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Xylella fastidiosa: options for its control

Parallel Workshop at Conference "Health Checks and Smart Treatments for Our Plants"
EXPO Milan, 15th July 2015

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Parallel Workshop at Conference "Health Checks and Smart Treatments for Our Plants" EXPO Milan, 15th July 2015

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AIM AND STRUCTURE OF THE WORKSHOP

The workshop "***Xylella fastidiosa*: options for its control**" was organised as a parallel session of the conference "Health Checks and Smart Treatments for Our Plants" at EXPO Milan on the 15th July 2015. This workshop was organised per invitation with a limited number of participants, experts in the field, with wide range of expertise, with the aim to provide a background document and ideas in preparation of a wider audience workshop to be organized in fall 2015 for identification and discussion of knowledge gaps and research priorities on *X. fastidiosa* in the EU. A summary of its conclusions were presented at the final session of the Conference "Health Checks and Smart Treatments for Our Plants" and the final report is to be published on the Bioeconomy website http://ec.europa.eu/research/bioeconomy/

The overall aim of the discussions was to discuss the control of the bacterial plant quarantine pathogen *X. fastidiosa*, sharing experiences, pinpointing bottlenecks and lacking 'tools', and identifying areas for conducting research in the EU. Consideration was also given to whether tools/technologies or management strategies, control measures/technologies used for other plant pests could also support the control of *X. fastidiosa*.

The meeting was structured around two sessions, the first one focusing on the presentation of country specific experiences from the US, Brazil and Italy and the second one allowing for collective discussions on the following themes and questions:

1. Detection/monitoring
    a. What is there? What has worked/failed?
    b. Which 'tools' are missing?
    c. What can we use from other systems?

2. Biology of bacterium/Control
    a. What is there? What has worked/failed?
    b. Which 'tools' are missing?
    c. What can we use from other systems?

3. Biology of vectors/Control
    a. What is there? What has worked/failed?
    b. Which 'tools' are missing?
    c. What can we use from other systems?

4. Putting the problem in the context of the various production systems (conventional, IPM, low input/organic)
    a. What is there? What has worked/failed?
    b. Which 'tools' are missing?

The workshop was moderated by Annette Schneegans, Research Policy officer at DG AGRI, and by Mike Jeger, Chair of the Scientific Panel on Plant Health of the European Food Safety Authority (EFSA). The workshop started with a number of presentations, followed by discussions.

PRESENTATIONS

The emerging worldwide threat *Xylella fastidiosa*

Rodrigo Almeida, University of California, Berkeley, California, USA, presented the state of the art of the emerging worldwide threat *X. fastidiosa*, discussing factors affecting plant disease epidemics (host, pathogen, vector, time, management practices, multitrophic interactions, abiotic conditions, surrounding vegetation), the pathogen *X. fastidiosa* and the main types of epidemics observed for this bacterium. Plant disease epidemics involve different layers of ecological complexity: environment, vector ecology, pathogen ecology, host plant ecology, outcome of interactions, disease management. *X. fastidiosa* is a xylem-limited bacterium, colonizing a wide range of host plants (over 300 plant species reported), in many species without causing disease symptoms. The main pathway for the introduction and dispersal into new areas of *X. fastidiosa* is considered the movement of infected, and potentially asymptomatic, planting material, particularly for vegetatively propagated crops. It is reported in the Americas, Italy, Taiwan and Iran. In North America it causes disease in grape at least since the 1880s. The major crops affected worldwide are grape, citrus, olive, peach, almond, plum, coffee, etc. The xylem sap-feeding insects are the only vectors, without pathogen-vector specificity, therefore it is considered that any xylem sap-feeding insect is a potential vector for this pathogen. Three main types of epidemics for *X. fastidiosa* were presented: the introduction of an invasive pathogen into new areas with susceptible hosts and vectors; introduction of a vector into an area with endemic pathogens; and pathogen adaptation to new host plant species.

The first is a typical situation in our global trade network where human-mediated transportation brings a new pathogen into new geographical areas where it finds susceptible hosts and endemic vector(s): this has been shown in several cases by phylogenetic analysis for various strains of *X. fastidiosa* and it is likely the case also of the Apulian outbreak where the strain from olive trees has been found genetically identical to a strain from oleander in Costa Rica. The outbreak in Apulia has also shown to be strongly characterized by a high social and media impact connected to the Mediterranean olive trees cultural heritage and to media presentation of science.

Another case is the introduction of a vector into an area with endemic pathogens. For example, the introduction in California of the glassy winged sharpshooter (GWSS) *Homalodisca vitripennis*, has caused a large impact on grape production. The GWSS reaches very large populations on citrus trees, which gives the occasion for more frequent encounters of vectors with the endemic pathogen *X. fastidiosa* and therefore to more successful infections, leading to higher disease incidence and also to the occurrence of new diseases, probably due to new vector-plant-pathogen associations. Also in this case the introduction of a new vector is mostly linked to human-mediated transportation.

The third case is new epidemics due to pathogen adaptation. In *X. fastidiosa*, recombination appears playing a more important role than point mutations. Such could be the case for example of the subspecies *morus* which is a recombinant of the subspecies *multiplex* and *fastidiosa*. Also the taxon ST53 is a recombinant member of the subspecies *pauca* genotype, only detected in Costa Rica and Italy.

Epidemiology and Management of Pierce's Disease in California

Rodrigo Krugner, Agricultural Research Service, USDA, California, USA, presented the epidemiology and management of Pierce's disease (PD) of grapevine in California. PD, caused by *X. fastidiosa* subspecies *fastidiosa*, costs California US$104 million per year (Tumber et al. 2014). Symptoms of PD include foliar discolouring and distortion, irregular patchy bark maturity, and defoliation with petioles remaining attached to canes. After infection, vine death may occur within one or two years. Diagnosis is based on symptoms and diagnostic testing by ELISA, PCR, and/or culturing followed by PCR. PD is present in most grape growing regions of California, but different species of xylem-sap feeding sharpshooters (Hemiptera: Cicadellidae) act as vectors in each affected region. As the vector species move into the vineyard a vine-to-vine spread of the pathogen can be observed. Although habitats such as non-cultivated land, orchard floor, and cover crops can have high percentage of grass cover during winter and spring months, only habitats with permanent grass cover (i.e., irrigated pastures and drainage ditches) were shown to sustain robust populations of the vector *Draeculocephala minerva* throughout the season. Despite higher numbers of *D. minerva* in irrigated pastures compared to weedy alfalfa fields, fewer plants tested positive for *X. fastidiosa* in pastures than in weedy alfalfa fields (Krugner et al. 2012). Glassy-winged sharpshooter (GWSS), *Homalodisca vitripennis*, is an invasive vector detected in southern California in 1990 but since then it has spread into other areas (Sorensen and Gill 1996). According to the California Department of Food and Agriculture (2001), about 150 ha of grapevines were lost in Temecula Valley due to Pierce's disease/GWSS in 1999.

GWSS uses evergreen plants such as citrus and olives as overwintering and reproductive host. *X. fastidiosa* is not known to infect citrus in California, but can infect olives. Vector transmission assays demonstrated that GWSS could transmit strains of both subspecies *multiplex* and *fastidiosa* to olive at low efficiency. Multi Locus Sequence Typing analysis (MLST) of olive strains of *X. fastidiosa* (LM10, RH, and Fillmore) showed that isolates were closely related to strains of subspecies *multiplex*. In pathogenicity tests using *X. fastidiosa* strains obtained from olives and inoculated to olives, grapevines, and almond plants showed that olive strains caused almond leaf scorch disease, but did not cause disease in olives or PD in grapevines (Krugner et al. 2014).

Exclusion of the pathogen, avoidance of the pathogen, cultural practices, control of insect vectors and disease resistance are some of the control measures for PD. For instance, simulation models indicated that efficient replacement of infected plants combined with a high degree of compliance among farms effectively slowed pathogen spread, resulting in replacement of few plants and high yields (Sisterson and Stenger 2013). Conventional backcross breeding (*Vitis arizonica* × *V. vinifera*) conducted at the USDA in Parlier, California, has identified advanced selections of table and raisin grapes that are resistant to PD. Several accessions of high fruit quality and resistance to PD were made available through the use of marker-assisted selection (Riaz et al. 2009).

For the control of PD, identification and removal of infected vines is recommended to reduce the source of inoculum as well as the reduction of GWSS populations in citrus orchards and vineyards by a combination of soil and foliar applied insecticides. However, apart from the chemical control of GWSS, native or exotic egg parasitoids of GWSS such as *Gonatocerus ashmeadi* and *Gonatocerus walkerjonesi* can have a great impact on vector populations by attacking 95 to 100% of vector eggs in some periods and regions (Krugner et al. 2009, Lytle and Morse 2012).

***Xylella fastidiosa* in citrus in Brasil – distribution, damages and management practices**

Silvio Lopes, Fundecitrus, São Paulo, Brazil, presented the distribution, damages and management practices for *X. fastidiosa* disease in citrus in the State of São Paulo. In 2015 citrus production covers 492 000 hectares (mostly sweet oranges) with 174 million productive trees. These plantations produce an estimate of 11.4 million tons of citrus fruit and 230 000 jobs. *X. fastidiosa* is a threat to citrus. It was first observed in the xylem in 1990 (Rossetti et al., 1990), with the cause of the disease experimentally demonstrated only in 1993 (Chang et al., 1993) and the vector transmission in 1996 (Roberto et al., 1996). The disease is called "Citrus variegated chlorosis" (CVC) which is characterized by yellow and gummy spots on leaves, smaller and hardened fruits (more fruits are therefore needed to fill a box), and progressive tree decline. Highly affected trees become unproductive and estimated 6 million trees (3%) were eliminated each year because of CVC. Several insect vectors have been identified. Based on first epidemiological data heavy losses were predicted but the overall production has not significantly declined. Disease management is based on planting of healthy nursery trees, elimination or pruning of symptomatic trees and control of the insect vectors (TPS, three-pronged system). In the past citrus nurseries were grown outdoors, today it is obligatory to grow nursery trees under insect proof screen houses with high hygiene standards. Vector control is based on treatments of citrus plants with systemic insecticides before and after leaving the nursery and, following insect population monitoring, systemic and contact treatments before start of fruit production and only contact treatment after starting fruit production. Pruning is performed for trees older than 3 years, showing initial symptoms, by cutting the symptomatic branch at least 70 cm below the lower leaf with symptoms. Scion substitution experiments have been conducted with the replaced scions on Rampur lime 'Cravo' rootstock showing no CVC symptoms (Lopes et al, 2010). Weeds in citrus orchards were found infected with *X. fastidiosa*, however they do not act as inoculum source for citrus trees (Lopes et al 2003). Although coffee (a second host of *X. fastidiosa* in Brazil) and citrus plantations are sometimes neighboring, the coffee strain of *X. fastidiosa* was never found naturally affecting citrus and vice versa. In conclusion, CVC continues causing losses to citrus growers in Brazil but the overall Brazilian production is not being significantly affected. The main reason is probably the deep decrease in the incidence of symptomatic trees (from 40% in 2011 to less than 7% in 2015). This significant decline is the consequence of (i) the broad and more intense use of the three-pronged management system to control Huanglongbing (HLB, another and potentially more damaging citrus disease), with the insect vectors of both diseases being controlled regionally and in a coordinated way by groups of growers, (ii) the removal of affected trees being carried out in large blocks, (iii) the migration of new citrus plantings to less affected areas, and (iv) the use of larger number of trees per unit of area.

Measures against *X. fastidiosa* in Apulia

Marina Barba, CRA - Plant Pathology Research Centre, Rome, Italy, presented the measures taken in Apulia against *X. fastidiosa*.

Following the discovery of *X. fastidiosa* near Gallipoli in Lecce province (IT) in October 2013, more than 30 000 diagnostic tests have been conducted with the aim of determining the northern limit of the outbreak area. The province is now divided into four areas: the infected zone (where the pathogen is considered established and rouging infected plants is not compulsory), an eradication zone where the pathogen is present in few areas and is under official control and eradication, a buffer zone where the pathogen is not present and which is subjected to intensive monitoring and control practices particularly focused on vectors populations; a surveillance zone north of the buffer zone with intensive monitoring surveys. In the above zones the infected plants have been mapped and the management of the monitoring data has been fully computerized. The graphical representation of the areas monitored and their results are available on the official website of the Apulia Region (www.emergenzaxylella.it).

On 10 February 2015, the Council of Ministers declared a state of emergency for *X. fastidiosa* in Apulia, followed by appointment of a Delegate Commissioner (State Forestry Corps). On 19 March 2015, an action plan approved for which a fund of 13.6 million Euro was allocated to implement measures including control of movement of plants and the control of the vectors' population. More specifically the actions taken were: Action 1. Removal of host plants located near roads, canals, green areas; Action 2. Control of vectors on wild herbs and weeds; Action 3. Phytosanitary treatments for the control of adult vectors; Action 4. Removal of infected plants; Action 5. Destruction of host species in nurseries; Action 6-9. Horizontal activities.

Regarding Action 1, 2 530 plants were removed on streets and parks for a covered surface of respectively 1 204 km and 263.93 ha in eradication and buffer zones. In Action 2 the juvenile stage of vectors on wild herbs and weeds were controlled mainly in surveillance, buffer and eradication zones. Concerning the Action 3, adult stage vectors were controlled by phytosanitary treatments mainly in surveillance, buffer and eradication zones. Agronomic practices such as soil tillage in spring has shown to significantly reduce vector juveniles' populations. In Action 4, eradication of infected plants took place mainly in Oria outbreak. Lastly, in Action 6-9. a series of different activities took place in order to raise awareness such as website launching, meeting with farmers, distribution of 16 000 informative leaflets and others.

Additionally, financial compensation procedures for farmers have been started by the Italian government and a new action plan will be issued by the commissioner in collaboration with experts. The State Forestry Corps is already involved in the management of *X. fastidiosa* emergency and The Forestry officers (about 500 units) will be used to improve phytosanitary controls on plants and plant products in the import through national points of entry and to contrast *X. fastidiosa*.

The epidemic of *Xylella fastidiosa* in Puglia: the state of the art

Donato Boscia, CNR - Institute for Sustainable Plant Protection, Bari, Italy, presented the state of the art of the epidemic of *X. fastidiosa* in Puglia, Italy.

An outbreak of *X. fastidiosa* has been found in Apulia (south-eastern Italy) in olive trees severely affected by a novel disease denoted "Olive Quick Decline Syndrome" (OQDS), a destructive disorder that appeared a few years ago in a restricted area near Gallipoli (province of Lecce, Salento peninsula). Although the etiology of the new disease has not yet been determined, the finding of this quarantine bacterium in the European Union (Directive 2000/29/EC) prompted urgent investigations to address the many open questions. Hereafter, a brief overview is presented of the olive disease, the main outcomes of the research program under way.

Detection and isolation of *X. fastidiosa:* The initial identification of the bacterium in the OQDS-affected olives was achieved through specific PCR assays, followed by sequence analysis (Saponari et al., 2013). Subsequently, an interlaboratory validation of serological (ELISA) and molecular (PCR) assays allowed the finalization of diagnostic procedures for a sensitive and reliable detection of the bacterium in olive tissues, which were adopted for large-scale surveys in the Apulian region (Loconsole et al., 2014).

Axenic cultures of the *X. fastidiosa* isolate present in the Lecce province have been obtained (Cariddi et al., 2014, Saponari et al., unpublished) from olive and other species hosting the bacterium. Electron microscope observations have disclosed accumulations of bacterial cells in the tracheary elements of olive with thick and rippled cell wall that are characteristic for *X. fastidiosa* (Cariddi et al., 2014).

Genetics and biology of the bacterial strain: Molecular data have provided strong evidence that the olive isolate of *X. fastidiosa* is related to the subspecies *pauca*, but is clearly distinct from the *pauca* strains so far characterized, so that a new "Sequence Type –ST" profile was assigned to it, based on multilocus sequence typing analysis. The distinctiveness of the olive isolate from the known *pauca* strains, strongly supports the notion that it represents a novel entity, for which the name *X. fastidiosa* strain CoDiRO has been proposed. Analysis of the draft genome of the CoDiRO strain recently obtained (Giampetruzzi et al., 2015) further confirmed the correctness of this taxonomic allocation. The surveys carried out in the contaminated Apulian area have shown that 18 plant species, including olive, almond and cherry, but not grapevine and citrus, are susceptible hosts under natural field infections.

Identification of the vector(s): In the course of a survey of hemipterans occurring in the affected olive groves initiated in November 2013 several individuals of *Philaenus spumarius* were collected, a high percentage of which (more than 50%) harboured *X. fastidiosa*. Transmission tests with field-collected insects showed the ability of *P. spumarius* to transmit *X. fastidiosa* strain CoDiRO to several hosts of the CoDiRO strain, olive included (Saponari et al. 2014; Cornara et al., unpublished).

PLENARY DISCUSSIONS

Detection and monitoring

Many plant species are reported as hosts of *X. fastidiosa* without expressing symptoms. In addition, in many host plants the development of symptoms can occur several months after infection. Expression of symptoms in the crops can be linked to multiple infection events and high populations of vectors. This makes early detection and surveys of *X. fastidiosa* difficult. To support detection and monitoring programs, there is a need to know well the epidemiology of *X. fastidiosa* in a given environment. Appropriate sampling strategies in the plants and in the landscape need to be developed (Where does the infection occur first in the plant? How are the bacteria distributed in the plant spatially and seasonally? Which plants should be sampled and where?). The knowledge of pathways of introduction and of the spread patterns in time and space is needed to support the planning of surveys, which can benefit also of remote sensing technology, including the analysis of standard photographs, or more sophisticated multispectral images acquired from manned aircraft.

The analysis of purpose-collected high resolution aerial photographs can serve for example to map areas where heavy pruning has occurred, or where trees show severe levels of canopy discoloration or defoliation. The use of more sophisticated aerial imagery, including multispectral and thermal imagery, could be studied to detect earlier and lower levels of disease symptoms in the canopies of olive trees.

Such mapping based on the visual or automated analysis of remote sensing data could inform the planning of in situ surveys. Because of their lower spatial definition compared to aircraft imagery, images obtained by Earth orbiting satellites are unlikely to detect disease symptoms before they are widespread. Imagery collected by Remotely Piloted Aerial Systems (RPAS, or 'drones') could be suited to survey smaller areas, but current aviation regulation prevents them for being used for regional surveys.

Citizen science could play a role in areas where disease is not yet present, e.g. by an early observation and reporting of typical symptoms in a given crop, however, as mentioned above, it is limited by the occurrence of many asymptomatic hosts and the sometimes long incubation period between initial infection and symptoms expression. There are effective molecular tools for the detection of the bacterium. The development of methodologies for field rapid detection can support surveys and reduce movement of samples from field to laboratory. Surveys and certification of nurseries can significantly reduce the spread of bacteria by eliminating distribution of infected plants to bacteria-free zones. The importance of international fora was highlighted as a means of providing opportunities for discussion, harmonisation and sharing of surveillance and monitoring of important emerging plant pests such as *X. fastidiosa* across the world.

Biology of the bacterium/control

With regard to pathogen adaption, although *X. fastidiosa* is a highly recombinant species, it was noted that the isolates of CoDiRO strain of in Apulia are genetically homogenous and belong to a single group. It was also observed that the frequency of recombination is expected to be higher in natural environments than in cultivated crops where genotypes are more isolated. There is some work showing that this pathogen can somehow adapt to higher temperatures but adaptation to lower temperatures has not been studied yet. *X. fastidiosa* genotypes are however typically associated with climates and crops.

With regard to control measures, although there are some ongoing research lines, there is not yet an effective control method of the pathogen applicable in the field. Control of *X. fastidiosa* is therefore currently achieved by removing sources of inoculum, using healthy plant propagation material and controlling the vector(s).

Use of resistant or tolerant varieties to *X. fastidiosa* can also play an important role in the disease management. Each genotype of *X. fastidiosa* is different in terms of host range (whereas the general biology of the bacterium will remain the same), therefore host range of a new genotype cannot be derived from literature but studies need to be conducted. However, due to vector preference for host plants, there will be a difference between the artificial host range inferred from laboratory studies and the actual host range determined by vectors for a given strain and region.

Participants stressed the importance of building the human capacity on how to culture, maintain and transfer *X. fastidiosa* in the European plant health and research laboratories, as culturing this bacterium is still difficult to perform and these skills need to be developed before starting to work.

The need to develop tools for functional work was highlighted, not only to identify functions, but also to disrupt them. With regard to research on bacterial biology, participants strongly recommended to capitalise on existing international expertise on *X. fastidiosa* research, to establish cooperation, exploit maximum synergies and avoid duplications.

Biology of vectors

As regards the biology of the vector, *X. fastidiosa* is exclusively transmitted by xylem sap-feeding insects of the order Hemiptera, sub-order Auchenorrhyncha, infraorder Cicadomorpha, superfamilies, Cercopoidea (spittlebugs or froghoppers), Cicadoidea (cicadas) and Membracoidea, (of this latter only the subfamily Cicadellinae (sharpshooters) is relevant). The list of potential European vectors of *X. fastidiosa* is provided in the EFSA Plant Health Panel (2015) Scientific Opinion on the risks to plant health posed by *X. fastidiosa* in the EU. The spittlebug *P. spumarius* has been proved to be a vector of *X. fastidiosa* in the Apulian outbreak. There is a general lack of knowledge as regards the role of all potential European insect vectors in the transmission and epidemics of *X. fastidiosa*. It is important to study their transmission capacity, ecology and behaviour, seasonality, as well as preferred host plants. Also in the USA and in Brazil, few research groups are involved in such activity. Such information is useful to understand for example how to interrupt the life cycle of the vector and how to control its spread in the environment. It would be important for research groups to develop systems to rear *X. fastidiosa*-free spittlebugs in laboratory colonies, which could then be used for experiments. Such knowledge is currently lacking for *P. spumarius*. Some potential vectors such as cicadas which are very abundant in Europe should also be studied.

Putting the problem in the context of the various production systems (conventional, IPM, low input/ organic)

Control measures to manage *X. fastidiosa* should be developed both for conventional agriculture with integrated pest and disease management programmes and for low input/organic farming. Control of *X. fastidiosa* in Brazil can be achieved in citrus orchards by controlling vectors at the borders of the plantations, however there is no experience on organic farming control methods. In northern California where the vectors (blue-green sharpshooters) move seasonally from riparian vegetation to the crops, it is possible to remove host plants from the riparian vegetation and to treat against the vectors only once a year, however when *X. fastidiosa* is spread by glassy-winged sharpshooters, repeated treatments are needed. Removal of herbaceous vegetation by soil tillage has been shown in Apulia to significantly reduce *P. spumarius* juvenile populations. Information on the population dynamics of the vector species are needed to develop a control strategy. To develop regional contingency plans, it is necessary to understand how cropping practices, weed management and insecticide treatments can affect bacterium spread and vector population and to gain information on the production systems and management practices applied. Differences across production systems may affect the effectiveness of the measures. Social and cultural acceptability as well as socio-economic impact of the measures need also to be considered. The need to develop long-term strategies based on crop diversification was also discussed highlighting the challenges due to the high numbers of host plants and vectors of this bacterium.

CONCLUSIONS AND RECOMMENDATIONS

The knowledge on the epidemiology of *X. fastidiosa* in a given environment is needed to develop control strategies and to support detection and monitoring. There is a need to develop appropriate sampling strategies in the plants (where does the infection occur first in the plant? How are the bacteria distributed in the plant spatially and seasonally?), as well as in the landscape (which plants to sample and where?). The knowledge of invasion pathways and of the spread patterns in time and space can support the planning of surveys. Also further development and validation of detection tools is needed.

There have been decades of research in the Americas on *X. fastidiosa*. It was agreed the European researchers should not reinvent the wheel but rather start building on existing knowledge and establish cooperation with researchers working on *X. fastidiosa* elsewhere. However, the host range in Europe needs to be determined as well the environmental influences. A key element for control will be the identification and development of resistant cultivars.

With regard to vectors, there is a lack of knowledge on the European vectors and on their ecology. There is a need to do research on transmission of the bacterium by insect vectors.

For production systems, contingency plans need to be developed taking into account their social impact and acceptability. Measures can include farming practices, vegetation management and vector control.

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The workshop "***Xylella fastidiosa*: options for its control**" was organised as a parallel session of the conference "Health Checks and Smart Treatments for Our Plants" at EXPO Milan on 15 July 2015. A summary of its conclusions was presented at the final session of the Conference. It was highlighted during discussion that the knowledge on the epidemiology of *X. fastidiosa* in a given environment is needed to develop control strategies and to support detection and monitoring. There is also a need to develop appropriate sampling strategies in the plants, as well as in the landscape. The knowledge of invasion pathways and of the spread patterns in time and space can support, together with further development and validation of detection tools, the planning of surveys. The participants agreed that he European researchers start building on existing knowledge and establish cooperation with researchers working on *X. fastidiosa* elsewhere in the world, however, the host and vectors range in Europe would need to be determined as well the environmental influences. A key element for control will be the identification and development of resistant cultivars. For production systems, contingency plans need to be developed taking into account their social impact and acceptability. Measures can include farming practices, vegetation management and vector control.

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