VA-mycorrhizal fungi and soil characteristics in avocado (*Persea americana* Mill.) orchard soils

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Abstract

Soils from avocado (*Persea americana* Mill.) orchards in Israel (IS) and California (CA), both sites with a Mediterranean climate, were sampled and analyzed for the species and quantities of vesicular-arbuscular mycorrhizal fungus (VAMF) spores in them, and for soil physical and chemical characteristics.

Numbers of spores were similar in soil from IS and CA but the dominant VAMF species were very different. In IS the most common fungi were *Sclerocystis sinuosa* and *Glomus macrocarpum*. In CA, *Gl. constrictum* was present in every orchard examined and *Gl. fasciculatum* was nearly as widespread. *Acaulospora* spp. and other *Glomus* spp. also were found, including *A. elegans* which has never before been reported from CA.

The differences in VAMF populations and species constituents found on two continents but in areas with similar climates and soil types may be due to host or edaphic factors. Different avocado rootstocks are used in the two countries and lower pH and higher soil fertility levels were present in CA soils.

The total VAMF spore populations in each orchard was about 275 per 100 mL soil. The population level was not correlated with any of the soil physical or chemical characteristics examined nor with avocado cultivar or age. In IS no fungus spores were found in three orchards; available P, Ca, Mg and Cu levels were high in these soils.

Introduction

Vesicular-arbuscular mycorrhizal fungi (VAMF) commonly are associated with the roots of most of the plants growing throughout the world (Mosse *et al.*, 1981). Although the fungi are obligate symbionts they are not highly host specific and one species may be found on various plants in the same locale. Also, one host plant can support mixed populations of VAM-fungus species.

Cultivation in general and monoculture in particular reduce the spectrum of species found in a soil and relatively few species are present after several years of continuous cultivation (Allen and Boosalis, 1983; Daniels Hetrick and Bloom, 1983). Insufficient information is available to establish whether the climax mycorrhizal species depends upon the crops grown, the edaphic conditions or the climate at a particular location. Nemec *et al.* (1981) compared citrus in California and Florida. In Florida *Gigaspora margarita* Becker and Hall was the most common species found and in California *Glomus fasciculatum* (Thaxter *sensu* Gerdemann) Gerdemann and Trappe was present at 86% of the sites examined. Most citrus isolates of the latter fungus are now known as *Gl. deserticola* Trappe, Bloss
and Menge (Trappe et al., 1984). *Gigaspora margarita* has been reported only once from California (Menge et al., 1983) but *Gl. fasciculatum* is common in Florida (Schenck and Smith, 1981).

This study was initiated to determine the occurrence of VAM fungi from soils of a single host, *Persea americana* Mill. (avocado), in Israel (IS) and California (CA). Avocado is grown extensively in the two localities and as a perennial crop presents a relatively stable environment for the development of a stabilized mycorrhizal population. The climates in the avocado-growing regions of both countries are similar (Mediterranean) and the soil types and growing conditions also are similar. It might be expected that the VAM-fungus species and quantities would be similar also.

**Methods**

**Sampling**

Avocado orchards were sampled in the principal growing regions within each country: in IS the northern half of the country (latitude 31.5–33.5 N) and in CA the San Diego–Santa Barbara area (latitude 32.4–34.5 N). Within each country, the number of orchards sampled in each sub-region was approximately proportional to the percent of avocado acreage in the various sub-regions. Soil samples were collected from 25 orchards in CA and 34 in IS in August; spore populations are near their maximum at that time (Gemma et al., 1989; Saif and Khan, 1975). Two average-looking trees were selected. The leaf litter was removed from an area 1 to 2 m from the tree trunk. Where drip irrigation was being practiced the samples were removed from within 30 cm of an emitter. A 30-cm diameter and 30-cm-deep hole was dug. The soil was mixed thoroughly in situ and a 1.5 L sample of the mixture was placed in a plastic bag. This treatment was designed to avoid the non-normal distribution of spores found in counts from small core samples (St. John and Koske, 1988).

**Spore extraction and identification**

The soil samples were refrigerated (4°C) until processing. Within 2 weeks of collection a 200-mL aliquot of each soil was wet sieved (37–650 μm) and layered onto sucrose solution (20, 40, 60%) and centrifuged at 1700 × g (Daniels Hetrick and Skipper, 1982). Sand and some root fragments settled under the 60% sucrose layer; very light organic matter, including most of the empty fungus spores remained floating on the water layer on top of the gradient. Except for the floating material, the supernatant was removed to a 37-μm sieve, washed, decanted into a grid-marked 5-cm plastic dish, and the VAM-fungi were identified and counted. Spore morphology was ascertained under a compound microscope and identification was made using the keys of Hall and Fish (1979) and Trappe (1982).

**Soil analysis**

Soil analyses were carried out by the Agricultural Extension Laboratory, Univ. of California. Saturation percentage (grams of water required to saturate 100 g of soil) was determined and electrical conductivity and pH were measured in the water of the saturation paste (Chapman and Pratt, 1961). Available P was extracted from soil by 0.5 M sodium bicarbonate (Chapman and Pratt, 1961). Exchangeable soil calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were measured in lithium chloride and lithium acetate extracts (Yaalon et al., 1962), and soil zinc (Zn), manganese (Mn) and copper (Cu) were extracted using DTPA (Lindsay and Norvell, 1978); all were quantified by atomic absorption spectrophotometry.

**Results**

**Spore numbers and species**

The total number of VAMF spores extracted from each of the orchard soils ranged from 0 to 21 mL⁻¹ and averaged 3 spores mL⁻¹ in both IS and CA (Table 1).

Nine species of VAM fungi were found in IS and six in CA (Table 1); four species were common to both countries. The most ubiquitous species in IS were *Sclerocystis sinuosa* Gerd. and Bakshi, *Gl. macrocarpum* Tul. and Tul., *Gl.