Arbuscular mycorrhizal fungal and dark septate endophytes colonization of plant roots from urban desert preserves and surrounding deserts

Aura Ontiveros-Valencia and Jean C. Stutz
Department of Applied Biological Sciences, Arizona State University, Mesa, AZ

INTRODUCTION

Biodiversity and species richness could be radically affected in urban ecosystems in comparison to preserved peripheral communities (Czech et al. 2000). McKinney (2002) suggested two possible strategies to encourage the conservation of native species in urban ecosystems; the preservation of urban remnants and the restoration of habitats. Nevertheless, these strategies could fail in the attempt to preserve the biodiversity of native species. A recent study of arthropod communities reported differences in species composition between peripheral deserts and urban desert remnants (Cook and Faeth 2006).

Plant roots can be colonized by several types of fungi, including saprophytic, pathogenic and mycorrhizal species. Mycorrhizal fungi are important microbiota that form an often mutualistic symbiosis (Brundett 2004) with the roots of terrestrial plants; in which fungi receive carbon compounds from the host plant and assist in mineral uptake. Arbuscular mycorrhizal (AM) fungi are the most common and oldest type of mycorrhiza which typically form arbuscules, hyphae and vesicles within roots (Brundett 1999). Dark septate endophytes (DSE) are another type of root colonizing fungi mainly classified in the phylum Ascomycota and have been found in over 600 plant species, especially plants growing in extreme environments (Jumpponen 2001).

Little is know about fungal colonization of roots of plants growing in urban preserves, but Stabler et al. (2001) found that AM fungal colonization was greater in native trees growing in urban desert preserves than native trees growing in residential areas. Our purpose was to analyze AM and DSE fungal colonization of plant roots at two urban desert preserves and two Sonoran desert sites surrounding the Phoenix metropolitan area.

METHODS/MATERIALS

Description of Site:
Four study sites were selected from existing study sites that are part of the Central Arizona-Phoenix Long-Term Ecological Research (CAP-LTER) under the Survey 200 project (Fig. 1). For purposes of this study, an urban desert preserve was considered such as an area of importance to desert wildlife and flora that is usually protected and is within or mostly surrounded by the city. A surrounding desert was understood as a site primarily outside of the city where urban development is scarce. The study sites (Fig. 2) were selected based on location and accessibility and included two urban desert preserves, North Mountain Preserve (hereafter referred to as U131) and South Mountain Park (hereafter referred to as U201), and two sites located in the Sonoran desert surrounding Phoenix metropolitan area, McDowell Mountain Regional Park (hereafter referred to as AD101) and Tonto National Forest/Goldfield Mountain, (hereafter referred to as AF141).

Sampling methods:
In order to select plants for soil sampling, a 50m transect (in a general east to west direction) was centered at the GPS-located center point for each site. At 5m intervals along the transect, the nearest living woody and succulent plant was selected and soil collected from the rhizosphere at the base of each plant. Surface debris was removed and soil and roots were collected to a depth of approximately 10 cm with a metal trowel, which was rinsed with 70% ethanol between samples. Soil samples were collected from the root zone of 10 woody plants and 10 succulent plants (including cacti) at each site for a total of 80 samples. All the samples were placed into self-sealing plastic bags and transported to ASU Polytechnic campus. Samples were stored at 4° C until analysis.

Root Colonization:
Roots were washed free of the soil, fixed in 50% ethanol, then cleared, bleached, and stained with 0.05% Trypan blue by a modification of the procedure of Koske and Gemma (1989) with the potassium hydroxide (KOH) concentration adjusted for woody and succulent plant roots. Because succulent plant roots are mostly thinner than woody plant roots, the concentration of KOH used was 1.5 % for the succulent plant roots and 4% for the woody plant roots. To assess the possible presence of DSE fungi, double staining was performed with Sudan IV staining (Barrow and Aaltonen, 2001) after staining with trypan blue. The roots were then transferred to a glass slide to quantify percent of AM and DSE fungal colonization with the method described by McGonigle et al (1990).

Statistical analysis:
Root colonization data was analyzed using ANOVA of a two factor factorial with sites and plant type as factors by using R version 2.7.2. Root colonization percentage was square root transformed to approximate normality. An alpha value of 0.05 was assumed for all statistical analyses.

Figure 1. Survey 200 sites. The four arrows point to the study sites U131, AD101, AF141 and U201. Map was provided by http://caplter.asu.edu/home/index.jsp

Figure 2. Study sites photos representing U131, AD101, AF141 and U201 (clockwise from upper left).

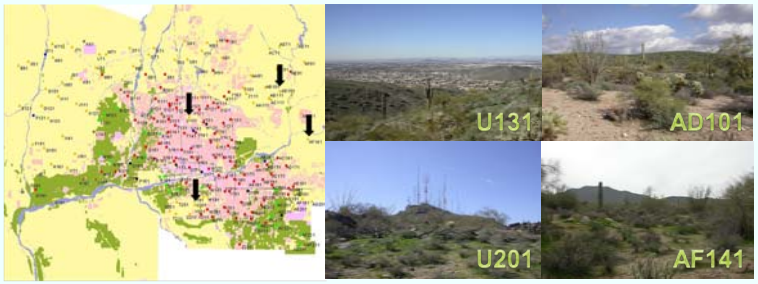


Figure 3. Total root colonization in woody and succulent plants by AM fungi (left) and colonization by type of plant (right) in roots collected at urban desert preserves (sites U131 and U201) and surrounding deserts (sites AD101 and AF141).

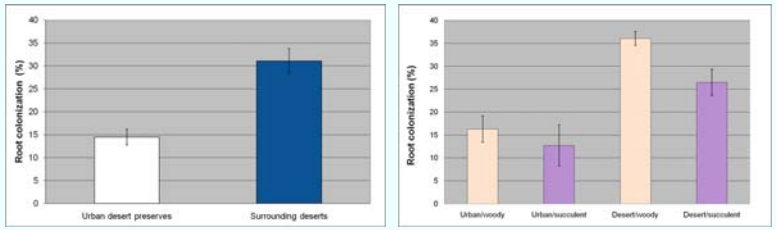
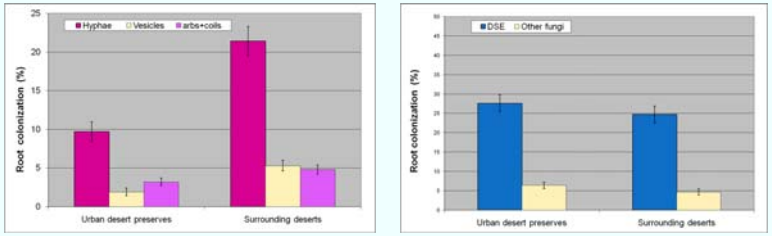


Figure 4. Formation of hyphae, vesicles, arbuscules and hyphal coils (left) and root colonization by DSE and other types of fungi (right) in roots collected at urban desert preserves (sites U131 and U201) and surrounding deserts (sites AD101 and AF141).



RESULTS

Total root colonization by AM fungi was higher in plants from surrounding deserts compared to urban desert preserves (Fig. 3)
There was a highly significant difference ($p<0.001$) in total colonization between urban desert preserves and surrounding deserts. While mean total colonization was lower in succulent plants in comparison to woody plants, this difference was not highly significant ($p=0.1265$).

Root colonization by AM fungal structure was higher in plants from surrounding deserts compared to urban desert preserves (Fig. 4).
There were highly significant differences in root colonization by hyphae and vesicles ($p<0.001$) and significant differences by arbuscules and hyphal coils ($p=0.026$) between urban desert preserves and surrounding deserts with greater % of the roots colonized by these structures from surrounding deserts. Root colonization in woody plants by vesicles was significantly higher ($p=0.002$) than root colonization in succulent plants.

Total root colonization by DSE and other fungi was not significantly different in plants from surrounding deserts compared to urban desert preserves (Fig.4)

CONCLUSION

AM fungal colonization was higher in plants from peripheral deserts versus urban desert preserves. Soil disturbance and compaction due to human activities are known to decrease root colonization (Entry et al 2002). Other possible factors such as increases in atmospheric nitrogen deposition, air and soil pollutants, and average ambient temperature (urban heat island effect) known to occur in urban ecosystems (Grimm and Redman 2004) could negatively impact root colonization. We are currently determining the AM fungal species that occur in the four study sites to determine if differences in AM fungal community structure may be associated with the urban desert preserves and surrounding deserts.

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REFERENCES

Barrow JR, Aaltonen RE (2001). Evaluation of the internal colonization of Atriplex canescens (Pursh) Nutt. roots by dark septate fungi and the influence of host physiological activity. Mycorrhiza. 4:199-205.

Brundett MC (1999). Introduction to Mycorrhizas (Webpage). http://www.ffp.csiro.au/research/mycorrhiza/intro.html CSIRO Forestry and Forest Products, Canberra.

Brundett MC (2004). Diversity and classification of mycorrhizal associations. Biol. Rev. 79:473-495.
Cook WM, Faeth SH (2006) Irrigation and land use drive ground arthropod community patterns in urban desert. Environmental Entomology. 35:1532-1540.

Cook WM, Faeth SH (2006). Irrigation and land use drive ground arthropod community patterns in urban desert. Environmental Entomology. 35:1532-1540.

Czech B, Krausman PR, Devers PK (2000). Economic associations among causes of species endangerment in the United States. Bioscience 50:593-601.

Entry JA, Rygiewicz PT, Watrud LS, Donnelly PK (2002). Influence of adverse soil conditions on the formation and function of Arbuscular mycorrhizas. Advances in Environmental Research 7:123-138.

Grimm NB, Redman CL (2004). Approaches to the study of urban ecosystems: The case for central—Phoenix. Urban Ecosystems 7:199-213

Jumpponen, A (2001). Dark septate endophytes - are they mycorrhizal? Mycorrhiza 11:207-211.

Koske RE, Gemma JN (1989). A modified procedure for staining roots to detect V-A mycorrhizas. Mycological Research 92: 486-488.

McGonigle TP, Miller MH, Evans DG, Fairchild DL, Swan JA (1990). A new method which gives an objective measure of colonization of roots by vesicular-arbuscular mycorrhizal fungi. New Phytologist 115: 495-501.

McKinney ML (2002). Urbanization, biodiversity, and conservation. BioScience. 52:883-890.

Stabler LB, Martin CA, Stutz JC (2001). Effect of urban expansion on Arbuscular mycorrhizal fungal mediation of landscape tree growth. Journal of Arboriculture. 27(4):193-201