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Original Article

Arbuscular mycorrhizal fungi promote the growth of *Dipteryx alata* Vogel

Fungos micorrízicos arbusculares promovem o crescimento de *Dipteryx alata* Vogel

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Abstract

The symbiosis between arbuscular mycorrhizal fungi (AMF) and fruit tree plants is a sustainable strategy for producing seedlings. However, information for *Dipteryx alata* Vogel., a native species, is still scarce. Thus, this study aimed to identify the most promising AMF inoculum for producing *D. alata* seedlings and their effects on growth. Seedlings were inoculated with *Clareoideoglomus etunicatum*, *Gigaspora albida*, *Gigaspora margarita*, a mixture of these three species, and an uninoculated control. Height, diameter, and chlorophyll index were evaluated at 30, 60, 90, 120, 150, and 180 days after seedling transplanting, while biomass production, quality index, dependence, and mycorrhizal efficiency were evaluated at 180 days. Greater diameter and height values were observed for *D. alata* seedlings at 180 days and inoculated with *G. albida*, *G. margarita*, and the mixture. AMF of the genus Gigaspora positively contributed to biomass production and seedling quality. *D. alata* seedlings show high mycorrhizal dependence on *G. albida* and *G. margarita* inoculum, which had good mycorrhizal efficiency. AMF, especially those of the genus Gigaspora, favor the production of high-quality *D. alata* seedlings.

Keywords: "baru", mycorrhizal dependence, *Gigaspora albida*, *Gigaspora margarita*, Dickson quality index.

Resumo

A simbiose entre fungos micorrízicos arbusculares (FMA) com plantas arbóreas frutíferas é uma estratégia sustentável para a produção de mudas. Entretanto, informações para *Dipteryx alata* Vogel., uma espécie nativa, são insuficientes. Assim, objetivamos identificar os inóculos de FMA mais promissores para *D. alata* e seus efeitos no crescimento das mudas. As mudas foram inoculadas com *Clareoideoglomus etunicatum*, *Gigaspora albida*, *Gigaspora margarita* e a mistura dessas três espécies, além do controle não inoculadas. As avaliações de altura, diâmetro e índices de robustez e de clorofila foram realizadas aos 30, 60, 90, 120, 150 e 180 dias após o transplantio das mudas, enquanto que a produção de biomassa, índice de qualidade, dependência e eficiência micorrízica foram aos 180 dias. Os maiores valores de altura e diâmetro foram observados nas mudas de *D. alata* aos 180 dias e inoculadas com *G. albida*, *G. margarita* e a mistura. Os FMA do gênero Gigaspora contribuíram positivamente na produção de biomassas e qualidade das mudas. As mudas de *D. alata* apresentam alta dependência micorrízica ao inóculo de *G. albida* e *G. margarita*, os quais tiveram boa eficiência micorrízica. Os FMA, especialmente do gênero Gigaspora, favorecem a produção de mudas de *D. alata* de alta qualidade.

Palavras-chave: baru, dependência micorrízica, *Gigaspora albida*, *Gigaspora margarita*, índice de qualidade de Dickson.

1. Introduction

In recent years, special attention has been given to the maintenance and restoration of native and commercial forest stands with the aim of meeting the objectives of sustainable development. Therefore, studies with the aim of establishing *ex situ* cultivation protocols of native forest species have increased, especially those aimed at the seedling production phase, and the use of bioinputs seems to be promising.

The use of arbuscular mycorrhizal fungi (AMF) represents a sustainable alternative that can contribute to the initial establishment of plants (Merlin et al., 2020; Khalediyan et al., 2020). Such microorganisms are obligate biotrophic fungi that establish symbiotic relationships with their host in exchange for photoassimilates that are as a source of energy for the formation and functioning of their structures (Gianinazzi et al., 2010). On the other hand, AMF promote a series of benefits for plants, among them increase in resistance to biotic and abiotic stresses and improvement in the absorption of nutrients from the soil by expanding the root interception zone (Kaur et al., 2020), in addition to acting on soil structure (Rillig et al., 2017; Ji et al., 2019).

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The use of AMF is limited to knowledge about the symbiotic establishment between plant and AMF, which compatibility may reflect the different responses of plants to mycorrhization when inoculated with different AMF's (Novais et al., 2014). Therefore, the selection of AMF inoculums and understanding the compatibility with the host plant is an important step towards overcoming the nursery challenges.

Among the native species found in the Brazilian Cerrado, "baru" or "cumbaru" (*Dipteryx alata* Vogel, Fabaceae) shows promising use in areas of recovery or implementation of agroforestry systems. In addition, the potential use is also economically related to the local sustainable agro-extractive activity of fruits, mainly aimed at family farming (Gonçalves et al., 2020).

However, information regarding the dependence of *D. alata* seedlings and AMF efficiency to different organisms is still insufficient, but we believe that AMF-plant interactions can result in efficient symbiosis, contributed to the production biomass, and of high-quality seedlings. Thus, the aim of this study was to identify the most promising AMF inoculum for *D. alata* seedlings and its effects on seedling growth.

2. Materials and Methods

2.1. General conditions and fruit collection

The experiment was carried out under protected environment – a structure covered with 150-micron thick transparent low-density polyethylene (LDPE) plastic film and laterally covered with black nylon screen with 70% shading (22°11'53.2"S, 54 °56'02.3"W, 400 m a.s.l.) from June to November 2019 in the municipality of Dourados/MS. According to the Köppen climate classification, the local climate is Am type, with hot summers and dry winters (Fietz and Fisch, 2017). Data on temperatures and relative humidity during the experimental period are shown in Figure 1, according to 'Embrapa Agropecuária Oeste' – CPAO, Dourados – MS.

Mature *D. alata* fruits were collected from random breeding matrices in remaining areas of native vegetation typical of Cerrado in Dourados/MS. After manual seed processing and selection, sowing was carried out in polypropylene tubes with capacity of 120 cm^3 previously filled with Bioplant® commercial substrate and kept in nursery with 70% shading and daily irrigation for 30 days until they reached average height of 8.0 cm. After the acclimatization period, seedlings were transplanted into pots with volumetric capacity of 7 dm^3, previously filled with the cultivation substrate.

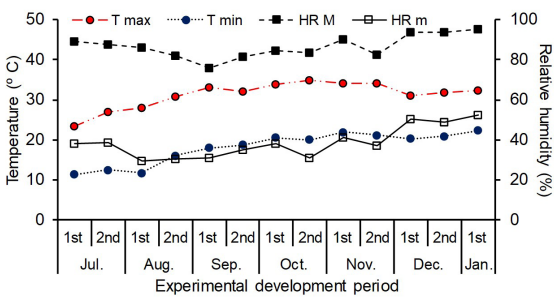

Figure 1. Average values of minimum and maximum temperatures and relative humidity during the period of experimental conduction of *Dipteryx alata* Vogel seedlings cultivated with arbuscular mycorrhizal fungi. 1st: first fortnight; 2nd: second fortnight.

2.2. Substrate and inoculum preparation and AMF inoculation

The experimental design used was randomized blocks, with four replicates, which each experimental unit consisted of two pots with one plant each. Seedlings were cultivated according to the inoculation of the following AMF: [1] *Clareoideoglomus etunicatum*, [2] *Gigaspora albida*, [3] *Gigaspora margarita* and [4] a mixture of these species (here called MIX from now own), in addition to non-inoculated seedlings (control) [5].

Initially, AMF isolates were obtained from the collection of the Laboratory of Organic Matter and Soil Microbiology at the State University of Mato Grosso do Sul/Aquidauana Campus, MS, in which mycorrhizal fungi species were multiplied in substrate from a mixture of soil with coarse sand (1:1, v/v), sterilized in autoclave, for once, at temperature of 121 °C and pressure of 1 atm for 60 min. After substrate sterilization, the material was placed in plastic trays with capacity of 20 dm^3, filling 70% of its volume, in which a soil layer containing AMF propagules (spores, hyphae and root fragments) was deposited in these recipients until completing total volume.

For AMF multiplication, *Urochloa decumbens* (Syn. *Brachiaria decumbens*) plants were used as hosts, which inoculated material was kept in greenhouse for a period of 120 days, being periodically irrigated. After this period, the plant material was removed, keeping only roots which, together with the cultivation substrate, were stored in plastic bags and used as source of inoculum.

The soil used in the experiment was composed of a mixture of Oxisols (USDA Classification) corresponding Distroferric Red Latosol (Brazilian Classification) with a clayey texture + coarse sand (2:1, v/v), and the soil was collected from profile B, in which it presented the following chemical attributes: pH H_2O: 5.2, P (Mehlich-1): 17.6 mg dm^{-3}, S-SO_4: 14.70 mg dm^{-3}, K: 0.60 $cmol_c$ dm^{-3}, Ca: 3.58 $cmol_c$ dm^{-3}, Mg: 1.38 $cmol_c$ dm^{-3}, Al: 0.17 $cmol_c$ dm^{-3}, H + Al: 6.41 $cmol_c$ dm^{-3}, organic matter: 22.24 g dm^{-3}, organic carbon: 12.90 g dm^{-3}, sum of bases: 5.56 $cmol_c$ dm^{-3}, cation exchange capacity: 11.97 $cmol_c$ dm^{-3}, V (%): 46.45, B: 0.41 mg dm^{-3}, Cu: 14.60 mg dm^{-3}, Fe: 47.10 mg dm^{-3}, Mn: 77.00 mg dm^{-3}, and Zn: 2.80 mg dm^{-3}.

Liming was performed according to Ribeiro et al. (1999), who recommends the application of 1 g dm^{-3} of limestone. Regarding the source of the corrective, hydrated lime with 95% PRNT was used, as it has quick neutralization action, based on soil analysis, with the aim of raising the base saturation to 65%. The soil of each pot, together with hydrated lime, was placed in plastic bag with capacity of 20 L^{-1}, inflated with air and shaken until complete homogenization, keeping it close to moisture corresponding to field capacity for 30 days, in addition to base fertilization with urea and dipotassium phosphate.

After preparation and liming, the experimental substrate was sterilized in autoclave, for once, at temperature of 121 °C and pressure of 1 atm. for 60 min. Soon after sterilization, the substrate was placed in plastic pots with capacity of 7 dm^3 and kept in protected environment. AMF inoculation was performed by adding 50 cm^3 pot^{-1} of inoculum per furrow at the time of seedling transplanting at depth of ± 3.0 cm, in direct contact with the root system of seedlings, whose inoculums were composed of soil mixture, spores and colonized *U. decumbens* roots. For MIX inoculation, approximately 15 cm^3 of each AMF species was added per pot^{-1}, and added 5 cm^3 of sterilized soil. For control seedlings, transplanting was performed without AMF inoculation.

During the experimental period, irrigation was individually performed for each pot, maintaining 70% of the water holding capacity in the substrate according to methodology proposed by Souza et al. (2000), and spontaneous plants were excluded when necessary.

2.3. Evaluated characteristics

Every 30 days, starting from 30 to 180 days after transplanting (DAT), plant height evaluations were carried out using ruler graduated in cm, having as an evaluation criterion the distance from the stem to the inflection of the highest leaf. Stem diameter was measured using digital caliper. From these two characteristics, the robustness index was calculated based on the height/diameter ratio (HDR). The chlorophyll index was measured using SPAD-502 portable chlorophyll meter (Soil Plant Analyzer Development), in which evaluations were performed on the first pair of leaves of seedlings in the morning.

After 180 DAT, destructive analyses of plants were carried out, in which entire seedlings were removed from pots, separating them into shoots (leaf + stem) and roots, which were previously washed in running water in order to remove the adhered substrate, and then the fresh masses of these organs were determined using a precision scale (0.0001 g). Subsequently, materials were placed in Kraft® paper bags and dried in oven with forced air circulation at 60°C ± 5 for 72 hours, being subsequently weighed to obtain the dry mass of shoots, roots and total (TDM). Using these values, the shoot/root ratio (SRR) was calculated.

The seedling quality standard was based on the Dickson quality index (DQI) calculated as proposed by Dickson et al. (1960) (Equation 1).

$$DQI = TDM / \left(HDR + SRR\right) \quad (1)$$

From the total dry mass values of mycorrhizal (MSM) and non-mycorrhizal - control (MSN) seedlings as a function of each AMF, dependence (MD) and mycorrhizal efficiency (ME) were calculated, as proposed by Plenchette et al. (1983) (Equations 2 and 3).

$$MD\left(\%\right) = \left(\frac{MSM - MSN}{MSM}\right) * 100 \quad (2)$$

$$ME\left(\%\right) = \left(\frac{MSM - MSN}{MSN}\right) * 100 \quad (3)$$

2.4. Data analyses

Data were submitted to the Shapiro-Wilk normality test and to analysis of variance and when significant by the F test ($p \leq 0.05$), means were compared by the Tukey test ± standard deviation for AMF ($p \leq 0.05$). Height, diameter, robustness and chlorophyll index data evaluated throughout the experimental period were analyzed in split-plots over time, and when significant by the F test, means were submitted to regression analysis, considering the best adjustments to mathematical models tested ($p \leq 0.05$) and determination coefficient ≥ 0.60.

3. Results

The height and stem diameter of *D. alata* seedlings increased with time, in addition effect for AMF alone, while the chlorophyll index was influenced only by DAT. The robustness index was not influenced by factors under study ($p > 0.05$). With regard to DAT, height presented quadratic adjustment with minimum calculated value of 9.50 cm at 60 DAT, while the maximum value was 15.10 cm at 180 DAT (Figure 2a, Table 1). The diameter showed linear growth with the highest value (6.52 mm) at 180 DAT (Figure 2b). For the chlorophyll index, cubic adjustment with maximum calculated value of 35.07 SPAD at 165 DAT was observed (Figure 2c).

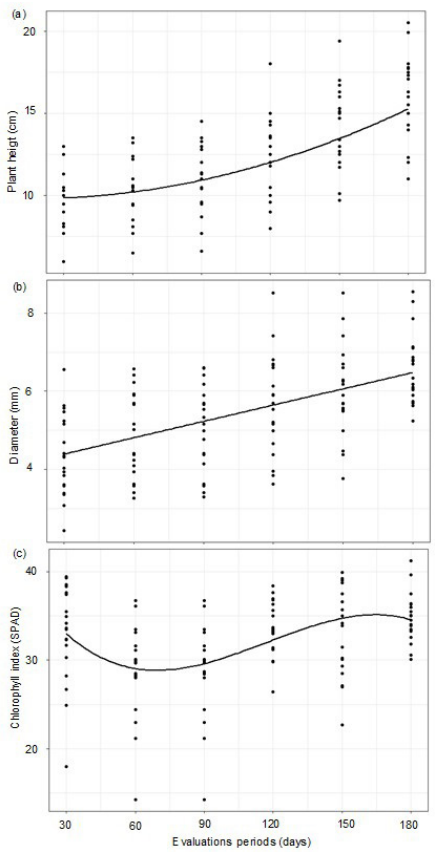

Figure 2. Plant height (a), stem diameter (b) and chlorophyll index (c) of *Dipteryx alata* Vogel seedlings grown during the experimental period.

With regard to AMF, the highest height values were 13.57 and 13.13 cm in seedlings inoculated with *G. albida* and *G. margarita*, respectively (Figure 3a). The greatest stem diameters were 5.97 and 6.18 mm with *G. margarita* and MIX inoculums, respectively (Figure 3b). In general, the fresh and dry mass of shoots and roots of *D. alata* seedlings showed the same response trend, that is, the highest values observed in seedlings inoculated with *G. albida* and *G. margarita* (Figures 4a-d), followed by those inoculated with *C. etunicatum* and MIX, statistically differing from non-inoculated ones, which had the lowest values.

On the other hand, shoot-root ratio values were higher (1.27) in seedlings inoculated with MIX, differing only from seedlings with *G. albida*, which had lower value (0.86) (Figure 4e). The highest Dickson Quality Indices (DQI) (3.22 and 2.80) observed in *G. albida* and *G. margarita* inoculated seedlings, statistically differing from values of MIX and non-inoculated seedlings, which had the lowest values (1.35 and 0.86, respectively) (Figure 4f).

With regard to mycorrhizal dependence, the highest values (72.87%) observed in seedlings inoculated with *G. margarita*, statistically differing from seedlings inoculated with *C. etunicatum* and MIX (Figure 5a). Mycorrhizal efficiency was higher when using *G. albida* and *G. margarita* inoculums, with values of 221.50 and 257.13%, respectively (Figure 5b).

4. Discussion

Based on the results of this study, we partially confirmed our initial hypothesis that AMF-plant interaction would result in efficient symbiosis, since inoculation with *G. albida* and *G. margarita* promoted better growth characteristics, biomass production and quality of *D. alata*, while *C. etunicatum* inoculum and the mixture of the three species did not contribute efficiently.

The chlorophyll index various during the experimental period due to temperature and relative humidity oscillations (Figure 1), considering the fact that this physiological index is very sensitive to changes in environmental conditions. Although in this study, AMF did not influence the chlorophyll index, there are reports in literature of the participation of these organisms in the synthesis of photosynthetic pigments, varying with host plants. Inoculation with *Rhizophagus irregular* in *Robinia pseudoacacia* L. seedlings showed positive interaction with stimulation of chloroplast gene expression (Chen et al., 2017). On the other hand, Carvalho et al. (2022) observed reduction in the chlorophyll index in *Hymenaea courbaril* L. seedlings inoculated with different AMFs. The authors attribute this effect to the low nutritional status of plants, in which symbiosis was not enough to raise the physiological index.

Table 1. Regression equations and coefficient of determination of plant height, stem diameter and chlorophyll index of *Dipteryx alata* Vogel seedlings as a function of evaluation periods (days after transplanting).

Evaluated characteristic	Equation regression	R^2
Plant height (cm)	$\hat{y} = 9.8330 - 0.0058x + 0.0002^{*}x^2$	0.99
Diameter stem (mm)	$\hat{y} = 3.9750 + 0.0139^{*}x$	0.99
Chlorophyll index	$\hat{y} = 43.7783 - 0.4997^{*}x + 0.0051^{*}x^2 - 0.00001^{*}x^3$	0.90

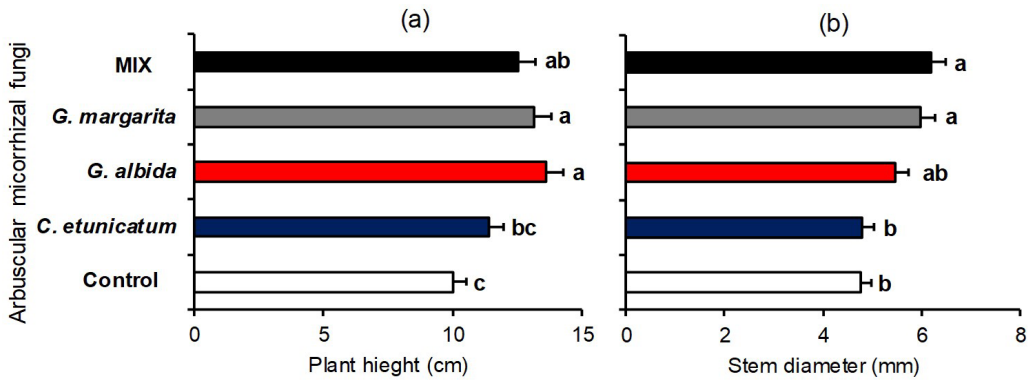

Figure 3. Plant height (a) and stem diameter (b) of *Dipteryx alata* Vogel seedlings in response to inoculation with arbuscular mycorrhizal fungi. Bars followed by different letters differ statistically from each other ± SD (Tukey Test, $p \leq 0.05$).

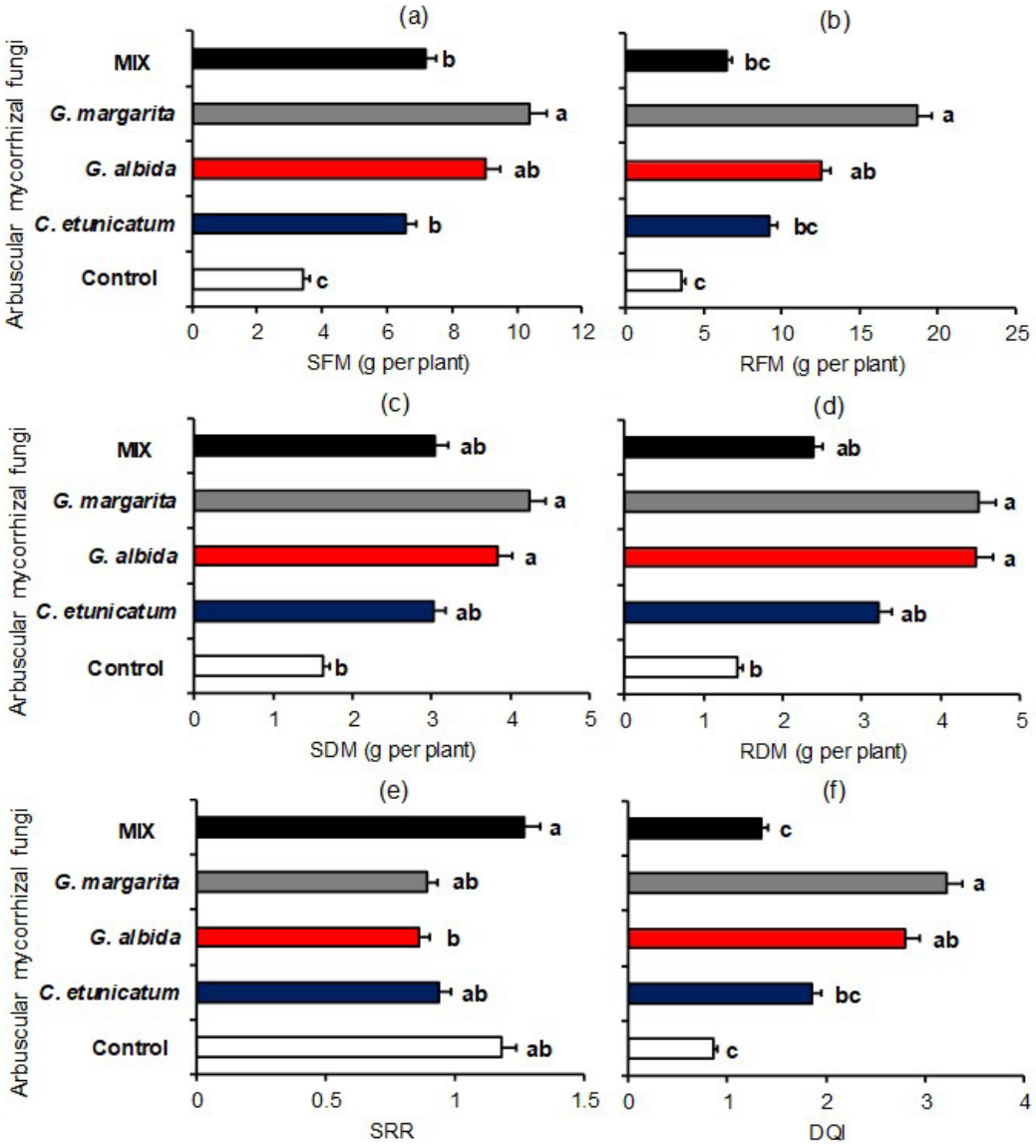

Figure 4. Shoot fresh mass (SFM, a) and roots (RFM, b), shoot dry mass (SDM, c) and roots (RDM, d), shoot/root ratio (SSR, e) and quality index (DQI, f) of *Dipteryx alata* Vogel seedlings in response to inoculation with arbuscular mycorrhizal fungi. Bars followed by different letters differ statistically from each other ± SD (Tukey Test, $p \leq 0.05$).

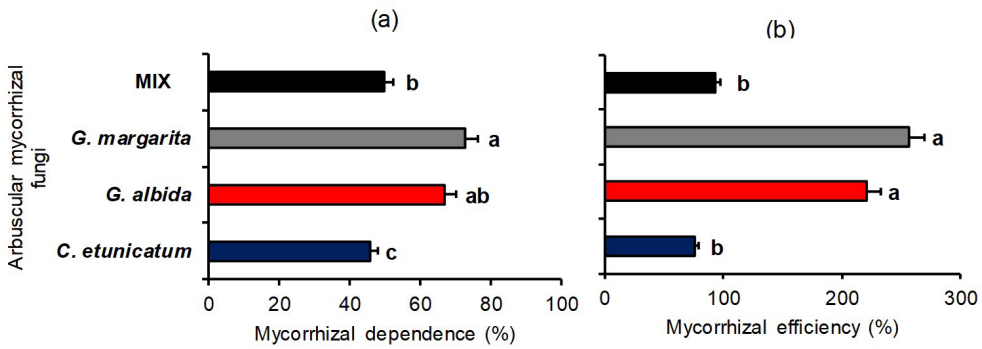

Figure 5. Mycorrhizal dependence (a) and efficiency (b) of *Dipteryx alata* Vogel seedlings produced in response to inoculation with arbuscular mycorrhizal fungi. Bars followed by different letters differ statistically from each other ± SD (Tukey Test, $p \leq 0.05$).

AMF not only acts on the soil physical and chemical properties, but the action of precursor compounds to glomalin acting in the capacity of regulating phytohormones is recognized; with regard to auxin, abscisic acid and methyl jasmonate in plants, acting in the promotion of plant growth (Chi et al., 2018), which may explain the better results in the growth of *D. alata* seedlings, but we reinforce that the beneficial effect is dependent on the plant species and AMF, as observed with *C. etunicatum* was not beneficial for *D. alata* seedlings like the other AMF, since it did not differ statistically from non-inoculated seedlings, different for seedlings inoculated with *G. albida*, and *G. margarita*.

The best responses of *D. alata* seedlings for biomass when inoculated with AMF is due to the participation of these organisms in the photosynthetic process. AMF can modulate the carboxylation process by stimulating enzymes related to the process, mainly ribulose-1,5 bisphosphate carboxylase/oxygenase and phosphoenolpyruvate carboxylase (Liang et al., 2019). However, we suggest that the AMF action mechanisms for *D. alata* may be directly related to the biochemical processes of photosynthesis rather than the synthesis of chloroplast pigments.

Although we have not determined the nutrient content in *D. alata* seedlings, one of the possible contributions of AMF to growth and biomass production is due to the fact that these microorganisms act directly in the process of absorbing nutrients from the soil, mainly due to the action of the mycelial network widely distributed in the soil, being able to intercept nutritional micro reservoirs beyond the exploration zone of roots (Smith and Read, 2010; Cavagnaro et al., 2015; Storer et al., 2018).

D. alata seedlings inoculated with MIX invested more in the aerial part than in the root system, which may suggest that in this condition the water and nutrient absorption switches are less accentuated. Thus, it is reported that late secondary species may not respond significantly to simultaneous inoculation with different species of arbuscular fungi, even with compatibility with the host. In this sense, the symbiotic establishment results in less accumulation of biomass, with the inoculation remaining more responsive to the nutritional status of the seedlings than the growth promotion, as observed by Goetten et al. (2016). Similarly, Outamamat et al. (2022) obtained growth rates greater than 34%, compared to control, when *Ceratonia siliqua* L. seedlings, in which, when isolating the mycorrhizal complexes obtained, were identified in greater degree, the predominant symbiosis of *Glomus* sp. and *Rhizophagus* sp.

As observed through the DQI values, the greatest response was observed upon inoculation of *D. alata* with arbuscular fungi belonging to the genus Gigaspora. However, when in mixed association with *C. etunicatum*, no significantly different results from control plants were expressed.

Based on this result, we believe that this response was mediated by an imbalance in the diversity of propagules present in the inoculum in MIX, where this disproportion, possibly in favor of the genus Gigaspora, caused a competition between mycorrhizal fungi for host resources, thus reducing the effects benefits of multiple symbiosis. Thus, suggesting that there is no synergism between the different isolates present in the MIX.

In this sense, there was a difference in relation to the results obtained by de Carvalho et al. (2022), where the authors observed that seedlings of *H. courbaril* showed greater growth when inoculated with *R. clarum* and MIX, differing from the isolated action of *C. etunicatum*, where the authors inferred that the response time to inoculation may also be related with the growth characteristics of the studied plant species, in which *H. courbaril* trees present slow growth in the initial phase.

It is also possible to associate that, depending on the composition of the MIX, some isolates have an intrinsic characteristic regarding competition and aggressiveness. In this sense, different genres have different colonization strategies that can directly influence the establishment of symbiotic relationships. As evaluated by Cano and Bago (2005) when investigating the competition and colonization strategies of *Glomus intraradices*, *Glomus proliferum*, and *Gigaspora margarita*, they concluded that there was similarity for the mode of colonization at the genus level. While, Glomus spp. are capable of extending the mycelial network from the point of inoculation and sporulating along the area of influence of the root, individuals belonging to the genus Gigaspora are less effective in colonizing the substrate, developing only close to the site of inoculation.

Silva et al. (2017a) observed that *Etlingera elatior* (Jack.) R. M. Sm. plants inoculated with *G. albida* showed greater leaf area and fresh shoot biomass, unlike inoculation with *C. etunicatum* and MIX (*G. albida* + *C. etunicatum*), in which the authors suggest that the response of greater compatibility and shorter response time (45 days after inoculation) when inoculated with *G. albida*, also suggesting that there is no synergism between *G. albida* and *C. etunicatum*.

The plant-AMF combination may improve growth parameters. Other combinations may present alterations, only in the mineral nutrition of the plant, thus suggesting a specificity of action for each symbiotic combination. This result corroborates results of this study, where inoculation with *D. alata* with *C. etunicatum* and MIX showed lower response when compared to seedlings inoculated with *Gigaspora albida* and *G. margarita* in terms of biomass production, showing not only compatibility, but also the mycorrhizal efficiency of the genus *Gigaspora*.

In addition, another factor may be related to response regarding the inoculation of seedlings with AMF, referring to the ability of mycorrhizae to act based on the fertility of the cultivation substrate. Therefore, Silva et al. (2017b) observed that *C. etunicatum* isolates were more effective in promoting growth and nutrient uptake for *Toona ciliata* M. Roem var. *australis* plants in soils with low P availability, while *Gigaspora margarita* was more effective in soils with higher availability of this nutrient, which may be linked to results obtained in this study, where *D. alata* plants were grown in substrate under conditions of adequate fertility, mainly in relation to P, thus promoting a more suitable environment for the performance of *G. albida* and *G. margarita*.

The plant response to mycorrhizal inoculation can be positive, neutral or negative, being influenced by factors controlled by the plant and the fungus (Smith and Smith, 2011). In addition, the colonization of plant roots by less effective arbuscular species represents a cost of photoassimilates, which it is possible to observe that plants inoculated with inefficient AMF have negative effect on promoting plant growth.

However, there are still several hypotheses to understand how the host plant establishes a symbiotic relationship with several AMF simultaneously. One of the possible answers to this question was presented by Bever et al. (2009) and later by Kiers et al. (2011), in which the authors point out that plants associated with an AMF MIX tend to allocate carbon photoassimilates differently, opting to benefit fungi that provide greater availability of nutrients, in which AMF would reward plants for increasing nutrient absorption, thus acting as a dynamic system between plant and AMF, which behavior is considered as a "biological trade" system.

A possible explanation for the fact that limiting conditions for plant growth affect fungal competition is based on the fact that host plants have low carbon budget, and the plant tends to control the colonization of its roots, preferring symbionts that add more activity for nutritional improvement or even induce tolerance due to environmental stress (Schmitt et al., 2013).

Mycorrhizal dependence was modified years ago by Janos (1988), reporting that mycorrhizal dependence refers to the plant's inability to grow in the absence of mycorrhiza under a given cultivation condition, especially soil fertility. On the other hand, mycorrhizal efficiency refers to the capacity of the fungus to colonize widely and early on various hosts, favor the absorption of nutrients from the soil and transfer them to the plant, thus stimulating its growth, development and production (Abbott et al., 1992).

It was verified that the highest symbiotic efficiency was established by *G. albida* and *G. margarita*, since the mixed association together with *C. etunicatum* presented significantly lower values compared to AMF isolates. The explanation for this fact is probably based on the theory that by establishing a symbiotic relationship with a given AMF, the latter can act to inhibit colonization by others, whether of similar genus or species.

Thus, we believe that greater mycorrhizal efficiency may be associated with greater root colonization, promoting greater mycorrhizal dependence of *D. alata* seedlings for individuals of the genus *Gigaspora*, with specificity for *G. albida* and *G. margarita*. This result corroborates data obtained by Werner and Kiers (2015), where the authors observed that *Rhizophagus irregulares* and *Glomus aggregatum* have the capacity to suppress the activity of other AMFs in relation to time, where the order of AMF colonization in the host plant (*Medicago truncatula* Gaertn) can influence the abundance of species in symbiotic association.

Further studies aimed at quantifying the dynamics of nutrient absorption, translocation and efficiency, in addition to photosynthetic and antioxidant metabolism in response to inoculation with AMF in this work should be carried out, adding information for *D. alata* propagation and cultivation.

In conclusion, inoculation with *Gigaspora albida* and *Gigaspora margarita* arbuscular mycorrhizal fungi contributes to the growth and quality of *Dipteryx alata* Vogel seedlings. The symbiosis between *D. alata* seedlings and AMF is mandatory due to its high dependency and mycorrhizal efficiency.

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