








ORIGINAL ARTICLE

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Application of increasing doses of phosphor in *Cordia trichotoma* seedlings

Aplicação de doses crescentes de fósforo em mudas de Cordia trichotoma

ABSTRACT: The objective of this work was to evaluate the initial response of *Cordia trichotoma* seedlings to increasing doses of phosphorus application. The experiment was carried out in a randomized block design, with five treatments (0, 150, 300, 450 and 600 mg dm⁻³ of P) in five replications. It was evaluated at 30, 60, 90 and 180 days at height, stem diameter, robustness index (H/DC), shoot dry mass (MSPA), root system dry mass (MSR), MSPA/MSR, total dry mass (MST) and the Dickson Quality Index (IQD). Furthermore, the maximum technical efficiency doses (DMET) were calculated. The variables showed a quadratic growth behavior for all variables, demonstrating the importance of fertilization with P in the growth of seedlings. However, the dose of 600 mg dm⁻³ showed symptoms of toxicity in the seedlings. The indicated DMET for fertilization with P was 221.43 mg dm⁻³, at 180 days.

RESUMO: O objetivo deste trabalho foi avaliar a resposta inicial de mudas de *Cordia trichotoma* a dosagens crescentes de aplicação de fósforo. O experimento foi realizado em delineamento de blocos casualizados, com cinco tratamentos (0, 150, 300, 450 e 600 mg dm⁻³ de P) em cinco repetições. Avaliou-se aos 30, 60, 90 e 180 dias à altura, diâmetro do coleto, índice de robustez (H/DC), massa seca da parte aérea (MSPA), massa seca do sistema radicular (MSR), MSPA/MSR, massa seca total (MST) e o Índice de Qualidade de Dickson (IQD). Ademais, calcularam-se as doses de máxima eficiência técnica (DMET). As variáveis apresentaram comportamento quadrático de crescimento para todas as variáveis, demonstrando a importância de adubação com P no crescimento das mudas. No entanto a dose de 600 mg dm⁻³ apresentou sintomas de toxidez nas mudas. A DMET indicada para adubação com P foi de 221,43 mg dm⁻³, aos 180 dias.

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1 Introduction

The limiting factor for the development of productive forestry of native species in Brazil is a lack of basic information about these species. According to Oliveira *et al.* (2020) investors' main difficulty is to measure profitability and as risk conditioners, to obtain accurate information about the investment. Therefore, it is only with a solid base of silvicultural practices and scientific proof of their effects that private sector investments in a forest production of native species can be carried out with the least possible technical risks.

Cordia trichotoma, known as brown laurel (louro pardo), has a high production potential, as it combines a wide geographic distribution, present in the South, Southeast, Midwest and Northeast regions (Trianoski *et al.*, 2017), with moderate growth rate and recognized wood quality (Trianoski *et al.*, 2017; Wille *et al.*, 2017). The species can be part of plantations providing restoration (Zimmermann *et al.*, 2017), pure forest stands for production (Santos *et al.*, 2017) and intercropping in agroforestry systems (Antonelli *et al.*, 2015).

The low natural fertility found in soils destined for forestry implantation, mainly in macronutrients such as phosphorus (P) (Gonçalves *et al.*, 2008), requires the practice of fertilization in order to meet the nutritional demand of the species. P is required in the formation of adenosine triphosphate, and, therefore, indispensable in cellular metabolic processes, so its absence or deficiency reduces the productive potential of cultivated plants (Taiz & Zeiger, 2013).

In practice, the high demand for plantations and the lack of specific fertilization recommendation for native species led to the use of the Eucalyptus genus plantation fertilization recommendation for native species. Species-specific recommendations are desirable as they provide adequate nutrition and promote better growth, in addition to being a more rational use of physical and economic resources. In this context, the objective of this work was to evaluate the initial response of *Cordia trichotoma* seedlings to increasing doses of phosphorus application.

2 Material and methods

The experiment was carried out in a greenhouse in a nursery located in the municipality of Lavras, in the south of the state of Minas Gerais (21° 13' 14.033" S and 44° 58' 0.232" W). The climate in the region is of the Cwb type according to the classification proposed by Köppen, with an average annual temperature of around 19.3°C, with average temperatures of 22.1° and 15° in the hottest month and in the coldest month, 8°, respectively, the normal annual precipitation is 1,530 mm, being the months of October to March with higher precipitation and the months of April to September with low precipitation and temperatures.

To evaluate the fertilization rates for the species, the experiment was designed in four randomized complete blocks with five fertilization rates and five replications, totaling 25 seedlings. Each pot contained a plant, with 7

dm³ in volume and was wrapped in a plastic bag properly sealed with adhesive tape. The pots remained in a greenhouse during the entire period of the experiment.

The cultivation substrate was a Red Latosol, collected in the municipality of Lavras - MG, at a depth of 20 to 40 cm, avoiding the fertile soil layer that could mask the effect of fertilizers. After air drying, the soil was sieved through a 5 mm sieve and a sample was taken for physical and chemical analysis. The physical and chemical analyzes of the soil were determined, according to Texeira *et al.* (2017) and presented in table 1.

Table 1. Physical and chemical analysis of the Red Latosol with a depth of 20 to 40 cm collected in Lavras-MG.

Tabela 1. Análise física e química do Latossolo Vermelho com profundidade de 20 a 40cm coletado em Lavras-MG.

Parameters	Red latosol
Sand content (dag.kg ⁻¹)	13.00
Silt content (dag.kg ⁻¹)	21.00
Clay content (dag.kg ⁻¹)	66.00
pH (em água)	5.50
MO (g kg ⁻¹)	1.22
P (Mehlich ⁻¹) (mg.dm ⁻³)	0.40
K (mg.dm ⁻³)	3.39
Ca (cmolc dm ⁻³)	1.45
Mg (cmolc dm ⁻³)	0.10
Al (cmolc dm ⁻³)	0.01
H + Al (cmolc dm ⁻³)	2.08
Sun of base (cmolc dm ⁻³)	1.56
CTC effective (cmolc dm ⁻³)	1.57
CTC pH at 7,0 (cmolc dm ⁻³)	3.64
Base saturation (%)	42.64
Saturation by Al (%)	0.64
Zn (mg.dm ⁻³)	0.55
Fe (mg.dm ⁻³)	32.52
Mn (mg.dm ⁻³)	4.11
Cu (mg.dm ⁻³)	2.44
S (mg.dm ⁻³)	11.54

Physical Where: pH: Hydrogen potential in water; CEC: Cation exchange capacity; OM: Organic matter.

Onde: pH: Potencial hidrogeniônico em água; CEC: Capacidade de troca de cátions; OM: Matéria orgânica.

Liming was carried out, based on the chemical analysis of the soils (Table 1), in order to raise the base saturation to 60%. Calcined dolomitic lime was used, with 36% of CaO, 14% of MgO (PRNT equal to 100%) and the doses calculated according to the Raij formula, maintaining, after application, the soil incubation for 30 days.

$$NC = \frac{(V2 - V1) * T}{100}$$

Where: NC is the need for liming in tons per hectare, for a layer 20 cm thick; T is the value of potential CTC or CTC at pH 7.0; V1 is the original base saturation percentage of the soil, as a result of the soil analysis; V2 is the desired base saturation percentage.

Cordia trichotoma seedlings were produced in tubes with a volume of 110 cm³ with substrate composed of 50% commercial substrate, 20% coconut fiber and 20% carbonized rice husk. Four seeds were sown per tube, and the seedlings remained in a shade house (50% intensity). At 30 days after germination, the seedlings were thinned, leaving only one plant per tube, and 60 days after germination, they were planted in pots, with an average height of 6 cm.

The treatments consisted of increasing doses of phosphorus, 0, 150, 300, 450 and 600 mg dm⁻³, which were based on the recommendation of P for pot, corresponding to 300 mg dm⁻³, according to Malavolta (2006). The doses of P were applied to the soil, during sowing, by phosphoric acid (H₃PO₄), in solution.

The height of the aerial part (H) was measured with the aid of a millimeter ruler and the diameter of the collar (DC) with the aid of a digital caliper at the ages of 180 days after planting.

After 180 days, destructive studies were carried out for the determination of dry matter. The seedlings were divided into shoots and roots, and the root system was separated from the substrate by washing with running water. The material was conditioned in an oven with forced air circulation, at 70 °C, until it reached a constant weight, being weighed on a precision analytical balance (0.01g). Total dry matter (TDM) was obtained from the sum of shoot dry matter (SDM) and root dry matter (RDM) values. To assess the quality, the robustness index (H / DC) was performed and the Dickson Quality Index (DQI) was determined:

$$IQD = \frac{MST(g)}{\frac{H(cm)}{DC(mm)} + \frac{MSPA(g)}{MSR(g)}}$$

The data obtained were subjected to analysis of variance and when there was a significant difference, the mean regression was performed at a 5% probability of error for the doses applied. In the case of regressions, the dose that provided the maximum technical efficiency (DMET) was obtained. The DMTE of the variables of interest corresponded to the first derivative of the adjusted equations equal to zero. The analyzes were performed using the SISVAR software.

3 Results and Discussion

The exclusive application of phosphorus in the growth of *Cordia trichotoma* seedlings presented a negative quadratic behavior, that is, the species responds positively with the increase of the applied dose up to a maximum point for most of the analyzed variables, Figure 1. The DMTE found were 251.13 mg/dm³, for H, 71.35 mg/dm³ for DC, 295 mg/dm³ for H/DC, 238 mg/dm³, for SDM, 255 mg/dm³, for RDM, 256 mg /dm³ for TDM, 188 for DIQ.

The positive linear behavior of the morphological variables of *Cordia trichotoma* to the application of

phosphorus at 180 days was described by Berghetti *et al.* (2020). The use of high doses, such as the 600 mg dm⁻³ dosage, resulted in a decrease in morphological parameters, being a clear response to phytotoxicity promoted by the excess absorption of the nutrient. This phenomenon allowed a better understanding of the limits of phosphorus application in *Cordia trichotoma*, and a more accurate modeling and prediction of technical efficiency doses for the species. Silva *et al.* (2021), emphasize the importance of using a correct dose of the nutrient, since high doses can generate phytotoxicity and low doses do not meet the plant's needs, both situations hindering the growth of seedlings.

The SDM/RDM index expresses the balance of seedling growth, considering that smaller ratios indicate the greater capacity of the seedlings to survive and establish themselves in the field (Honorio *et al.*, 2019). This variable was the only one that presented a positive quadratic function, with the increasing means with the increase of all tested doses, which indicates that the plant had less growth of the root system to the detriment of the growth of the area, at high doses, which demonstrate lower quality of the seedling. This result is one of the responses to phytotoxicity promoted by the high doses of P applied, as well as observed by the drop in growth of all studied variables.

The growth response of the morphological and seedling quality variables referring to the application of fertilization with P reveal that *Cordia trichotoma* requires a good management of soil nutrition for better silvicultural performance. Berghetti *et al.* (2020) emphasize the low performance of *Cordia trichotoma* in soils with low fertility, notably tropical and subtropical soils, being the demanding species with good soil fertility.

The influence of P on seedling growth is evident, as this nutrient is responsible for several metabolic processes, plant respiration, photosynthetic rate and Calvin cycle (Taiz & Zeiger, 2013). Furthermore, Brazilian soils have low P availability, which provides a high adsorption capacity of the element by soil aggregates, reducing its absorption by plants (Fleitas *et al.*, 2018). Thus, according to the author, it is the nutrient that most limits plant growth in Brazil.

The mean DMTE of the studied variables was 221.43 mg dm⁻³, which corresponds to a lower dose than that recommended for P fertilization in pots by Malavolta (2006). A result similar to the work by Sthal *et al.* (2013) in *Eucalyptus dunnii* seedlings in which they found a DMTE of 256 mg dm⁻³. Antonelli *et al.* (2015), in field planting of *Cordia trichotoma*, studying increasing doses of NPK, using eucalyptus base fertilization for Rio Grande do Sul, the authors observed that the fertilization of 66 g of N, 44 of P₂O₅ and 18 of K₂O, was ideal for the growth of the species at 10 months of age.

Several studies are carried out in order to improve the ways of fertilization, with the objective of reaching the maximum production of the cultures. *Cordia trichotoma* has a clear response to fertilization, as noted by Antonelli *et al.* (2015) and Berghetti *et al.* (2020) however, it is also possible to distinguish harmful effects caused by fertilizer

overdose, observed in this work with the development of the 600 mg dm⁻³ treatment when compared to the others, thus highlighting the existence of an optimal range of fertilization for the species, indicated by the DMTE of 221.43 mg dm⁻³. As established for P, in the present

study, the optimal dosages for the other nutrients must also be estimated in future studies for the most efficient recommendation of fertilization for *Cordia trichotoma*.

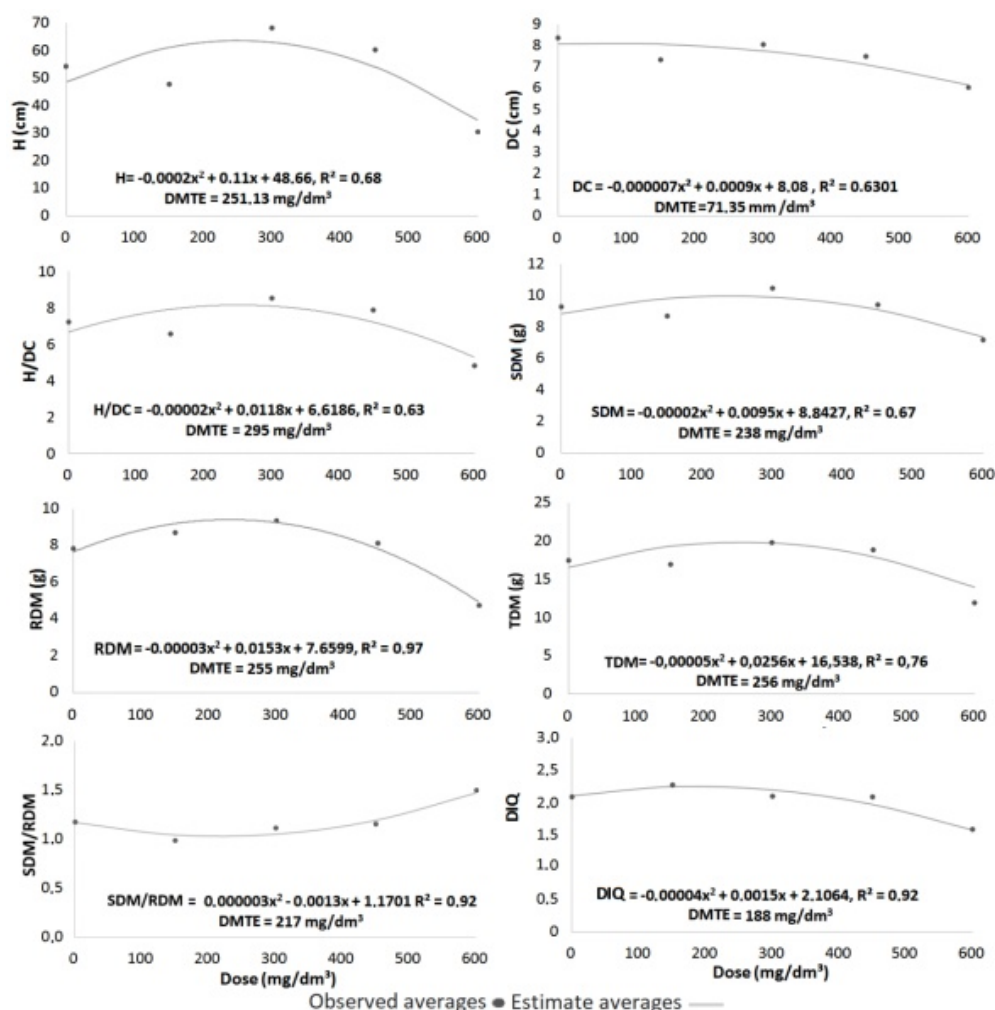


Figure 1. Effect of P doses on height growth (H), stem diameter (DC), robustness index (H/DC), shoot dry mass (MSPA), root dry mass (MSR), dry mass total (MST), MSPA/MSR and the Dickson Quality Index (IQD), at 180 days of age of *Cordia trichotoma* seedlings.

Figura 1. Efeito das doses de P no crescimento em altura (H), diâmetro de coleto (DC), índice de robustez (H/DC), massa seca da parte aérea (MSPA), massa seca radicular (MSR), massa seca total (MST), MSPA/MSR e o Índice de Qualidade de Dickson (IQD), aos 180 dias de idade das mudas de *Cordia trichotoma*.

4 Conclusion

Phosphorus directly influences the morphological growth of *Cordia trichotoma* seedlings, with a dosage of 221.43 mg.dm⁻³ destined, at 180 days.

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Conceptualization; Data curation; Formal analysis; Methodology; Visualization; Writing – original draft and Writing – review & editing; Paloma Carvalho Diniz: Data curation; Writing – original draft and Writing – review & editing; Vinícius Augusto Campos: Data curation; Writing – original draft and Writing – review & editing; Manuela Dias Gonzaga: Data curation; Writing – original draft and Writing – review & editing; Lucas Amaral de Melo: Conceptualization; Funding acquisition; Resources.

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Conflict of interest: The authors declare no conflicts of interest.

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