Arbuscular Mycorrhizal Fungi in the Amaryllidaceae

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Introduction

The vast majority (80%) of plants form symbioses with arbuscular mycorrhizal fungi (AMF; Glomeromycota) for resource acquisition. Recent analyses suggested that phylogenetically-related species showed more similar levels of mycorrhizal root colonization and interactions with the host than expected by chance. If such patterns are widespread, a phylogenetic framework may enable a more predictive perspective of mycorrhizal-plant interactions than currently available.

In this study, we assessed whether AMF root colonization and plant responses to AMF varied with phylogeny in the Amaryllidaceae.

The Amaryllidaceae are a cosmopolitan family of bulbous petaloid monocots that comprise three distinct groups: the Agapanthoideae, Allioideae and Amaryllidoideae (Figure 1, 2). Amaryllidaceae is a particularly interesting angiosperm family because it includes many species with horticultural and medicinal importance. A relatively robust understanding of the major clades within Amaryllidaceae exists (Figure 1), but there is little information on their mycorrhizal associations.

We asked three questions:

1. What is the range of AMF root colonization across the Amaryllidaceae, and Is the extent of colonization related to phylogenetic position?
2. Does root colonization lead to distinct changes in the rhizosphere among clades?
3. Are these mycorrhizal associations functional, and is plant performance concordant with phylogenetic position?

Methods

1. We surveyed AMF root colonization and rhizosphere activity (Questions 1,2) in soil and root samples collected under *Agapanthus*, *Allium*, and representatives of the Amaryllidaceae from the major clades (Figure 1). Samples were analyzed for soil fertility (N,P,C), fungal: bacterial ratio, the activity of microbial enzymes associated with C and N cycling, and mycorrhizal root colonization.

1. Mycorrhizal infectivity and functioning(Question 3) was assessed using a corn (*Zea mays*) bioassay. Seedlings were grown in rhizosphere soil from the same plants noted above and assessed for biomass accumulation, foliar N, and mycorrhizal root colonization. *Zea mays* grown in native prairie soil was used as a positive control.

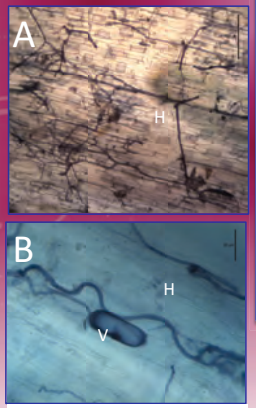


Figure 2. (A) Abundant hyphae (H) in root of *Stembergia*; (B) Hyphae (H) and vesicle(V) in roots of *Narcissus*.

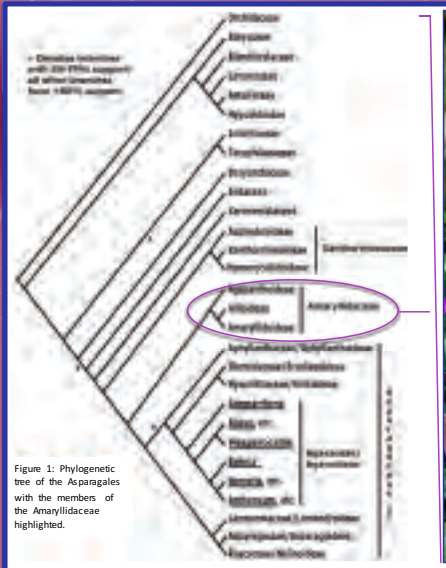
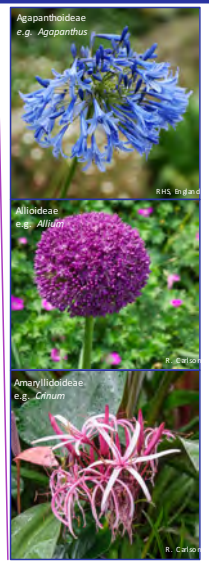


Figure 1: Phylogenetic tree of the Asparagales with the members of the Amaryllidaceae highlighted.



Results

On average, 69.5% (range 0 – 100%) of Amaryllidaceae roots were colonized by AMF (Figure 2). Levels of colonization did not differ significantly among taxa (Question 1).

Rhizosphere soils in the Allioideae and Amaryllidoideae were similar in fertility and microbial activity (Figure 3; $p>0.05$). These soils had a consistent negative effect on plant biomass accumulation (Figure 5). Even so, positive (e.g. *Sternbergia*) to strongly negative effects on biomass accumulation (e.g. *Amaryllis*) were recorded (Figure 4).

Rhizosphere soils of the Agapanthoideae were distinct (Questions 2, 3) due to increasing levels of AMF root colonization, rhizosphere acid phosphatase activity, and lower levels of soil N in this group. These soils also enhanced plant biomass accumulation (Figure 5).

Conclusions

We found that AMF functioning, but not root colonization, appeared to best correspond to phylogenetic position.

Plant responses to Amaryllidoideae and Allioideae were largely similar, while the Agapanthoideae produced significantly different responses. Such responses were consistent with their phylogenetic position (Figure 1).

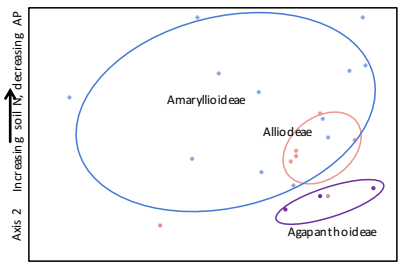


Figure 3: Non-metric multi-dimensional scaling plot of 22 Amaryllidaceae samples using Bray-Curtis distance metric (stress = 0.0609). Axis 1, R^2 0.959; Axis 2, R^2 0.0655. AP, acid phosphatase activity.

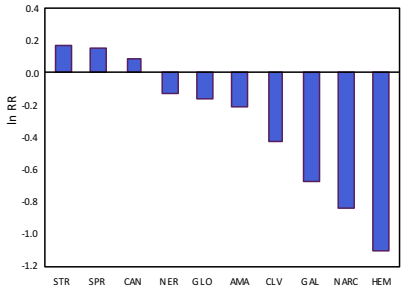


Figure 4: Response ratio (ln RR) of shoot biomass in Amaryllidaceae soils. In RR > 0 indicates a positive growth response, ln RR< 0 denotes suppression. STR, *Stembergia*; SPR, *Sprekelia*; CAN, *Canna*; NER, *Nerine*; GLO, *Gloriana*; AMA, *Amaryllis*; CLV, *Clivia*; GAL, *Galanthus*; NARC, *Narcissus*; HEM, *Hemereocallis*.

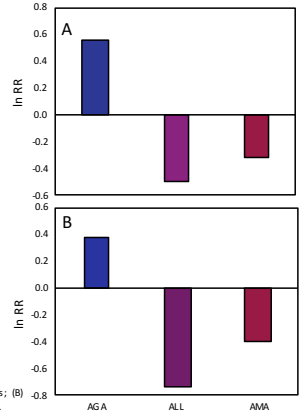


Figure 5 (right): Response ratio (ln RR) of (A) shoot biomass; (B) root biomass in Amaryllidaceae soils relative to the control. AGA, Agapanthoideae; ALL, Allioideae; AMA, Amaryllioideae.

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