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Soil properties linked to *Phytophthora cinnamomi presence and oak decline in Iberian dehesas*

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Dehesas cover about 3,100,000 ha in the Iberian Peninsula, and support an outstanding diversity of wildlife and flora endemisms. These open woodlands provide Spain and Portugal inhabitants with a high-quality food, derived from animal production, sustain rural population, and act as retardants of soil erosion and desertification, which are considered primary environmental concerns in the Mediterranean basin. Dehesas are considered examples of sustainable use, though in the last few decades intensive land use, imposed by a concomitant change in the technological and socio-economic conditions, and common agricultural policies threat their conservation. Soil compaction and erosion, oak regeneration failure, dieback of old-ageing stands, and loose of biodiversity are some of the most common threats.

At the same time, a severe decline of Quercus ilex (Holm oak) has been reported since the 1990s in the southern Iberian Peninsula, and more recently in France, Italy, and Morocco. In the Iberian Peninsula, the decline has been mostly observed in dehesas, where a combination of factors, possibly acting in synergy, have been put forward to explain the disease. Severe drought episodes, flooding, and rapid fluctuations in soil water content have been reported as predisposing factors favoring tree invasion by bark borer insects and/or pathogenic fungi.

It is mostly ignored to what extent decline is a natural or a man-induced process, and if it is associated to either basic, management-related soil properties, or both. To bring insight to this problem, extensive and integrative comparisons of some soil properties related to hydromorphism were initiated, comprising pairs of adjacent non-symptomatic and symptomatic Q. ilex trees. In 2008, 48 dehesa stands from western Spain (Cáceres), half of them located along stream banks and the other half located in slopes, were intensively studied. In each stand, soil and root samples were taken under 3 non-symptomatic (healthy) and 3 symptomatic (declined) trees, at surface, 50, 100 and 150 cm depths. Soil texture, redox potential, mineral N, and the presence of *Phytophthora cinnamomi* were determined. Soil bulk density was measured at the surface, and soil compactness was measured through a digital penetrometer at 0-40 cm depth.

In the stream banks, fine-textured soils were significantly more common under declined trees than under healthy ones, while in slopes the contrary trend occurred. Differences were clearly observed at layers located at 100 and 150 cm depth. Soil bulk density was moderate, with mean values of 1.05 and 1.07 g cm-3 (0-5 cm depth), and 1.28 and 1.30 g cm-3 (5-10 cm) for healthy and declined oaks, respectively.

Regarding soil resistance to penetration, values under declined oaks were significantly (p=0.012) higher below 20 cm depth, probably due to compaction caused by old cultivation practices. Most of the soil samples analyzed showed a high level of oxidation (superoxic and manoxic), 28% were suboxic and only 0.7% were anoxic, with a possible limitation of root growth. Although not significant, soils trended to be more reduced under declined oaks at stream banks, with a contrary tendency at slopes (Table 1). The presence of *P. cinammomi* in soil was positively related to oak decline in stream banks (p=0.011), but not in slopes, and associated to more compacted soils (p=0.05). The presence of *P. cinammomi* in roots was positively correlated with oak decay (p=0.01), being more abundant among 50-100 cm depth in slopes, and among 100-150 cm depth in the stream banks, but in both cases was mostly associated to fine-textured soils. In conclusion, Q. ilex decline was not related with anoxic conditions limiting root growth, but with soil properties leading to restricted water availability for trees in slopes, and with soil conditions favorable for *P. cinnamomi* root-infections in the stream banks.