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Bibliographic inventory of the endomycorrhizal species associated with the olive tree (*Olea europaea* L.)

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ABSTRACT

All the endomycorrhizal species associated to the olive tree in the world were listed in this bibliographic inventory. Fifty endomycorrhizal species were isolated from the rhizosphere of the olive tree; the majority of them were encountered in Spain (21 species), followed by Morocco (20 species) and Italy (15 species). The lowest spore's number was encountered in Israel, Greece and Tunisia with 2 species. *Glomus mosseae* was the most common species in the world, actually was cited in eight countries, and followed by *G. intraradices* in seven countries. Six genera of the endomycorrhizal species were detected. The *Glomus* genus was the most dominant represented by 29 species, followed by *Gigaspora* with 7 species. *Acaulospora* and *Scutellospora* with 5 species for each. 1 species for both of *Entrophospora* and *Geosiphon.*

Key words. Endomycorrhizae, olive tree (*Olea europaea* L.), *Glomus, Gigaspora Acaulospora*, *Scutellospora, Entrophospora, Geosiphon.*

INTRODUCTION

The cultivated olive (*Olea europaea* L.) is a tree that can live for thousands of years. It easily adapts to poor stony soils even in dry lands. With roots that can dive deep, the olive finds the needed elements for its growth (Argenson *et al*., 1999).

In natural systems, a lack of nutrients often limits plant growth. Therefore plants supplement their nutrient requirements by mycorrhizae (Ortas, 2002). This symbiotic association, formed by a fungus and plant roots, affects 95% of the known plants (Selosse *et al*., 2002). Better fed, a mycorrhized plant grows more, fructifies abundantly and, above all, acquires improved resistance to environmental stresses such as drought (Fusconi and Berta, 2012), cold (Zhu *et al.*, 2010) and root pathogens (Akhtar *et al.*, 2008). These mycorrhizae are hence an integral part of the root system (Gianinazzi *et al*., 1983).

Among the types of mycorrhizae observed in nature, there is one that is found on the vast majority of cultivated plants, it is the arbuscular mycorrhizal (AM). These are symbiotic

associations observed in 200 botanical families representing 1,000 genera and about 300,000 plant species (Bhagyaraj, 1991) including angiosperms, gymnosperms, pteridophytes, and some bryophytes with a limited range of fungi belonging to a single order, that of Glomeromycota (Schüßler and Walker, 2011).

Apart from the influence of AMF on nutrient up-take, other positive aspects of mycorrhization include raise of plant growth (Pasqualini *et al*., 2007; Dag *et al*., 2009; Sheng *et al*., 2009; Shokri and Maadi, 2009), increase of the rate of photosynthesis and transpiration, greater stomatal conductance (Caravaca *et al*., 2003; Wu and Zou, 2010), enhancement of nursery and post-trans planted response and decrease of transplanting stress (Carretero *et al*., 2009; Dag *et al*., 2009), increase of plant tolerance to drought (Marulanda *et al*., 2007), salt stress (Sheng *et al.*, 2009) and serpentine edaphic stress (Doubkova *et al*., 2012), as well as protection from nematodes attack (Castillo *et al*., 2006), improvement of water use efficiency (Bolandnazar *et al*., 2007) and amelioration of fruit quality (Nzanza *et al*., 2012).

Olive plants are a particularly mycotrophic plants (Roldan-Fajardo and Barea, 1986), it has been shown that mycorrhizal fungi reduce the stress suffered by olive plantlets at transplant and that they increase their resistance to disease, improve their water relations and nutrient uptake, increase their rate of photosynthesis, and generally improve their vigour aspects of great importance in plant propagation systems (Davies *et al.*, 2000). In addition, these fungi can change the morphology of the root system, favoring the establishment of young plants (Citernesi *et al.*, 1998 and Junaid Alam, 2014).

In this study, we have inventoried all the endomycorrhizal species encountered in the rhizosphere of the olive tree.

RESULTS AND DISCUSSION

Catalog of the olive tree endomycorrhizal species:

Acaulospora denticulate: Italy (Mira, 2009). Brazil (Vieira *et al*., 2011).
Acaulospora laevis : Italy (Ganz *et al.*, 2002).
Acaulospora mellea : Morocco (Chliyeh *et al.*, 2014).
Acaulospora scrobiculata : Italy (Mira, 2009). Brazil (Vieira *et al*., 2011; Dos Reis Ferreira, 2014).
Acaulospora sp. ; Morocco (Kachkouch *et al.*, 2012; Chliyeh *et al.*, 2014). Algeria (Sidhoum and Fortas, 2013).
Entrophospora kentinensis : Morocco (Kachkoulch *et al.*, 2012; Chliyeh *et al.*, 2014).
Geosiphon pyriforme : Spain (Calvente *et al.*, 2004)
Gigaspora albida : Morocco (Chliyeh *et al.*, 2014).
Gigaspora decipiens: Italy (Mira, 2009).
Gigaspora gigantea: Italy (Mira, 2009).
Gigaspora margarita: Italy (Mira, 2009).
Gigaspora rosea : Italy (Mira, 2009). Brazil (Dos Reis Ferreira, 2014).
Gigaspora sp.: Morocco (Kachkouch *et al*., 2012; Chliyeh *et al.*, 2014c). Greece (Chatzistathis *et al*., 2013).
Gigasporum margarita: Spain (Rapparini and Rotondi, 2006).
Glomus brasillianum : Spain (Calvente *et al.*, 2004 ; Rapparini and Rotondi, 2006).
Glomus caledonium : Spain (Calvente *et al.*, 2004 ; Porras-Soriano *et al.*, 2006). Jordan (Jamil Mohammad *et al*., 2003).
Glomus claroideum : Spain (Porras Soriano *et al.*, 2002; Porras Piedra *et al*., 2005; Caravaca *et al.*, 2005; Soriano *et al.*, 2006 ; Porras-Soriano *et al.*, 2009);
Glomus clarum : Spain (Calvente *et al.*, 2004 ; Rapparini and Rotondi, 2006) ; Morocco (Kachkouch *et al.*, 2012). Jordan (Jamil Mohammad *et al*., 2003). Brazil (Dos Reis Ferreira, 2014).
Glomus constrictum : Spain (Azcón-Aguilar *et al*., 2003).
Glomus deserticola : Spain (Azcón-Aguilar *et al*., 2003 ; Rapparini and Rotondi, 2006).
Glomus diaphanum : Morocco (Chliyeh *et al.*, 2014).

Table 1. Number of the endomycorrhizal species isolated from the rhizosphere of the olive tree around the world.

	Italy	Spain	Morocco	Brazil	Israel	Greece	Tunisia	Jordan	Algeria
Species	15	21	20	8	2	2	2	4	7

Glomus etunicatum: Spain (Calvente *et al.*, 2004 ; Rapparini and Rotondi, 2006) ; Morocco (Kachkouch *et al.*, 2012 ; Chliyeh *et al.*, 2014). Brazil (Dos Reis Ferreira, 2014).
Glomus fasciculatum : Spain (Calvente *et al.*, 2004 ; Troncoso de Arce *et al*., 2005)
Glomus geosporum : Morocco (Chliyeh *et al.*, 2014). Spain (Rapparini and Rotondi, 2006).
Glomus glomerulatum : Morocco (Chliyeh *et al.*, 2014).
Glomus intraradices : Spain (Caravaca *et al*., 2002, 2003; Marìn-Zamora *et al*., 2002 ; Porras Soriano *et al.*, 2002; Estaún *et al*., 2003; Calvente *et al.*, 2004 ; Porras Piedra *et al*., 2005; Castillo *et al*., 2006 ; Soriano *et al.*, 2006 ; Rapparini and Rotondi, 2006 ; Troncoso *et al.*, 2008 ; Porras-Soriano *et al.*, 2009 ; Cantos *et al*., 2009). Algeria (Meddad-Hamza *et al*., 2010). Israel (Dag *et al*., 2009 ; Kapulnik *et al*., 2010). Morocco (Chliyeh *et al.*, 2014). Italy (Mira, 2009; Tataranni *et al.*, 2010; Landi *et al*., 2010). Tunisia (khabou *et al*., 2010 ; Mechri *et al.*, 2014b). Argentina (Bompadre *et al*., 2013 ; 2014).
Glomus invermaium : Italy (Ganz *et al.*, 2002).
Glomus lamellosum : Spain (Calvente *et al.*, 2004)
Glomus luteum: Spain (Calvente *et al.*, 2004).
Glomus Macrocarpum: Algeria (Sidhoum and Fortas, 2013). Egypt (El-Deeb, 2000).
Glomus manihotis : Morocco (Chliyeh *et al.*, 2014). Spain (Calvente *et al.*, 2004).
Glomus monosporum : Jordan (Jamil Mohammad *et al*., 2003).
Glomus mosseae: Spain (Rinaldelli and Mancuso 1996; 1998 ; Marìn-Zamora *et al*., 2002 ; Porras Soriano *et al.*, 2002 ; Estaún *et al*., 2003 ; Calvente *et al.*, 2004 ; Porras Piedra *et al*., 2005 ; Castillo *et al*., 2006 ; Rapparini and Rotondi, 2006; Soriano *et al.*, 2006; Porras-Soriano *et al.*, 2009 ; Algeria (Meddad-Hamza *et al*., 2010). France (Binet *et al.*, 2007). Jordan (Karajeh and Al-Raddad, 1999 ; Jamil Mohammad *et al*., 2003) ; Israel (Dag *et al*., 2009 ; Kapulnik *et al*., 2010). Italy (Citernesi and Vitagliano, 1996 ; Citernesi *et al.*, 1998 ; Vitaglianoand Citernesi, 1999 ; Landi *et al*., 2010). Egypt (El-Deeb, 2000). Brazil (Vieira *et al*., 2011).
Glomus multicaulis : Algeria (Sidhoum and Fortas, 2013).
Glomus occultum : Spain (Calvente *et al.*, 2004)
Glomus pansihalos: Morocco (Chliyeh *et al.*, 2014c).
Glomus proliferum: Spain (Calvente *et al.*, 2004)
Glomus sinuosum: Spain (Calvente *et al.*, 2004)
Glomus sp. : Morocco (Chliyeh *et al.*, 2014c); Algeria (Sidhoum and Fortas, 2013). Greece (Chatzistathis *et al*., 2013). Italy (Briccoli Bati *et al.*, 2003). Tunisia (Mechri *et al.*, 2014a).
Glomus tenue : Italy (Mira, 2009).
Glomus trimurales: Morocco (Chliyeh *et al.*, 2014).
*Glomus versiform*e: Morocco (Kachkouch *et al.*, 2012).
Glomus viscosum: Spain (Calvente *et al.*, 2004; Rapparini and Rotondi, 2006; Landi *et al*., 2010). Italy (Briccoli Bati and Godino, 2002).
Glomus fasciculatum: Morocco (Chliyeh *et al.*, 2014c). Spain (Rapparini and Rotondi, 2006).
Scutellospora calospora: Italy (Ganz *et al.*, 2002).
Scutellospora fulgida: Morocco (Chliyeh *et al.*, 2014c).
Scutellospora heterogama: Morocco (Chliyeh *et al.*, 2014c). Brazil (Dos Reis Ferreira, 2014).
Scutellospora nigra: Morocco (Chliyeh *et al.*, 2014c).
Scutellospora sp.: Morocco (Chliyeh *et al.*, 2014c). Algeria (Sidhoum and Fortas, 2013). Italy (Mira, 2009).
Scutellospora pellucida: Brazil (Vieira *et al*., 2011).

Based on this list, fifty endomycorrhizal species were isolated from the rhizosphere of the olive tree, belonging to six genera. The *Glomus* genus was the most dominant represented by 29 species, followed by *Gigaspora* with 7 species.

Acaulospora and *Scutellospora* with 5 species for each. 1 species for both of *Entrophospora* and *Geosiphon.*

Based on data in the table 1, the majority of the endomycorrhizal species associated to the olive tree were encountered in Spain (21 species), followed by Morocco (20 species) and Italy (15 species). The lowest spore's number was encountered in Israel, Greece and Tunisia with 2 species. *Glomus mosseae* was the most common species in the world, actually was cited in eight countries, and followed by *G. intraradices* in seven countries. Different endomycorrhizal species belonging to different genera were not identified.

CONCLUSION

Several studies and works should be done and realized to develop the use of the endomycorrhizal species because of their benefic effects to the plants, especially to the olive tree.

Table 1. Number of the endomycorrhizal species isolated from the rhizosphere of the olive tree around the world.

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