



Revista Brasileira de Ciências Agrárias

ISSN: 1981-1160

agrarias.prppg@ufrpe.br

Universidade Federal Rural de
Pernambuco
Brasil

Vitorazi Filho, José Antônio; Mendonça Freitas, Marta Simone; Martins, Marco Antônio;
dos Santos, Paulo Cesar; Cordeiro de Carvalho, Almy Junior

Arbuscular mycorrhizal fungi and phosphate fertilization on star fruit tree seedlings

Revista Brasileira de Ciências Agrárias, vol. 12, núm. 1, 2017, pp. 14-19

Universidade Federal Rural de Pernambuco
Pernambuco, Brasil

Available in: <http://www.redalyc.org/articulo.oa?id=119050448003>

- How to cite
- Complete issue
- More information about this article
- Journal's homepage in redalyc.org

redalyc.org

Scientific Information System

Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal

Non-profit academic project, developed under the open access initiative

Arbuscular mycorrhizal fungi and phosphate fertilization on star fruit tree seedlings

José Antônio Vitorazi Filho¹, Marta Simone Mendonça Freitas¹, Marco Antônio Martins¹,
Paulo Cesar dos Santos¹, Almy Junior Cordeiro de Carvalho¹

¹ Universidade Estadual do Norte Fluminense Darcy Ribeiro, Av. Alberto Lamego, 2.000, Parque Califórnia, CEP 28013-600, Campos dos Goytacazes-RJ, Brasil. E-mail: josevitorazi@yahoo.com.br; msimone@uenf.br; marco@uenf.br; pcsantos18@hotmail.com; almy@fruticultura.org

ABSTRACT

The success of star fruit cultivation deployment begins with the use of good quality seedlings. Thus the inoculation of mycorrhizal fungi in culture seedling can be an alternative, since it was found success in both growth as nutritional aspect fruit species. In this sense, the aim of this study was to evaluate the effects of arbuscular mycorrhizal fungi (AMFs) on growth and mineral composition of star fruit seedlings, cultivated under different doses of phosphorus (P). The experiment was conducted in a greenhouse and the experimental design used was randomized blocks in a 3 x 4 factorial scheme, with three microbiological treatments (without inoculation, *Rhizofagus clarum*, *Glomus etunicatum*) and four doses of P (0, 50, 100 and 200 mg kg⁻¹ soil) with four replications. Plants were harvested four months after sowing for biometric and nutritional analysis. In the soil without phosphate fertilization, *R. clarum*, provided increments of 49% in height, 99% in dry matter production and 86, 129 and 108% in the contents of N, K, and Ca, respectively, in relation to the control. Regardless of phosphate fertilization, the content of P, Mg, and S in the dry matter weight was 19.2, 17.6 and 23.6% higher in the treatment inoculated with *R. clarum*, in relation to the control. Mycorrhizal dependence of star fruit tree varied according to fungus species and the P dose used, being greater when the fungus *R. clarum* was used in absence of P.

Key words: *Averrhoa carambola* L.; mineral composition; mycorrhiza

Fungos micorrizicos arbusculares e adubação fosfatada em mudas de caramboleira

RESUMO

O sucesso da implantação do cultivo da caramboleira inicia-se com a utilização de mudas de boa qualidade, nessa linha a inoculação de fungos micorrizicos em mudas da cultura pode ser uma alternativa, visto que foi verificado sucesso tanto no crescimento como em aspecto nutricionais em espécies frutíferas. Nesse sentido, objetivou-se com esse trabalho avaliar a inoculação de fungos micorrizicos arbusculares (FMAs) no crescimento e composição mineral das mudas de caramboleira, cultivadas com doses de fósforo (P). O delineamento estatístico utilizado foi de blocos ao acaso, num fatorial 3 x 4, com três tratamentos microbiológicos (sem inoculação, *Rhizofagus clarum*, *Glomus etunicatum*) e quatro doses de P (0, 50, 100 e 200 mg kg⁻¹ de solo) e quatro repetições. As plantas foram colhidas aos quatro meses após a semeadura para análises biométricas e nutricionais. No solo sem adubação fosfatada, o fungo *R. clarum* proporcionou incrementos de 49% na altura, 99% na produção de massa de matéria seca e de 86, 129 e 108% nos conteúdos de N, K e Ca, respectivamente, em relação ao controle. Independente da adubação fosfatada, o conteúdo de P, Mg e S na massa de matéria seca foi 19,2, 17,6 e 23,6% maior no tratamento inoculado com *R. clarum*, em relação ao controle. A dependência micorrizica da caramboleira variou de acordo com a espécie de fungo e a dose de P utilizada, sendo maior quando se utilizou o fungo *R. clarum* na ausência de P.

Palavras-chave: *Averrhoa carambola* L.; composição mineral; micorriza

Introduction

Star fruit (*Averrhoa carambola* L.), a species originated in Asia and in the family Oxalidaceae, has a great potential to be better exploited in Brazil, mainly for being adapted to tropical climates, without occurrence of frosts, and for its great acceptance by Brazilian and global consumers in the market of exotic fruits (Bastos, 2004).

Although it presents a productive potential, which can reach 60 t ha⁻¹ (Bastos, 2004), star fruit tree is still grown under low technological conditions, mainly due to the lack of cultivation techniques and/or varieties adapted to the different growing conditions. Most of the orchards in production in Brazil were formed from seedlings derived from cultivars in Florida and Malaysia (Bastos et al., 2009).

The beneficial effects of arbuscular mycorrhizal fungi have been demonstrated in the most varied conditions and plant species, in most cases, stimulating plant growth as a result of its effect on plant nutrition, especially in increasing the absorption of phosphorus (Freitas et al., 2004; Santos et al., 2011; Heitor et al., 2016; Pereira et al., 2016).

The production of star fruit seedlings is one of the limiting factors to the commercial expansion of the culture, due to the time it takes to be formed and begin to set fruit. An alternative to the preparation of these seedlings is to use AMFs, which have contributed to reduce the production time of several fruit trees such as citrus (Altoé et al., 2008), yellow passion fruit (Cavalcante et al., 2001; Cavalcante et al., 2002), sweet passion fruit (Anjos et al., 2005; Vitorazi et al., 2012), papaya (Lima et al., 2011) and cashew (Weber et al., 2004), in addition to reducing phosphate fertilization (Riter Netto et al., 2014).

Considering that there are few studies on star fruit crops in Brazil and that there are no reports on the relation between mycorrhizal symbiosis and seedling production of this fruit tree, the present study aimed to evaluate the effects of mycorrhizal fungi and phosphate fertilization on growth and mineral composition of star fruit seedlings.

Materials and Methods

The experiment was conducted in a greenhouse at the Universidade Estadual do Norte Fluminense, located in Campos dos Goytacazes, RJ (21° 19' 2" S; 41° 10' 40" W; at an elevation of 14 m above sea level). During the experiment period, daily minimum temperature ranged from 12.5 °C to 24.0 °C, the average temperature was 19.9 °C and the maximum daily temperature ranged from 21°C to 40°C with an average of 32.9 °C. The experimental design was randomized blocks in a 3x4 factorial combination of three microbiological treatments (without inoculation, *Rhizophagus clarum*, *Glomus etunicatum*) and four doses of phosphorus (0, 50, 100 and 200 mg kg⁻¹ soil), with four replications. The experimental unit was composed of a plastic pot containing 3 kg of soil and five plants per vase.

The substrate used for the experiment was soil collected at 0-20 cm depth, sieved, mixed with sand 1:2 (v/v) and sterilized in an autoclave twice at a temperature of 121°C for 1 hour. After autoclaving, the substrate presented the following

chemical characteristics: pH in water = 5.5; organic matter = 13.79 g dm⁻³; P = 4.0 mg dm⁻³; S = 19.0 mg dm⁻³; K⁺ = 1.6 mmol_c dm⁻³; Ca²⁺ = 8.0 mmol_c dm⁻³; Mg²⁺ = 6.4 mmol_c dm⁻³; Al³⁺ = 1.0 mmol_c dm⁻³; H+Al = 15.3 mmol_c dm⁻³; SB = 16.40 mmol_c dm⁻³; T = 31, 70 mmol_c dm⁻³; Fe = 56.17 mg dm⁻³; Cu = 0.15 mg dm⁻³; Zn = 1.79 mg dm⁻³; Mn = 25.25 mg dm⁻³ and B = 0.45 mg dm⁻³.

A dose of 20 mg kg⁻¹ of N as NH₄NO₃ was applied for each treatment. 120 mg kg⁻¹ of KCl was used in treatment 0 P for K-correction. For treatment 50 P, 219.5 mg kg⁻¹ of KH₂PO₄ was used for the correction of K and P. For treatment 100 P, we used 219.5 mg kg⁻¹ of KH₂PO₄ and 222.5 mg kg⁻¹ of NaH₂PO₄ H₂O. Finally, 219.5 mg kg⁻¹ of KH₂PO₄ and 667.3 mg kg⁻¹ of NaH₂PO₄ H₂O were used in 200 P dose. After fertilization, the soil was incubated for 15 days, and kept properly moistened.

The substrate used for inoculum multiplication was a mixture of soil and sand 1:2 (v/v), sterilized in an autoclave twice, at 121 °C, for 1 hour. 50 g of initial inoculum were added to the substrate, placed in 3kg pots, constituting a mixture of soil containing spores, hyphae and colonized roots, with the fungus of each species to be studied: *R. clarum* and *G. etunicatum*. The initial inoculum of the fungus was removed from the collection of fungal species of the Soil Microbiology Sector of UENF. Then, 15 seeds of *Brachiaria brizantha*, disinfested in a 0.5 % sodium hypochlorite solution for 10 minutes and rinsed with deionized water, were sown in each pot. Four months after sowing, shoot was cut and, thirty days after cutting, the soil mixture containing spores, hyphae and sliced thin roots was used as inoculum.

Star fruit seeds cv. *Malasia* were placed in water for four hours before planting. Ten seeds were planted per pot. After germination and seedling development has begun, a thinning was carried out, leaving five plants per pot. Before sowing, 50 g of AMFs species inoculum were added to the inoculated treatments. Inoculants were placed 2-3 cm below the soil surface. The plants were irrigated daily, using deionized water.

The plants were harvested four months after planting. Average height and shoot dry mass were determined after drying in an oven of forced air ventilation at a temperature of 65 °C for 48 hours. After being dried, the samples were ground in a Willey Mill and stored in hermetically sealed bottle (Malavolta, 1997). Fine roots were collected, washed with water, cut approximately 2 inches in length and stored in 50 % ethanol for further assessment of root colonization percentage. Roots were colored according to (Grace & Stribley, 1991), with adaptations, to determine the percentage of mycorrhizal colonization. The roots were taken under a microscope in order to observe the presence of structures of AMFs.

Levels of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) in the shoot were determined. Plant material was subjected to oxidation by sulfuric digestion and the extract was obtained, from which nitrogen was determined by Nessler method (Jackson, 1965), phosphorus by molybdate colorimetric method (Malavolta, 1997) and potassium by flame emission spectrophotometry. Ca, Mg and S were quantified, after oxidation of plant material by digestion nitro-perchloric, by atomic absorption spectrometry and by turbidimetry with barium chloride.

Relative mycorrhizal dependence (RMD) of star fruit trees was assessed through the ratio between the increase in shoot dry matter production of mycorrhizal plants compared to non-mycorrhizal ones and shoot dry matter of non-mycorrhized plants, with the result expressed as a percentage (Bethlenfalvay et al., 1982).

Analyses of variance were performed for quantitative variables, averages of microbiological treatments were compared by Tukey test at 5 % probability, and P doses were analyzed by polynomial regression.

Results and Discussion

Effects of interactions between fungal species and P doses on shoot dry matter production and height of star fruit tree were observed (Table 1). In the absence of phosphate fertilization, shoot dry matter production and height of star fruit tree, in treatments inoculated with *R. clarum*, were 99 and 49 % higher, respectively, than the results obtained in the control treatment, showing the efficiency of this fungal species in promoting star fruit tree growth in the absence of P. The estimated doses of P of 125.40; 143.80 and 160.45 mg kg⁻¹ soil, respectively for *G. etunicatum*, without inoculation, and *R. clarum* were the ones that provided the greatest dry matter production. Results similar to those found in the present study for the species *R. clarum* at P dose of 0 were observed by Freitas et al. (2006) in *Mentha arvensis*, by Soares & Martins (2000) in *Passiflora edulis*, by Samarão & Martins (1999) in *Psidium guajava* L. and by Sato et al. (1999), with *Heliconia* sp. and *Gerbera* sp.

When phosphate fertilization was not used, the highest percentage of mycorrhizal colonization was 85%, observed in the treatment with *R. clarum* (Figure 1), which provided greater dry matter production (Table 1). The increase of phosphate fertilization resulted in reduced mycorrhizal colonization in star fruit seedlings inoculated with the fungus *R. clarum*. According to (Smith & Read, 1997), in soils with low availability of P the highest mycorrhizal colonization is usually followed by stimuli in plant growth; however this stimulus has not been observed for star fruit plants inoculated with *Glomus etunicatum*.

The observed differences in dry matter production of star fruit tree among the different microbiological treatments can, according to (Sieverding, 1991), occur because arbuscular mycorrhizal fungi demonstrate preference for specific hosts, and symbiotic efficiency is influenced by plant and fungus genotypes, as well as by environmental conditions.

According to Moreira & Siqueira (2002), the decrease in mycorrhizal colonization with increased P doses can be

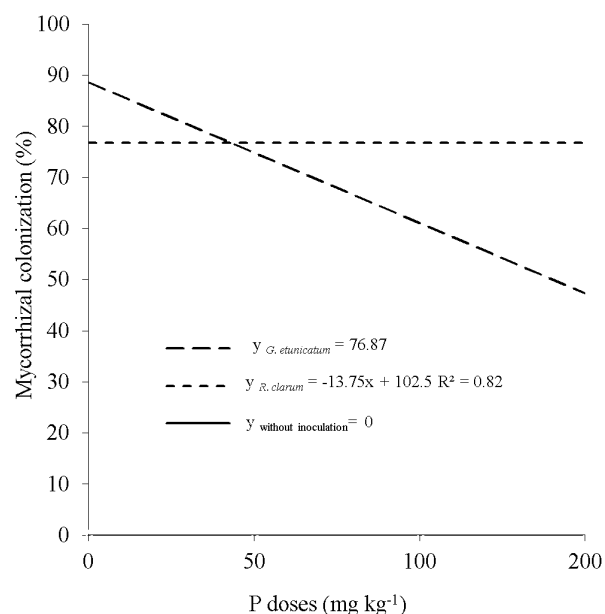


Figure 1. Mycorrhizal colonization (%) of star fruit tree roots in relation to microbiological treatments and P doses

explained by phosphatase activity in roots, which is low. As a result, the lecithin found in these roots is freed and binds to carbohydrates of the mycorrhizal fungus, inhibiting its growth. On the other hand, phospholipid biosynthesis is increased and, as a result, cell permeability, root exudation of amino acids, root colonization and infection are decreased. Higher doses of P increased photosynthesis and assimilate availability on the roots by inhibiting the mycorrhizal fungus propagules. Several studies have demonstrated that different species of AMFs should be tested in a same plant under the same environmental conditions to select efficient AMFs for their ability to promote the growth of their host (Melloni et al., 2000; Bressan et al., 2001; Weber et al., 2004; Freitas et al., 2006). It should be emphasized that in the control treatment the value found for mycorrhizal colonization was zero.

For the contents of N, K, and Ca, interaction between species of fungi and P doses were observed (Figures 2, 3 and 4), respectively. In the absence of phosphate fertilization, the contents of N, K, and Ca in shoot dry matter were 86, 108 and 129%, respectively, higher than the contents found in treatments inoculated with *R. clarum* in comparison to the control treatment. Bressan et al. (2001) observed that arbuscular mycorrhizal fungi inoculation increased foliar concentrations of N and K. Melloni et al. (2000) also found interactions in the contents of N, K, and Ca of the shoot. The estimated P doses of 162.6, 206.1 and 131.9 mg kg⁻¹ soil for the control, *R. clarum* and *G. etunicatum*, respectively, were

Table 1. Shoot dry matter production and height of star fruit plants in relation to microbiological treatments and P doses

Fungus	Shoot dry matter (g pot ⁻¹)					Height (cm plant ⁻¹)				
	P (mg kg ⁻¹ soil)				Average	P (mg kg ⁻¹ soil)				Average
	0	50	100	200		0	50	100	200	
<i>R. clarum</i>	4.00 a	7.67 ab	8.10 a	8.30 a	7.02	17.8 a	24.0 a	23.9 a	23.2 a	22.2
<i>G. etunicatum</i>	2.29 b	8.00 a	7.84 a	6.96 b	6.27	12.4 b	23.2 a	23.1 a	22.0 a	20.2
Without inoculation	2.01 b	6.47 b	7.36 a	7.57 ab	5.85	11.9 b	22.8 a	22.7 a	22.5 a	20.0
Average	3.09	6.52	8.40	7.50		14.8	21.3	24.7	22.3	
CV (%)		10.88					7.99			

The averages followed by the same letter, uppercase letter in the column and lowercase letter in the line, do not differ from each other, based on the Tukey test (P<0,05)

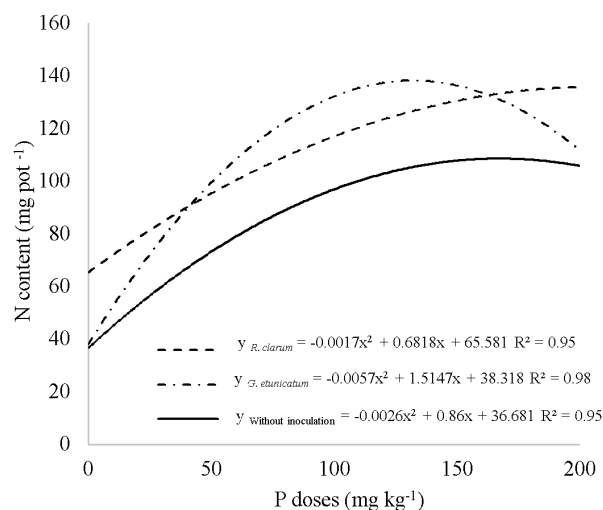


Figure 2. N contents (mg pot⁻¹) in leaf dry matter of star fruit seedlings in relation to microbiological treatments and P doses

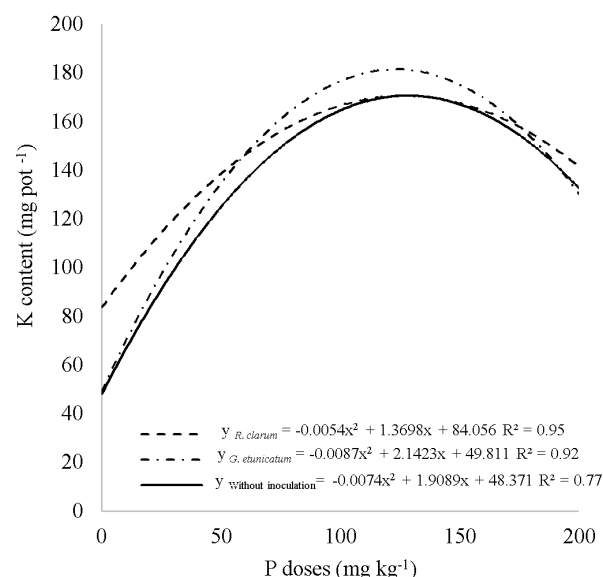


Figure 3. K content (mg pot⁻¹) in leaf dry matter of star fruit seedlings in relation to microbiological treatments and P doses

the ones that achieved the largest increments in N content in shoot dry matter. For K, P estimated doses were 128.3, 126.5 and 123.1 mg kg⁻¹ soil; and for Ca, P estimated doses were 117, 110.6 and 110.8 mg kg⁻¹ soil for the control, *R. clarum* and *G. etunicatum*, respectively.

The contents of P, Mg, and S in shoot were influenced by both microbiological treatments and P doses (Table 2). Regardless of phosphate fertilization, plants inoculated with *R. clarum* presented greater contents of P, Mg, and S than the ones in the control treatment, with increments of 19.2, 17.6 and 23.7 percent, respectively. According to P doses, the contents of P ($P = -0.0005x^2 + 0.20x + 1.85$, $R^2 = 0.99^{**}$), Mg ($Mg = -0.0013x^2 + 0.327x + 10.52$, $R^2 = 0.89^{**}$) and S ($S = -0.00061x^2 + 0.1846x + 3.83$, $R^2 = 0.98^{*}$) showed quadratic responses. Freitas et al. (2006) working with *M. arvensis* L., found similar results for P contents.

The greatest value for mycorrhizal dependence was observed in plants inoculated with the fungus *R. clarum* and in the absence of P (Figure 5). As the doses of P were

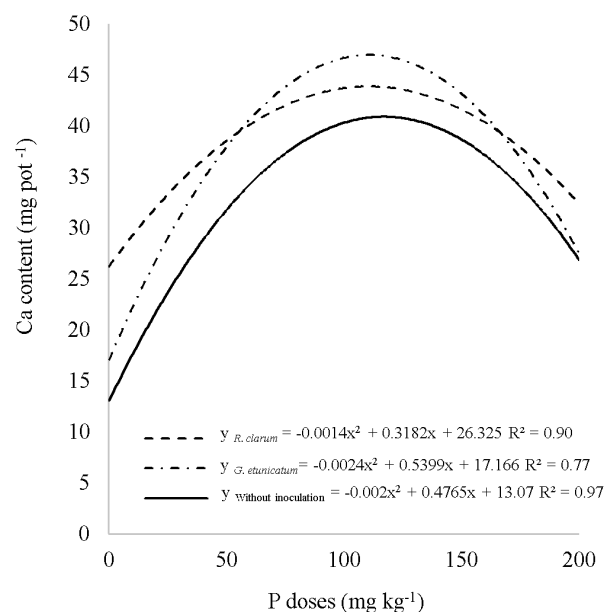


Figure 4. Ca content (mg pot⁻¹) in leaf dry matter of star fruit seedlings in relation to microbiological treatments and P doses

Table 2. Contents of P, Mg, and S in shoot dry matter mass of star fruit tree in relation to microbiological treatments and P doses

Treatment	P	Mg	S
	(mg pot ⁻¹)		
<i>R. clarum</i>	14.6 a	23.4 a	13.5 a
<i>G. etunicatum</i>	12.2 b	22.2 ab	11.2 ab
Without inoculation	11.6 b	19.9 b	10.9 b
CV (%)	14.9	14.1	23.2

The averages followed by the same letter, uppercase letter in the column and lowercase letter in the line, do not differ from each other, based on the Tukey test ($P < 0.05$)

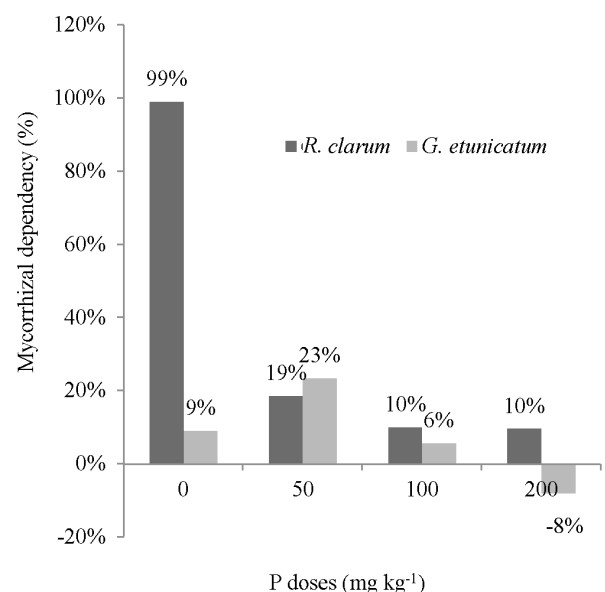


Figure 5. Mycorrhizal dependency of star fruit tree in relation to microbiological treatments and P doses

incremented, mycorrhizal dependency values decreased, while in plants grown with the fungus *G. etunicatum* at 200 P dose the value was negative. This means that the fungus *G. etunicatum* provided a reduction in dry matter production compared with the control treatment at the mentioned P dose. Melloni et al. (2000) working with 'Rangpur' lime, verified a decrease in the

percentage of mycorrhizal dependence with increased doses of P in the substrate, and that the fungus *G. etunicatum* presented negative mycorrhizal dependency values. Freitas et al. (2006) working with *M. arvensis* L., also found similar results.

Conclusions

In the absence of phosphate fertilization, inoculation of star fruit seedlings with *R. clarum* promoted greater increments in dry matter production, height and in the contents of nitrogen, potassium, and calcium.

The contents of phosphorus, magnesium and sulphur were greater in star fruit seedlings inoculated with *R. clarum*, regardless of phosphate fertilization.

Acknowledgments

We are grateful to Prof. Dr. Renato de Mello Prado, UNESP Jaboticabal, for providing the star fruit seeds used in this study and to CNPq and FAPERJ for financial support.

Literature Cited

- Altoé, J.A.; Marinho C.S.; Muniz R. de E.A.; Rodrigues L.A.; Gomes M.M. de A. 'Cleópatra' mandarin submitted to mycorrhization and to a brassinosteroid analogue. *Acta Scientiarum Agronomy*, v.30, n.1, p.13-17, 2008. <http://dx.doi.org/10.4025/actasciagron.v30i1.1114>.
- Anjos, E.C.T. dos; Cavalcante, U.M.T.; Santos, V.F.; Maia, L.C. Production of mycorrhized sweet *Passion fruit* seedlings in disinfected and phosphorus fertilized soil. *Pesquisa Agropecuária Brasileira*, v.40, n.4, p.345-351, 2005. <http://dx.doi.org/10.1590/S0100-204X2005000400005>.
- Bastos, D.C. A cultura da carambola. *Revista Brasileira de Fruticultura*, v.26, n.2, p.1-2, 2004. <http://dx.doi.org/10.1590/S0100-29452004000200001>.
- Bastos, D.C.; Scarpore Filho, J.A.; Fatinansi, J.C.; Pio, R. Influence of biologic age of stock plant and type of star fruit (*Averrhoa carambola* L.) stem cuttings in root adventitious formation. *Ciência e Agrotecnologia*, v.33, n.esp., p.1915-1918, 2009. <http://dx.doi.org/10.1590/S1413-70542009000700037>.
- Bethlenfalvai, G.J.; Brown, M.S.; Pacovsky, R.S. Relationships between host endophyte development in mycorrhizal soybean. *New Phytology*, v.90, n.3, p.537-542, 1982. <https://doi.org/10.1111/j.1469-8137.1982.tb04486.x>.
- Bressan, W.; Siqueira, J.O.; Vasconcellos, C.A.; Purcino, A.A.C. Mycorrhizal fungi and phosphorus on growth, yield and nutrition of intercropped grain sorghum and soybean. *Pesquisa Agropecuária Brasileira*, v.36, n.2, p.250-260, 2001. <http://dx.doi.org/10.1590/S0100-204X2001000200015>.
- Cavalcante, U.M.T.; Maia, L.C.; Costa, C.M.C.; Cavalcante, A.T.; Santos, V.F. Effect of arbuscular mycorrhizal fungi, phosphorus supply, and soil sterilization on growth of yellow *Passion fruit* seedlings. *Revista Brasileira de Ciência do Solo*, v.26, n.4, p.1099-1106, 2002. <http://dx.doi.org/10.1590/S0100-06832002000400028>.
- Cavalcante, U.M.T.; Maia, L.C.; Costa, C.M.C.; Santos, V.F. Mycorrhizal dependency of passion fruit (*Passiflora edulis* f. *flavicarpa*). *Fruits*, v.56, p.317-324, 2001. <http://www.fruits-journal.org/articles/fruits/pdf/2001/05/cavalcante.pdf>. 20 Nov. 2015.
- Freitas, M.S.M.; Martins, M.A.; Carvalho, A.J.C. Growth and mineral composition of mint in response to arbuscular mycorrhizal fungi inoculation and phosphorus fertilization. *Horticultura Brasileira*, v.24, n.1, p.11-16, 2006. <http://dx.doi.org/10.1590/S0102-05362006000100003>.
- Freitas, M.S.M.; Martins, M.A.; Curcino, I.J. Yield and quality of essential oils of *Mentha arvensis* in response to inoculation with arbuscular mycorrhizal fungi. *Pesquisa Agropecuária Brasileira*, v.39, n.9, p.887-894, 2004. <http://dx.doi.org/10.1590/S0100-204X2004000900008>.
- Grace, C.; Stribley, P.A. Safer procedure for routine staining of vesicular-arbuscular mycorrhizal fungi. *Mycological Research*, v.95, n.10, p.1160-1162, 1991. [http://dx.doi.org/10.1016/S0953-7562\(09\)80005-1](http://dx.doi.org/10.1016/S0953-7562(09)80005-1).
- Heitor, L.C.; Freitas, M.S.M.; Brito, V.N.; Carvalho, A.J.C.; Martins, M.A. Crescimento e produção de capítulos florais de calêndula em resposta à inoculação micorrízica e fósforo. *Horticultura Brasileira*, v.34 n.1 p. 26-30, 2016. <https://dx.doi.org/10.1590/S0102-053620160000100004>.
- Jackson, M.L. Soil chemical analysis. New Jersey: Prentice Hall, 1965. 521p.
- Lima, K.B.; Martins, M.A.; Freitas, M.S.M.; Olivares, F.L. Fungos micorrízicos arbusculares, bactérias diazotróficas e adubação fosfatada em mudas de mamoeiro. *Revista Brasileira de Fruticultura*, v.33, n.3, p.932-940, 2011. <https://dx.doi.org/10.1590/S0100-29452011000300029>.
- Malavolta, E. Avaliação do estado nutricional das plantas: princípios e aplicações. 2.ed. Piracicaba: Potafôs, 1997. 319p.
- Melloni, R.; Nogueira, M.A.; Freire, V.F.; Cardoso, E.J.B.N. Phosphorus levels and arbuscular mycorrhizal fungi on growth and mineral nutrition of *Citrus limonia* (L.) Osbeck. *Revista Brasileira de Ciência do Solo*, v.24, n.4, p.767-775, 2000. <http://dx.doi.org/10.1590/S0100-06832000000400009>.
- Moreira, F.M.S.; Siqueira, J.O. Microbiologia e bioquímica do solo. 2.ed. Lavras: Editora UFLA, 2002. 626p.
- Pereira, J.A.P.; Vieira, I.J.C.; Freitas, M.S.M.; Prins, C.L.; Martins, M.A.; Rodrigues, R. Effects of arbuscular mycorrhizal fungi on *Capsicum* spp. *The Journal of Agricultural Science*, v.154, n. 5, p.828-849, 2016. <http://dx.doi.org/10.1017/S0021859615000714>.
- Riter Netto, A.F.; Freitas M.S.M.; Martins, M.A.; Carvalho, A.J.C.; Vitorazi Filho, J.A. Efeito de fungos micorrízicos arbusculares na bioprodução de fenóis totais e no crescimento de *Passiflora alata* Curti. *Revista Brasileira de Plantas Medicinais*, v.16, n.1, p.1-9, 2014. <http://dx.doi.org/10.1590/S1516-05722014000100001>.
- Samarão, S.S.; Martins, M.A. Influência de fungos micorrízicos arbusculares, associada à aplicação de rutina, no crescimento de mudas de goiabeira (*Psidium guajava* L.). *Revista Brasileira de Fruticultura*, v.21, n. 2, p.196-199, 1999.

- Santos, P.C.D.; Lopes, L.C.; Freitas, S.D.J.; Sousa, L.B.D.; Carvalho, A.J.C.D. Initial growth and nutritional content of yellow passion fruit subjected to fertilization with different nitrogen sources. *Revista Brasileira de Fruticultura*, v.33, n. esp., p.722-728, 2011. <http://dx.doi.org/10.1590/S0100-29452011000500101>.
- Sato, A.Y.; Nannetti, D. de C.; Pinto, J.E.B.P.; Siqueira, J.O. Application of arbuscular mycorrhiza to micropropagated heliconia and gerbera plants during acclimatization period. *Horticultura Brasileira*, v.17, n.1, p.25-28, 1999. <http://dx.doi.org/10.1590/S0102-05361999000100007>.
- Sieverding, E. Vesicular-arbuscular mycorrhiza management in tropical agrosystems. Eschborn: Deutsche Gesellschaft fuer Technische Zusammenarbeit GmbH, 1991. 371p.
- Smith, S.E.; Read, D.J. *Mycorrhizal symbiosis*. 2.ed. San Diego: Academic Press, 1997. 605p.
- Soares, A.F.C.; Martins, M.A. Effects of arbuscular mycorrhizal fungi, associated with the addition of phenolic compounds, on the growth of passion fruit plants (*Passiflora edulis* f. *flavicarpa*). *Revista Brasileira de Ciência do Solo*, v.24, n. 4, p.731-740, 2000. <http://sbcs.solos.ufv.br/solos/revistas/v24n4a05.pdf>. 20 Nov. 2015.
- Vitorazi Filho, J.A., Lima, K.B., Freitas, M.S.M., Martins, M. A., Olivares, F.L. Crescimento de mudas de maracujazeiro-doce inoculadas com fungos micorrízicos arbusculares e bactérias diazotróficas sob diferentes doses de fósforo. *Revista Brasileira de Fruticultura*, v.34 n.2, p.442-450, 2012. <https://dx.doi.org/10.1590/S0100-29452012000200017>.
- Weber, O.B.; Souza, C.C.M.; Gondin, D.M.F.; Oliveira, F.N.S.; Crisóstomo, L.A.; Capron, A.L.; Saggin Júnior, O. Inoculation of arbuscular micorrhizal fungi and phosphate fertilization on dwarf cashew seedlings. *Pesquisa Agropecuária Brasileira*, v.39, n.5, p.477-483, 2004. <http://dx.doi.org/10.1590/S0100-204X2004000500010>.