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Host compatibility and fertilization level modulate mycorrhizal establishment and growth of two ornamental shrubs

Running title: Mycorrhizal establishment in two ornamental shrubs

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Summary

We evaluated mycorrhizal responses of two container-grown ornamental shrubs, *Photinia* x *fraseri* and *Lantana camara* cultivated in soilless substrate with two fertilization regimes and inoculated with two mycorrhizal inocula, a commercial one (Symb) and an experimental one (MicroLab). Fertilization rate, inoculum type and plant genotype differentially affected mycorrhizal colonization, plant growth and mineral nutrition. At high fertility levels a significant reduction of mycorrhizal colonization occurred in both shrubs inoculated with Symb, while MicroLab successfully colonized *L. camara* roots. In *P. fraseri* MicroLab increased shoot dry weight at low fertility by 44.3% and 78.6% compared with control and Symb, respectively. In *L. camara* Symb increased plant height and shoot fresh weight at both fertility levels, compared with MicroLab and Control. Our work shows that host plant/mycorrhizal symbionts compatibility and fertilization may modulate the establishment and performance of mycorrhizal symbioses in container-grown woody ornamentals.

Introduction

Beneficial soil microorganisms are key elements of biological soil fertility, being able to modify the availability, uptake and use of soil resources - phosphorus (P), nitrogen (N) and other mineral nutrients - and to supply, directly and indirectly, ecosystem services such as the completion of biogeochemical cycles, soil aggregation and carbon sequestration (PIMENTEL *et al.,* 1997). Among beneficial microbes, arbuscular mycorrhizal fungi (AMF) represent the most important group, living in symbiotic association with the roots of the major agricultural crops, including cereals, legumes, fruit trees, vegetables and ornamentals. AMF obtain photosynthates from the host plants in exchange of mineral nutrients such as P, N, sulfur (S), potassium (K), calcium (Ca), iron (Fe), copper (Cu), and zinc (Zn), which are absorbed and translocated to the root cells by means of large extraradical hyphal networks spreading from colonised roots to the

45 soil (SMITH and READ, 2008). In addition, AMF increase plant tolerance to biotic and abiotic
46 stresses (AZCÓN-AGUILAR and BAREA, 1997; KAPULNIK and KOLTAI, 2009; BOTHE, 2012).
47 Different AMF species and isolates may differentially affect plant performance, depending on
48 their ability to establish a rapid and extensive root colonization, to develop a large extraradical
49 hyphal absorbing network and to protect plants from pathogen attack (AVIO *et al.,* 2006;
50 LEWANDOWSKI *et al.,* 2013). On the other hand, diverse plant species differ in the extent to
51 which they depend on AMF, mycorrhizal dependency varying with plant taxa, soil P content
52 and efficiency of the inoculated AMF strain (KOIDE *et al.,* 2000).
53 The production of hardy ornamental nursery stocks is an important horticultural sector in many
54 countries, such as Italy, The Netherlands and United States (AIPH, 2011). In all countries,
55 container cultivation has been increasingly used in the last 10-15 years in consideration of its
56 advantages, such as fast plant growth, year-round marketing and easy plantation establishment.
57 Water and nutrients are often applied in excess to container nursery crops and this results in
58 water wastage and environmental pollution due to the leaching of fertilizers and plant
59 protection products (INCROCCI *et al.,* 2014). New approaches to irrigation and fertilization
60 management, including plant inoculation with AMF, are needed in order to improve water and
61 nutrient use efficiency and minimize the loss of water and nutrients in nursery production.
62 Woody ornamental plants are generally grown in artificial substrates under high application
63 rates of chemical fertilizers and pesticides, which limit the incidence and beneficial effects of
64 AMF (KOLTAI, 2010). A number of studies showed positive effects of AMF inoculation on
65 growth, flower yield, mineral content and drought tolerance of ornamental plants (LINDERMAN,
66 2003; PINIOR *et al.,* 2005; PERNER *et al.,* 2007; JAVAID and RIAZ 2008; MEIR *et al.,* 2010).
67 Other works reported large variations in symbiotic functioning in container-grown plants,
68 which showed different levels of mycorrhizal colonization at varying fertilization rates (DAVIES
69 *et al.,* 2000; BERRUTI *et al.,* 2013) and altered growth responses after inoculation with diverse

AMF taxa (LOVATO *et al.,* 1995; GAUR and ADHOLEYA, 2005). Some studies reported faster growth in different container-grown woody ornamentals, such as *Viburnum suspensum*, *Podocarpus macrophyllus* and *Pittosporum tobira,* when inoculated with different AMF species (CREWS *et al.,* 1978), even at high fertilization rates (JOHNSON *et al.,* 1980; POPE, 1980; PONDER, 1984).

In the perspective of low-input, sustainable plant production systems, the introduction of efficient mycorrhizal symbionts into the growth media of containerized plants represents a promising environment-friendly bio-fertilization and bio-enhancement strategy, allowing an efficient use of soil nutrients, reducing the need of chemical fertilizers and pesticides, and reducing environmental impact.

In this work, we evaluated mycorrhizal responses of two container-grown ornamental shrubs, *Photinia* x *fraseri* Dress (Rosaceae) and *Lantana camara* L. Calippo Gold® (Verbenaceae), inoculated with two mixed AMF inocula and cultivated under two different fertilization regimes. The two species were selected in consideration of their commercial value, as they are widely used in landscaping (SWARBRICK, 1986; LARRABURU *et al.,* 2007). The specific obiectives of this study were: i) to assess how fertilization rate and inoculum type affect AMF colonization and plant growth performance, ii) to compare the symbiotic performance of a commercial mixed inoculum with an experimental one, containing two highly infective and efficient AMF strains, selected in our laboratories, iii) to select the best combinations among host plant, fungal symbiont and fertilizer level for AMF application in sustainable horticultural production.

Materials and methods

Fungal material

94 Two different mixed AMF inocula were utilised. The first one was a commercial product
95 Symbivit® (MYBATEC srl, Novara) and, according to the label, composed of zeolite,
96 expanded clay and six AMF species belonging to the genus *Glomus* (Symb, hereafter). The
97 second inoculum was composed of a mixture of two AMF isolates, *Funneliformis mosseae*
98 IMA1 (T. H. Nicolson & Gerd.) C. Walker & A. Schüssler (formerly known as *Glomus*
99 *mosseae*) and *Rhizophagus intraradices* IMA6 (N.C. Schenck & G.S. Sm.) C. Walker & A.
100 Schüssler (formerly known as *Glomus intraradices*). These isolates were previously studied
101 and selected for their high symbiotic performance at the laboratory of Microbiology,
102 Department of Agriculture, Food and Environment (DAFE), University of Pisa, Italy
103 (MicroLab, hereafter).
104 Each isolate of MicroLab inoculum was produced in ten 8-L pots filled with a sandy loam soil
105 and calcinated clay (OILDRI, Chicago, IL, USA) (1:1 by volume). Top soil was collected in
106 San Piero (Pisa) and had the following characteristics: pH(H_2O), 8.0; clay, 15.3%; silt, 30.1%;
107 sand, 54.5%; organic matter, 2.2% (Walkley-Black); total N (Kjeldahl), 1.3 g Kg^{-1}; extractable
108 P, 17.6 mg kg^{-1} (Olsen's method); extractable K, 149.6 mg Kg^{-1}. The substrate was steam-
109 sterilized (121° C for 30 min, on two consecutive days) to kill naturally occurring endophytes.
110 *Sonchus asper* L., *Helianthus annuus* L. and *Trifolium alexandrinum* L. were grown as trap
111 plants for four months, then shoots were excised and roots were chopped into 1 cm segments.
112 The substrate, containing mycorrhizal roots, extraradical mycelium, spores and sporocarps, was
113 air-dried at room temperature and utilised as crude inoculum.
114 The ability to establish mycorrhizal symbioses of AMF inocula was tested using *Cichorium*
115 *intybus* L. (cichory) as test plant and MicroLab or Symb inocula at the concentration used in
116 the experiment. Nine replicate tubes were used for each inoculum and maintained in a growth
117 chamber at 27±1°C with 16 h of photoperiod for four weeks. The percentage of mycorrhizal
118 root length of test plants, assessed as described below, was greater than 20% for both inocula.

119

120 **Plant material and experimental condition**

121 The experiment was carried out in a research glasshouse at DAFE from April to July 2012.
122 Uniform rooted cuttings of *P. fraseri* and *L. camara* Calippo Gold® were obtained from a
123 commercial nursery (Vannucci Piante, Pistoia, Italy). Their mycorrhizal status was assessed
124 before transplanting on 10 individuals of each species. Percentages of AMF colonization were
125 assessed under a dissecting microscope with the gridline intersect method (GIOVANNETTI and
126 MOSSE, 1980), after clearing and staining plant roots with Trypan blue in lactic acid (0.05%).
127 Rooted cuttings were transplanted into 16-cm diameter plastic pots filled with approx. 3.3 L of
128 peat-pumice mixture (1:1 v/v). Dolomite (8 g/L) was added to the susbtrate to increase pH to
129 7.0±0.2. Two fertility levels were compared adding: 5 g/L (high fertility, HF) or 1.7 g/L (low
130 fertility, LF) of controlled release fertilizer (Osmocote® Exact Standard 8-9M 15N-9P-11K +
131 2MgO + trace elements; Everris Italia srl, Treviso, Italy). AMF inoculum was added into the
132 transplant hole to ensure a good contact with the roots. The inoculation rate was 330 g (10%
133 w/v) for MicroLab and 49.5 g (1.5% w/v) per pot for Symb, according to the manufacturer's
134 recommended rate. In order to inoculate control plants, a mock inoculum was produced by
135 sterilising the appropriate amount of Symb and MicroLab. All pots received 120 mL of a
136 filtrate, obtained using a mixture of the two AMF inocula, to ensure a common microbiota to
137 all treatments.
138 For each plant species, the experiment consisted of a factorial design (3x2) with three fungal
139 treatments (two AMF inocula and the control), two fertility levels and 12 replicates. In all
140 treatments irrigation was regulated by some commercial irrigation controllers (GP1, Delta-T
141 Devices Ltd, Burwell, Cambridge, United Kingdom) connected to a tensiometer (SWT4,
142 Delta-T Devices). Soil water content remained close to water-container capacity during all the
143 experimental period as the substrate matricial potential ranged from -40 hPa to -10 hPa.

144

145 **Measurements**

146 Four months after transplant, three separate plants were sampled from each treatment to
147 determine the following parameters: plant height, number of inflorescences (in *L. camara*),
148 fresh (FW) and dry weight (DW) of roots and shoots. Roots were carefully washed under
149 running water to remove the substrate. Dry weights (DWs) were measured after drying the
150 samples at 80°C in a ventilated oven until constant weight. Root DW was determined on a
151 subsample consisting of half of each fresh root system. The second half of the root system
152 was used to determine the level of mycorrhizal colonization. Root samples were cleared and
153 stained as described above. Leaf nutrient content was assessed in triplicate in oven-dried
154 samples. Tissues were ground to powder and digested in a mixture of sulphuric/perchloric
155 acid. Potassium, calcium and magnesium concentrations were quantified by atomic absorption
156 spectrophotometry (Varian Model Spectra-AA240 FS, Australia). Phosphorus content was
157 measured colorimetrically using molybdenum blue method (OLSEN and SOMMERS, 1982). The
158 reduced nitrogen content was determined by the micro-Kjeldahl method (AOAC, 1999) while
159 nitrate concentration was measured colorimetrically using the salicylic-sulphuric acid method
160 (CATALDO *et al.,* 1975).

161

162 **Statistical analysis**

163 ANOVA of plant growth parameters and mycorrhizal colonization data were performed on
164 SPSS 19.0 software (IBM Corp., Armon, NY Inc, USA) and differences between means were
165 determined using the Tukey procedure. Percentage colonization data were arcsine-
166 transformed before analysis.

167

168 **Results**

169 **Mycorrhizal colonization of *Photinia x fraseri* and *Lantana camara***

170 At transplant, the rooted cuttings of *P. fraseri* and *L. camara* showed no colonization.

171 At the end of the experiment (four months after inoculation) AMF symbioses were detected in

172 all inoculated plants at both fertility levels. The absence of AMF colonization in uninoculated

173 controls demonstrated that cross-contamination was successfully prevented.

174 Root colonization of *P. fraseri* was significantly influenced by both fertilization rate ($P<0.001$)

175 and inoculum type ($P<0.001$). At HF rate, *P. fraseri* inoculated with either Symb or MicroLab

176 showed a significant ($P<0.001$) and consistent reduction of mycorrhizal root length, compared

177 with colonization at LF rate, from 4.3 to 0.3% and from 33.4 to 8.9%, respectively (Fig. 1a).

178 Such data show the high compatibility of MicroLab with *P. fraseri*, as colonization level of

179 MicroLab-inoculated *P. fraseri* was approximately 7 and 29 times greater than Symb-

180 inoculated plants at LF and HF rates, respectively (Fig. 1a). When inoculated with Symb,

181 colonization of *P. fraseri* roots occurred only in a few points of the root system. By contrast,

182 MicroLab-inoculated plants contained a high amount of fungal structures, arbuscules and

183 vesicles.

184 The behaviour of *L. camara* proved dissimilar with a significant interaction ($P = 0.014$)

185 between fertility levels and AMF treatments. Interestingly, MicroLab inoculum was not

186 affected by the fertilization rate when applied to *L. camara* plants; in this species mycorrhizal

187 root length ranged from 42.7% ± 9.8 to 46% ± 1.96 at high and LF levels (Fig. 1b). By

188 contrast, Symb inoculum was affected by fertilization rates as root colonization percentage

189 was 4.8% ± 2.1 and 33.3% ± 5.7 at HF and LF, respectively (Fig. 1b). Arbuscules were well

190 developed in cortex cells of all colonized plants of *L. camara*.

191

192 ***P. fraseri* growth responses to AMF inoculation and fertilization rate**

193 In *P. fraseri,* all growth parameters except root DW were lower at LF than at HF, irrespective
194 of the inoculum treatment. At HF, MicroLab and control treatments yielded the highest values
195 for all growth parameters, compared with Symb inoculum, which decreased plant height and
196 root dry weight by 32.8%, and 29.4%, respectively (Table 1). At LF, MicroLab increased
197 shoot FW (63.6± 4.7 g plant^{-1}) by 42.6% and 64.3% with respect to the controls and Symb-
198 inoculated plants, respectively. The positive effect of MicroLab inoculation at LF was also
199 observed for shoot DW, which increased by 44.3% and 78.6% compared with the controls
200 and Symb inoculated plants (Table 1). In *P. fraseri*, leaf N concentration was higher in
201 inoculated than non-inoculated plants at both fertility levels. In particular, compared with
202 control MicroLab and Symb applications increased N leaf concentration, respectively, by 12.7
203 and 8.1% at HF, and by 7.6 and 12.4% at LF. Fertilization rate and AMF inoculation affected
204 leaf nitrate concentration, as HF provided the highest nitrate concentration and Symb
205 inoculation yielded an enhanced nitrate concentration compared with MicroLab and control
206 treatments. Leaf Mg concentration was marginally affected by inoculum treatment, while no
207 statistically significant differences were recorded for K and Ca (Table 2). A significant
208 interaction was detected for leaf P concentration, which was affected by inoculation only at
209 HF, where Symb treatment enhanced P content by 29.5%, compared with MicroLab and
210 control treatments. At LF, no statistical differences were found among the inoculation
211 treatments (Table 2).
212
213 ***L. camara* growth responses to AMF inoculation and fertilization rate**
214 In *L. camara,* all growth parameters except root DW were lower at LF than at HF regardless
215 of the inoculum treatment (Table 3). Interestingly, the performance of Symb inoculum proved
216 dissimilar in this species compared with *P. fraseri.* In particular, Symb applications increased
217 plant height by 14.2 and 12.9% at HF, and by 17.9 and 14.8% at LF, compared with

MicroLab and Control, respectively. Likewise, shoot FW increased by 14.7 and 38.8% at HF, and by 74.7 and 95.2% at LF, compared with MicroLab and Control, respectively.

The number of inflorescences was markedly affected by fertilization levels in control and MicroLab treatments, which showed the highest values at HF, with increases of 128% and 89%, respectively, compared with LF (Table 3). A significant interaction between AMF inoculum and substrate fertility was found for shoot DW: HF increased shoot DW by 26%, 141 and 162% for Symb, MicroLab and the control, respectively (Table 3).

In *L.camara,* leaf concentration of N, N-NO_3, P and Mg significantly depended on AMF inoculation. In particular, the application of Symb inoculum yielded the highest N-NO_3 concentration, with average nitrate increases of 178% and 218% at HF and LF, respectively (Table 4). A significant interaction was detected for leaf N concentration, which was affected by AMF inoculation only at HF, where Symb treatment enhanced N content by 35.6%, compared with MicroLab and control treatments. At LF, no statistical differences were found among the inoculation treatments. Neither the type of inoculum nor the fertilization regime affected significantly leaf content of both Ca and K, while Mg was influenced significantly only by the fertilization (Table 4).

Discussion

To the best of our knowledge, this is the first study evaluating the effect of AMF inoculation on growth and mycorrhizal development of two woody ornamentals, *P. fraseri* and *L. camara*, under standard or reduced fertilization regime. This work demonstrates that i) fertilization and inoculum type differentially affects AMF colonization and plant growth performance, also in dependence of fertilization rate, *ii*) the level of host plant/AMF symbionts compatibility may modulate the establishment of a well-balanced symbiotic relationship and plant growth responses.

243 The establishment of a functional mycorrhizal symbiosis is critical to the success of many
244 horticultural woody species, as AMF influence root functioning, water relations and soil
245 nutrients uptake (BUSQUETS *et al.,* 2010; KOLTAI *et al.,* 2010). Here, the commercial inoculum
246 Symb and the experimental one MicroLab differed in their ability to colonize the roots of the
247 two ornamental shrubs under investigation. Indeed a significant reduction of mycorrhizal root
248 colonization occurred in both species at the highest fertility level when inoculated with Symb,
249 while MicroLab successfully colonized *L. camara* roots under both fertilization regime. High
250 concentrations of plant available nutrients, P in particular, have been widely reported to
251 suppress AMF establishment (SMITH and READ, 2008), depending on plant species and
252 inoculum type (BALZERGUE *et al.,* 2013). In contrast, the successful colonization of *L. camara*
253 roots by Microlab suggests the ability of the AMF isolates *R. intraradices* IMA6 and *F.*
254 *mosseae* IMA1 to tolerate high fertilization levels. Inoculum composition and species identity
255 may have played a role in the modulation of mycorrhizal symbiosis establishment with the two
256 host species, as previously reported in a study comparing different nonspecific commercial
257 AMF inocula (BERRUTI *et al.,* 2013).
258 Our data clearly show that the host plant genotype was the main factor determining AMF root
259 colonization, as Symb did not reach a mycorrhizal root length higher than 5 % in *P. fraseri*
260 even at low fertility level, while it reached 33.3% in *L. camara*. Host compatibility, *i.e*. the
261 ability of a particular AMF isolate to establish a rapid and extensive mycorrhizal symbiosis
262 with a specific host plant, is modulated not only by fungal genotypes controlling spore
263 germination, germling growth and infection structures (appressoria), but also by host plant
264 factors, mainly affecting fungal growth and appressorium development on the root surface and
265 intraradical growth (GIOVANNETTI and AVIO, 2002). Nevertheless, host compatibility has not
266 been as widely investigated as functional compatibility, *i.e*. the reciprocal exchange of
267 nutrients, considered the key factor of symbiotic efficiency (GIANINAZZI-PEARSON, 1984;

268 RAVNSKOV and JAKOBSEN, 1995). Actually, the success of a given inoculum in terms of root
269 colonization is not predictable (TARBELL and KOSKE, 2007) since it largely depends on plant
270 genotype, as showed by results obtained on a number of different ornamental species grown in
271 container, where mycorrhizal root length ranged from 18% to 70% (PÜSCHEL *et al.,* 2014) or
272 from 0.4% to 20% (CARPIO *et al.,* 2003).
273 Enhanced uptake of mineral nutrients and improved plant growth are generally regarded as the
274 most important benefits provided by AMF to their host plants (SMITH and READ, 2008). Here,
275 growth responses and mineral leaf contents of *P. fraseri* and *L. camara*, depended on the
276 identity of the inoculum as well as on the fertilization rate. In *P. fraseri*, the higher mycorrhizal
277 colonization obtained with MicroLab corresponded to increased plant height and biomass
278 production, in particular at low fertilization rate, compared with control and Symb inoculated
279 plants. Our results are in contrast with those obtained by DAVIES *et al.* (2000) on *P. fraseri*,
280 where AMF application resulted in lower root colonization, with no effects on vegetative
281 growth. Increased plant height and shoot FW were obtained in *L. camara* when inoculated with
282 Symb at both fertility levels. Interestingly, *L. camara* root FW and DW were negatively
283 affected by Symb at high fertility rate, confirming previous results on the ability of AMF to
284 modify root architecture and length and suggesting a complex interaction among plant, fungus
285 and fertility levels (BERTA *et al.,* 1995). In contrast, AMF enhance soil uptake of several
286 nutrients, including P and N, by means of an extensive extraradical hyphal network spreading
287 from colonized roots to the surrounding environment (AVIO *et al.,* 2006). In this work, AMF
288 inoculation and/or fertilization rates significantly affected N, N-NO_3, P and Mg leaf
289 concentration in *P. fraseri* and in *L. camara*, while no effects were detected regarding K and
290 Ca, in agreement with previous data on the shrub *Ipomea carnea* grown under different
291 fertilization regimes (CARPIO *et al.,* 2009).

In conclusion, our work shows that the complex interactions among plants, soil and AMF require the selection the best combinations among host plant, fungal symbiont and fertilizer level in order to efficiently introduce AMF inoculation in the production of woody ornamentals. Indeed, mycorrhizal inoculation cannot be regarded as a production factor like a chemical fertilizer, since AMF isolates differ in their growth-promoting abilities under different climatic and edaphic conditions, while host plants vary in the level of mycotrophy *i.e*. the dependence from mycorrhizal establishment for a good growth performance. Further studies are needed to reveal how different AMF isolates, agronomic practices and inoculation protocols modulate the establishment and performance of the symbiosis in soilless cultivation of woody ornamentals in order to select the most effective inocula to be utilised for sustainable commercial nursery production.

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Table 1. Effects of arbuscular mycorrhizal inoculum and fertilization rate on some growth parameters of container-grown *Photinia* x *fraseri* as determined four months after transplants.

Inoculum type	Height (cm)	Shoot FW (g plant^{-1})	Shoot DW (g plant^{-1})	Root FW (g plant^{-1})	Root DW (g plant^{-1})
High fertility rate					
Control	62.9±2.03 [y]b	84.9±8.36 b	28.4±3.30 b	12.8±0.83 b	1.7±0.09 b
MicroLab	65.1±3.78 c	92.2±8.65 b	29.7±3.04 b	13.0±1.18 b	1.7±0.05 b
Symb	43.0±3.57 a	44.8±4.03 a	14.2±1.19 a	9.1±0.71 a	1.2±0.19 a
Low fertility rate					
Control	50.9 ±3.78 b	44.6±1.58 a	15.1±1.01 b	8.0±0.79 b	1.4±0.15 b
MicroLab	59.7±4.11 c	63.6±4.73 b	21.8±1.31 c	10.3±0.61 b	1.8±0.14 b
Symb	41.1±2.75 a	38.7±2.12 a	12.2±0.40 a	6.2±0.52 a	1.1±0.15 a
Significance					
AMF	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Fertility	0.025	< 0.001	< 0.001	< 0.001	0.316
AMF*Fertility	0.328	0.013	0.041	0.374	0.375

[y]Values are means ± SE of six replicate pots for each treatment. When interactions are not significant, different letters within columns indicate statistically different pooled values at both fertility rates among inoculum treatments. When interactions are significant, letters indicate statistically different values within inoculum treatments at each fertility rate.

Table 2. Effects of arbuscular mycorrhizal inoculum and fertilization rate on leaf nutrient concentration of container-grown *Photinia* x *fraseri* as determined four months after transplants.

Inoculum type	N (g kg^{-1})	N-NO_3 (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})
High fertility rate						
Control	17.3±0.43[y]a	2.3±0.24 a	7.8±0.44 a	14.0±0.39 a	12.7±0.94 a	3.0±0.08 b
MicroLab	19.5±0.74 b	2.7±0.08 b	7.8±0.74 a	15.2±2.44 a	11.1±0.35 a	2.8±0.13 ab
Symb	18.7±0.36 b	5.3±0.04 c	10.1±0.19 b	17.0±1.20 a	12.3±0.78 a	2.6±0.11 a
Low fertility rate						
Control	14.5±0.20 a	1.6±0.05 a	5.9±0.20 a	14.1±0.13 a	12.1±0.72 a	2.9±0.12 b
MicroLab	15.6±0.38 b	2.0±0.16 b	5.5±0.38 a	13.6±0.60 a	12.3±0.23 a	2.9±0.08 ab
Symb	16.3±0.46 b	4.1±0.09 c	5.6±0.21 a	14.9±1.76 a	11.5±0.78 a	2.7±0.04 a
Significance						
AMF	0.005	< 0.001	0.027	0.342	0.613	0.040
Fertility	< 0.001	< 0.001	< 0.001	0.312	0.935	0.526
AMF* Fertility	0.296	0.098	0.018	0.685	0.300	0.667

[y]Values are means ± SE of three replicate pots for each treatment. When interactions are not significant, different letters within columns indicate statistically different pooled values at both fertility rates among inoculum treatments. When interactions are significant, letters indicate statistically different values within inoculum treatments at each fertility rate.

Table 3. Effects of arbuscular mycorrhizal inoculum and fertilization rate on some growth parameters of container-grown *Lantana camara* as determined four months after transplants.

Inoculum type	Height (cm)	Number of inflorescences	Shoot FW (g plant^{-1})	Shoot DW (g plant^{-1})	Root FW (g plant^{-1})	Root DW (g plant^{-1})
High fertility rate						
Control	44.8±0.56[y]a	19.0±1.86 b	134.0±5.96 a	29.7±1.52 a	32.9±1.63 b	3.83±0.27 c
MicroLab	44.3±1.89 a	15.7±1.88 b	162.1±15.92 a	36.5±1.96 a	44.7±3.18 c	5.14±0.32 b
Symb	50.6±2.14 b	8.3±0.86 a	186.0±21.94 b	27.0±4.16 a	19.0±2.49 a	1.20±0.29 a
Low fertility rate						
Control	37.7±1.31 a	9.7±0.62 a	56.3±3.95 a	12.3±0.66 a	17.5±1.84 a	2.15±0.29 a
MicroLab	36.7±1.57 a	8.1±0.67 a	62.9±4.42 a	13.9±0.87 a	19.3±1.40 a	2.39±0.15 a
Symb	43.3±0.99 b	7.6±0.57 a	109.9±5.22 b	19.9±1.01 b	36.7±3.59 b	3.9±0.40 b
Significance						
AMF	< 0.001	< 0.001	< 0.001	0.302	0.021	0.001
Fertility	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.017
AMF* Fertility	0.983	0.004	0.498	0.024	< 0.001	< 0.001

[y]Values are means ± SE of six replicate pots for each treatment. When interactions are not significant, different letters within columns indicate statistically different pooled values at both fertility rates among inoculum treatments. When interactions are significant, letters indicate statistically different values within inoculum treatments at each fertility rate.

Table 4. Effects of arbuscular mycorrhizal inoculum and fertilization rate on leaf nutrient concentration of container-grown *Lantana camara* as determined four months after transplants.

Inoculum type	N (g kg^{-1})	N-NO_3 (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})
High fertility rate						
Control	24.7±0.25[y]a	2.4±0.14 a	7.2±0.34a	20.1±2.28 a	25.0±0.66 a	8.6±0.23 b
MicroLab	26.0±1.49 a	2.3±0.09 a	7.5±0.51 ab	20.9±2.16 a	29.7±2.80 a	8.7±0.48 b
Symb	34.3±1.19 b	6.6±0.85 b	9.1±0.28 b	26.4±4.77 a	29.4±4.73 a	7.3±0.70 a
Low fertility rate						
Control	23.1±0.09 b	1.7±0.06 a	7.4±0.32 a	18.9±0.53 a	23.0±1.01 a	6.7±0.25 b
MicroLab	22.1±1.22 ab	2.0±0.02 a	8.5±0.44 ab	23.5±1.44 a	26.9±2.40 a	7.6±0.25 b
Symb	21.0±0.24 a	5.9±0.46 b	8.1±0.30 b	21.5±2.13 a	30.9±2.77 a	6.6±0.29 a
Significance						
AMF	0.003	< 0.001	0.017	0.216	0.109	0.037
Fertility	< 0.001	0.126	0.723	0.562	0.638	0.003
AMF*Fertility	< 0.001	0.801	0.057	0.315	0.713	0.348

[y]Values are means ± SE of three replicate pots for each treatment. When interactions are not significant, different letters within columns indicate statistically different pooled values at both fertility rates among inoculum treatments. When interactions are significant, letters indicate statistically different values within inoculum treatments at each fertility rate.

Legends

Figure 1 Mycorrhizal colonization of *Photinia x fraseri* (a) and *Lantana camara* (b) inoculated with two different types of mixed arbuscular mycorrhizal inoculum, MicroLab (blank) and Symb (light grey), and cultivated under two fertility levels, 4 months after transplant. Bars represent standard errors.

Figure 2 Growth responses of *Photinia x fraseri* (a) and *Lantana camara* (b) inoculated with two different types of mixed arbuscular mycorrhizal inoculum, MicroLab and Symb, and cultivated at low fertility levels, 75 days after transplant.

Figure 1

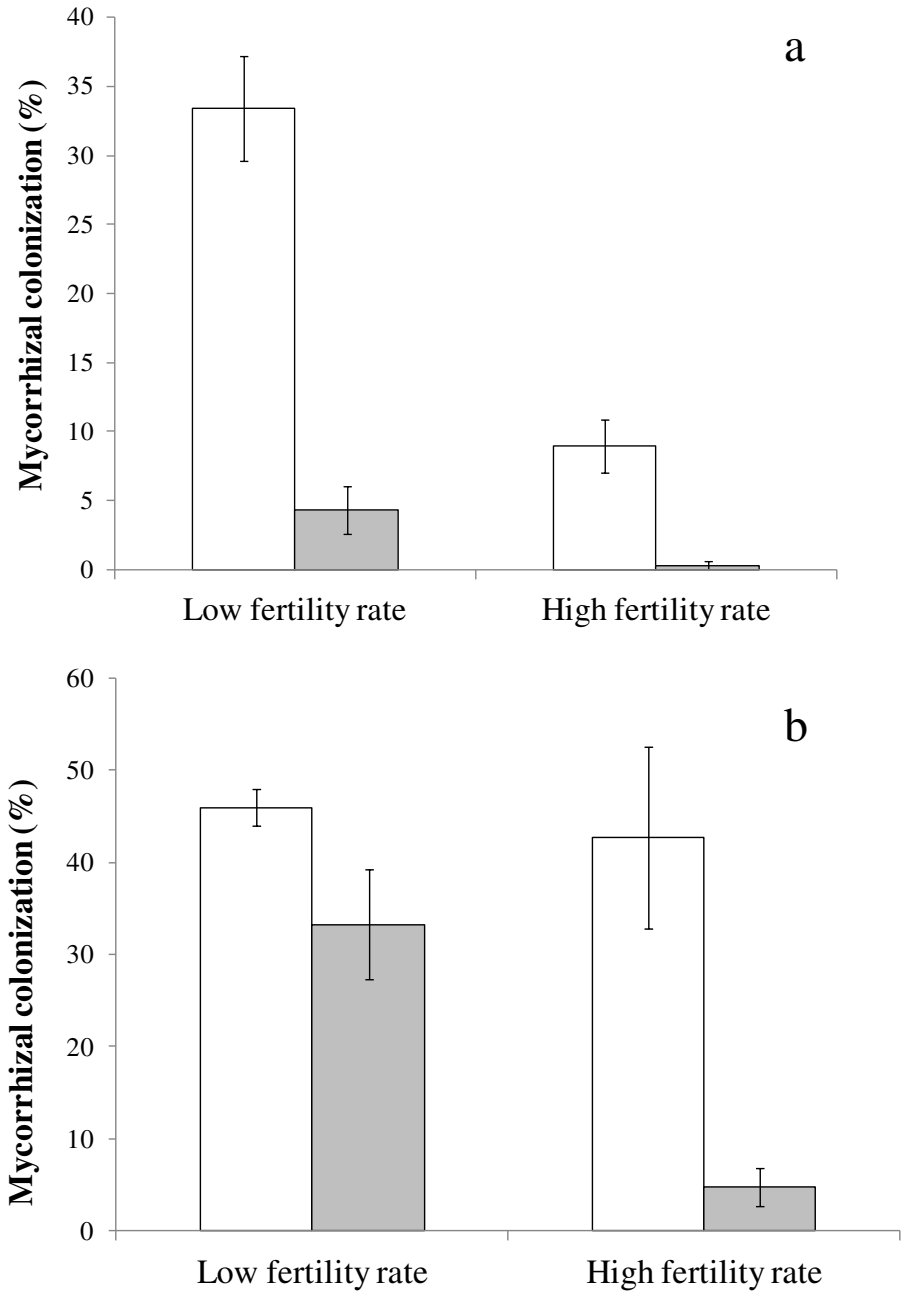
a
Mycorrhizal colonization (%)
40
35
30
25
20
15
10
5
0
Low fertility rate
High fertility rate
b
Mycorrhizal colonization (%)
60
50
40
30
20
10
0
Low fertility rate
High fertility rate

Figure 2