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Plant Health Research Priorities for the Mediterranean Region

SUPPLEMENT 1

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Introduction

The Compendium on the 'Plant Health Research Priorities for the Mediterranean Region', published in 2020 to celebrate the International Year of Plant Health (IYPH), was the first joint Euphresco and CIHEAM Bari initiative launched to improve the coordination of research efforts (from research funding to research activities) on plant health and plant protection in the Mediterranean region and to enhance cooperation of stakeholders within the area. The compendium was prepared on the basis of information and views collected from national experts from the Balkan-Mediterranean, Eastern Mediterranean, Maghreb, and Western Mediterranean sub-regions on the important pests, the research priorities, the research infrastructures and the capacity.

This supplement is an update of the Compendium. It contains the experts' indications of the research needs for the priority pests listed in the compendium and the details on the discussions undertaken in 2021 with representatives of national organisations involved in phytosanitary research. The supplement also provides details on the phytosanitary problems for which the Mediterranean countries share the same interest and which should be addressed in the short-term.

The joint CIHEAM-Euphresco online workshop, organized on the 12 of May 2021, was an opportunity for high level officials from organisations involved in policy making, research funding and research implementation in the Mediterranean region to meet, exchange views, discuss, and identify common priorities for phytosanitary research on the basis of the preliminary findings described in the Compendium.

The workshop was attended by around 80 people from 20 Mediterranean countries (Albania, Algeria, Bosnia & Herzegovina, Croatia, Egypt, France, Greece, Italy, Lebanon, Libya, Malta, Morocco, North Macedonia, Portugal, Slovenia, Spain, Syria, Tunisia, Turkey, United Kingdom) and several international organizations and initiatives: the Arab Society for Plant Protection, the European and Mediterranean Plant Protection Organization, the Mediterranean Phytopathological Union, the Near East Plant Protection Organization, the Secretariat of the International Plant Protection Convention, the European Food Safety Authority, the Interreg Med and the Interreg Balkan Med Secretariats, the Joint Programming Initiative on Agriculture, Food Security and Climate Change, the Partnership for Research and Innovation in the Mediterranean Area, and the Union For the Mediterranean (The agenda and the list of workshop participants are provided in Appendix 1).

During the workshop, the operational/ research gaps and the research priorities were reported by national experts on the following pests: *Xylella fastidiosa*, citrus tristeza virus, '*Candidatus* Liberibacter' spp. (agents of Citrus Huanglongbing disease), *Bursaphelenchus xylophilus*, *Erwinia amylovora*, plum pox virus, *Fusarium oxysporum* f.sp. *albedinis*, *Rhynchophorus ferrugineus*, *Phyllosticta citricarpa*, '*Candidatus* Liberibacter solanacearum', and *Drosophila suzukii*.

Working group sessions were organized to allow representatives from the Balkan, Near Eastern, North African, and Western European countries to present their needs and the national research activities planned in the short-term in order to identify synergies, both in terms of important pests and in terms of research topics, on which countries could work together. National organizations to involve in future collaborative research projects were also identified.
The results of the working groups were reported in a final roundtable discussion on how to initiate transnational research activities on important pests and how countries could benefit from the CIHEAM Bari - Euphresco initiative.

The main conclusions agreed upon in the workshop were the following:

• The Compendium is a useful tool to summarise the plant health research priorities for the Mediterranean region. It was suggested to periodically update the content through the publication of supplements.

• Dedicated workshops are needed to allow country representatives to continue the work on the research topics under the guidance of CIHEAM Bari, Euphresco and other interested international organizations.

• CIHEAM Bari and Euphresco will act as facilitators of future regional actions, but the endorsement of Mediterranean countries is needed. Countries were invited to propose contact point/s that will be responsible for the coordination of follow-up activities at national level.

After the international workshop, two teleconferences were organized in October 2021 by Euphresco and the CIHEAM Bari to further refine the research lines and to plan future work.

A first teleconference was organised on 11 of October 2021 with eight international organisations/initiatives (the Arab Society for Plant Protection, the Mediterranean Phytopathological Union, the Near East Plant Protection Organization, the European Food Safety Authority, the Joint Programming Initiative on Agriculture, Food Security and Climate Change, the Partnership for Research and Innovation in the Mediterranean Area, and the Union for the Mediterranean) to find out their interest in the initiative and define a role in supporting it (the agenda and the list of participants are provided in Appendix 2).

A second teleconference was organised on 20 of October 2021 with the national contact points of 15 countries: Algeria, Croatia, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Palestine, Portugal, Slovenia, Spain, Tunisia, Turkey) to discuss common research lines for transnational collaboration (the agenda and the list of participants are provided in Appendix 2).

During the October teleconferences, it was agreed to focus the efforts on four research topics, which are those that received the support from a large number of countries in the four Mediterranean sub-regions.

The selected research topics are:

1. Epidemiological studies on the potential vectors of *Xylella fastidiosa*. Countries were informed that the topic was already covered by the Euphresco project 2020-F-341 'The insect vectors of *X. fastidiosa*', and the Mediterranean countries interested were invited to join the project.
2. Validation of DNA extraction from different matrices/hosts of *X. fastidiosa*. It was suggested to develop a short topic description to be proposed via the 2022 Euphresco round of transnational collaboration.
3. Development/validation of diagnostic tests to identify exotic/severe strains of citrus tristeza virus. It was suggested to develop a short topic description to be proposed via the 2022 Euphresco round of transnational collaboration.
4. Research topic on tomato brown rugose fruit virus (TBRFV). It was proposed to develop a short topic description to be proposed via the 2022 Euphresco round of transnational collaboration

More information on the research topics is provided in paragraph 3.3.

During discussions with countries, three pests of importance to the Mediterranean region were identified in addition to those already included in the Compendium.

More information on the three pests is provided in paragraph 3.2.

This supplement is structured in 3 chapters: chapter 1 focusses on the priority research lines presented by the experts on the important pests; chapter 2 focusses on the national activities and on the priority pests as presented by countries during the international workshop of May 2022; chapter 3 focusses on transnational research lines and the endorsements by the Mediterranean countries.

1. - Research priorities for important pests

During the international workshop on 12 of May 2021, the research priorities on the important pests listed in the Compendium were presented by selected experts from different countries, as follows:
Xylella fastidiosa presented by Franco Valentini (CIHEAM-Mediterranean Agronomic Institute of Bari, Italy);
Citrus tristeza virus presented by Dorsaf Yahiaoui (Citrus Technical Centre, Tunisia);
'*Candidatus* Liberibacter' spp., the agents of Citrus Huanglongbing disease, presented by Jaime Cubero (National Center Institute for Agricultural Research and Food Research and Technology, Spain);
Bursaphelenchus xylophilus presented by Isabel Abrantes (University of Coimbra, Portugal);
Erwinia amylovora presented by Samia Laala (Algerian National Advanced School, Algeria);
Plum pox virus presented by Melike Yurtmen (Biological Control Research Institute, Turkey);
Fusarium oxysporum f. sp. *albedinis* presented by Moulay Hassan Sedra (Morocco);
Rhynchophorus ferrugineus presented by Francesco Porcelli (University of Bari, Italy);
'*Candidatus* Liberibacter solanacearum' presented by Jason Sumner-Kalkun (Science and Advice for Scottish Agriculture, Scotland) & Assunta Bertaccini (University of Bologna, Italy);
Phyllosticta citricarpa presented by Eleni Kalogeropoulou (Benaki Phytopathological Institute, Greece);
Drosophila suzukii presented by Gianfranco Anfora (University of Trento, Italy).
In addition to the pests reported in the Compendium, other pests were identified in the same workshop, of which *Spodoptera frugiperda* and tomato brown rugose fruit virus (ToBRFV) were considered of regional importance. Priority research lines for *S. frugiperda* were prepared by CABI experts and for ToBRFV by Adrian Fox (Fera Science Ltd, United Kingdom).
The research lines to address the challenges posed by these pests are presented in this chapter.

***Xylella fastidiosa* (Xf)** - Several leaf scorch diseases

Biology/epidemiology

- To understand the differences of virulence of Xf subspecies and strains
- To identify and characterize pathogenicity determinants
- To clarify the role of bacteria/fungi associated with disease development in olive trees
- To better understand host plants-pathogen interactions
- To increase knowledge on vectors

Surveillance/diagnostics

- To validate the use of drone imagery and high spatial sensing approaches for early detection
- To validate the use of spy insects for early detection

Risk analysis

- To identify pathways and develop models to predict the spread under climate change scenarios

Management

- To identify new resistant/tolerant germplasm for important Mediterranean plants and resistance biomarkers
- To identify molecules (minerals, peptides, nanoparticles) for control
- To validate the use of microorganisms (e.g. plant host microbial communities, bacteriophages) for control
- To validate the use of active substances (e.g. chemicals, biopesticides) for control

Citrus tristeza virus (CTV) - Citrus tristeza disease

Biology/epidemiology

- To identify and characterize pathogenicity determinants for the diverse tristeza symptoms

Surveillance/diagnostics

- To validate diagnostic tests for CTV strains that are responsible for severe diseases

Management

- To assess tristeza tolerant rootstocks for their resistance to other biotic and abiotic stresses
- To validate cross protection control strategies based on mild isolates that provide long-term protection against the severe CTV strains
- To engineer transgenic resistance (e.g. based on RdRp) in commercial cultivars

Erwinia amylovora **(Ea)** - Fire blight disease of pome fruits

Biology/epidemiology

- To improve knowledge on the genetic variability
- To improve knowledge on the (potential) insect vectors
- To improve knowledge on the molecular mechanisms of host plant-pathogen interaction and on disease transmission mechanisms

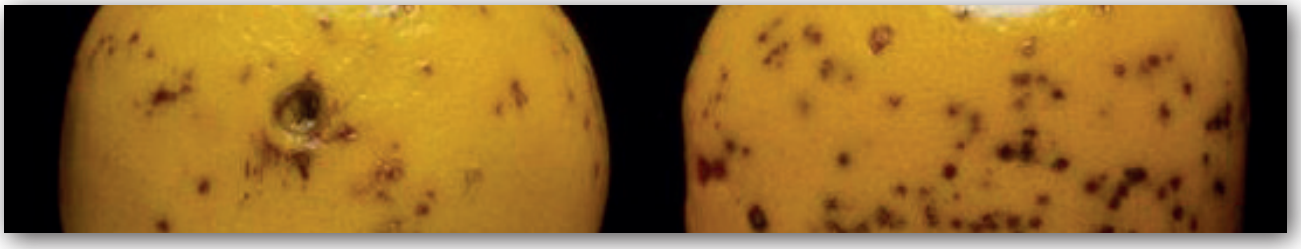
Surveillance/diagnostics

- To validate tests for *in situ* diagnosis (field, nursery and commercial entry points)
- To validate the use of remote sensing technologies for field monitoring

Management

- To identify resistant/tolerant germplasm and resistance biomarkers
- To validate control strategies based on plant defense activators
- To validate control strategies based on plant extracts
- To validate control strategies based on biological control with antagonistic bacteria
- To validate the use of active substances (e.g. chemicals, biopesticides) for vector control

Phyllosticta citricarpa - Citrus black spot disease



Biology/epidemiology

- To improve knowledge on the molecular mechanisms of host-pathogen interactions, pathogenicity and host plant resistance
- To improve knowledge on the population structure of *P. citricarpa* and other *Phyllosticta* spp.

Surveillance/diagnostics

- To identify markers for the molecular characterization of strains and to track their movement
- To validate diagnostic tests that discriminate *P. citricarpa* and *P. paracitricarpa*

Risk analysis

- To improve knowledge on migration pathways of *P. citricarpa* and other *Phyllosticta* spp. from diverse areas

Management

- To identify resistant germplasm
- To validate eco-friendly chemical control strategies
- To validate post-harvest treatments

***'Candidatus* Liberibacter asiaticus', *'Ca* L. africanus', *'Ca* L. americanus'** - Huanglongbing disease of citrus (HLB)

Biology/epidemiology

- To identify and characterize virulence factors (e.g. effectors)
- To improve knowledge on disease transmission mechanisms and host plant-pathogen interaction (e.g. biofilms, effectors bifunctionality)
- To improve knowledge on the vector life cycle

Surveillance/diagnostics

- To validate sampling procedures
- To validate the use of new diagnostic methods (e.g. LAMP, droplet PCR, nanopore sequencing)

Risk analysis

- To improve knowledge on the pathways of introduction of the vector *Diaphorina citri*

Management

- To identify resistant/tolerant germplasm
- To validate control strategies based on immunity inducers (e.g. peptides)
- To validate control strategies based anti-biofilm agents
- To validate control strategies for vectors (e.g. chemical, biological)

Fusarium oxysporum* f.sp. *albedinis - Bayoud disease of date palm

Biology/epidemiology

- To identify new genetic markers
- To improve knowledge on the biology and epidemiology of new strains that can overcome resistance

Surveillance/diagnostics

- To improve knowledge on the presence of Bayoud's foci

Management

- To validate control strategies based on microbiological control and soil resistance and suppressiveness
- To validate integrated pest management protocols
- To validate the use of conventional or biotechnological tools for date palm genetic improvement programmes

Drosophila suzukii - Spotted wing drosophila (SWD)

Surveillance/diagnostics

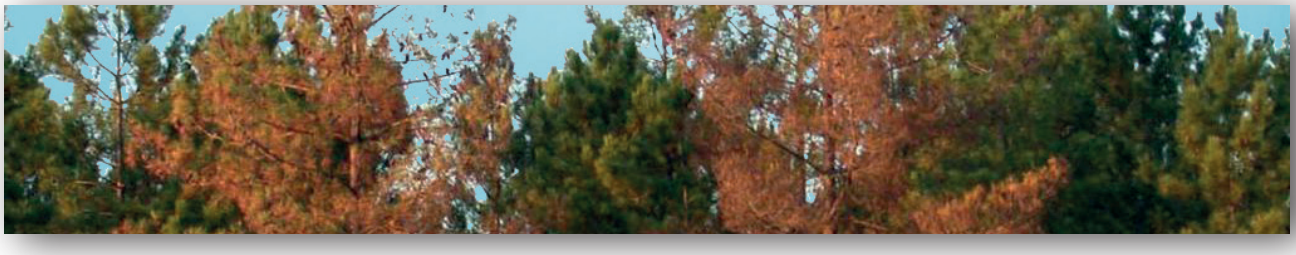
- To validate the use of new diagnostic methods
- To validate the use of traps for surveillance and early warning

Management

- To validate integrated pest management protocols
- To validate control strategies based on biological control (parasitoids and predators: augmentative and classical biological control; microorganisms)
- To validate control strategies based on cultural practices (e.g. landscape management, net protection, pruning and mulching, sanitation, mass trapping)

- To validate control strategies based on developmental disruption approaches (e.g. sterile insect technique, RNA interference, CRISPR/Cas9)
- To validate eco-friendly chemical control strategies (bioagrochemicals, adjuvants)
- To validate post-harvest treatments (e.g. use of CO_2, refrigeration, irradiation)

Bursaphelenchus xylophilus - Pine wilt disease



Biology/epidemiology

- To improve knowledge on the virulence of *Bursaphelenchus* species and individuals
- To identify and characterize new pathogenicity determinants
- To improve knowledge on the role of bacteria associated with disease development
- To predict insect vector dispersion routes under climate change scenarios

Surveillance/diagnostics

- To validate the use of imagery and/or high spatial sensing data for early detection

Management

- To validate the use of gene-knockout methodology
- To identify resistance biomarkers to include in breeding programmes
- To identify resistant/tolerant germplasm under climate change scenarios
- To identity attractive/repulsive tree volatiles and specific pheromones and improve more efficient traps

Plum pox virus (PPV) - Sharka disease of stonefruits

Biology/epidemiology

- To improve knowledge on the epidemiology of PPV, in particular for strains that infect almonds and walnuts
- To improve knowledge on the epidemiology of aphid vectors
- To improve knowledge on the impact of climate change on host-pathogens-vector interaction

Surveillance/diagnostics

- To improve knowledge on the distribution of PPV
- To improve knowledge on the distribution of aphid vectors
- To validate the use of remote sensing (e.g. drone technology) for early detection.

Rhynchophorus ferrugineus - Red palm weevil (RPW)

Management

- To validate control strategies based on *RPW* symbionts disruption
- To validate control strategies that target newly hatched or young larvae
- To validate control strategies based on biological control

***Candidatus* Liberibacter solanacearum (CaLsol)** - Zebra chip disease of potato

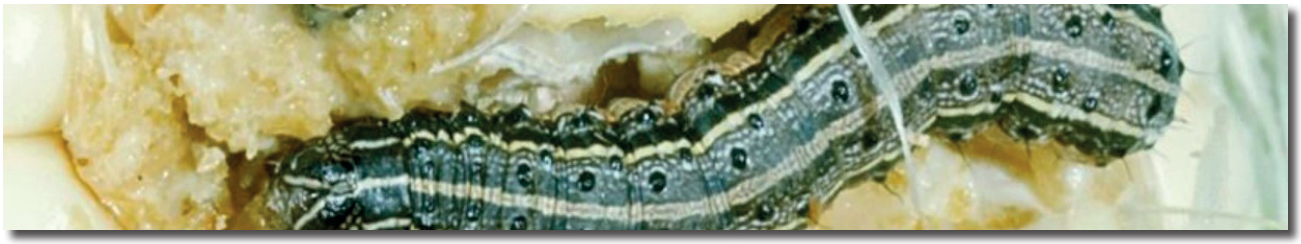
Biology/epidemiology

- To improve knowledge on the behaviour and ecology of psyllids vectors
- To improve knowledge on the host plants
- To improve knowledge on the association of *CaLsol* and other pathogens (e.g. phytoplasmas, viruses)
- To improve knowledge on the variability of *CaLsol* strains at genetic and transcriptomic level
- To better understand host plants-pathogen interactions
- To understand the differences of pathogenicity of *CaLsol* strains in the various host plants
- To improve knowledge on weed plant hosts and their role in the pathogen's epidemiology
- To improve knowledge on the transmissibility by seeds
- To develop models on land use and its impact on *CaLsol* and vectors epidemiology
- To validate methods for culturing *CaLsol* on artificial media

Surveillance/diagnostics

- To improve knowledge on the distribution of *CaLsol* and its psyllids vectors

Spodoptera frugiperda - Fall armyworm



Biology/epidemiology

- To develop models to forecast the seasonal spread and impact of migrating population in European temperate regions

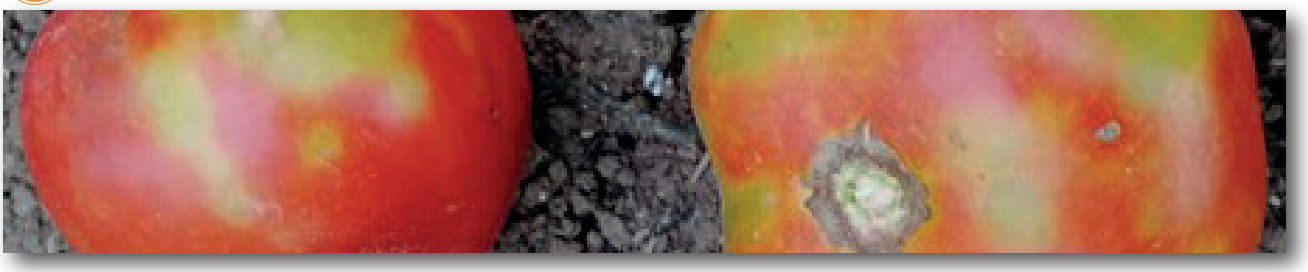
Surveillance/diagnostics

- To validate the use of traps (e.g. pheromone-based) to enhance monitoring activities

Management

- To validate methods for augmentative biological control such as viruses, bacteria, and nematodes
- To validate classical biological control using parasitoids from South America
- To validate agroecological approaches (e.g. flowering habitats, tillage, cover crops) for Mediterranean areas
- To understand the impact of the use of chemical insecticides on natural enemies and the environment

Tomato brown rugose fruit virus (ToBRFV)



Biology/epidemiology

- To improve knowledge on the survival of the virus (e.g. in soil, in compost)

Risk analysis

- To improve knowledge on the risk from soil systems for onward contamination (e.g. via root fragments)

Management

- To validate methods for disinfection of surfaces, tools, etc.
- To validate protocols for safe crop rotation

2. - National research programmes

During the international workshop held on 12 of May 2021, working group sessions were organized to allow representatives from the Balkans, Near Eastern, North African, and Western European countries to present the important pests and the national research priorities, ongoing or planned research activities and the main plant health research stakeholders (e.g. ministries, National Plant Protection Organizations, academia, research institute, official testing laboratories).

Inputs to the discussion were also gathered from the representatives of international organizations and initiatives.

The outcomes of the discussions held within each working group are summarised in this chapter.

Balkans working group (Albania, Croatia, Greece, North Macedonia, Slovenia)

The working group was chaired by Ms Plavec (HAPIH, Croatia) and Mr Livieratos (CIHEAM Chania).
Two high-level representatives from Albania, 1 from Croatia, 3 from Greece, 5 from North Macedonia, 1 from Slovenia, 1 from Interreg Med Secretariat and 1 from Interreg Balkan Med Secretariat participated in the working-group.

Priority pests

21 priority pests were identified.
3 of which were shared by several countries: *Xylella fastidiosa, Erwinia amylovora* and *Aleurocanthus spiniferus*.
Other important pests were: citrus tristeza virus, tomato brown rugose fruit virus, Citrus viroids, *Phyllosticta citricarpa, Fusarium circinatum, Phytophthora ramorum,* fruit flies, *Cydia pomonella, Tuta absoluta, Drosophila suzukii, Aromia bungii, Spodoptera frugiperda, Anoplophora chinensis, Anoplophora glabripennis, Popillia japonica, Halyomorpha halys, Agrilus planipennis, Meloidogyne incognita.*

Priority research lines

To develop and validate new diagnostic tools and methods; to improve surveillance and early detection (including remote sensing); to develop and validate new IPM approaches; to develop epidemiological and forecasting modelling; to develop Pest Risk Analyses; to improve knowledge on the impact of climate change on plant health; to increase knowledge on the plant microbiome.

Near East working group (Lebanon, Turkey)

The working group was chaired by Mr Al-Jboory & Mr Choueiri (ASPP).
Six high-level representatives from Lebanon, 2 from Turkey and 1 from the Union for the Mediterranean participated in the working-group.

Priority pests

15 priority pests were identified.
7 of which were shared: *Xylella fastidiosa*, tomato brown rugose fruit virus, citrus tristeza virus, plum pox virus, *Spodoptera frugiperda, Drosophila suzukii, Halyomorpha halys, Erwinia amylovora*.
Other important pests were: *Rhynchophorus ferrugineus, Fusarium oxysporum* f.sp. *cubense* Tropical Race 4, *Pseudomonas savastanoi* pv. *savastanoi, Phytophthora infestans, Ralstonia solanacearum, Synchytrium endobioticum, Anoplophora chinensis, Bursaphelenchus xylophilus*.

Priority research lines

To improve pest surveillance, pest detection and characterization; to improve knowledge on host plants and vectors; to develop and validate new IPM strategies; to improve knowledge on the impact of climate change on plant health.

North Africa working group (Algeria, Egypt, Libya, Morocco, Tunisia)

The working group was chaired by Mr Deng (IPPC) and Mr Chouibani (NEPPO).
Two high-level representatives from Algeria, 1 from Egypt, 1 from Libya, 1 from Morocco, 1 from Tunisia and 2 from the initiative 'Partnership for Research and Innovation in the Mediterranean Area' participated in the working-group.

Priority pests

12 priority pests were identified.
6 of which were shared by several countries: citrus tristeza virus, *Xylella fastidiosa, Fusarium oxysporum* f.sp. *albedinis, Rhynchophorus ferrugineus, 'Candidatus* Liberibacter' spp., *Phyllosticta citricarpa.*
Other important pests were: *Drosophila suzukii, Erwinia amylovora, Spodoptera frugiperda, Dactylopius opuntiae, Ceratitis capitata, Bactrocera zonata*.

Priority research lines

To improve pest surveillance, monitoring and management; to develop and validate fast and reliable detection methods; to increase knowledge on vector identification and their population dynamics; to increase knowledge on hosts spp.; to develop and validate new Integrated Pest Management (IPM) approaches (including biopesticides); to improve knowledge on the impact of climate change on plant health; to understand the mechanisms of resistance to pesticides; to develop and validate methods and instruments for precision plant protection.

Western Europe working group (France, Italy, Malta, Portugal, Spain)

The working group was chaired by Ms Mugnai (MPU) and Mr Horn (EPPO). One high-level representative from France, 1 from Italy, 1 from Malta, 2 from Portugal, 3 from Spain, 1 from EFSA and 1 from FACCE-JPI Secretariat participated in the working-group.

Priority pests

13 priority pests were identified.

4 of which were shared by several countries: *Xylella fastidiosa, 'Candidatus* Liberibacter' spp.*, Phyllosticta citricarpa, Bursaphelenchus xylophilus*. Other important pests were: citrus tristeza virus, tomato brown rugose fruit virus*, Fusarium circinatum, Bactrocera dorsalis, Anoplophora chinensis, Anoplophora glabripennis, Leptinotarsa decemlineata, Globodera rostochiensis, Globodera pallida*.

Priority research lines

To develop and validate new diagnostic tools and methods; to improve surveillance strategies (early detection, sampling methods, modelling, barcoding); to improve vector identification and control; to develop and validate new IPM strategies; to develop Pest Risk Analysis; to improve knowledge on the resistance of plants and resistance of pests to pesticides; to improve knowledge on the impact of climate change on plant health; to improve the taxonomy of cryptic species; to support work on agriculture 4.0 and onehealth.

3. - Transnational research collaboration

Following the international workshop organized on 12 May 2021, national contact points were identified for the following Mediterranean countries: Algeria, Croatia, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Palestine, Portugal, Slovenia, Spain, Tunisia, Turkey. The national contact points were in charge of identifying the national experts to be involved in the transnational research activities on the plant health priorities for the Mediterranean region.

The information gathered during the workshop was discussed with the relevant national experts during the teleconference organised on 20 October 2021. The results of these discussions are reported in this chapter: paragraph 3.1 lists the expressions of interest on the research priorities for the pests included in the Compendium (*Xylella fastidiosa*, citrus tristeza virus, *Erwinia amylovora*, *Candidatus* Liberibacter spp. agents of Huanglongbing of citrus, *Phyllosticta citricarpa*; paragraph 3.2 shows the fact sheets for the pests that were identified as relevant for the Mediterranean region wich were not included in the Compendium (*Spodoptera frugiperda*, tomato brown rugose fruit virus, *Anoplophora chinensis*); and paragraph 3.3 provides the descriptions of research topics for transnational cooperation (Xylella diagnostics, CTV diagnostics, ToBRFV biology) that were shortlisted.

3.1 - Common research priorities for project proposals

Based on the research priorities provided by experts from 14 countries (nominated by country's representatives), a short list of priority research topics was prepared according to the following criteria:

- pests and research priorities are shared by most countries in the four Mediterranean sub-regions
- research priorities are not addressed in past or ongoing projects, but rather in projects that are starting or are in the planning stage
- research activities can be undertaken in small/medium sized projects
- research priorities are relevant to policy makers

Research lines evaluated as priorities from each country's representatives are hereafter listed following the ranking of interest obtained in Table 1 and Figure 1.

Table 1. Preferences provided by country's representatives and experts for the short-listed research topics. Each research line is marked with a different colour.

Country	Xf vectors	Xf diagnostics	CTV rootstock tolerance	CTV diagnostics severe, exotic strains	CTV pre-immunization	HLB vectors surveillance	Ea strain typing	Ea vectors	Ea resistance/ tolerance	CBS chemical treatment, resistance
Algeria	●			●						
Egypt	●	●	●	●	●	●				●
France	●	●								
Greece		●	●	●		●	●	●	●	
Italy	●	●	●	●	●	●				●
Lebanon		●					●	●	●	
Malta	●	●	●							
Morocco	●	●		●			●			
Palestine	●	●					●	●	●	
Portugal	●	●		●		●	●		●	
Slovenia	●	●					●	●		
Spain	●	●		●		●			●	●
Tunisia	●	●	●	●	●	●			●	●
Turkey	●	●				●	●	●	●	

Legenda:
Xf *Xylella fastidiosa*
CTV citrus tristeza virus
HLB Huanglongbing of citrus
Ea *Erwinia amylovora*
CBS Citrus black spot disease

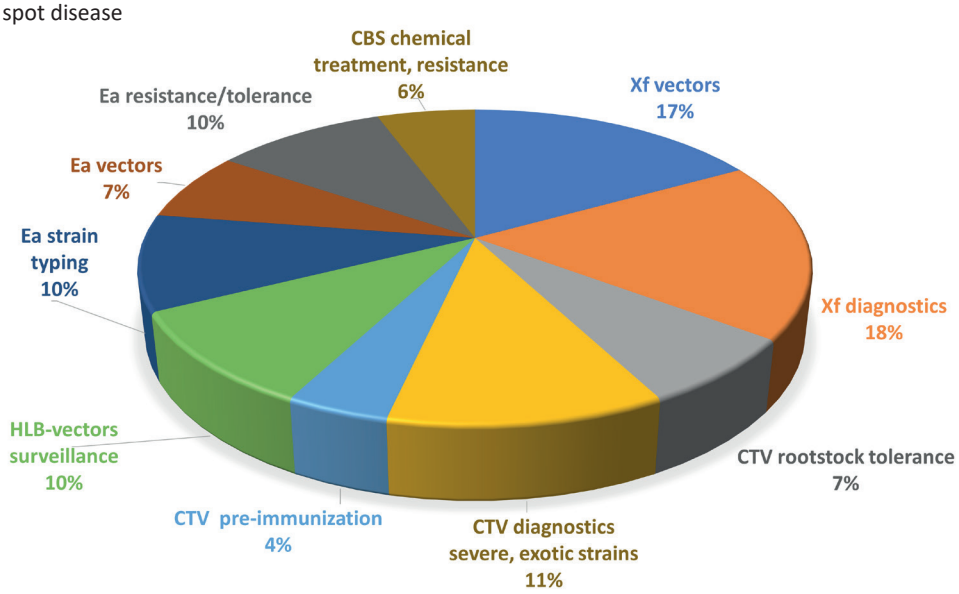


Figure 1. Preferences for short-listed research topics (%) . Each research line is marked with a different colour.

Table 2. Ranking of research topics based on countries' preferences.

Rank	Research topic	%
1	Diagnosis of *X. fastidiosa* on important Mediterranean plants and their matrices - *Xf diagnostics*	*18*
2	Study on *X. fastidiosa* vectors – *Xf vectors*	*17*
3	Development of diagnostic tests to identify severe strains of citrus tristeza virus on large scale – *CTV diagnostics severe strains*	*11*
4	Identification of resistant/tolerant germplasm to *E. amylovora - Ea resistance/ tolerance*	*10*
4	Improvement of knowledge on the genetic variability by strain typing of *E. amylovora - Ea strain typing*	*10*
4	Validation of sampling and diagnostic procedures using vectors for the surveillance of HLB agents – *HLB vectors surveillance*	*10*
5	Identification of potential vectors – *Ea vectors*	*7*
5	Rootstocks tolerance to tristeza disease and other biotic and abiotic stresses– *CTV rootstock tolerance*	*7*
6	Improvement of control strategies to Citrus black spot disease by eco-friendly chemical treatment/resistance – *CBS chemical treatment/resistance*	*6*
7	Investigation of mild isolates of citrus tristeza virus for preimmunization against severe strains – *CTV preimmunization*	*4*

3.2 Additional priority pests for the Mediterranean region

In this paragraph, *Spodoptera frugiperda*, tomato brown rugose fruit virus and *Anoplophora chinensis* are reported as additional priority pests to those of the Compendium. A brief description is therefore provided based on the information from the EPPO datasheet and CABI datasheet.

Table 3. Additional priority pests provided by some country representatives. Each pest is marked with a different colour.

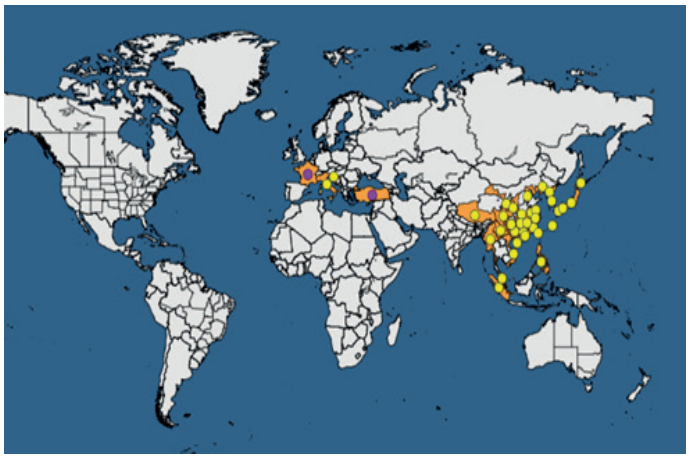
Country	*Anoplophora chinensis*	*Spodoptera frugiperda*	ToBRFV	Others
Algeria				*Erwinia amylovora, Fusarium oxysporum* f. sp. *albedinis, Globodera* spp., *Heterodera* spp.
Egypt				*Bactrocera zonata, Ceratitis capitata*
France				Tomato leaf curl begomovirus, *Bactrocera dorsalis*
Greece				
Italy				*Anoplophora glabripennis, Bactrocera dorsalis*
Lebanon				Plum pox virus, *grapevine yellows, Pseudomonas* spp., *Xanthomonas juglandis, Fusarium* spp., *Fusarium oxysporum* f.sp. *cubense* (TR4), *Ambrosia beetle, Rosellinia necatrix, Phytophthora infestans*
Malta				
Morocco				*Tuta absoluta, Drosophila suzukii, Dactylopius opuntiae*, tomato leaf curl New Delhi virus, tomato yellow leaf curl virus
Palestine				*Xylella fastidiosa*, Ambrosia beetle, *Pseudomonas savastanoi*
Portugal				
Slovenia				Tomato mottle mosaic virus
Spain				
Tunisia				
Turkey				

Anoplophora chinensis

Anoplophora chinensis is a long-horned beetle polyphagous on woody hosts. This species is able to attack and cause damage to fruit trees, ornamental and forest plants.

Geographical distribution

A. chinensis is native to Asia. The species occurs primarily in China, Japan and the Korean peninsula. In the EPPO region, several outbreaks occurred from 2000 to the present day. The arthropod has been eradicated in Denmark, Germany, The Netherlands and Switzerland. In Croatia, France, Italy and Turkey eradication or containment measures are in place.



Hosts

A. chinensis feeds on over 100 hosts in at least 30 plant families. In Asia, *A. chinensis* is a serious pest of citrus orchards and has a wider host range which also includes conifers in the genera *Pinus* and *Cryptomeria*. In Asia, *A. chinensis* is also an important pest of many stone and pome fruit, and mulberry trees. In Europe, *Acer* has been indicated as the most commonly infested genus, followed by *Betula* and *Corylus*.

Economic impact

A. chinensis seriously damages Citrus trees and harms apple, pear and other fruit and nut trees, but also forestry plantations and woody ornamentals. Due to its wide host range, *A. chinensis* could have extremely high economic impacts in countries where it is introduced. The most important damage is caused by larvae. These bore into the wood of living trees reducing the quality and value of the wood and causing the death of trees.

The information above is based on the EPPO datasheet on *A. chinensis*, revised in 2020 by Matteo Zugno and Mariangela Ciampitti from the Phytopatological Laboratory Lombardia Region, Vertemate con Minoprio, Italy and the CABI datasheet. The EPPO datasheet with more information on the pest can be viewed and downloaded from the EPPO Global Database. The CABI datasheet is available from the CABI Invasive Species Compendium.

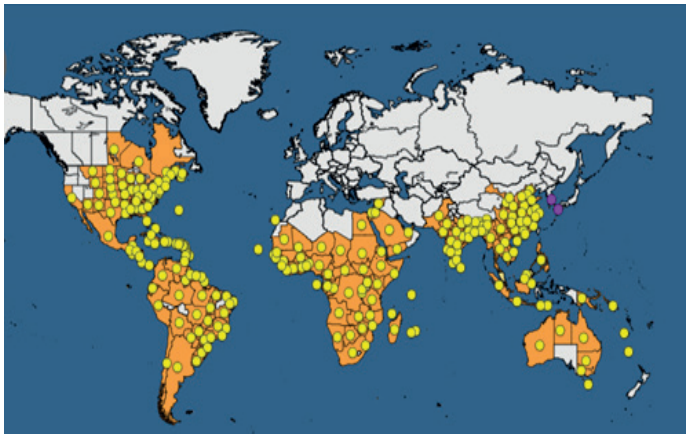
Female *A. chinensis*. Courtesy of M. Maspero (Fondazione Minoprio, Italy).

Exit holes of *A. chinensis*. Courtesy of M. Maspero (Fondazione Minoprio, Italy).

Spodoptera frugiperda

Spodoptera frugiperda (fall armyworm) is one of the most important plant pests of recent years, due to the dramatic change of its geographical distribution and its polyphagy.

Geographical distribution



S. frugiperda is native to tropical-subtropical areas of the Americas and during summer it migrates into southern and northern temperate American regions. The pest was first reported in West Africa in 2016, and over the next two years it spread throughout sub-Saharan Africa, and then reached Egypt in 2019. In 2018, *S. frugiperda* was reported in India. In the same year it was also reported in Yemen, Bangladesh, Myanmar, Sri Lanka, Thailand, and more recently (2019), in China, South Korea, Japan, Pakistan, Laos, Philippines, Indonesia, and Vietnam. During the first months of 2020 it has reached mainland Australia.

Hosts

S. frugiperda is a polyphagous pest with a host range (observed in the Americas) of 353 plants belonging to 76 families, mainly Poaceae, Asteraceae and Fabaceae. The greatest damage is observed in grasses, particularly maize and sorghum, which are the main hosts, along with other crops, such as rice, cotton and soybean. In addition to crop species the pest also attacks ornamental plants (such as chrysanthemums, carnations, geraniums) and weeds.

Economic impact

Damage results from leaf-eating and healthy plants usually recover quite quickly, but a large pest population can cause defoliation and resulting yield losses; the larvae then migrate to adjacent areas in true armyworm fashion.

In the Americas the pest is considered an economically important pest of cultivated crops, particularly maize, rice, sorghum, and sugarcane: in the south-eastern states of the USA, during the period 1975-1983 it caused annual average yield loss of 60 million USD and in Brazil it is considered the most important pest of maize. Maize infestation has been reported to be between 26.4 and 55.9%. Yield decrease has been estimated from 11.57% up to 73%.

Recently *S. frugiperda* has been considered by FAO as a potential food chain threat for Africa, Asia and Oceania. Concerning the EPPO region, the area most suitable for the pest establishment is the far south of Spain, Portugal, Italy, Greece and Cyprus, where it has been estimated that if the pest were to establish it could have four generations per year. In these areas, *S. frugiperda* could cause yield and quality losses in crops such as maize and rice.

The information above is based on the EPPO datasheet on *S. frugiperda*, revised in 2020 by Tiziana Panzavolta from the University of Florence (UNIFI), Italy and the CABI datasheet. The EPPO datasheet with more information on the pest can be viewed and downloaded from the EPPO Global Database. The CABI datasheet is available from the CABI Invasive Species Compendium. More information on the pest is also available from the CABI Fall armyworm portal.

S. frugiperda adult. Museum set specimen. ©Lyle J. Buss/University of Florida/Bugwood.org - CC BY 3.0 US.

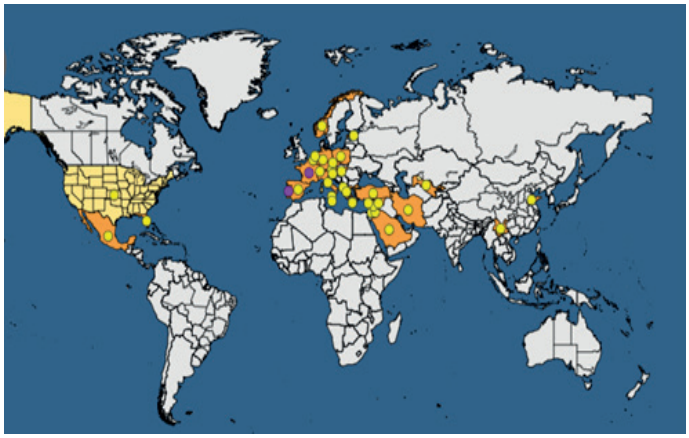
S. frugiperda larva on maize cob. ©Phil Sloderbeck/Kansas State University/ Bugwood.org - CC BY-NC 3.0 US.

S. frugiperda larval damage on maize (Zea mays). ©University of Georgia/Bugwood.org - CC BY 3.0 US.

Tomato brown rugose fruit virus

Tomato brown rugose fruit virus is an emerging virus that can cause serious damage to pepper and tomato production.

Geographical distribution



Tomato brown rugose fruit virus was first recorded in the Jordan valley and Israel between the autumn of 2014 and spring 2015. The virus did not derive from existing Tobamovirus present in the region, so it is likely to have been imported to this area of intensive tomato production from other regions of the world. Since then, the virus has been reported in several countries in the EPPO region. The virus is considered transient under eradication in a number of countries such as Cyprus, France, the Netherlands, Spain and the United Kingdom.

Hosts

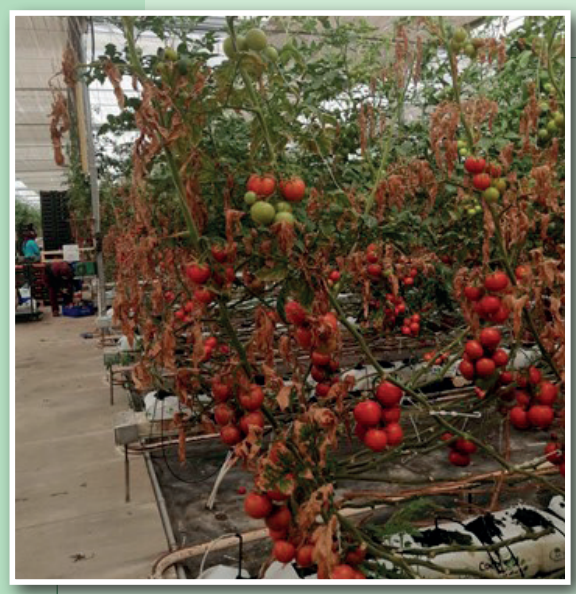
Tomato (*Solanum lycopersicum*) and pepper (*Capsicum annuum*) are the only confirmed natural hosts of tomato brown rugose fruit virus.

Economic impact

Although there are no specific data on the damage caused by tomato brown rugose fruit virus, its economic impact (direct and indirect) could be very high because only preventive measures can be applied and there are no curative approaches other than rouguing after the virus has been detected in a specific field/ greenhouse. The virus can infect up to 100% of the plants in a crop and cause 30-70% loss of tomato yield on plants. Due to the symptoms, the fruits of infected plants lose market value or are unmarketable. Infection can also significantly reduce plant vigour that can reduce the length of the production period and lead to premature death of the plant. A higher impact is expected in intensive glasshouse production areas than in open fields. One example of the economic impact of the virus, based on claims due to a specific tomato brown rugose fruit virus introduction that was contained by successful eradication, resulted in a cost of 100 k Euros/ha of tomato greenhouse crop.

The information above is based on the EPPO datasheet on tomato brown rugose fruit virus, prepared by the EPPO Secretariat based on the pest risk analysis performed by EPPO in 2019 and the CABI datasheet. The EPPO datasheet with more information on the pest can be viewed and downloaded from the EPPO Global Database. The CABI datasheet is available from the CABI Invasive Species Compendium.

ToBRFV marbling on fruit (Israel, 2019). Courtesy of C. Picard (European and Mediterranean Plant Protection Organization, France).



ToBRFV symptoms on tomato plants. Courtesy of T. Demir (Akdeniz University, Turkey).

ToBRFV symptoms on pepper fruits. Courtesy of R. Alkowni (An-Najah National University, Palestine)

3.3 Research topic descriptions

After the October meeting, the following research topics received an expression of interest from several countries and were shortlisted:

- Detection and identification of severe strains of citrus tristeza virus
- Insights into the biology of tomato brown rugose fruit virus: virus survival in soil
- Diagnosis of *Xylella fastidiosa* on important Mediterranean plants and their matrices
- The insect vectors of *Xylella fastidiosa*

Regarding the last topic, countries were invited to join an Euphresco project on "Insect vectors of *Xylella fastidiosa* (2)" that started recently rather than beginning a new collaboration (https://zenodo.org/record/4675795#.YYlUBGDMKUl).
The first three research topics are described in this paragraph.

Detection and identification of severe strains of citrus tristeza virus

Description of the problem the research should solve

Citrus tristeza virus (CTV) (Genus Closterovirus) is responsible for one of the most devastating virus diseases of citrus worldwide (Roistacher, 1991). The virus is present in all continents and the most common symptom is the quick decline observed in different citrus species such as sweet orange (*Citrus sinensis*), mandarins (*C. reticulata*), grapefruits (*C. paradisi*), kumquats (*Fortunella* spp.) and limes (*C. aurantifolia*) when grafted on sour orange (*C. aurantium*) or lemon (*C. limon*) rootstocks; other severe expressions of CTV infection are the seedling yellows, observed in nursery, and stem pitting that causes irregular growth of phloem tissues producing pits in the wood of sweet orange and grapefruit, low fruit-bearing and significantly reduced quality.
To date, six major CTV reference strains have been described: T36 (Karasev *et al*., 1995), T3 (Hilf *et al*., unpublished), VT (Mawassi *et al*., 1996), T68 (Harper, 2013), T30 (Albiach-Marti *et al*., 2000) and RB (Harper *et al*., 2010) mainly based on their genomic features. However, the relationship between genotype and phenotype is still unclear and a classification based on phenotype is not advisable (Harper, 2013).
Until recently, strain identification has been possible using a lengthy protocol based on the combination of serological, molecular and biological indexing tests. In particular, monoclonal antibodies (MCA13) (Permar *et al*., 1990) and the multiple molecular markers (MMM) (Hilf *et al*., 2005) have been found useful to diagnose severe CTV strains. The MCA13 antibody is no longer commercially available, which negatively impacts the diagnostic protocol currently in use. The project will aim to develop fast and efficient molecular tests for the detection and identification of CTV strains and in particular, the severe strains.

Description of the expected results

Project activities will focus on: a) gathering information on available diagnostic tools or tests that are currently being developed; b) collecting reference material to cover the diversity of CTV isolates; c) performing *in silico* analysis of viral DNA sequences and design primers or probes for the molecular detection and identification of CTV strains; d) organizing a test performance study to validate the test(s) identified/developed. The project expected result is the development and validation of molecular test(s) for the detection and identification of severe strains of CTV.

Insights into the biology of tomato brown rugose fruit virus: virus survival in soil

Description of the problem the research should solve

Tomato brown rugose fruit virus is an emerging tobamovirus that was first observed in 2014 and 2015 on tomatoes in Israel and Jordan. Since, outbreaks of the virus have been reported from other Middle Eastern countries but also from the EPPO region and North America. The virus causes major concerns for growers of tomato and pepper as it reduces the vigour of the plant, causes yield losses and virus symptoms make the fruits unmarketable. The virus is recommended for regulation (EPPO A2 list) and regulated in the EU (Emergency measures, 2019).

Tobamoviruses can survive outside of the host on inert and biological surfaces as well as in nutrient film solutions and soil for months without losing their virulence (EPPO, 2020; Li *et al*., 2016; Smith *et al*., 2019). The ability to survive in the soil or on plant debris allows microorganisms to maintain a viable inocula between cropping seasons, through crop rotations, or during periods when conditions are unfavorable for infection of the host. Therefore, this turns the soil into a potentially long-term reservoir of viable inocula. Studies on the survival of tomato brown rugose fruit virus have been ongoing in Israel (EPPO, 2020), but additional information should be collected considering the type of soil, the environmental conditions, the crop cultivated and the management practices, etc.

The goal of the project is to increase knowledge on the survival of tomato brown rugose fruit virus in soil in order to achieve a better management. It is expected that the project makes links with relevant national and international research initiatives such as the Euphresco project 2019-C-326 'Soil-borne plant pathogens survival in soil', the Euphresco project 2019-A-324 'Reliable detection of pathogens in soil' and others.

Description of the expected results

The project will develop new knowledge on the survival of tomato brown rugose fruit virus in soil in different agro-ecological and pedoclimatic conditions. Survival in composting will also be considered. The project will validate tests for the diagnosis of the tobamovirus in soil and compost (including eDNA approaches) and will develop management guidelines.

Diagnosis of *Xylella fastidiosa* on important Mediterranean plants and their matrices

Description of the problem the research should solve

Xylella fastidiosa is a bacterium which can cause severe diseases in economically important fruit crops and many other woody plants. The outbreak of *X. fastidiosa* in olive trees in Southern Italy and the presence of the bacterium in Mediterranean plant species in the natural and urban landscapes of Italy, France, Spain and Portugal, constituted a major change to its geographical distribution. *X. fastidiosa* is a polyphagous bacterium that can infect the xylem of a wide range of cultivated and wild host plants. A total of 638 plant species have been reported in the scientific literature as plant hosts of *X. fastidiosa* (EFSA, 2021).

Diagnostic protocols have been validated for the major hosts, such as olive (*Olea europaea*) and *Prunus* spp., but work is still needed to validate protocols on other plant species and their matrices, with a particular focus on Mediterranean flora. There is also a need to develop and validate DNA extraction methods that are high-throughput and that can be performed on large volumes of (Mediterranean) plant matrices.

Description of the expected results

The project will validate protocols (DNA extraction, serological and molecular tests) for the diagnosis of *Xylella fastidiosa* in several Mediterranean plant species. The project will also contribute to building diagnostic capacity of Mediterranean countries.

Appendix 1
INTERNATIONAL WORKSHOP
Plant Health Research Priorities for the Mediterranean Region

Online meeting 2021-05-12
9 AM – 1 PM (GMT+1)

09:00	**OPENING** **Compendium on the Plant Health research priorities for the Mediterranean region** Baldissera Giovani (EPPO-EUPHRESCO) Anna Maria D'Onghia (CIHEAM Bari)
09:20	**EPPO Pest data sheets** Nico Horn (EPPO)
09:30	**The impact of important pests for the Mediterranean region** *Research Priorities* Franco Valentini (CIHEAM Bari, Italy) Dorsaf Yahiaoui (CTA, Tunisia) Jaime Cubero (INIA/CSIC, Spain) Isabel Abrantes (UC, Portugal) Samia Laala (ENSA, Algeria) Melike Yurtmen (BCRI, Turkey) Moulay Hassan Sedra (Morocco) Francesco Porcelli (UniBA, Italy) Jason Sumner-Kalkun (SASA, Scotland) Eleni Kalogeropoulou (BPI, Greece) Gianfranco Anfora (FEM, Italy)
10:15	**Working Group discussions by country's representatives*** *How to work together on common priorities* BALKANS: Albania, Bosnia, Croatia-Herzegovina, Greece, North Macedonia, Slovenia Chaired by Yannis Livieratos (CIHEAM Chania) & Jelena Plavec (HAPIH) NORTH AFRICA: Algeria, Libya, Morocco, Tunisia Chaired by Mekki Chouibani (NEPPO) & Arop Deng (IPPC-FAO) NEAR EAST: Egypt, Lebanon, Syria, Turkey Chaired by Ibrahim Al-Jboory & Elia Choueiri (ASPP) WESTERN EUROPE: France, Italy, Malta, Portugal, Spain Chaired by Nico Horn (EPPO) & Laura Mugnai (MPU)
11.30	**Plenary presentations** *Working Group reports by chairs*
12.00	**Plenary discussions** *How to initiate collaborative research activities on important pests* *How to benefit from the Compendium*
13.00	**CLOSING** Placido Plaza (CIHEAM)

WORKING-GROUP PARTICIPANTS

BALKANS

ALBANIA
Alban Isufi - *Ministry of Agriculture and Rural Development*

BOSNIA & HERZEGOVINA
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CROATIA
Tisa Vizek Borovina, Ivica Delic - *Ministry of Agriculture*

GREECE
Christos Arampatzis - *Ministry of Agriculture*
Panagiotis Milonas - *Benaki Phytophatological Institute*

NORTH MACEDONIA
Mentor Zekiri - *Ministry of Agriculture, Forestry and Water Economy*
Stanislava Lazarevska, Kiril Sotirovski - *University of Ciril and Methodius*

SLOVENIA
Erika Oresek - *Ministry of Agriculture Forestry and Food*

CIHEAM Bari - *Marwa Mourou*

INTERNATIONAL
Themistoklis Chatzikonstantinou - *Interreg-Balkan Mediter Secretariat*

INTERNATIONAL
Francesca Marcato - Interreg-Med Secretariat

NEAR EAST

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Michel Efram, Wassim Habib, Zinette Moussa, Ziad Rizkb
Lebanese Agricultural Research Institute

SYRIA
Eyad Mohammad - *Ministry of Agriculture & Agrarian Reform*

TURKEY
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Arafat Hanani

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Ahmed Kamal El-Attar - *Ministry of Agriculture and Land Reclamation*

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Rachid Ioutichene - *Ministry of Agriculture and Rural Development*
Hamid Bensaad - *National Institute of Plant Protection*

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Abdallah Mohamed Adaa - *University of Sebha*

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Faouzi Bakkaoui - *National Institute of Agronomic Research*

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Franco Valentini

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Fabrice Dentressangle, Ali Rhouma - *Partnership for Research and Innovation in the Mediterranean Area*

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Pio Federico Roversi - *Council for Agricultural Research and Economics*

MALTA
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National Institute for Agricultural and Veterinarian Research
Pedro Fevereiro - *InnovPlantProtect*

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Ester Esteban - *National Institute for Agricultural Research and Food Technology*
Estrella Fernandez - *Spanish State Research Agency*

CIHEAM Bari
Ahmed Elhussein

INTERNATIONAL
Giuseppe Stancanelli - *European Food Safety Authority*

INTERNATIONAL
Paloma Melgarejo - *Joint Programming Initiative on Agriculture, Food Security and Climate Change*

Appendix 2

TELECONFERENCE WITH INTERNATIONAL ORGANIZATIONS & FUNDERS

Agenda

11 October, 2021

14:00	**Welcome** Anna Maria D'Onghia (CIHEAM Bari)
14:10	**Overview of workshop outputs, endorsements by countries and actions for the next months** Anna Maria D'Onghia (CIHEAM Bari) Baldissera Giovani (EPPO-EUPHRESCO)
14:30	**Possible contributions from international organizations** 5 min per organization
15.20	**Wrap-up** Anna Maria D'Onghia (CIHEAM Bari) Baldissera Giovani (EPPO-EUPHRESCO)
15.30	**End**

LIST OF PARTICIPANTS

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the Arab Society for Plant Protection

Laura MUGNAI
the Mediterranean Phytopathological Union

Giuseppe STANCANELLI
the European Food Safety Authority

Paloma MELGAREJO
the Joint Programming Initiative on Agriculture, Food Security and Climate Change

Ali RHOUMA
the Partnership for Research and Innovation in the Mediterranean Area

Anna Maria D'ONGHIA & Biagio DI TERLIZZI
CIHEAM Bari

Baldissera GIOVANI
Euphresco

TELECONFERENCE WITH NATIONAL CONTACT POINTS

Agenda

20 October, 2021

10:00	**Welcome** Anna Maria D'Onghia (CIHEAM Bari)
10:05	**Overview of workshop outputs and actions for the next months** Anna Maria D'Onghia (CIHEAM Bari) Baldissera Giovani (EPPO-EUPHRESCO)
10:30	**Agreement on the research topics to shortlist and possible involvement of countries** 5 min per country/organization
11.55	**Wrap-up** Anna Maria D'Onghia (CIHEAM Bari) Baldissera Giovani (EPPO-EUPHRESCO)
12.00	**End**

LIST OF PARTICIPANTS

Rachida IOUTICHENE, Fatiha KECHOUT
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SUPPLEMENT 1

2022

Compendium on the plant health research priorities for the Mediterranean region

coordinated by
the International Centre for Advanced Mediterranean Agronomic Studies
and
the Euphresco network for phytosanitary research coordination and funding