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Bibliographic inventory of endomycorrhizal species associated to the rhizosphere of the date palm (*Phoenix dactylifera*)

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ABSTRACT: The work presented here aims to establish, from the bibliography, inventory of endomycorrhizal species reported in the rhizosphere of the date palm. 89 fungal species have been reported across the world (Egypt, Oman Soltanat, Soutern Arabia, India, London, and the Arabian Peninsula). Morocco is represented by 29 species, reported in the regions of Tafilalet and Zagoura. The *Glomus* genus was the most represented, with 34 species followed by *Scutellospora* with 21 species and species of the genus *Acaulospora,* with 11 species. It then comes the genus of *Entrophospora* (5 species), *Gigaspora* (4 species) and *Diversispora* (3 species). The *Rhizophagus* genera are each represented by two species. By cons, a single species has been cited for each *Sclerocystis, Septoglomus, Paraglomus, Ambispora, Funneliformis, Claroideglomus and Archaeospora* genera.

KEYWORDS: *Phoenix dactylifera,* rhizosphere, endomycorrhizae, inventory, bibliography.

1 INTRODUCTION

The date palm (*Phoenix dactylifera* L.), monocotyledon, is widely adapted to arid climates zones in the Middle East and North African[1]. these areas, the palm trees are an important part of the Saharan oasis protect the environment because vegetation against the effects of desertification and creates a microclimate essential for the proper development of the underlying cultures[2,3,4].

However, many constraints, climatic deteriorations especially with the emphasis of the drought and its effects on water availability, themselves founders of the oasis, soil salinity and fungal diseases such as fusarium, influence the performance of the palm trees[5].

Palm groves that have demonstrated throughout history an amazing resilience and adaptation are currently more fragile. During the last decade, biotic and abiotic stresses and problems related to the management of oasis soils have increased the destruction of palm groves and the reduction of agricultural production in these environments[6]. These threats and hazards necessitate nursery production of good quality seedlings among others by the use of controlled mycorrhization.

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In fact, mycorrhizae play an important role in the maintenance of plants in their habitats and their natural regeneration[7]. Described for the first time by Frank[8], they refer, as their name suggests, to existing associations between soil fungi and plant roots. Only for half a century that the importance, significance and universality of these associations have been identified. Currently, it is estimated that 90% of land plants are mycorrhizal[9,10]. Several studies have shown that mycorrhizae play an important role in plant species[11], mainly in the growth[12], mineral nutrition, especially phosphorus[13,14], water supply, the resistance of plants to drought and disease[15] and nutrient accumulation[16,17] and survival after transplantation.

Endomycorrhizae colonize the roots of young date palm seedlings and protect them against *Fusarium oxysporum* f. sp. *Albedinis*[18,19]. They also simulate plant growth, in particular at the level of nutrient-poor soils and improve establishment and survival[20,21,22], the distribution of certain fungal species AM depends on soil type, species of the host and some specific combinations plant-soil[23].

Better still, the diversity and distribution of the resulting CMA temporary ecological processes acting on plant and fungal communities such as the temperature, pH and the level of soil P and the genotype of plants. These are factors that limit the distribution of CMA species such as *Glomus* sp. And *Acaulospora leavis*[24]. The CMA may also be influenced by the chemical and physical changes in factors such as soil type, cropping practices and other environmental factors such as soil moisture[25].

The short-term objective of this study is to collect native species in the rhizosphere of the date palm to multiply under controlled conditions in order to obtain an effective inoculum applicable nursery to produce vigorous plants can survive after transplantation. But before work in this direction, it seems important to know first the species of fungi in the rhizosphere endomycorrhizal date palm reported in various research projects.

Thus, the importance of the diversity of mycorrhizal fungi determines the importance of plant diversity and increases plant productivity[26]. In Morocco, although mycological inventories have been established in recent years, including, those of El-Assfouri[27]; Haimed[28]; Haimed[29]; El Kholfy[30]; Larouz[31], Ouabbou[32], Outcoumit[33], Ajana[34], Chliyeh[35] and Nounsi[36]. So far, no inventory of the date palm endomycorrhizal related species has been performed.

Inventory of endomycorrhizal species reported in the rhizosphere of *Phoenix dactylifera*

Acaulospora colossica P.A. Schultz, Bever & J.B. Morton, 1999 **:** Morocco[37].

Acaulospora denticulata Sieverd. & S. Toro., 1987 **:** Morocco[37].

Acaulospora longula Spain & N.C. Schenck, 1984**:** Arabian Peninsula[38].

***Acaulospora* sp1** Gerdemann and Trappe, 1974 **:**Egypt[39].

***Acaulospora* sp1** Gerdemann and Trappe, 1974 : Morocco[2].

***Acaulospora* sp1** Gerd. & Trappe, 1974**:** Morocco[41].

***Acaulospora* sp2** Gerd. & Trappe. 1974 : Morocco[41]**.**

***Acaulospora* sp2** Gerdemann and Trappe, 1974 **:** Morocco[2].

***Acaulospora* sp3** Gerd. & Trappe, 1974 : Morocco[41].

***Acaulospora* sp3** Gerdemann and Trappe, 1974 : Morocco[2]**.**

Acaulospora spinosa Walker C et Trappe, 1981: Southern Arabia[42].

Ambispora gerdemannii (S.L. Rose B.A.Daniels et Trappe) Walker C., Vestberg et A. Schubler, 2007: Southern Arabia[42], Soltanat oman[43]**.**

Archaeospora leptoticha (Schenck N.C & G.S. Sm.) J.B. Morton & D. Redecker. 2001 : Southern Arabia[42].

Claroideoglomus drummondii Błaszk & Renker, Renker & Buscot, 2006 **:** Soltanat oman[43]**.**

Diversispora omaniana walker C. et Schussler A., 2004: Arabian Peninsula[43].

Diversispora aurantia (Blaszk., Blanke, Renker & Buscot) Walker. C & Schüßler A., 2006 **:** Arabian Peninsula[43]**.**

Diversispora spurca *(*Pfeiff.C.M, Walker.C & Bloss) WalkerC. & SchüßlerA. 2004**:** Arabian Peninsula[43].

Entrophosphora infrequens (I.R.Hall) Ames R.N. & Schneid.R.W., 1979 **:** India[44] (Sharma *et al .,* 2014).

Entrophospora colombiana Spain & Schenck.N.C. 1984 : Southern Arabia[42].

Entrophospora kentinensis Wu C.G & Liu.Y.S.,1995: Morocco[37].

***Entrophospora* sp1** Ames R.N & Schneid R.W. 1979 **:** Morocco[37].

***Entrophospora* sp2** Ames R.N & Schneid R.W. 1979 **:** Morocco[37].

Funneliformis africanum (Błaszk & Kovács) Walker C. & Schüßler A., 2010 : Soltanat Oman[43].

Gigaspora albida Scenck et Smith, 1982 : Southern Arabia[42] (El-yahya'ei et *al.,* 2011), India[44].

Gigaspora dicipiens Hall I.R & Abbott L.K., 1984 : India[44]

Gigaspora gigantea (NicolsonT.H. & Gerd.) Gerd. & Trappe., 1974: Southern Arabia[42] , India[44]**.**

Gigaspora margarita BeckerW.N & Hall I.R. 1976**:** Egypt[39].

Glomus caledonium (NicolsonT.H & Gerd.) Trappe & Gerd. 1974**:** Egypt[39]**.**

Glomus verruculosum Blaszk, 1997 **:** Egypt[39] **.**

Glomus aggregatum Schenck N.C & Sm. G.S. 1982**:** Morocco[2,41]**,** Southern Arabia[42] .

Glomus arenarium Błaszk., Tadych & Madej., 2001: Arabian Peninsula[38].

Glomus aureum Oehl et Sieverd., 2003 : Southern Arabia[42].

Glomus badium Oehl, Redcker D. et Sieverd, 2005 : Southern Arabia[42]**.**

Glomus caledonium (NicolsonT.H. et Gerd.) Trappe et Gerd. 1974: Southern Arabia[42].

Glomus clarum NicolsonT.H. et Schenck N.C., 1979 : Southern Arabia[42], Maroc[37], Egypt[39].

Glomus constrictum Trappe, 1977 : Southern Arabia[42] **,** Morocco[2,41].

Glomus coronatum Giovann, 1991 **:** Southern Arabia[42]**.**

Glomus eburneum **L.**J.Kenn., J.C. Stutz et J.B. Morton, 1999 **:** Southern Arabia[42]**.**

Glomus etunicatum Becker et Gerderman. 1977 **:** Southern Arabia[42], Arabian Peninsula[38]**,** Morocco[41].

Glomus fasciculatum Gerd .et Trappe, 1974 **:** Southern Arabia[42], Maroc[2,41], Arabian Peninsula[38]**,** India[44].

Glomus geosporum (Nicolson T.H. et Gerd.) Walker C., 1982 **:** Southern Arabia[42].

Glomus hoi Berch. S.M et Trappe, 1985 **:** Southern Arabia[42].

Glomus intraradices Schenck N.C. et Sm. G.S. 1982 **:** Southern Arabia[42], Maroc[41].

Glomus macrocarpum Tul. & C. Tul., 1844 : Morocco[2,41] **,** Southern Arabia[42]**.**

Glomus manihotis Howeler R.H , Sieverdet Schenck N.C., 1984 : Southern Arabia[42]**.**

Glomus microaggregatum Koske ,Gemma et Olexia, P.D. 1986 : Southern Arabia[42].

Glomus microcarpum Tul. et Tul. C.1845**:** Southern Arabia[42], India[44].

Glomus mosseae (NicolsonT.H. et Gerd.) Gerd. et Trappe, 1974 : Morocco[2,41], Southern Arabia[42] , India[44]**,** Egypt[39].

Glomus proliferum Dalpé et Declerck. 2000: Southern Arabia[42], Maroc[37].

Glomus pulvinatum (Henn.) Trappe & Gerd. 1974**:** Arabian Peninsula[38].

Glomus sinuosum (Gerd et Bakshi.B.K) Almeida R.T et Schenck N.C., 1990: Southern Arabia[42].

***Glomus* sp1** Ames. R.N & Schneid. R.W., 1979 : Morocco[41].

***Glomus* sp1** Ames R.N. &. Schneid. R.W , 1979 **:** Morocco[37]**.**

***Glomus* sp1** Tul. et C. Tul.,1845 **:** Southern Arabia[42].

***Glomus* sp2** Tul. et C. Tul.,1845 : Southern Arabia[42]**.**

***Glomus* sp2** Tul. & C. Tul., Emend Walker C. & Schüßler A.,1845 : Morocco[37]**.**

***Glomus* sp2** Ames. R.N & Schneid. R.W., 1979 **:** Morocco[4].

***Glomus* sp3** Tul. et Tul.C., 1845 : Southern Arabia[42].

Glomus spurcum Pfeiff. C.M, Walker C. & Bloss., 1996**:** Southern Arabia[42] (Al-yahya'ei *et al.,* 2011).

Glomus verruculosum Blaszk ., 1997 **:** Southern Arabia[42].

Glomus versiforme (P. Karst.) Berch. S.M., 1983: Southern Arabia[42], Arabian Peninsula[38]**.**

Paraglomus occultum (Walker C) J.B. Morton et Redecker D., 2001: Southern Arabia[42].

Racocetra fulgida (Koske et Walker.C) Oehl, Souza F.A et Sieverd., 2009 : Southern Arabia[42].

Racocetra gregaria (Schenck N.C. et NicolsonT.H.) Oehl, Souza F.A et Sieverd, 2009**:** Southern Arabia[42].

Rhizophagus Arabicus Dang. P.A. 1896 : Arabian Peninsula[43].

Rhizophagus Dang. P.A. 1896 : London[45].

Sclerocystis coreimoides (Berk. & Broome) Redecker D. & Morton J.B, Morton & Bruns, 2000: India[44].

Scutellospora aurigloba (Hall I.R.) Walker C. & Sanders F.E., 1986: Southern Arabia[42].

Scutellospora calospora (Nicolson T. H. et Gerd.) Walker C. et Sanders F.E., 1986 **:** Southern Arabia[**42**].

Scutellospora castanea Walker C. 1993: Southern Arabia[42].

Scutellospora cerradensis Spain & Miranda J., 1996**:** Southern Arabia[42].

Scutellospora erythropa (Koske & Walker C.) Walker C. & Sanders F.E., 1986**:** India[44].

Scutellospora fulgida Koske & Walker C. 1986: Southern Arabia[42.]

Scutellospora gilmorei (Trappe & Gerd.) Walker C. & Sanders F.E., 1986**:** Southern Arabia[42].

Scutellospora gregaria (Schenck N.C. & Nicolson T.H.) Walker C. & Sanders, F.E., 1986**:** Morocco[41].

Scutellospora heterogama (NicolsonT.H. & Gerd.) Walker C. & Sanders F.E., 1986**:** Southern Arabia[42], India[44], Soltanat Oman[43].

Scutellospora nigra (Redhead J.F.) Walker C. & Sanders F.E., 1986**:** India[44]**,** Soltanat Oman[43].

Scutellospora nodosa Błaszk. 1991 **:** Southern Arabia[42].

Scutellospora pellucid *(*Nicolson T.H. & Schenck N.C.) Walker C. & Sanders F.E., 1986: Southern Arabia[42].

Scutellospora projecturata Kramad & Walker C., 2000 : Southern Arabia[42].

Scutellospora reticulata (Koske D.D. Mill. & Walker C.) Walker C. & Sanders F.E., 1986**:** Southern Arabia[42].

***Scutellospora* sp.** Walker C. & Sanders F.E., 1986**:** Egypt[39].

***Scutellospora* sp1** Walker C. & Sanders F.E., 1986**:** Morocco[41].

***Scutellospora* sp1** Walker C. & Sanders F.E., 1986: Morocco[2].

***Scutellospora* sp2** Walker C. & Sanders F.E., 1986**:** Morocco[41].

***Scutellospora* sp2** Walker C. & Sanders F.E. 1986**:** Morocco[2]**.**

Scutellospora spinosissima Walker C. & Cuenca, 1998 **:** Southern Arabia[42]**.**

Scutellospora weresubiae Koske & Walker C., 1986: Southern Arabia[42].

Septoglomus nakheelum Sieverd , Silva G.A. & Oehl., 2011: Arabian Peninsula[43].

Endomycorrhizal species reported in the rhizosphere of Phoenix dactylifera concerned only few countries in the world: Morocco, Egypt, Oman, Southern Arabia, India, London, Arabian Peninsula. 89 fungal species are cited and it is the species belonging to the genus Glomus which are the most dominant, 34 species, followed by the Scutellospora genus, 21 species and those of Acaulospora, 11 species. Entrophospora is represented by 5 species, Gigaspora by 4 species and only three species for Diversispora genus. The Rhizophagus and Racocetra genrera are represented by two species each. For cons, the

Sclerocystis genres Septoglomus, Paraglomus, Ambispora, Funneliformis, Claroideglomus Archaeospora and are represented by only one species each.

Table 1: Number of endomycorrhizal species isolated in the rhizosphere of the date palm in different countries of the world

countries	Morocco	Egypt	Southern Arabia	Soltanat Oman	India	London	Arabian Peninsula
Number of species	29	7	48	5	11	1	11

2 DISCUSSION

The inventory of endomycorrhizal fungi presented in this work, will have a global vision on the wealth of endomycorrhizae associated with the rhizosphere of date palm, reported in different countries. The date palm is among the plants that can harbor both ectomycorrhizae[46] and endomycorrhizae[47,48,49]. The number of mycorrhizal species (89) remains very modest in your opinion, which means that the species associated with the rhizosphere of the date palm are little studied. Regular samples in different areas of the palm groves that can help develop a comprehensive inventory of species.

It should also be noted that it is the species belonging to the Glomus genus, which are the most dominant (34 species) relative to other species[50,51,52,53,54]. The species of this genus better attending semiarid and arid environments. Thus, they are considered the most suitable habitat subject to constraints such as drought and soil salinity[55,56]. Better yet, in terms of behavior of sporulation of AMF species, the majority of Glomus species sporulate studied throughout the year unlike other species such as those belonging to the Scutellospora and Acaulospora genera sporulate mainly in spring and tautomne[41].

The diversity of species endomycorrhizal observed in the rhizosphere of the date palm growing in different countries of the world (Egypt, Oman Sultanate, Southern Arabia, India, London, and the Arabian Peninsula) depends on several factors, such as seasonality[2], soil edaphic factors[57] as well as climate factors[58]. In addition, it was reported that even the kinds of MFA of the same family and species of the same genus have different symbiotic capabilities, ability evaluated by the root colonization rate by the AMF and the number of spores formed[59]. In another study on the distribution of CMA in arid environments, Jacobson[60] noted that the humidity at ground level also has a significant influence on populations of CMA. Indeed, Kaushal[69] mentioned that in semi-arid areas, the AMF populations are highest during the rainy season. In the same way, agricultural practices[61], including soil fertilization[62,63] and irrigated agriculture may also affect the composition of the AMF and may even lead to low species diversity of AMF[64,65]. Similar studies have shown that sporulation is seasonal fungal endomycorrhizal[66,67,68].

The highest number of endomycorrhizal species was reported in Southern Arabia, 48 species, this number is probably due to environmental parameters characteristic of this area of the world (arid)[42]. In Morocco, the number is also important, 29 species, compared to that reported in other agro ecosystems. It should also be noted that 12 species were isolated from the rhizosphere of the olive tree growing in mixture with the date palm in palm groves of Tafilalt and Zagoura[40].

The presence of endomycorrhizal fungi at the palm of soil is necessary to sustain date palms in their habitat. They facilitate, indeed, access to minerals and plants to water, and increase tolerance to abiotic stress conditions (drought, salinity or soil) and biotic (pathogens attacks)[37] (Sghir *et al.,* 2014). Studies on the diversity of AMF associated with date palm around the world are still rare[42] (Al-Yahya'ei *et al.,* 2011). All these studies have concerned only a few sites only with limited samples. Better yet, the problem of identification of the spores is very difficult. Therefore, it is likely that the species mentioned in this work are a small part of a large complex of fungi existing endomycorrhizal. This number which is still underestimated could be improved further research work will be made in this area in order to better use of endomycorrhizal fungi in the sustainability and conservation of date palm cultivation in the oases.

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