Evaluation of the tolerance of canafistula (*Peltophorum dubium*) under different nitrogen doses

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ABSTRACT

The species *Peltophorum dubium* is widely recognized in Rio Grande do Sul with the common name Canafistula belonging to the Fabaceae family. If there is a deficiency of mineral elements in the soil, the species may experience a decreased response to growth, resulting in slower development. In view of the above, it is intended to evaluate the growth of the Canafístula species in response to different nitrogen dosages. In this way, we sought to determine the plant's response to varying levels of this element. The variables analyzed were: stem diameter, number of leaves, shoot height, shoot mass, root length, root mass and dry mass of both shoots and roots. First, sowing was carried out. On March 20, the seedlings were transplanted to the pots. A randomized block design was used with five replications for each treatment. A total of 20 vessels were subdivided into 4 treatments, T1, T2, T3 and T4 of N doses (0, 40, 80, 120 kg ha-1 respectively). The harvest was carried out on June 19, removing them from the pots. It was left in an open air circulation kiln. The results of the analysis of variance showed a significant effect of the nitrogen doses applied to the Canafístula seedlings for all the variables evaluated except the root dry mass. In all variables, the adjusted regression curve was quadratic and thus the point of maximum technical efficiency for each response variable was determined. The best treatment was T2, which was the critical dose. The T4 that obtained the highest N dose was observed to exceed the critical dose because the culture presented nitrogen toxicity resulting in senescence of the treatment, having as the most severe treatment for the culture. With the results obtained in this research, it was evident that nitrogen plays an extremely relevant role in the production of Canafístula, since it was demonstrated by the results of the analysis of variance a significant effect for all variables except root dry mass.

Keywords: Varied Levels, Fertilization, Growth, Critical Dose, *Peltophorum dubium seedlings*.

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INTRODUCTION

The species *Peltophorum dubium* belonging to the Fabaceae family is widely recognized in Rio Grande do Sul with the common name Canafístula, although it is also known by other denominations, such as Angico-bravo in São Paulo. The etymology of its scientific name *Peltophorum* refers to the meaning "what drives the disc", referring to the stigma of the flower. In addition, in the Tupi-Guarani language, this tree is called ibira-puita-guassú, which translates as "big-redwood" (LONGHI, 1995).

The wood produced by this species has a significant economic value, which is attributed both to its versatility of use and to the quality of its wood. Therefore, it is extremely important to promote a vigorous growth of this plant, considering its economic potential. Understanding the relevance of macronutrients in plant nutrition becomes fundamental in this context, since they are essential chemical elements for vigorous plant development.

In cases of deficiency of these mineral elements in the soil, the species may experience a decreased response to growth, resulting in slower development even in the case of a crop belonging to the legume category (a group known for its ability to fix atmospheric nitrogen through symbiosis with bacteria). Therefore, maintaining proper macronutrient levels in the soil is essential to ensure robust and healthy growth of this plant, which is critical to its economic viability.

Initially, when choosing the object of this research, a certain degree of difficulty was obtained to find relevant scientific literature on the subject in question. However, as the experiment progressed and after a few weeks of research, some scientific articles were identified and reviewed that addressed the influence of fertilization on the species under study. According to Carvalho (2002), most of these scientific studies corroborated the hypothesis that this crop has a substantial demand for fertilization, particularly when it comes to macronutrients.

The objective of this research is to evaluate the growth of Canafístula in the face of different doses of nitrogen, in order to understand the response of this plant to different amounts of this element and to establish parameters to optimize the nutritional management of the species in cultivation environments.

THEORETICAL FRAMEWORK

Canafístula is part of the legume family Fabaceae and is a native tree species that can be called by several popular names such as Angico-bravo for example (CARVALHO, 2002). As for the characteristics, it prefers moist clay soils with great depth of riverbanks, occurring in dense primary forest as well as in secondary formations. Its dispersion is vast and rich, especially in the regions closest to the great river (LORENZI, 2008).

According to Corrêa (1931), its wood has greater durability in dry places and has several uses, being intended for sleepers, bodywork, cooperage, clotheslines, lathes, saddles, civil construction, carpentry and dyeing. Its roots, fruits, and leaves can be used as medicinal properties. Canafístula also enables urban reforestation and property dividing fences. Its fruiting is abundant and develops mainly in the red and clayey soils of the river banks.

Canafístula is among the 15 most important forest species aimed at the sawmill market in the South region (RUSCHEL, 2003) with large-scale capacity for wood production in the Center-South of Brazil (CARVALHO, 1998). On the wood, it has a light pinkish-pink sapwood color, an irregular heartwood that alternates between pinkish-brownish and dark pinkish beige, medium-coarse texture and indistinct flavor (CARVALHO, 2002).

Between the months of March-April the fruits ripen, however the small pods remain viable on the tree for several months. To obtain the seeds, it is recommended that the fruits (pods) of the tree be harvested when they reach the paleaceous color. Sowing can be done with the pods as if they were seeds, however this can result in the formation of crooked or defective seedlings. That said, when possible, you should extract the seeds from the pods. For an easier operation, they can be left in the sun to dry and after that use manual or mechanical friction (LORENZI, 2008).

Its flowering occurs between the months of December and February, starting its production process between 8 and 12 years old with the maturation of the seeds from April to June. Its dispersion occurs autochorically, with barochoric being the main one, by gravity, and anemochoric, when dispersion occurs by wind. Its seeds can be found in the soil seed bank (CARVALHO, 2002).

According to Marchiori & Alves (2012), more specifically in the state of Rio Grande do Sul under analysis, Canafístula is geographically distributed in the Upper Uruguay Seasonal Forest, being one of the most representative, surrounding the riparian forest of the great river up to the municipality of Barra do Quaraí, reaching the Uruguayan department of Artigas and the northeast of the Argentine province of Entre Rios. The Canafístula attracts the eyes of the beholder because it is able to make an ornamentation between the yellow of its numerous flowering that contrasts with the green of the other trees in the canopy, an event that occurs between the months of December and April.

According to Mattei & Rosenthal (2002), in the state of Rio Grande do Sul, the territorial surface cover in relation to forests has been successively decreasing more and more, remaining less than 1/3 of the total area, being restricted only to preservation areas, parks, reserves, small percentages in areas of difficult access and in rural properties represented by small remnants that are generally partially exploited. This resulted in the threat of extinction of several species of high value and economic interest, one of them being the Canafístula.

MACRONUTRIENTS

Macronutrients are a group of essential nutrients needed in large quantities for plant growth and development. They perform distinctive functions in the life of the plant, although in some cases it is possible to replace them with other elements. Thus, macronutrients perform three main functions, acting as structural components, constituting enzymes or playing the role of enzymatic activators (MALAVOLTA, 2006).

Macronutrients, namely nitrogen (N), phosphorus (P) and potassium (K), are the mineral elements that, in many cases, play a decisive role in the development of agricultural crops. This is due to its high quantitative demand (in the case of N and K) or its tendency to become insoluble in the soil (as is the case with phosphorus, P). It is worth mentioning that, with the exception of legumes that have the ability to fix atmospheric nitrogen in symbiosis with bacteria, as is the case of Canafístula, the three nutrients can be supplied through fertilization, whether organic or mineral, in most crops and soil types (BISSANI et al., 2008).

In its structural form, the element participates in the molecule of one or more organic compounds, such as amino acids and proteins composed of N; pectate formed by Ca, which is known to be a polygalacturonic acid salt of the middle lamella of the cell wall; the center of the tetrapyrrolic nucleus of chlorophyll occupied by Mg. The enzyme constituent is an individual case of the previous one, it is related to elements, usually metals or transition elements, for example Mo, which is within the prosthetic group of enzymes and which are essential for their activity, such as Cu, Fe, Mn, Mo, Ni, Zn. Finally, the enzymatic activator that does not participate in the prosthetic group of the element, dissociable from the protein portion of the enzyme (apoenzyme), is useful for its activity, such as Na+, K+, Rb+, Cs+, among others (MALAVOLTA, 2006).

NITROGEN

Nitrogen (N) is considered an essential element for plants due to its presence in nucleic acids and proteins, molecules crucial for all biological processes. Being a fundamental constituent, nitrogen is the nutrient that plants demand in greater quantity. An essential element is characterized as one that plays an intrinsic role in the structure or metabolism of a plant, the lack of which results in severe abnormalities in plant growth, development, reproduction, or may even prevent the plant from completing its life cycle (TAIZ et al., 2017).

According to Raij (1981), nitrogen is found in the soil mainly in its organic form, being a mobile element. The surplus, which is a small, highly variable part of the total content, is present in the inorganic forms of ammonium, and especially nitrate. In cases of adequate aeration and not too acidic pH, ammonium is transformed into nitrate quickly. Its absorption occurs through the roots of plants, in the form of nitrate, known to be a free form not adsorbed to the soil that basically enters the plant along with water, so the mass flow almost entirely meets the requirements of crops. The same occurs with sulfur, consumed in the form of sulfate.

Nitrogen makes up 5% of the organic matter in the soil. In organic form, it represents approximately 98% and only 2% in mineral form (MALAVOLTA, 2006). Appropriate nitrogen fertilization consequently improves the leaf contents of this and other nutrients, especially P, which results in an increase in growth and productivity (BONNEAU et al., 1993).

MATERIAL AND METHODS

The experiment was carried out in the experimental area of the Agronomy course of the Federal University of Pampa - Unipampa - Itaqui Campus, with latitude 29º09'50"S and longitude 56º33'09"W. The area is located in the municipality of Itaqui, on the western border of Rio Grande do Sul, with a Cfa climate, according to the Koppen climate classification, meaning that there is no defined dry season with a humid subtropical climate with hot summers (WREGE et al., 2012). It should be noted that the soil is characterized as a Dystrophic Clay Plintosol (EMBRAPA, 2018).

Initially, sowing took place between January 16 and 17, using 72-cell trays. Three seeds were placed in each cell, in a mixture of commercial substrate and sieved soil, with a ratio of 1:1. During the initial phase of plant development, the seedlings were kept under the protection of a shade cover, with 50% shading. On March 20, the seedlings were transplanted to pots with a volume of 2,000,000 dm^3.

A randomized block design was used with four treatments and five replications for each treatment. For cultivation in pots, the soil of the experimental area was used as substrate. The 4 treatments, T1, T2, T3 and T4 consisted of N doses (0, 40, 80 and 120 kg.ha-1, respectively), with five replicates for each treatment, totaling 20 experimental units. To calculate fertilization, the Manual of Fertilization and Liming for the States of Rio Grande do Sul and Santa Catarina (SBCS, 2016) was used, and the Black Wattle was used as a reference because it is within the same family. For the Black Acacia crop, the recommended dose according to the manual and according to the soil analysis of the experimental area is 40 kg.ha-1. The N doses were deposited in the form of urea, using SFT for phosphorus and potassium chloride fertilization, and mixed together with the soil in the pots. For the SFT dose, 351 kg ha-1 was supplied, equivalent to 2.33 g vase, and for the potassium chloride proportions, 206 kg ha^{-1} was supplied, being 1.37 g vase-1.

The thinning of the plants was carried out 14 days before the time of harvest, when there were two. On June 19, the harvest was carried out, removing them from the pots, classifying them according to the treatment, washing the roots in running water and taking them to the soil laboratory for evaluations. For the evaluations, a caliper, a tape measure and a precision scale were used. Stem diameter, shoot height, root length, shoot green mass and root green mass were evaluated. To measure the dry mass of the shoot and root, the seedlings were left in paper bags to deposit them in an oven with open air circulation at 65 °C for about 3 days.

The records obtained were submitted to an analysis of variance, and the statistical software R was used to conduct the statistical analysis. For statistical analysis, the data were evaluated for normality and homoscedasticity.

RESULTS AND DISCUSSION

The results of the analysis of variance showed a significant effect of the nitrogen doses applied to the Canafístula seedlings for all variables evaluated except root dry mass (MSR). In all the variables analyzed, the adjusted regression curves showed a quadratic behavior, allowing the determination of the point of maximum technical efficiency for each response variable.

Table 1. ANOVA board.

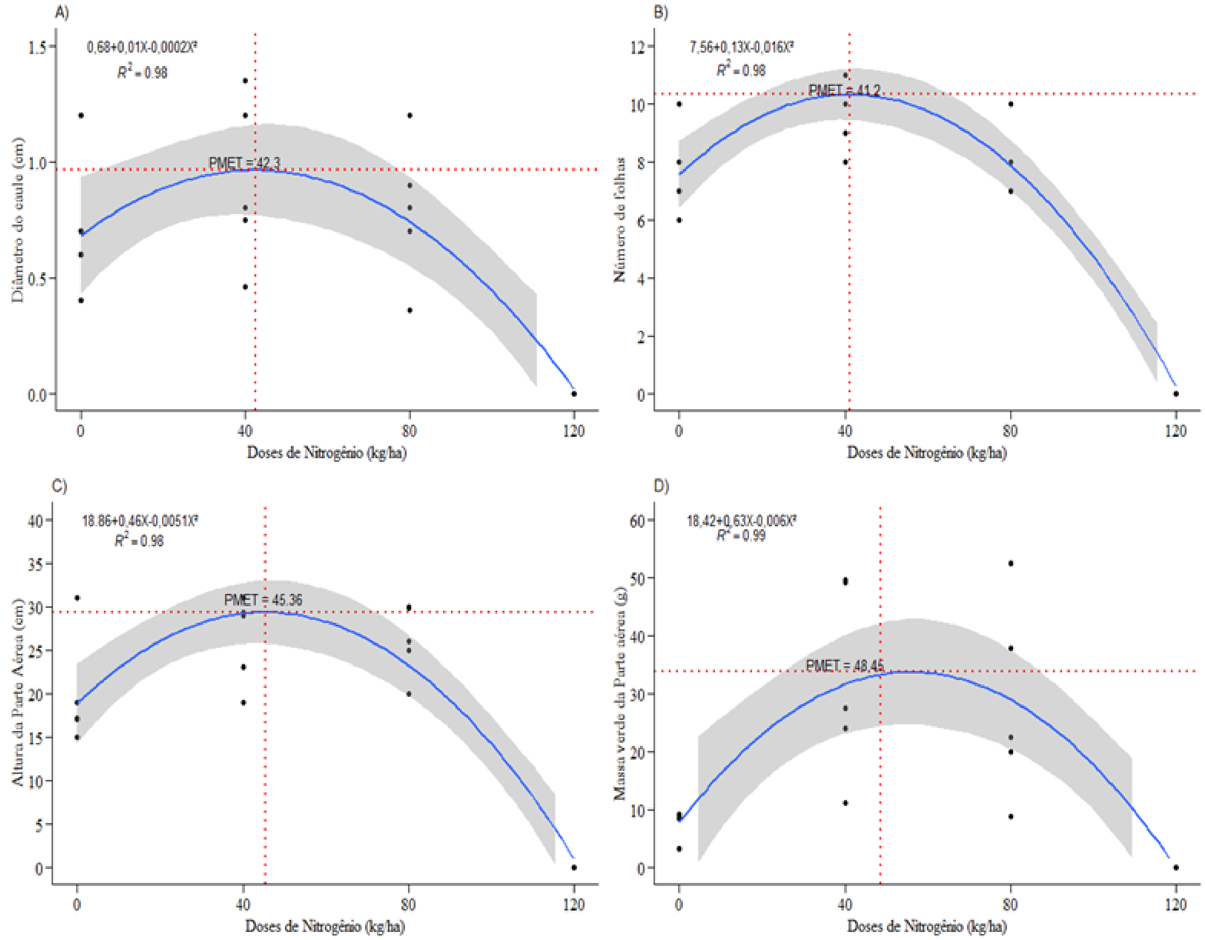
QM								
FV	DC	NF	APA	MPA	CR	MR	MSPA	MSR
Kicked	2,5*	289,9*	2310,9*	3094,8*	2265,5*	98,1*	495,9*	12,53**
Residue	1,3*	21,2*	333,6*	4877,8*	450,6*	153,8*	630,9*	21,83**
CV	46,5*	17,7*	25,3*	88,1*	29,4*	92,4*	83,6*	101,08**

Source: Prepared by the authors (2023)
*Significant at 5% ($p<0.05$) according to the Barlett test;
**Not significant at 5% ($p<0.05$) according to the Barlett test.
QM: Mean square; FV: Sources of variation; Treatment: Treatment; CV: Coefficient of variation; DC: Neck diameter; NF: Number of sheets; APA: Height of the aerial part; MPA: Mass of the aerial part; CR: Root length; MR: Green mass of the root; MSPA: Shoot dry mass; MSR: Dry root mass.

The maximum technical efficiency of a crop designates how much is the upper limit of production, depending on nutrient doses. This point is the maximum increase of the variable studied as a function of the increase in the availability of nutrients for the crop (ORTIGARA et al., 2012). In this context, it is crucial to identify the point of maximum technical efficiency, since this allows determining the most effective treatment and assessing whether the dose applied was adequate. In this way, both excessive application, which would lead to fertilizer waste, and insufficiency, which would require larger doses, is avoided, ensuring a more precise and efficient use of resources.

Figure 1 shows the results of the study on the growth of Canafístula seedlings (scientific name: *Peltophorum dubium*) under controlled conditions, where different doses of nitrogen were applied.

Figure 1: Growth of Canafístula seedlings, grown in pots with different doses of nitrogen. A) Stem Diameter (cm); B) Number of Sheets; C) Height of the Aerial Part (cm) and D) Green Mass of the Aerial Part (g)



Source: Prepared by the authors (2023)

In graph A, the diameter of the stem is observed under different doses of nitrogen, as can be seen in the dose 40 kg.ha-1 the diameter of the stem was larger compared to treatment 1 and treatment 3 because if the percentage difference in values of treatments 1, 2 and 3 is calculated (Appendix 1) there are lower values in treatments 1 and 3, where we will have 23.25% and 13.15% less production respectively, with higher percentages of production in treatment 2 demonstrating the behavior of the curve. The analysis of this graph allowed us to estimate the dose corresponding to the PMET of 42.3 kg $^{ha-1}$ of nitrogen for plant height.

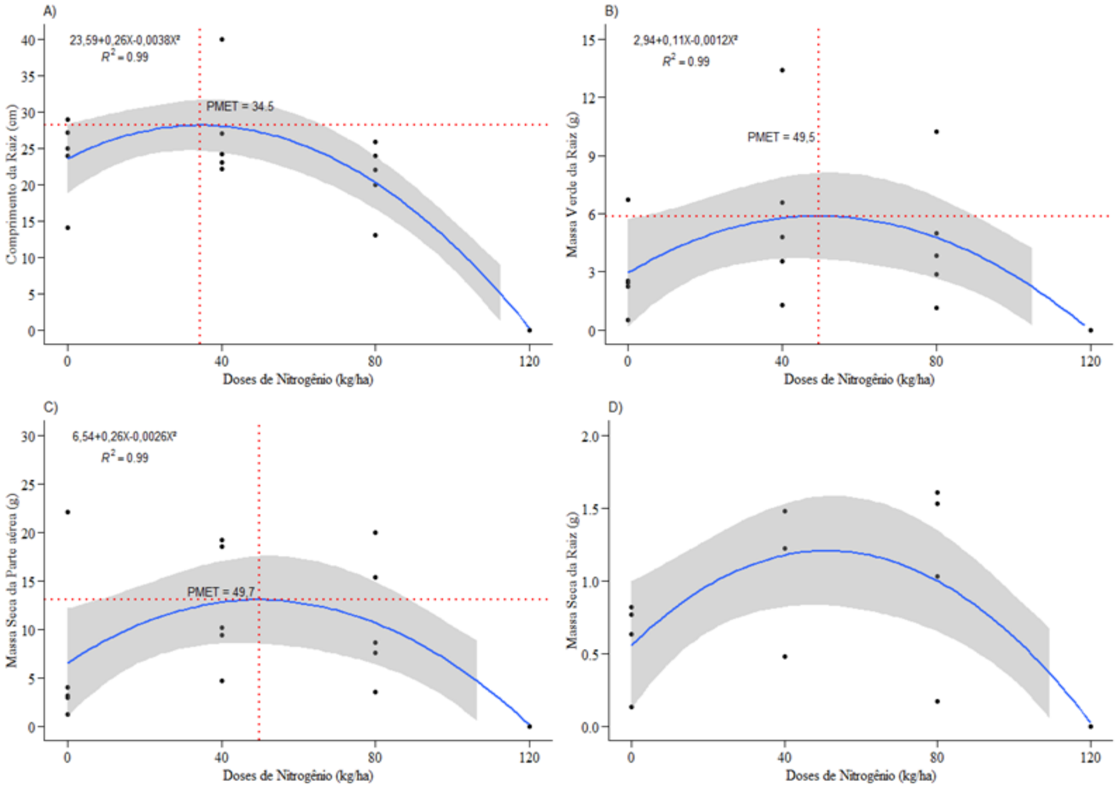
In relation to graph B, we have the number of leaves at different doses of N, observing that at the dose 40 kg $^{ha-1}$ the number of leaves is higher compared to treatments 1, 3 and 4 with the MET point being 41.2 kg $^{ha-1}$ of nitrogen.

In Graph C, the height of the aerial part was identified, with a greater increase in the dose of 40 kg $^{ha-1}$. In treatments 1 and 3, there are lower averages in these treatments, with percentage differences of 24.45% and 0.38% of production less, and a higher average in treatment 2, as shown in graph C. The MET point is 45.36 kg $^{ha-1}$ of nitrogen.

As for graph D, which refers to the green mass of the shoot, we have a low green mass of the shoot in treatments 1, 3 and 4 and a high green mass of the shoot in treatment 2, resulting in a higher yield at the dose 40 kg $^{ha-1}$. The MET point is 48.45 kg $^{ha-1}$.

Figure 2 presents the results for the variables Root Length (in centimeters), Green Root Mass, Shoot Dry Mass and Root Dry Mass (all masses are in grams). These parameters are indicators of the effect of nitrogen on both root and shoot growth, providing a holistic approach to species performance in varied fertilization contexts.

Figure 2: Growth of Canafístula seedlings, grown in pots with different doses of nitrogen. A) Root length (cm); B) Green root mass (g); C) Shoot dry mass (g) and D) Root dry mass (g)



Source: Prepared by the authors (2023)

Specifically in the T1 treatment, there was no maximum expression of the culture due to the fact that there was no application of nitrogen, phosphorus and potassium. In this way, Canafístula obtained a low development, resulting in low height of the aerial part, a smaller number of leaves as well as a smaller diameter of the stem and lower dry mass and green mass of the root and aerial part.

In the T2 treatment, although it was not the highest dose, it was possible to observe a more vigorous development of Canafístula, with successive progress each week. It should be noted that Canafístula can take advantage of almost or all the full dose observed by the PMET in figures 1 and 2. For a better understanding, the dose used in this treatment was 40 kg.ha-1, however in some variables it was observed that the plant would better use a dose above 40 kg.ha-1, which is the case of the green mass of the root (Figure 2, B). However, the opposite occurred, where Canafístula would better use a dose below 40 kg.ha-1, which is the example of root length (Figure 2, A). This value is of great value because it is possible to measure a dose more accurately without wasting nitrogen application.

In the T3 treatment, where the highest dose was applied, it was observed that Canafistula absorbed excess N and unbalanced the metabolism resulting in a lower growth, as it was a high dose, which resulted in waste, therefore not recommended. As an example, there was a gradual decrease in the nitrogen dose of 80 kg.ha-1. A valid hypothesis for this treatment would be to divide the dose in two, avoiding the imbalance of the plant's metabolism.

In the T4 treatment, it was considered as zero since it was not possible for the culture to remain until the end of the experiment, in other words, there was plant toxicity due to the high dose of nitrogen, which resulted in Senescence of the Canafistula. For this reason, the chart shows the lowest growth.

Cruz et al. (2011) who analyzed the growth and quality of Fedegoso seedlings grown in a red-yellow latosol in response to macronutrients also found low growth averages in all the attributes examined, in the treatment without added nutrients, which shows that the macronutrient contents preliminarily present in the soil used as substrate to produce Fedegoso seedlings are low. Even with small plant growth averages, which can be explained by Liebig's Minimum law, where plant development is limited by the nutrient that has the least availability in the soil, even if the others are at higher levels for plants. Thus explaining the reason why treatment 1 was not the best since there was no application of any of the nutrients limiting its development. It should also be remembered that the lower value found in the PMET in root length that obtained a non-significant result in root dry mass (Figure 2), it is concluded that this is due to the vessels that limit root growth and can influence the variable in relation to nitrogen doses.

In relation to Treatment 4, which obtained the highest dose of N, it was observed that it exceeded the critical dose because the crop presented nitrogen toxicity resulting in senescence of the treatment, it was concluded that this treatment was the most severe for the crop because it presented burning of edges and tips of leaves, wilting of them, among others. The critical dose for a certain nutrient is defined by some authors as that recommended to be applied to the substrate and below in which the production of a certain species is significantly limited (Cruz, 2007). In view of this result, we can assess that Treatment 2 would be the critical dose for the species, since it was the dose of nitrogen where the species was able to receive, being the recommended dose to be applied to the substrate and below the dose where the plant is sensibly limited. If we use the dose of treatment 3 for the purpose of seedling production, it would be a waste of nitrogen because the growth decreased due to the fact that the excess of N interfered in the physiology of the plant resulting in lower growth, a fact observed by the PMET that demonstrated that treatment 2 that there was no application in excess of N resulting in growth without interference in the physiology of the plant.

The absence of nitrogen verified by Venturin et al. (1999), who cultivated seedlings of *Peltophorum dubium* (Angico-amarelo) in a Red Yellow Latosol with low nutrient availability, promoted a development deficit in height and diameter, as well as a deficit in the production of dry matter of shoots and root system. It was also concluded by the same authors that the species used indicates high nutritional requirement for N. This confirms the values of the PMET in figures 1 and 2 when referring to the diameter of the stem and height of the aerial part, being one of the lowest values, behind only the length of the root and the number of leaves. On the other hand, Braga et al. (1995) analyzed that seedlings of *Aspidosperma polyneuron* (peroba rosa) cultivated with the absence of nitrogen did not obtain influenced height development, a result that differs from that observed in Angico-amarelo in relation to this same growth trait. It was also highlighted that peroba rosa did not exhibit high nutritional requirement in nitrogen.

According to Massad et. al (2021) in its production of baru seedlings under different volumes of tubes and doses of osmocote that coincidentally are also part of the Fabaceae family where the height of the aerial part, the diameter of the stem, the dry mass of the aerial part, the dry mass of the root and total dry mass were evaluated, it was observed that there was a significant effect between the factors evaluated, in this case, tube volumes and osmocote doses, for the variables height, shoot dry mass, root dry mass, total dry mass and Dickson Quality Index (DQI) of baru seedlings at 120 days of age. In the same work there was a point of maximum technical efficiency where the response was quadratic for the variables height, shoot dry mass, root dry mass, total dry mass and DQI. Proving that in seedlings of the same family there are satisfactory responses regarding development, when the maximum level of technical efficiency is not exceeded. When exceeded, it is perceived that there may be a reduction in the means of the variables, as reported in the higher doses of Osmocote in the aforementioned study and as occurred in the experiment with Canafístula.

Therefore, high or low doses of nitrogen are avoided, or even any other fertilizer used, as they result in a nutritional imbalance of the plant, which can harm or even make it impossible for them to grow in pots or in the case of nurseries, influencing their survival later in the field, after planting. Highlighting the importance of more specific studies in order to improve plant development and improve the use of the fertilization technique, as well as efficient use without economic losses to users, facilitating access to information and making a more standardized recommendation or at least with a scientific basis.

FINAL CONSIDERATIONS

From the results obtained in this research, the effect of different nitrogen doses on Canafístula growth was determined, including variables such as stem diameter, number of leaves, shoot height, shoot mass, root length and root mass. Thus, it was perceived that a plant was highly responsive to nitrogen availability, since the results obtained from the analysis of variance had a significant effect for all variables except root dry mass.

The point of maximum technical efficiency for each of the response variables was identified, understanding the ideal behavior of the plant in relation to nitrogen fertilization, realizing that the best treatment according to the MET point is at the dose 40 kg.ha-1. In the other treatments, as in the case of T1, there was a low response of the plant due to the non-application of nutrients. On the other hand, excessive N applications, which was the case of T3, resulted in a nutritional imbalance of the plant, resulting in lower growth. Applications above 80 kg.ha-1 plant senescence was perceived referring to T4.

The use of this nutrient was optimized and the critical dose of nitrogen that Canafístula can receive without limitations was established, being then T2 because it is the recommended dose in which the plant was able to receive. However, in a future study it would be interesting to carry out an experiment increasing the number of treatments and decreasing the amount between doses, applying 5 treatments, such as 0, 20, 40, 60 and 80 kg.ha-1.

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