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### ► To cite this version:

Thierry Mateille, M. Achouri, M. Ater, A. Belaj, Guillaume Besnard, et al.. PESTOLIVE: a mediterranean research project for understanding and managing soil-borne parasites on olive using historical and ecological approaches. 5. International Conference Olivebioteq 2014, Nov 2014, Amman, Jordan. hal-01603037

**HAL Id: hal-01603037**

**<https://hal.science/hal-01603037>**

Submitted on 3 Jun 2020

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# PESTOLIVE: A MEDITERRANEAN RESEARCH PROJECT FOR UNDERSTANDING AND MANAGING SOIL-BORNE PARASITES ON OLIVE USING HISTORICAL AND ECOLOGICAL APPROACHES

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## Abstract

PESTOLIVE (*Contribution of olive history for the management of soil-borne parasites in the Mediterranean Basin*) is a project funded by ARIMNet, an ERANET action supported by the 7th European Framework Programme and by non-European Mediterranean countries. PESTOLIVE aims at producing knowledge and tools for a new and efficient management of plant-parasitic nematodes (PPN) and plant-pathogenic fungi (PPF) in olive (*Olea europaea* L.) cropping systems and nurseries, while reducing the use of pesticides. Because of the anthropic continuum from *Olea* post-glacial refuges to Oleasters (domestication) and then to olive-trees (breeding and cropping), the fragmentation of the PPN and PPF communities and of their natural enemies could explain the scattered diversity of the control techniques (especially resistance rootstocks, biocontrol, cropping strategies) developed and applied all around the Mediterranean Basin. The novelty of PESTOLIVE is based on: *i*) the analysis and the management of the parasite diversity (ecology of communities) instead of controlling emblematic species (population approach), and *ii*) the involvement of knowledge about the historical co-adaptation of soil-borne parasite and natural enemies communities to olive-tree domestication (origins and past assemblages) and breeding that follows the history of *O. europaea* around the Mediterranean Basin.

**Keywords:** Breeding, domestication, management, olive, root-parasites.

## Hypothesis about soil-borne pest control by managing their diversity

Following objectives for restoration of disturbed agro-systems, it is becoming urgent to understand the contribution of parasitism within all degradation functions, in particular that of PPN and PPF, and especially in the context of fast programmed elimination of pesticides. On the other hand, the control of plant parasites leads to the decrease of their biodiversity whose risk should be assessed if biodiversity is considered as the driving force of ecological

resilience. Then, evaluating the ecological sustainability of plant resistance and of biocontrol strategies by assessing their long-term effects on parasite communities appears as a new research alternative for crop protection. The diversity of parasite communities can thus inform on the aptitude of environment to either facilitate or not the epidemic phenomena, on resistance and the resilience capacities of soils. The comparative studies of environment with contrasted anthropic levels (Mateille *et al.*, 2008) will seek for information and knowledge about biotic trade-offs in ecosystems, in order to introduce them in agro-systems (resilience).

Considering olive protection, PPN and PPF control strategies appear to be developed in each Mediterranean producing country according to their own constraints, depending above all on the parasite diversity encountered in each of them (Lockwood, 1988). Despite their high quality, researches conducted on plant resistance and biocontrol would lead to empirical results and practices if they are not based on knowledge about the origins of the parasite communities and about their past assemblages. Because of the anthropic continuum from *Olea* post-glacial refuges to Oleasters (domestication) and then to olive-trees (breeding and cropping), the fragmentation of the PPN and PPF communities and of their associated antagonists could be hypothesized and could explain their present distribution.

### **Aim of PESTOLIVE**

The aim of PESTOLIVE ([www1.montpellier.inra.fr/CBGP/pestolive](http://www1.montpellier.inra.fr/CBGP/pestolive)) is to help the development of new sustainable management strategies by involving enlightenment about historical co-adaptation of soil-borne parasite communities to olive-tree domestication, breeding and cropping. In order to provide adequate answers to questions emerging from the weakening of Mediterranean eco-anthroposystems due to soil-borne parasites, PESTOLIVE would develop an integrated network of pan-Mediterranean research focused on two soil-borne pest groups, PPN and PPF, and on their common antagonists, especially mycorrhizae.

### **Background: olive and associated soil-borne pests in the Mediterranean Basin**

Soil-borne parasites such as PPN and PPF are major damaging pests on olive trees, mainly in nurseries. They significantly contribute to economic losses in the top-ten olive producing countries in the world.

#### *Olive diversity*

The olive (*Olea europaea* L., Oleaceae) is one of the first domesticated trees (Zohary and Hopf, 2000). Phylogeography and population genetic studies have demonstrated the existence of highly differentiated oleaster genetic pools in the eastern and western parts of the Mediterranean Basin (Besnard *et al.*, 2001), which might have persisted in these two areas during the Pleistocene climatic glaciations (Terral *et al.*, 2004). “Modern” cultivars were selected in these regions, with a major contribution of the eastern wild stock (Besnard *et al.*, 2011). This olive diversity may induce various degrees of pathogenicity in soil-borne pests.

#### *Olive cropping systems*

During the last 20 years, olive cultivation expanded in certain countries such as Greece and Spain and, to a lesser extent, Italy and Portugal (Therios, 2009). New cropping programs push olive production with high technologies in South Mediterranean countries (e.g. Plan "Maroc Vert"). Several training systems, planting and harvest practices are used in Mediterranean countries according to varieties and to climatic conditions (Gucci and Cantini, 2004). Most of olive orchards in Mediterranean area were established for rainfall cultivation. Nowadays some of the traditional acreage is considered to be under irrigation and the most common method is a local variant of drip irrigation although irrigation schedules follow empiric standards. Even

fertilization is applied according to the interpretation of the growers about the need of the trees and nevertheless the nutritional status of regional olive groves seems fairly satisfactory (Godini, 2006). This large diversity of technical practices may influence a wide range of soil functions, including the contribution of soil-borne pests.

#### *Plant-parasitic nematodes*

Olive tree serve as hosts to a large number of PPN, of which root-knot nematodes (*Meloidogyne* spp.), root-lesion nematodes (*Pratylenchus* spp.), and spiral nematodes (*Helicotylenchus* spp.) (Fig. 1A) that are pathogenic and widely distributed in olive orchards and olive nurseries in the Mediterranean Basin (Castillo *et al.*, 2010). Their pathogenic effects result from disruption of plant root growth and function. Nematodes' damage to olive is particularly evident in nurseries, where optimum irrigation practices favour root proliferation and increased nematode populations (El-Borai and Duncan, 2005).

#### *Soil-borne plant-pathogenic fungi*

PPF as *Verticillium dahliae* (Fig. 1B) and *Phytophthora* spp. are the main soil-borne diseases affecting olive. *V. dahliae* occurs worldwide, whereas *Phytophthora* spp. attacks olive in waterlogged soils (Jimenez Diaz *et al.*, 1998). The large dispersion of *V. dahliae* has occurred concomitant with both the expansion of the olive crop and the changes in cropping practices, e.g. the use of self-rooted planting stocks, high-tree-density planting, drip-irrigation, reduced tillage, etc. in newly cultivated soils or fertile soils previously cropped with *V. dahliae* hosts (Jimenez Diaz *et al.*, 2011).

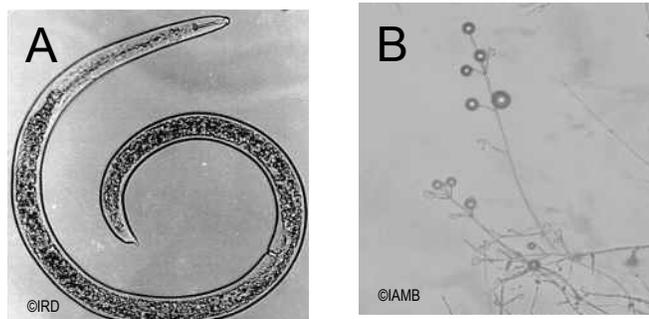


Figure 1: olive soil-borne pests. A: *Helicotylenchus* spp.; B: *Verticillium dahliae*.

#### *Mycorrhizae as antagonists*

Vesicular-Arbuscular-Mycorrhizal (VAM) fungi are obligate plant symbionts known for their general ability to promote plant health. VAM are consistently seen in olive roots in long-established plantations (Calvente *et al.*, 2004). However, there is not enough knowledge concerning the effect of cropping practices, olive varieties and environment (soil type and climate) on the biodiversity of VAM in the Mediterranean Region. In olive, some studies have demonstrated beneficial effects of VAM in reducing severity of root-knot nematodes and development of *Verticillium* wilt (Castillo *et al.*, 2006; Meddad-Hamza *et al.*, 2010).

### **Description of PESTOLIVE**

PESTOLIVE is breakdown in four scientific work-packages (Fig. 2). In WP1 (olive domestication and breeding), the analysis of the wild and cropped olive diversity (phylogeography and population genetics) all around the Mediterranean Basin associated with domestication history and breeding is a prerequisite to understand co-evolutionary patterns between pathogens and the olive tree. In WP2 (response of soil-borne organisms to

domestication and breeding), the spatial distribution of PPN, PPF and associated antagonists is explored to investigate: *i*) co-phylogeographic correspondences between plant and parasite diversities, and *ii*) life-strait genetic variation involved in community assemblages forced by anthropisation. In WP3 (response of soil-borne organisms to plant-resistance (ancestral & cultivars)), resistance against PPN and PPF is tackled in order to look for new resistance sources and to assess the durability of the resistance in terms of time remanence and of parasite diversity conservation. In WP4 (response of soil-borne organisms to cropping systems (low vs high inputs)), the capacity to manage PPN and PPF communities in a soil diversity conservation approach is assessed considering the very large range of olive production systems in the Mediterranean countries. PESTOLIVE is managed and coordinated in a specific work-package (WP0\_project management).

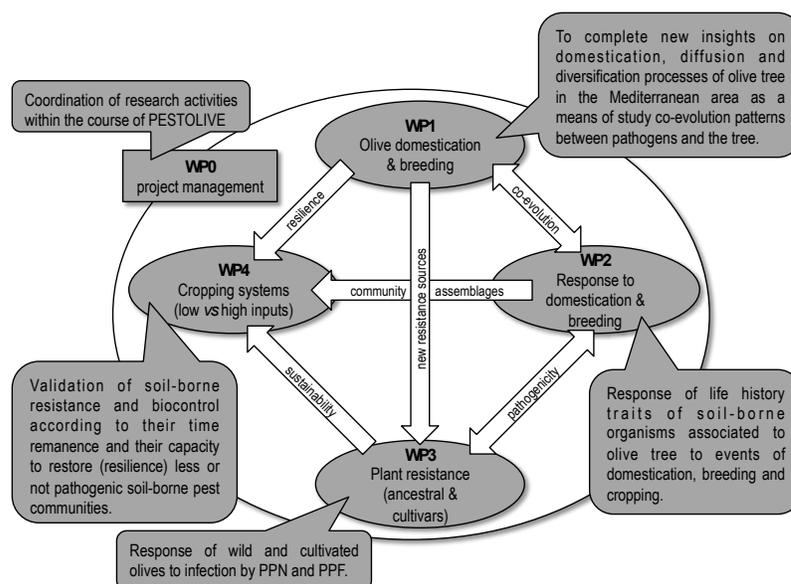


Figure 3: PESTOLIVE work packages and links.

### Partners involved in PESTOLIVE

PESTOLIVE involves 18 research and high education organisations from seven Mediterranean countries (Fig. 3) in order to promote international multidisciplinary collaboration, training co-supervision and shared technical platforms within the consortium. Attachments with national and international councils will guaranty communication with local producer organisations in order to fit with olive and oil production constraints vs to implement production strategies with innovative methods for soil-borne pest management. PESTOLIVE is part of the 10 projects funded by ARIMNet\_2012 (Coordination of Agricultural Research in the Mediterranean Area), an ERANET action supported by the 7<sup>th</sup> European Framework Programme and by non-European Mediterranean countries.

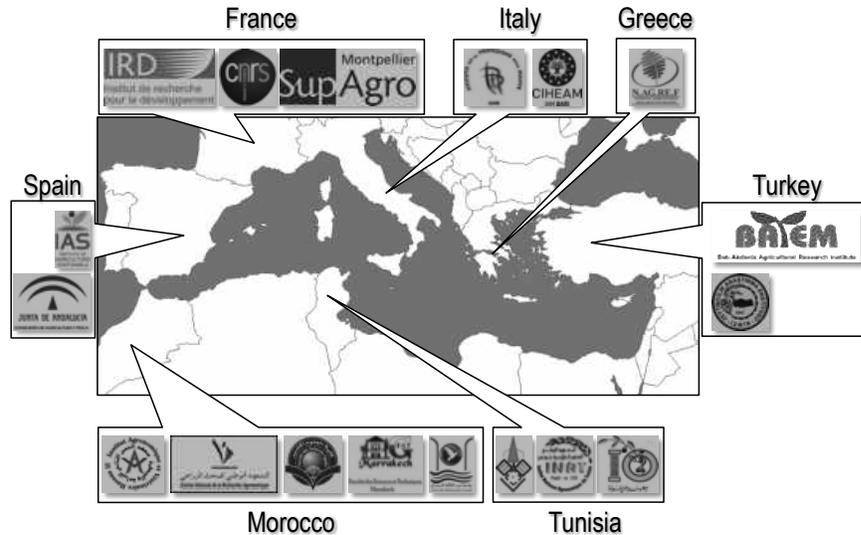


Figure 3: Research and high education organisations involved in PESTOLIVE.

### Acknowledgements

ARIMNet is coordinated by Dr. F. Jacquet and M. Ollagnon (INRA, France) and PESTOLIVE is co-funded by ANR (France), GDAR (Turkey), INIA (Spain), IRESA (Tunisia), MENESFCRS (Morocco) and NAGREF (Greece).

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