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Trichoderma as a growth promoter in *Astronium urundeuva* (M. Allemão) Engl.

Trichoderma como promotor de crescimento em *Astronium urundeuva* (M. Allemão) Engl.

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The low growth is one of the biggest problems encountered in the production of native forest seedlings. Fungi of the genus *Trichoderma* are microorganisms capable of potentialize the plant growth. Thereby, this article aims to evaluate the efficiency of *Trichoderma* inoculation, as a plant growth promoter of Aroeira seedlings (*Astronium urundeuva* (M. Allemão) Engl.), in the greenhouse. The isolated ones, at the approximate concentration of conidia at 1 x 10^9 per colonized gram of rice, were individually mixed with the soil in a homogeneous form in the experiments with and without phosphate fertilization. For the control treatment, sterilized rice without *Trichoderma* was used. Two experiments were carried out, at 50 and 100 days after the sowing (DAS). Were evaluated the biomass characteristics of the selected crop through the dry mass of aerial part, the root dry mass and the total dry mass, as well as the relative efficiency and quality index of Dickson. The experiment whose received the natural fertilizer phosphate, occurred a variation of 25.4 to 925% in growth promotion, compared to the control treatment. The experiment without fertilizer showed a variation of 26.5 to 425.4% in growth, compared to the control treatment. The results demonstrate the capacity of isolated *Trichoderma* to promote an initial growth with or without natural fertilize phosphate to Aroeira.
Keywords: aroeira, biostimulant, forest seedlings.

O crescimento lento é um dos maiores problemas encontrados na produção de mudas florestais nativas. Os fungos do gênero *Trichoderma* são microrganismos capazes de potencializar o crescimento das plantas. Assim, este artigo tem como objetivo avaliar a eficiência da inoculação de *Trichoderma*, como promotor de crescimento de mudas de Aroeira (*Astronium urundeuva* (M. Allemão) Engl.), em casa de vegetação. Os isolados, na concentração aproximada de conídios de 1 x 10^9 por grama colonizada de arroz, foram misturados individualmente ao solo de forma homogênea nos experimentos com e sem adubação fosfatada. Para o tratamento controle foi utilizado arroz esterilizado sem *Trichoderma*. Foram realizados dois experimentos, aos 50 e 100 dias após a semeadura (DAS). Foram avaliadas as características da biomassa da cultura selecionada através da massa seca da parte aérea, a massa seca da raiz e a massa seca total, bem como a eficiência relativa e o índice de qualidade de Dickson. O experimento que recebeu o fertilizante natural fosfatado, ocorreu uma variação de 25,4 a 925% na promoção do crescimento, em relação ao tratamento controle. O experimento sem adubo apresentou variação de 26,5 a 425,4% no crescimento, em relação ao tratamento controle. Os resultados demonstram a capacidade do *Trichoderma* isolado em promover um crescimento inicial com ou sem fertilizante natural fosfatado para Aroeira.
Palavras-chave: aroeira, bioestimulante, mudas florestais.

1. INTRODUCTION

The forest stand in Brazil have been located where the soil presents low levels of macronutrients, especially for phosphor. The phosphor (P) is one of the macronutrients that limits the plant growth, for acting in the important production of energy (ATP), DNA and RNA [1]. The concentration of soluble P is low in most of these soils, only 20% of this soluble powder is available to the plant, the rest becomes unavailable because of the absorption, precipitation and organic conversion [2].

The species *Astronium urundeuva* (M. Allemão) Engl. (aroeira) belongs to the Anacardiaceae family, owning a large geographic distribution in Americas, presenting a natural

distribution in South America, that can be founded in plant formation of caatinga, Cerrado and rain forests, with the area varying depending on the local, reaching up to 30 m in height [3]. It was widely explored for having a heavy, compact and rot- resistant wood the low growth is one of the biggest problems encountered in the production of native forest seedlings. The aroeira is classified as a tardy or climax species [3].

In this context, with the accelerated growth of agriculture, seeking for efficient alternatives that do not cause damage to environment, which can be used to the contribute to the growth of agricultural production and, consequently, decrease the risks of consuming contaminated food with pesticides [4]. The use of microorganisms such as *Trichoderma* spp. can contribute to the plant growth, which can reduce input costs. These fungi are rhizosphere colonizer and are free-living, being one of the most studied because they present plant growth promotion activity and phytopathogen biocontrol agents [5-7]. They can provide a wide range of benefits to the plant, such as significant increase of seed germination [8], improve nutrient absorption and efficient use of fertilizer in function of the phosphate solubilization ability, higher growth, higher weight of dry root and aerial part, increases the side roots [7, 9], increase the resistance to hydraulic stress, to salt and high temperature [10], act in the biological control of parasitism, hyperparasitism, mycroparasitism and promotes systematic disease resistance, growth hormones synthesis such as auxin, gibberellins and cytokines [11-15].

In the production of seedling in native species, the *Trichoderma* is not used much, but there are some results that prove their efficiency in case of emergency and cambará growth (*Gochnatia polymorpha* (Less.) Cabrera) and in the growth promotion of Rubber tree (*Hevea brasiliensis* Muell. Arg.) [16, 17] and eucalyptus [18]. Considering the lower level of nutrient soils of Cerrado and the propitiated benefits through the interaction of plant x *Tricchoderma*, the study have the objective of evaluate the isolations of *Trichoderma* in the promotion of initial growth of aroeira (*Myracrodruon urundeuva* Fr. All.) in soils with and without fertilize natural phosphate.

2. MATERIAL AND METHODS

The experiments were conduct in greenhouses and in the Laboratory of Microbiology of the Universidade Federal do Tocantins, *campus* of Gurupi (11°43'S e 49°04'W, a 280 m of altitude). According to Köppen classification, the weather of the region is Aw, defined as tropical hot and humid with a raining season in the summer and dry season in the winter.

Two independent experiments were carried out, one with phosphate fertilizer and another without phosphate fertilizing, both inoculated with *Trichoderma* isolates. Each experiment had a completely randomized design (CRD), containing six treatments, being five treatments inoculated with different species of *Trichoderma* spp. and a control treatment without inoculation, with 10 repetitions. The isolates were previously characterized by sequencing of TEF region (Translation Elongation Factor) and identified by access codes in GenBank (Table 1) at Biologic Institute of São Paulo.

Table 1. GenBank access codes for the Trichoderma *isolates (TEF region - translation elongation factor) used in this study.*

Isolate	Species identification	GenBank access	Reference
UFT 201	*T. asperelloides* GJS 04-217	DQ381958	[19]
UFT 202	*T. harzianum* CIB T23	EU279989	[20]
UFT 203	*T. harzianum* CIB T23	EU279989	[20]
UFT 204	*T. longibrachiatum* DAOM 167674	EU280046	[20]
UFT 205	*T. asperelloides* GJS 04-217	DQ381958	[19]

Pots with a capacity of 2 kg were used. The substrate used was removed from the superficial layer of the soil (0-20 cm) a dystrophic latossolo Vermelho-amarelo [21], medium texture, in an experimental cultivation area at the Federal University of Tocantins, Gurupi-TO, previously sieved in a 4 mm mesh. Collected samples were analyzed in Soil Laboratory of UFT, obtaining the following characteristics: Ca +Mg 2.55 cmol dm^{-3}; Ca 1.80 cmol dm^{-3}; Mg 0.75 cmol dm^{-3}; Al 0.00 cmol dm^{-3}; H+Al 5.54 cmol dm^{-3}; K 0.21 cmol dm^{-3}; CTC (T) 8.31 cmol dm^{-3}; SB 2.76 cmol dm^{-3}; K 83.54 mg dm^{-3} (ppm); P (Mel) 5.85 mg dm^{-3} (PP); V 33.27%; M 0.00%; Mat. Org. 2.56% 25.59 g dm^{-3}; pH $CaCl_2$ 4.80, H_2O 5.38 [22].

The *Trichoderma* isolates were grown separately in a petri dish containing PDA medium (200 g potato, 20 g dextrose, 15 g agar in 1000 mL water) and incubated at 25 ± 2 C with a photoperiod of 12 hours in BOD camera (Biochemical Oxygen Demand), for seven days, a determined period for the growth of *Trichoderma* colonies. Polypropylene bags containing 300 g of commercial rice and 300 mL of distilled water were prepared and autoclaved at 121º C for 1 hour. After cooling, six 5 mm diameter disks of each isolate were placed separately, grown in BDA medium. Every two days, the substrate containing rice was revolved to facilitate gas exchange, breakdown of mycelial aggregates and increase of sporulation. After seven days of incubation, 1 g of rice was removed to qualify the spore's concentration. From spore suspensions obtained by adding 9 mL of H_2O and 1 g of the colonized substrate in a test tube, homogenization was performed in a vortex mixer [18]. Each one of the suspensions, an aliquot was taken to count the spores, with the aid of a Neubauer chamber. The average *Trichoderma* isolates sporulation of conidia was 2.4 x 10^9 (UFT 201), 1.4 x 10^9 (UFT 202), 2.2 x 10^9 (UFT 203), 2.0 x 10^9 (UFT 204) and 1.1 x 10^9 (UFT 205).

Were used 30 g of each bag of rice colonized with *Trichoderma* for subsequent infestation in the soil. The *Trichoderma* isolates were individually mixed in the soil as a homogeneous form at the experiments with and without phosphate fertilization. For the control treatment, at the both experiments, were use 30 g of sterilized rice and without *Trichoderma*.

In the experiment with phosphate fertilization, 0.3 g of phosphate were used in each repetition, being mixed homogeneously together with the *Trichoderma* isolates. The phosphate concentrate used was Angico, obtained from Galvani (Fertilize Industry), with a 32% content of P_2O_5.

A week after the *Trichoderma* isolates being inoculate do the soil, occurred a planting of 5 seeds of aroeira per vase, the depth was 0.5 cm, without previous treatment of the seeds. Paring was made 15 days after the planting, leaving one plant per vase. Irrigation was performed manually, twice a day, once in the morning and once in the afternoon, for 100 days.

Two evaluations were performed, one at 50 days after sowing (DAS) and another at 100 DAS. Plants were dried in a forced-air oven at 65 to 70°C for 72 hr. The morphological parameters evaluated were: height (H); root length (RL); neck diameter (ND); shoot dry mass (SDM); root dry mass (RDM); total dry mass (TDM). At 100 DAS in both experiments, the relative efficiency of each treatment was determined, calculated according to the formula: ER = (SDM inoculated with the isolates/SDM without inoculant) x 100. Also, the Dickson quality index (DQI) was determined at 100 DAS, which is the relation between total dry mass (TDM) by the sum of the ratio between height (H) and stem diameter (SD) and the shoot dry mass (SDM) by root dry mass (RDM) [23]: DQI = [TDM / (H / ND) + (SDM /TDM)]. The data were submitted to analysis of variance using the statistical program ASSISTAT version 7.7 beta and the mean were compared by the Duncan test at 5% probability.

3. RESULTS AND DISCUSSION

In the first experiment, in a natural phosphate fertilized soil, considering the variables stem diameter (SD), shoot dry mass (SDM), root dry mass (RDM) and total dry mass (TDM), all isolates were superior ($p < 0.05$) the control at 50 days after sowing (DAS) (Table 2). The height (H), root length (RL), SD and RDM values of the UFT 203 isolate were about 110, 35.9, 58.3 and 366.6% higher than the control treatment, respectively. The isolate UFT 202 was superior

($p<0.05$) to the other isolates in SDM and TDM, being 925 and 211.7% superior in relation to the control treatment (Table 2).

*Table 2. Average values of height (H), root length (RL), stem diameter (DC), shoot dry mass (ADM), root dry mass (RDM), total dry mass (TDM) and Dickson's Quality Index (DQI) of aroeira (*Astronium urundeuva *(M. Allemão) Engl.) inoculated* Trichoderma*, in natural phosphate soil.*[1]

Treatments	H (cm)	LR (cm)	SD (mm)	SDM (g)	RDM (g)	TDM (g)	DQI
			50 DAS[2]				
Control	5.1±0.5^{d}	6.4±0.4^{c}	1.2±0.05^{d}	0.04±0.00^{e}	0.03±0.00^{e}	0.08±0.00^{e}	---
UFT 201	7.5±0.6^{c}	8.6±0.6^{a}	1.5±0.06^{c}	0.21±0.01^{c}	0.05±0.00^{d}	0.27±0.01^{c}	---
UFT 202	9.2±0,8^{b}	8.6±0,5^{a}	1.7±0.06^{b}	0.41±0.02^{a}	0.12±0.01^{b}	0.53±0.02^{a}	---
UFT 203	10.7±1.1^{a}	8.70,6^{a}	1.9±0.06^{a}	0.35±0.01^{b}	0.14±0.01^{a}	0.49±0.02^{b}	---
UFT 204	6.4±0.4^{cd}	7.30,6^{bc}	1.6±0.05^{b}	0.20±0.01^{c}	0.07±0.00^{c}	0.28±0.01^{c}	---
UFT 205	6.3±0.5^{cd}	7.90,7^{ab}	1.6±0.04^{b}	0.17±0.01^{d}	0.06±0.00^{d}	0.23±0.01^{d}	---
C.V(%)[3]	13.6	10.5	5.9	4.1	8.3	3.9	---
			100 DAS				
Control	9.3±0.7^{c}	22.8±1.9^{b}	2.0±0.1^{b}	0.33±0.03^{b}	0.55±0.04^{c}	0.89±0.08c	0.17±0.01^{c}
UFT 201	19.2±2.0^{ab}	31.2±2.8^{a}	3.2±0.2^{a}	1.70±0.11^{a}	2.68±0.25^{ab}	4.41±0.39^{ab}	0.67±0.06^{a}
UFT 202	21.7±2.3^{a}	31.0±3.1^{a}	3.2±0.3^{a}	1.90±0.21^{a}	2.91±0.28^{a}	4.87±0.41^{a}	0.67±0.06^{a}
UFT 203	19.1±1.9^{ab}	30.8±3.0^{a}	3.2±0.3 a	1.70±0.19^{a}	2.7±0.27^{ab}	4.42±0.40^{ab}	0.67±0.06^{a}
UFT 204	21.4±2.1^{a}	28.6±2.7^{a}	3.1±0.03^{a}	1.70 ±0.18^{a}	2.40±0.25^{b}	4.10±0.39^{b}	0.53±0.05^{b}
UFT 205	18.5±1.9^{b}	24.8±2.2^{b}	3.0±0.03^{a}	1.80±0.17^{a}	2.7±0.26^{ab}	4.64±0.44^{ab}	0.69±0.06^{a}
C.V(%)	10.3	9.6	9.0	12.9	11.5	9.8	10.9

[1]Means followed by the same lower case letter in the column do not differ by Duncan test at 5% probability. [2]DAS = Days after sowing. [3]Coefficient of variation.

In H, SD, RDM the isolate UFT 203 was superior ($p<0.01$) to the other isolates (Table 2). For the variable LR the isolates UFT 201, UFT 202, UFT 203 and UFT 205 did not differ among themselves but were superior ($p<0.05$) to the control and isolate UFT 204. The isolate UFT 205 did not differ statistically from the isolate UFT 204. For TDM there was variation among isolates from 187 to 562.5% in relation to the control (Table 2).

At 100 DAS the isolates UFT 201, UFT 202, UFT 203 and UFT 204 were superior ($p<0.05$) to the control in all the parameters evaluated. The isolate UFT 205 did not differ from the control (Table 2). The values of H, SD, SDM, RDM and TDM of isolate UFT 202 were about 133.3, 60, 475, 429 and 447% higher than the control at 100 DAS, respectively (Table 2 and Figure 1A). In H the isolates UFT 201, UFT 202, UFT 203 and UFT 204 were superior to the control and did not differ among themselves. For LR and SDM all isolates were superior ($p<0.05$) to the control and did not differ among themselves. For RDM and TDM the isolates UFT 201, UFT 202, UFT 203 and UFT 205 were superior and did not differ statistically. In the Dickson Quality Index (DQI), the isolates UFT 201, UFT 202, UFT 203 and UFT 205 were superior ($p<0.05$) to UFT 204 and did not differ statistically among themselves, with a variation of 211 to 305% in relation to the control at 100 DAS (Table 2).

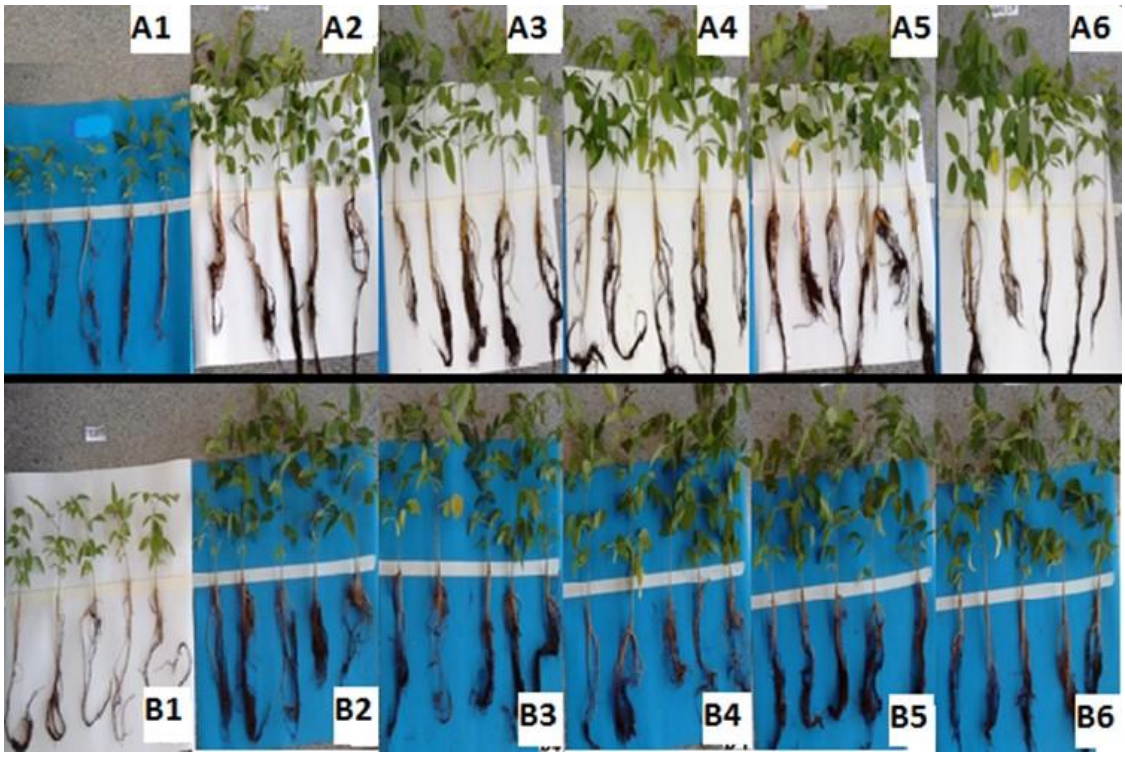

*Figure 1. Aerial part and root, at 100 days after sowing, of mastic (*Astronium urundeuva *(M. Allemão) Engl.) inoculated with isolates of* Trichoderma*, with and without phosphate fertilization, where: Experiment 1, with phosphate fertilization - A1) control, A2) UFT 201, A3) UFT 202, A4) UFT 203, A5) UFT 204 and A6) UFT 205. Experiment 2, without phosphate fertilization - B1) control; B2) UFT 201, B3) UFT 202; B4) UFT 203, B5) UFT 204 and B6) UFT 205.*

As for the relative efficiency (RE), that relates the biomass of the aerial part of the inoculated treatments with *Trichoderma* with the biomass of the aerial part of the control, all isolates were superior ($p<0.05$) to the control, not existing significant difference between them, with average superiority of 415% in relation to the control (Figure 2A).

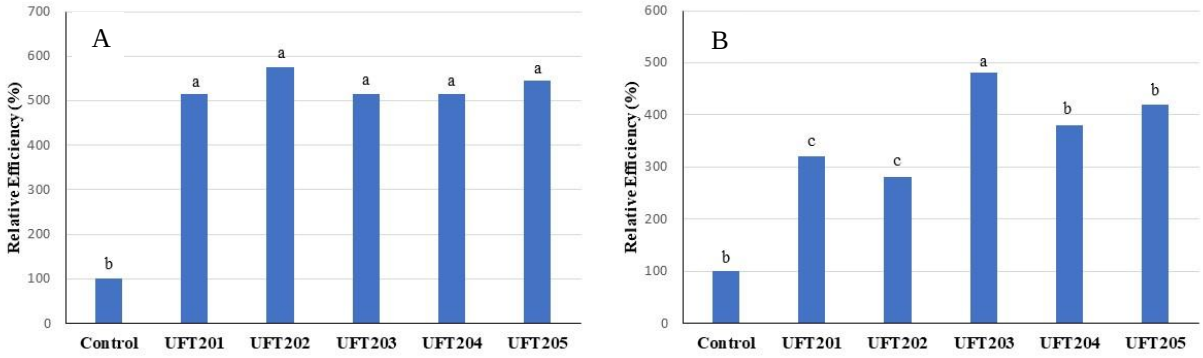

*Figure 2. Relative efficiency of mastic trees (*Astronium urundeuva *(M. Allemão) Engl.) inoculated with isolates of* Trichoderma *in relation to the control without inoculation, in soil with fertilization of natural phosphate (A) and without fertilization of natural phosphate (B) (Means followed by the same lower case letter do not differ by Duncan's test at 5% probability).*

In the second experiment on soil not fertilized with natural phosphate, at 50 DAS, the isolates used were superior ($p<0.05$) to the control in the parameters H, SD, SDM and TDM (Table 3). For H there was no significant difference between the isolates, being up to 135% higher than the control. For LR the isolates UFT 201, UFT 203 and UFT 204 did not differ from

the control, and the isolates UFT 202 and UFT 205 were superior ($p<0.05$) to the control by 34.8 and 44.9%, respectively. The isolate UFT 202 was superior ($p<0.05$) to the other isolates in the variables RDM and TDM, outperforming the control by 275 and 325%, respectively. In SD the performance of isolates ranged from 26.5 to 41% relative to the control.

*Tabela 3. Mean values of height (H), root length (RL), stem diameter (SD), shoot dry mass (SDM), root dry mass (RDM), total dry mass (TDM) and Dickson Quality Index (DQI) from (*Astronium urundeuva *(M. Allemão) Engl.) inoculated with* Trichoderma*, in soil without natural phosphate fertilization.*[1]

Treatments	H (cm)	LR (cm)	SD (mm)	SDM (g)	RDM (g)	TDM (g)	DQI
			50 DAS[2]				
Control	4.0±0.4^{b}	6.9±0.7^{c}	1.1±0.1^{c}	0.07±0.00^{d}	0.04±0.00^{d}	0.12±0.01^{d}	---
UFT 201	9.4±0.8^{a}	7.4±0.7c	1.6±0.1^{ab}	0.28±0.02^{bc}	0.05±0.00^{cd}	0.34±0.03^{c}	---
UFT 202	8.8±0.8^{a}	9.3±0.9^{ab}	1.6±0.1^{a}	0.36±0.03^{a}	0.15±0.02^{a}	0.51±0.04^{a}	---
UFT 203	8.2±0.7^{a}	8.1±0.9^{bc}	1.4±0.1^{b}	0.32±0.03^{ab}	0.08±0.01^{b}	0.40±0.03^{b}	---
UFT 204	9.1±0.8^{a}	7.8±0.8^{c}	1.5±0.1^{ab}	0.29±0.02^{bc}	0.07±0.01^{bc}	0.37±0.03^{bc}	---
UFT 205	9.0±1.0^{a}	10.0±1.1^{a}	1.5±0.1^{b}	0.27±0.02^{c}	0.06±0.00^{bc}	0.33±0.03^{c}	---
C.V(%)[3]	10.9	12.1	9.6	11.28	20.74	10.56	---
			100 DAS				
Control	11±0.7^{c}	15±1.2^{c}	2.3±0.1^{b}	0.5±0.04^{d}	0.59±0.05^{d}	1.09±0.10^{d}	0.19±0.01^{d}
UFT 201	19±1.2^{b}	26±2.2^{a}	3.4±0.2^{a}	1.6±0.11^{c}	2.0±0.21^{c}	3.75±0.33^{c}	0.56±0.04^{c}
UFT 202	19±1.3^{b}	23±1.8^{b}	3.5±0.2^{a}	1.4±0.15^{c}	3.0±0.29^{a}	4.49±0.43^{b}	0.73±0.08^{ab}
UFT 203	23±1.7^{a}	26±2.3^{a}	3.6±0.2^{a}	2.4±0.2.3^{a}	3.1±0.30^{a}	5.63±0.56^{a}	0.78±0.07^{a}
UFT 204	19±1.5^{b}	26±2.4^{a}	3.5±0.2^{a}	1.9±0.18^{b}	2.4±0.21^{b}	4.38±0.44^{b}	0.68±0.06^{b}
UFT 205	23±1.8^{a}	23±1.9^{b}	3.4±0.2^{a}	2.1±0.22^{b}	3.0±0.29^{a}	5.17±0.50^{a}	0.70±0.06^{b}
C.V(%)	7.4	7.5	6.5	10.8	9.4	9.5	8.5

[1]Means followed by the same lower case letter in the column do not differ by Duncan test at 5% probability. [2]DAS = Days after sowing. [3]Coefficient of variation.

At 100 DAS, all isolates were superior ($p<0.05$) to the control in the parameters evaluated (Table 3 and Figures 3B). The isolates UFT 203 and UFT 205 were superior ($p<0.05$) to the others and the control in the parameters H and DTM.

For LR the isolates UFT 201, UFT 203 and UFT 204 were 73% superior to the control at 100 DAS (Table 3). For SD the isolates did not differ statistically, showing superiority to the control varying between 47 to 55.8%, respectively. The isolate UFT 203 was superior ($p<0.05$) to the other isolates in SDM, with a superiority of 71% in relation to the isolate UFT 202 and 389.8% superior to the control. In RDM the isolates UFT 202, UFT 203 and UFT 205 were superior ($p<0.05$) to the other isolates and the control, ranging from 408 to 425.4% in relation to the control. For DQI the isolate UFT 203 was superior ($p<0.01$) to the isolates UFT 201, UFT 204 and UFT 205, differing by 39% in relation to the isolate UFT 201 and 310% for the control (Table 3).

As for the relative efficiency (RE), in this experiment with inoculation of *Trichoderma* in soils without natural phosphate fertilization, all isolates were superior ($p<0.05$) to the control and among the isolates the UFT 203 was superior ($p<0.05$) to the others (Figure 2B).

The promotion of the growth of the plants provided by *Trichoderma* is attributed to the valorization of the biomass of roots, there is a greater mobilization and uptake of nutrients increasing the rate of photosynthesis in the plant [24], a result that was verified in the present work that can be observed in Tables 2 and 3 and Figures 1 and 2.

Plant growth can also be related to the capacity of *Trichoderma* to solubility phosphates and siderophores. Several papers report this ability [13, 16, 25]. *Trichoderma* produce organic acids such as gluconic, fumaric and citric acid that can decrease soil pH facilitating the solubilization

of phosphates, micro and macro-nutrients vital to the plant such as iron, manganese and magnesium [25, 26].

Using 14 *Trichoderma* stipes extracted from the rhizosphere of forest trees such as *Pinus roxburghii*, *Cedrus deodara*, *Bambusa bambos*, *Psidium guajava* and *Quercus* sp., tested *in vitro* and in a greenhouse with chickpea (*Cicer arietinum* L.), Kapri and Tewari (2010) [27] proved the potential in phosphate solubilization of the isolates and growth promotion. Similar results were reported by Chagas Junior et al. (2014) [28] in the culture of cowpea bean (*Vigna unguicula* L. (Walp.)) cultivated in soil of the Cerrado Tocantinense with *Trichoderma* inoculation.

Isolates of *Trichoderma* are able to promote plant growth by synthesizing the hormone indoleacetic acid (IAA) [29]. Hoyos-Carvajal et al. (2009) [30] evaluating the production of secondary metabolites in 101 isolates of *Trichoderma* found that 60% of the strains were able to produce AIA or auxin-like.

The potential as plant growth promoter by fungus of the genus *Trichoderma* spp. has also been reported to biocontrol and colonization capacity of the rhizosphere [26]. There are several defense mechanisms used by the fungus, among them is the production of secondary metabolites (antibiotics) and antifungal enzymes, being more than 100 bioactive compounds, acting as hyperparasitism and competition for nutrients [31].

In plants of short cycle, the fungus *Trichoderma* presented biomass increment in several researched cultures, such as for beans [32], soybean [33], rice [13], tomatoes [34, 35] and in black oats [36]. Species of long cycle have also been researched to verify the action of the fungus *Trichoderma* in its initial growth. In *Pinus radiata* using *T. atroviride*, Reglinski et al. (2012) [37] found an increase in root biomass and by more than 40%, and more than 12% in diameter compared to the control. In *Pinus radiata* Hohmann *et al.* (2011) [5] found increases of 16% in height and 31% in root dry weight compared to the control. Santos et al. (2008) [38] evaluated the effect of isolates on the root and aboveground development of *Eucalyptus urograndis* and found a 79% root development and 42.2% aboveground development with the isolate CEM 522. In rubber tree (*Hevea brasiliensis* Muell. Arg.) *Trichoderma* promoted increases in diameter by 13.81%, height by 22.19%, above ground dry mass by 39.96% and root dry mass by 21.13% compared to the control [16]. In cambará (*Gochnatia polymorpha) T. harzianum* promoted growth of 165.7% for height, 1,700% for root dry biomass and 2,940% in MSPA relative to the control [17]. In *Eucalyptus urophylla* and *Eucalyptus brassiana* Chagas Junior et al. (2021) [39] concluded that the inoculation of *Trichoderma* promoted the initial growth of seedlings of these species, where there was specificity for the different species of *Trichoderma* in relation to the plant species, with better relationship between the species *E. urophylla* with *T. longibrachiatum* and *E. brassiana* with *T. harzianum*.

At 100 days the isolate UFT 205 inoculated in the soil with natural phosphate fertilization showed 32.6% higher DQI, while the isolate UFT 203, without fertilization of the soil with natural phosphate, was 50% higher than the result obtained by Kratka and Correia (2015) [40]. The DQI results obtained using *Trichoderma* at 100 DAS with or without phosphate fertilization were superior to the results found by Tsukamoto Filho et al. (2013) q41] in *Myracrodruon urundeuva* Fr. All. which was 0.19 at 110 days.

The action of growth promoting fungi on plants is specific and may vary according to the environment, the substrate used, the climate, the humidity, the strain used, the availability of nutrients as well as the interference of other micro-organisms. For this range of factors that can influence the action of this fungus and considering the economic and environmental importance of native forest species the results are relevant for the improvement of silvicultural techniques, requiring more specific studies to know the mechanisms in growth promotion of forest seedlings by *Trichoderma*.

4. CONCLUSION

The inoculation of different *Trichoderma* species promoted the plant growth of aroreira (*Astronium urundeuva* (M. Allemão) Engl.) in soils fertilized or not with natural phosphate. The

isolate UFT 203 was an efficient growth promoter of mastic, considering all the variables evaluated at 100 DAS, inoculated in soils with or without fertilization with natural phosphate.

The results are relevant for the improvement of silvicultural techniques with the inoculation of microorganisms that promote plant growth.

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