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Arbuscular mycorrhizas in a tropical coastal dune system in Yucatan, Mexico

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ABSTRACT

The main goal of this work was to determine the presence of arbuscular mycorrhizas in coastal dunes of Sisal, Mexico, and the seasonal and spatial changes in the arbuscular mycorrhizal fungal (AMF) community. The study was conducted at three coastal dune zones: embryonic, mobile and stabilized dunes. At each dune zone we chose five dominant plant species, collected roots and determined the percent of mycorrhizal colonization. We also took five soil samples at each dune zone to evaluate AMF spore density and number of infective propagules. The overall AMF colonization ranged from 15 to 19 % depending on the dune zone and the season. The density of spores in 50 g soil was higher during the rainy (11.1 ± 2.6) compared to the dry season (1.55 ± 0.2). AMF were present in root samples of all the plants studied, and infective propagules were present in all dune zones; this held true for both sampling seasons. The presence of viable AMF propagules across the successional vegetation gradient indicates the important role of this interaction on plant survivorship in stressful conditions such as that present in Sisal.

Introduction

Coastal dune vegetation of the Yucatan Peninsula is considered species-rich due to the influence of the flora of the Caribbean islands and the Peninsula of Florida (Moreno-Casasola & Espejel 1986). However, the coastal dune vegetation of the Yucatan Peninsula also presents the highest cover loss (28.4 % in 24 yr) of all coastal dune systems in Mexico (Seingier *et al.* 2009). Plant species which grow in coastal dunes are subject to saline aspersion, constant burying, insolation and low water and nutrient availability (Ievinsh 2006). Several authors have pointed out that mutualistic interactions such as that between plants and arbuscular mycorrhizal fungi (AMF) (phylum Glomeromycota) have helped plants to overcome harsh environmental conditions present in these systems (Koske *et al.* 2004; Alarcón & Cuenca 2005; Ievinsh 2006).

Arbuscular mycorrhizal fungi have been shown to promote plant resistance to drought and to saline stress (Evelin *et al.* 2009), as well as increase the efficiency of plant nutrient uptake (mainly of phosphorus and nitrogen) (Koske *et al.* 2004).

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The latter is because AMF hyphae are spread throughout the substratum, which increases the plant's root surface area thus favoring greater water and nutrient uptake (Smith & Read 2008). Arbuscular mycorrhizal fungi establish an interaction with the plant's root system when propagules (mycelia, spores and portions of colonized roots) come into contact with roots. However, the probability of contact between propagules and roots has been shown to increase during the rainy season when root growth is higher (He *et al.* 2002).

Numerous studies have reported changes in plant composition from the coastline toward inland (successional stages) with a positive correlation with population of AMF fungi in coastal dunes (Sigüenza *et al.* 1996; Corkidi & Rincón 1997a). For example, plant species found in embryonic dunes have characteristics similar to those of pioneer species, such as greater resource allocation to growth and weak association with AMF (Cakan & Karatas 2006). Because of this, such dune zone exhibits a lower number of infective propagules and lower AMF colonization potential (Corkidi & Rincón 1997a). In contrast, plant species which establish in mobile dunes, which have a more humid soil, lower concentration of salts and a greater amount of mineral nutrients, exhibit greater levels of AMF colonization and more viable propagules in soil.

The association between AMF and coastal dune plants has been reported along the dune stabilization gradient (Koske *et al.* 2004), and benefits from this mutualism include increased plant growth (Corkidi & Rincón 1997b) to increased substratum stabilization (Koske & Polson 1984). Although the interaction between AMF and plants in coastal dune systems has been studied over the last 50 yr worldwide (Nicolson 1960), field studies addressing this topic have been scarce in Mexico. One of the few exceptions is the work by Sigüenza *et al.* (1996) conducted in a Mediterranean system in Baja California which reported an inverse relationship between water availability and sporulation. On the other hand, studies conducted under controlled conditions have reported a positive effect of AMF on growth of several plant species from dune systems of the Gulf of Mexico (Corkidi & Rincón 1997b). The main goal of the present work was to determine the presence of AMF in a coastal dune system in Sisal, Yucatan, Mexico, and describe seasonal and spatial changes in the AMF community associated with the coastal dune vegetation. Specifically, we addressed the following: (1) extent of AMF colonization in roots of dominant plant species of the coastal dune vegetation in the study area; (2) the number of AMF spores; and (3) the number of infective AMF propagules. These variables were estimated during two seasons (dry and rainy) and at three coastal dune zones found from the shoreline and moving inland (classified as embryonic [ED], mobile [MD] and stabilized dunes [SD]).

Materials and methods

Study site

The work was conducted in a coastal dune site close to the port of Sisal, located in the northeast portion of the Yucatan Peninsula, Mexico (21°11′13N, 89°58′26W). This zone had a low level of human disturbance, and plant cover was greater than 80 %. Climate at the study site is BS0(h′)(x′) semidry (García 1981), with a mean annual temperature that ranges from 24 to 26 °C and a mean annual precipitation of 600 mm. Vegetation structural complexity, density and height increase as one moves inland. Floristic composition and structure studies of the coastal sand dunes of Peninsula of Yucatan have been done by Espejel (1984) recording 202 species of angiosperms, of which 20 species grow on beaches and foredunes and 163 species are distributed indistinctly in foredunes and mangrove habitats. For the beaches and foredunes she mentioned the following herbs: *Sesuvium portulacastrum*, *Euphorbia buxifolia*, *Cakile lanceolata*, *Atriplex canescens*, *Ipomoea pes-caprae*, *Sporobolus virginicus*, *Distichlis spicata*, and shrubs *Suriana maritima*, *Tournefortia gnaphalodes*, *Scaevola plumierii*. For the internal and stabilized ridges (tops and slacks) and humid area close to mangrove she mentioned from Sisal the shrubs and trees *Maytenus phyllantoides*, *Caesalpinia vesicaria*, *Bravaisia tubiflora*, *Pithecellobium keyense*, *Krugiodendron ferreum*, *Bumelia retusa*, *Jacquinia aurantiaca*, *Coccoloba uvifera*, *Capparis incana*, *Gymnanthes lucida*, *Metopium brownei*, *Bursera simaruba* and *Diospyros cuneata*.

Selection of plant species

Quadrats were positioned mainly along one transect perpendicular to the coast according to the Braun–Blanquet approach (Mueller-Dombois & Ellenberg 1974). Quadrat size varied from 1 × 1 m (in the beaches) to 4 × 4 m in the coastal thicket. On the beach, plant cover is scattered, some species occur in patches surrounded by bare sand; in such cases quadrats were located in each of the patches, usually 1–2 m^2 in size, for example *S. portulacastrum*. In the case of beach pioneers with runners, e.g. *I. pes-caprae* and *S. virginicus* which may cover larger areas, quadrats were bigger. The following data were collected: species composition for each dune system using an ordinal scale and dominant species in each. Each dune zone was classified based on the life form of the dominant plant species as follows: pioneer vegetation found from the shoreline to the first dune or embryonic dune (ED), low shrub vegetation established on the second dune or mobile dune (MD), and higher shrub vegetation found in the stabilized dune zone (SD). Five dominant plant species were selected at each dune zone based on percent cover (see Fig 1).

Root and soil samples

Root and soil samples were collected in Mar. and Jul. 2005, which corresponds to months of dry and rainy season, respectively. Root samples taken for each species were 2 mm or less in diameter, and five individuals per species were used for each dune zone (ED, MD and SD), resulting in a total of 150 samples. Roots were carefully identified to belong to plant species of interest; roots were kept on plastic bags and transported to the laboratory.

Five 1 kg soil samples were randomly collected at each dune zone (ED, MD, SD) and for both seasons (dry and rainy). These samples were used for spore extraction and quantification as well as to estimate the number of AMF infective propagules. Samples were taken from depths not greater than 10 cm, as this is where most propagules are found.