Research Note: Spatial Variation of AM Fungal Spore Numbers under Canopies of *Acacia raddiana*

XUELI HE
Faculty of Life Sciences
Northwest Science and Technology
University of Agriculture and Forestry
Shaanxi, P.R. China and Faculty of Life Sciences
Bar-Ilan University, Ramat-Gan, Israel

STANISLAV PEN-MOURATOV
YOSEF STEINBERGER
Faculty of Life Sciences
Bar-Ilan University
Ramat-Gan, Israel

The spatial variation of arbuscular mycorrhizal fungal spores under the canopy of *Acacia raddiana* was studied in a desert system. Soils samples from the base of the stem, its canopy radius, and outside its canopy at four stations in the Negev desert were collected from a 0 to 50 cm depth at sections of 10 cm each. The mean spore density was found to fluctuate between 265 100 g⁻¹ to 105 100 g⁻¹ in fluvisols and calcareous fluvisols, respectively. Our results suggest that spore density and spore distribution were found to be directly correlated with soil type, elucidating the importance of soil physical composition on AM fungi distribution in desert soil ecosystems.

**Keywords** arid ecosystem, Negev Desert, desert soils, fungal distribution

Arbuscular mycorrhizal fungal (AMF) associations are ubiquitous in desert ecosystems and may play an important role in plant establishment and growth by bridging between plant and soil (Allen, 1983; Dhillion & Zak, 1993; Skujinš & Allen, 1986). The abundance of arbuscular mycorrhizal fungi and their spores are dependent on type and physical characteristics of soil (Bethlenfalvay et al., 1988; Ortega-Larrocea et al., 2001).

Bever et al. (1996) and Sanders & Fitter (1992) have postulated that the host plant may play a significant role in every phase of the life history of AM fungi (spore germination, hyphal development and colonization, and sporulation) by regulating carbon allocation to roots, producing secondary metabolites, or changing soil environmental conditions. Therefore, investigating the spatial distribution and richness of AM fungal spores related to host plants in the Negev Desert might be

Received 11 October 2003; accepted 20 January 2004.
Address correspondence to Prof. Y. Steinberger, Faculty of Life Sciences, Bar-Ilan University, Ramat-Gan 52900, Israel. E-mail: steinby@mail.biu.ac.il

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helpful for understanding the ecological role of AM fungi in desert ecosystems and the relationship between AM fungal distribution and the growth of desert plants (He et al., 2002a, 2002b).

We hypothesized that sampling location soil type and depth will strongly reflect the abundance and distribution of AM fungal spores in a desert ecosystem. The aim of this study was to determine the influence of soil type on the abundance and distribution of AM fungal spores in the *A. raddiana* rhizosphere in a desert soil ecosystem.

Soil samples were collected at four sites along a soil type gradient running from the northern Negev Desert 25 km east of Dimona (30°58'N; 35°20'E), with lithosol type soil, mean annual temperature of 20°C and mean annual rainfall of 150 mm, south toward the Dead Sea, in the Arava Valley-Ein Ofarim (30°45'N; 35°18'E), with calcareous fluvisol type soil, mean yearly temperature ranging between 22 and 24°C and mean rainfall of 42 mm, southwest toward the Faran Desert (30°12'N; 34°55'E), with fluvisol type soil, mean annual temperature range between 20 and 22°C, mean annual rainfall of approximately 50 mm, and to the north near Sede Boker, Ramat Boker (30°48'N; 34°45'E), with yermosol type soil, mean annual temperature of 18°C and mean annual rainfall of 97 mm (Dan et al., 1972, 1977). All four sites represent arid conditions with a common feature of low and unpredictable rainfall, desert climate, mild, rainy winters and hot, dry summers.

*Acacia raddiana* Savi is a typical summer-active shrub that grows in many wadis. It originates from the savannahs of Africa and penetrated the Negev from the far south (Evenari et al., 1982). Recent studies had shown an increase in VAM colonization in the root area of Acacia, reflecting vigorous growth of these trees (Ishii, 2000).

**Methods**

Soil samples at the base of the *A. raddiana* stem, the canopy radius (2 m), and outside the canopy (2 m from canopy edge) as control (interplant) were collected at the four sites in the summer of 2000. The soil samples were collected in three replicates from a depth of 50 cm at each location and were divided into sections corresponding to 0–10, 10–20, 20–30, 30–40 and 40–50 cm depths. They were placed in individual plastic bags and transported to the laboratory in an insulated container and sieved (2 mm mesh size) before processing.

Twenty-five grams of soil from each replicate were used for spore extraction. The total AM fungal spore number was determined by wet sieving (45–500 µm), sucrose density centrifugation (Ianson & Allen, 1986) and counting under a stereoscopic microscope at ×40.

All data were subjected to statistical analysis of variance using the SAS model (ANOVA, Duncan’s multiple range test and correlation coefficient) and were used to evaluate differences between separate means.

**Results**

The mean spore density was found to be significantly higher (*P* < 0.05) at the Faran site (265 100 g⁻¹ soil) than at Ramat Boker (127 100 g⁻¹ soil), Dimona (162 100 g⁻¹ soil), and Ein Ofarim (105 100 g⁻¹ soil). Similar differences were obtained between Ramat Boker, Dimona, and Ein Ofarim. However, no significant differences (*P* > 0.05) were found between Ramat Boker and Ein Ofarim. Sampling location relative to plant stem had a significant effect on the mean spore density. These values were found to be significantly higher (*P* < 0.05) only at the base of the stem rather than in the canopy radius. At the 0–10 cm soil layer, the mean spore density was found to range between 96 100 g⁻¹ soil and 268 100 g⁻¹ soil, increased slightly with
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depth and reached a maximum value of 285 100 g\(^{-1}\) soil (Faran site), 110 100 g\(^{-1}\) soil (Ein Ofarin) at the 20–30 cm depth and 140 100 g\(^{-1}\) soil (Ramat Boker) and 168 100 g\(^{-1}\) soil (Dimona) at the 30–40 cm depth, then declined gradually with depth. A similar depth variation pattern was found in the different sampling locations relative to the plant stem, however, no significant differences were found between sampling depths (Figure 1).

**FIGURE 1** Mean spore density 100 g\(^{-1}\) soil samples taken at (A) canopy base, (B) canopy radius, and (C) control, at four sites: (I) Dimona; (II) Ramat Boker; (III) Ein Ofarin; and (IV) Faran, under *A. raddiana* (● 0–10 cm; ▪ 10–20 cm; ▲ 20–30 cm; ■ 30–40 cm; ▣ 40–50 cm).

**Conclusion**

Our results demonstrate that the mean spore density related to the canopy of *A. raddiana* in a Negev Desert ecosystem was 165 100 g\(^{-1}\) soil, and the distribution of spore density in the soil was extremely variable. Sampling location had a significant effect on spore density. The mean spore density at the Faran site (265 100 g\(^{-1}\) soil)
was significantly higher than in Ramat Boker (127 100 g⁻¹ soil) and Ein Ofarin (105 100 g⁻¹ soil). The highest spore densities under the canopy of A. raddeiana in the four sampling stations were found at different soil depths.

This result may be closely related to soil type and not to environmental conditions, which were found to be similar in soil moisture and organic matter content (Pen-Mouratov et al., 2003). At the Faran site, soil conditions were favorable for plant inhabitance and fungal reproduction, and vice versa in the other three stations where they were less auspicious (soil layers contain very little soil and numerous small stones).

The microenvironment of a relatively small gap surrounded by the tested shrub may not be greatly affected, and the roots from the bordering shrub may invade the gap. Thus, there may be no significant difference between small gaps and under the canopy.

Our results suggest that spore density and spore distribution were found to be directly correlated with the soil type, elucidating the importance of soil physical composition on AM fungal distribution in desert soil ecosystems.

References


