POnTE
PestOrganisms
ThreateningEurope

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POnTE Project findings and achievements

Xylella fastidiosa

What is *Xylella fastidiosa*

Xylella fastidiosa is one of the most harmful plant associated bacteria in the world. It can colonize more than 550 plant species and is pathogenic on a wide range of them, including grapevine, citrus, almond, oleander, peach, coffee, avocado, olive tree, and oak. Once confined to America, *Xylella fastidiosa* was first detected in Europe in 2013, on olive trees in Apulia.

The name *Xylella* comes from xylem, the plant vascular tissue that conveys water and dissolved minerals from the roots to the rest of the plant and also provides physical support, as *Xylella fastidiosa* establishes in the xylem vessels of host plants. The pathogen blocks the passage of drought and mineral nutrients causing severe water stresses, and as a consequence, in some cases, the death of the infected plant. The adjective *fastidiosa* is used due to the difficulties in isolating and culturing the bacterium, that was first discovered as agent in the 'California vine disease' described by Newton Pierce in 1892. The first successful isolation was performed in 1978 and a formal identification as the main agent responsible for Pierce's disease is dated 1987.

Outside Europe, the economic impact of *Xylella fastidiosa* is significant especially on citrus orchards in Brazil and grapevines in California. As a primary agent of Pierce's disease, the bacterium causes economic losses of around 100 million dollars per year in California. According to initial estimates, between 2013 and 2014, *Xylella fastidiosa* destroyed 8,000 hectares of olive groves in Apulia (Southern Italy) and, subsequently, it has expanded considerably to presently include a demarcated territory of about 7,000 km2, causing losses of around 53 million euros.
As of today, there is no curative treatment against *Xylella fastidiosa*. That makes the elimination of the sources of inoculum, the infected plants, and the control of the population of the insects transmitting the pathogen from one plant to another the only available strategy to contrast the spread of the bacterium.

Credits: EPPO

Symptoms of *Xylella fastidiosa* infection on citrus

a. *Xylella fastidiosa* in Europe

Since the first detection in Apulia, the presence of the bacterium in the open field has been reported in France (Corsica and the Provence Alpes Cotes d'Azur region), Spain (Balearic Islands, Madrid and Comunitat Valenciana-province of Alicante), Italy (Tuscany) and Portugal (Porto). Olive and almond are the major crop species affected by the bacterium. In Italy and, to a significantly lesser extent, Spain and France, the impact of the outbreaks, the size of the infected areas and the potential impact of the eradication measures triggered a social debate involving citizens and policy makers.

b. The POnTE Project

POnTE stands for Pest Organisms Threatening Europe. The 2015–2019 POnTE Project is an integrated response of European research to the emerging threat of invasive plant pests. Once a 'Northern world' problem originated by trade, today non-native plant pests are considered a global threat. According to some estimates they cost global economies up to 1.4 trillion dollars in biodiversity and economic losses. Global threats require a global response, and scientists and governments are expanding research networks all over the world, as well as the scientific disciplines involved, to be prepared to grapple with crop and forestry destructive pathogens. Financed by the European Union Horizon 2020 program, the POnTE Project brought together 25 partners from Europe and Latin America with expertise in plant sciences, entomology, agro-engineering and economics in order to develop a comprehensive and multidisciplinary approach to understanding of a group of plant 'pathosystems' including *Xylella fastidiosa* to which a relevant part of the project is dedicated is. The goal of the project is the development of early detection and surveillance tools, state-of-the-art knowledge and practical solutions against the spread of the pathogen within the EU territory, providing science-sound and effective prevention, control, mitigation and management solutions, covering phytosanitary as well as socio-economic dimensions

Credits: IPSP-CNR Bari

Symptoms of *Xylella fastidiosa* infection on olive trees

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Researchers of the IPSP-CNR of Bari and the POnTE Project at work

POnTE and *Xylella fastidiosa:* main findings and results

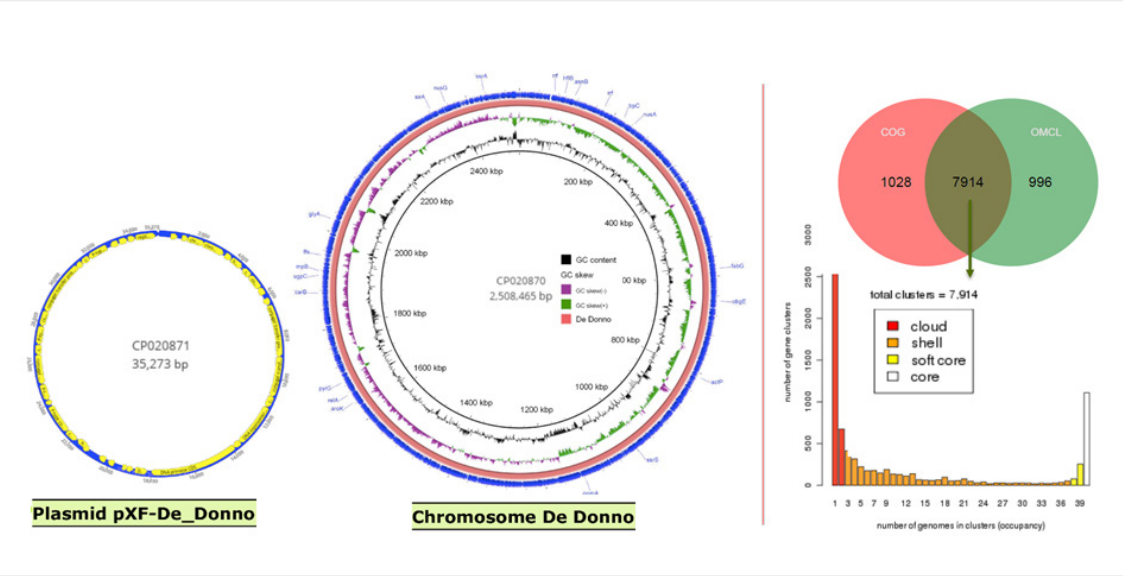
1. Scientists sequenced the complete genome of the *Xylella fastidiosa* strain associated with Olive Quick Decline Syndrome in Apulia. The strain, named 'De Donno', is the most virulent detected in the EU so far.

Why is this important?

The "De Donno" is the first EU reference sequenced strain and a basic element for designing future strategies of prevention, management and control of the infection. Thanks to the genome sequencing, scientists confirmed a link between the Italian and Costa Rican strains, supporting the hypothesis about the Central American origin of the bacterium detected in Apulia, and that plant material exchanges with these countries pose major risks and should be accurately monitored. Plus, studies outlined the great genetic variability among the isolates found in Europe, suggesting that several independent introductions have occurred in the EU and confirming the high level of adaptability of the bacterium.

Challenges

The genome sequencing is the first and essential step for building knowledge on the characteristics of the *Xylella fastidiosa* pathosystems in the EU and worldwide. The traits and the features that make this strain very aggressive in olives (and other species) are still unknown. On the other hand, leveraging genetics to understand the interactions that the pathogen establishes with the olive plants that succumb to the infections is critical for developing tools to counteract its detrimental impact. The genetic characterization of the pest is an essential element of this approach. However, it is not enough. Scientists must match the current knowledge on the genetics of the bacterium with pathogenicity tests on the field ("study the pathogen in the real world"). In particular, a program of laboratory tests with the different strains and the potential hosts is needed to complement the genetic information with a more complete comprehension of the actual interactions of the *Xylella fastidiosa* epidemics with the variegated environments in which it establishes.



Credits: IPSP-CNR Bari

The genome diagram of the *Xylella fastidiosa* 'De Donno' strain

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Field trials of olive varieties resistant to the infection

2. Tests have demonstrated empirically that the De Donno strain is the main cause of the Olive Quick Decline Syndrome in Apulia and that **some olive varieties show traits of resistance to the infection.** Once inoculated with the bacterium on the field and in greenhouses, some olive cultivated varieties expressed less severe symptoms compared to the most widespread varieties in Apulia, which suffered a deadly impact from the bacterium.

Why is this important?

Thanks to the discovery of these traits of resistance, the Italian and European authorities could repeal the prohibition of planting new olive trees in the infected area, giving new hope to olive growers living in the lands where the bacterium is impossible to be eradicated.

Challenges

The traits of resistance in olive germplasm are one of the most promising areas for research to control the spread of *Xylella fastidiosa* on olive trees in Italy. In fact, the resistance relates not only to the symptoms but also to the bacterium population (the reason because it is named “resistance” and not “tolerance”), reducing the risk of contagion. Tests in laboratory, greenhouses and on the field are time and resource consuming but must continue to ensure the possibility for maintaining the high cultural and economic valued olive groves in Southern Apulia with no risk for the rest of the EU territories.

Credits: IPSP-CNR Bari

Field trials of olive varieties resistant to the infection

Credits: IPSP-CNR Bari

The spittlebug *Philaenus spumarius*, the main vector of *Xylella fastidiosa* in Apulia

3. Results of the experiments provided **information and potential solutions to keep the vector population under control**.

Scientists have carried out specific studies on the spittlebug *Philaenus spumarius*, the main ascertained vector of *Xylella fastidiosa* in Apulia. Feeding themselves with the plant sap, the spittlebugs can acquire the bacterium from infected plants and transmit (spread) to others. Specific tests provided the first measurement of the active movement of this insect. *Philaenus spumarius* is the dominant species of 'sap-feeder' fauna in Europe, but researchers also identified new candidate vectors, such as *Neophilaenus campestris* and *Philaenus italosignus*.

As part of the POnTE Project, scientists demonstrated that key actions taken at the appropriate time can reduce the population of *Philaenus spumarius*, possibly mitigating the spread of *Xylella fastidiosa*. These steps should primarily address juvenile spittlebugs. It is also critical to decimate the adults before they acquire the ability to transmit the bacterium. In this regard, within the project, several formulations were tested and compared.

Why is this important?
As of today, expanding the knowledge of the vector and setting up strategies for the control of its population are essential for the eradication of *Xylella fastidiosa*. The transmission is known to be non-specific, so all sap-feeder insects are considered potential vectors in Europe, until proven otherwise. Hence, the importance of identifying the insect "vectors" occurring in an area affected by *Xylella fastidiosa* is critical for designing sustainable and well-targeted control strategies. Nonetheless, spittlebugs had a minor role in the well-studied epidemics in the American continent, thus very scarce information was available before the beginning of the project.

Challenges

The POnTE Project findings also raised new questions about the transmission of the disease. Continuing research into this aspect is paramount for the management, monitoring and control of the pest. Further surveys and studies to gather more detailed information on the relation between specific local species and the transmission of the infection are needed.

Regarding control strategies, testing of chemical formulations to control adult spittlebugs showed that the majority of the products had low persistence compared to the bugs' life span. This suggests that new products and chemicals are needed, along with trials to determine the proper timing and number of applications for the effective management of this vector. Moreover, an integrated pest management approach is the best option to manage spittlebug populations along with a sustainable strategy to reduce the progress of infections in olive groves or other crops.

When on the ground, the spittlebug *Philaenus spumarius* protects itself with foam

Credits: IPSP-CNR Bari

Credits: IPSP-CNR Bari

Capture of *Philaenus spumarius* specimens

4. Thanks to the POnTE Project, researchers tested a wide range of options to **control the *Xylella fastidiosa* related diseases in the infected plants**, taking into account the widest range of potential solutions. These experiments, however, generally take longer than the 4-year time span of the POnTE Project. Exploring end exploiting the community of microbes (microbiome) living in the xylem tissues of the plants gave some encouraging results on the *Xylella fastidiosa* subspecies infecting vines in the US. However, their effectiveness on olive trees and the Apulian strain is still to be demonstrated. The use of N-acetyl-cysteine on *Xylella-infected* citrus in Brazil showed promising results, but after 4 years of testing on infected olive trees in Apulia, no significant amelioration of the disease was recorded. This indicates that the damage and the interactions that *Xylella fastidiosa* establish in citrus are different from those in olives, which provides additional evidence on the great complexity of this pathogen, requiring case by case specific experimental testing and control actions.

Why is this important?

Since a cure for *Xylella fastidiosa* is still unavailable, finding practical ways to keep the bacterium related diseases under control is one of the most effective ways to defuse the pest threat.

Challenges

The ongoing experiments require long-time efforts and multiannual tests. Most of them are in the preliminary stages, in particular, the pioneering research on the olive tree xylem microbiome. Even when there are encouraging results on some of the solutions tested, further research is required to identify the most effective application methodology on the ground

Credits: IPSP-CNR Bari

Susceptible olive trees treated with N-acetyl cysteine. Despite repeated applications, plants show severe dieback and poor vegetation.

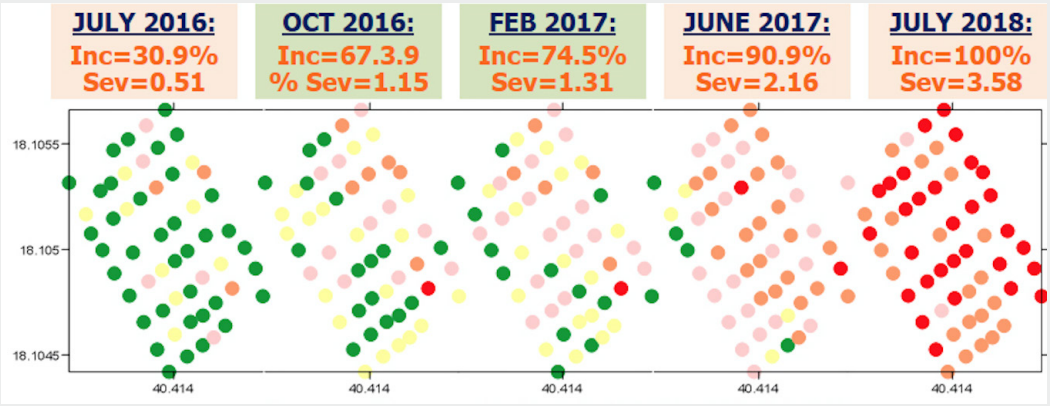
5. Remote sensing systems for early identification of *XF* infected trees were successfully tested. These work at the pre-visual stage also, i.e. when the symptoms are not yet evident. This can mitigate the invasiveness of the sampling and tests needed on the farm.

Why is this important?

This technology enhances the timeliness and the precision of surveys when large areas are to be inspected. More accurate predictions of potential spread and more targeted interventions reduce the invasiveness of the sampling activity. This is important not only to ensure an early warning system but also to lessen the burden of some controls on the spot, improving the social acceptance of plant health management measures.

Challenges

The POnTE Project demonstrated that an early warning system is scientifically plausible, even for pests with very slow symptomatology such as *Xylella fastidiosa* associated olive quick decline syndrome. Now, this knowledge must be translated into practical strategies, both in the development of machinery and in the design of plant health management programs.



Credits: J.A. Navas (IAS-CSIC, Spain)

Graphic representation of the progress of incidence (Inc) and severity (Sev) of *Xylella fastidiosa* symptoms in a olive orchard in Apulia from July 2016 to July 2018

6. The researchers collected important epidemiological data following for several years the expansion of the disease in some olive groves. Olive groves showed over four years a dramatic increase of the disease incidence (reaching in most cases 100% of diseased trees) and symptom severity. Overall, the data collected confirmed that under the favorable conditions occurring in Apulia and without applying control measures, infections rapidly expand and progress decimating the entire groves.

Why is this important?

Monitoring the expansion of the disease in the olive groves has shown that initial disease foci determine the spatial pattern of the diseased trees, with new disease foci often appearing close to the initial disease foci suggesting a short distance secondary spread by insect vectors. This first dataset of information on how the disease progresses reinforces the concept of removing susceptible infected plants and of controlling the insect for reducing the chances of further expansion.

Challenges

Disease severity and incidence for the cv. Leccino thought to be resistant to *Xylella fastidiosa* support the evidence that growing olive cultivars with traits of resistance may contribute to mitigate the impact of the infections. More experimental data are needed to estimate the impact of using alternative crops and resistant species for the reconstruction of the olive growing area decimated by the epidemics.

The Home Page of the POnTE Project website

Credits: IPSP-CNR Bari

Researchers talking to students on the *Xylella fastidiosa* epidemic in Apulia

7. Researchers have been disseminating the results of POnTE through a website, leaflets and brochures available in several partner languages **and in particular in hundreds of meetings and conferences** with other scholars, institutions and stakeholder representatives, and citizen organizations in Italy and Europe.

Why is this important?

Xylella fastidiosa epidemic is still a topic sparking controversy in Apulia, due to the economic and cultural value of olive trees in the region. Against this background, the direct engagement of scientists and experts in the communication to citizens is a crucial innovation.

Challenges

Differently from other plant pests, the olive quick decline in Southern Italy made the headlines news. The announcement of the eradication program sparked debate in society, unveiling the importance of taking into account the social and economic dimensions of plant pest management. The need for supplying science-based solutions that are feasible on the ground and the ability to explain the research contributions to non-experts are among the main challenges for scientists dealing with invasive plant species. This is why the POnTE Project included social scientists and gave importance to communicate the most relevant achievements to citizens. This is a small yet significant first step to shorten the gap between science and society and reinforce the trust between scientists and citizens, that appear to be the most sensitive issue of our time.

Credits: IPSP-CNR Bari

Researchers talk to farmers

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