de valores acima de 85% de emergência de plântulas com sementes submetidas a escarificação mecânica. *Trichoderma* spp. a partir de 9,0 $mL.L^{-1}$ não favorece ganhos no percentual de plântulas normais de *H. courbaril* em sementes com e sem escarificação mecânica. A dose de máxima eficiência técnica (DMTE) do biorregulador Acadian® é de 8,50 $mL.L^{-1}$ em sementes escarificadas de jatobá aumenta o percentual de emergência de plântulas.

Termos para indexação: *Ascophyllum nodosum,* biorreguladores*,* escarificação mecânica.

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INTRODUCTION

Hymenaea courbaril L. belongs to the Fabaceae family and Caesalpinioideae subfamily, is a native forest species, semi-deciduous, belonging to the group of late secondary or climax species, and is used in popular medicine, civil construction, composition of heterogenous plantations and afforestation of parks and gardens (Costa et al., 2018). In addition to the common name already mentioned, depending on the region in Brazil it is called *jataí, jataí amarelo, jataí peba, jataí vermelho, jitaí, farinheira, jataíba, burandã, imbiuva, jatobá miúdo* and *jatobá da caatinga* (Paixão et al., 2019).

According to Ristau et al. (2018), the fruit is composed of seeds (25 to 40% of weight), pod (50 to 70%), and pulp (5 to 10%). The protein value of jatobá fruit flour is similar to that of cornmeal and higher than that of cassava flour (Menezes-Filho et al., 2019). It is worth highlighting that 100 grams of the fruit provides 115 calories, 29.4 grams of glucose, and 33 milligrams of vitamin C (Ramos et al., 2018; Silva et al., 2019), and the vitamin C concentration in *H. courbaril* fruit flour is similar to that of orange and 9 times higher than that of açaí pulp.

In addition to the medicinal relevance, it also has forest and environmental importance due to its potential as a carbon-fixing and -storing plant (Costa et al., 2018). However, *H. courbaril* remains with no protection and the trees are threatened by predatory logging in most of the Amazon.

Besides affecting the long-term supply of wood, the destruction of *H. courbaril* trees can also reduce the supply of its important products. In the state of Roraima, the *H. courbaril* tree blooms between March and May and its fruiting occurs between August and October (Shanly and Medina, 2005).

H. courbaril seeds are ovoid, with dark red color, glabrous, with an average fresh seed mass of 3.53 grams (Almeida et al., 2011). *H. courbaril* seeds, when ripe, exhibit dormancy due to impermeability to water of the seed coat, so treatment is necessary to overcome dormancy, and a mechanical scarification is a form that allows increments in the percentage of seedling emergence (Duarte et al., 2016).

Within these perspectives, mechanical scarification methods and bioregulators function as activators of metabolism and reactivate physiological processes in the different phases of germination, so they have been used as pre-germination treatments to optimize the germination of dormant seeds (Junges et al., 2016; Costa et al., 2018).

Acadian® based on pure extracts of *Ascophyllum nodosum* seaweed stimulates radicle emergence, elongation, and growth of the piliferous region of the root system, resulting in better seedling establishment and water/nutrient absorption (Neumam et al., 2017).

Another bioregulator used is Stimulate®, whose function is to establish hormonal balance, differentiation, cell elongation, and promote germination of seeds and better growth of the root system, promoting a greater capacity to absorb nutrients and water by the roots of higher plants (Rós et al., 2014; Smiderle and Souza, 2021).

Trichoderma spp. can generate benefits in the processes of germination as well as in the initial growth of seedlings of forest species through the treatment of seeds and application in soil (Costa et al., 2018; Junges et al., 2016). In addition, Junges et al. (2016) reported positive results in the gain of the percentage of emergence of *Peltophorum dubium (Fabaceae)* seedlings promoted by *Trichoderma* spp., pointing to its potential to be used in the treatment of *orthodox* seeds.

In view of the above, the present study establishes the following research problem: Can different concentrations of Acadian®, Stimulate®, and *Trichoderma* spp. be effective in promoting the emergence and vigor of *H. courbaril* seedlings with or without mechanical scarification?

MATERIAL AND METHODS

The study was conducted in the Seed Analysis Laboratory (LAS) and the seedling nursery of the forestry sector of Embrapa Roraima from May to October 2020. The species used in the present study was *H. courbaril*. Its fruits were hand-collected from trees present in an area of Submontane Dense Ombrophilous Forest with emerging canopy, located at the geographic coordinates 1°38’29” North latitude and 60°58’11” West longitude, in the municipality of Boa Vista (RR), Brazil, in April 2020.

The climate of the municipality of Boa Vista - RR is Am (tropical monsoon climate), with average temperatures of 27.2 °C in the hottest month and 23.3 °C in the coldest month, with an annual average of 25.4 °C. The average annual rainfall is 1808 mm, with mean values of 365 mm and 26 mm for the months of highest (June) and lowest (February) precipitation, respectively.

The collected ripe fruits were selected by removing from the lot those with mechanical injury and deteriorated, to obtain a uniform sample. Subsequently, they were properly cleaned, pulped and the seeds were washed in running water. For the biometric characterization of the seeds, they were measured in the middle region, using a digital caliper with an accuracy of 0.01. For the studies of pre-germination treatments, *H. courbaril* seeds were subjected to the mechanical scarification treatment, with sandpaper nº 100, by manually frictioning them until the rupture of the seed coat and appearance of the cotyledonary tissues on the opposite side of the hilum/embryonic axis. The concentrations of Acadian®, Stimulate®, and *Trichoderma* spp. used were: 0.0, 5.0, 10.0, 15.0 $mL.L^{-1}$ for each 0.5 kg of seeds, applied as pre-germination treatment by soaking the seeds for 30 minutes. Seeds that did not receive bioregulators served as a control. Seed treatment was carried out according to the methodology recommended by Nunes (2005), in which the different concentrations of the bioregulators were applied directly to the bottom of a transparent plastic bag for each treatment, and then the seeds were placed inside the plastic bag and shaken manually for 30 minutes so that the hormone reached all seeds.

The experimental design used was completely randomized, in a 4 x 3 x 2 factorial scheme, corresponding to four concentrations (0, 5.0, 10.0 and 15.0 $mL.L^{-1}$), three hormones (Stimulate®, Acadian® and *Trichoderma* spp.) with and without mechanical scarification of seeds, with four replicates, each of which consisting of 25 seeds.

In order to complement and elucidate the results of the present study, the seeds were sown in sand of medium particle size at 1.0 cm depth in 30 cm x 40 cm x 10 cm plastic trays in a greenhouse with an average temperature of 27 ± 5 °C and relative humidity of 60% to 70% in the experimental period. The variables evaluated were: emergence speed (ES, index) (Maguire, 1962) and seedling emergence (E, %), obtained by daily counts until the stabilization of the counts of all treatments. During the initial vigor stages of the seedlings, substrate moisture content was maintained by manual irrigation, in a total of four daily irrigations. Seedling emergence started nine days after sowing (DAS).

Results of vigor were expressed as a percentage of normal seedlings, counted during the evaluations. A normally emerged seedling was the one which, after breaking the surface of the substrate, showed well-differentiated and developed plumule, cotyledons, and hypocotyl.

To verify the assumptions of the analysis of variance (ANOVA), the data were first assessed for: a) normality with Shapiro-Wilk test ($p<0.01$) and b) homoscedasticity by Bartlett test ($p<0.01$). When there was the normality of residuals and homogeneity of variances, the data were subjected to ANOVA, followed by Tukey test ($p<0.01$) to compare the means. Quantitative variables were subjected to regression analysis to verify the response of seed vigor as a function of the concentrations. Data analysis was performed in the statistical program Sisvar (Ferreira, 2014).

RESULTS AND DISCUSSION

For the biometric characterization of the seeds, their mean values were 26.38 (length (mm)), 20.57 (width (mm)), and 12.37 (thickness (mm)) and individual fresh mass of *H. courbaril* seeds (mean value of 5.70 g). Similar values were described by Andrade et al. (2010) and Duarte et al. (2016) for *Hymenaea courbaril*, by Botelho et al. (2000) for *Hymenaea stigonocarpa* Mart.ex Hayne and Cruz et al. (2001) for *Hymenaea intermedia*.

According to the analysis of variance, there was no significant interaction between the factors: bioregulator (B), Scarification (S), and Concentrations (C), for the variables seedling emergence (%E), emergence speed (ES, index), and normal seedling (NS) (Table 1); therefore, the effect of each factor was evaluated separately. In addition, it showed a significant effect of factors (B), (S) and (C), isolated, for the variables seedling emergence (%E), emergence speed (ES, index) and normal seedling (NS) of *H. courbaril.*

H. courbaril seeds showed higher results for seedling emergence percentage, in the presence of mechanical scarification at concentration of 0.0 mL.L^{-1}, i.e., control (Table 1), compared to non-scarified seeds (control), suggesting that scarification with sandpaper nº 100 on the opposite side of the hilum/embryonic axis is adequate for overcoming seed dormancy and inducing emergence.

These results corroborate those reported by Costa et al. (2017) for *H. courbaril* in a study on the effect of scarification with sandpaper nº 100 on the opposite side of the hilum/embryonic axis, as these authors also verified that, under such conditions, it was possible to obtain superiority and uniformity in the emergence of seedlings of this species.

In general, in the present study, the emergence of seedlings, with seeds of *H. courbaril* without mechanical scarification, obtained mean values of 48.5%, results considered unsatisfactory according to Brasil (2009). Ribeiro et al. (2021), evaluating different methods of scarification in seeds of this same species, recorded zero seedling emergence in seeds without scarification (control). These results make it possible to indicate with reliability the use of the pre-germination treatment of mechanical scarification to overcome the physical dormancy of *H. courbaril* seeds.

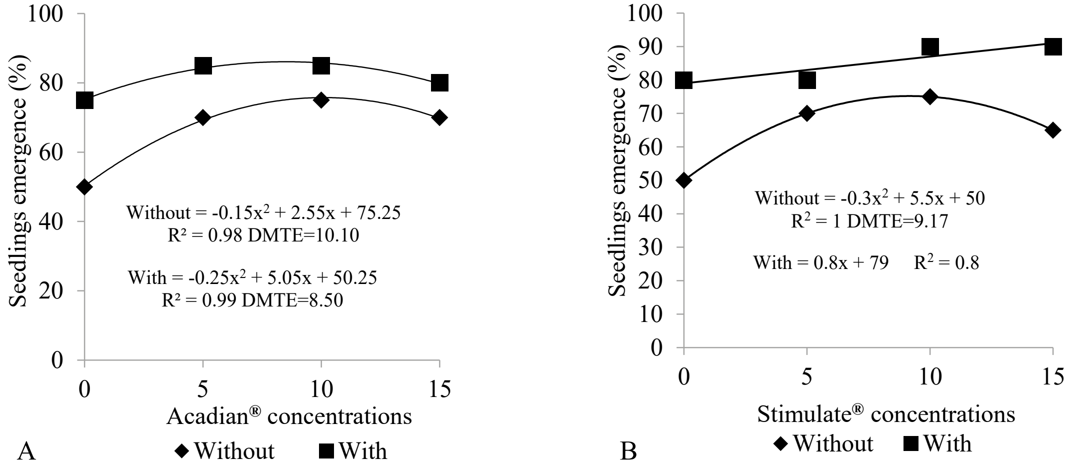
Figure 1 (A) showed that the percentage of emergence of *H. courbaril* seedlings in relation to the concentrations attributed to the bioregulator Acadian® showed that the concentrations of 5.0 and 10.0 mL.L^{-1} with mechanical scarification resulted in a 12% increase in seedling emergence when compared with seeds that did not receive the bioregulator (Figure 1 A). In turn, seeds without mechanical scarification and Acadian® concentrations showed a decrease of 34% in emergence compared to those with scarification and in the absence of Acadian® concentrations for the same variable (Figure 1 A). In addition, there was a 33% superiority in the emergence of *H. courbaril* seedlings without mechanical scarification of seeds at the concentration 10 mL.L^{-1} of Acadian®, which led to similar performance to the results obtained with seeds scarified at zero concentration, that is, in the absence of the bioregulator Acadian® (Figure 1 B).

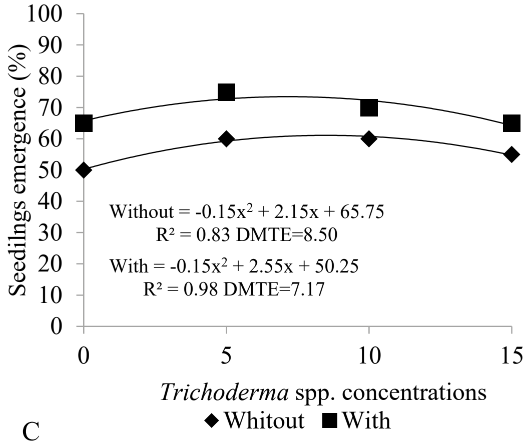
In addition, for the emergence of *H. courbaril* seedlings the estimated dose of maximum technical efficiency (DMTE) of Acadian® for seeds with scarification was 8.50 mL.L^{-1}, corresponding to 86.09% seedling emergence (Figure 1), whereas for seeds without scarification the DMTE was 10.10 mL.L^{-1} of Acadian®, which resulted in 75.21% seedling emergence (Figure 1).

Table 1. Summary of the analysis of variance for seedling emergence (%E), emergence speed (ES, index) and normal seedling (NS) of *H. courbaril* as a function of the bioregulator (B), concentrations (0, 5, 10 and 15 mL.L^{-1}) and physical scarification (with and without), as well as their interactions.

Sources of variation	DF	Mean square		
		E (%)	ES (index)	NS(%)
Bioregulator (B)	2	1895.833**	26.840**	1817.708**
Scarification (S)	1	7520.833**	83.633**	3796.875**
Concentration (C)	3	1145.833**	13.223**	1449.652**
B x S	2	145.833ns	2.577ns	109.375ns
B x C	6	104.167ns	2.007ns	262.152ns
S x C	3	201.389ns	0.622ns	88.541ns
B x S x C	6	76.389ns	0.467ns	67.708ns
Residual	96	160.417	1.0213	219.791
Mean		70.416	4.8467	63.958
CV (%)		17.99	20.85	20.18

**Significant and ns not significant at 1% probability level ($p<0.01$) by the F test. DF: degrees of freedom. CV: Coefficient of variation.





D

	Seedlings Emergence (%)			
	Concentrations			
	0	5	10	15
Bioregulators	With mechanical scarification			
Acadian®	a	a	ab	ab
Stimulate®	a	a	a	a
Trichoderma	a	b	b	b
	Without mechanical scarification			
Acadian®	a	a	a	a
Stimulate®	a	a	a	a
Trichoderma	a	b	b	b

**Significant at 1% probability level (p<0.01)

Figure 1. Mean values of seedlings emergence obtained using three bioregulators Acadian® (A), Stimulate® (B) *Trichoderma* spp. (C) at four concentrations 0, 5.0, 10.0 and 15.0 mL.L^{-1} respectively, and as well as a table (D) with Tukey test results in *H. courbaril* seeds without and with mechanical scarification.

In turn, Stimulate® led to seedling emergence of approximately 90% at concentration of 10.0 mL.L^{-1}, which was also found with 15.0 mL.L^{-1} of the bioregulator (Figure 1 B). However, for the emergence of seedlings with the bioregulator Stimulate®, the estimated DMTE was 9.17 mL.L^{-1} for seeds without mechanical scarification, which led to emergence percentage of 75.21% (Figure 1B).

It is suggested that this interaction between hormone and Stimulate® concentrations can enhance the maintenance of physiological processes that culminate with cytokinin activity and influences cell elasticity and plasticity (growth), promoting different responses in the vigor of *H. courbaril* seedlings (Kolachevskaya et al., 2017).

In addition, the emergence of seedlings with mechanical scarification of seeds without Stimulate®, compared with non-scarified seeds, was 30% lower, a result that confirms the inhibitory action of the seed coat on this variable (Figure 1 B).

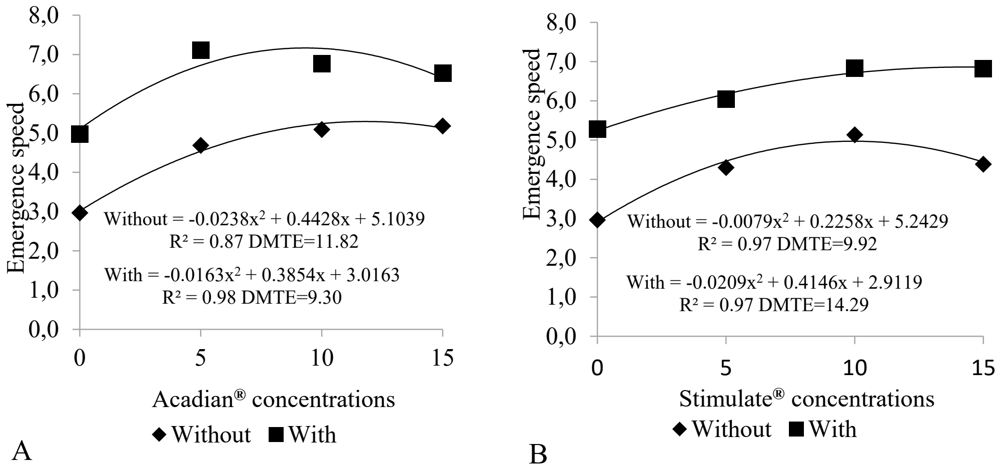
The results of the present study reinforce the importance of knowing the emergence potential of *H. courbaril* seedlings native to the northern region of Brazil, for commercial use by producers and nursery managers in the state of Roraima.

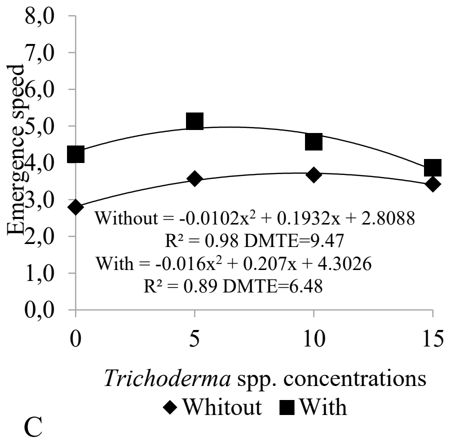
Although the concentration of 5.0 mL.L^{-1} of *Trichoderma* spp. applied to *H. courbaril* seeds with mechanical scarification resulted in the maximum percentage of emergence (75%), with DMTE of 7.17 mL.L^{-1} promoting 76.45%, for the Stimulate® hormone the maximum percentage of emergence (90%) was obtained at a concentration of 10.0 mL.L^{-1} in seeds with mechanical scarification. Furthermore, the concentrations of 5.0 and 10.0 mL.L^{-1} of the bioregulator obtained from algae extracts (Acadian®) applied in *H. courbaril* seeds with mechanical scarification resulted in 85% seedling emergence (Figure 1 A). These results make it possible to indicate with greater reliability that it is feasible to perform pre-germination treatment using mechanical scarification in *H. courbaril* seeds and the aforementioned concentrations of plant bioregulators (Acadian®, Stimulate® and *Trichoderma* spp.) to overcome seed dormancy, aiming at large-scale production of seedlings.

When comparing the emergence speed of *H. courbaril* seedlings with and without mechanical scarification of seeds between the concentrations of the three plant bioregulators tested, it was found that *H. courbaril* seeds with mechanical scarification led to higher ES (index) at all concentrations of bioregulators tested compared to the control, except for the concentration of 15.0 mL.L^{-1} of *Trichoderma* spp., as shown in Figures 2 A, B, C.

In turn, the DMTE for emergence speed of *H. courbaril* seedlings with mechanical scarification (Figure 2 A) was obtained with the concentration of 14.29 mL.L^{-1} of the hormone Stimulate® with 6.86 ES (index). There was also superiority in emergence speed with seeds subjected to mechanical scarification and treated with the hormone Acadian® at a DMTE of 9.30 mL.L^{-1} with 7.16 ES (index), which led to values close to the results obtained with Stimulate® at a concentration of 14.29 mL.L^{-1} in scarified seeds (Figures 2 A, B).

The results of the present study showed that appropriate concentrations of Stimulate®, Acadian®, and *Trichoderma* spp. positively influenced the emergence of *H. courbaril* seedlings, except for the concentration of 15.0 mL.L^{-1} of *Trichoderma* spp., which may have been excessive, even causing inhibition. According to Souza et al. (2017), a faster





Emergence Speed				
	Concentrations			
	0	5	10	15
Bioregulators	With mechanical scarification			
Acadian®	a	a	a	a
Stimulate®	a	ab	a	a
Trichoderma	a	b	b	b
	Without mechanical scarification			
Acadian®	a	a	a	a
Stimulate®	a	a	a	a
Trichoderma	a	b	b	b

**Significant at 1% probability level (p<0.01)

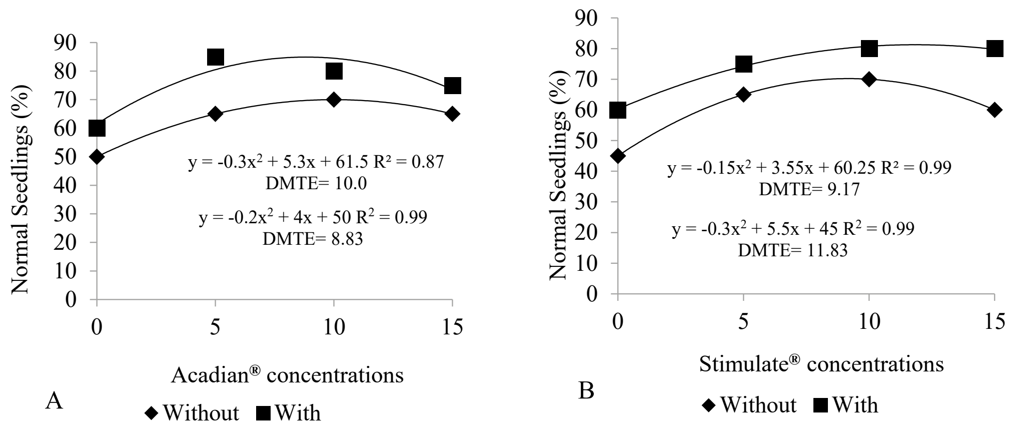
D

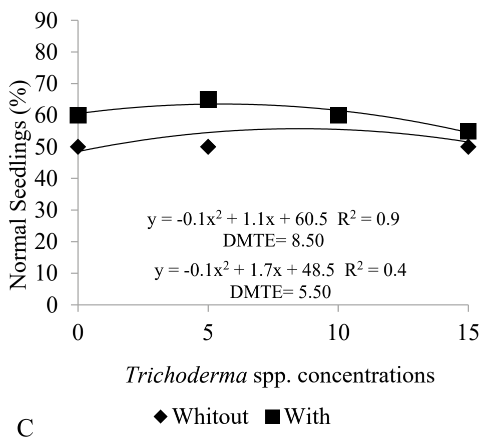
Figure 2. Mean values for seedling emergence speed obtained with treatment using three bioregulators Acadian® (A), Stimulate® (B) *Trichoderma* spp. (C) at four concentrations 0, 5.0, 10.0 and 15.0 mL.L^{-1} respectively, and as well as a table (D) with Tukey test results in *H. courbaril* seeds without and with mechanical scarification.

germination (higher ES [index]) stay for lower time subject to adverse conditions found in the soil, such as temperature variation, water stress, and attack of pests and pathogens. In this case, the use of plant bioregulators was favorable to the emergence speed of *H. courbaril* seedlings, being indicated under the conditions of the present study.

The results obtained in this study reinforced those reported by Carvalho et al. (2018), who found that the ideal concentration of Stimulate® optimized the percentage of emergence in *Acacia mangium* (Fabaceae), which has orthodox seeds. Oliveira et al. (2020) verified that *H. courbaril* seeds without mechanical scarification and treated with Stimulate® at concentrations of 20 and 30 mL.L^{-1} had values lower than 24% in the percentage of emergence, and these concentrations of Stimulate® contributed decisively to the inhibitory or reductional effect on this variable. According to Singh et al. (2019), inadequate concentrations of plant bioregulators can lead to deterioration due to phytosanitary, physiological, biochemical, and cytological alterations in the seeds, culminating in low emergence or even embryo death.

In mechanical scarification with the presence of the bioregulator Acadian® at a concentration of 5.0 mL.L^{-1}, on average the emergence speed (index) was 27 percentage points higher when compared with *Trichoderma* spp. at a concentration of 5.0 mL.L^{-1}, while the highest value of emergence speed (6.84) for Stimulate® was found at a concentration of 10.0 mL.L^{-1} with mechanical scarification (Figures 2 A, B, C). Thus, it demonstrates that the mechanical scarification of *H. courbaril* seeds concomitantly with hormone and the above-mentioned concentrations allow *H. courbaril* seeds to express maximum vigor and establish vigorous seedlings (Figures 3 A, B, C).





Normal Seedlings				
	Concentrations			
	0	5	10	15
Bioregulators	With mechanical scarification			
Acadian®	a	a	a	a
Stimulate®	a	a	a	a
Trichoderma	a	b	b	b
	Without mechanical scarification			
Acadian®	a	a	a	a
Stimulate®	a	a	a	a
Trichoderma	a	b	b	b

**Significant at 1% probability level (p<0.01)

D

Figure 3. Mean values of the percentage of normal seedlings obtained with the treatment using three bioregulators Acadian® (A), Stimulate® (B) *Trichoderma* spp (C) at four concentrations 0, 5.0, 10.0 and 15.0 mL.L^{-1} respectively, and as well as a table (D) with Tukey test results in *H. courbaril* seeds without and with mechanical scarification.

In addition, the highest percentage of normal seedlings (85%) was found with DMTE of 8.83 $mL.L^{-1}$ of Acadian® in scarified seeds, while for non-scarified seeds the DMTE of Acadian® was 10.0 $mL.L^{-1}$ and it led to a value of 70%, that is, there was a 17.65 percentage points increase to obtain normal *H. courbaril* seedlings.

On the other hand, for *H. courbaril* seeds without mechanical scarification and without the addition of Acadian®, the percentage of normal seedlings was equal to 50% (Figure 3 A), suggesting once again the need for mechanical scarification for the continuity of the germination process by the embryo. The results described in the present study as well as in the national and international literature show that the physical dormancy of *H. courbaril* seeds is always present (Pierezan et al., 2012; Soares et al., 2017; Costa et al., 2019; Dourado et al., 2020) and needs to be overcome with mechanical scarification and as well as adequate concentrations of hormones based on cytokinin, indole butyric acid and gibberellic acid applied in the seeds.

Additionally, the presence of the lignified coat in the seeds may limit the vigor of *H. courbaril* seedlings, resulting in an uneven stand of seedlings, confirmed by the works of Dourado et al. (2020) and Costa et al. (2019) and also demonstrated with the data of the present study.

An increase in the percentage of normal seedlings according to the increase in the DMTE of 11.83 $mL.L^{-1}$ with 84.91% of Stimulate® was found in scarified seeds (Figure 3 B), indicating that the input of Stimulate® solution was sufficient to promote effective changes in hormonal balance.

On the other hand, it was verified that seeds without mechanical scarification at the concentration of 10.0 $mL.L^{-1}$ of Stimulate® led to 70% of normal seedlings, while the concentration of 5.0 $mL.L^{-1}$ of Stimulate® resulted in 65% of normal seedlings and the concentration of 15.0 $mL.L^{-1}$ of Stimulate® promoted 60% of normal seedlings.

On the other hand, seeds without mechanical scarification and without the addition of Stimulate® (Figure 3 B) led to the lowest percentage of normal seedlings (45%) compared to the Stimulate® concentrations mentioned above.

These results show that the rigid coat, involving the seeds of the species under study, does not totally restrict the entry of water and hormones to overcome dormancy, but probably the differentiated concentrations of Stimulate® were sufficient to promote significant changes in the hormonal balance that controls the physiological dormancy process, making the metabolism of seeds more active and the embryo fit for resuming the development and consequently promoting more gain of normal *H. courbaril* seedlings.

According to Zerlin et al. (2016), gibberellin at concentrations suitable for each species, when applied exogenously, can double the synthesis of proteins in seeds, which favors germination. However, the promotion of gains in seedling vigor for all studied variables was verified in the present study for *H. courbaril* seeds.

Souza et al. (2016) reported that, during the period of stratification of *Prunus persica* seeds at 7 °C, there was an increase in the production of normal seedlings due to the adequate concentration of growth-promoting substances, such as gibberellins and indoleacetic acid, as well as the reduction of abscisic acid, a germination-inhibiting substance. According to Menegatti et al. (2019), a fully developed embryo requires specific and adequate conditions to promote complete development and ensure the establishment of a new seedling.

Figure 3 C shows that seeds with mechanical scarification and inoculated with *Trichoderma* spp. at the DMTE of 5.50 $mL.L^{-1}$ led to 65.0% of normal seedlings, compared with the other concentrations. According to Normative Instruction 45 (IN 45), which regulates the production of seeds from commercial crops in Brazil, the minimum germination acceptable for commercialization is 80%.

Therefore, considering the recommended standard and according to the results obtained, it is possible to infer that seeds with and without scarification and concentrations of *Trichoderma* spp. did not reach the minimum value of emergence stipulated by the legislation, generally showing 50 to 65% of normal seedlings.

The results of the present study reinforce the importance of knowing the performance of *H. courbaril* seeds from Roraima state and combinations of bioregulator concentrations regarding seedling vigor, which can provide information for the selection of plant material suitable for commercial use by producers and nursery managers in the microregion of Boa Vista-Roraima.

A higher percentage of vigorous seedlings with adequate commercial characteristics is one of the primary factors for the success of the species, resulting in the economic return of the capital invested by producers and nursery managers.

It is known that a longer time of permanence of the seedlings in the nursery and the use of a greater number of seeds to compensate for the loss of viability and vigor generate a high cost of production. In addition, physical scarification on the opposite side of the hilum/embryonic axis of *H. courbaril* seeds requires labor and extra cost for the nursery manager.

However, this management is justified as it compensates for the loss in viability and vigor of seedlings. In addition, the physical scarification and treatments in seeds with the dose of maximum technical efficiency using plant bioregulators recommended in the present study for *H. courbaril* promote gains in the percentage of emergence, homogeneity and vigor of seedlings and, ultimately, reduction of costs and in the period to obtain commercial seedlings.

CONCLUSIONS

Acadian® at a concentration of 5.0 $mL.L^{-1}$ in scarified seeds of *H. courbaril* leads to a greater increase in the percentage of seedling emergence and the percentage of normal seedlings.

The dose of maximum technical efficiency (DMTE) of the bioregulator Acadian® is 8.50 $mL.L^{-1}$ and, in scarified seeds of *H. courbaril*, it increases the percentage of seedling emergence.

The dose of maximum technical efficiency (DMTE) of Stimulate® is 9.17 $mL.L^{-1}$ to obtain a high percentage of emergence of *H. courbaril* seedlings with seeds subjected to mechanical scarification.

Trichoderma spp. from 9.0 $mL.L^{-1}$ does not favor gains in the percentage of normal seedlings of *H. courbaril* grown from seeds with and without mechanical scarification.

Mechanical scarification of *H. courbaril* seeds with addition of treatments using plant bioregulators enables the efficient overcoming of physical and physiological dormancy, making it possible to optimize the rate of seedling emergence for large-scale production of uniform seedlings.

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