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GROWTH PROMOTION OF *Schizolobium parahyba* var. *amazonicum* SEEDLINGS USING STRAINS OF *Trichoderma* spp. UNDER PHOSPHORUS RATES

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Resumo

Promoção de crescimento em mudas de Schizolobium parahyba var. amazonicum usando cepas de Trichoderma spp. sob doses de fósforo. Fungos do gênero *Trichoderma* são de grande importância para o incremento e promoção de diferentes espécies vegetais. Além disso, recentemente, estão atrelados a maior aquisição de nutrientes. Assim, objetivou-se com este trabalho avaliar o desenvolvimento inicial e a promoção de mudas de paricá [*Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby], com a aplicação de *Trichoderma* spp., em função de doses de fósforo (P). O delineamento utilizado foi blocos casualizados, em esquema fatorial de 4 x 5 (cepas e doses), com sete repetições, nas doses 0, 64, 128, 192 e 256 mg dm^{-3} de P_2O_5 (superfosfato triplo). As características avaliadas foram altura de planta (PH), diâmetro do caule (SD), massa fresca das folhas (LDW), massa seca das folhas (LDW), massa fresca caulinar (SFW), massa seca caulinar (SDW), massa fresca da parte aérea (SHFW) e massa seca da parte área (SHDW). Concluiu-se que as cepas de *Trichoderma* spp. promoveram o crescimento do paricá, sendo a cepa *Trichoderma harzianum* IBLF 006 WP, a que proporcionou maior incremento entre as diferentes variáveis, na dose em torno de 128 mg dm^{-3}.
Palavras-chave: Paricá, cepa, *Trichoderma harzianum*, *Trichoderma asperellum*.

Abstract

Fungi of the genus *Trichoderma* are significantly important for promoting the growth of different plant species. Moreover, they have been connected to high nutrient absorption. Thus, the objective of this study was to evaluate the initial development of seedlings of Brazilian firetree [*Schizolobium parahyba* var. *amazonicum (Huber ex Ducke) Barneby*] with application of *Trichoderma* spp. and phosphorus (P) rates. A randomized block design with seven replications was used, in a 4×5 factorial arrangement (strains and P rates); the P rates were applied using 0, 64, 128, 192, and 256 mg dm^{-3} of P_2O_5 (triple superphosphate). The characteristics evaluated were plant height (PH), stem diameter (SD), leaf fresh weight (LFW), leaf dry weight (LDW), stem fresh weight (SFW), stem dry weight (SDW), shoot fresh weight (SHFW), and shoot dry weight (SHDW). The results showed that *Trichoderma* spp. promotes satisfactory conditions for growing *Schizolobium parahyba* var. *amazonicum*, and the strain *Trichoderma harzianum* IBLF 006 WP at P_2O_5 rate of approximately 128 mg dm^{-3} provided the highest increase in the evaluated variables.
Keywords: Brazilian firetree, strain, *Trichoderma harzianum*, *Trichoderma asperellum*.

INTRODUCTION

Planted forests in Brazil include exotic species, mainly from the genera *Pinus*, *Corymbia*, and *Eucalyptus*, as they are useful for reforestation and wood production. Their wood is used in civil construction and several other areas; however, the variability of wood species in the Amazon region is very high and several wood species have not yet been explored. Brazilian firetree (*Schizolobium parahyba* var. *amazonicum*) is an Amazonian species of high economic potential that is gaining space among forest species, as it has fast increase in diameter and height, allowing its use in few years (ALMEIDA *et al*., 2013).

This species has also been highlighted due to its good adaptation to different edaphoclimatic conditions and widespread use of its wood, which makes it an alternative for meeting the demand for forest raw materials. It is a legume species, also known as parica, Cuiabano pine, Amazonian guapuruvu, and others. In addition, it has a wide geographic distribution and can be found in several states of Brazil, including Amazonas, Mato Grosso, Para, Rondonia, and Acre (BRITO *et al*., 2017; CORDEIRO *et al*., 2015), presenting good adaptation to other regions of the country, as the Central-West, at the initial growth phase (DUARTE *et al*., 2016).

Its adaptation has been linked to proper fertilizer application throughout its cycle; phosphorus (P) is one of the essential macronutrients for its growth, affecting even the quality of its wood (SILVA *et al*., 2020). This nutrient is little absorbed by plants; however, it is one of the most used elements for soil fertilization in Brazil, since P can interact with highly weathered soils, which are widely found under tropical and subtropical conditions (VILAR; VILAR, 2013).

Brito *et al*. (2017) reported the importance of P fertilization to promote plant height, improve shoot dry matter, leaf area, root dry matter, and stem diameter, and increase P, Ca, and Mg contents; however, excess P is harmful to most of these variables, emphasizing the importance of testing the effect of fungi and biofertilizers and their connection with P rates.

Fungi of the genus *Trichoderma* are often used as inoculants for several agricultural crops and are among the most studied biocontrol agents in the world. A significant feature of these fungi is their high potential for use as a biocontrol, due to their mycoparasitic capacity to improve plant health, and as plant growth promoters. They have been successfully used and formulated as biofertilizers for promoting growth of forest species (CHAGAS JUNIOR *et al.*, 2021; FERREIRA *et al.*, 2021).

Growth promoting effects of fungi were found for the species *Cabralea canjerana*, *Cedrela fissilis*, *Cordia trichotoma*, *Erythrina cristagalli,* and *Luehea divaricate,* benefiting several characteristics, including plant height, stem diameter, and chlorophyll *a* and *b*, total chlorophyll, and carotenoid contents, however, depending on the species and inoculant used (*Trichoderma asperelloides* and *Trichoderma harzianum*), with similar results to the control in some cases; in addition, they can be safely used by growers (GRIEBELER *et al*., 2021).

According to Santos et al. (2020), the growth promoting effect on *Handroanthus serratifolius* is connected to the time of application, number of applications, and even its use alone, has beneficial effects on different variables and conditions for seeds and seedlings. Strains of *T. harzianum* are effective and beneficial to the process of initial plant growth and for germination through seed treatment and/or application to the soil. They also report that species of the genera *Aspergillus*, *Penicillium,* and *Trichoderma* are particularly efficient solubilizers of P, as they can increase its absorption, can be used alone or combined with mineral and/or organic fertilizers to increase crop yields, and are a more sustainable way to maintain soil fertility (ALTOMAR; TRINGOVSKA, 2011).

Thus, the objective of this study was to evaluate the initial development of seedlings of Brazilian firetree [*Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby] with application of *Trichoderma* spp. and phosphorus (P) rates.

MATERIAL AND METHODS

The experiment was carried out at the Universidade Estadual de Goiás, Ipameri Unit, in a greenhouse consisted of a metal structure and dimensions of 30×7×3.5 m, covered with a transparent polyethylene film, with a 25% shade screen on the sides.

A randomized block design with seven replications was used, in a 4×5 factorial arrangement (strains of *Trichoderma* spp. and phosphorus rates). The P rates were applied using 0, 64, 128, 192, and 256 mg dm^{-3} of P_2O_5 (triple superphosphate), corresponding to approximately 0, 28.0, 55.9, 83.9, and 87.4 kg ha^{-1} of P, respectively (Caione *et al*., 2012).

The sampling unit consisted of eight-liter pots filled with a Typic Hapludox (Latossolo Vermelho-Amarelo Distrofico; collected in the 0-20 cm layer. Soon after soil collection, it was sieved and 3.5 g of limestone was added to each kilogram of soil. The soil was then stored for 30 days under irrigation every four days with 80% of its water retention capacity. The results of the soil chemical analysis showed pH ($CaCl^2$) of 4.9; 24.1 g dm^{-3} of organic matter; 1.5 mg dm^{-3} of P (resin); 303 mmol$_c$ dm^{-3} of H+Al; 4.1 mmol$_c$ dm^{-3} of K; 18.2 mmol$_c$ dm^{-3} of Ca; 7,5 mmol$_c$ dm^{-3} of Mg; and 53.6 mmol$_c$ dm^{-3} of cation exchange capacity (CEC).

The treatments with *Trichoderma* spp. included soil fertilizer application with the different P rates plus addition of 80 mg dm^{-3} of N and 80 mg dm^{-3} of K_2O. They were divided into control (T_1), with no application of *Trichoderma* spp.; *Trichoderma hazianum* IBLF 006 WP (Ecotrich WP) (T_2); *Trichoderma hazianum* IBLF 006 SC (Predatox SC) (T_3); and *Trichoderma asperellum* URM 5911 (Quality WG) (T_4).

The seeds were disinfected with 2% sodium hypochlorite for two minutes. Then, they were immersed in a sulfuric acid (70%) and distilled water (30%) solution for approximately 30 minutes to overcome dormancy (Rodrigues *et al.*, 2019). They were then washed under running water for five minutes and planted, using three seeds per pot; a thinning was carried out at 30 days, maintaining only the most vigorous seedling.

Irrigation with 80% of the field capacity in the pots was carried out every two days (Duarte *et al.*, 2016). The treatments with *Trichoderma* spp. were applied soon after planting, using 8 mL of a suspension (4 x 10^8 conidia pot^{-1}), through a manual pressure sprayer (550 mL).

The variables evaluated were: plant height (PH; cm), measured from the ground to the apex of the plant stem, using a ruler; stem diameter (SD; mm) measured at two centimeters from the ground, using a digital caliper; leaf fresh weight (LFW; g plant^{-1}), considering the total weight of leaves of the plant; stem fresh weight (SFW; g plant^{-1}), considering the total weight of the plant stem; leaf dry weight (LDW; g plant^{-1}) and stem dry weight (SDW; g plant^{-1}) - the fresh plant parts were packed in Kraft paper bags and kept in a forced air circulation oven at 65 °C for 72 hours, and then weighed; shoot fresh weight (SHFW; g plant^{-1}), considering the total weight of the aerial part of the plant (LFW + SFW); shoot dry weight (SHDW; g plant^{-1}), considering LDW + SDW, evaluated 140 days after germination.

Tests of residual normality and homoscedasticity were performed. The data were then subjected to analysis of variance, the means were subjected to the Scott-Knott test at 5 % of probability and regression, using the software SISVAR (FERREIRA, 2011).

RESULTS

Table 1 shows that the sources of variation (strains and P rates) and the interaction between them had significant effects ($p \leq 0.01$) on all analyzed variables, indicating that P rates and application of strains of *Trichoderma* spp. affected the initial development of *S. parahyba* var. *amazonicum*.

Table 1. Mean squares for plant height, stem diameter, leaf fresh weight, leaf dry weight, stem fresh weight, stem dry weight, shoot fresh weight, and shoot dry weight of seedlings of *Schizolobium parahyba* var. *amazonicum* (Brazilian firetree) grown under different phosphorus rates (0, 64, 128, 192, and 256 mg dm^{-3} of P_2O_5), with application of three strains of *Trichoderma* spp.

Tabela 1. Quadrado médio das variáveis altura da planta, diâmetro do caule, massa fresca das folhas, massa seca das folhas, massa fresca do caule massa seca do caule, massa fresca da parte área e massa seca da parte área, sob diferentes doses de fósforo (0, 64, 128, 192 e 256 mg dm^{-3} de P_2O_5), com a aplicação de três cepas de *Trichoderma* spp., em mudas de *S. parahyba* var. *amazonicum* (Brazilian firetree).

Source of variation	**Degrees of freedom**	**Plant Height**	**Stem Diameter**	**Leaf fresh weight**	**Leaf dry weight**
Strain (S)	3	3224.02**	21.78**	435.47**	108.40**
Rates (R)	4	243.55**	2.12**	103.76*	25.73**
S x R	12	489.29**	4.67**	480.26**	75.81**
Block	6	145.64	0.91	42.38	3.27
Error	114	32.60	0.46	31.50	4.09
CV (%)		8.06	8.26	26.38	24.51
Source of variation	**Degrees of freedom**	**Stem fresh weight**	**Stem dry weight**	**Shoot fresh weight**	**Shoot dry weight**
Strain (S)	3	1634.31**	119.73**	867.07**	92.56**
Rates (R)	4	181.69**	13.14**	86.14*	15.02**
S x R	12	263.19**	38.87**	325.38**	52.02**
Block	6	83.15	3.14	59.87	2.87
Error	114	35.22	3.30	29.66	3.25
CV (%)		21.48	19.11	22.24	20.30

* = significant at 1%, and ** = significant at 5% probability by the F test; CV (%) = coefficient of variation.

In a previous analysis, the treatment with the strain IBLF 006 WP (T_2) presented higher means than those found for the control treatment (T_1) for all analyzed variables, when considering all P rates, which indicated growth promotion and better development through the synergism between the fungus and the plant (Table 2). The strain IBLF 006 SC (T_3) also showed beneficial effects, except for plant height, stem diameter, and leaf fresh weight, with antagonistic effect from the strain URM 5911 (T_4). It is important to report that the beneficial combination achieved was possible for this form of application, time of application, and volume and type of product because, despite the use of the strain IBLF 006, the wettable powder-based product was more interesting than the concentrated suspension.

The treatment with application of the strain *T. harzianum* IBLF 006 WP (T_2), using P_2O_5 rates between 0 and 41.5 mg dm^{-3}, presented synergisms and beneficial effects on plant height (PH) for *S. parahyba* var. *amazonicum* seedlings, resulting in heights of approximately 85-87 cm. It confirms that the interaction between P combined with the strain IBLF 006 WP and the plant results in little increases in plant height. However, the effect of higher P rates becomes negative for the growth of these plants, but with low decreases in height: only 5 cm with the maximum P rate applied (Figure 1).

Table 2. Mean plant height (PH), stem diameter (SD), leaf fresh weight (LFW), leaf dry weight (LDW), stem fresh weight (SFW), stem dry weight (SDW), shoot fresh weight (SHFW), and shoot dry weight (SHDW) of seedlings of *Schizolobium parahyba* var. *amazonicum* (Brazilian firetree) grown under phosphorus rates with application of strains of *Trichoderma* spp.

Tabela 2. Média das variáveis altura da planta (PH), diâmetro do caule (SD), massa fresca das folhas (LFW), massa seca das folhas (LDW), massa fresca do caule (SFW) massa seca do caule (SDW), massa fresca da parte área (SHFW) e massa seca da parte área (SHDW), para as diferentes doses de fósforo, com a aplicação de três cepas de *Trichoderma* spp., em mudas de *S. parahyba* var. *amazonicum* (Brazilian firetree).

Strains	**PH** (cm)	**SD** (mm)	**LFW** (g plant^{-1})	**LDW** (g plant^{-1})
Control (T_1)	71.52 b	8.26 b	18.57 b	8.23 d
IBLF 006 WP (T_2)	81.83 a	8.99 a	26.51 a	12.40 a
IBLF 006 SC (T_3)	71.59 b	8.32 b	20.44 b	9.65 c
URM 5911 (T_4)	58.41 c	7.09 c	19.89 b	10.72 b
Mean	70.84	8.17	21.35	10.25
Strains	**SFW** (g plant^{-1})	**SDW** (g plant^{-1})	**SHFW** (g)	**SHDW** (g)
Control (T_1)	24.66 c	7.77 b	21.62 c	7.01 d
IBLF 006 WP (T_2)	35.89 a	11.39 a	31.20 a	10.89 a
IBLF 006 SC (T_3)	29.91 b	10.79 a	25.18 b	9.22 b
URM 5911 (T_4)	20.03 d	8.07 b	19.96 c	8.39 c
Mean	27.62	9.51	24.49	8.88

Means followed by the same letter in the columns are not different from each other by the Scott-Knott test at 5% probability.

Stem diameter presented a quadratic response, with the maximum point at 116 mg dm^{-3} of P_2O_5, and a mean of 9.5 millimeters (T_2), which again indicated that there was synergism between the strain and the plant species, even with the application of fertilizers (Figure 1). Furthermore, treatments with application of *Trichoderma* spp. showed a quadratic performance in stem diameter, with means of 8.83 mm (81.7 mg dm^{-3} of P_2O_5) for T_3 and 8.1 mm (40 mg dm^{-3} of P_2O_5) for T_4. It denoted that the strains of *Trichoderma* spp. provided increases in stem diameter for Brazilian firetree, in all combinations; however, it was more beneficial when using the strains IBLF 006 WP and IBLF 006 SC, both from *T. harzianum*, and P_2O_5 rates below 128 mg dm^{-3}.

Leaf fresh weight (LFW) presented a linear response in the control treatment (T_1), as LFW increased as P rates were increased; the highest rate tested resulted in an increase of 34.5 g. Despite the most advantageous condition, the treatment with *T. harzianum* IBLF 006 WP was efficient for LFW only when using the P_2O_5 rate of 132 mg dm^{-3}, which resulted in an increase of 30.9 g; this increase was small and approximately 10.4% lower when compared to that in the control (Figure 1).

The stem fresh weight (SFW) of plants treated with *T. harzianum* IBLF 006 WP (T_2) and *T. harzianum* IBLF 006 SC (T_3) presented a quadratic response, with maximum points at 116 and 94 mg dm^{-3} of P_2O_5, corresponding to 38 g and 36 g, respectively (Figure 2). Thus, the application of these strains increased SFW in 42% when compared to the treatment without application (26 g). Stem dry weight (SDW) also presented a quadratic response; the treatment T_3 with P_2O_5 rate of 78 mg dm^{-3} resulted in a 18% higher SDW than the control, but only 3.6% higher than T_2.

The results found for shoot fresh weight (SHFW) and shoot dry weight (SHDW) confirmed the responsive effect to P, in addition to the high growth promoting effect of the evaluated strains. In general, at high P_2O_5 rates, above 117 mg dm^{-3}, the effect of the strains becomes inefficient and does not provide a viable increase in growth for *S. parahyba* var. *amazonicum* plantations (Figure 2).

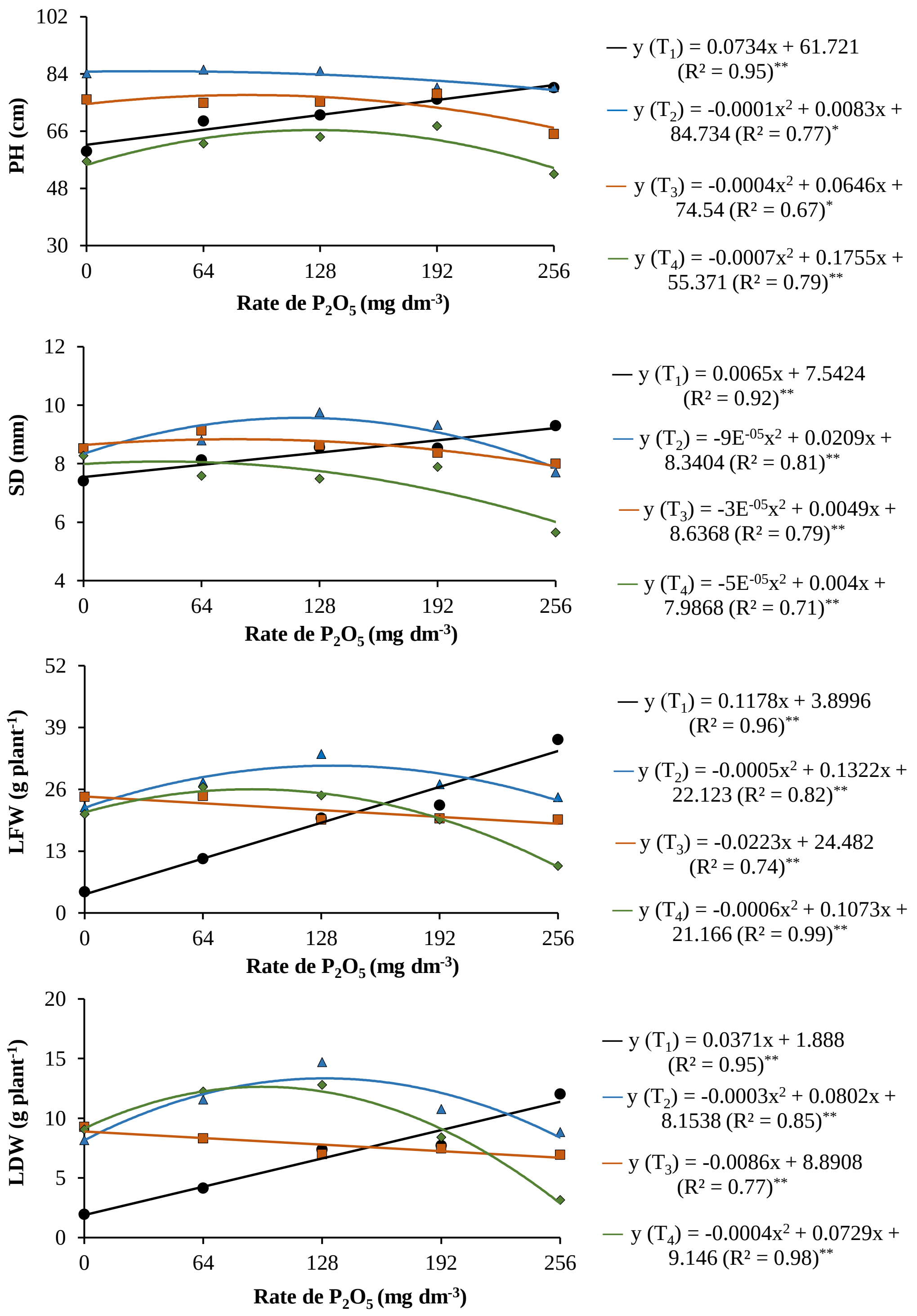

Figure 1. Plant height (PH), stem diameter (SD), leaf fresh weight (LFW), and leaf dry weight (LDW) of seedlings of *Schizolobium parahyba* var. *amazonicum* (Brazilian firetree) as a function of different P rates, with application of *Trichoderma* strains (T_1 = control with no application of *Trichoderma* spp.; T_2 = *T. hazianum* IBLF 006 WP; T_3 = *T. hazianum* IBLF 006 SC; T_4 = *T. asperellum* URM 5911).

Figura 1. Altura da planta (PH), diâmetro do caule (SD), massa fresca das folhas (LFW) e massa seca das folhas (LDW), em função das diferentes doses de fósforo, com a aplicação de cepas de *Trichoderma* strains (T_1 - control, without application of *Trichoderma* spp.; T_2 – *T. hazianum* IBLF 006 WP; T_3 – *T. hazianum* IBLF 006 SC; T_4 – *T. asperellum* URM 5911), em mudas de *S. parahyba* var. *amazonicum* (Brazilian firetree).

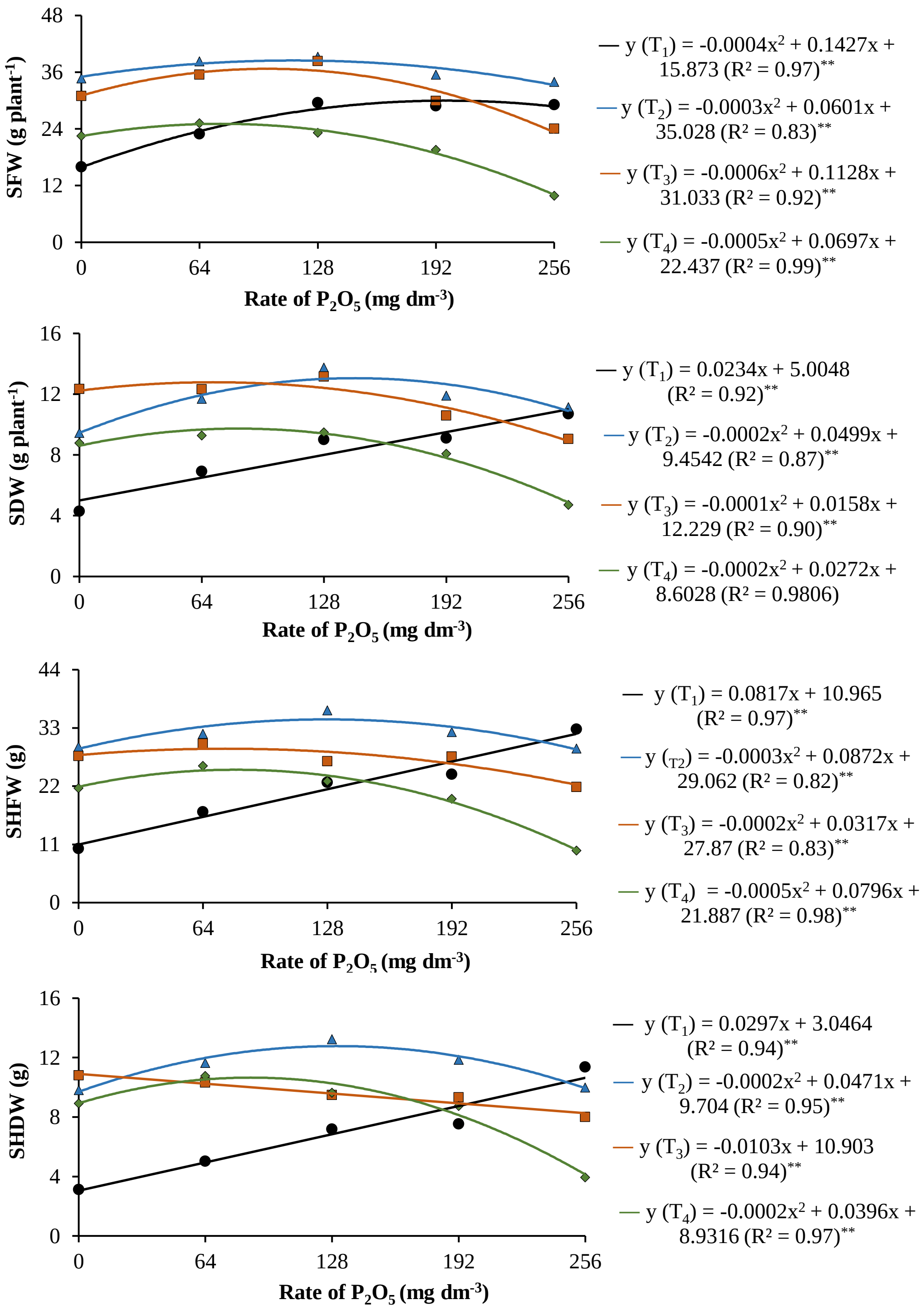

Figure 2. Stem fresh weight (SFW), stem dry weight (SDW), shoot fresh weight (SHFW), and shoot dry weight (SHDW) of seedlings of *Schizolobium parahyba* var. *amazonicum* (Brazilian firetree), as a function of different P rates, with the application of *Trichoderma* strains strains (T_1 - control, without application of *Trichoderma* spp.; T_2 – *T. hazianum* IBLF 006 WP; T_3 – *T. hazianum* IBLF 006 SC; T_4 – *T. asperellum* URM 5911).

Figura 2. Massa fresca do caule (SFW), massa seca do caule (SDW), massa fresca da parte aérea (SHFW) e massa seca da parte aérea (SHDW), em função das diferentes doses de P, com a aplicação de cepas de *Trichoderma* strains (T_1 - control, without application of *Trichoderma* spp.; T_2 – *T. hazianum* IBLF 006 WP; T_3 – *T. hazianum* IBLF 006 SC; T_4 – *T. asperellum* URM 5911), em mudas de *S. parahyba* var. *amazonicum* (Brazilian firetree).

DISCUSSION

Donoso *et al.* (2008) evaluated the effect of *T. harzianum* and an organic compound formed from plant residues on growth of seedlings of *Pinus radiata* in nurseries and found that *T. harzianum* had a significant effect on root area, but no other significant effects, differing from the results found in the present study (Table 1).

Some isolates of *Trichoderma* are recognized as growth promoters for plants, as they solubilize minerals, making them available in the soil and, thus, facilitating their absorption by plants. Soil macro and micronutrients undergo a dynamic balance of solubilization affected by the microflora, which determines the accessibility and absorption of nutrients by roots. The plant growth mainly promoted by *T. harzianum* is due to its ability to solubilize many important nutrients to plants, including phosphorus (MACHADO *et al.*, 2012), with a high efficiency at lower P rates, as found in the present study, reducing the moisture close to the roots and directly affecting their multiplication in the soil (Figures 1 and 2). According to Altomare *et al.* (1999), the ability of isolates of *T. harzianum* to solubilize nutrients from compounds, such as phosphate rocks, manganese oxide, iron oxide, and metallic zinc, confirms the need for using it under low soil P availability conditions, and its opposite effect under high P availability.

Amaral *et al.* (2017) evaluated the effect of different proportions of a vermicompost and two *Trichoderma* spp. on propagation of caroba (*Jacaranda micrantha* Cham.) and found differences between the isolates for different characteristics. The present study showed greater oscillations in plant height, stem diameter, and leaf weights (Figure 1) and lower oscillation in stem and shoot weights (Figure 2). Amaral *et al.* (2017) also found significant gains in plant height and stem diameter when using 50% vermicompost and *T. virens*; however, no significant effect was found for number of leaves and shoot dry weight of seedlings, which only increased under no combination with vermicompost and with absence of *Trichoderma* spp., but presenting values well below the other treatments.

The effect of the treatment with the strain URM 5911 (*T. asperellum*) on stem dry weight (SDW) was evident, with interesting results when the increase is transformed into kg ha^{-1}. P rates to be applied in the field would be reduced 2.3 - fold when compared to the treatment T_1 and 1.6-fold when compared to T_2, resulting in reductions in costs and increases in profitability (Figure 2). Moreover, the strain URM 5911 is viable for increasing fresh and dry leaf weights and shoot weight, however, T_2 is still superior by promoting beneficial effects to greater number of variables, and is viable even with increases in P rates.

The potential of *Trichoderma asperellum* as a substrate conditioner for producing coffee seedlings was evaluated by Jesus et al. (2011), using a concentration of $1x10^5$ UFC g^{-1} in two trials, one with a commercial substrate and the other with an industrialized substrate. They found that the addition of the soil conditioner with *T. asperellum* resulted in an increase of 20 mg $plant^{-1}$ in stem dry weight for the commercial substrate and 17 mg $plant^{-1}$ for the industrialized substrate, and reported that this high accumulation of dry phytomass is related to the production of hormones or other growth factors, to a high efficiency in the use of some nutrients, and to the increased availability and absorption of nutrients by the plants.

Caione *et al*. (2012) evaluated the growth of Brazilian firetree seedlings in a substrate fertilized with nitrogen (N), phosphorus (P), potassium (K), and a combination of these nutrients and found that the analyzed fertilizers promoted significant results for all variables. In addition, the treatment that provided the highest total dry weight accumulation was that formulated with a combination of the three nutrients, followed by treatment with only P, which was considered determinant for plant development. However, not only P could increase plant development, but the application of *Thichoderma* spp. was essential for promoting a better growth, making the seedlings ready to be planted in the field with the same size as the control seedlings, but in a shorter time.

Díaz and Gonzáles (2018) evaluated the effect of a *T. harzianum* biostimulant at different concentrations and found significant results for plant height at 60 days, mainly at the concentration of 40 g L^{-1} for *Leucaena leucocephala* Lam plants and at the concentrations of 20 and 40 g L^{-1} for *Albizia saman* Jacq. Merr.; and for number of leaves and plant height at 60 and 90 days, and shoot weigh at 90 days for *Cedrela odorata* L. The treatments increased and benefited the three species, indicating that the application of the biostimulant could be used for growth promotion for these species. These results corroborate those found for the treatments with application of strains of *Trichoderma* spp. in the present study, as the application was performed at only one time, and applications at other times could provide greater increases and synergism.

Brito et al. (2017) evaluated the effect of arbuscular mycorrhizal fungi and phosphorus fertilization on the production of Brazilian firetree seedlings and found that the inoculation with the fungi provided greater growth and accumulation of P, K, Mg, and Ca in the aerial part of the seedlings. Seedlings could be produced on substrates containing fungi to obtain better nutritional status and growth, without need for P fertilization. Similar to the results found in the present study, the addition of fungi of the genus *Trichoderma* spp. increased the potential of the plants to explore the soil or helped them to absorb and use nutrients more efficiently. It was better shown at the lowest P rates. The adaptive capacity of plant species is possibly linked to their ability to establish themselves in an environment and to live synergistically with the local microflora and fauna.

Soldan *et al.* (2018) evaluated forest species inoculated with *Trichoderma* spp. and the commercial product Trichonat® and fertilized with rock phosphate and found the best results in growth and nutrient extraction for *Eugenia pyriformis* (Cambess) plants when using the product without fertilization and when using *Trichoderma* spp. with phosphate fertilization; for *Myrcianthes pungens* (O. Berg.), *Trichoderma* sp. increased the insertion point of the first branches, but the treatments did not affect the extraction of P and other nutrients. In general, the application of the fungus and the of P resulted in higher gains and would enable the plant to develop faster and increase its adaptive capacity, as shown in this research. The application of the fungi can be carried out after fertilization, thus allowing a higher synergism and possibly greater growth promotion; however, it can also be done together with fertilizers and as a mixture with soil, which can also increase the beneficial effects.

The strain *T. harzianum* IBLF 006 WP resulted in a reduction in P fertilization by approximately 156, 262, 111, and 139 kg ha^{-1} for SFW, SDW, SHFW, and SHDW, respectively, representing approximately 48% when compared to the control. It denotes the importance of this strain for further studies related to nutritional efficiency of other nutrients; increases in the ability of plants to reach and absorb nutrients with application of lower rates or even no application of nutrients by enabling the use of nutrients already present in the soil; and combinations with other nutrients. The P rates recommended for combination with treatment T_2 (*Trichoderma harzianum* - IBLF 006 WP) are between 110 to 128 mg dm^{-3}, corresponding to P_2O_5 rates of 220 to 256 kg ha^{-1}; a P rate that results in similar benefits, based on the different variables analyzed and without causing damage, corresponds to approximately 117 mg dm^{-3} or 234 kg ha^{-1} of P_2O_5 (Figures 1 and 2).

CONCLUSIONS

- The different strains of *Trichoderma* spp. showed satisfactory performances in promoting growth of seedlings of Brazilian firetree (*Schizolobium parahyba* var. *amazonicum*) under different phosphorus rates, and a more favorable combination with the plant species.
- The strain of *Trichoderma harzianum* IBLF 006 WP was the most efficient in increasing plant height, stem diameter, and leaf, stem, and shoot fresh and dry weights with P_2O_5 rates between 110 and 128 mg dm^{-3}.

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