RGSA – Revista de Gestão Social e Ambiental
ISSN: 1981-982X
Data de submissão: 01/15/2023
Data de aceite: 03/15/2024
DOI: https://doi.org/10.24857/rgsa.v18n8-005
Organização: Comitê Científico Interinstitucional
Editor Chefe: Christian Luiz da Silva
Avaliação: Double Blind Review pelo SEER/OJS

INITIAL GROWTH OF RED TENT SEEDLINGS (ADENANTHERA PAVONINA L.) IN SOIL ENRICHED WITH DIFFERENT DOSES AND NITROGENOUS SOURCES

Cristiane Ramos Vieira[1]
Roberto Juliano Benedito Serra[2]
Maicon Marinho Vieira Araujo[3]
Marcelo Dias de Souza[4]

ABSTRACT

Purpose: To evaluate the initial growth of red tent seedlings in different doses and sources of N.

Theoretical framework: Based on scientific articles found on search engines and books in the area of soil fertility and plant nutrition. This is to support the explanation of how the morphological characteristics of seedlings, which explain their growth, are affected by nitrogen fertilization, depending on the dose and source of fertilizer applied.

Method: The experiment was carried out in a completely randomized design with five doses of N and five replications, using urea and ammonium sulfate as sources, which were evaluated separately. The doses tested were: T0 – without addition of N; T1 – 50 mg dm^{-3}; T2 – 100 mg dm^{-3}; T3 – 150 mg dm^{-3}; T4 – 200 mg dm^{-3}, for each source tested. At the end of 90 days, the morphological characteristics of the seedlings were evaluated: height, diameter, height/diameter ratio, dry mass of the aerial part, dry mass of the root part, aerial dry mass/root dry mass ratio, height/aerial dry mass ratio and, Dickson quality index.

Results and conclusion: Growth, dry mass production and seedling quality were greater at a dose of 200 mg dm^{-3} when using urea as a source of N. When the source was ammonium sulfate, the greatest growth in height occurred at a dose of 100 mg dm^{-3}, however, the greatest growth in diameter, the greatest production of dry mass and quality, were observed at a dose of 200 mg dm^{-3}. This is the recommended dose for the species studied.

Research implications: These results indicate that nitrogen fertilization is essential for the quality growth of red seedlings, and the dose to be applied is essential for this to happen, since values lower than this dose may not allow the plant to perform at its maximum. growth potential. Meanwhile, higher doses do not guarantee greater growth and will result in unnecessary expenses and, probably, loss of growth due to toxicity.

Originality/value: Using nitrogen fertilizers, in the correct dose for the species, increases its growth potential and guarantees the production of quality seedlings within the nursery.

Keywords: Seedling Production, Nitrogen Fertilizers, Plant Morphology, Forest Nursery.

CRESCIMENTO INICIAL DE MUDAS DE TENTO VERMELHO (ADENANTHERA PAVONINA L.) EM SOLO ENRIQUECIDO COM DIFERENTES DOSES E FONTES NITROGENADAS

[1] Universidade de Cuiabá (UNIC), Cuiabá, Mato Grosso, Brasil.
E-mail: cris00986@hotmail.com Orcid: http://orcid.org/0000-0003-1936-1343
[2] Universidade de Cuiabá (UNIC), Cuiabá, Mato Grosso, Brasil.
E-mail: roberto.serra@hotmail.com Orcid: https://orcid.org/0000-0002-1762-6371
[3] Universidade de Cuiabá (UNIC), Cuiabá, Mato Grosso, Brasil.
E-mail: maicon.marinho@outlook.com Orcid: https://orcid.org/0000-0002-7200-4751
[4] Universidade de Cuiabá (UNIC), Cuiabá, Mato Grosso, Brasil.
E-mail: marcelo.dias@florestal.eng.br Orcid: https://orcid.org/0000-0002-4348-4645

RESUMO

Objetivo: Avaliar o crescimento inicial de mudas de tento vermelho em diferentes doses e fontes de N.

Referencial teórico: Baseado em artigos científicos encontrados em sites de buscas e em livros da área de fertilidade do solo e de nutrição de plantas. Isso para embasar a explicação de como as características morfológicas das mudas, que explicam sobre o seu crescimento, são afetadas pela adubação nitrogenada, a depender da dose e da fonte do adubo que são aplicadas.

Método: O experimento foi realizado em delineamento inteiramente casualizado com cinco doses de N e cinco repetições, tendo como fontes a ureia e o sulfato de amônio, que foram avaliadas separadamente. As doses testadas foram: T0 – sem adição de N; T1 – 50 mg dm^{-3}; T2 – 100 mg dm^{-3}; T3 – 150 mg dm^{-3}; T4 – 200 mg dm^{-3}, para cada fonte testada. Ao final de 90 dias, foram avaliadas as características morfológicas das mudas: altura, diâmetro, relação altura/diâmetro, massa seca da parte aérea, massa seca da parte radicular, relação massa seca aérea/massa seca radicular, relação altura/massa seca aérea e, índice de qualidade de Dickson.

Resultados e conclusão: O crescimento, a produção de massa seca e a qualidade das mudas de tento foram maiores na dose de 200 mg dm^{-3} ao utilizar a ureia como fonte de N. Quando a fonte foi o sulfato de amônio, o maior crescimento em altura se deu na dose de 100 mg dm^{-3}, porém, o maior crescimento em diâmetro, a maior produção de massa seca e qualidade, foram observadas na dose de 200 mg dm^{-3}. Sendo esta a dose recomendada para a espécie estudada.

Implicações da pesquisa: Esses resultados indicam que a adubação nitrogenada é fundamental para o crescimento com qualidade das mudas de tento vermelho, sendo a dose a ser aplicada fundamental para que isso aconteça, já que, valores inferiores a essa dose podem não permitir que a planta apresente o seu máximo potencial de crescimento. Ao passo que, doses superiores não garantem crescimento maior e implicarão em gastos desnecessários e, provavelmente, perdas de crescimento por toxidez.

Originalidade/valor: Utilização de adubos nitrogenados, na dose correta para a espécie, aumenta seu potencial de crescimento e garante produção de mudas de qualidade dentro do viveiro.

Palavras-chave: Produção de Mudas, Adubos Nitrogenados, Morfologia de Plantas, Viveiro Florestal.

CRECIMIENTO INICIAL DE PLÁNTULAS DE CARPA ROJA (ADENANTHERA PAVONINA L.) EN SUELOS ENRIQUECIDOS CON DIFERENTES DOSIS Y FUENTES NITROGENADAS

RESUMEN

Propósito: Evaluar el crecimiento inicial de plántulas de carpa roja en diferentes dosis y fuentes de N.

Marco teórico: Basado en artículos científicos encontrados en motores de búsqueda y libros en el área de fertilidad del suelo y nutrición vegetal. Esto es para apoyar la explicación de cómo las características morfológicas de las plántulas, que explican su crecimiento, se ven afectadas por la fertilización con nitrógeno, dependiendo de la dosis y la fuente de fertilizante aplicada.

Método: El experimento se llevó a cabo en un diseño completamente aleatorizado con cinco dosis de N y cinco repeticiones, utilizando urea y sulfato de amonio como fuentes, que se evaluaron por separado. Las dosis ensayadas fueron: T0 – sin adición de N; T1 – 50 mg dm-3; T2 – 100 mg dm-3; T3 – 150 mg dm-3; T4 – 200 mg dm-3, para cada fuente ensayada. Al final de los 90 días, se evaluaron las características morfológicas de las plántulas: altura, diámetro, relación altura/diámetro, masa seca de la parte aérea, masa seca de la parte radicular, relación masa seca aérea/masa seca radicular, relación altura/masa seca aérea e índice de calidad de Dickson.

Resultados y conclusión: El crecimiento, la producción en masa seca y la calidad de las plántulas fueron mayores a una dosis de 200 mg dm-3 cuando se utilizó urea como fuente de N. Cuando la fuente fue sulfato de amonio, el mayor crecimiento en altura se produjo a una dosis de 100 mg dm-3, sin embargo, el mayor crecimiento en diámetro, la mayor producción de masa seca y calidad, se observaron a una dosis de 200 mg dm-3. Esta es la dosis recomendada para las especies estudiadas.

Implicaciones de la investigación: Estos resultados indican que la fertilización nitrogenada es esencial para el crecimiento de calidad de las plántulas rojas, y la dosis a aplicar es esencial para que esto suceda, ya que los valores inferiores a esta dosis pueden no permitir que la planta se desempeñe al máximo. Mientras tanto, las dosis más altas no garantizan un mayor crecimiento y resultarán en gastos innecesarios y, probablemente, pérdida de crecimiento debido a la toxicidad.

Originalidad/valor: El uso de fertilizantes nitrogenados, en la dosis correcta para la especie, aumenta su potencial de crecimiento y garantiza la producción de plántulas de calidad dentro del vivero.

Palabras clave: Producción de Plántulas, Fertilizantes Nitrogenados, Morfología Vegetal, Vivero Forestal.

1 INTRODUCTION

Brazilian soils are naturally acidic and poor in nutrients (Silva et al., 2011; Costa Filho et al., 2013). Because of its highly weathered character, it generally has low base contents, such as Ca, Mg and K. Another characteristic is that, because of its fine particle size, it can have high clay contents, which can increase the ability to adsorb P. In addition to these elements, N will be another element that will be in low concentrations, both because of the acidity of the soil and because of its low natural content in organic matter.

However, N is one of the nutrients most absorbed by plants because it is related to several vital reactions without which no plant could grow and produce, as reported by Marschner (1995) and Malavolta et al. (1997). This element is part of the cell's components and participates in processes such as ionic absorption, photosynthesis, respiration, cell multiplication and differentiation (Malavolta, 2006).

Therefore, it is not always an advantage to use the soil under natural conditions as the only component of the substrate for the production of forest seedlings. Since the quality of these cuttings will depend on the physical and nutritional quality of the substrate used during this phase, this quality will be related to their capacity for survival in the field.

According to what was reported by Freitas et al. (2017), among the substrates used for the production of seedlings of native arboreal species, stands out the subsoil land, which is still widely used in nurseries. Hence the importance of fertilizing during the production of seedlings in the nursery, as mentioned by Dutra et al. (2015), when they highlighted that one of the ways to produce seedlings of good quality and that have a chance of survival after transplanting is through balanced nutrition, using mineral fertilizers.

According to Cardoso et al. (2016) the proper development of seedlings will occur when the soil is fertile and presents adequate concentrations of nutrients, mainly N, P and K, whose requirements by plants are generally greater than the capacity of the soil supply. Thus, one of the most important stages of forestry is the definition of the ideal fertilizer for each species in the various stages of its development (Ciriello et al., 2014).

In view of this, it is seen that it is indispensable to carry out more exact and concrete research, testing the growth of each species as a function of a determined quantity and source of nutrient, so that their adequate nutritional requirements are known. One of the forest species for which there is a need to obtain information about its nutrition, mainly as regards the requirement in N, is Adenanthera pavonina L. (red tent).

The red tento is a species of forest in the Fabaceae family, also known as the carolina tento, dragon's eye or tento. It is a legume native to India and Malaysia, introduced in Brazil for urban and rural afforestation (Lorenzi et al., 2003). Currently, it is found mainly in the states of Mato Grosso, Mato Grosso do Sul, cities in the interior of São Paulo, Minas Gerais and Northeast Region (Rodrigues et al., 2009). The carolina try has ornamental purposes, in the afforestation of streets and squares, for shading, crafts and medicines, and its seeds and wood are used as phytotherapics (Kissmann et al., 2008).

Some research has contributed to demonstrating the importance of N in the growth of plants during the process of the production of seedlings. However, it is difficult to find research with the attempt, particularly in the case of fertilizing. Belapart et al. (2013) recommended doses of 224 and 448 mg dm-3 of N for seedlings of Calophyllum brasiliense. Falcão Neto et al. (2014) recommended 75 mg dm-3 of N for seedlings of Dipteryx lacunifera. Goulart et al. (2017) recommended 100 mg dm-3 of N for Tabebuia serratifolia seedlings. Besides these, other authors have observed the importance of nitrogenous fertilization for the production of seedlings of forest species, such as Guedes et al. (2011) Ciriello et al. (2014) Moretti et al. (2015) and Cardoso et al. (2016).

In view of this, an experiment was developed with the objetive of assessing the initial growth of A. pavonina cuttings after submission to different levels and sources of N, with a separate evaluation as to the effects of these fertilizers, during production in a nursery.

2 THEORETICAL FRAME

The theoretical benchmark was based on scientific articles and books published in the areas of Soil Fertility and Plant Nutrition. For a better understanding, the theoretical reference on the study carried out was made up of some items; one of them, characterizing the species studied; the other, the effects of nitrogen on the production of seedlings of quality and, in the final subitem, nitrogenous fertilization in the production of seedlings of forest species.

2.1 ADENANTHERA PAVONINA

Adenanthera pavonina is a species of legume belonging to the Fabaceae family, subfamily Mimosoideae, popularly known as red, carolina, dragon's eye or tento. It is a tree legume, native to India and Malaysia, which was introduced in the Americas, including Brazil, for the composition of urban and rural afforestation (Lorenzi et al., 2003). It is not known, for sure, when the species was introduced in Brazil, but, according to Corrêa (1978), in 1978, its entry was already registered as "many years ago", so it is a species considered adapted and widely disseminated in all the states of the country.

The yellow inflorescences of this species are formed mainly in March-April, with long axillary or terminal peduncles in short racemes. The fruits are in the form of narrow, flattened, brown, spiral pods when opened, exposing the globose, flattened, hard, bright red seeds. Seeds can vary in shade, shape and size, which on average is 10 x 12 mm, and these have been widely used in the crafts and production of medicines, especially phytotherapics (seeds and wood), for the treatment of lung infections and chronic ophthalmia (Kissmann et al., 2008).

According to Cardoso et al. (2005), the species produces large quantities of seeds, and these are orthodox behavior, requiring pregerminative treatment, due to dormancy, due to the waterproofing of the integument to water. It is a semi deciduous species, reaching from 15 to 20 meters in height and growing fast, having a canopy suitable for shading herbaceous plants, shrubs and creepers, which do not tolerate high luminous intensities (Fonseca; Perez, 2001). Allied to the high adaptability throughout the country, its potential for use in the recovery of degraded areas has been observed, and its adaptation has been attested in several experiments (Kissmann et al., 2008).

2.2 EFFECTS OF NITROGEN ON THE PRODUCTION OF QUALITY SEEDLINGS

Most organic components in plants contain N, which is absorbed by the roots in the form of nitrate (NO3-) or ammonium (NH4+) ions (Malavolta et al., 1997). N acts in several physiological functions, as it is a constituent of many cellular elements, including amino acids, proteins, nucleic acids, chlorophylls and coenzymes. Therefore, it participates in processes such as ionic absorption, cell division, photosynthesis and respiration (Taiz; Zeiger, 2013; Raven et al., 2016). According to Malavolta (2006), because it is an element directly related to vegetative growth, its effects are also directly reflected in the size of the leaf area, in the production of vegetative buds, in parchment and in the content of proteins in grains.

This macronutrient is the most abundant in the plant, as well as the most demanded, depending on the functions mentioned above (Malavolta et al., 1996). The main sources of N for fertilization via soil used in Brazil are urea (CO(NH2)2) and ammonium sulfate ((NH4)2SO4) (Malavolta et al., 2002).

For this reason, in her deficiency of N in plants, Vieceli (2017) points out, as main symptoms, the reduction of plant growth, which occurs due to cellular components having N in their constitution. In addition, yellowing of the leaves; slow growth of stems; smaller number, size and thickness of the leaves; and early defoliation.

Studying the growth of teak (Tetona grandis) in nutritional solution, Barroso et al. (2005) observed the greatest reduction in seedling growth after the omission of N. In this case, the plants presented symptoms such as generalized chlorosis, paralysis of the emission of new roots and rotting of secondary roots. Omission of N and Ca resulted in the smallest accumulation of dry mass, with a fall, on average, of 90 and 80%, respectively, in relation to the seedlings submitted to treatment with a complete nutritional solution.

On studying the omission of nutrients in cuttings of paricá (Schizolobium amazonicum), Marques et al. (2004) noted morphological changes due to nutrient deficiency. In the deficiency of N, which was the one that most limited the plant's growth, the effects began to be observed at 10 days after transfer to the nutritional solution. These seedlings showed a reduced size, a smaller number of leaves, a less developed root system and a dark color.

The nutritional status reflects the plant's internal quality, and the adequate nutritional content in the plant tissue will lead to better development, resistance to pathogens and better adaptability to the new site after planting (Del Quiqui et al., 2004). However, according to Furtini Neto et al. (2000), the demand for nutrients varies according to the species, climatic season, stage of growth, and is more intense in the initial stage of plant growth.

An example is the study conducted by Duboc (2005), when researching the initial development and nutrition of several native tree species under fertilization, the author observed a difference in the nutritional requirements of each species, even as a function of the successive stages of their growth. For the N, for example, the pioneer species showed a high nutritional requirement, in the Dense Cerrado and in the Gallery Forest. However, secondary species had low nutritional requirements for N at both sites.

2.3 NITROGENOUS FERTILIZER FOR THE PRODUCTION OF FOREST SEEDLINGS

When assessing the growth of saplings of umburana (Amburana cearensis), Dutra et al. (2015) found that they developed further when applying N and P to the substrate. The highest height, height-to-neck diameter ratio, dry root mass and better seedling quality indices were obtained after the applications of 193, 245, 250 and 167 mg dm-3 of N, respectively.

Positive results of fertilization with N were also found by Goulart et al. (2016), when analyzing the production of yellow ipê seedlings (Tabebuia serratifolia) in response to nitrogenous fertilization with ammonium sulfate in five doses (0, 75, 150, 225 and 300 mg dm-3). The authors found greater gains in growth and quality, with the application of N, when this was between 90 and 110 mg dm-3.

Guedes et. al (2011) analyzed the effects of urea-based nitrogenous fertilization on the growth of andiroba seedlings (Carapa guianensis). In this case, the highest mean for height growth was observed after the application of 0.65g per plant and, for neck diameter, the best dose was 0.91g per plant.

When studying the effect of nitrogenous fertilization on the production of seedlings of seven-shells (Samanea inopinata), using ammonium sulfate, Cruz et al. (2006) observed influence on almost all morphological parameters evaluated, except for the relationship between air dry mass/dry root mass and cervical height/diameter. For this species, the authors recommended applying 0.91 g of ammonium sulfate per seedling, combined with organic compound.

Another characteristic that should be studied, with respect to fertilization, is the overdose. According to Scholberg et al. (2000) overdose of N may promote overgrowth of plant parts; prolongation of the growing cycle; and increased occurrence of fruit with defects, which remain small and slowly mature late.

In the same sense, Leite et al. (2010) noted that nitrogenous fertilization with urea as its source increased the production of jambolan seedlings (Syzygium cumini). However, doses above 2,106 mg dm-^{3} caused depressive effects on seedlings.

Agreeing with the study of Bezerra et al. (2018), who evaluated sources and doses of N, in the production of Euterpe oleracea (musk seedlings) and found that high doses of N, regardless of source, resulted in the formation of poor quality seedlings. This poor quality was influenced by the reduction in root growth and cervical diameter.

Tucci et al. (2009) evaluated the effects of increasing doses of N, with urea as its source, on the production of mahogany seedlings (Swietenia macrophylla) and found that increasing doses of N (40; 80; and 120 g N ton-1), contributed to increase growth in stem diameter, dry mass of leaves, total dry mass and content of N, P and Ca in seedlings leaves. However, these results decreased at doses of 160; 200; and 240 g N ton-1. With the maximum dose used (240 g N ton-1), there was a negative effect on the diameter of the stalk and the air dry mass, impairing the quality of the cuttings.

3 METHOD

The experiment was carried out at the plant house of the Faculty of Agronomy of the University of Cuiabá (UNIC), located on the campus Beira Rio I, in Cuiabá - MT, at the coordinates 15º37'28"S and 56º05'11"O. The predominant climate of the region is tropical savanna, according to Köppen classification.

Red-tasted seeds were collected, on the ground, under randomly chosen mother trees, located at the Federal University of Mato Grosso, Cuiabá campus, at 15º36'36"S and 56º03'57"O. The collection took place over seven days, from seeds not attacked by pests, collected under the same mother trees. These seeds were mechanically scarred with sandpaper n. 80 at one end and then were placed to germinate in plastic bags of 10x20 cm filled with soil. After 15 days of scarification, the emergencies of the seedlings began, and, after 30 days, the seedlings were already suitable for transplanting for the treatments tested in the experiment.

The soil used was the dystrophic Red Latosol with a sandy loam texture, collected in an area of Cerrado native to the Federal Institute of Mato Grosso (IFMT), campus of São Vicente da Serra. After collection, a sample of this soil was taken, dried in the air, sieved in 2 mm mesh and submitted to chemical and particle size characterization, following methods described by Embrapa (1997) and its results are presented in Table 1.

Table 1

Chemical and particle size characterization of the dystrophic Red Latosol used in the experiment, prior to the application of N doses

pH	**K**	**P**	**H+Al**	**Al**	**Ca**	**Mg**	**SB**
$CaCl_2$	mg dm^{-3}		$cmol_c\ dm^{-3}$				
4,50	70,20	1,43	6,25	0,25	1,92	0,67	2,77
CTC_T	**t efetiva**	**V**	**m**	**MO**	**Areia**	**Silte**	**Argila**
$cmol_c\ dm^{-3}$		%		g kg^{-1}			
9,02	3,02	30,71	8,28	34,61	538	54,30	407,70

pH in CaCl2 - ratio 1:2,5; P and K - in Mehlich; H+Al - in calcium acetate pH7,0; Al, Ca and Mg - in KCl 1N; SB - sum of bases; CTCT - total capacity for exchange of cations; t effective - effective capacity for exchange of cations; V - saturation by bases; m - saturation by aluminum; MO - organic matter; Sand, silt and clay - density meter method.
Source: Prepared by the authors (2024)

The soil was calcareated with dolomitic limestone, 79% PRNT, the characteristics of which are shown in Table 2, prior to the addition of nitrogenous fertilizers and kept in incubation for seven days, in plastic bags of 30x40 cm with capacity for one kilo, under daily irrigation. The amount of limestone applied was calculated based on soil analysis (Table 1) following the method of increasing saturation by bases to 50%.

Table 2

Chemical and physical characteristics of the limestone used

CaO	**MgO**	**PN**	**PRNT**	**Residual action**
%				
24,0	17,1	84,4	79	15,0

Source: Prepared by the authors (2024)

After incubation, the seedlings were transplanted into the plastic bags with previously prepared and calcareated soil, where they remained for 10 days in an adaptation period. After another 10 days, solutions containing macronutrients (except N) and micronutrients were applied. In the case of macronutrients, 300 mg.dm^{-3} of P using KH2PO4; 140 mg.dm^{-3} of K using KCl and K2SO4 (100 mg.dm^{-3} of KCl and 40 mg.dm^{-3} of K2SO4), in solution, according to Passos (1994). The micronutrient solution was prepared using Alvarez's method (1974), with: B 0.81 mg.dm^{-3}, Mn 3.66 mg.dm^{-3}, Zn 4.0 mg.dm^{-3}, Cu 1.33 mg.dm^{-3} and Mo 0.15 mg.dm^{-3} as sources of H3BO3, MnCl2.4H2O, ZnSO4.7H2O, CuSO4.5H2O and (NH4)6Mo 24.4H2O, respectively.

After applications of the nutrient solutions, the nitrogenous fertilizer was applied according to the treatment tested, as well as its source. The treatments tested were: T0 - without addition of N; T1 - 50 mg dm-3 N; T2 - 100 mg dm-3 N; T3 - 150 mg dm-3 N; T4 - 200 mg dm-3 N. These doses were tested with both urea (45% N) and ammonium sulfate (21% N) as sources of N, in two separate experiments. The design employed was entirely casualized, with five repetitions.

At the end of 90 days, the morphological characteristics were assessed, being: height of the aerial part (H), with a graduated ruler, measured from the base of the soil until the last leaf of the plant; neck diameter (DC), measured with digital caliper; being possible, later, to determine the relationship height/diameter (H/DC). To analyze the dry mass, the cuttings were sectioned in part air (MSPA) and part root (MSPR), taken to the oven for the forced circulation of air at 65ºC until a constant weight, and weighed in a semi-analytical balance. With these data, it was possible to determine the total dry mass (MST), the relationship between height and air dry mass (H/MSA), the ratio between air dry mass and root dry mass (MSPA/MSPR), the Dickson quality index (IQD, based on Dickson et al. (1960) and the N content based on Malavolta et al. (1997).

The data were interpreted by means of regression analysis and the graphs were mounted using the statistical program R, after the verification of the normality of the data.

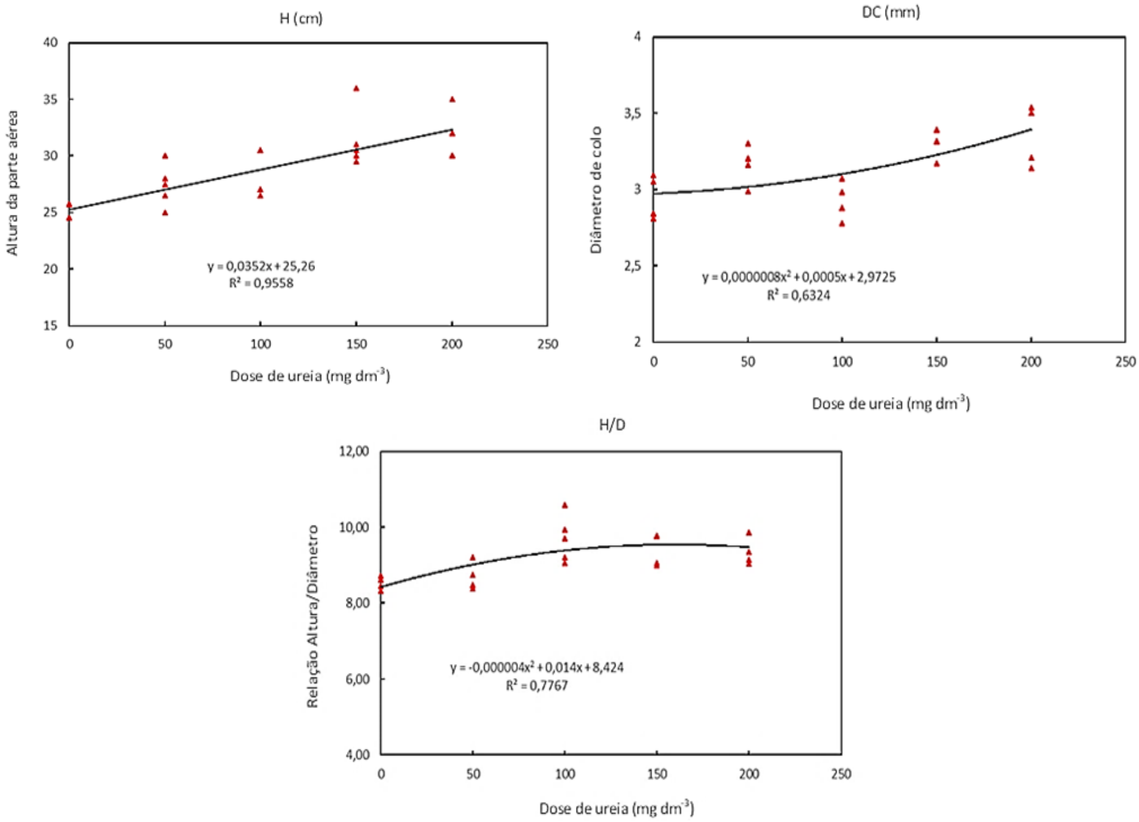
4 RESULTS AND DISCUSSIONS

4.1 GROWTH OF TEMPTATION SEEDLINGS AFTER FERTILIZATION WITH N DOSES USING UREA

The effects of N-fertilizing with urea as its source are shown in the figures below (Figures 1, 2 and 3). It is observed that the tenth is a fertilization-responsive species with N.

Figure 1

Height (in cm), neck diameter (DC in mm), neck height/diameter ratio (H/D) of tense seedlings after soil fertilization with N, urea source



Source: Prepared by the authors (2024)

The height showed a linear response to the application of N, when the source was urea (Figure 1), having its maximum value in 35 cm and mean of 31.8 cm in the dose of 200 mg dm-3. For seedlings that did not receive nitrogenous fertilization (witness treatment) the height growth achieved was at most 28 cm and average 25 cm. In percentage terms, an average increase of 6.8 cm is observed at the 200 mg dm-3 dose of N, representing 32.5% more than the control. Therefore, fertilizing with N proved necessary during the initial phase of growth of the saplings in the nursery. It is worth pointing out that, height is one of the morphological characteristics most analyzed when it is intended to choose the seedlings that will be planted in the field, being therefore a characteristic that indicates the quality of the seedlings (Gomes; Paiva, 2013). This difference between the growth in height of the saplings in soil with and without the addition of N demonstrates that, when fertilizing, they can grow faster and reach the size that qualifies them for planting in the field, in less time. This is a more favorable situation when one intends to produce seedlings, principally with a commercial stamp.

The diameter of the collector (Figure 1) showed increasing quadratic growth, with the application of N. It is observed that at the dose of 200 mg dm-3 the cuttings showed maximum growth in diameter, which was 3.92 mm, having as average 3.38 mm. For the seedlings from the control treatment, the maximum growth was 3.13 mm and the mean growth was 2.93 mm. This shows an average 15.4% increase in the 200 mg dm-3 dose, relative to the control. Therefore, growing characteristics for both height and diameter growth, this is interesting, because it allows to indicate an equilibrium in both the growth of the aerial part and the root part of the seedlings. Therefore, these seedlings are of better quality. In addition, growth in diameter is also used to recommend molting for field planting, because it is related to its ability to survive environmental adversities.

Fanti and Perez (2003) verified average growth in height of 10.67 cm, in saplings of try submitted to low luminosity with NPK, at 90 days. In another study, Gonçalves (2018) found an average height of 17.78 cm for the stent seedlings growing in substrate plus P at a dose of 500 mg dm-3. However, 19 cm high in seedlings submitted to 100 mg dm-3 of N. This same dose of N was the one that provided the largest growth in diameter. Therefore, in the present case, fertilizing with N provided growth in height and diameter, higher than that observed by these authors.

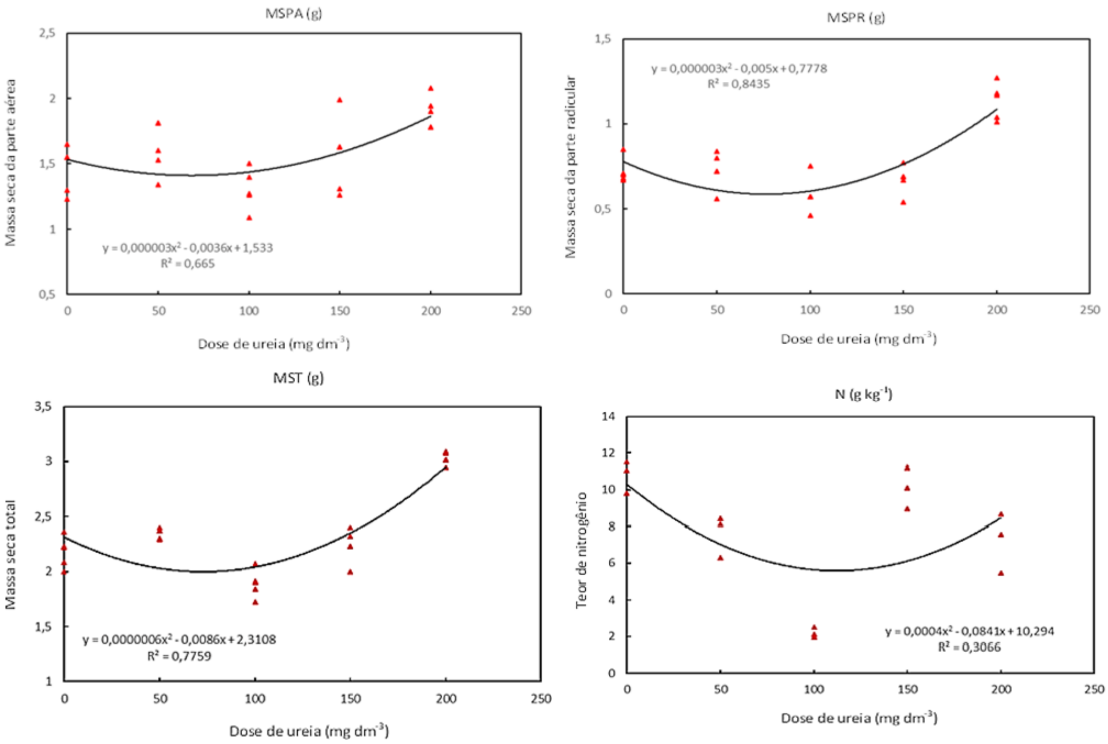
As recommended by Xavier et al. (2009), the seedlings most suitable for planting are those that show a growth interval in height between 20 and 40 cm and, 2 mm in diameter. Therefore, all treatments, at the end of 90 days, provided average growth in height and diameter, compatible with what was recommended by the cited authors. However, it is interesting to point out that, for treatments with applications of N, this recommended size, possibly, was obtained in less time.

For the height-to-diameter ratio the type of equation adjusted was the quadratic decreasing, with the highest mean for the cuttings at the dose of 100 mg dm-3. However, in this case, it does not matter the highest value, since the lowest averages for this relationship, would indicate a smaller difference between the growth of the aerial part and the growth of the root part, and, therefore, a higher quality of growth for the cuttings. According to Sturion and Antunes (2000), the lower the ratio between height and diameter, the greater the chances of survival of the plant in the field. In this case, the lowest mean was observed in the treatment with the witnesses, however, because of the lower growth in height and in diameter of the cuttings in this treatment. Birchler et al. (1998) recommend that the value obtained for this characteristic should be less than 10 and, considering the averages obtained for each treatment, it can be observed that this recommendation was achieved for all treatments tested.

With regard to the production of dry mass of the saplings (Figure 2), the best results were also observed in the cuttings submitted to the dose of 200 mg dm-3.

Figure 2

Dry mass of the air part (MSPA in g), dry mass of the root part (MSPR in g), total dry mass (MST in g) and N content (in g kg-1) of tense seedlings after soil fertilization with N, urea source



Source: Prepared by the authors (2024)

When evaluating the dry mass of the part of the air, it was found that the maximum value for this characteristic was obtained in cuttings at the dose of 200 mg dm-3 of N, in which they presented an average of 1.90 g. In percentage terms, the mean increase was 30.1% in relation to the control treatment, in which the mean was 1.46 g. These results are interesting because the dry mass of the upper part is related to the plant's photosynthetic capacity, since it also refers to the mass of the leaves, which is the main organ responsible for the process. In addition, it corroborates to indicate better growth after fertilization with N, since the greater growth in height was also observed in the seedlings at the dose of 200 mg dm-3. In this way, the saplings of the attempt are not only growing in height, they are also producing mass in the air, which will confer on them greater capacity for survival in the field.

The results of the dry mass of the root part were similar, when comparing the aerial part with the root part, indicating equilibrium in the mass production between these parts analyzed. The greatest production of root mass is related to the plant's capacity to absorb water and, together with this water, the nutrients it needs to grow and develop. According to Gomes and Paiva (2013), root production also has a major influence on the survival and initial growth of seedlings in the field, so the more abundant the root system, the greater survival. In this case, the maximum value for mass production was observed in the cuttings at the dose of 200 mg dm-3, where the mean was 1.13 g. An increase of 56.9% in relation to the results for seedlings in the control treatment, with an average of 0.72 g.

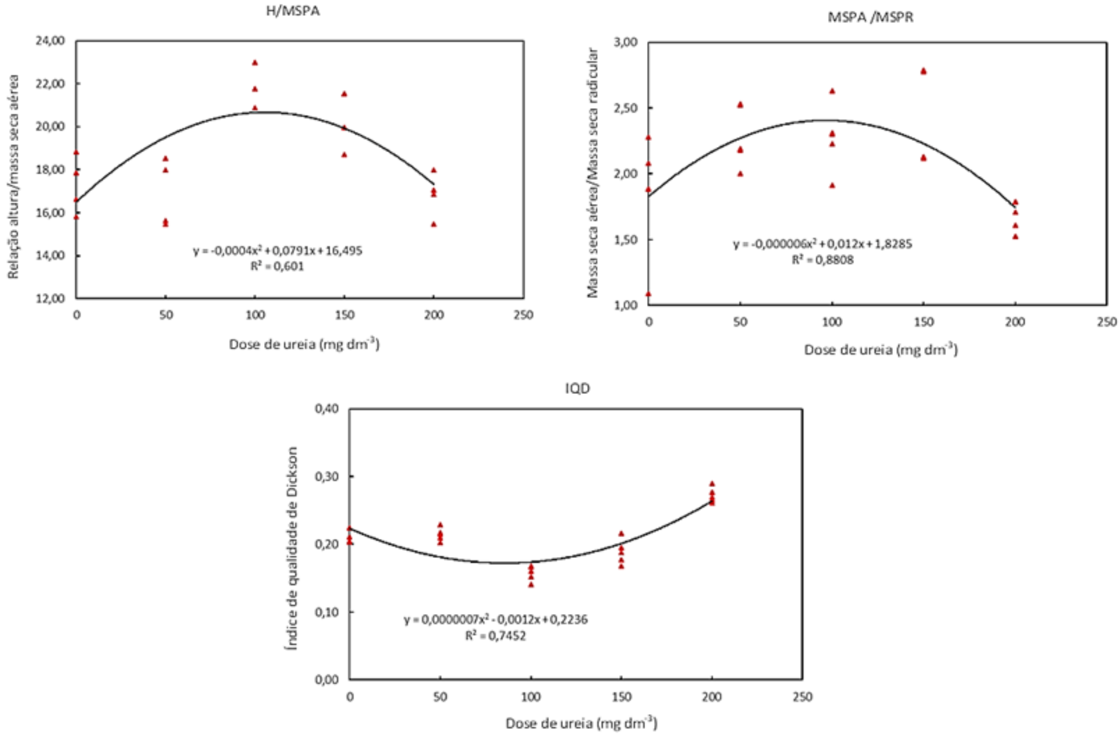
Thus, the total dry mass was also higher in the cuttings at the dose of 200 mg dm-3 of N, in which they presented mean of 3.03 g, which was 28.1% higher than that observed in the control treatment (mean of 2.18 g). Therefore, the importance of nitrogenous soil fertilization is verified for the increase in dry mass of the saplings.

However, this production of dry mass was not related to the final levels of N, in the leaves of the tentative cuttings. Because, for this characteristic, the average N content, at the end of 90 days, was 10.30 g kg-1 in the seedlings in the witness treatment and 6.9 g kg-1 in the seedlings in the 200 mg dm-3 dose of N. This result may be related to the moment at which the analysis was carried out, since it only took place at the end of 90 days, when, probably, the seedlings submitted to applications with the maximum dose of N had already absorbed a large part of what was added to the soil, for their growth and production of dry mass. This can be corroborated by the results observed previously. While, in the witness treatment, the N made available by the plant was that present in the organic matter of the soil and, as the N in the organic form may take a while to undergo mineralization so that it can finally be absorbed by the plants, this may have collaborated for the result observed in the present case.

The relationship between the height/dry mass of the aerial part (Figure 3) was lower in the dose of 200 mg dm-3 of N (16.87), which is the most interesting result to qualify the cuttings and to confirm that the growth and production of dry mass are occurring in a more balanced manner in this treatment. According to Gomes and Paiva (2013), the smaller the quotient obtained from this relationship, the more lignified the sapling will be and the greater its survival in the field. However, in all treatments, the averages obtained were above 16.

Figure 3

Aerial height-to-dry mass ratio (H/MSPA), air dry mass ratio/root dry mass ratio (MSPA/MSPR) and Dickson quality index (IQD) of tense seedlings after soil fertilization with N, urea source



Source: Prepared by the authors (2024)

When analyzing the relationship between the dry mass of the aerial part/dry mass of the root part (Figure 3), the lowest mean was also observed in the cuttings at the dose of 200 mg dm-3 (1.69). These data are confirming the results previously observed and that indicate, in this case, that the production of dry mass of the aerial part and the production of dry mass of the root part, showed less difference in the cuttings at the dose of 200 mg dm-3 of N. Indicating, in this way, cuttings of better quality at the maximum dose of N.

These data that qualify the cuttings submitted to the dose of 200 mg dm-3 of N as the best, are confirmed by analyzing the Dickson quality index (Figure 3), for which the highest mean (0.27) was observed in this treatment.

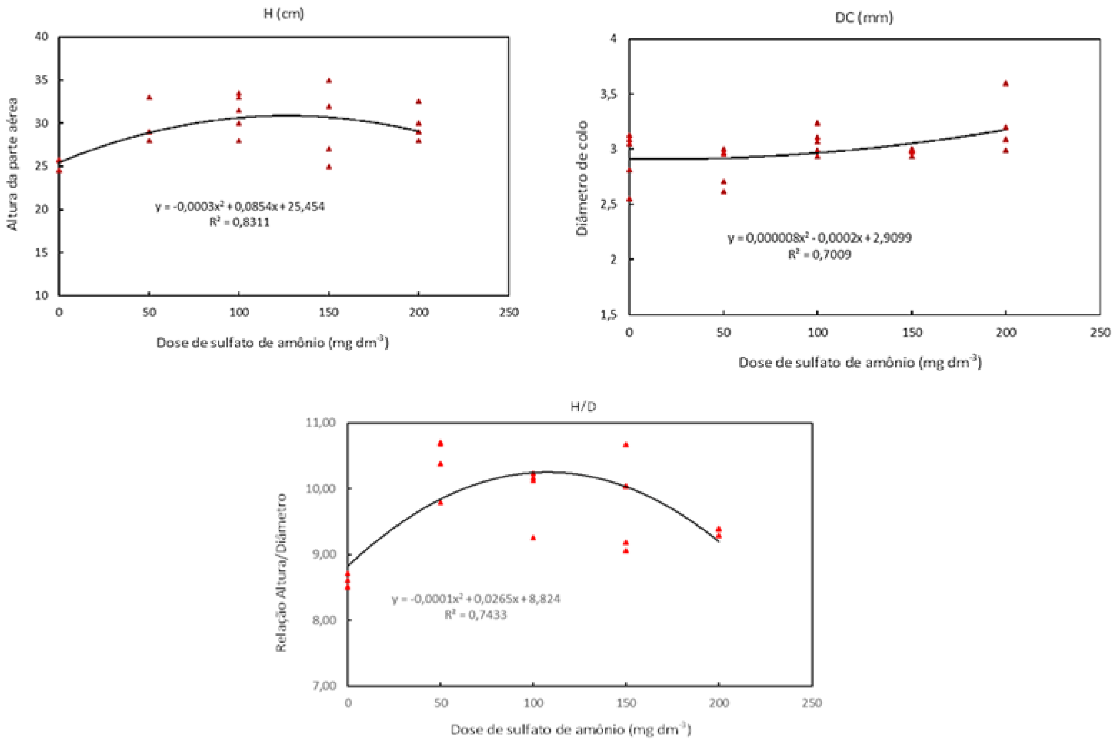
4.2 GROWTH OF TENTATIVE SEEDLINGS AFTER FERTILIZATION WITH N DOSES USING AMMONIUM SULFATE

The tentative seedlings also proved to be responsive to nitrogenous fertilization, using ammonium sulfate as their source. This was verified, when analyzing the growth and the production of dry mass, which, in general, were greater in seedlings submitted to development on a substrate composed of fertilized soil. These results are shown in Figures 4, 5 and 6.

In Figure 4 are the results for growth in height, with adjustment of quadratic equation decreasing; growth in diameter, for which increasing quadratic equation and; the ratio height/diameter, for which a decreasing quadratic was adjusted.

Figure 4

Height (in cm), neck diameter (DC in mm), collar height/diameter ratio (H/D) of tense seedlings after soil fertilization with N, source ammonium sulfate



Source: Prepared by the authors (2024)

The highest growth in height of the saplings was observed at the dose of 100 mg dm-3 of N, however, all nitrogenous fertilization treatments provided better conditions than the control treatment. At the dose of 100 mg dm-3 (mean of 31.2 cm), this growth was 35.6% higher than that observed in the control treatment, demonstrating the responsiveness of the attempt to fertilization. At the 150 and 200 mg dm-3 doses, the means were similar, 29.2 cm and 29.7 cm, respectively. Comparing growth in height, based on the sources used, similar means are found, 31.8 cm was the highest average when using urea and 31.2 cm when using ammonium sulfate, however, in different doses. Therefore, the optimal dose for the growth in height of the saplings of the try will depend on the nitrogenous source to be used. According to Gomes and Paiva

(2013), adequate nitrogenous fertilization promotes an increase in the height of the seedlings of forest species. However, this response will depend on numerous factors, such as environment, genotype, dose and source of N (Marques et al. 2006).

The dose of 100 mg dm-3 of N was also outstanding when analyzing growth in diameter, where seedlings had an average of 3.07 mm. However, the highest mean observed for this characteristic was 3.19 mm, in the dose of 200 mg dm-3, whose mean increase was 8.1% higher compared to the control treatment, indicating less responsiveness for this characteristic. However, the increase is important because the diameter, along with the height, are the morphological characteristics most analyzed to recommend planting seedlings in the field, since this growth is directly related to the capacity of their survival after planting. Knowing this characteristic is particularly important when one wants to catch the seedlings and quickly recompose a given area. According to Souza et al. (2006) seedlings with the largest increment in diameter have greater capacity for formation and growth of new roots.

Xavier et al. (2009) recommend that seedlings have a growth interval in height between 20 and 40 cm and, 2 mm in diameter, so that they are taken for planting in the field. Considering the average for these two morphological characteristics, it appears that in all treatments these recommendations were reached. However, as previously mentioned, when fertilizing with N was carried out, this growth was observed in less time, which is favorable because it allows for the production of more seedlings in less time, mainly in the case of a commercial nursery.

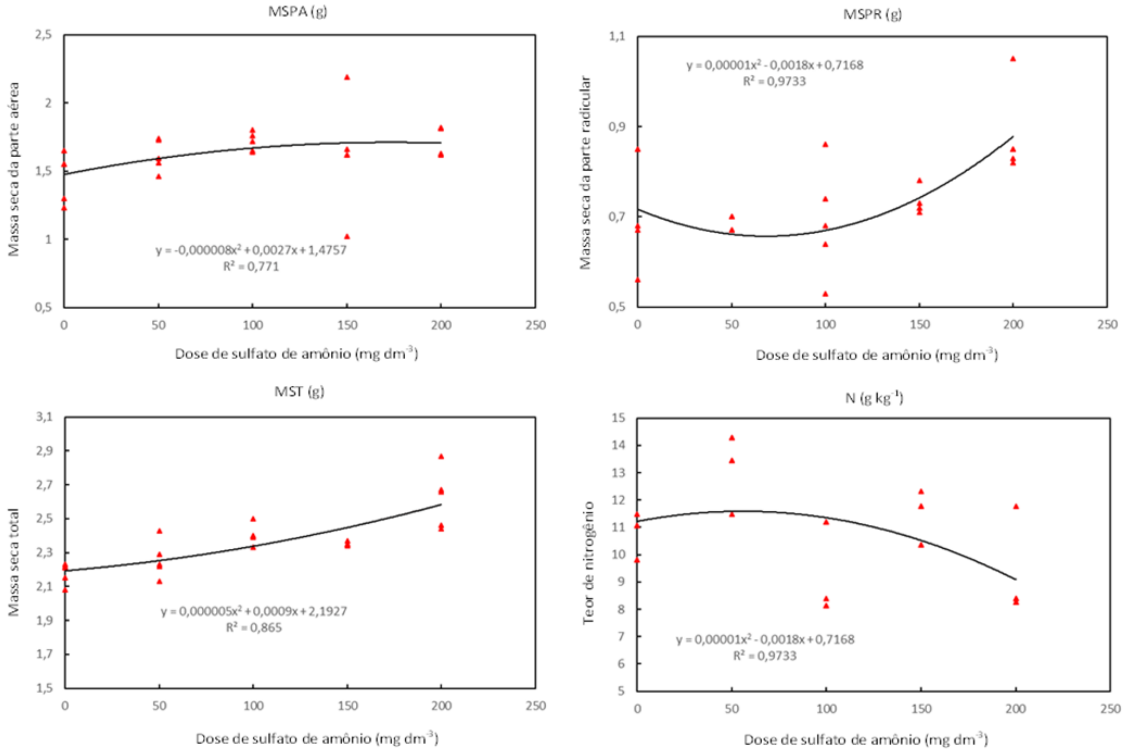
For the height/diameter ratio, averages were observed that were growing from 0 to 50 mg dm-3, reducing again in the seedlings submitted to the dose of 100 mg dm-3. Results influenced by growth in height and diameter, which were higher at 100 mg dm-3 e; reduction in growth in height at later doses. However, what is interesting for this characteristic are the lower values, since these indicate smaller differences for the growth of the aerial part and the root part of the plant. Therefore, there was an increase in the quality of the seedlings from the dose of 100 mg dm-3, since the lowest mean in the treatment of the witness is related to the reduced increase for growth in height, a characteristic that is not desirable.

According to Moreira and Moreira (1996), the H/D ratio indicates the quality standard of the seedlings and can be used to evaluate the quality of the forest seedlings, because, besides reflecting the accumulation of reserves, it ensures greater resistance and better fixation in the soil (Arthur et al., 2007). According to Birchler et al. (1998), its value should be less than 10, so considering the averages obtained for each treatment, it is observed that only in the dose of 50 mg dm-3 this value was not reached.

Besides growth, mass production (Figure 5) is also related to the quality of the seedlings. In this case, fertilizing with N also favored the production of dry mass in the tentative cuttings. Adjusting increasing quadratic equations for the dry mass of the root and total e; decreasing quadratic equations for the dry mass of the air part and for the N content of the leaves.

Figure 5

Dry mass of the air part (MSPA in g), dry mass of the root part (MSPR in g), total dry mass (MST in g) and N content (in g kg-1) of tense seedlings after soil fertilization with N, source ammonium sulfate



Source: Prepared by the authors (2024)

For the dry mass of the aerial part, all fertilization treatments provided higher yields, however, the highest averages were observed for cuttings at doses of 100 and 200 mg dm-3. In this case, this mass production was 14.6% (1.71 g) and 16.1% (1.74 g) higher, respectively, in relation to the control treatment (mean of 1.46 g). This may help to explain the observed results for growth in height, since, with greater dry mass of the aerial part, one can have more foliar mass, and in this way, a greater photosynthetic rate, which is reflected later in greater growth. This characteristic indicates the rusticity of a seedling, with the higher values representing more lignified and rustic changes, with greater production potential in environments with adverse conditions (Gomes; Paiva, 2013).

The production of dry root mass (Figure 5) was higher at the dose of 200 mg dm-3, where the mean was 0.88 g, with little difference between the other treatments. In this case, the increase was 18.2% in relation to the witness. This production of dry mass is related to the result observed for growth in diameter, besides, it refers to the plant's capacity to absorb water and to feed itself on the elements that were made available by the substrate. According to Gomes and Paiva (2013), the diameter of the cuttings accounts for 70-80% of the differences in the weight of dry matter of the cuttings.

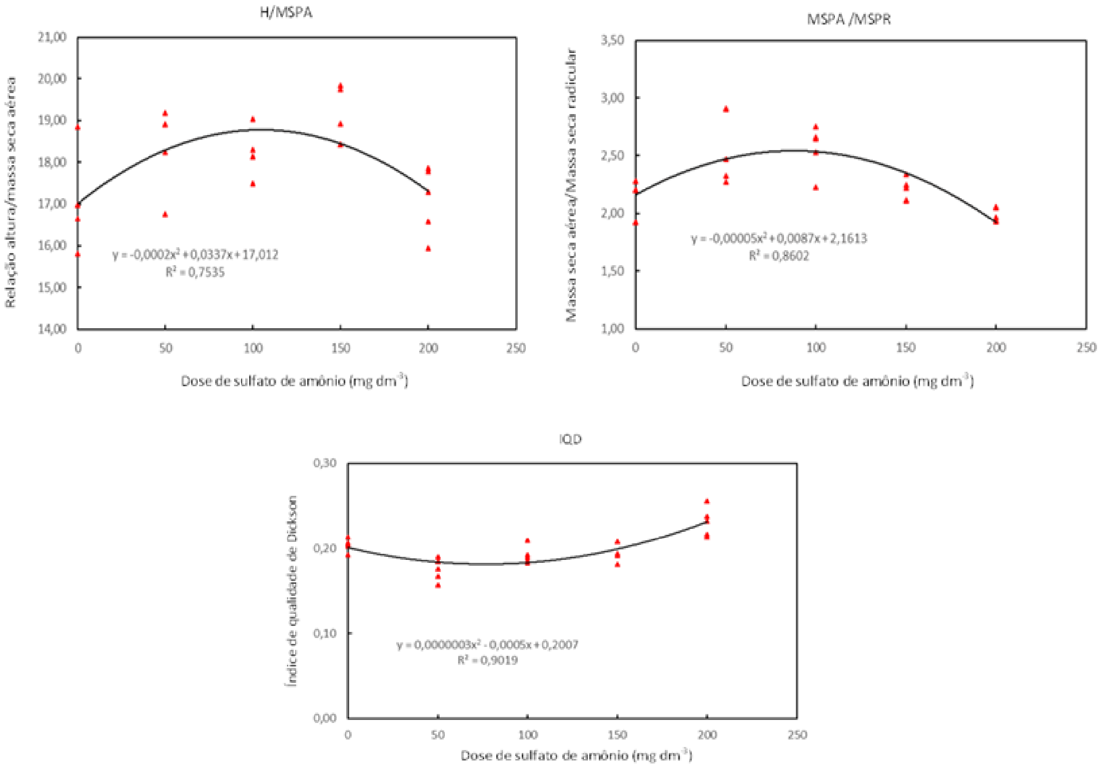
Thus, the highest mean for total dry mass (Figure 5) was obtained for seedlings at the dose of 200 mg dm-3 (2.62 g), and the second highest mean (2.40 g) was observed at the dose of 100 mg dm-3 of N. In these treatments, the increase was 16.8% and 9.2%, respectively, higher than that obtained in the cuttings in the control treatment (mean of 2.18 g).

The level of N was generally higher in seedlings submitted to a dose of 50 mg dm-3, which was not where they stood out in relation to their growth. This may have occurred as a comment on the results obtained for the N doses when the urea was used. As the analyzes of the levels of N only took place at the end of 90 days, probably the seedlings submitted to applications with maximum doses of N had already absorbed a large part of what was added to the soil, for its growth and production of dry mass. So they've grown faster and faster. This is corroborated by the observed results for growth and mass production of the stent at the maximum doses of N when using ammonium sulfate as a source.

Another morphological characteristic that indicates about the quality of the seedlings, is the relationship between height/dry mass of the upper part (Figure 6), which was lower in the seedlings in the treatment controls (17.05) and with 200 mg dm-3 (17.09), the latter, as a function of the greater production of dry mass of the upper part. A similar result was obtained when the relationship between the dry mass of the aerial part/dry mass of the root part was analyzed (Figure 6), a characteristic for which the lowest mean were also observed in the seedlings submitted to the control treatment (2.10) and in the dose of 200 mg dm-3 (1.99). However, the lower mean in the treatment of the witness is related to the lower growth in height, which is not an interesting result when one wants to produce seedlings with potential for planting in the field. Therefore, growth is taking place, with higher quality, in the dose of 200 mg dm-3 of N, since in this one observes a better balance between growth and production of dry mass.

Figure 6

Aerial height-to-dry mass ratio (H/MSPA), air dry mass ratio/root dry mass ratio (MSPA/MSPR) and Dickson quality index (IQD) of tense seedlings after soil fertilization with N, source ammonium sulfate



Source: Prepared by the authors (2024)

Thus, the highest mean for the Dickson quality index (Figure 6) was observed in the seedlings submitted to the 200 mg dm-3 dose of N, indicating a better balance between growth and dry mass production when soil is fertilized. Thus, it is possible to obtain seedlings with a higher quality for planting in the field.

5 FINAL CONSIDERATIONS

Soil fertilization with increasing doses of N positively influenced growth and mass production of tense seedlings, regardless of the source used, urea or ammonium sulfate.

The growth and production of dry mass, of the saplings of tension, submitted to the fertilization of the soil using urea as their source, were greater in the dose of 200 mg dm-3. Providing better quality seedlings at this dose.

The highest growth in height of the seedlings submitted to soil fertilization using ammonium sulfate as a source was in the dose of 100 mg dm-3. However, the greater growth in diameter, production of dry mass and the quality of the cuttings showed more satisfactory averages, in the dose of 200 mg dm-3, and this is the recommended one.

Results such as these can stimulate the use, more often, of nitrogenous fertilizers to improve the quality of seedlings produced in the nursery. It is known that the quality of the seedling is directly related to its ability to survive in the field and to its first years of post-planting growth. This implies mentioning that it may also be related to the quality of the tree to be produced. In addition, using the right fertilizer at the right dose can make the nurseryman manage to produce more seedlings in less time, which is interesting when it comes to a production with a commercial objetive, for example.

Further work should be carried out if the objective is testing with other doses, other types of sources, or other species. It is important that the correct dose is used for each species and that the same dose is not generalized to all species, as this may lead to losses in the growth capacity of some species and longer nursery time.

REFERENCES

Alvarez, V. H. (1974). *Equilíbrio de formas disponíveis de fósforo e enxofres em dois latossolos de Minas Gerais*. 125f. Dissertação (Mestrado em Solos e Nutrição de Plantas). Universidade Federal de Viçosa, MG, Brasil.

Arthur, G. A., Cruz, P. C. M., Ferreira, E. M. (2007). Esterco bovino e calagem para formação de mudas de guanandi. *Pesquisa agropecuária Brasileira*, 42(6), 843-850. https://doi.org/10.1590/S0100-204X2007000600011.

Barroso, D. G., Figueiredo, F. A. M. M.A., Pereira, R. C., Mendonça, A. V. R., Silva, L. C. (2005). Diagnóstico de deficiências de macronutrientes em mudas de teca. *Revista Árvore*, 29(5), 671-679. https://doi.org/10.1590/S0100-67622005000500002.

Belapart, D., Leite, S. M. M., Girotto, M. D., Pedrone, L. P. (2013). Efeito de diferentes doses de nitrogênio e cálcio no desenvolvimento inicial do guanandi. *Unimar Ciências*, 22(1-2), 71-77. http://ojs.unimar.br/index.php/ciencias/article/view/490.

Bezerra, J. L. S., Andrade Neto, R C., Lunz, A. M. P., Araújo, C. S., Almeida, U. O. (2018). Fontes e doses de nitrogênio na produção de mudas de açaizeiro (*Euterpe oleracea* Mart). *Enciclopédia Biosfera, Centro Científico Conhecer*, 15(27), 541-552. https://www.conhecer.org.br/enciclop/2018a/agrar/fontes.pdf.

Birchler, T., Rose, R. W., Royo, A., Pardos, M. (1998). La planta ideal: revision del concepto, parametros definitorios e implementaction practica. *Investigacion Agraria*, *Sistemas y Recursos Forestales*, 7(1-2), 109-121. https://compostamasvi.com/ebooks/plantaideal.pdf.

Cardoso, S. S., Pereira, I. S., Rodrigues, V. L.F., Moraes, E. C., Gaia, J. M. D. (2005). Métodos para superação da dormência de sementes de tento – vermelho *Adenanthera pavonina* L. *Museu Emilio Goeldi*, 1, 87-92.

Cardoso, A. A. S., Santos, J. Z. L., Tucci, C. A. F., Silva Junior, C. H., Venturin, N. (2016). Respostas nutricionais de mudas de sumaúma à adubação nitrogenada, fosfatada e potássica. *Científica*, 44(3), 421-430. https://doi.org/10.15361/1984-5529.2016v44n3p421-430.

Ciriello, V., Guerrini, I. A., Backes, C. (2014). Doses de nitrogênio no crescimento inicial e nutrição de plantas de guanandi. *Cerne*, 20(4), 653-660. 10.1590/01047760201420041445.

Corrêa, M. P. (1978). *Dicionário das plantas úteis do Brasil e das exóticas cultivadas*. Rio de Janeiro: Imprensa Nacional.

Costa Filho, R. T., Valeri, S. V., Cruz, M. C. P. (2013). Calagem e adubação fosfatada no crescimento de mudas de *Mimosa caesalpinifolia* Benth. em Latossolo vermelho-amarelo. *Ciência Florestal*, 23(1), 89-98. https://doi.org/10.5902/198050988442.

Cruz, C. A. F., Paiva, H. N., Guerrero, C. R. A. (2006). Efeito da adubação nitrogenada na produção de mudas de sete-cascas (*Samanea inopinata* (Harms) Ducke). *Revista Árvore*, 30(4), 537-546. https://doi.org/10.1590/S0100-67622006000400006.

Del Quiqui, E. M., Martins, S. S., Pintro, J. C., Andrade, P. J. P., Muniz, A. S. (2004). Crescimento e composição mineral de mudas de eucalipto cultivadas sob condições de diferentes fontes de fertilizantes. *Acta Scientiarum Agronomy*, 26(3), 293-299. https://doi.org/10.4025/actasciagron.v26i3.1826.

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

Duboc, E. (2005). *Desenvolvimento inicial e nutrição de espécies arbóreas nativas sob fertilização, em plantios de recuperação de áreas de cerrado degradado*. 173f. Tese (Doutorado em Agronomia). Universidade Estadual Paulista “Júlio de Mesquita Filho”, SP, Brasil.

Dutra, T. R., Massad, M. D., Sarmento, M. F. Q., Matos, P. S., Oliveira, J. C. (2015). Crescimento de mudas de umburana (*Amburana cearensis*) em resposta à adubação com nitrogênio e fósforo. *Agropecuária Científica no Semiárido*, 11(4), 42-52.

Embrapa. Centro Nacional de Pesquisa de Solos. *Manual de métodos de análise de solos*. (2ª. ed.). Rio de Janeiro: Embrapa.

Falcão Neto, R., Cavalcante, I. H. L., Rocha, L. F., Costa, L. S., Albano, F. G., Beckmann-Cavalcante, M. Z. (2014). Estado nutricional de mudas de castanha-do-gurguéia em função de adubação nitrogenada e tratamento de substrato. *Magistra*, 26(1), 28-37. https://doi.org/10.1590/S1806-66902011000400016.

Fanti, S. C., Perez, S. C. J. G. A. (2003). Influência do sombreamento artificial e da adubação química na produção de mudas de *Adenanthera pavonina* L. *Ciência Florestal*, 13(1), 49-56. https://doi.org/10.5902/198050981723.

Fonseca, S. C. L., Perez, S. C. J. G. A. (2001). Germinação de sementes de olho-de-dragão (Adenanthera pavonina L.): ação de poliaminas na atenuação do estresse salino. *Revista Brasileira de Sementes*, 23(2), 14-20. 10.17801/0101-3122/rbs.v23n2p14-20.

Freitas, E. C. S., Paiva, H. N., Leite, H. G., Oliveira Neto, S. N. (2017). Crescimento e qualidade de mudas de *Cassia grandis* Linnaeus f. em resposta à adubação fosfatada e calagem. *Ciência Florestal*, 27(2), 509-519. https://doi.org/10.5902/1980509827732.

Furtini Neto, A. E., Siqueira, J. O., Curi, N., Moreira, F. M. S. (2000). Fertilização em reflorestamentos com espécies nativas. In: Gonçalves, J. L. M., Benedetti, V. *Nutrição e fertilização florestal* (pp. 351-383). Piracicaba: IPEF. p.351-383.

Gomes, J. M., Paiva, H. N. (2013). *Viveiros florestais*. Viçosa: UFV.

Gonçalves, R. H. (2018). *Nitrogênio e fósforo no crescimento inicial de mudas de carolina (Adenanthera pavonina Linneaus)*. 23f. Monografia (Graduação em Engenharia Florestal). Universidade Federal do Recôncavo Baiano, BA, Brasil.

Goulart, L. M. L., Paiva, H. N., Leite, H. G., Xavier, A., Duarte, M. L. (2017). Produção de mudas de ipê-amarelo (*Tabebuia serratifolia*) em resposta a fertilização nitrogenada. *Floresta e Ambiente*, 24, 1-9, 2017. https://doi.org/10.1590/2179-8087.137315.

Guedes, M. G. M., Silva Junior, M. L., Silva, G. R., Silva, A. L. P., Lima Junior, J. A. (2011). Efeito da adubação nitrogenada na produção de mudas de andiroba (*Carapa guianensis* aublet). *Enciclopédia Biosfera - Centro Científico Conhecer*, 7(12), 1-8. https://conhecer.org.br/ojs/index.php/biosfera/article/view/4545.

Kissmann, C., Scalon, S.P.Q., Scalon Filho, H., Ribeiro, N. (2008). Tratamentos para quebra de dormência, temperaturas e substratos na germinação de *Adenanthera pavonina* L. *Ciência Agrotécnica*, 32(2), 668-674. https://doi.org/10.1590/S1413-70542008000200051.

Leite, G. A., Freitas, P. S. C., Medeiros, L. F., Medeiros, P. V. Q., Mendonça, V. (2010). Adubação nitrogenada na produção de mudas de *Syzygium cumini* L. *Revista Verde*, 5(4), 164-169. https://www.gvaa.com.br/revista/index.php/RVADS/article/view/344.

Lorenzi, H., Souza, H. M., Torres, M. A. V., Bacher, L. B. (2003). *Árvores exóticas no Brasil*: madeireiras, ornamentais e aromáticas. Nova Odessa: Instituto Plantarum.

Malavolta, E., Vitti, G. C., Oliveira, S. A. (1997). *Avaliação do estado nutricional das plantas*: princípios e aplicações. (2ª. ed.). Piracicaba: POTAFOS.

Malavolta, E., Pimentel-Gomes, F., Alcarde, J. C. (2002). *Adubos e adubações*. São Paulo: Nobel.

Malavolta, E. (2006). *Manual de nutrição mineral de plantas*. São Paulo: CERES.

Marques, T. C. L. L. S. M, Carvalho, J. G., Lacerda, M. P. C., Mota P. E. F. (2004). Crescimento inicial do paricá (*Schizolobium amazonicum*) sob omissão de nutrientes e de sódio em solução nutritiva. *Cerne*, 10(2), 184-195. https://www.redalyc.org/pdf/744/74410204.pdf.

Marques, V. B.; Paiva, H. N.; Gomes, J. M.; Neves, J. C. L. (2006). Efeitos de fontes e doses de nitrogênio no crescimento de mudas de sabiá (*Mimosa caesalpiniaefolia* Benth.). *Scientia Forestalis,* (71), 77-85. https://www.ipef.br/publicacoes/scientia/nr71/cap08.pdf.

Marschner, H. (1995). *Mineral nutrition of higler plants*. (2ª. ed.). New York: Academic Press.

Moreira, F. M. S., Moreira, F. W. (1996). Característica de germinação de 64 espécies de leguminosas florestais nativas da Amazônia, em condições de viveiro. *Acta Amazônica*, 26(1/2), 3-16. https://doi.org/10.1590/1809-43921996261016.

Moretii, B. S., Furtini Neto, A. E., Benatti, B. P., Deccetti, S., Lacerda, J. J. J., Stehling, E. C. (2015). Nitrogen, potassium and phosphorous fertilizer suggestions for australian red cedar in Oxisol. *Floresta*, 45(3), 599-608. 10.5380/rf.v45i3.36554.

Passos, M. A. A. (1994). *Efeito da calagem e de fósforo no crescimento inicial da algaroba (Prosopis juliflora* (SW) DC)*.* 57f. Tese (Doutorado em Fitotecnia). Universidade Federal de Viçosa, MG, Brasil.

Raven, P. H., Evert, R. F., Eichhom, S. E. (2016). *Biologia Vegetal*. (8ª. ed.). Rio de Janeiro: Guanabara Koogan.

Rodrigues, A. P. D. C., Oliveira, A. K. M., Laura, V. A., Yamamoto, C. R., Chermouth, K. S., Freitas, M. H. (2009). Tratamentos para superação da dormência de sementes de *Adenanthera pavonina* L. *Revista Árvore*, 33(4), 617-623. https://doi.org/10.1590/S0100-67622009000400004.

Scholberg, J. M. S., McNeal, B. L., Boote, K. J., Jones, J. W., Locascio, S. J., Olson, S. M. (2000). Nitrogen stress efects on growth and nitrogen accumulation by led-growth tomato. *Agronomy Journal*, 92, 159-167. http://dx.doi.org/10.2134/agronj2000.921159x.

Silva, T. A. F., Tucci, C. A. F., Santos, J. Z. L., Batista, I. M. P., Miranda, J. F., Souza, M. M. (2011). Calagem e adubação fosfatada para a produção de mudas de *Swietenia macrophylla*. *Floresta*, 41(3), 459-470. http://dx.doi.org/10.5380/rf.v41i3.23992.

Souza, C. A. M., Oliveira, R. B., Lima, J. S. S. (2006). Crescimento em campo de espécies florestais em diferentes condições de adubação. *Ciência Florestal*, 16(3), 243-249. https://doi.org/10.5902/198050981905.

Sturion, J. A., Antunes, B. M. A. (2000). Produção de mudas de espécies florestais. In: Galvão, A. P. M. *Reflorestamento de propriedades rurais para fins produtivos e ambientais*. (pp. 125-150). Colombo: Embrapa.

Taiz, L., Zeiger, E. (2013). *Fisiologia vegetal*. (5ª. Ed). Porto Alegre: Artmed.

Tucci, C. A. F., Lima, H. N., Lessa, J. F. (2009). Adubação nitrogenada na produção de mudas de mogno (*Swietenia macrophylla* King). *Acta Amazônica*, 39(2), 289-294. https://doi.org/10.1590/S0044-59672009000200007.

Vieceli, C. A. (2017). *Guia de deficiências nutricionais em plantas*. Curitiba: PUCPR.

Xavier, A., Wendling, I., Silva, R. L. (2009). *Silvicultura clonal*: princípios e técnicas. Viçosa: UFV.