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SCIENTIFIC ARTICLE

# Native mycorrhizal fungi induce positive and differential effects on initial growth in *Capsicum* spp.

## Hongos micorrizógenos nativos inducen efectos positivos y diferenciales en el crecimiento temprano in *Capsicum* spp.

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**ABSTRACT**

Cultivation of *Capsicum* spp. requires a prior growth phase in the greenhouse, and the interaction with arbuscular mycorrhizal fungi (AMF) during this phase can improve such growth. Under greenhouse conditions, this study estimated the effect of colonization by three native AMF (*Funneliformis geosporum, Claroideoglomus claroideum, and Glomus ambisporum*) during the initial growth of two species of *Capsicum* (*C. chinense* Jacq. and *C. annuum* L.). The results show a high percentage of AMF colonization in the roots of *C. annuum* (95.98±2.57) and C. *chinense* (89.75±11.62), with no significant differences among the AMF species (F=0.12, p  0.7308). However, significant differences were present in the *Capsicum* species in terms of height (F=112.21, p 0.0001) and fresh root biomass (F= 27.17, p 0.0001). In all the growth variables, an interaction between the AMF and *Capsicum* species was observed (F 12.43, $p<0.05$), suggesting differential effects of the AMF species. In the interaction of *C. claroideum* and *C. annuum*, the seedlings presented significantly greater height, dry aerial biomass, fresh and dry root biomass, while *G. ambisporum* triggered greater height and root biomass in *C. chinense* seedlings. Our results show that inoculation with native AMF can increase the initial performance of *Capsicum* species.

**KEYWORDS**

Interaction, *Funneliformis geosporum, Claroideoglomus claroideum, Glomus ambisporum*, sweet chili, habanero chili

**RESUMEN**

El cultivo de *Capsicum* spp. requiere una fase de crecimiento en invernadero, la interacción con hongos micorrizógenos arbusculares (HMA) durante esta fase puede incrementar este crecimiento. En este estudio se estimó, bajo condiciones de invernadero, el efecto de la colonización por tres especies nativas de HMA (*Funneliformis geosporum, Claroideoglomus claroideum y Glomus ambisporum*) en el crecimiento temprano de dos especies de *Capsicum* (*C. chinense* Jacq. y *C. annuum* L.). Los resultados muestran un alto porcentaje de colonización micorrízica en las raíces de *C. annuum* (95.98±2.57) y *C. chinense* (89.75±11.62), sin diferencias significativas entre especies de HMA (F=0.12, $p\leq 0.7308$). Sin embargo, se presentaron diferencias significativas entre las especies de *Capsicum* en altura, (F=112.21, $p\leq0.0001$) y biomasa fresca radical (F= 27.17, $p\leq0.0001$). En todas las variables de crecimiento se observó una interacción entre los HMA y las especies de *Capsicum* (F≥12.43, p<0.05), sugiriendo efectos diferenciales de las especies de HMA. En la interacción de *C. claroideum* con *C. annum*, las plántulas presentaron diferencias significativas en altura, biomasa aérea seca, así como en el peso fresco y seco de la raíz, mientras que *G. ambisporum* provocó la mayor altura y biomasa radical en plántulas de *C. chinense*. Nuestros resultados muestran que la inoculación con HMA nativos puede incrementar el crecimiento temprano de especies de *Capsicum.*

**PALABRAS CLAVE**
Interacción, *Funneliformis geosporum*, *Claroideoglomus claroideum*, *Glomus ambisporum*, chile dulce, chile habanero

## Introducción

Arbuscular mycorrhizal fungi (AMF) colonize the roots of at least 80% of terrestrial plant species (Berruti et al. 2016). This interaction is mutualist in type since both symbionts benefit (Walder and van der Heijden 2015; Kothe and Turnau 2018; Waller et al. 2018). The AMF obtain photosynthates from the plants for their nutrition (Balestrini and Bonfante 2014), and form an extensive network of extraradical hyphae that allow greater exploration of the soil, promoting increased translocation of water and largely immobile nutrients (Quiñones-Aguilar et al. 2012; Nouri et al. 2014; Pozo et al. 2015), favoring growth and crop production (Nava-Gutierrez et al. 2012), as well as conferring tolerance to stress conditions induced by both biotic and abiotic factors (Carreón-Abud et al. 2013; Herrera-Parra et al. 2014).

In Mexico, AMF have been used to promote increased production in various agricultural crops such as papaya (*C. papaya* L.) (Constantino et al. 2010; Quiñones-Aguilar et al. 2012, 2014), tomato (*Solanum lycopersicum* L.) (Alvarado et al. 2014), and soybean (*Glicine max* L.) (Díaz et al. 2015), counteracting the effect of hydric stress, increasing fruit size (Baum et al. 2015; Vázquez-Hernández et al. 2020) and improving seed protein content (Berta et al. 2014; Bona et al. 2016). They have been used to a lower extent in crops of chili, despite the economic importance of this plant to the country since its annual cultivation produces 2,689,391.93 tons of fruit (SIAP 2020).

Production of chili (*Capsicum* spp.) requires an initial phase of growth under greenhouse conditions (Macías et al. 2013), in which inoculation with AMF can reduce the growth time of the seedlings, confer resistance to the stress caused by transplantation into their definitive sites of cultivation, and improve absorption of mineral nutrients (Chitarra et al. 2016; Tekaya et al. 2017). It also increases the photosynthetic rate and regulates stomatal conductance (Bárzana et al. 2014; Tekaya et al. 2017).

Despite reports describing the positive effect of the use of AMF in *Capsicum* spp. (increased growth, nutrition, and fruit production: Baum et al. 2015), it can also cause negative effects. For example, seedlings of *C. annuum* inoculated with HMA *Glomus aggregatum* N. C. Schenck & G. S. Smith., *G. intraradices* N. C. Schenck & G. S. Smith and *G. mosseae* (Nicol. & Gerd.) Gerd & Trappe did not increase production and fresh fruit weights (Russo and Perkins-Veazie 2010); however, the effects may be dependent on the AMF particular strain employed (Ortas et al. 2011; Ortas and Ustuner 2014). The cost/benefit balance of the interaction between the AMF and the plants depends on the identity of both participants, and, particularly for plants from the genus *Capsicum*, it has been observed that the response to inoculation can vary according to the species of AMF and the cultivar (Reyes-Tena et al. 2016; González-Mendoza et al. 2015).

On the other hand, most of the AMF utilized in agricultural systems correspond to non-native strains, which limits their effectiveness in terms of promoting plant growth, since they must compete with native AMF and the local microbiota (Kouadio et al. 2017). In contrast, the use of native AMF strains has demonstrated greater efficiency in terms of increasing the nutrition and growth of host plants (Reyes-Ramírez et al. 2014).

However, it has been demonstrated that different AMF strains, even when native, have a differential effect on different plant species. For example, depending on the interaction between AMF and genotype, the inoculation with AMF *Rhizophagus clarus* and *Gigaspora margarita* in *Zea mays* L. genotypes caused a positive response in the local variety, with increases of 17% and 14% in biomass and P. The formula genotype (isoline and GM) had a negative response to inoculation, with a decrease of around 30% in biomass and P concentration in inoculated plants (Londoño et al. 2019). In *C. annuum*, inoculation with *G. mosseae*, *G. intraradices*, *G. etunicatum* W.N. Becker & Gerd., *G. clarum* T.H. Nicolson & N.C. Schenck and *G. caledonium* (T.H. Nicolson & Gerd.) Trappe & Gerd. promoted mycorrhizal colonization in the plants and increased, by different percentages, aerial biomass, dry root biomass, and phosphorus content (Ortas et al. 2011). It is evident that the positive, negative, or null effects depend on the AMF-host species combination (Ortas and Ustuner 2014; Seifi et al. 2014; Ronsheim 2016; Avio et al. 2017).

In this study we try to solve the following research questions: are AMF colonization values influenced by the identity of the host plant? Do the different varieties of chili respond differentially to inoculation with different AMF species? To answer these questions, we designed an experiment to determine the effect of three native AMF species on the initial growth of *Capsicum* spp. and specifically to evaluate(i) whether differential colonization by AMF is presented depending on the species of *Capsicum* inoculated, and (ii) whether there is a differential response in the growth in *Capsicum* spp. according to the AMF with which they are inoculated.

## Materials and Methods

### Propagation and identification of AMF

The AMF used in this study were isolated from soil collected from the tropical low deciduous forest of the Cuxtal ecological reserve in Yucatán, Mexico (20°52′07.44′′ N, 89°36′51.64′′ W), in which the predominant soil type is Leptosol, with depths ranging from 0 to 25 cm (Díaz-Garrido et al. 2005). The climate is warm subhumid with rains during summer and winter. The mean annual precipitation is 900 mm, and the mean annual temperature is 27.5 °C (García 1973). The dominant vegetation type is tropical low deciduous forest (Flores and Espejel 1994).

The AMF were propagated in pots of 10-kg capacity filled with soil that had been sieved and mixed with sterile sand (1:1 v/v), in which individuals of sorghum cv. Criollo (*Sorghum bicolor* L.) were sown as trap plants (Herrera-Parra et al. 2021). These pots were maintained in a greenhouse at a mean temperature of 36±2 °C and relative humidity of 46.5%, with irrigation to field capacity as required. After 12 weeks, irrigation was suspended to stimulate sporulation of the AMF (Herrera-Parra et al. 2021). At the end of week 16, a 100 g soil sample was taken and homogenized with Tween© 20 (0.05%) in water from each propagation pot, the AMF was extracted using the wet sieving and centrifugation method (Gerdeman and Nicholson 1963), and the soil solution was filtered through a series of sieves of mesh sizes 600, 425, 90 and 25 μm. The AMF spores were extracted from the retained fractions using the saccharose gradient technique (Sieverding 1983).

Identification and confirmation of the AMF species was conducted according to the morphological characteristics of shape, size, color, texture, spore wall ornamentation and support hypha type (Abbott and Robson 1979; Talukdar and Germida 1993). For this, preparations were composed on slides with part of the extracted spores, using polyvinyl alcohol and lactic acid glycerol with Melzer reagent (1:1 v/v) as a mounting medium. Light pressure was applied to each coverslip to rupture the spores and the slides, then left to dry at ambient temperature for 72 h. Species were identified using a compound microscope and taxonomic keys (Schenck and Pérez 1990; Schüßler and Walker 2010). The most abundant AMF spores in the propagation pots were identified as *Funneliformis geosporum* C. Walker & A. Schüßler, *Claroideoglomus claroideum* C. Walker A. and *Glomus ambisporum* C. Walker & A. Schüßler (Figure 1).

### Extraction of AMF from propagation pots

The AMF spores were extracted from the propagation pots using the method of wet sieving and centrifugation (Gerdeman and Nicholson 1963) and deposited in 1.5 mL vials containing sterile distilled water. To disinfect the spores, the sterile water was extracted from the vials and Tween© 20 added at 0.05%. The vials were then centrifuged at 500 rpm for 1 minute, the supernatant eliminated, and Chloramine T added at 2%, followed by centrifugation at 500 rpm for 15 minutes. These two procedures were repeated twice, the supernatant was then removed, and a mixture of gentamicin (100 ppm) and streptomycin


Figure 1. Spores of the arbuscular mycorrhizal fungi employed in this study: (A) *Claroideoglomus claroideum* C. Walker A., (B) *Funneliformis geosporum* C. Walker & A. Schüßler, and (C) *Glomus ambisporum* C. Walker & A. Schüßler.

(200 ppm) was added to each vial to conserve the spores prior to storage at 4 °C until inoculation.

### Inoculation of *Capsicum* spp. with native AMF

The seeds of *Capsicum* spp. were disinfected with sodium hypochlorite at 1% p/v, followed by rinsing twice with sterile distilled water, while the substrate was steam sterilized over three days for one hour each day at 100 °C (Herrera-Parra et al. 2021). The sterile substrate [pH 7.4, Nitrogen 1.16%, Phosphorous 2.34 (mg kg-1), Organic matter 10.62%] was then used to fill 72-cell germination trays, depositing one sweet chili (*C. annuum* cv. Criollo) or habanero chili (*C. chinense* cv. Calakmul) seed and 30 spores of the AMF species in each cell, according to treatment.

The germination trays were covered with black plastic for five days to induce seed germination and maintained in greenhouse at 28±2 °C, with relative humidity of 64 % and an average light intensity of 400 lux. The total percentage of root colonization and colonization by vesicles of the AMF were estimated in five plants per treatment: the roots were washed with tap water, transported to laboratory, and stained according to the technique of Phillips and Hayman (1970). Permanent preparations were produced with the stained roots to observe the structures of the AMF (mycelium, spores, vesicles, and coils) and percentage of colonization was quantified (McGonigle et al. 1990).

### Variables measured

Following 47 days of growth after sowing, the seedlings were harvested; both the total and vesicles percentage of root colonization by AMF were measured, and the effects of the AMF evaluated by measuring variables associated with the growth of the *Capsicum* spp: seedling height (cm), fresh root biomass, dry aerial biomass and dry root biomass (g) (after drying at 60 °C for 72 h).

### Experimental design and data analysis

The experimental design had a factorial arrangement of 2 x 3=6 treatments, comprising two species of *Capsicum* (*C. annuum* cv. Criollo and *C. chinense* cv. Calakmul) and three species of AMF (*F. geosporum*, *C. claroideum* and *G. ambisporum*). Each treatment consisted of 30 replicates distributed in a completely random experimental design. To estimate differences in the total percentage of colonization and colonization by vesicles of the AMF, the mixed generalized linear model with binomial distribution was used, with logit link function of proportions with binomial errors. To estimate the principal effects (of AMF and *Capsicum* species) and their interaction on the growth variables between *Capsicum* species, an analysis was performed through a mixed generalized linear model of normal distribution and identity link function for continuous data with normal errors. In both cases, the procedure GLIMMIX was used with the statistical package Statistical Analysis System (SAS) ver. 9.3.

## Results

### Colonization of AMF in *Capsicum* spp.

The AMF species used in the study (*F. geosporum*, *G. ambisporum* and *C. claroideum*) colonized the roots of the *Capsicum* spp. seedlings. The percentages of total colonization were considered high; in *C. annuum*, values from 94 to 99% were found, while in *C. chinense*, the values found were from 76 to 98% (Figure 2). In the case of colonization by vesicles, a value of 6.8% was found in *C. annuum* with both *C. claroideum* and *G. ambisporum*, with a value of 14.83% found in *C. chinense* with *G. ambisporum*. In terms of both percentage of total co-

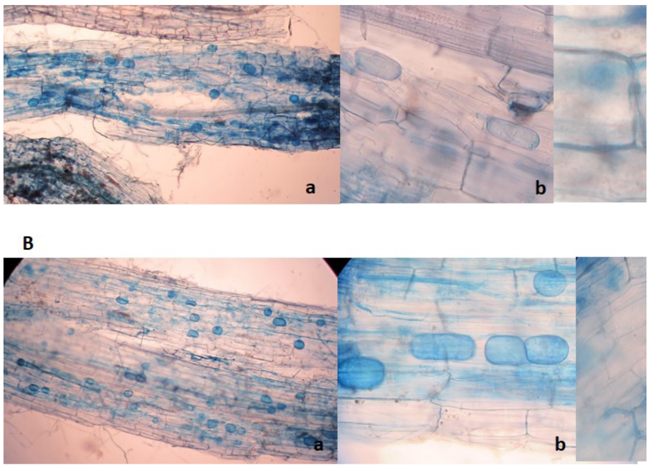


Figure 2. Arbuscular mycorrhizal root colonization of *Capsicum* spp. seedlings. (A) Roots of *C. annuum* colonized by spores and mycelium (a) (10X), vesicles (b)(40X) and coils (c)(100X). (B) Roots of *C. chinense* colonized by spores and mycelium (a) (10X), vesicles (b)(40X) and coils (c)(40X).

lonization and colonization by vesicles, no significant differences were found between the two *Capsicum* species (F= 0.12, p<0.7308), by AMF species (F= 0.37, p<0.6957) or by the interaction AMF x *Capsicum* species. (F= 0.09, p<0.9112).

## Effect of inoculation of AMF on the growth variables of *Capsicum* spp.

Significant differences in growth variables were only present between the *Capsicum* species for seedling height (p<0.0001) and fresh root biomass (p<0.0001) (Table 1), while the effect of colonization by the AMF and its interaction with the *Capsicum* species had significant (p<0.0001) effects in all the growth variables evaluated (Table 1).

## Initial growth of *Capsicum* spp on inoculation with AMF

The response of the plants to inoculation with the different AMF species was variable; in *C. annuum*, the tallest seedlings were recorded when inoculated with the species *C. claroideum* (8.45±0.55 cm), presenting significant differences (p<0.0001) with respect to inoculation with the other two AMF species. In *C. chinense*, the tallest seedlings were present with *G. ambisporum* inoculation (6.2±0.34 cm), differing significantly (p<0.0001) in this regard to the effect of either *F. geosporum* or *C. claroideum* (Fig. 3). With respect to the growth response of the two C*apsicum* species inoculated with the same AMF, *F. geosporum* and *C. claroideum* both induced a significant difference in height (p<0.0001) between the two *Capsicum* species, while inoculation with *G. ambisporum* caused no significant differences (p<0.7715) in height between the two *Capsicum* species (Figure 3).
A significantly (p<0.0001) greater dry aerial biomass was registered in the *C. annuum* seedlings inoculated with *C. claroideum* (0.17±0.01 g) and *G. ambisporum* (0.05±0.01 g), than with *F. geosporum*, in which the dry aerial biomass was lower (0.01± 0.07 g). In the case of *C. chinense*, the greatest dry aerial biomass was obtained with *G. ambisporum* (0.09±0.01 g), and this effect differed significantly (p<0.0001) from that of inoculation with *F. geosporum* and *C. claroideum*. In comparison with this response between the *Capsicum* species, differences were observed in the increase in dry aerial biomass, with the greatest effect found in

**Table 1. Effects of the factors (*Capsicum* and AMF species) and of their interaction on the growth variables evaluated.**

| Factors | Growth variables | | | |
|---|---|---|---|---|
| | Seedling height (cm) | Dry aerial biomass (g) | Fresh root biomass (g) | Dry root biomass (g) |
| | ***P*** | ***P*** | ***P*** | ***P*** |
| *Capsicum* species | 0.0001** | $0.3518^{\text{n.s.}}$ | 0.0001** | $0.1172^{\text{n.s.}}$ |
| AMF | 0.0001** | 0.0001** | 0.0001** | 0.0001** |
| AMF x *Capsicum* species | 0.0001** | 0.0001** | 0.0001** | 0.0001** |

** significant difference p≤0.0; n.s.= not significant p≤0.1

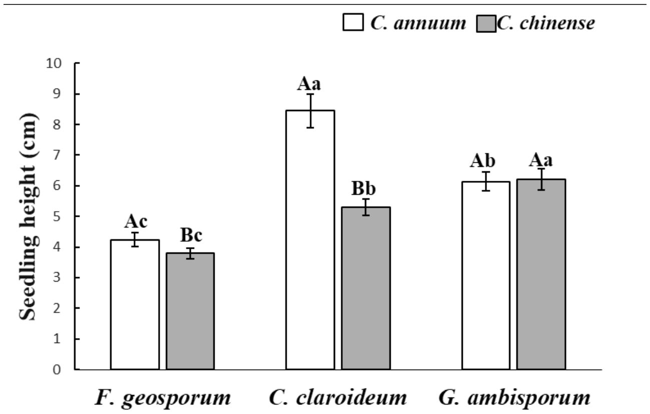


Figure 3. Effect of inoculation with AMF on seedling height in *C. annuum* and *C. chinense* 47 days after sowing. Lower case letters denote significant differences between AMF species for the same *Capsicum* species. Upper case letters denote significant differences between species of *Capsicum* inoculated with the same species of AMF.

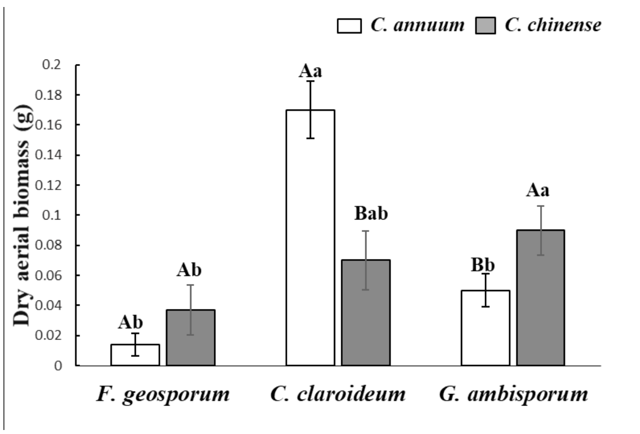


Figure 4. Effect of AMF on the dry aerial biomass of *C. annuum* and *C. chinense* 47 days after sowing. Lower case letters denote significant differences between AMF species for the same *Capsicum* species. Upper case letters denote significant differences between species of *Capsicum* inoculated with the same species of AMF.

*C. annuum* inoculated with *C. claroideum* ($p<0.0001$), and in C. chinense inoculated with G. ambisporum ($p< 0.0001$). There were no significant differences between the two Capsicum species inoculated with F. geosporum ($p<0.3205$) (Figure 4).

Regarding the fresh root biomass, inoculation with C. claroideum promoted significantly ($p<0.0001$) higher values (0.30±0.03 g) in C. annuum, compared to inoculation with *F. geosporum* (0.02±0.01 g) or *G. ambisporum* (0.10±0.02 g). In *C. chinense*, inoculation with *G. ambisporum* promoted significantly ($p<0.0001$) greater fresh root biomass (0.41±0.05) than the other two AMF species. A comparison between the two *Capsicum* species showed significant differences on inoculation

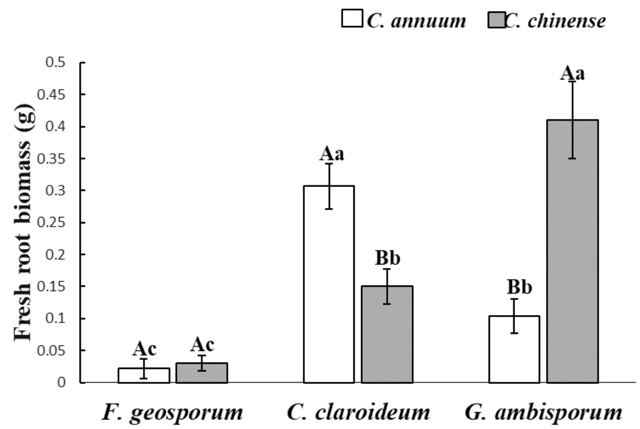


Figure 5. Effect of AMF on the fresh root biomass of *C. annuum* and *C. chinense* 47 days after sowing. Lower case letters denote significant differences between AMF species for the same *Capsicum* species. Upper case letters denote significant differences between species of *Capsicum* inoculated with the same species of AMF.

with *C. claroideum* ($p<0.0001$) and *G. ambisporum* ($p<0.0001$), while inoculation with *F. geosporum* did not cause a differential response between the *Capsicum* species ($p<0.4413$) (Figure 5).

Greater dry root biomass was observed in *C. annuum* (0.03± 0.005 g) inoculated with *C. claroideum*, and in *C. chinense* (0.03±0.005 g) inoculated with *G. ambisporum;* the lowest dry root biomass values were found in both *Capsicum* species inoculated with *F. geosporum*: in *C. annuum* (0.004±0.002 g) and in *C. chinense* (0.01±0.002 g). A comparison between the two *Capsicum* species revealed significant ($p<0.001$) differences among all the inoculation treatments;

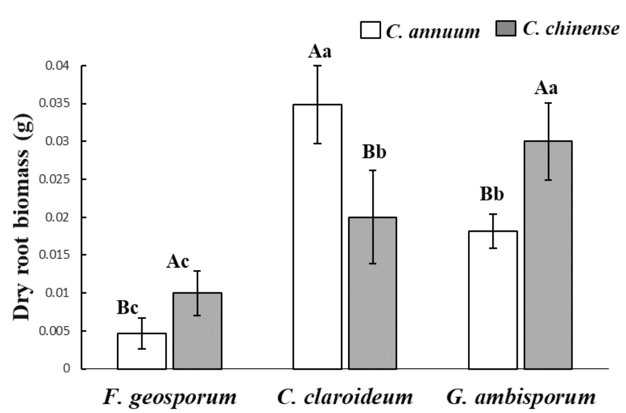


Figure 6. Effect of AMF on the dry root biomass of *C. annuum* and *C. chinense* 47 days after sowing. Lower case letters denote significant differences between AMF species for the same *Capsicum* species. Upper case letters denote significant differences between species of *Capsicum* inoculated with the same species of AMF.

*C. annuum* had greater dry root biomass than *C. chinense* when inoculated with *C. claroideum*, while *C. chinense* showed greater dry root biomass than *C. annuum* when inoculated with *F. geosporum* and *G. ambisporum* (Figure 6).

## Discussion

The native AMF species used in this experiment showed high percentages of colonization of the roots of the *C. annuum* and *C. chinense* seedlings, regardless of *Capsicum* species, suggesting that, at this initial growth stage, the *Capsicum* species are highly colonizable. This interaction has also been reported in cultivars of *Cucumis melo* L. For example, the cultivar Zhongnong, inoculated with consortia called TV (*Claroideoglomus* sp., *Funneliformis* sp., *Diversispora* sp., *Glomus* sp. and *Rhizophagus* sp.), and BF (G. *intraradices*, G. *microaggregatum* Koske, Gemma & P. D. Olexia and G. *claroideum* N. C. Schenck & G. S. Smith), successfully colonized the roots of the seedlings 46 days after inoculation (Chen et al. 2017). Early growth stages of the cultivars Demire, Jalapeño Serrano, De Árbol and Poblano, inoculated with the AMF species G. *mosseae*, G. *etunicatum*, G. *intraradices*, G. *clarum* and G. *caledonium*, had high percentages of colonization (44.9 to 93.3%) and differential effects on the growth and physiology of the seedlings (Ortas et al. 2011; González-Mendoza et al. 2015; Reyes-Tena et al. 2016). In the present study, the AMF had the same potential for colonizing the roots of *Capsicum* spp. cultivars. This effect is related to the initial growth stage of the seedling root, in which interaction with the AMF facilitates the uptake of nutrients and water, and confers tolerance to abiotic and biotic stresses during initial growth stages (Cesaro et al. 2020; Sallaku et al. 2019).

In both *Capsicum* species, total colonization by AMF promoted the growth and production of biomass differentially, suggesting that AMF species do not have the same effect on *Capsicum* species, even if they have similar colonization values, which has been observed in other studies (Treseder 2013; Jin et al. 2017).

These responses could be associated with the genetic capacity of each *Capsicum* species to establish the interaction, which depends on the compatibility between the host and the AMF species (Veresoglou and Rillig 2014; Seifi et al. 2014; Ronsheim 2016). In studies with the AMF species *Rhizophagus irregularis* and *Glomus clarum* in different cultivars of *C. annuum* (California Wonder, Cherry pepper, Bell pepper and Thai pepper), greater initial growth was reported in the seedlings (Beltrano et al. 2013). The cultivar De árbol presented stems of greater diameter with *G. intraradices* F18 inoculation (González-Mendoza et al. 2015). However, in the cultivars known as Jupiter, Demre and Camelot, null or negative effects were reported in terms of seedling growth and fruit production when they were inoculated with *R. irregularis*, *G. intaradices*, *G. mosseae* and *G. agregatum* N.C. Schenck & G.S. Smiths (Russo and Perkins-Veazie 2010; Reyes-Ramírez et al. 2014).

It is possible that the responses of the cultivars of *Capsicum* spp. inoculated with the AMF, may be associated with their genetic improvement, since an erosion is caused during the process of genetic selection which reduces the translocation of nutrients and the formation of arbuscules (Salloum et al. 2018). This diminishes the functionality of the symbiosis, reducing its positive impact on biomass production in the plants (Jin et al. 2017; Bazghaleh et al. 2018).

In other interactions of AMF and species of annual cycles, such as *Z. mays*, *Oryza sativa* L. and *Triticum turgidum* L., subjected to processes of genetic improvement to obtain productive materials, these plants become demanding of P but show a reduced capacity for colonization by AMF in comparison to materials that have not been manipulated in such a way (Singh et al. 2012; Chu et al. 2013). This suggests that the AMF responses are affected by the host, variety, genetic manipulation, and conditions in which the plants are established, which together could induce a selection pressure that favors certain specific host-AMF combinations that can benefit or not the growth of the cultivars, as occurred with the species of *Capsicum* and AMF studied.

It has been reported that the presence of AMF in roots of horticultural crops does not always provide a mutual benefit (Reyes-Ramírez et al. 2014; Erdinç et al. 2017; Jin et al. 2017; Bazghaleh et al. 2018). This was the case in the present study with the inoculation of *F. geosporum*, which promoted the least growth in the seedlings, suggesting that the interaction is less functional (Kim et al. 2017) compared to the other AMF species used. In the arbuscular mycorrhizal interaction, the AMF provide nutrients and improve the metabolism of their hosts, which reduces the cost implied by the consumption of the host's photosynthates by the AMF. When this occurs, it is considered that the plant obtains a benefit that is reflected in its growth (Johnson and Graham 2013). However, such a benefit was not observed with inoculation of *F. geosporum* in the *Capsicum* species evaluated in this study.

The AMF can present different functionalities during the growth of their hosts that range from mutualist to parasitic, depending on environmental changes as well as, mainly, the availability of P and N (Hoeksema et al. 2010; Jin et al. 2017). For example, inoculation with the AMF species *Glomus mosseae, G. microcarpum, G fasciculatum* and *G. caledonium* promoted the initial growth of *O. sativa*, regardless of the soil P content. However, when inoculation was performed with the AMF species *G. etunicatum*, plant growth was not promoted under any conditions of P availability (Dhillion 1992). Thus, inoculation with the AMF *Glomus intraradices* suppressed the initial growth of *Trifolium subterraneum* L., but presented its greatest effect during the stage of production (Li et al. 2005).

Considering that the present study was conducted in the early growth stage, it is necessary that future studies consider these factors, as well as other *Capsicum* spp. growth stages, to validate if this response induced by *F. geosporum* is maintained over time.

The AMF colonized the *Capsicum* species and, although the percentages of colonization were considered high, the associations with the AMF did not present the same effect on the growth of the cultivars. These results highlight the importance of selecting AMF strains that are capable of colonizing roots in a short period of time, but also those that can promote a benefit of this association in their hosts in the initial growth stage and produce healthy, vigorous seedlings of greater size capable of tolerating stress conditions when transplanted to their definitive sites of cultivation.

## Conclusion

All the AMF evaluated in this study colonized the roots of the *Capsicum* spp. and promoted, to different degrees, the growth of the seedlings. In *C. annuum*, inoculation with *C. claroideum* produced the greatest seedling growth, but in *C. chinense*, this was found with inoculation of *G. ambisporum*. The differential growth observed is associated with the genotype of the species of *Capsicum* and their compatibility with the AMF species evaluated.

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