DOI: 10.5433/1679-0359.2025v46n3p861

Bioregulators Stimulate® and Acadian® as growth stimulants for *Mezilaurus itauba* TAUB. EX MEZ seedlings

Biorreguladores Stimulate® e Acadian® como estimulantes de crescimento de mudas de *Mezilaurus itauba* TAUB. EX MEZ

Camila de Almeida Milhomem[1]*; Luiz Fernandes Silva Dionisio[2]; Aline das Graças Souza[3]; Oscar José Smiderle[4]

Highlights

The bioregulator Stimulate® promoted greater development in all evaluated variables.
The rate of 0.35 ml L^{-1} resulted in better seedling growth.
There was no significant interaction between bioregulators and rates.
The bioregulator Acadian® was less effective compared to Stimulate®.

Abstract

The use of plant bioregulators has proven effective in increasing the vigor of seedlings of various forest species, playing a fundamental role in stimulating their morphological and physiological development. This study aimed to evaluate the effect of bioregulators at different rates on the initial growth and quality of *Mezilaurus itauba* seedlings. The study was conducted in a greenhouse using seeds collected in Mucajaí-RR, Brazil. The experimental design was completely randomized, in a 2x4 factorial arrangement, with two plant growth regulators (Acadian® and Stimulate®) and four rates (0, 0.2, 0.4, and 0.6 ml L^{-1}), with four replicates each. At 180 days, the following variables were evaluated: a) plant height (H), b) stem collar diameter (SD), c) height increase (HI), d) diameter increase (DI), e) shoot dry weight (SDW), f) root dry weight (RDW), g) total dry weight (TDW), and h) Dickson Quality Index (DQI). There was no interaction between rates and bioregulators. The bioregulator Stimulate® promoted greater development in HI, DI, SDW, RDW, TDW, and DQI compared to Acadian®. Regarding rates, greater development was observed

[1] Postgraduate Student of the master's Program in Agronomy, Universidade Federal de Roraima, UFRR, Boa Vista, RR, Brazil. E-mail: camilamilhomem5@gmail.com
[2] Prof. Dr., Universidade do Estado do Pará, Departamento de Ciências Florestais, UEPA, Castanhal, PA, Brazil. E-mail: fernandesluiz03@gmail.com
[3] Profª Drª, in Plant Production, Universidade Federal da Paraíba, Campus II, Areia, PB, Brazil. E-mail: alinedasgracas@yahoo.com.br
[4] Dr. in Plant Science, Department of Seeds, Brazilian Agricultural Research Corporation, EMBRAPA, Boa Vista, RR, Brazil. E-mail: oscar.smiderle@embrapa.br
* Author for correspondence

Received: Sept. 13, 2024 Approved: May 25, 2025

for all variables at 0.35 ml L^{-1}. The rate of maximum technical efficiency of Stimulate® for good initial development of *Mezilaurus itauba* seedlings is 0.35 ml L^{-1}.
Key words: *Mezilaurus itauba.* Seedling production. *Ascophyllum nodosum*, Stimulate®.

Resumo

O uso de biorreguladores vegetais tem demostrado eficácia no aumento do vigor de plântulas de várias espécies florestais, desempenhando papel fundamental no estímulo ao desenvolvimento morfológico e fisiológico das espécies florestais. Nesse estudo, objetivou-se avaliar o efeito de biorreguladores em diferentes doses no crescimento inicial e qualidade de mudas de Mezilaurus itauba. O estudo foi conduzido em casa de vegetação, com sementes coletadas em Mucajaí-RR. O delineamento experimental foi o inteiramente casualizado, em esquema fatorial 2x4, sendo dois reguladores de crescimento vegetal (Acadian® e Stimulate®) e quatro doses (0; 0,2; 0,4; 0,6 ml L^{-1}), com quatro repetições cada. Aos 180 dias, foram avaliadas as seguintes variáveis: a) altura de planta (H), b) diâmetro do coleto (DC), c) incremento em altura (IA), d) incremento em diâmetro (ID), e) massa seca da parte aérea (MSPA), f) massa seca da raiz (MSR), g) massa seca total (MST), e h) Índice de Qualidade de Dickson (IQD). Não houve interação entre doses e biorreguladores. O biorregulador Stimulate® promoveu maior desenvolvimento de plantas para as variáveis IA, ID, MSPA, MSR, MST e IQD em comparação com o Acadian®. Em relação as doses, observou-se maior desenvolvimento das plantas para todas as variáveis na dose de 0,35 ml L^{-1}. A dose de máxima eficiência técnica de Stimulate® para um bom desenvolvimento inicial de mudas de Mezilaurus itauba é de 0,35 ml L^{-1}.
Palavras-chave: Mezilaurus itauba. Produção de mudas. Ascophyllum nodosum, Stimulate®.

Introduction

The success of restoration, recovery, and/or reforestation projects is directly linked to seedling quality and proper nursery management practices (Marinho et al., 2022; S. A. B. Silva et al., 2024), resulting in higher survival and growth rates in the field (Dionisio et al., 2021). In addition, practices such as strict irrigation control, balanced fertilization, hardening, and the use of appropriate substrates enhance plant acclimatization, decrease post-transplant stress, and accelerate initial establishment in the field. These factors not only lead to higher survival rates and more uniform growth, but also bring significant economic benefits by reducing the costs of replanting and silvicultural treatments.

The species *Mezilaurus itauba* Taub. ex Mez, popularly known as "itaúba," is native to the Amazon region and widely distributed in the state of Roraima, Brazil (Smiderle & Souza, 2022). It is classified as a climax species that regenerates easily in open areas (Lanssanova et al., 2013). Itaúba wood is highly durable and resistant, with high commercial value, making it suitable for various uses. As a result, it is one of the most sought-after species in the Amazon, often targeted in forest management plans and illegal logging (E. S. Silva et al., 2022).

Although this species occurs throughout the Amazon, research on the factors that influence the growth and development of itauba seedlings is still incipient (Marinho et al., 2022). Due to the scarcity of information on proper management techniques, seedling production remains limited, whether for timber purposes or for the enrichment and recovery of degraded areas. This technical knowledge gap must be addressed with new research focused on developing suitable methodologies for itauba seedling production and management.

Biostimulants are organic compounds, either natural or synthetic, that modify a plant's morphological or physiological processes (Campos et al., 2020). They can be applied to seeds or plants via foliar application to promote plant growth (Oliveira et al., 2019). Bioregulators act as activators of physiological metabolism at various developmental stages (Costa et al., 2018; Maia et al., 2024), contributing to the formation of new tissues and, consequently, to the development of roots, leaves, flowers, fruits, and seeds (Petri et al., 2016). In a study by Smiderle and Souza (2021), the use of plant bioregulators helped overcome the physical and physiological dormancy of *Hymenaea courbaril* L., resulting in higher seedling emergence rates.

Different bioregulators have varying effects on plant metabolism, largely due to the presence of auxin, gibberellin, and cytokinin. These endogenous regulators stimulate cell division, seed germination, and bud break in plants under abiotic stress (Giolo et al., 2021). To ensure their maximum effectiveness, it is important to consider the species, applied rate, environmental conditions, available nutrients, and the formulation of the bioregulator (Du Jardin, 2012).

Research on forest species is still in its infancy, and no study has yet evaluated the use of the bioregulators Acadian® and Stimulate® in supporting the initial growth of itauba seedlings. Therefore, the objective of this study was to evaluate the effect of Acadian® (Ascophyllum nodosum) and Stimulate® at different rates on the initial growth and quality of itauba seedlings.

Material and Methods

The experiment was conducted in a greenhouse at Embrapa Roraima. The studied species was *Mezilaurus itauba* Taub. ex Mez. Fruits were collected from trees located at 1°38'29" N latitude and 60°58'11" W longitude, in the municipality of Mucajaí - RR.

After collection, the seeds were processed and sown in beds filled with medium-grain sand, maintained under manual irrigation with four waterings per day.

At 30 days after sowing, the seedlings had reached a uniform height of approximately 5.0 cm, at which point they were transplanted into 2-L bags containing a substrate composed of 25% sand + 25% soil + 25% carbonized rice husk + 25% organic compost (v/v: 1:1:1:1). The substrate had the following chemical characteristics, determined according to (Empresa Brasileira de Pesquisa Agropecuária, [EMBRAPA], 1997): pH - 6.7; P - 0.87 cmolc dm^{-3}; K - 0.31 cmolc dm^{-3}; Ca - 11.0 cmolc dm^{-3}; Mg - 0.7 cmolc dm^{-3}; H+Al - 1.1 cmolc dm^{-3}; organic

matter - 3.7 dag kg^{-1}; CEC - 13.31 dag kg^{-1}; sum of bases - 12.01 dag kg^{-1}; Zn - 16.5 mg dm^{-3}; Fe - 13.5 mg dm^{-3}; Mn - 88.6 mg dm^{-3}; Cu - 0.3 mg dm^{-3}; B - 0.5 mg dm^{-3}; S - 17.2 mg dm^{-3}.

The bioregulators Acadian® (a 100% natural bioactivator derived from *Ascophyllum nodosum* seaweed) and Stimulate® (a liquid bioregulator from Stoller do Brasil Ltd., composed of three plant growth regulators: indolebutyric acid [IBA], kinetin, and gibberellic acid [GA3]) were applied directly to the seedling substrate using an automatic graduated pipette. The established rates were applied in four small 2 cm-deep depressions on the substrate surface, positioned 2 cm from the plant collar, in the afternoon at 16h30, using four different rates for each plant growth regulator.

The experimental design was completely randomized in a 2×4 factorial arrangement, corresponding to two plant growth regulators (Acadian® and Stimulate®) and four rates (0, 0.2, 0.4, and 0.6 ml L^{-1}), with four replicates. Each replicate consisted of one plant. At 180 days after transplanting (DAT), shoot height (H) was measured with a graduated ruler and stem collar diameter (SD) with a digital caliper. Increases in stem collar diameter (SD) and shoot height (SH) were calculated from data collected every 30 days over the 180-day period.

The plants were then dried in a forced-air oven at 65 °C for 72 h until reaching constant weight, after which they were weighed to determine dry weight.

At 180 days, the following variables were evaluated: a) plant height (H), b) stem collar diameter (SD), c) height increase (HI), d) diameter increase (DI), e) shoot dry weight (SDW, g $plant^{-1}$), f) root dry weight (RDW, g $plant^{-1}$), g) total dry weight (TDW, g $plant^{-1}$), and h) Dickson Quality Index (DQI). The DQI was calculated using the formula DQI = TDW / [(H/SD) + (SDW/RDW)], as proposed by Dickson et al. (1960).

Stem height and diameter growth over 180 days were analyzed using repeated measures ANOVA. The assumptions of ANOVA were verified through the Shapiro-Wilk test for normality ($p > 0.05$) and visual inspection with QQ plots (Crawley, 2012; Zuur et al., 2009), and through the Bartlett test for homoscedasticity ($p > 0.05$). Once these assumptions were met, the data were subjected to analysis of variance. In the absence of interaction between factors, the rates of Stimulate® and Acadian® (0, 0.2, 0.4, and 0.6 ml L^{-1}) were evaluated using regression analysis, and comparisons between bioregulators were made using Student's t-test at the 5% probability level. Regression models for each variable were selected based on the significance of the regression coefficients and the highest coefficient of determination (R^2).

Results and Discussion

Stimulate® provided greater average height growth at 90, 120, 150, and 180 days after transplanting, differing significantly ($p = 0.001$) from Acadian® during these same periods. At 180 days, plants treated with Stimulate® had an average height of 22.2±3.5 cm (Figure 1a) and an average SD of 4.8±1.8 cm (Figure 1b), while those treated with Acadian® had an average height of 18.1±6.1 cm (Figure 1a) and an average SD of 4.6±1.8 cm (Figure 1b).

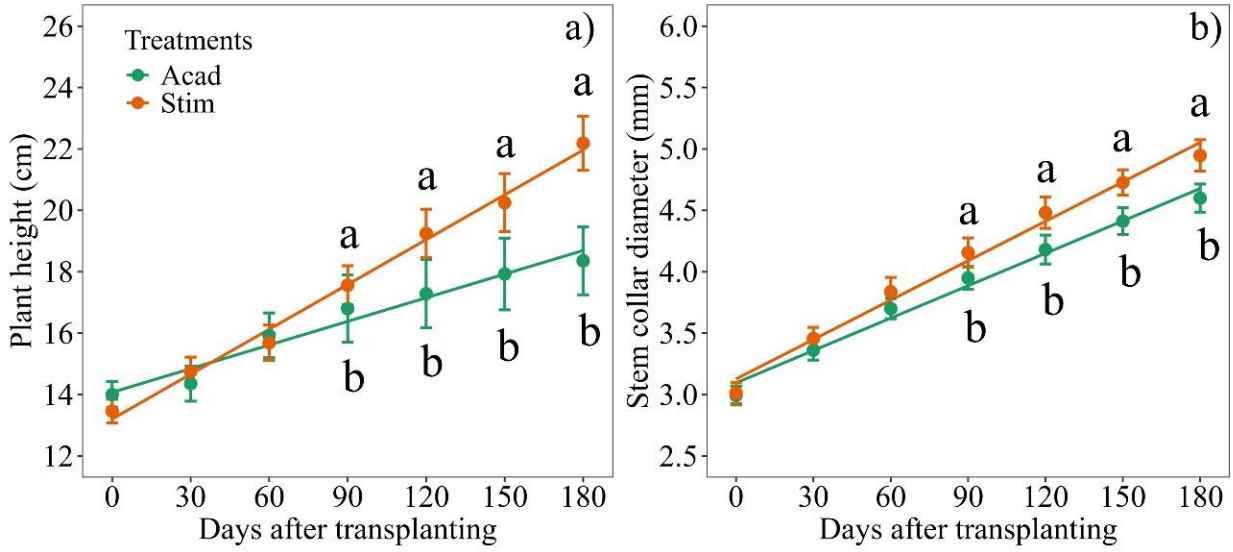

Figure 1. Cumulative growth in height (a) and stem collar diameter (b) of itauba (*Mezilaurus itauba*) seedlings over 180 days after transplanting. Means followed by different letters differ statistically from each other by Student's t-test ($p<0.05$).

The effectiveness of the bioregulator is attributed to the beneficial compounds it contains, such as amino acids, humic substances (humic and fulvic acids), plant growth hormones, vitamins, and other elements, including organic substances derived from seaweed extract (Frioni et al., 2021; Kolachevskaya et al., 2017). Seaweed extract is a natural source of growth-promoting compounds and can enhance plant development by delaying senescence, thereby increasing the photosynthetic rate and resulting in greater plant height (De Saeger et al., 2020). The specific application rates and timing of Stimulate® were crucial to obtaining these results, confirming that the biofertilizer stimulated growth in both height and diameter of *M. itauba* plants.

Stem collar diameter also increased more with the application of Stimulate® at 180 DAT (Figure 1b), indicating that this bioregulator positively influences plant growth parameters by supporting physiological processes that lead to biomass accumulation and plant development. Similar findings were reported by Lunelli et al. (2015), who observed significant increases in leaf number and stem collar diameter in *Vriesea carinata* Wawra (Bromeliaceae) treated with Stimulate®.

No significant interaction was observed between rates and bioregulators for any of the variables analyzed; however, each factor had an isolated effect. All variables fit a quadratic regression model. At 180 DAT, the rates of maximum technical efficiency (RMTE) were determined for each variable. The rate of 0.31 ml L^{-1} was most effective for plant height (H), while 0.36 ml L^{-1} was most effective for stem collar diameter (SD). For height increase (HI) and diameter increase (DI), the most efficient rates were 0.32 ml L^{-1} and 0.31 ml L^{-1}, respectively (Figure 2). The positive response of *M. itauba*

plants to Stimulate® is comparable to the findings of Smiderle and Souza (2022), who reported that 0.28 ml L^{-1} was the RMTE for stem collar diameter growth in *Hymenaea courbaril* seedlings.

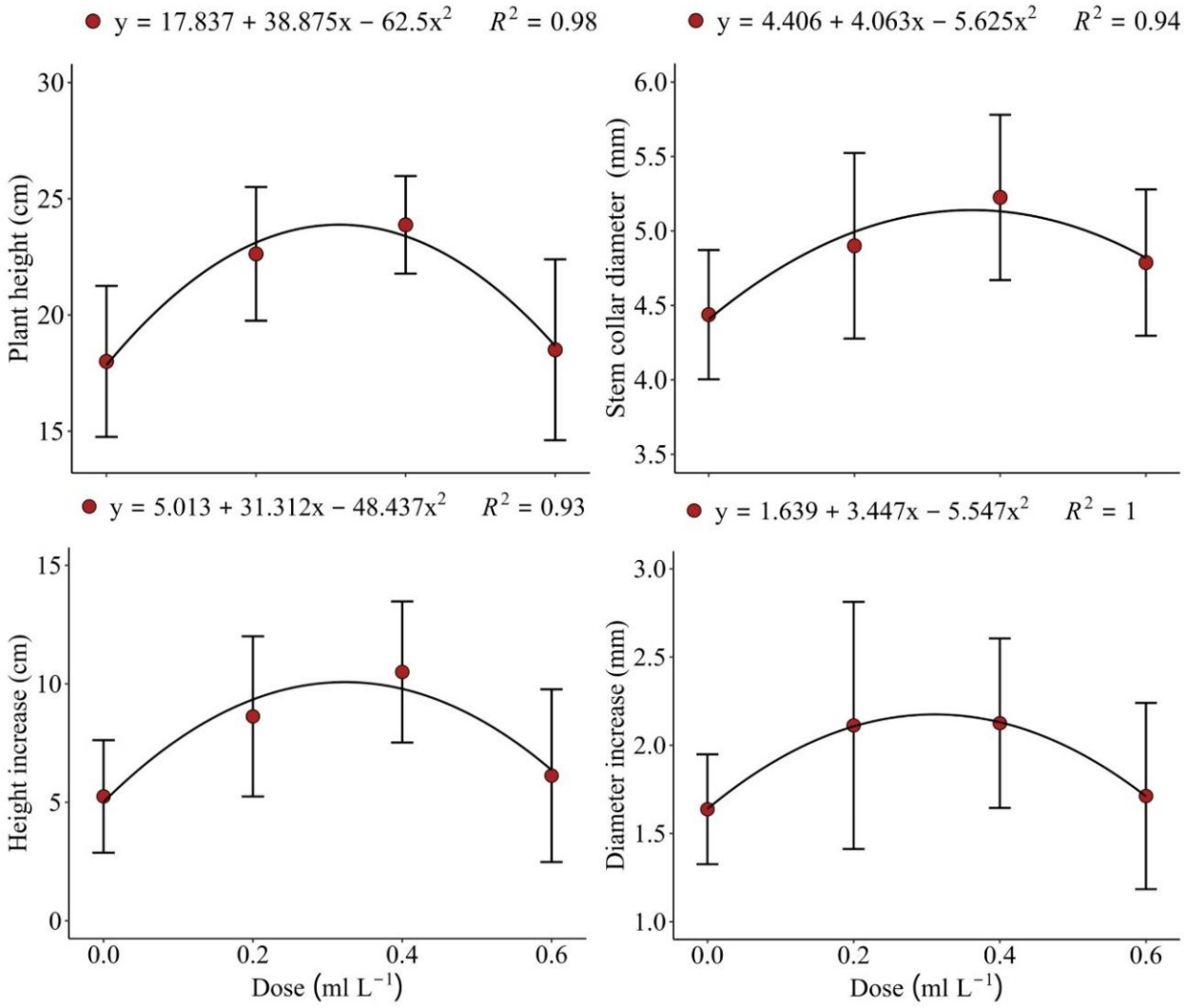

Figure 2. Mean values of plant height (a), stem collar diameter (b), height increase (c), and diameter increase (d) as a function of rates of the bioregulators Acadian® and Stimulate® (0, 0.2, 0.4, and 0.6 ml L^{-1}) in itauba (*Mezilaurus itauba*) seedlings at 180 days after transplanting.

The notable results across all analyzed variables, regardless of the bioregulator used, support the efficacy of these products in the early development of plants. Studies by Ribeiro et al. (2017) and Abrantes et al. (2011) also reported increased plant height (at rates between 1 ml L^{-1} and 6 ml L^{-1} of Stimulate®) in plants sprayed with growth regulators,

stating that hormonal activity is more intense during the vegetative phase compared to the production phase, which justifies the use of biofertilizers at this stage. Leal et al. (2020) observed that seaweed extract (Acadian®) increased stem collar diameter in pepper plants, a result also observed in this study at the 0.36 ml L^{-1} rate. These findings highlight the importance of applying bioregulators at different concentrations during the initial development of *M. itauba* seedlings.

Shoot dry weight (3.97±0.26 g), RDW (6.29±0.19 g), TDW (10.25±0.44 g), and DQI (2.05±0.33) reached the RMTE at concentrations of 0.35 ml L^{-1} (SDW, RDW, and TDW) and 0.40 ml L^{-1} (DQI) (Figure 3).

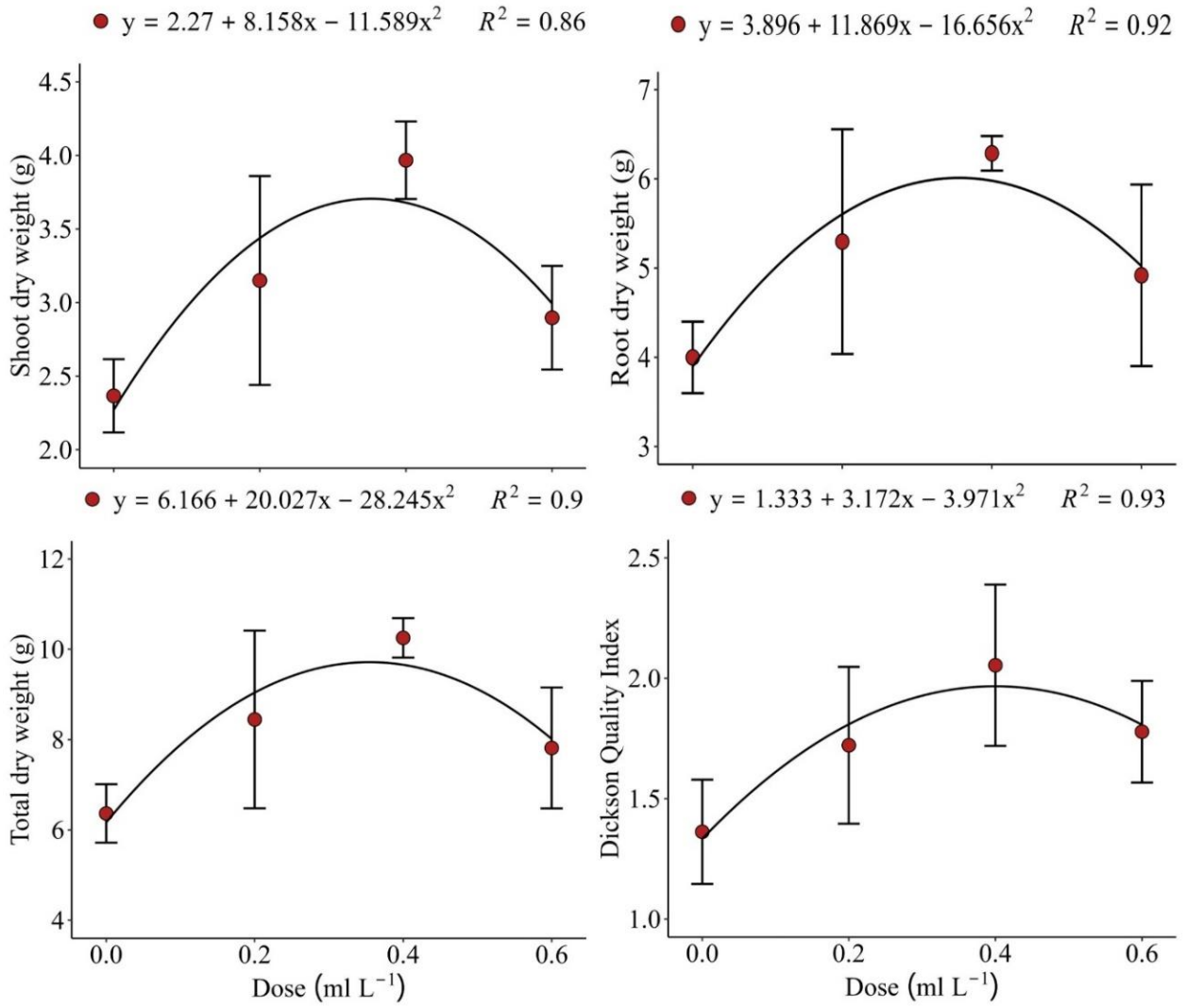

Figure 3. Shoot dry weight (a), root weight (b), total dry weight (c), and Dickson Quality Index (d) as a function of rates of the bioregulators Stimulate® and Acadian® (0, 0.2, 0.4, and 0.6 ml L^{-1}) in itaúba (*Mezilaurus itauba*) seedlings at 180 days after transplanting.

The similar behavior of the rates across the analyzed variables indicates that the biostimulant, when applied at an appropriate rate, promotes positive changes in plant metabolism and physiology, resulting in enhanced growth and development.

Regarding the plant bioregulators, no significant effect was observed on plant height and stem collar diameter (Figures 4a and 4b); however, significant differences were noted for height increase (HI) and diameter increase (DI). The application of the biostimulant Stimulate® resulted in a greater average HI of 9.0±3.2 cm and an average DI of 2.1±0.5 mm (Figures 4c and 4d).

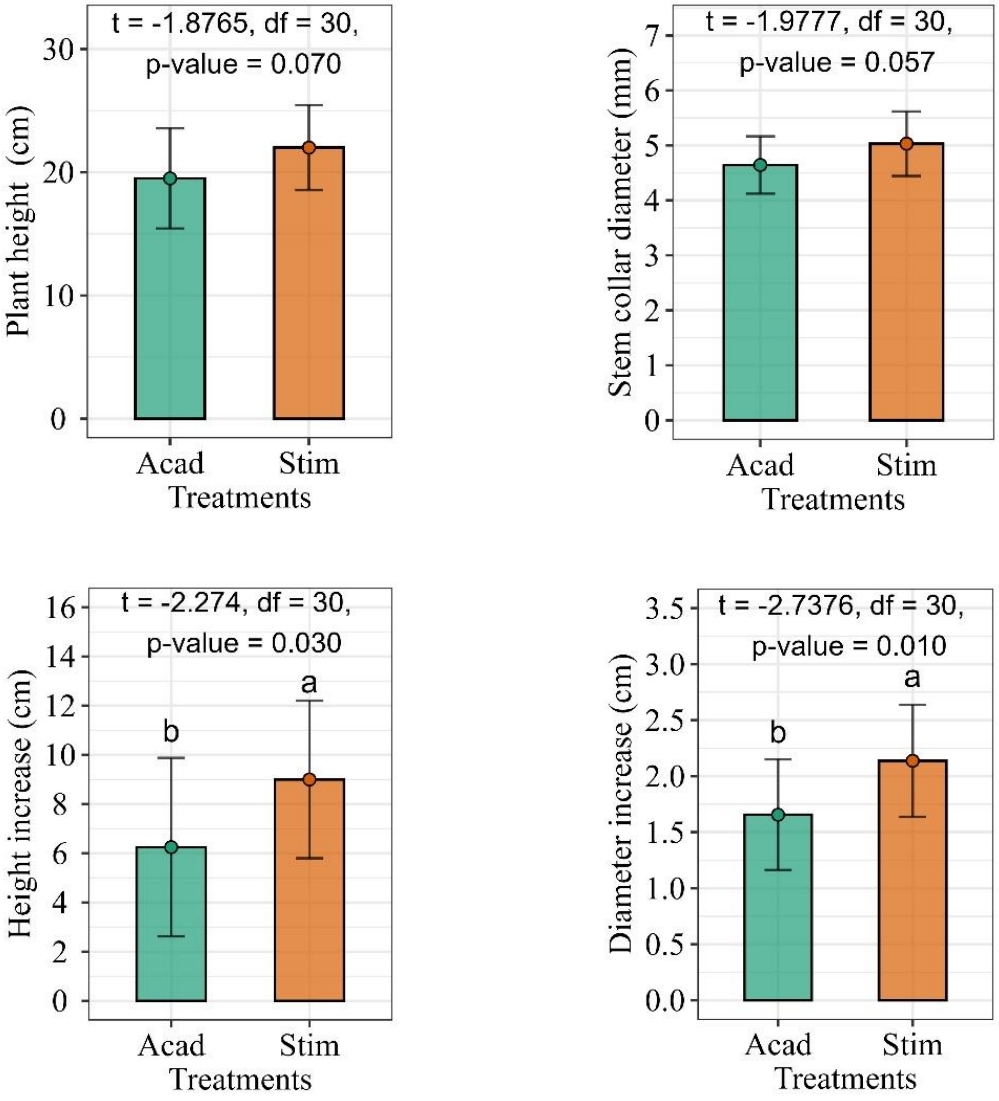

Figure 4. Mean values of plant height (a), stem collar diameter (b), height increase (c) and diameter increase (d) with the use of bioregulators Acadian® and Stimulate® in itaúba (*Mezilaurus itauba*) seedlings at 180 days after transplanting. Means followed by different letters differ statistically from each other by Student's t-test ($p<0.05$).

The bioregulators exerted positive effects on growth parameters such as height and diameter (Figure 4), likely due to their composition. These products are derived from seaweed extracts, primarily from Ascophyllum nodosum, and contain amino acids, humic acids, polysaccharides, and a complex of vitamins.

When Stimulate® was applied to M. itauba plants, increases in height and diameter exceeded those observed with Acadian®. According to Dantas et al. (2012), Stimulate® exhibits a synergistic effect that may enhance plant height by influencing cell division, differentiation, and elongation, thereby promoting growth and development.

A significant difference between the bioregulators was observed for the variables SDW, RDW, TDW, and DQI (Figure 5). The highest means were recorded in treatments with Stimulate®, resulting in 3.45±0.65 g for SDW (Figure 5a), 5.58±0.78 g for RDW (Figure 5b), 9.35±1.50 g for TDW (Figure 5c), and 1.87±0.31 for DQI (Figure 5d).

The results also revealed a significant difference in DQI among the biostimulants, with Stimulate® yie'lding a mean value of 1.87. According to Smiderle and Souza (2021), DQI is a reliable indicator for assessing the quality of native forest species in northern Brazil, as it reflects the robustness and balance in biomass allocation among plant organs, both of which are critical parameters for reliably recommending seedling quality. Watts (1990) considers 0.20 to be the minimum acceptable DQI value.

Overall, the plant growth regulator Stimulate® provided higher values than Acadian® for all tested variables (Figure 5). Its positive effect can be attributed to its strong capacity to stimulate root development, enhancing the absorption of water and nutrients. It may also contribute to improved hormonal balance within the plant (Rezende et al., 2017), and promote quicker and more uniform establishment, improving nutrient uptake and overall performance (Dantas et al., 2012). These results support the effectiveness of bioregulators in seedling production, enhancing overall quality.

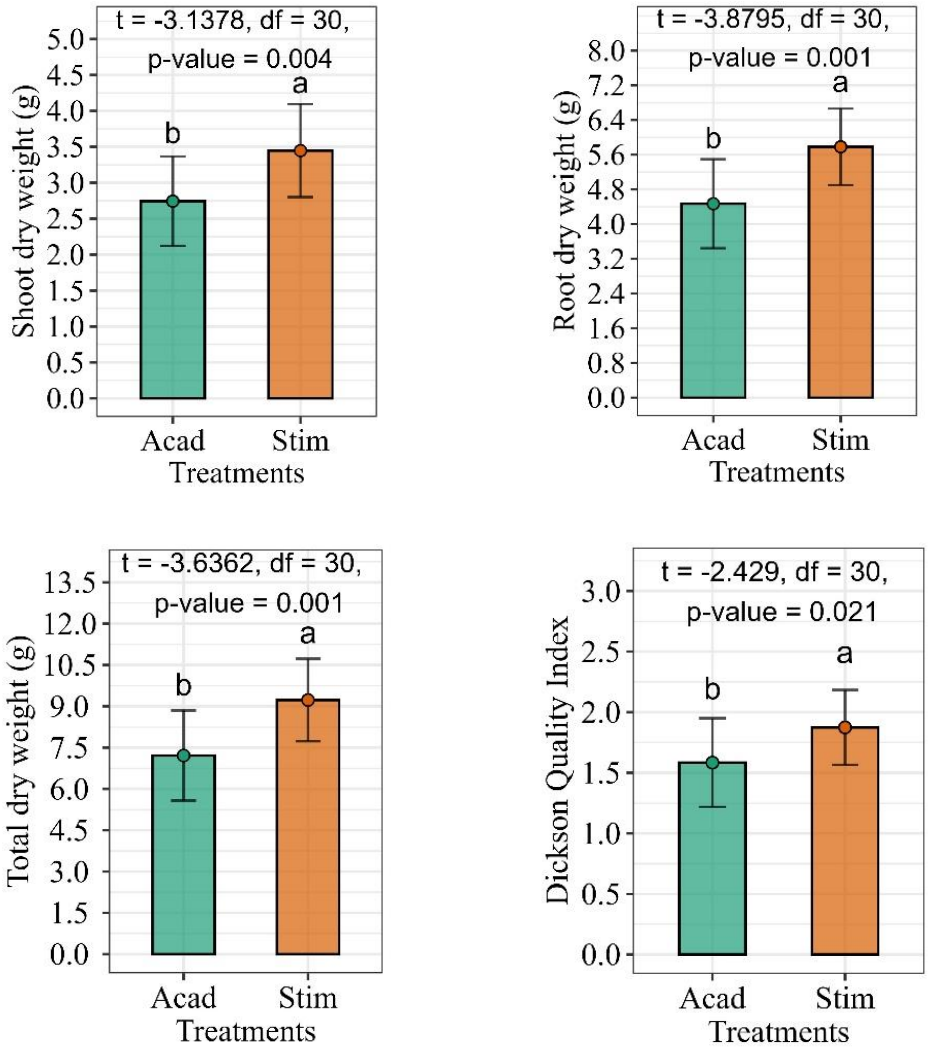

Figure 5. Mean values of shoot dry weight (a), root dry weight (b), total dry weight (c), and Dickson Quality Index (d) obtained with the use of the biostimulants Acadian® and Stimulate® on itauba (*Mezilaurus itauba*) seedlings at 180 days after transplanting. Means followed by different letters differ statistically from each other by Student's t-test ($p<0.05$).

Conclusions

The rate of maximum technical efficiency for the bioregulators Acadian® and Stimulate® was 0.35 mL L^{-1}, which is recommended for the production of Mezilaurus itauba seedlings with quality, robustness, and reduced nursery time.

The application of Stimulate® resulted in higher mean values for all evaluated variables and superior performance compared with the bioregulator Acadian®.

Stimulate® at a rate of 0.35 ml L^{-1} had a positive influence on all morphological parameters evaluated in *Mezilaurus itauba* seedlings at 180 days after transplanting.

References

Abrantes, F. L., Sá, M. E., Souza, L. C. D., Silva, M. P., Simidu, H. M., Andreotti, M., Buzetti, S., Valério, W. F, & Arruda, N. (2011). Uso de regulador de crescimento em cultivares de feijão de inverno. *Pesquisa Agropecuária Tropical, 41*(2), 148-154. doi: 10.5216/pat.v41i2.8287.

Campos, T. S., Santos S. W., & Oliveira, V. J. D. (2020). Uso de bioestimulantes no incremento da produtividade de grãos. *Revista Agrotecnologia-Agrotec, 11*(1), 9-15

Costa, N. C. R., Carvalho, F. J., Juliatti, F. C., Castro, M. V., & Cunha, W. V. (2018). Diversity of fungi in seeds of hymenaea stignocarpa and hymenaea courbaril before and after fungicide treatments. *Bioscience Journal, 34*(4), 868-874. doi: 10.14393/BJ-v34n1a2018-41866

Crawley, M. J (2012). *The R book* (2nd ed.). John Wiley & Sons.

Dantas, A. C. V. L., Queiroz, J. M. de O., Vieira, E. L., & Almeida, V. O. (2012). Effect of gibberellic acid and the biostimulant stimulate® on the initial growth of tamarind1. *Revista Brasileira de Fruticultura, 34*(1), 8-14. doi: 10.1590/S0100-29452012000100004

De Saeger, J., Van Praet, S., Vereecke, D., Park, J., Jacques, S., Han, T., & Depuydt, S. (2020). Toward the molecular understanding of the action mechanism of Ascophyllum nodosum extracts on plants. *Journal of Applied Phycology, 32*(1), 573-597. doi: 10.1007/s10811-019-01903-9

Dickson, A., Leaf, A. L., & Hosner, J. F. (1960). Quality appraisal of white spruce and white pine seedling stock in nurseries. *The Forestry Chronicle, 36*(1), 10-13. doi: 10.5558/tfc36010-1

Dionisio, L. F. S., Schwartz, G., Almeida, M. J. S., Rocha, T. S., & Corvera, R. (2021). Effects of pruning and recipient volume on seedlings' quality of Bertholletia excelsa bonpl. (Lecythidaceae). *European Academic Research, 9*(2), 1198-1212

Du Jardin, P. (2012). *The science of plant biostimulants -a bibliographic analysis.* (Ad Hoc Study Report).

Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA (1997). Central Nacional de Pesquisa de Solo. Manual de métodos de análise de solos.(2a. ed). Rio de Janeiro.

Frioni, T., Weide, J. V., Palliotti, A., Tombesi, S., Poni, S., & Sabbatini, P. (2021). Foliar vs. soil application of *Ascophyllum nodosum* extracts to improve grapevine water stress tolerance. *Scientia Horticulturae, New York, 277*(1), 109-117. doi: 10.1016/j.scienta.2020.109807

Giolo, R., Rodrigues, R., Galati, V. C., Barbara, M., & Vrech, M. A. (2021). O uso de estimulante afeta ou não o desenvolvimento inicial da cana-de-açúcar? *Scientific Electronic Archives, 14*(3), 46-52. doi: 10.36560/14320211210

Kolachevskaya, O. O., Sergeeva, L., Flokova, K., Getman, I. A., Lomin, S. N., & Alekseeva, V. V. (2017). Auxin synthesis gene tms1 driven by tuber specific promoter alters hormonal status of transgenic potato plants and their responses to exogenous phytohormones. *Plant Cell Reports, Knoxville, 36*(2), 419-435. doi: 10.1007/s00299-016-2091-y

Lanssanova, L. R., Ubialli, J. A., Arce, J. E., Pelissari, A. L., Favalessa, C. M. C., & Drescher, R. (2013). Avaliação de funções de afilamento para a estimativa de diâmetro de espécies florestais comerciais do bioma amazônico mato-grossense. *Floresta, 43*(2), 205-214. doi: 10.5380/rf.v43i2.26518

Leal, Y. H., Oliveira, S. V. F., Dias, T. J., Silva, T. I., Silva, L. M. P., Graças, S. A., Lucena, M. F. R., Rodrigues, L. S., & Smiderle, O. J. (2020). Edaphic respiration in bell pepper cultivation under biological fertilizers, doses and application times. *Emirates Journal of Food and Agriculture, 32*(6), 434-442. doi: 10.9755/ejfa.2020.v32.i6.2118

Lunelli, N. P., Kanashiro, S., & Tavares, A. R. (2015). Efeito de bioestimulante composto de cinetina, ácido indolbutírico e ácido giberélico em epífitas, visando a restauração florestal. *Hoehnea, 42*(2), 337-344. doi: 10.1590/2236-8906-39/2014

Maia, S., Smiderle, O. J., Souza, A. G., Torres, S. B., & Benedito, C. P. (2024). Uso de tetrazolio en la viabilidad de semillas y biorreguladores en la emergencia de plántulas de araçá-boi (*Eugenia stipitata* McVaugh). *Cultivos Tropicales, 45*(2), 8-13

Marinho, D. S., Ferreira, E., Roos, E., Coelho, J. P. S., Souza, J. P. L., & Moreira, A. G. (2022). Qualidade e desenvolvimento inicial de mudas de itaúba, em tubetes de diferentes volumes. *Acta Biologica Brasiliensia, 5*(2), 32-48. doi: 10.18554/acbiobras.v5i2.7223

Oliveira, E., Oliveira, C. J, Jr., Bera, H., Netto, Barros, C. A., Henrique, A. S. S., & Souza, F. M. L. (2019). *Influência de biorreguladores na germinação em sementes de (Tabebuia roseo-alba).*

Petri, J. L., Hawerroth, F. J., Leite, G. B., Sezerino, A. A., & Couto, M. (2016). *Reguladores de crescimento para frutíferas de clima temperado.* EPAGRI.

Rezende, G. F., Machado, B. Q. V., de Sá Junior, A., de Sousa, L. B., & Lana, R. M. Q. (2017). Efeitos da aplicação de bioestimulantes em sementes de algodão. *Revista Verde de Agroecologia e Desenvolvimento Sustentável, 12*(1), 177-181. doi: 10.18378/rvads.v12i1.4299

Ribeiro, L. D. O., Vieira, E. L., Girardi, E. A., Carvalho, E. V., & Ribeiro, M. D. O. (2017). Bioestimulante vegetal na produção de mudas de tabaco. *Magistra, 29*(2), 200-207.

Silva, E. S., Bonfatti, E. A., Jr., A Silva, G. A. O., Curvo, K. R., Stangerlin, D. M., Melo, R. R., & Souza, A. P. (2022). Deterioração da superfície de cinco madeiras amazônicas expostas ao intemperismo natural. *Madera y Bosques, 28*(2), e2822405. doi: 10.21829/myb.2022.2822405

Silva, S. A. B., Souza Lopes, T. de, Oliveira, W. F. C., Marinho, L. D. S. B., Costa, T. R., Moraes, C. B., & Souza, P. B. (2024). Avaliação germinativa de *Handroanthus heptaphyllus* (Ipê-roxo) em diferentes tipos de substrato. *Observatório de la Economía Latinoamericana, 22*(4), e4232-e4232. doi: 10.55905/oelv22n4-134

Smiderle, O. J., & Souza, A. G. (2021). Do scarification and seed soaking periods promote maximum vigor in seedlings of *Hymenaea courbaril*? *Journal of Seed Science, 43,* e202143030. doi: 10.1590/2317-1545v43254481

Smiderle, O. J., & Souza, A. G. (2022). *Cartilha de sementes de espécies florestais em Roraima.*

Watts, D. J., & Hunt, G. E. (1990). Waste Reduction Techniques. *Water Environment & Technology, 2*(9), 85–87. http://www.jstor.org/stable/24660510

Zuur, A. F., Ieno, E. N., Walker, N., Saveliev, A. A., & Smith, G. M. (2009). *Mixed effects models and extensions in ecology with R.* Springer.