

GLOMALES I: A MONOGRAPH OF *Glomus* spp. (*Glomaceae*) IN THE SUNFLOWER RHIZOSPHERE OF HARYANA, INDIA

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SUMMARY

Seven species of *Glomus* (*Glomus mosseae*, *G. fasciculatum*, *G. scintillans*, *G. versiforme*, *G. geosporum*, *G. macrocarpum* and *G. diaphanum*) from sunflower rhizosphere are described and illustrated. A key to species of the genus *Glomus* is also prepared based on morphological characters. Spores of these species were identified on the basis of their morphological characters such as hyphal attachment, spore ornamentation, wall layers and spore color and size.

Key words: sunflower rhizosphere, *Glomus* species, Vesicular Arbuscular Mycorrhizal fungi (VAM)

INTRODUCTION

Members of *Endogonaceae* are widely distributed in agricultural and forest soils throughout the world. Among arbuscular endomycorrhizal fungi in the order *Glomales*, 56% of the described species are in the genus *Glomus* (Morton and Benny, 1990), including species formerly in the genus *Sclerocystis* (Almeida and Schenck, 1990). Species of *Glomales* are separated by morphological characters residing mostly in a variety of subcellular structures in spores that have been defined as "layers" (Berch, 1987), walls (Walker, 1983) or zones (Maia *et al.*, 1993). However, no effort seems to have been directed to isolate and describe VAM fungi associated with the sunflower. With this objective, surveys were conducted to isolate and identify species of *Glomus* on sunflowers in Haryana, India.

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MATERIALS AND METHODS

An extensive investigation of *Glomales* in the sunflower rhizosphere in Haryana, India, had been conducted to collect various species from various areas using wet sieving and decanting technique (Gerdemann and Nicolson, 1963). Spores were multiplied in the greenhouse with maize as host plant. For taxonomic purpose, spores were mounted in PVLG medium.

RESULTS AND DISCUSSION

All seven species of the genus *Glomus* were isolated and identified by using manuals of Trappe (1982), Morton and Benny (1990), Schenck and Perez (1990) and Mukerji (1996).

Glomus

The genus includes both sporocarpic and non-sporocarpic species. Those with chlamydospores develop the spores terminally, on a single undifferentiated hypha. The spores are formed at the end of a hypha which may be constricted at the point of attachment to the spore, have parallel side walls, or become markedly occluded at the point of attachment to the spores. The spore wall can have one to many layers, without ornamentation. Germination is either into old subtending hypha or more rarely through the spore wall. Vesicles and arbuscules have been found in *Glomus*.

***Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trappe**

Spores rarely filled with hyphae, sporocarp containing 1-10 spores (sometimes), diameter of subtending hypha at widest part 18-50 μm , outer surface of inner wall is not ornamented; thin, hyaline outer wall may not be obvious. Spores are more than 100 μm in size, subtending hypha is generally funnel-shaped with cup-shaped septum (Figure 1 A and B).

***Glomus fasciculatum* (Thaxter sensu Gerd.) Gerd. and Trappe**

Chlamydospores formed in loose aggregation in sporocarp; chlamydospores are 80-120 μm when globose, smooth or seemingly rough from adherent debris. Spore wall is 4.2 μm thick, hyaline to yellow, the thicker walls often minutely perforated with thick inward projections, hyphal walls occluded at maturity (Figure 1 E and F).

***Glomus geosporum* (Nicol. and Gerd.) Walker**

Chlamydospores formed singly, globose to sub-globose or broadly ellipsoid, 100-250 μm in width, smooth, dark yellow-brown at maturity. Spore wall 5-20 μm thick, 2-3 layered, spore with loosely sleeve-like hyphal attachment at right angle to spore wall, at least 180 μm long, 10-20 μm diameter in young spores, oil droplets present in young spores (Figure 1 K).

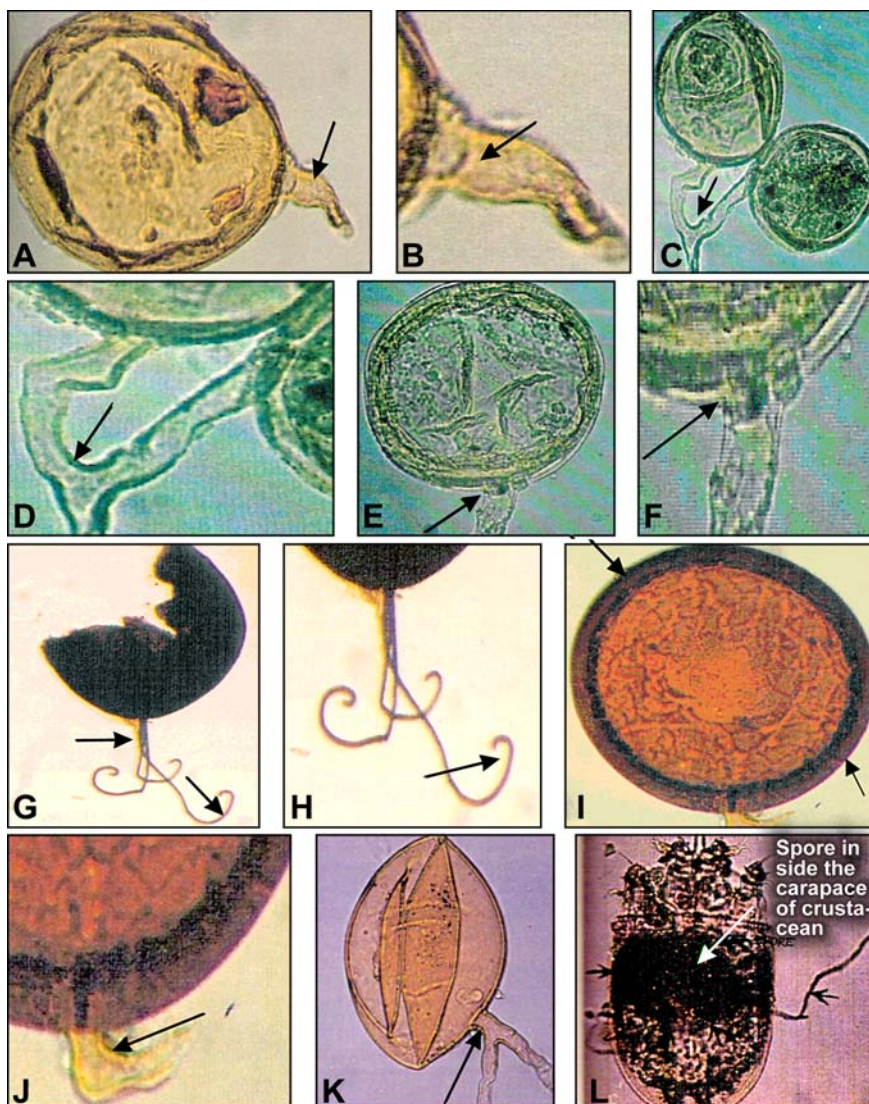


Figure 1 (A and B): Spores of *Glomus mosseae* ($10 \times 40X$), arrow shows funnel-shaped attachment (1A), cup shaped septum (1B);

Figure 1 (C and D): -spores of *Glomus diaphanum* ($10 \times 40X$), arrow shows common hyphal attachment;

Figure 1 (E and F): -spores of *Glomus fasciculatum* ($10 \times 40X$), arrows show hyphal attachment (E and F);

Figure 1 (G and H): -spores of *Glomus scintillans* ($10 \times 40X$), arrow shows hooked ends (H);

Figure 1 (I and J): -spores of *Glomus macrocarpum* ($10 \times 40X$), arrows show much occluded hyphal attachment (J) and cross channels in wall layers (I);

Figure 1 (K): -spore of *Glomus geosporum* ($10 \times 40X$), arrow shows hyphal attachment at right angle to the spore;

Figure 1 (L): -spore of *Glomus versiforme* ($10 \times 40X$), arrow shows spore in crustacean carapace.

***Glomus macrocarpum* Tul. and Tul.**

Resting spores red brown to dark brown (honey colored), 120-400 μm in width, subtending hypha not inserted, spore without a plug but may be much occluded by lateral walls, spores borne singly, multilayered with cross channels in walls with lignified ingrowth from outer side of the wall (Figure 1 I and J).

***Glomus scintillans* Rose and Trappe**

Chlamydospores formed singly, globose to sub-globose, dark brown to black in color, with long subtending hypha (1-3 rarely) with hooked ends, size of spores >150 μm , spore wall not distinct, with outer rough surface (Figure 1 G and H).

***Glomus diaphanum* Mor. and Walk.**

Azygospores borne in soil, spores mostly two in number, joined through a common hyphal attachment with mother hyphae, spores in variable shapes, yellow to yellowish brown, 100-250 μm in diameter, wall layers 2-3, irregular, subtending hyphae hyaline and convoluted (Figure 1 C and D).

***Glomus versiforme* Berch**

Chlamydospores borne in soil, single, germinate inside the carapace of crustaceans, brown to black in color, elliptical in shape, with long hyphal attachment, hypha not hyaline, spore size 100-200 μm , wall layers inseparable, outer wall spiny (Figure 1 L).

Table 1: Key to the species *Glomus*

1.1. Spores >100 μm in diameter, subtending hypha generally funnel-shaped with cup-shaped septum	<i>Glomus mosseae</i>
1.2. Spores in loose aggregation, 80-120 μm in diameter, globose, outer wall minutely perforated with thick inward projections	<i>Glomus fasciculatum</i>
1.3. Spores globose to sub-globose or ellipsoid, 100-250 μm with loosely sleeve-like hyphal attachment at right angle to spore wall	<i>Glomus geosporum</i>
1.4. Spores dark red-brown or honey colored, round or globose, 120-400 μm in diameter, subtending hypha not inserted, hyphal attachment much occluded, spore wall multilayered with cross channels	<i>Glomus macrocarpum</i>
1.5. Spores globose to sub-globose, > 150 μm in size, black in color, long subtending hyphae with hooked ends	<i>Glomus scintillans</i>
1.6. Spores mostly in group of two, joined with a common hyphal attachment, size 100-250 μm	<i>Glomus diaphanum</i>
1.7. Spores jet black in color, elliptical shape, 100-200 μm in size, outer wall spiny	<i>Glomus versiforme</i>

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GLOMALES I: UNA MONOGRAFÍA DE *Glomus* spp. (*Glomaceae*) EN LA RIZÓSFERA DEL GIRASOL DE HARYANA, INDIA

RESUMEN

Se describieron e ilustraron siete especies de *Glomus* (*Glomus mosseae*, *G. fasciculatum*, *G. scintillans*, *G. versiforme*, *G. geosporum*, *G. macrocarpum* y *G. diaphanum*) de la rizósfera del girasol. Además se preparó una clave de las especies del género *Glomus* sobre la base de caracteres morfológicos. Se identificaron esporas de esas especies de acuerdo con características morfológicas como adherencia hifal, ornamentación de las esporas, capas de las paredes y color y tamaño de las esporas.

GLOMALES I: MONOGRAPHIE SUR LA SORTE *Glomus* spp. (*Glomaceae*) DANS LA RHIZOSPHERE DU TOURNESOL A HARYANA, INDE

RÉSUMÉ

Sept espèces du genre *Glomus* (*Glomus mosseae*, *G. fasciculatum*, *G. scintillans*, *G. versiforme*, *G. geosporum*, *G. macrocarpum* et *G. diaphanum*) de la rhizosphère du tournesol sont décrites et illustrées. Une clef de détermination de l'espèce au sein du genre *Glomus* est préparée sur la base des caractères morphologiques. Les spores de ces espèces ont été identifiées sur des caractères morphologiques tels que l'attachement des hyphes, l'ornementation des spores, la paroi, la couleur et la taille des spores.

