

Production of *Euterpe precatoria* Mart. seedlings in response to different dosages of nitrogen and potassium

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Abstract

The success of açai establishment as a monoculture is associated with the care regarding seedling quality and health. From this perspective, this study aimed to evaluate the influence of nitrogen and potassium to produce seedlings of *Euterpe precatoria* Mart. The experiment was set up in a randomized block design in a 5x5 factorial arrangement, with the first factor corresponding to nitrogen levels (0, 15, 30, 45, and 60 mg dm⁻³ of N) and the second factor consisting of the potassium levels (0, 40, 80, 120, and 160 mg dm⁻³ of K), split into 20, 40, and 40% of the total dosage. The following were evaluated 300 days after harvesting: seedling height, stem diameter, number of active leaves, dry root, shoot, and total mass, and the Dickson Quality Index. The data were subjected to univariate analysis and then to regression analysis. A significant effect was observed only for the N levels, with a positive linear response on all variables analyzed. Thus, the nitrogen levels influenced the growth and quality of *E. precatoria* seedlings 300 days after transplanting. Potassium fertilization for *E. precatoria* seedlings during the nursery phase was not responsive to any variable. In addition, there was no effect of the interaction between the N and K levels on the growth of *E. precatoria* seedlings 300 days after transplanting, and seedlings subjected to increasing nitrogen levels were responsive, showing good morphological attributes.

Keywords: açai tree, amazon, extractivism, fertilization

Introduction

Belonging to the family Arecaceae, açai (*Euterpe precatoria* Mart.) is a native, autochthonous palm tree with a single stem present in recurrently flooded areas and mainly covering the Brazilian states of Acre, Pará, Rondônia, and Amazonas, with the latter being the leading açai producer in the country (Henderson, 1995, Ramos et al., 2018, Ramos et al., 2019). The açai palm tree stands out due to its significant economic potential since almost all its vegetative parts can be used, especially the fruit, which is used fresh and after industrially processed (Yamaguchi et al., 2015, Wojciechowska & Karolak, 2019).

(Carvalho et al., 2016) mention that the opening of new crop areas to suppress the productivity required by the industry has been growing since 1995, especially between 2002 and 2012. With the reduction in the dependence on the extractive system, (Martinot et al., 2017) reported that the gradual change from extractivist

practices to agro-industrial cultivation has been potentiated by the use of higher quality materials (Ramos et al., 2021).

The success of new commercial areas depends mostly on the use of healthy, early seedlings with high morphological standards and good adaptation after implementation in the field (Miranda et al., 2018). In this scenario, according to (Bezerra et al., 2018), the production of açai seedlings aims to favor the crop's regularity and mitigate the problem of uneven germination. The authors also mentioned that, to achieve faster seedling standardization, plants must be fertilized during initial growth to favor nutrient uptake.

Nitrogen (N) stands out among the main nutrients required for early plant development, influencing several growth and development physiological reactions (Soares et al., 2020). (Guerra et al., 2020) mention that, because it is directly correlated with biomass accumulation,

N influences the primary plant metabolism and the production of secondary metabolites, a characteristic already mentioned by (Taiz & Zeiger, 2015).

In addition to N, potassium (K) is equally important throughout plant development as balanced fertilization favors osmotic regulation (Evaristo et al., 2020). (Melo et al., 2020) reported that, because K is an enzymatic activator, many physiological processes depend indirectly on its availability, highlighting its participation in plant respiration and photosynthesis.

From this perspective, the nutrient requirements of seedlings throughout the vegetative phase should be met by incorporating these nutrients into the substrate, favoring the implementation of new growing areas and optimizing the crop yield. In this scenario, the objective of this study was to evaluate the influence of nitrogen and potassium on the production of seedlings of *Euterpe precatoria*.

Material and Methods

The experiment was conducted at the seedling production nursery of Embrapa Acre, Highway BR-364, Km 14, in Rio Branco, Acre, at the geographic coordinates 10°1'30"S, 67°42'18"W, at an approximate elevation of 160 m a.s.l. from December 2017 to November 2018 in a screened nursery with 50% shading. The climate of the region is hot and humid, fitting the *Am* type according to the Köppen classification (Alvares et al., 2013), with a mean annual temperature of 26.2 °C, relative humidity of 80%, and annual rainfall rates ranging from 1,700 to 2,400 mm.

The seedlings were produced in 4-L polyethylene bags measuring 18 cm in diameter and 30 cm in height containing an Acrisol substrate taken from the surface layer (0-20 cm) and subjected to liming, with the following characteristics: Ca = 4.95 cmol_c dm⁻³; Mg = 1.09 cmol_c dm⁻³; K = 0.02 cmol_c dm⁻³; Al+H = 0.45 cmol_c dm⁻³; CEC (pH₇) = 6.85 cmol_c dm⁻³; SB = 6.4 cmol_c dm⁻³; P = 10.6 cmol_c dm⁻³; pH (H₂O) = 7.25; 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. Subsequently, based on the chemical analysis of the soil, 100 mg kg⁻¹ of P was applied to the substrate via single superphosphate.

The seeds used in the study came from native plants located in Feijó, Acre, and were sown in the substrate containing saw powder. Seedling emergence began 35 days after sowing and achieved uniformity after 60 days, during which period the seedlings were in the "toothpick" stage and were transplanted to allow one plant per container.

The seedlings were irrigated daily using

an intermittent sprinkler system in the morning and afternoon. Weed control was performed by manual removal. Anthracnose control was performed by applying the fungicides tebuconazole + trifloxystrobin and pyraclostrobin + epoxiconazole every two weeks, both at the concentration of 2.5 ml per liter of water, according to (Nogueira et al., 2017).

The experimental design was in randomized blocks (DBC), with three replications and five plants per plot, in a 5x5 factorial arrangement whose first factor represented the N levels (0, 15, 30, 45, and 60 mg of N per dm⁻³ of soil), applied as urea, and the second factor corresponding to the K levels (0, 40, 80, 120, and 160 mg of K per dm⁻³ of soil), applied as potassium chloride, totaling 25 treatments.

In order to promote the best application of treatments in both factors, the nutrient levels were diluted in distilled water, and then 100 mL of the solution was applied per bag containing 4 kg of substrate. Furthermore, aiming to provide effective nutrient incorporation, fertilization was split to supply 20%, 40%, and 40% of the total levels at 40, 130, and 220 days after transplanting, respectively.

The following evaluations were performed 300 days after transplanting: seedling height (SH), stem diameter (SD), and the number of active leaves (NL). The SH was estimated in centimeters using a ruler, considering the highest visible height (from the surface of the substrate to the highest point of the seedling). The SD, in millimeters, was measured at 1 cm from the surface of the substrate using a digital caliper. The NL was determined by counting all open leaves (physiologically active).

For the destructive evaluations, the seedlings were removed from the containers, washed in running water, and separated into shoot (stipe and leaves) and root, both of which were packed separately in paper bags and dried to constant weight in a forced-air oven at 55 °C for 72 hours. Subsequently, the dry shoot mass (DSM), root mass (DRM), and total mass (DTM) were determined in grams using an analytical balance (Benincasa, 1988).

After determining these parameters, it was possible to calculate the Dickson Quality Index (DQI) as a function of seedling height (SH), stem diameter (SD), dry shoot mass (DSM), dry root mass (DRM) and total mass (DTM), according to the following equation (Dickson et al., 1960):

$$DQI = \frac{DTM (g)}{SH (cm) / SD (mm) + DSM (g) / DRM (g)}$$

The collected data were subjected to discrepancy analysis by the (Grubbs, 1969) test,

normality of residuals by the (Shapiro-Wilk, 1965) test, and homogeneity of variances by the Levene test (Gastwirth et al., 2009). Once the assumptions were met, the analysis of variance was performed by the F-test (Snedecor & Cochran, 1948), followed by regression and when the data were significant for quantitative variables (levels).

Results and discussion

The analysis of variance showed a significant effect ($p < 0.05$) when using the nitrogen (N) levels for all variables studied, whereas potassium (K) and the N x K combination did not influence the growth and development of açai seedlings ($p > 0.05$) (Table 1). The coefficient of variation (CV) indicates good experimental precision, ranging from 6.64% to 16.23%.

The lack of influence of the K levels is possibly due to the low availability of this nutrient in the substrate and the CEC value observed since, because K is mobile, it is rapidly absorbed and may therefore have only met the initial nutrient requirement. However, although the result is not significant, this nutrient is important for seedling growth and development and can assist directly in the uptake and movement of other nutrients, in addition to favoring water balance, making the plant resistant to biotic and abiotic stresses (Reetz Jr., 2016).

(Bezerra et al., 2020) mention that, during the seedling formation phase, potassium fertilization positively influences biochemical and physiological reactions, especially stomatal control, carbohydrate transport, transpiration, and tissue turgescence. The authors also reported that, when applying silicate or potassium sulfate, it is possible to obtain high-quality seedlings while paying attention to the dosages provided so that a biometric decrease does not occur in the plants.

In contrast to potassium, nitrogen had a positive linear effect on all variables analyzed. Therefore, when applied gradually, this nutrient provides gains in seedling quality, and its incorporation becomes more effective. According to (Figure 1), better height and diameter results were observed as the N levels applied increased.

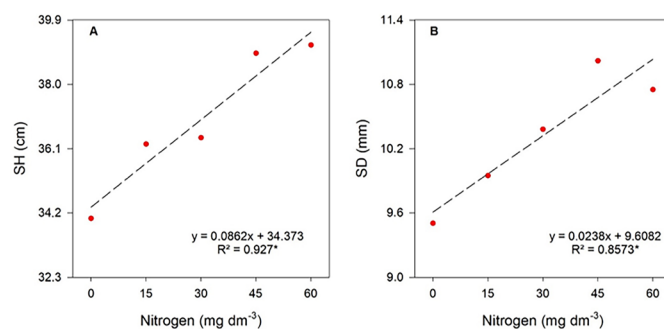


Figure 1. Seedling height (SH) (A) and stem diameter (SD) (B) of açai seedlings (*E. precatoria*) as a function of nitrogen levels, Rio Branco, Acre, 2021.

Although it has shown a linear effect for seedling height and stem diameter, studies with higher nitrogen levels have reported a reduction in these variables. (Bezerra et al., 2018) used urea, calcium nitrate, and ammonium sulfate as nitrogen sources and obtained a negative quadratic response with increasing nitrogen levels regardless of the material applied, evidencing a contrary effect to that observed in the present study.

The variables in question are important non-destructive morphometric descriptors and, according to (Boechat et al., 2020), the quotient obtained between both represents the seedling's balance, which is used to estimate the possible plant stretching and the survival capacity in the field as well as the rusticity, thus reducing losses caused by the transport process and adaptability.

Furthermore, in addition to plant height and stem diameter, the number of leaves is equally important to assess which seedlings have higher survival percentages when transplanted to the field. For this variable, increasing nitrogen levels stimulate the formation of new leaves (Figure 2), and although the difference expressed between the dosages is not of great magnitude, the absence of N provides an inferior leaf development compared to the other treatments.

As a quality standard, the State (Commission of Seeds and Seedlings of Pará, 1997) estimates that açai seedlings under good growing conditions must present at least five leaves considered physiologically mature, which

Table 1. Analysis of variance in blocks in the 5x5 factorial arrangement for the variables dry root mass (DRM), dry shoot mass (DSM), total dry mass (DTM), seedling height (SH), stem diameter (SD), number of leaves (NL), and Dickson Quality Index (DQI) of açai seedlings (*E. precatoria*) as a function of nitrogen and potassium levels, Rio Branco, Acre, 2021

Source of variation	GL	DRM	DSM	DTM	SH	SD	NL	DQI
Nitrogen (N)	4	0.26*	4.65*	6.89*	67.59*	5.57*	1.04*	0.12*
Potassium (k)	4	0.09 ^{ns}	0.67 ^{ns}	1.22 ^{ns}	4.04 ^{ns}	0.98 ^{ns}	0.10 ^{ns}	0.04 ^{ns}
N x K	16	0.07 ^{ns}	0.50 ^{ns}	0.86 ^{ns}	7.63 ^{ns}	0.54 ^{ns}	0.08 ^{ns}	0.02 ^{ns}
Block	2	0.07 ^{ns}	6.05*	7.28*	16.94 ^{ns}	4.31*	0.94*	0.08*
Residuals	48	0.06	0.54	0.89	10.10	0.5	0.11	0.02
Mean	-	1.55	4.62	6.17	36.96	10.32	5.07	0.94
CV (%)	-	15.27%	15.95%	15.26%	8.60%	6.83%	6.64%	15.54%

* - significant at the 0.05 level of probability; ^{ns} - not significant.

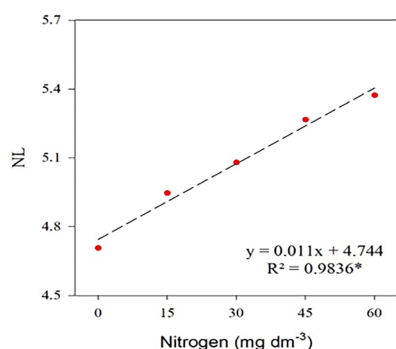


Figure 2. Number of leaves (NL) of açai seedlings (*E. precatoria*) as a function of nitrogen levels, Rio Branco, Acre, 2021.

can be achieved when applying nitrogen levels higher than or equal to 23.27 mg dm⁻³. Therefore, the influence of nitrogen on the number of leaves results from the direct contribution of this macronutrient to the expansion of the leaf area, an extremely important structure when seeking higher seedling survival rates in the field (Azevedo et al., 2021).

Studies on biomass accumulation have reported that the dry shoot (DSM) and root masses (DRM) are correlated with seedling rusticity and their subsequent performance in the growing area (Silva et al., 2018). The results expressed in (Figure 3) corroborate this statement as both variables showed an increase in biomass when higher N levels were applied.

(Nascimento et al., 2019) stated that there is a positive correlation between nitrogen fertilization and dry mass production. The authors reported that this effect occurs because N significantly increases the interaction between enzymatic reactions and plant metabolism, resulting in greater chlorophyll availability in the leaves and thus generating photoassimilates that act directly in the production of biomass in the plant structure.

The total dry mass is directly influenced as the N levels increase, a characteristic already observed when measuring the shoot and root dry masses. The N levels of

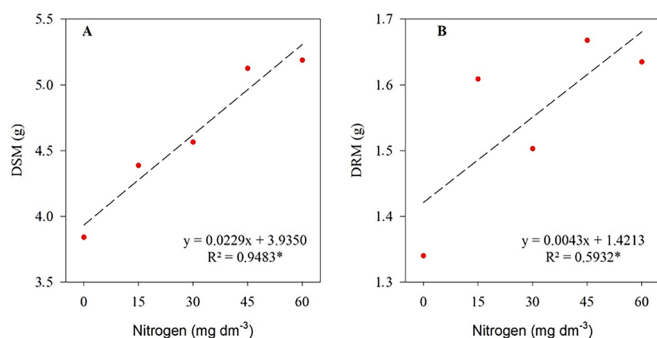


Figure 3. Dry shoot (DSM) (A) and root mass (DRM) (B) of açai seedlings (*E. precatoria*) as a function of nitrogen rates, Rio Branco, Acre, 2021.

45 mg dm⁻³ and 60 mg dm⁻³ produced higher results (6.80 g and 6.82 g respectively) than in the seedlings fertilized with 0 mg dm⁻³ of N, evidencing that the increase in the N level provides higher yields (Figure 4).

(Ferreira et al., 2021) reported that, due to the importance of N, the lack of this nutrient during seedling formation reduces plant growth, development, the accumulation of total biomass, and the subsequent crop yield. Corroborating this statement, all variables evaluated increased as the N levels increased, which is consistent with the relevance of this nutrient for the crop.

The Dickson Quality Index (DQI) is a great indicator of seedling quality as it generally considers parameters such as seedling robustness and balance in biomass distribution (Marques et al., 2018). In this variable, the presence of N results in indices higher than 0.90, whereas the absence of N reduces this value to 0.79 (Figure 5).

When biomass allocation occurs proportionally in the different plant organs, the DQI is highly representative as it indicates whether seedlings conducted in a given environment can withstand adverse conditions after transplanting, i.e., the higher this index, the better the seedling quality (Ribeiro et al., 2021).

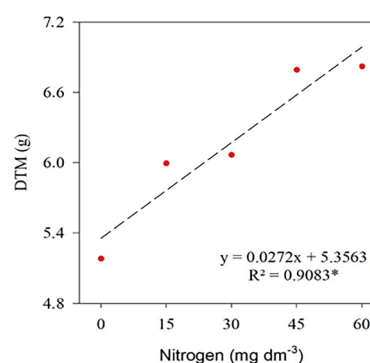


Figure 4. Total dry mass (DTM) of açai seedlings (*E. precatoria*) as a function of nitrogen levels, Rio Branco, Acre, 2021.

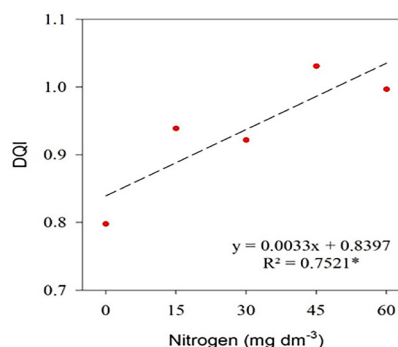


Figure 5. Dickson Quality Index (DQI) of açai seedlings (*E. precatoria*) as a function of nitrogen levels, Rio Branco, Acre, 2021.

Conclusions

Nitrogen levels influence the growth and quality of *Euterpe precatoria* seedlings 300 days after transplanting.

Potassium fertilization for *E. precatoria* seedlings during the nursery phase is not responsive to any variable.

There is no effect of the interaction between N and K levels on the seedling growth of *E. precatoria* 300 days after transplanting.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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