REVISTA CONTRIBUCIONES A LAS CIENCIAS SOCIALES

Bioregulators promote emergence of african mahogany seedlings?

Biorreguladores promovem emergência de plântulas de mogno africano?

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ABSTRACT
Using bioregulators has proven to be effective for the vigor of seedlings of several forest species, besides reducing the unevenness of emergence and development. In view of the above, the present study establishes the following research problem: can Acadian® and Stimulate® applied to African mahogany seeds at different doses be effective in promoting emergence and vigor of seedlings? The experimental design used was completely randomized, in a 2 x 5 factorial scheme, corresponding to two hormones (Stimulate® and Acadian®) and five doses (0.0; 0.05, 0.1; 0.2 and 0.4 ml L^{-1}), with four replicates, each with 25 seeds. Acadian® at the dose of maximum technical efficiency of 0.17 ml L^{-1} is efficient in reducing emergence time and increasing the percentage of seedlings with two expanded leaves, promoting better uniformity of seedlings and higher yield in the use of African mahogany propagating material. Stimulate® does not promote gains in the percentage of emergence and inhibits the vigor of African mahogany seedlings.

Keywords: *Khaya ivorensis*, forest seeds, *Ascophyllum nodosum*, Stimulate®.

RESUMO
O uso de biorreguladores tem mostrado eficaz no vigor de plântulas de diversas espécies florestais, além de reduzir a desuniformidade de emergência e desenvolvimento. Diante do exposto, o presente estudo estabelece o seguinte problema de pesquisa: Acadian® e Stimulate® em diferentes doses aplicados em sementes de mogno africano podem ser eficazes na promoção

de emergência e vigor de plântulas? O delineamento experimental utilizado foi o inteiramente casualizado, em esquema fatorial 2 x 5, sendo dois hormônios (Stimulate® e Acadian®) e cinco doses (0, 0,05; 0,1, 0,2, e 0,4 ml L^{-1}), com quatro repetições, sendo cada uma delas composta de 25 sementes. O Acadian® na dose de máxima eficiência técnica 0,17 ml L^{-1} é eficiente na redução do tempo de emergência e aumento de plântulas com duas folhas expandidas promovendo melhor uniformização de plântulas e maior rendimento no uso do material propagativo do mogno africano. O Stimulate® não promove ganhos no percentual de emergência e inibe o vigor de plântulas de mogno africano.

Palavras-chave: *Khaya ivorensis*, sementes florestais, *Ascophyllum nodosum*, Stimulate®.

1 INTRODUCTION

African mahogany (*Khaya ivorensis*) belongs to the Meliaceae family and is native to different African countries (SILVA et al., 2020). It was introduced in Brazil in the 1970s, with the aim of replacing Brazilian mahogany (*Swietenia macrophylla*), which is intensely exploited by the timber sector and currently under the threat of extinction (SOUZA et al., 2020a). Currently, African mahogany can be considered a good long-term investment; its noble wood is highly appreciated in the European and North American markets (SOUZA et al., 2020b), with a value quoted in dollars, and the price of the cubic meter of its wood is 84% higher than that of eucalyptus lumber (ITTO, 2021). With the increase in the demand for viable and vigorous seeds to meet conservation programs and the production of seedlings for environmental reforestation (BAKHTAVAR; AFZAL; BASRA, 2019), considering that *Khaya ivorensis* is propagated preferably through seeds (SILVA et al., 2020), there has been the need for methodologies that promote greater seedling emergence, being fundamental to obtain a uniform stand as well as enabling direct seeding in the field (BAKHTAVAR; AFZAL; BASRA, 2019).

Within these perspectives, plant bioregulators have been used as pre-germination treatments of forest seeds to optimize and promote maximum emergence and vigor of seedlings in shorter time of permanence in the nursery and/or direct seeding in the field. According to Smiderle and Souza (2022), seaweed-based bioregulators function as activators of metabolism and reactivate the physiological processes of seeds in the different stages of germination.

Currently, the agricultural market has several products based on plant bioregulators, such as Acadian® (*Ascophyllum nodosum*), which is based on seaweed. According to Smiderle and Souza (2022), at the ideal dose it promotes maximum emergence and vigor of seedlings as well

as rapid initial growth and efficient photosynthetic apparatus in *Hymenaea courbaril* seedlings (SMIDERLE et al., 2022).

Another bioregulator used is Stimulate®, whose function is to establish hormonal balance, differentiation and cell elongation, besides promoting germination of forest seeds (SMIDERLE; SOUZA, 2022) and better growth of the root system, promoting greater capacity for absorption of nutrients and water by the roots of forest seedlings (SMIDERLE et al., 2022).

For Smiderle and Souza (2022), seaweed-based bioregulators and Stimulate®, when applied at ideal concentrations in forest seeds, promote, inhibit or modify their physiological processes. In view of the above, the present study establishes the following research problem: can Acadian® and Stimulate® applied to African mahogany seeds at different doses be effective in promoting emergence and vigor of seedlings?

2 MATERIAL AND METHODS

The present study was conducted at the Seed Analysis Laboratory (LAS) and greenhouse of Embrapa Roraima from October to November 2022. The species used in the present study was *Khaya ivorensis*. The seeds were manually collected from trees in an area of Submontane Dense Ombrophilous Forest with an emerging canopy, located at the geographic coordinates 02°15'00" North latitude and 60°39'54" West Longitude, in the municipality of Cantá, RR, Brazil, in October 2022.

For the biometric characterization of the seeds, their length (mm) and width (mm) were measured using a digital caliper with 0.01 mm accuracy, in the middle part, and the average values recorded were 4.08 mm and 2.57 mm, respectively. In addition, the individual fresh mass of African mahogany seeds was obtained (average value of 0.37 g) using a precision scale (0.001 g).

Initially, African Mahogany seeds were subjected to the determination of water content by the oven method at 105 ± 3 °C/24 h, as described in the Rules for Seed Analysis - RAS (BRASIL, 2013), and then the pre-germination treatments described below were performed.

For studying the pre-germination treatments, *Khaya ivorensis* seeds were subjected to doses of Acadian® and Stimulate®: 0, 0.05, 0.1, 0.2, and 0.4 ml L^{-1} for every 10.0 g of seeds, applied as pre-germination treatment, in which the seeds were soaked for 30 minutes. It is worth mentioning that seeds which did not receive bioregulators served as a control. The seed treatment

was performed according to the methodology recommended by Smiderle and Souza (2022), as follows: the different doses 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 to distribute the hormone homogeneously.

The experimental design used was completely randomized, in a 2 x 5 factorial scheme, corresponding to two hormones (Stimulate® and Acadian®) and five doses, with four replicates, each with 25 seeds.

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

Vigor results were expressed as percentage of normal seedlings, counted in each count. Emerged seedling was considered to be the one with a plumule longer than three centimeters, after breaking the substrate surface. The doses of maximum technical efficiency were obtained by deriving and equaling to zero the average quadratic production functions that best fitted the data (equation 1 and 2) (TIESDALE; NELSON; BEATON, 1993).

$$y = cx^2 + bx + a \quad \textbf{(1)}$$

$$\frac{dy}{dx} = 2cx+b=0 \quad \textbf{(2)}$$

To check the assumptions of the analysis of variance (ANOVA), the data were first analyzed for: a) normality with the Shapiro-Wilk test ($p > 0.01$), b) homoscedasticity with the Bartlett test ($p > 0.01$). When there was normality of the residuals and homogeneity of the variances, the data were subjected to analysis of variance (ANOVA), followed by Tukey test ($p<0.01$) to compare the means. Quantitative variables were subjected to regression analysis in

order to assess the response of seed vigor as a function of the applied doses of hormones. Data analysis was performed in the statistical program Sisvar (FERREIRA, 2014).

3 RESULTS AND DISCUSSION

The average water content in African mahogany seeds, when treated, was 6.8%. Seed water content directly influences various aspects of physiological quality, so determination is critical in official seed lot quality tests (Silva *et al*., 2020). In the present study, the water content was low, which is favorable for orthodox seeds such as those of African mahogany, since a high water content can affect the quality of forest seeds not only in the storage period, but also during processing operations, and hinder management, according to Souza; Smiderle; Pedrozo, (2019).

According to the analysis of variance, there was significant interaction between the factors Hormone (H) and doses (D) for the variables seedling emergence (E, %), emergence speed (ES, index), mean time to obtain 50% emergence (MT, days), normal seedlings (NS, %), seedlings with two leaves (S2L, %) (Table 1).

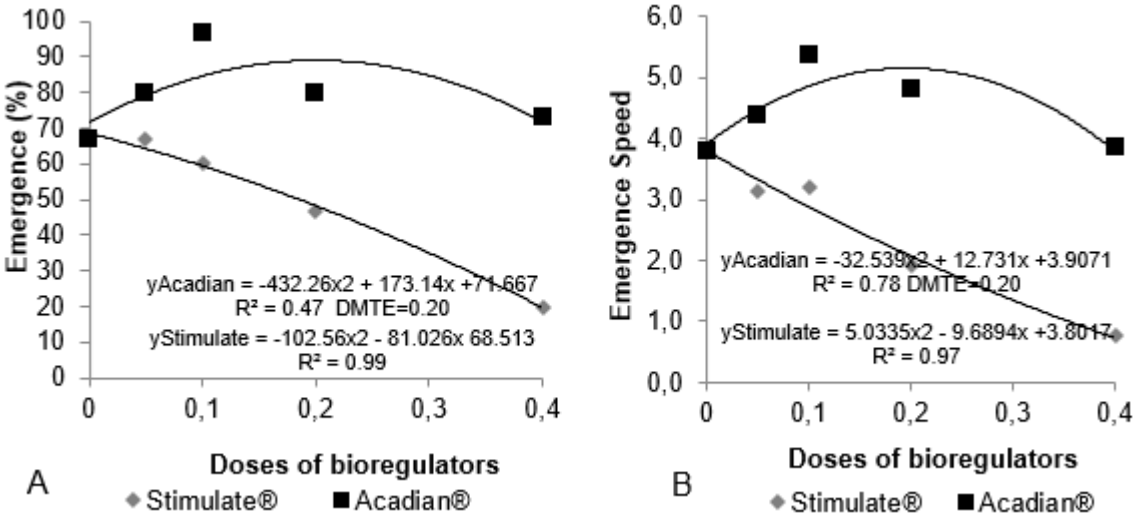
Table 1- Summary of the analysis of variance for seedling emergence (E, %), emergence speed (ES, index), mean time to obtain 50% emergence (MT, days) normal seedlings (NS, %), seedlings with two leaves (S2L, %) of African mahogany as a function of two hormones and five doses applied to the seeds.

		Mean square				
Sources of variation	**DF**	**E (%)**	**ES (index)**	**MT (days)**	**NS (%)**	**S2L (%)**
Hormone (H)	1	7434.6202**	31.9873**	99.1935**	6002.2550**	3999.6000**
Dose (D)	4	1174.9941**	4.4784**	45.6852**	989.1758**	1955.5611**
H x D	4	869.1532*	2.9742**	36.0580**	1135.8800**	711.1222**
Residual	30	240.4882	0.6890	4.1583	225.8338	133.3333
Mean		65.60	3.46	19.04	67.4	60.00
CV (%)		13.62	11.93	10.71	11.87	9.61

**, *Significant at 1% and 5% probability levels ($p<0.01$) by the F test. DF: degrees of freedom. CV: Coefficient of variation %.
Source: Authors

When comparing the emergence speed of African mahogany seedlings between the doses of the plant bioregulators tested, it was found that Acadian®, applied to African mahogany seeds, led to better ES (index) when compared to Stimulate®, as shown in Figure 1B.

Figure 1- Trend curves for seedling emergence (A) and emergence speed (B) obtained using two bioregulators under five doses (Acadian®: 0, 0.05, 0.1, 0.2, and 0.4 ml L^{-1} Stimulate®: 0, 0.05, 0.1, 0.2, and 0.4 ml L^{-1}) in African mahogany seeds.



**, *Significant at 1% and 5% probability levels ($p<0.01$) by the F test
Source: Authors

Figure 1 (A) shows the percentage of emergence of African mahogany seedlings as a function of the doses established for the bioregulator Acadian®, and the dose of maximum technical efficiency (DMTE) found was 0.2 ml L^{-1}, which led to a 31.2% increase in seedling emergence when compared to the control (Figure 1A).

These results showed that the interaction between genotype and doses of Acadian® may have promoted adequate hormonal balance, making the metabolism of African mahogany seeds active and the embryo fit for resuming its development in shorter seedling emergence time.

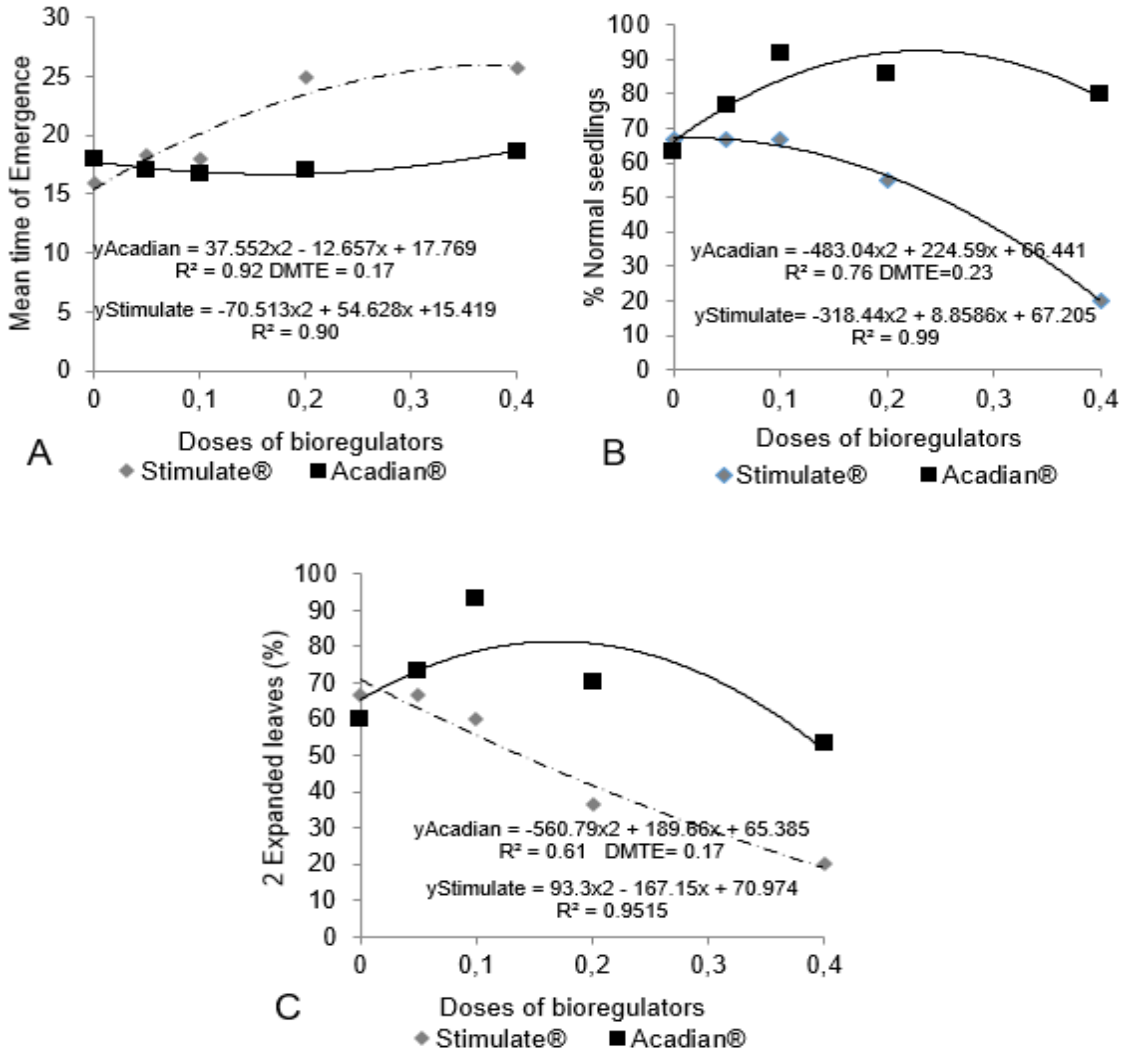
On the other hand, the 0.4 ml L^{-1} dose of Stimulate® applied to African mahogany seeds led to seedling emergence percentage of 20%, a result that confirms inhibitory action in the germination process of the species. In turn, the 0.4 ml L^{-1} dose of Acadian® promoted emergence of 73% (Figure 1A).

Regarding the emergence speed of African mahogany seedlings (Figure 1B), the DMTE was 0.20 ml L^{-1} for the bioregulator Acadian®. According to Smiderle and Souza (2021), seeds with higher ES (index) remain for a shorter period subject to adverse conditions in the soil, such as temperature variation, water stress, pest attack and pathogens.

The results presented in Figure 1B show that the bioregulator Acadian® promoted higher emergence speed in African mahogany seedlings up to the DMTE of 0.20 ml L^{-1}, as well as a shorter mean time of emergence (MT) up to the DMTE of 0.17 ml L^{-1} (Figure 2A). On the other

hand, the different doses of Stimulate® applied to African mahogany seeds (Figure 1B) contributed decisively to the inhibitory or reductional effect on ES (index) and higher MT (Figure 2A).

Figure 2- Trend curves for mean time of emergence (A), normal seedlings (B) and seedlings with two expanded leaves (C) obtained using two bioregulators (Acadian® and Stimulate®) under five doses (0, 0.05, 0.1, 0.2, and 0.4 ml L^{-1}), in African mahogany seeds.



**, *Significant at 1% and 5% probability levels ($p<0.01$) by the F test
Source: Authors

Smiderle and Souza (2022), in a study with *Hymenaea courbaril* seeds under application of Stimulate® at dose of 15 ml L^{-1}, showed an inhibitory effect on ES (index), as found in the present study. According to Smiderle and Souza (2022), inadequate doses of Stimulate® can lead to deterioration of the seed through physiological, biochemical, and cytological changes,

culminating in low emergence and longer time of emergence or even embryo death. This result was found in the present study for African mahogany seeds subjected to different doses of Stimulate® (Figures 1A and 2A).

The application of Stimulate® to African mahogany seeds caused a reduction in the percentage of normal seedlings with the increase in the doses (Figure 2B), indicating that the absorption of the bioregulator solution was efficient to limit vigor and cause effective disequilibrium in the hormonal balance of African mahogany seeds.

On the other hand, the highest percentage of normal seedlings (92%) was observed at the DMTE of 0.23 ml L^{-1} of Acadian®, resulting in uniformity in the stand of seedlings with two expanded leaves (Figure 2C). The increase in the percentage of normal seedlings with the increase in the concentration of Acadian® up to the aforementioned DMTE (Figure 2A, B and C) was determinant for promoting greater vigor of the seedlings.

According to Normative Instruction 45 (NI 45), which regulates the production of seeds from commercial crops in Brazil, the minimum acceptable emergence for commercialization is 80%.

Therefore, considering this standard and based on the results obtained for seedling emergence, it is possible to infer that African mahogany seeds with application of the bioregulator Acadian® up to the DMTE of 0.20 ml L^{-1} reach emergence above 90%, unlike the bioregulator Stimulate®, under which they did not reach the minimum value of emergence stipulated by the legislation, generally showing 20 to 60% of normal seedlings.

The results of the present study reinforce the importance of knowing the performance of African mahogany seeds and combinations of bioregulator doses to be applied to standardize and increase the vigor of seedlings. Thus, it can provide essential information for the selection of plant material suitable for commercial use by producers and nurserymen in the micro region of Boa Vista, Roraima, Brazil. The higher percentage of seedlings and vigor with adequate commercial characteristics is one of the primary factors for the success of the species, promoting the economic return of the capital invested by producers and nurserymen.

4 CONCLUSIONS

Acadian® at the dose of maximum technical efficiency of 0.20 ml L^{-1} applied to African mahogany seeds promotes greater increment in seedling emergence percentage.

Acadian® at the dose of maximum technical efficiency of 0.17 ml L^{-1} is efficient in reducing emergence time and increasing the percentage of seedlings with two expanded leaves, promoting uniformity of seedlings and higher yield in the use of African mahogany propagating material.

Stimulate® does not promote gains in the percentage of emergence and inhibits the vigor of African mahogany seedlings.

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