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Production of single assai palm, *Euterpe precatoria* Mart., seedlings subjected to nitrogen and potassium doses

Angelita Gude Butzke[1], Rychaellen Silva de Brito[1], Romeu de Carvalho Andrade Neto[2], Aureny Maria Pereira Lunz[2], Sergio da Silva Fiuza[1]

[1] Universidade Federal do Acre, Rio Branco, Acre, Brasil. E-mail: angelgude@yahoo.com.br, rychaellenbrito@gmail.com, sergiofiuza@live.com

[2] Empresa Brasileira de Pesquisa Agropecuária, Embrapa Acre, Rio Branco, Acre, Brasil. E-mail: romeu.andrade@embrapa.br, aureny.lunz@embrapa.br

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ABSTRACT

Given the importance that the species *Euterpe precatoria* exerts on the market, tied to a few studies referring to the initial phase of the crop, the objective was to evaluate the production of seedlings of single assai palm *(Euterpe precatoria* Mart.) submitted to increasing doses of nitrogen and potassium. The seedlings were arranged in a randomized block design in a 5x5 factorial scheme. The first factor comprised nitrogen doses (0, 15, 30, 45, and 60 mg dm^{-3} of N) and the second potassium (0, 40, 80, 120, and 160 mg dm^{-3} of K), applied in installments, 20, 40 and 40%. Plant height (PH), stem diameter (SD), and the number of active leaves (NL) were evaluated at 90, 180, 240, and 300 days after pricking out, as well as ideal installment scans using the data obtained. Evaluations of the dry mass of the stipe (EDM), leaf (LDM), shoots (SDM), root (RDM), and total (TDM) were also evaluated at 300 days after pricking out, and the relationship between PH/SD and SDM/TDM was established. The data were submitted to univariate analysis and regression analysis. It was observed that the interaction between N x K was not significant, thus presenting the isolated effect of both. It was concluded that the K doses influence the stem diameter at 180 and 240 days and the PH/SD ratio. N presents increasing linear responses in almost all variables except PH/SD, and N split in the proportions of 30%, 30% and 40% for seedling production up to 300 days after pricking out is recommended.

Keywords: Native Forest species, Monoculture, Palm trees.

Produção de mudas de açaizeiro solteiro submetidas a doses de nitrogênio e potássio

RESUMO

Mediante a importância que a espécie *Euterpe precatoria* exerce frente ao mercado, atrelado a poucos estudos referente a fase inicial da cultura, objetivou-se avaliar a produção de mudas de açaizeiro solteiro (*Euterpe precatoria* Mart.) submetidas a doses crescentes de nitrogênio e potássio. As mudas foram arranjadas em delineamento em blocos casualizados em esquema fatorial 5x5, sendo o primeiro fator as doses de nitrogênio (0, 15, 30, 45 e 60 mg dm^{-3} de N) e o segundo de potássio (0, 40, 80, 120 e 160 mg dm^{-3} de K), aplicados de forma parcelada, 20, 40 e 40%. Foram avaliados a altura da planta (PH), diâmetro do coleto (SD) e número de folhas ativas (NL) aos 90, 180, 240 e 300 dias após a repicagem bem como o parcelamento ideal mediante os dados obtidos. Também foram realizadas avaliações da massa seca do estipe (EDM), folha (LDM), parte aérea (SDM), raiz (RDM) e total (TDM) aos 300 dias após a repicagem e estabelecida a relação entre PH/SD e SDM/TDM. Os dados foram submetidos a análise univariada e análise de regressão. Foi observado que a interação entre N x K não foi significativa, apresentando, portanto, o efeito isolado de ambos. Conclui-se que as doses de K influenciam o diâmetro do coleto aos 180 e 240 dias assim como a relação PH/SD. O N apresenta respostas linear crescente em quase todas as variáveis, exceto PH/SD e recomenda-se o parcelamento de N nas proporções de 30%, 30% e 40% para a produção de mudas até 300 dias após repicagem.

Palavras-chave: Espécies florestais nativas, Monocultivo, Palmeiras.

1. Introduction

The Amazon rainforest is known worldwide for its species diversity, with potential exploitation due to the amplitude of plant materials not classified and studied (Batista et al., 2017). The family Arecaceae is commonly disseminated, with emphasis on the abundance of species of *Euterpe precatoria* e *Euterpe oleracea* in the states of Amazonas and Pará, respectively (Rodrigues et al., 2016; Ramos et al., 2019). The genus *Euterpe* is constantly exploited, with many applications in the market, which adds high value to products derived from its processing. Its fruit is commonly used, especially the extraction of pulp intended for fresh and processed consumption, due to the high levels of nutrients and vitamins (Yamaguchi et al., 2015).

Even with the importance mentioned above, the species *Euterpe precatoria* still has limitations regarding the cultivation method and exploitation because of its predominance in natural areas (Martinot et al., 2017). Boeira et al. (2020) mention that, for the state of Amazonas, the extractivist method represents about 80% of the production of açaí, being a social and cultural practice tied to family agriculture. Zambrana et al. (2017) report that the market demand for this species generates pressure regarding the migration from extractivist to agroforestry and monoculture systems.

The pressure to increase the production scale to serve non-producing and export regions can cause negative impacts on the collecting communities although the difficulty of establishing the species in agro-industrial systems (Martinot et al., 2017). The government of the state of Acre, aiming at the market potential associated with the single assai palm, encouraged production through harvesting in native areas and subsequent domestication (Lopes et al., 2019). However, when referring to domestication for the implementation of commercial areas, it is necessary to identify the factors capable of affecting the development of the species (Trautenmuller et al., 2017).

For the assai palm, the nursery phase can be considered limiting to the quality of the seedling that will be implanted in the field. Because it has a longer seedling production period when compared to other fruit species, it is crucial to understand the nutritional demand of the plant while changing so that they have full development (Aguilar et al., 2020). Adopting fertilization practices, it is possible to obtain beneficial responses such as reducing the length of stay in the nursery, resulting in cost reduction already in the initial phase (Chen et al., 2018).

One of the nutrients required by the plant already in the early stages of its development is nitrogen (N), which promotes growth and development, but, when used erroneously, can cause a reverse effect by interfering with the absorption of other nutrients (Silva et al., 2020). Also, potassium (K) is important in this phase since it aids in biochemical and physiological reactions. Considering the importance that *E. precatoria* has in the market, tied to a few studies regarding the initial phase of species, the present study aimed to evaluate the impact of nitrogen and potassium doses on the production of seedlings of single assai palm (*Euterpe precatoria* Mart.).

2. Material and Methods

The experiment was conducted in the seedling production nursery of Embrapa Acre, Rio Branco, Acre (10º1'30"S, 67º42'18"W, and an altitude of 160 m), between December 2017 and November 2018, in a screened nursery with 50% luminosity. According to the köppen classification, the climate of the region is hot and humid, Am-type, with a relative humidity of 80% and rainfall between 1,700 and 2,400 mm annually (Alvares et al., 2013).

For the production of seedlings, polyethylene bags with a capacity of 4 kg were used, measuring 18 cm in diameter and 30 cm in height, containing, as substrate, soil removed from the surface layer (0-20 cm) of Argissolo Vermelho, previously subjected to the analysis and with the following characteristics: Ca = 4.95 cmolc dm^{-3}; Mg = 1.09 cmolc dm^{-3}; K = 0.02 cmolc dm^{-3}; Al+H = 0.45 cmolc dm^{-3}; CEC (pH7) = 6.85 cmolc dm^{-3}; Sum of bases = 6.4 cmolc dm^{-3}; P = 10.6 cmolc dm^{-3}; pH (H_2O) = 7.25; Base saturation (V%) = 93.25; OM = 14.51 g kg^{-1}; Coarse Sand = 175.38 g kg-1; Fine Sand = 491.5 g kg^{-1}; Clay = 206.85 g kg^{-1}; Silt = 126.20 g kg^{-1}. Based on results from the soil chemical analysis, 100 mg kg^{-1} of P were applied using simple superphosphate as the source.

The seeds were collected from fruits from native plants in the municipality of Feijó, Acre, and sown in containers with dust. The beginning of seedling emergence was observed at 35 days after sowing, with uniformity only at 60 days, when they were in a "toothpick" stage, being left one plant per container. After pricking out, they were irrigated daily by an intermittent sprinkler system with a watering shift in the morning and afternoon. It is emphasized that for the control of anthracnose, fortnightly applications were performed and alternated with fungicides tebuconazole + trifloxystrobin and pyraclostrobin + epoxiconazole; the concentration of 2.5 mL of the commercial product per liter of water was used, as Nogueira et al. (2017). The control of weeds was manually performed.

The randomized block design (DBC) was used, with three replications and five plants per plot in a 5x5 factor scheme. The first factor comprised N doses (0, 15, 30, 45, and 60 mg of N per kg of soil) applied using urea as the source. The second factor was composed of K doses

(0, 40, 80, 120, and 160 mg of K per kg of soil) applied using potassium chloride as the source, both diluted in distilled water. Fertilization was performed in installments, applying 20%, 40%, and 40% at 40, 130, and 220 days after pricking out, respectively.

At 90, 180, 240, and 300 days after pricking out, the following evaluations were performed: plant height (PH), in centimeters, obtained with the aid of a graduated ruler, measuring from the base of the seedlings, close to the substrate, to the point of emission of the last leaflet of the youngest leaf; the stem diameter (SD), in millimeters, measured at 1 cm from the surface of the substrate with the aid of a digital caliper and the number of active leaves (NL) determined by counting all open leaves (physiologically active). From the variables mentioned above, a calculation was performed to determine the ideal installment of fertilization performed according to the higher potential of assai palm response by increasing the doses in the measurement periods of 90, 180, 240, and 300 days after pricking out through the following increment calculation:

$$\text{Increment} = \frac{\text{value of dose x - dose value 0}}{\text{value 0}}$$

At 300 days after pricking out, the seedlings were removed from the containers, washed in running water, separating each plant into stipe, leaves, and root, both packed separately in paper bags and dried in an air-forced circulation oven at 55 ºC for 72 hours, until reaching constant mass. Then, the dry mass of stipe (EDM), leaf (LDM), and root (RDM) were obtained using a precision scale (Benincasa, 1988). Subsequently, the shoot dry mass was determined (SDM), total dry mass (TDM), PH/SD ratio, and SDM/RDM according to Dickson et al. (1960).

The data were submitted to the analyses of the assumptions that precede the ANOVA, which were the presence of discrepant data by the Grubbs test (1969), residue normality by the Shapiro-Wilk test (1965), and homogeneity of variances by the Levene test (Gastwirth et al., 2009). After the assumptions, the analysis of variance and the F test was performed (Snedecor and Cochran, 1948). When significant for quantitative variables (doses), regression analysis was performed.

3. Results and Discussion

When performing univariate analysis, it was found that there was no significant interaction ($p>0.05$) between the factors nitrogen (N) and potassium (K), regardless of the variable. When using potassium fertilization, only the variables stem diameter at 180 and 240 days after pricking out (F4.48 = 2.77, p = 0.04 and F4.48 = 2.60, p = 0.05) PH/SD ratio (F4.48 = 4.24, p = 0.00) downstream significance. On the other hand, nitrogen fertilization was significant for the number of leaves at 180 (F4.48 = 3.39, p = 0.01), 240 (F4.48 = 4.47, p = 0.00), and 300 (F4.48 = 9.16, p = 0.00) days; stem diameter at 180 (F4.48 = 6.76, p = 0.00), 240 (F4.48 = 6.02, p = 0.00), and 300 (F4.48 = 11.19, p = 0.00) days; plant height at 180 (F4.48 = 3.28, p = 0.02), 240 (F4.48 = 2.88, p = 0.04), and 300 (F4.48 = 4.03, p = 0.00) days; root dry mass (F4.48 = 4.75, p = 0.00); stipe dry mass (F4.48 = 6.42, p = 0.00); leaf dry mass (F4.48 = 9.80, p = 0.00); total dry mass (F4.48 = 7.76 p = 0.00); SDM/RDM ratio (F4.48 = 5.45, p = 0.00).

Even without significance for the number of leaves and plant height, potassium does not negatively influence the variables mentioned, even in the highest concentrations. Ramalho et al. (2020) mention that excess K in the substrate generates toxicity to the seedling, and if there is a deficiency in water availability, it is potentiated. Similarly, Melo et al. (2020) report that the shoot and root are harmed when K is applied excessively, which is not observed in this study during the conduction phase of the experiment.

At 180 and 240 days after pricking out, potassium doses exert a quadratic effect on the stem diameter. Based on the equation obtained through polynomial regression, it was possible to estimate the doses of 79 mg dm-3 and 92,5 mg dm-3 as the maximum response point for the variable in question, assuming that higher doses than that cause a decrease in stem diameter (Figure 1). Araújo et al. (2020a) mention that substrates containing high levels of boron, nitrogen, and potassium promoted the increase of morphological variables, emphasizing stem height and diameter.

In a study carried out by Araújo et al. (2020b) quadratic effect was evidenced for the stem diameter when using controlled-release fertilizer with 16% potassium for seedling production, corroborating the results of the present study. For nitrogen at 180 days after pricking out, it is possible to observe a linear increase in the stem diameter in terms of installment and application of doses (Figure 2). The evaluation at 90 days was not significant through the low concentration applied, only 20% of the total dose of each treatment, thus not differentiating from the treatment without N.

It is evidenced that seedlings submitted to 45 and 60 mg dm^{-3} of N provided the maximum development in the four evaluation periods for the variable. Aguilar et al. (2020) report that seedlings with larger diameters are more resistant to curving and damage caused by physical injury. In addition, because it is tied to the Dickson quality index, SD is also considered a good parameter regarding the quality of seedlings (Massad et al., 2020).

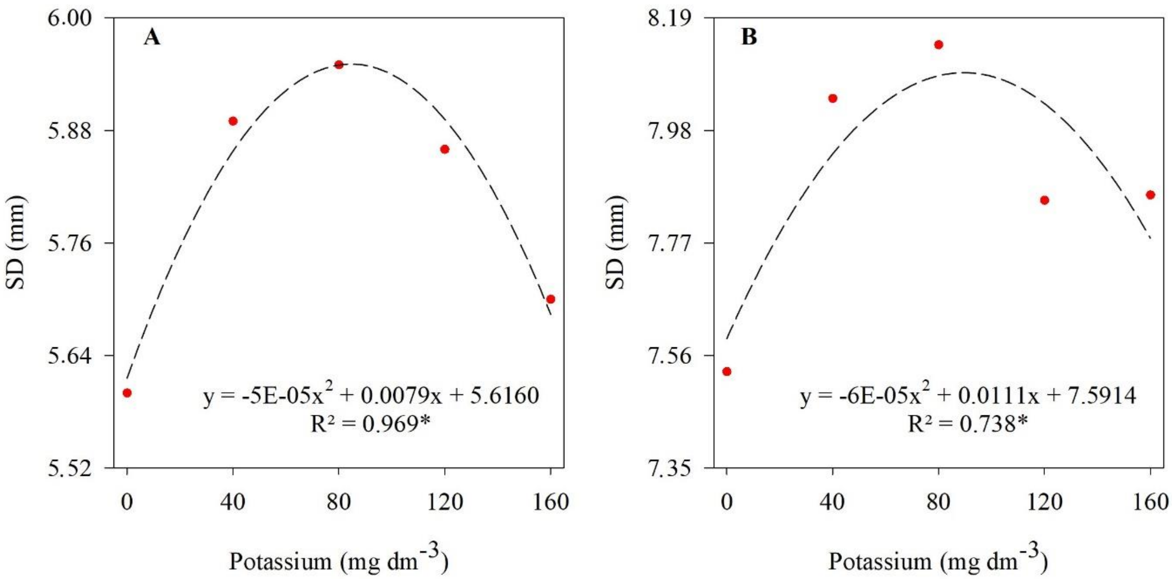

Figure 1. - Stem diameter (SD) of single assai palm (*E. precatoria*) seedlings according to potassium doses at 180 (A) and 240 (B) days after pricking out, Rio Branco, Acre, 2021. * Significant ($p < 0.05$)

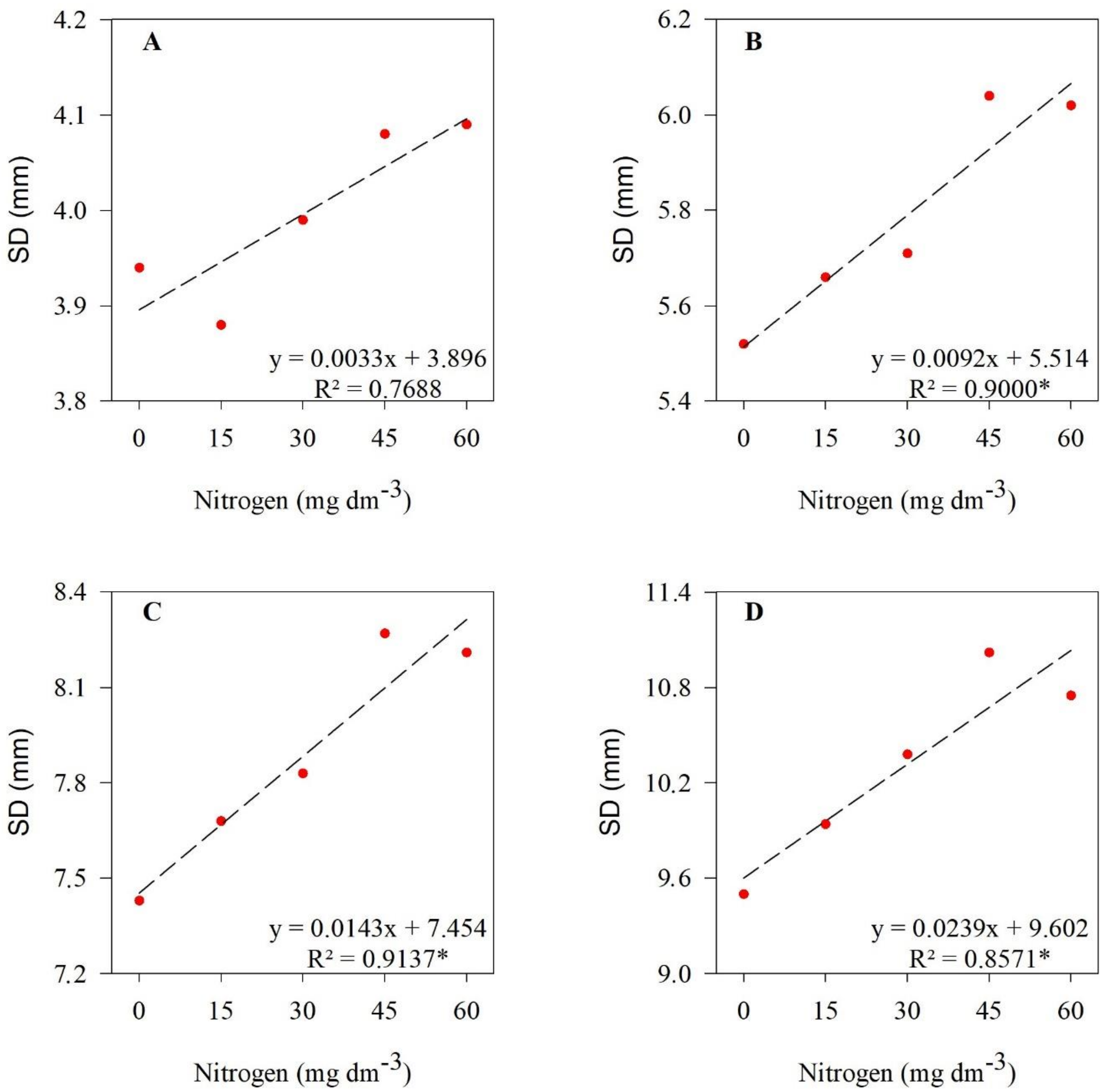

Figure 2. Stem diameter (SD) of single assai palm (*E. precatoria*) seedlings according to nitrogen doses at 90 (A), 180 (B), 240 (C), and 300 (D) days after pricking out, Rio Branco, Acre, 2021. * Significant ($p < 0.05$)

The growth and development of the seedling depend on the availability of N in the substrate because this macronutrient is used in the biosynthesis of nucleic acids, proteins, and chlorophyll (Morais et al., 2017; Srivastava et al., 2019). The gains shown in Figure 3, indicate that in the cultivation conditions, the percentages of N applied affect the growth of single assai pal seedlings through the discrepancy observed between the treatment of 0 mg dm^{-3} and 60 mg dm^{-3}. The seedlings are highly responsive to the doses applied in all periods evaluated (Figure 3). The absence of N on both days after pricking out culminated in statistically lower seedlings, a response already reported by Silva et al. (2020) that the absence of this nutrient affects the growth and development of the shoot.

Among the evaluation times, it is observed that only at 90 days after pricking out, all doses had the same percentage on average of active leaves; after this period, there are divergences between the doses applied (Figure 4). For this variable, increasing doses of N stimulate its development, which generally results in gains for the seedling, emphasizing the doses of 45 and 60 mg dm^{-3}. The number of active leaves can be considered an excellent indicator of plant quality since the doses also exert an increasing linear effect on plant height and stem diameter at 180, 240, and 300 days after pricking out.

Araújo et al. (2018) mention that there is a correlation between the mentioned parameters, which can directly influence biomass accumulation. Since only the stem diameter was influenced by potassium doses, the analysis of the increment rate was performed only to estimate the effect of nitrogen fertilization. Based on this and considering the most representative results within each evaluation period, the ideal N installment was estimated, as shown in Table 1.

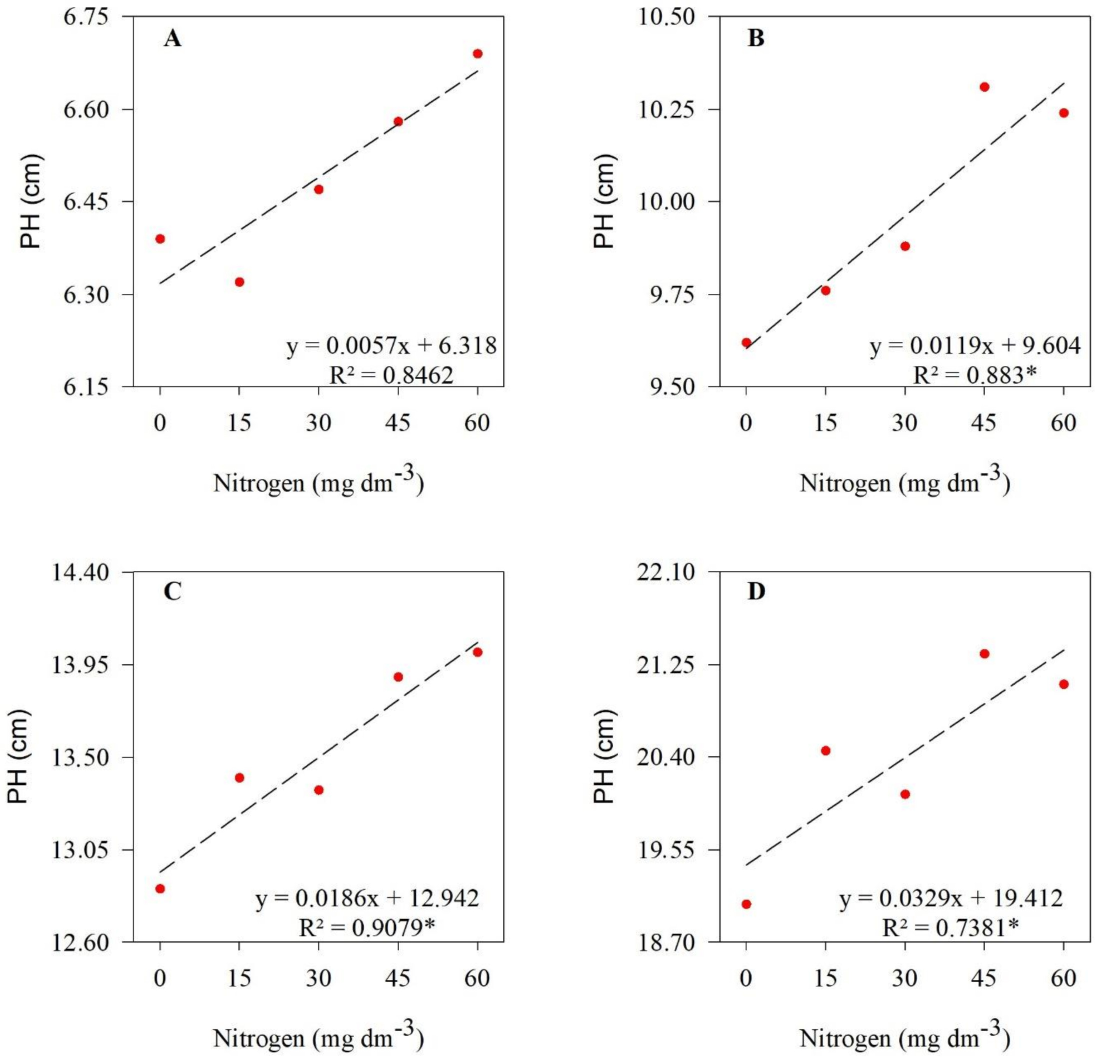

Figure 3. Plant height (PH) of single assai palm (*E. precatoria*) seedlings according to nitrogen doses at 90 (A), 180 (B), 240 (C), and 300 (D) days after pricking out, Rio Branco, Acre, 2019. * Significant ($p < 0.05$)

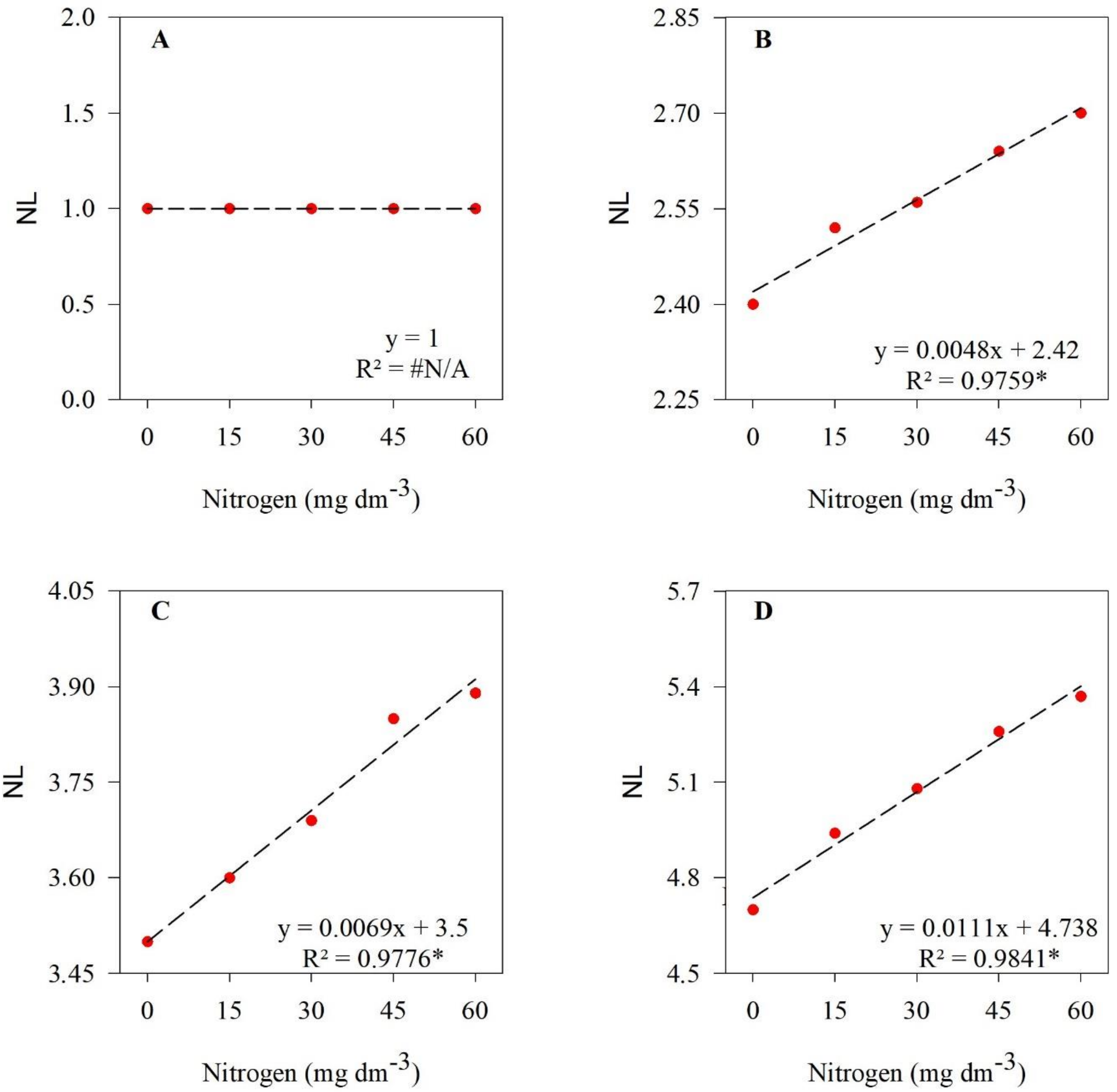

Figure 4. Number of leaves (NL) of single assai palm (*E. precatoria*) seedlings according to nitrogen doses at 90 (A), 180 (B), 240 (C), and 300 (D) days after pricking out, Rio Branco, Acre, 2019. * Significant ($p < 0.05$)

Table 1. Optimization of the parceling of nitrogen doses according to the highest response potentials of the variables plant height (PH), stem diameter (SD), and number of active leaves (NL) of *E. precatoria*, Rio Branco, Acre, 2021.

DAP	Increased response potential (%)			∑	μ	Estimated portion	
	PH	SD	NL			%	≅
90 - 180	7.17	9.42	12.50	29.09	9.70	28.30%	30%
180 - 240	8.94	11.31	11.14	31.39	10.46	30.53%	30%
240 - 300	12.07	16.00	14.26	42.33	14.11	41.17%	40%

DAP - Days after pricking out; μ - media and ∑ - summation.

Plant height and stem diameter gains occur gradually during the evaluation periods (Table 1). Even though the number of active leaves is not presenting the same behavior, it is verified that between 240 and 300 days after pricking out, there is a higher increment rate for the variable in question. Based on the response potential, nitrogen fertilization is recommended in the proportions of 30%, 30% and 40%, with 1st parceling at 90 DAR followed by 2nd and 3rd at 180 and 240 DAR. Araújo et al. (2016), when studying the effect of nutrient omission on the growth and nutritional status of assai palm seedlings, reported that the nutrients most required for the crop are N > K> S > Ca > Mg > P > Mn > Zn > B > Cu in this order. The authors also report that N and K influence leaf dry mass production and leaf area. Corroborating the observations mentioned above, Figure 5 shows that 300 days after pricking out, the dry mass contents of stipe (A), leaf (B), root (C), and total (D) have greater responses when the seedlings were submitted to 45 and 60 mg dm^{-3}

It is noted that the absence of nitrogen fertilization limits biomass accumulation in all vegetative parts of the seedling. Second Lima et al. (2018), the transport of nutrients within the plant depends on the symbiotic relationship between the root and shoot, the latter responsible for directing carbohydrates, phytohormones, and nutrients to the root. Acevedo et al. (2020) report that, when effectively available, N helps in the process of formation of new roots, as well as in root expansion, causing better efficiency regarding the absorption of other nutrients and subsequent distribution of them throughout the plant.

In the literature, the Dickson quality index is commonly used to estimate the quality of the seedling produced, indicating the potential for adaptability and development when they are available in the field. In addition to encompassing the main allometric parameters, it is possible to obtain significant responses by using the plant height/stem diameter ratio and shoot dry mass/root dry mass (Figure 6). It is observed that only potassium fertilization influences the PH/SD ratio, demonstrating a quadratic effect, with the dose of 77.50 mg dm-3 causing the lowest relationship between the variables.

Mota et al. (2021) mention that it is possible to monitor the quality of the seedling already implanted in the field using the variable mentioned above. For the SDM/RDM ratio, nitrogen fertilization was significant, resulting in a linear increase, indicating biomass allocation satisfactorily through the doses applied. According to Yang et al. (2018), the relationship between shoot and root dry mass is highly correlated with water and nutrient availability, and deficiency may cause a decrease.

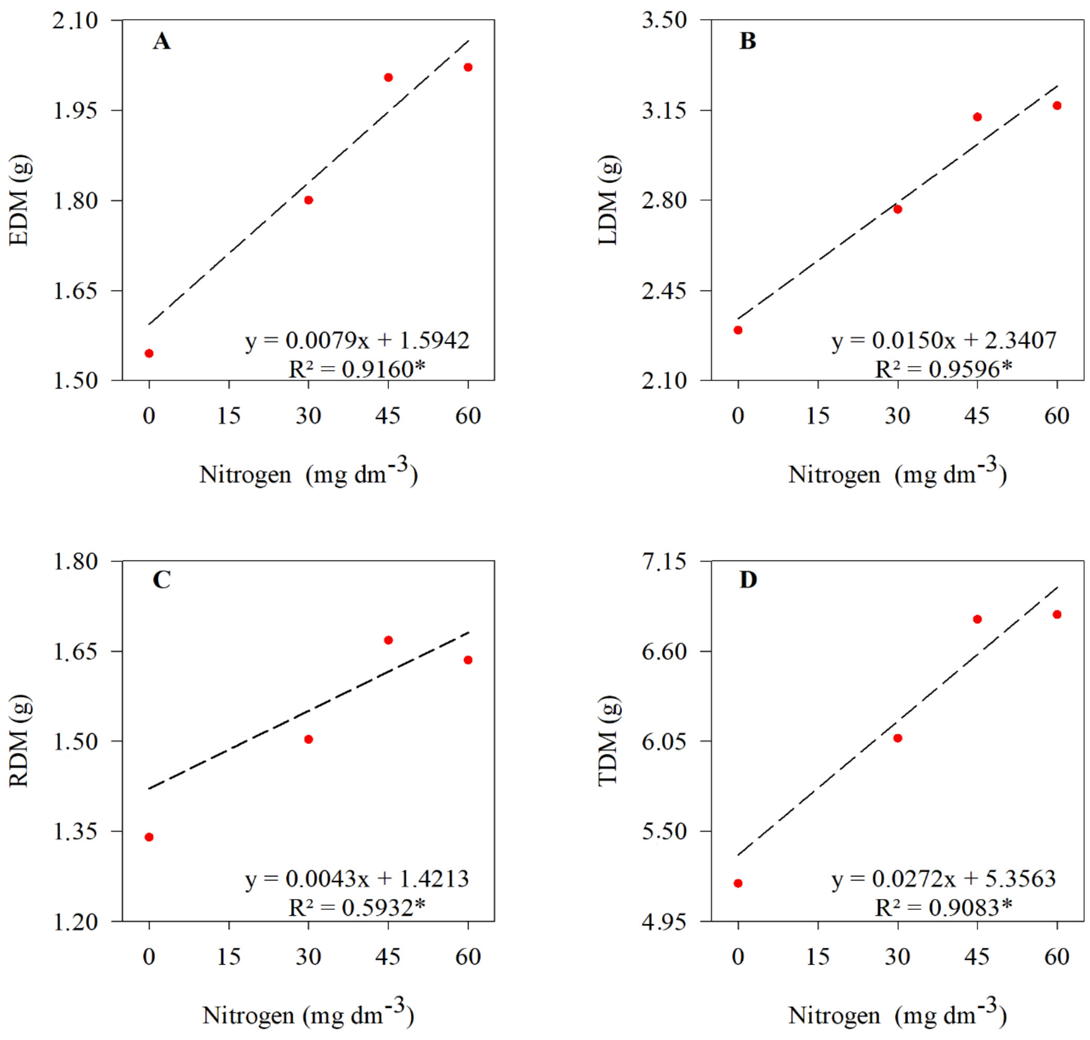

Figure 5. Dry mass of the stipe (EDM) (A), leaf (LDM) (B), root (RDM) (C), and total (TDM) (D) of single assai palm seedlings (*E. precatoria*) according to the nitrogen doses at 300 days after pricking out, Rio Branco, Acre, 2021. * Significant ($p < 0.05$)

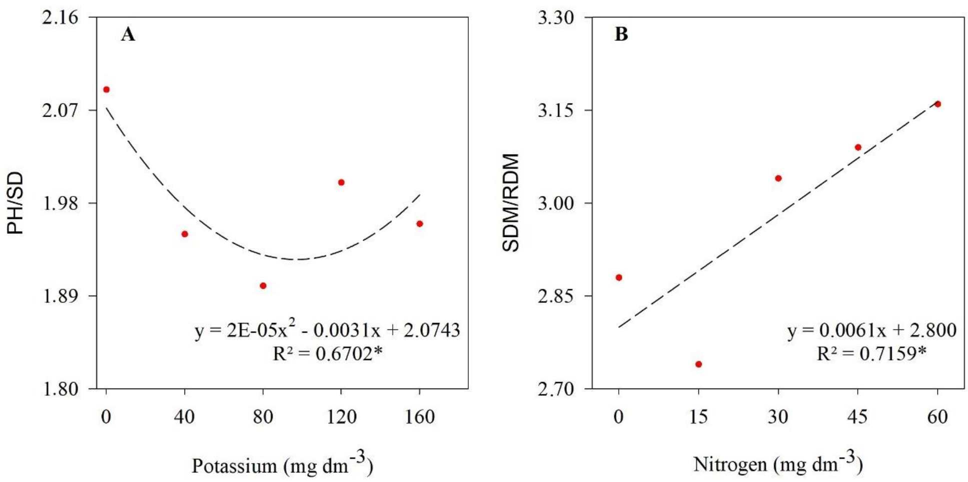

Figure 6. Ratio of plant height/stem diameter (PH/SD) (A) and shoot dry mass/root dry mass (SDM/RDM) (B) of single assai palm (*E. precatoria*) seedlings according to the potassium (A) and nitrogen (B) doses at 300 days after pricking out, Rio Branco, Acre, 2021. * Significant ($p < 0.05$)

4. Conclusions

Potassium fertilization influences the stem diameter at 180 and 240 days and the plant height/stem diameter ratio of single assai palm seedlings. Almost all variables of single assai palm seedlings are responsive to nitrogen fertilization except plant height/stem diameter ratio. For optimal nitrogen parceling in single assai palm seedlings, applications at 90, 180, and 240 days after pricking out are recommended, in the proportions of 30%, 30% and 40%, respectively.

Authors' Contribution

Conceptualization: Rychaellen Silva de Brito, Angelita Gude Butzke, Romeu de Carvalho Andrade Neto, Aureny Maria Pereira Lunz, Sergio da Silva Fiuza; project administration: Romeu de Carvalho Andrade Neto; formal analysis: Rychaellen Silva de Brito, Angelita Gude Butzke, Romeu de Carvalho Andrade Neto, Aureny Maria Pereira Lunz, Sergio da Silva Fiuza; Methodology: Rychaellen Silva de Brito; Supervision: Romeu de Carvalho Andrade Neto.

Validation: Rychaellen Silva de Brito, Angelita Gude Butzke, Romeu de Carvalho Andrade Neto, Aureny Maria Pereira Lunz, Sergio da Silva Fiuza; Visualization: Rychaellen Silva de Brito, Angelita Gude Butzke, Romeu de Carvalho Andrade Neto, Aureny Maria Pereira Lunz, Sergio da Silva Fiuza; Writing - original draft: Rychaellen Silva de Brito; Writing - review & editing: Rychaellen Silva de Brito, Angelita Gude Butzke, Romeu de Carvalho Andrade Neto, Aureny Maria Pereira Lunz, Sergio da Silva Fiuza.

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