A pesquisa em CIÊNCIAS BIOLÓGICAS:

Desafios atuais e perspectivas futuras

2

Clécio Danilo Dias da Silva
Danyelle Andrade Mota
(Organizadores)

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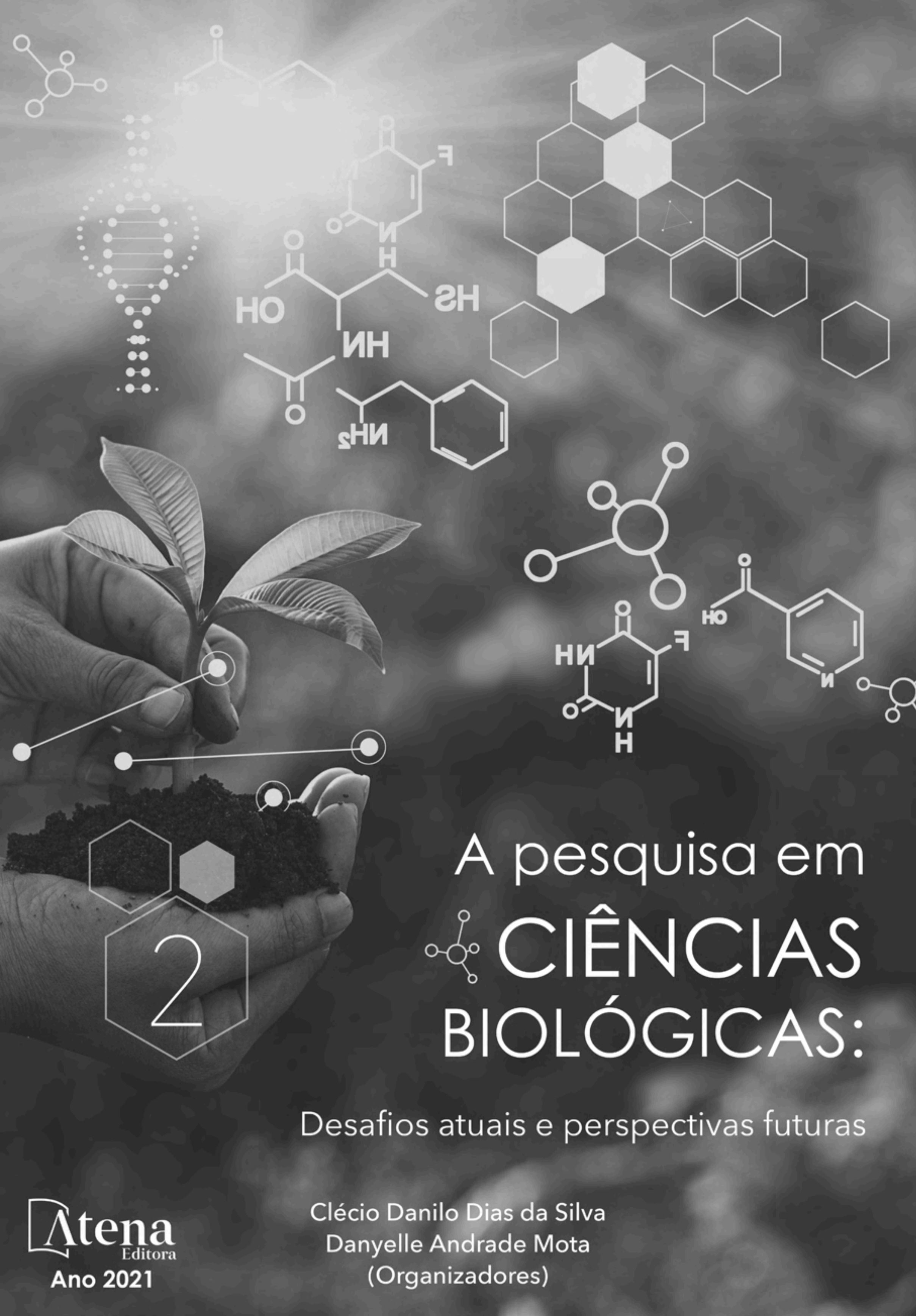

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APRESENTAÇÃO

As Ciências Biológicas, assim como as diversas áreas da Ciência (Naturais, Humanas, Sociais e Exatas), passam por constantes transformações, as quais são determinantes para o seu avanço científico. Nessa perspectiva, a coleção “A Pesquisa em Ciências Biológicas: Desafios Atuais e Perspectivas Futuras”, é uma obra composta de dois volumes com uma série de investigações e contribuições nas diversas áreas de conhecimento que interagem nas Ciências Biológicas.

Assim, a coleção é para todos os profissionais pertencentes às Ciências Biológicas e suas áreas afins, especialmente, aqueles com atuação no ambiente acadêmico e/ou profissional. Cada volume foi organizado de modo a permitir que sua leitura seja conduzida de forma simples e com destaque por área da Biologia.

O Volume I “Saúde, Meio Ambiente e Biotecnologia”, reúne 17 capítulos com estudos desenvolvidos em diversas instituições de ensino e pesquisa. Os capítulos apresentam resultados bem fundamentados de trabalhos experimentais laboratoriais, de campo e de revisão de literatura realizados por diversos professores, pesquisadores, graduandos e pós-graduandos. A produção científica no campo da Saúde, Meio Ambiente e da Biotecnologia é ampla, complexa e interdisciplinar.

O Volume II “Biodiversidade, Meio Ambiente e Educação”, apresenta 16 capítulos com aplicação de conceitos interdisciplinares nas áreas de meio ambiente, ecologia, sustentabilidade, botânica, micologia, zoologia e educação, como levantamentos e discussões sobre a importância da biodiversidade e do conhecimento popular sobre as espécies. Desta forma, o volume II poderá contribuir na efetivação de trabalhos nestas áreas e no desenvolvimento de práticas que podem ser adotadas na esfera educacional e não formal de ensino, com ênfase no meio ambiente e manutenção da biodiversidade de forma de compreender e refletir sobre problemas ambientais.

Portanto, o resultado dessa experiência, que se traduz nos dois volumes organizados, objetiva apresentar ao leitor a diversidade de temáticas inerentes as áreas da Saúde, Meio Ambiente, Biodiversidade, Biotecnologia e Educação, como pilares estruturantes das Ciências Biológicas. Por fim, desejamos que esta coletânea contribua para o enriquecimento da formação universitária e da atuação profissional, com uma visão multidimensional com o enriquecimento de novas atitudes e práticas multiprofissionais nas Ciências Biológicas.

Agradecemos aos autores pelas contribuições que tornaram essa edição possível, e juntos, convidamos os leitores para desfrutarem as publicações.

Clécio Danilo Dias da Silva
Danyelle Andrade Mota

SUMÁRIO

CAPÍTULO 3

SALINITY ASSESSMENT IN THE GERMINATION OF *LAGUNCULARIA RACEMOSA* (L.) C. F. GAERTN. FOR SELECTING MANGROVE RESTORING SITES

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ABSTRACT: The aim of this work was to identify and analyze the saline tolerance throughout the white mangrove propagules of *L. racemosa* germination, a halophyte and monotypic species, to contribution to the mangrove restoration. A total of 450 propagules were subjected to different salinities. The propagules were divided into three replicates (r) of 30 propagules for each salinity treatment (t) of 0, 15, 25, 40 and 60. Germinability (G), Germination Velocity Index (GVI), Germination Mean Time (GMT), Germination Mean Velocity (GMV) and Root Formation (RF) were applied to the experiment. The results showed that G and GVI tend to be very sensitive to the concentration of high salinity (salinity of 60). In spite of this, the germination of the propagules was successful up to the salinity of 40. The mangrove is composed of halophytic plants, capable to support and grow in saline environments. The present experiment identified the white mangrove species *Laguncularia racemosa* as fully capable of germinating in freshwater, presenting a variation in germination depending on different salinity. In this way, this species contributes to development and improvement of the techniques, used in the germination of propagules to produce seedlings for the restoration of mangroves.

KEYWORDS: Salinity stress, white mangrove, propagule germination, ecological restoration.

AVALIAÇÃO DA SALINIDADE NA GERMINAÇÃO DE *LAGUNCULARIA RACEMOSA* (L.) C. F. GAERTN. VISANDO A SELEÇÃO DE SÍTIOS DE RECUPERAÇÃO DE MANGUEZAIS

RESUMO: Identificou-se e analisou-se a tolerância salina na germinação em propágulos de mangue branco *L. racemosa*, uma espécie halófita e monotípica, para contribuir para a restauração do manguezal. Um total de 450 propágulos foram submetidos a diferentes salinidades. Os propágulos foram divididos em três réplicas (r) de 30 propágulos para cada tratamento de salinidade (t) de 0, 15, 25, 40 e 60. Os índices de Germinabilidade (G), Velocidade de Germinação (GVI), Tempo Médio

de Germinação (GMT), Velocidade Média de Germinação (GMV) e Formação de Raizn (RF) foram aplicados ao experimento. Os resultados mostraram que G e GVI tendem a ser muito sensíveis à concentração de alta salinidade (salinidade de 60). Apesar disso, a germinação dos propágulos foi bem sucedida até a salinidade de 40. O manguezal é composto por plantas halófitas, capazes de suportar e crescer em ambientes salinos. O presente experimento identificou a espécie de manguezal branco *Laguncularia racemosa* como totalmente capaz de germinar em água doce, apresentando uma variação na germinação dependendo de diferentes salinidades. Dessa forma, essa espécie contribui para o desenvolvimento e aperfeiçoamento das técnicas, utilizadas na germinação de propágulos para produzir mudas para a restauração de manguezais em áreas sob influência de diferentes salinidades.
PALAVRAS - CHAVE: Estresse de salinidade, mangue branco, germinação de propágulos, restauração ecológica.

INTRODUCTION

Mangroves are part of the most threatened coastal ecosystems in the tropical and subtropical regions of the world. At least 35-50% of these coastal forests have been destroyed, with an annual loss of 0.4% of the total remaining mangroves in the world (Along 2002; FAO 2007; Ferreira and Lacerda 2016; Hamilton and Casey 2016). López-Portillo et al. (2017) report that the main causes of mangrove degradation may be of natural origin, such as erosion and indirect effects caused by tsunamis, or of anthropogenic origin caused by pollution, aquaculture, etc.

According to Paula et al. (2012) and Mochel (2016), there are several reasons for the importance of mangroves, besides being nurseries for many species of ecological and economic value: they influence the local and global climate, assist in the control of floods, act in the production of oxygen and in the sequestration of carbon in the coastal zone. The mangrove ecosystem works like a biological filter retaining pollutants, produces organic matter and protects the coastline from erosion, reducing the energy of tides, waves and winds (Tang et al. 2020).

Ecological recovery of mangroves therefore is of fundamental importance, it repaires losses and restoring functions in areas subject to human intervention, as well as it renovates the socio-environmental benefits mangroves provide to the coastal zone. Ecological restoration, according to the Society for Ecological Restoration (SER 2004) and McDonald et al. (2016), assists in the recovery of an ecosystem that has been degraded. Viana (1990) has described recovery as divided into two categories: restoration and rehabilitation. The restoration seeks to recover the original form of the ecosystem, in the phytosociological sense. The term rehabilitation deals with the reestablishment of ecosystem functions, independent of species and their structure after environmental impact.

The ecological restoration of mangroves can be performed involving basically two procedures: natural recovery and artificial recovery (Clough et al. 1997). For the natural restoration, Mochel (2016) considers the establishment of propagules and seedlings, starting with their distribution by natural processes, as the circulation of the tides in the ecosystem. Artificial recovery requires procedures induced by human actions, such as assessment of propagules and their distribution, or planting of nursery seedlings and seedling transplantation.

In degraded mangroves, the ecosystem can suffer various imbalances, such as saline, hydric, climatic, biological and sedimentary. To reverse the damage caused by mangrove degradation, a number of ecological recovery processes and techniques are developed. One of these processes is the production of nursery seedlings and, for this, the germination of propagules is necessary (Mochel and Fonseca, 2019).

In Brazil, mangroves are distributed from the northern tip of Amapá (N 4º 20') to the county of Laguna-SC (S 28º 30') (Schaeffer-Novelli 1989). The coastal Amazon has the largest continuous area of mangroves in the world (8,900 km²), 50% of this total belong to the Maranhão coastline (Kjerfve et al. 2002). On the island of Sao Luis, in the state of Maranhão, the mangroves are distributed in an area of 18,895 hectares on the coast as fringes, behind beaches, coastal strands and sandy dunes, or bordering rivers and streams (Silva and Mochel 1994). Although the mangrove areas of Maranhão state are preserved, Mochel et al. (2002) emphasize that there was a loss in mangroves of about 10,000 ha between 1972 and 2002.

On the Brazilian Amazon coast are found the species *Avicennia schaueriana* Stapf & Leechm. ex Moldenke and *Avicennia germinans* (L.) L. (black mangrove or siriba), the red mangrove species *Rhizophora mangle* L., *Rhizophora harisonii* Leechm. and *Rhizophora racemosa* G. Mey, the buttonwood mangrove *Conocarpus erectus* L. and the white mangrove *Laguncularia racemosa* (L.) C. F. Gaertn (Mochel 2011).

The white mangrove *Laguncularia racemosa* (Combretaceae) is a monotypic species occurring in mangroves of West Africa and the Americas, in fringes close to the land (Tomlinson 1986). The tree can reach a height up to 20 m, although it is common to be found in a bush form (Schaeffer-Noveli and Cintron 1986). This species, like the other mangrove species, is subject to diverse natural and anthropogenic environmental stresses. Clewell and Aronson (2012) defined stress as a normally occurring condition or a periodic event, that may be more detrimental to some species than others. The author also points out that there are factors such as saline water shock and anoxia that cause stress conditions in mangroves.

Although the vegetal species of mangroves are facultative halophytes, which means plants capable of completing their reproductive cycle and presenting optimal growth in low salinity environments, their seedlings are sensitive to the presence of sodium chloride, and a saline substrate can affect many aspects of the its growth and physiology (Tomlinson 1986; Parida and Jha 2010).

The germination plant analysis is the one of the most used processes for the determination of tolerance to water and saline stress (Larcher 2000). Plants that live in a brackish environment, such as those living in mangroves, have morphological and physiological adaptations to tolerate constant hydric and saline stress. These adaptations vary with species, and those with high salinity tolerance tend to grow more slowly than less tolerant species (Sobrado 2004). Therefore, salinity plays important roles in regulating mangrove growth and distribution (Wang et al. 2011).

This research aimed to analyze the effect of different concentrations of salinity on the germination of *L. racemosa* propagules, and the identification of its salt tolerance, in order to contribute to the selection of the most suitable areas of mangrove to be recovered.

METHODS

Study area

The Maranhão Island is formed by the municipalities of São Luis, São José de Ribamar, Paço do Lumiar and Raposa, located in the Coastal Region of the State of Maranhão (IMESC 2011). The propagules were collected between the mangroves of Raposa and São José de Ribamar, in the Mangue Seco beach northeast of the municipality of São Luis, Maranhão (S 2º 27' 06.86", W 44° 09' 20.33" and S 2º 27' 21.81", W 44° 09' 45.76" (Fig. 1). The site features a variety of coastal ecosystems such as mangroves, sandbank, dunes and salt marshes. Mangrove forests are relatively homogeneous and are concentrated in the mouths of rivers and streams. The salinity of the Igarapé Mangue Seco is high, with an average of 40.

According to Koppen and Geiger (1928) classification, the region between the municipalities of São José de Ribamar and Raposa presents a Aw climate which fits in between equatorial and tropical patterns, with two well marked seasonal periods, a rainy (January to June) and drought (July to December).

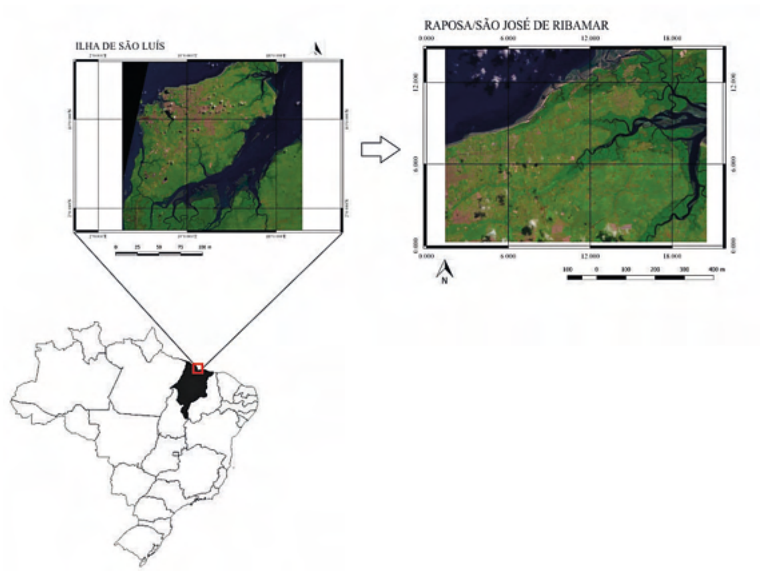

Fig. 1 Area of São José de Ribamar and Raposa municipalities where propagules were carried out (Images *Landsat 8 Sensor OL*I sensor - United States Geological Survey).

Field sampling

A total of 450 ripe propagules of *Laguncularia racemosa* were collected manually directly from the branch of the tree and placed into a straw basket to avoid dehydration during the fruiting season between April and May 2016. The healthy propagules were selected according to the recommendations of Goforth and Thomas (1979), to achieve the greatest possibility of success in their development. The propagules were then transported to the Mangrove Laboratory/CERMANGUE - Mangrove Recovery Center in Department of Oceanography and Limnology, Federal University of Maranhao.

Experimental design

The total of 450 propagules were divided into three replicates (r) of 30 propagules for each treatment (t) of salinity. For each salinity treatment the propagules were placed to soak until the primary root emission, in sterile plastic trays, previously labeled with the identified different salinities.

The estuarine water, used in the experiment, was collected in the Mangue Seco Channel, in the same region where the propagules were collected, and the salinity was verified with a Q767-3 Quimis refractometer. The water was transported in plastic bottles to the laboratory CERMANGUE-UFMA, where dilutions and concentrations were carried out from the salinity control of the collection site, for the execution of the experiment. To obtain the salinity 60, sea water was subjected to controlled evaporation until the desired salt concentration was reached. In all treatments the salinity was obtained with a refractometer.

The experiment was divided into five trays containing treatments with concentrations of salinities 0, 15, 25, 40 and 60. In each tray were placed 30 propagules. Three replicates of salinity concentrations were performed for each treatment.

The influence of salinity on germination of the propagules was monitored daily at the same time for 10 days. The salinity was checked and corrected daily to avoid salinity increase due to evaporation. The propagules were considered germinated when the primary root emission reached 2 mm.

Germination tests

To analyze the influence of salinity on the germination of *Laguncularia racemosa* propagules, the following variables were evaluated: Germinability (G%) to inform the amount of propagules that germinated in the experiment; Germination Mean Velocity (GMVdays $^{-1}$) to measure velocity of germination (Maguire 1962; Santana and Ranal 2000); Germination Mean Time (GMT days) to measure time of germination (Ranal and Santana 2006, 2009); and the beginning of root formation (RF days) refers to the date the first root appeared.

The G, GMT and GMV variables were processed using the GerminaQuant 1.0 software used for germination calculations (Marques et al. 2015), whose formulas are:

Germinability: G = $\left(\frac{N}{30}\right)$x100

with: N = number of seedlings germinated at the end of the experiment

Germination Mean Time: GMT = $\sum ni\ ti$ / $\sum ni$

with: ni = number of germinated propagules per day; ti = incubation time;

Germination Mean Velocity: GMV = $\frac{1}{GMT}$

The Germination Velocity Index (GVI) was calculated using the formula:

GVI = $\left(\frac{G1}{T1} + \frac{G2}{T2} + \frac{G3}{T3}\right) \ldots + \left(\frac{Gi}{Ti}\right)$

with: G1 to Gi = number of seedlings germinated each day; T1 to Ti = time (days)

Statistical analyses

The comparison of the germination tests between the different saline concentrations was carried out using the Analysis of Variance (ANOVA One-Way) and Tukey test, considering the homogeneity presuppositions of variances. Kruskall-Wallis non-parametric analysis (p <0.05), followed by Mann-Whitney test, was used in case of absence of these assumptions. The homogeneity of the variances was analyzed by the Levene test (Levene 1960).

Statistical data were processed in Statistica 6.0 and PAST 3.14 software (Hammer 2001). The statistical analyzes were evaluated for a critical level of significance of α = 0.05 (Zar 1998).

A Cluster analysis, using the Euclidean distance by the mean binding method, was applied to evaluate the similarity between the salinity treatments in relation to the physiological measures of germination. The similarity profile (SIMPROF) was used to test the statistical significance of the formed groups (Clarke and Warwick 2001). For this evaluation, PRIMER 6.0 software was used. The Multidimensional Scaling (MDS) was applied to verify the level of similarity or dissimilarity between the different concentrations of salinity and the physiological measures of germination.

A Principal Component Analysis (PCA), based on a variance-covariance matrix, was used to verify the association of different physiological measurements with salinity concentrations. The significance of the axes was tested by randomization in the randomized Broken Stick model with 9,999 replicates per bootstrap (Jackson 1993). The sorting analyzes (MDS and PCA) were performed using the PAST software 3.14 (Hammer 2001).

RESULTS

The results of the difference between the treatments and the comparison of means of the physiological measurements regarding the germination of the *Laguncularia racemosa* propagules under the effect of different salinities, are presented in Table 1.

Salinity Concentration	Variables				
	G (%)	GVI	GMT (days)	GMV ($days^{-1}$)	RF (days)
0	95.50 ^{a}	5.41 ^{a}	6.23 ^{a}	0.161 ^{a*}	2.67 ^{a}
15	96.60 ^{a}	5.01 ^{a}	6.47 ^{a}	0.155 ^{a*}	2.67 ^{a}
25	87.80 ^{a}	4.36 ^{a}	6.69 ^{a}	0.151 ^{a*}	3.67 ^{a}
40	80.00 ^{a}	3.95 ^{a}	6.59 ^{a}	0.152 ^{a*}	3.33 ^{a}
60	17.78 ^{b}	0.99 ^{b}	6.00 ^{a}	0.167 ^{a*}	3.66 ^{a}

Table 1. Germination values for *Laguncularia racemosa* propagules submitted to different salinity treatments (G-germinability; GVI-germination velocity index; GMT-germination mean time; GMV-germination mean velocity; RF-root formation; Same letter does not differ from each other at the 0.05% probability level).

* Applied nonparametric Kruskal-Wallis test, with later Mann-Whitney test.

The treatment with the highest germination rate (G) was the treatment with salinity of 15, followed by salinity 0 with 96.6% and 95.5%, respectively. The lowest germinability occurred at salinity of 60. There was a significant difference between germinability (p = 0.0002) and salinities.

The germination velocity index (GVI) was similar to germinability. The results showed significant differences between the lowest and highest salinities (p = 0.0007). The highest value of GVI occurred in the salinity of 0 with 5.41 and the lowest salinity of 60 with 0.99, showing that lower salinities result in higher germination speed and germination capacity.

Regarding the variable germination mean time (GMT), the results did not present significant differences between the treatments (p = 0.6), in this way, a 6-day pattern was found for all treatments.

For the mean germination mean velocity (GMV) no significant difference was observed ($p = 0.134$) in the interaction between germination and the salinities 0, 15, 25, 40 and 60.

Root formation (RF) was faster throughout the treatments with concentrations of salinity 0 and 15, appearing within two days. With salinities from 25 on the root appeared on the third day. However, there were no significant differences between all treatments and root formation ($p = 0.54$).

Based on salinity and physiological measurements represented in cluster analysis, a large group could be identified, consisting of saline concentrations of 0, 15, 25 and 40, being dissimilar to the salinity of 60. The SIMPROF test confirmed the established group and their difference in relation to the highest salinity used in the experiment (Fig. 2). Thus, the results indicate that salinity of 60 tends to be less similar between physiological measurements than other salinities, with less expressive concentrations.

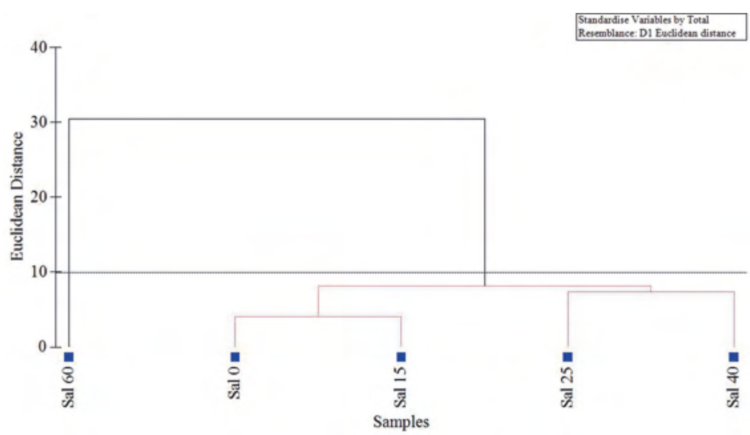

Fig. 2 Cluster analysis of the salinity treatments in relation to the physiological measures of *Laguncularia racemosa* propagules germination.

Similar to clustering, Multidimensional Scaling (MDS) grouped the most similar salinity treatments among physiological measures (Fig. 3). The graph shows a tendency to form two groups. The most similar group consists of salinities of 0, 15, 25 and 40 and the other group with only 60. Lower salinities tend to have different rates when compared to higher salinities.

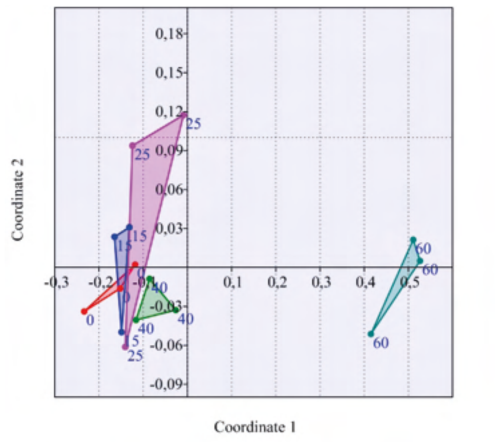

Fig. 3 Multidimensional Scaling (MDS) of different salinities levels and physiological measures of *Laguncularia racemosa* propagules germination.

The first two axes of the Principal Component Analysis (PCA) explained 98.1% of the total data variability, with axis 1 (68.8%) and axis 2 (29.3%), thus being sufficient to represent the factorial variance. The PCA verified the association of the physiological measurements with the salinity treatments (Fig. 4).

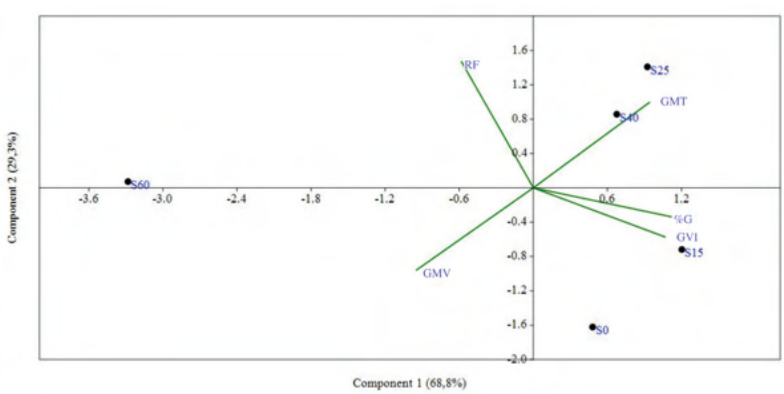

Fig. 4 Principal Component Analysis (PCA) between physiological measures (G-germinability, GVI-germination velocity index, GMT- germination mean time, GMV-germination mean velocity and RF-root formation) in different salinities.

Analyzing the association of physiological measurements in relation to salinity levels from the point of view of component 1, salinities 25, 40 and 60 show a tendency to associate with RF and GMT.

Considering component 2, GMV, GVI and % G showed a tendency to be associated with lower salinities 0 and 15, however, GMV showed a tendency to associate with salinity

60 . The GVI and % G tend to be lower in concentrations of 25, 40 and 60.

DISCUSSION

For some plant species the ability to enter estuarine environments depends on their tolerance to the salinity level throughout the germination (Krauss et al. 1998). The increase of salinity leads to a reduction and/or delay in the germination of both halophytic and glycophytic species (less salt tolerant) (Khan and Ungar 1984; Katembe et al. 1998). Although mangrove species have adapted to tolerance salinity, they are sensitive to higher salinities in the germination process (Ungar 1996; Khan and Abdullah 2003; Debez et al. 2004).

Studies have shown that young seedlings grow best under low salinity, while adults are affected in their growth both by high salinity and total absence of dissolved salts (Baskin and Baskin 2014). Possibly due to the salinity affecting the propagules variability, most mangrove species release their fruits in the rainy season, to increase the chances of survival under conditions of low salinity in the ecosystem (Bunt et al. 1982). River estuaries with high and medium salinity soils have been shown to be good habitats for mangrove forest growth. (Kantharajan et al. 2018). According to this Fernandes et al. (2005) observed, that the flowering and fruiting of *L. racemosa* occurs from January to March with greater intensity, and from June to August with lower intensity.

Considering the results, the germinability and the rate of germination were very sensitive to the concentration of high salinity (60), when they were significantly affected by the different salt concentrations. This effect can be justified, since with the passage of time the propagule loses the potential of germination due to the high saline content.

The growth of many halophyte species is optimal under relatively low salinities (Flowers et al. 2008). *Laguncularia racemosa* is rarely dominant, except when salinity is low (Jiménez 1985). In general, *L. racemosa* propagules, collected in the São José de Ribamar/Raposa region, are strongly subjected to stress conditions, mainly high salinities, as observed in the estuarine salinity used as control (40). In spite of this, the germination of the propagules was successful until the salinity of 40, possibly indicating that the propagules of the region are adapted to the adverse local conditions. The germination performance of the propagules was reduced considerably in the highest salinity (60), the germination rate and germination speed index decreased. There is research indicating the importance of salt to some mangroves, as well as evidencing that distinct species show different tolerances to salinity (Pezeshki et al. 1989).

Santana and Ranal (2004) described that a higher the germination speed index leads to greater germination capacity of the seeds, which means, if the germination occurs at the beginning of the experiment, this value will be higher than if it occurs late. In the experiment with propagules of *L. racemosa* from São José de Ribamar/Raposa, GVI values showed a significant variation throughout the treatments with a salinity of 60.

As for the germination mean time and the mean velocity, the data showed that the lower the mean time, the higher grows the germination speed of the seeds, thus confirming that the mean germination time and mean germination velocity are two inversely proportional quantities (Ranal 2000).

In relation to the beginning of the root formation, Ye et al. (2005), studying the effects of salinity on the germination of mangrove plants of the genus *Acanthus*, *Aegiceras* and *Avicennia*, showed, that the beginning of the root formation varied from 3 to 7 days in low and high salinities, respectively. In this experiment, the root formation start ranged from 2 days for low salinity to 3 days for salinity from 25.

Some experiments have shown, that the optimum salinity concentration for mangrove species is much lower than that of seawater (Clough 1993). Moreover, the increase in salinity causes the plant to reach a tolerance limit, in which the adaptations to stress are limited and can cause its death (Larcher 2000, Oliveira 2005). Salt is generally not a requirement for growth, since most mangroves can grow in freshwater (Tomlinson 1986; Ball 1988).

Mangroves do not develop in exclusively sweet regions due to competition with freshwater species. Salinity is a limiting factor for species that are not adapted to the saline environment. In addition to be a limiting factor, Lichtenthaler (1996) has shown, that salinity in the mangrove can be considered a factor of stress (stimulating stress) in low concentrations and stress (negative stress) until it exceeds the limit of tolerance of the species. However, some mangrove forests are located far from estuaries in areas of low salinity soil (Jayatissa et al. 2008).

Although the mangrove grows and supports saline environments, the present experiment identified that the *Laguncularia racemosa* mangrove species is fully capable of germinating in fresh water and presents a variation in germination as a function of salinity.

CONCLUSIONS

In conclusion, our results indicate that the most efficient germination occurred with propagules submitted to concentrations ranging from fresh water to salinity of 15. In order to stimulate a more efficient germination, *Laguncularia racemosa* seedlings should be kept soaked in concentrations ranging from freshwater to salinity of 15 during the production process of seedlings for the recovery of degraded mangroves.

The present study generated relevant information, regarding the impact of saline stress on the germination of *L. racemosa* propagules. In this way, it contributes to the development and improvement of the techniques used in the germination of propagules for the production of seedlings, aiming the ecological recovery of mangroves.

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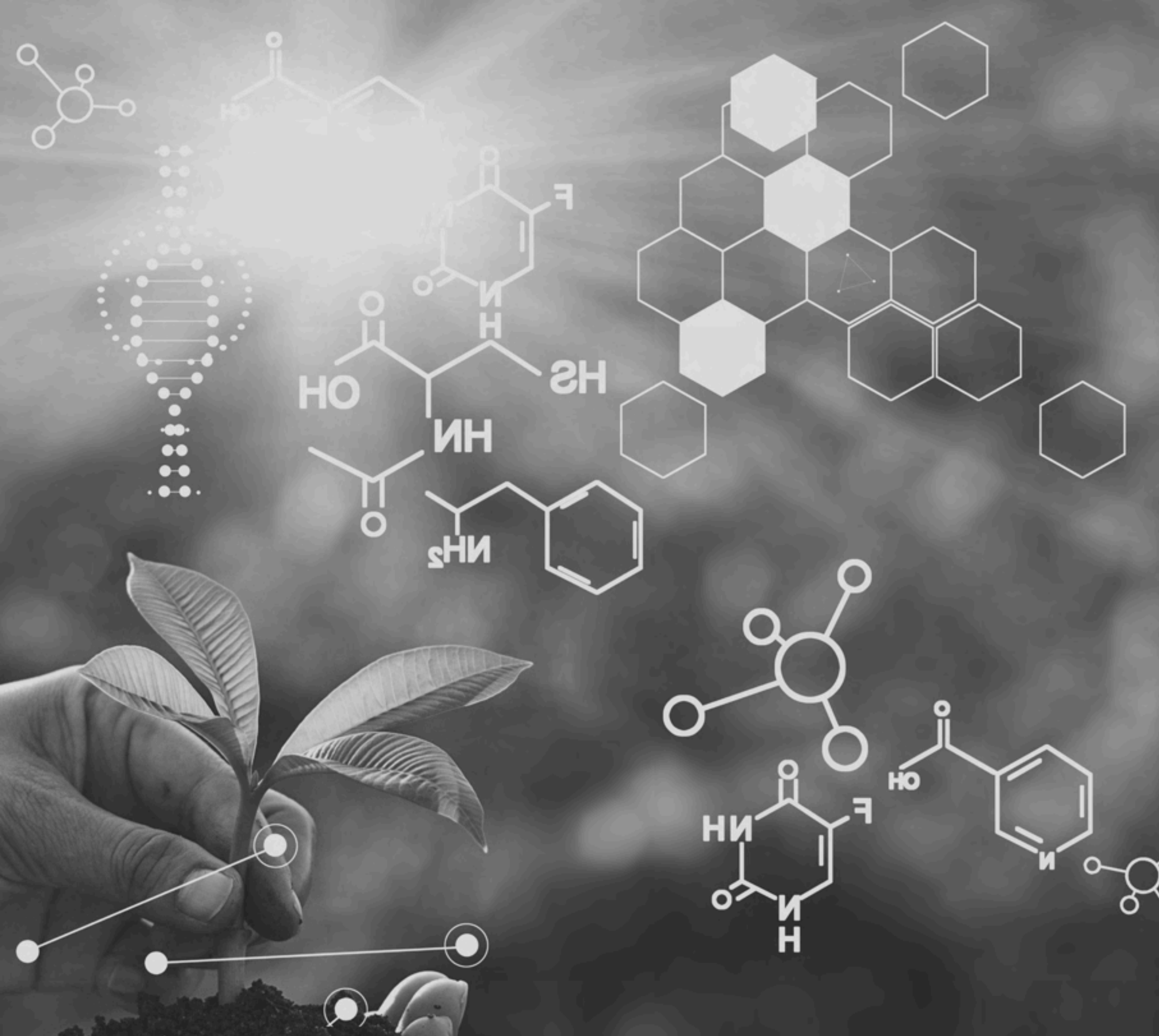

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