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First batch of practice abstracts for end-users

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Abstract

This deliverable contains the resume and contents of the 12 practice abstracts already developed under the Project's activity. 18 more are expected to be delivered in the second batch, resulting in a total of 30 practice abstracts by the end of the Project.

Table of contents

1.	Introduction.....	4
2.	Summary of Practice Abstracts	5
3.	Description of Practice Abstracts	6
3.1	Survey on user requirements for OPTIMA IPM system: results obtained from carrot growers in France	6
3.2	Survey on user requirements for OPTIMA IPM system: results obtained from vineyard growers in Italy	6
3.3	Survey on user requirements for OPTIMA IPM system: results obtained from apple orchard growers in Spain	7
3.4	Detection of downy mildew on grape leaves with spectral image analysis	7
3.5	Detection of downy mildew on grape leaves with deep-learning on high resolution RGB images.....	8
3.6	Biological control of grape downy mildew	8
3.7	Chemical control of grape downy mildew	9
3.8	Biological control of Alternaria leaf blight in carrots	10
3.9	Assessment of optimal operative parameters for a vineyard smart sprayer	10
3.10	Reducing the use of plant protection products in carrot fields by band spray applications	11
3.11	Optimal spray configuration for an efficient and sustainable PPP use in apple trees	11
3.12	Development of artificial apple trees for laboratory trials	12

1. Introduction

The European Innovation Partnership for Agricultural productivity and Sustainability (EIP-AGRI) was launched in 2012 to contribute to the European Union's strategy "Europe 2020" for smart, sustainable and inclusive growth. This strategy sets the strengthening of research and innovation as one of its five objectives and supports a new interactive approach to innovation: European Innovation Partnerships¹.

The resulting innovative knowledge and easy accessible end-user material from this project will feed into the EIP-AGRI website for broad dissemination. The end-user material to be produced contains a substantial number of summaries for practitioners in the EIP common format ("practice abstracts"), including the characteristics of the project (e.g. contact details of partners, etc).

All Horizon 2020 multi-actor projects and thematic networks as well as all EIP-AGRI Operational Groups use this common format to provide farmers, foresters, advisers or whoever is interested with short and concise practical information. The use of the EIP-AGRI common format facilitates not only the exchange of knowledge, but also the contact between potential partners in innovation projects. It contributes to building up a unique repository of practical knowledge across the EU via the [EIP-AGRI project database](#) which supports the dissemination of results of all interactive innovation projects.

A full package of practice abstracts will be produced by OPTIMA project, containing all the outcomes/recommendations which are ready for practice. A "practice abstract" is a short summary of around 1000-1500 characters (word count – no spaces) which describes the main information/recommendation/practice that can serve the end-users in their daily practice. Guidance and templates for these practice abstracts are available on the [EIP-AGRI web site](#). A total target number of 30 practice abstracts is foreseen for the project. 12 are delivered in this first batch.

¹ <https://ec.europa.eu/eip/agriculture/en/about>

2. Summary of Practice Abstracts

Nº	Language	Partner	WP	Title
<u>1</u>	English French	UNITO together IRSTEA/AO/INVENIO	with 1	Survey on user requirements for OPTIMA IPM system: results obtained in France
<u>2</u>	English Italian	UNITO together TdV/CAFFINI	with 1	Survey on user requirements for OPTIMA IPM system: results obtained in Italy
<u>3</u>	English Spanish	UNITO together UPC/FEDE	with 1	Survey on user requirements for OPTIMA IPM system: results obtained in Spain
<u>4</u>	English	WR	2	Detection of downy mildew on grape leaves with spectral image analysis
<u>5</u>	English	WR	2	Detection of downy mildew on grape leaves with deep-learning on high resolution RGB images
<u>6</u>	English	AUA	3	Biological control of grape downy mildew
<u>7</u>	English	AUA	3	Chemical control of grape downy mildew
<u>8</u>	English	AUA	3	Biological control of Alternaria leaf blight in carrots
<u>9</u>	English Italian	ILVO together UNITO/TdV/CAFFINI	with 4	Assessment of optimal operative parameters for a vineyard smart sprayer
<u>10</u>	English	ILVO together IRSTEA/AO/INVENIO/CAFFINI	with 4	Reducing the use of plant protection products in carrot fields by band spray applications
<u>11</u>	English Spanish	UPC together with FEDE	4	Optimal spray configuration for an efficient and sustainable PPP use in apple trees
<u>12</u>	English Spanish	UPC	4	Development of artificial apple trees for laboratory trials

3. Description of Practice Abstracts

3.1 Survey on user requirements for OPTIMA IPM system: results obtained from carrot growers in France

In the ambit of OPTIMA WP1 activities, a survey aimed at collecting indications from farmers about their needs and expectations concerning OPTIMA IPM approach, was carried out in the carrot pilot area in France, in Nouvelle Aquitaine region. Results pointed out that farmers, generally follow IPM voluntary plant protection strategy, but only few applications concerns bio-PPP. Carrot growers do not use bio-PPPs for the control of *Alternaria D* as no bio-product is currently registered in France. Growers are generally in favour of the adoption of bio-PPPs. Farmers showed interest in the development of new bio-PPPs enabling to protect carrot crop from other diseases. In general terms, the interviewed farmers declared to be interested in the development of more precise Decision Support Systems able to address them in the timing and management of spray application and they also encouraged the development of tools for early disease detection. Farmers showed great interest in the development of optimized sprayer since the localization of sprays is a factor of the reduction of the quantities of PPP. OPTIMA IPM approach was therefore considered interesting, but farmers pointed out complementary actions to the project such as the development of resistant varieties, the quantification of fungi spores and the use of electrostatic spraying.

3.2 Survey on user requirements for OPTIMA IPM system: results obtained from vineyard growers in Italy

In the ambit of OPTIMA WP1 activities a survey aimed at collecting indications from farmers about their needs and expectations concerning OPTIMA IPM approach was carried out in the vineyard pilot area in Italy, in Piemonte region. Results pointed out that most of farmers actually follow IPM voluntary plant protection strategy, but they generally do not use bio-PPPs in particular for the control of downy mildew. They are generally in favour of the adoption of bio-PPPs provided that the efficacy is proven and that the frequency of the application can be compatible with other operations to carry out in the vineyard. Farmers look also for the development of new bio-PPPs enabling to protect vines from other diseases like golden flavesence and Escà disease. In general terms the interviewed farmers declared to be interested in the development of more precise Decision Support Systems able to address them in the timing and management of spray application and they also encouraged

the development of tools for early disease detection. One concern was pointed out regarding the realization of smart sprayers which should not be too complicated to operate and especially not too expensive if compared to a conventional one. OPTIMA IPM approach was therefore considered interesting, but farmers remarked the importance to link environmental with economical sustainability.

3.3 Survey on user requirements for OPTIMA IPM system: results obtained from apple orchard growers in Spain

Spanish farmers from the pilot zone (Épila, Zaragoza) were consulted in the OPTIMA project framework, in order to catalogue their working conditions in apple fields. The objective was also to record their expectations with the IPM OPTIMA system and therefore serve as a realistic guide for future work in the project. Concerning plant protection strategy, the major part of the farmers declared to follow voluntary or mandatory protocols of IPM. Spanish producers, also declared to mix two or more synthetic PPP for the same application, but concerning the use of bio-PPP, it was observed that the farmers generally do not mix them together with other products. It has to be pointed out that no specific bio-PPP are commonly used for treatments in the examined pilot area, at exception of the copper and sulphur based products, that are considered as “bio-PPP”, and they are very reticent to use this kind of formulates. Regarding spraying equipment, the majority of farmers are using a conventional axial fan sprayer, with or without deflectors. Majority of the interviewed farmers and field technicians has considered the development of disease early detection instruments and refined disease prediction models as the most promising activity within OPTIMA project. Concerning the spray adjustment, and determination of most adequate volume rate, most of farmers indicated that they do not consider the canopy structure to determine the volume rate. The only changes they use to arrange is the working pressure and, eventually, forward speed. They were a bit sceptic to reduce the amount of liquid/PPP.

3.4 Detection of downy mildew on grape leaves with spectral image analysis

Downy mildew (*Plasmopara viticola*) is an endemic disease that affects vineyards worldwide. The disease can cause severe crop loss when it is not detected in an early stage. Early detection as part of an integrated pest management (IPM) system would be enormously beneficial to not just the farmer but also to the wider environment. In the scope of OPTIMA WP2, a state-of-the-art decision support system (DSS) will be used to determine the risk of

disease outbreak. In this research, we investigated the early detection of downy mildew with spectral image analysis, as input to the DSS, in order to precisely localise and quantify the infection, so that appropriate plant protection product type, dose, timing and location will be recommended. Image data was acquired in the field and in the greenhouse, using a spectral camera with high spectral resolution (200 bands). The spectral images were processed by a linear discriminant analysis that highlighted that the wavelengths at 550, 720, and 750 nm were most discriminative for classifying mildew infection from healthy leaf tissue. From this research, it was concluded that downy mildew can be detected in an early stage with spectral image analysis using a selection of wavelength bands.

3.5 Detection of downy mildew on grape leaves with deep-learning on high resolution RGB images

Downy mildew (*Plasmopara viticola*) is an endemic disease that affects vineyards worldwide. The disease can cause severe crop loss when it is not detected in an early stage. Early detection as part of an integrated pest management (IPM) system would be enormously beneficial to not just the farmer but also to the wider environment. In the scope of OPTIMA WP2, a state-of-the-art decision support system (DSS) will be used to determine the risk of disease outbreak. In this research, we investigated the early detection of downy mildew with deep-learning and spectral analysis, as input to the DSS, in order to precisely localise and quantify the infection, so that appropriate plant protection product type, dose, timing and location will be recommended. Image data was acquired in the field and in the greenhouse, using a high spatial resolution colour camera (10 Mp). Disease spot classification was done with deep-learning using a convolutional neural network (CNN) that was trained and tested on the high resolution RGB images. Ground truth annotations were done by experienced crop experts. The CNN (we used YOLOv3) had a precision of 89.5% and a recall of 82.3%. From this research, it was concluded that downy mildew can be detected in an early stage with RGB image based deep-learning.

3.6 Biological control of grape downy mildew

Grape downy mildew, caused by the obligate parasite *Plasmopara viticola*, attacks all European vine varieties and may cause large losses of production, especially in warm and humid climates. The pathogen affects all green parts of the vine, especially the leaves, and also the branches. Common symptoms include oily, yellowish and angular lesions on leaves, located between the veins, but also necrosis of the stem or shoot. As the disease

progresses, after warm and humid nights, a white mycelium (downy mildew) can be observed on the lower leaf surface. Biological control of grape downy mildew is mainly based on the application of copper compounds as contact fungicides, leading to accumulation of this heavy metal in the topsoil in many European countries. As a consequence, the use of copper fungicides is now restricted by European Union Regulation 2018/1981 to 4 kg/ha/year. OPTIMA project is searching alternative products to reduce the use of copper-based formulations. Tests are in progress in Greece and Italy on biological plant protection products such as *Trichoderma* spp., *Bacillus amyloliquefaciens*, *Pythium oligandrum*, *Bacillus pumilus*, *Aureobasidium pullulans*, laminarin, eugeniol, geraniol and thymol. Practical recommendations are: the use of tolerant varieties or at least of less sensitive varieties; balanced fertilization with reduced nitrogen to avoid excessive vigour and canopy development; the use of natural products and elicitors to enhance plant self-defence that are registered in several EU countries such as cerevisane and orange oil; the use of Decision Support Systems to optimize PPP use and application timing.

3.7 Chemical control of grape downy mildew

Grape downy mildew, caused by the parasite *Plasmopara viticola*, attacks all European varieties and may cause large losses of production, especially in warm and humid climates. The pathogen affects all green vine parts, especially leaves and bunches. Main symptoms include oily, yellowish and angular lesions on leaves, located between the veins and necrosis of the stem or shoot. OPTIMA project is searching alternative products to reduce the use of chemical PPP and optimize their efficacy. Both pre-infection (protective) and post-infection (systemic or penetrant) fungicides are widely used for the control of grape downy mildew. Pre-infection fungicides include copper-based fungicides, dithiocarbamates (e.g. mancozeb, metiram), phthalimides (folpet) and quinones (dithianon) that are applied close to an infection event. Post-infection should be applied as soon as possible after an infection event and prior to the appearance of oilspots. Currently registered in EU post-infection fungicides include: phenylamides (e.g. melalaxyl, benalaxyl), Qil (e.g. amisulbrom, ciazofamid), phosphonates (e.g. fosetyl-aluminum, potassium phosphonate), QoSI (e.g. ametoctradin), carboxylic acid amides (e.g. mandipropamid, iprovalicarb, dimethomorph, benthialicarb, valifenalate), benzamides (e.g. zoxamide, fluopicolide), QoI (e.g. famoxadone, pyraclostrobin), oxathiapiprolin, fluazinam and cymoxanil. Fungicide resistance to some of these chemicals, such as QoI or CAA fungicides, have been reported and in order to prevent the development of fungicide resistance, practical recommendations are to apply the at-risk

fungicides in combinations as a tank mix and to rotate fungicides with different mechanisms of action.

3.8 Biological control of Alternaria leaf blight in carrots

Alternaria leaf blight caused by the fungus *Alternaria dauci* is the major foliage disease of carrots in most areas of production, responsible for important economic losses worldwide. *A. dauci* causes severe defoliation in carrot crops, especially under conditions of high moisture and temperature. While foliar symptoms are the most common, *A. dauci* can also infect the stems, the inflorescences and seeds developing in umbels. Foliar symptoms appear as small, green-brown lesions. The lesions enlarge and infected tissue becomes dark brown to black, sometimes surrounded by a chlorotic halo.

Control of *Alternaria dauci* is mainly based on the use of different fungicides as no biocontrol product is approved for carrots. OPTIMA project is searching into alternative products to reduce the use of synthetic chemicals. Tests are in progress in France and Greece with biological plant protection products including *Bacillus subtilis* and *Bacillus pumilus*, seaweed or plant extracts, *Trichoderma* spp. First results in greenhouse trials are promising.

Practical recommendations are: the use of commercial treated seeds and partial resistant varieties; reasoned nitrogen fertilization and without excess; avoid leaving crop residues on the plot; the use of Disease forecast models to optimize pesticide use and application timing.

3.9 Assessment of optimal operative parameters for a vineyard smart sprayer

In the ambit of OPTIMA WP4 activities a set of laboratory and field tests were carried out in order to select the optimal configuration of a Caffini Synthesis tower shaped air-assisted sprayer, starting point for the development of the OPTIMA smart sprayer for vineyards. In laboratory tests aimed at assessing the vertical spray profiles using different types of nozzles (conventional hollow cone, conventional flat fan and air induction flat fan) were made using an ad hoc test bench. Results pointed out that the most effective sprayer configurations to precisely match the vine target at full growth stage were obtained activating 6+6 nozzles flat fan nozzles operated at 4 bar pressure. Tests made with a sonic anemometer to evaluate the air velocities on the target pointed out that setting the PTO revolution speed at 450 rev/min and using the low fan gear enabled to get average air velocities between 4 and 6 m/s in correspondence of the target, which is the optimal range to maximise spray deposition and prevent spray drift. Field tests pointed out that using the optimised sprayer configurations

with flat fan nozzles, either conventional or air induction, the average spray deposit on the leaves increased by 40% with respect to that obtained using a reference conventional axial fan sprayer equipped with hollow cone nozzles operated at 14 bar pressure.

3.10 Reducing the use of plant protection products in carrot fields by band spray applications

Carrots are high value crops that unfortunately demand high amounts of fungicides to be applied in numerous applications to properly control *Alternaria* leaf blight. Severe epidemics of this disease can reduce the yield up to 40-60%. Under high pressure, no single control measure is sufficient to manage the disease adequately on its own. Therefore, the disease management currently relies on the combination of plant protection products (PPPs), the use of partial resistant varieties and monitoring with a disease forecaster. The use of PPPs (synthetic or biologic) could be reduced by the use of band spray applications instead of broadcast applications, by using an appropriate nozzle configuration (combination of nozzle type, size, spray angle) at optimal nozzle height and distance. These optimal settings depend on the carrot growth stage, planting system and cultivar, which determine the leaf foliage width and thus the target zone. As an example, configurations with 4 nozzles per bed (either 4 standard flat fan nozzles XR 80 04 or XR 80 02, 4 air induction nozzles AI 80 04, or 2 air induction nozzles AI 110 04 in combination with 2 off-center nozzles AIUB 85 04) have been shown to have a clear advantage over standard broadcast applications, with lower application rates (L/ha), much lower losses outside the target zone (up to 33%), good uniformity, and higher deposition for target zone widths from 1.2 to 1.8 m in a planting system with 1.83 m beds and 0.5 m inter-bed distance. In addition, the lowest levels of spray deposition recovery were obtained with the broadcast application with XR 110 04 nozzles, justifying the improvement of spray applications of carrot crops with optimized technologies using adjusted nozzles types and band spray configurations.

3.11 Optimal spray configuration for an efficient and sustainable PPP use in apple trees

One of the objectives of OPTIMA project is to develop a smart-sprayer for a more efficient and sustainable use of Plant Protection Products (PPP) in apple trees. The starting point was the Futur Inverter Qi 9.0 H30 (Pulverizadores Fede S.L., Cheste, Spain), which represents the high level of the technology available in the market. Twelve different nozzles technologies which may lead to an improvement in the distribution were selected and tested in

laboratory conditions. During the trials, vertical distributions of all the configurations were evaluated using a vertical test bench (AAMS-Salvarani, Maldegem, Belgium). Complementarily, coverage trials were arranged using artificial apple trees and measured using water sensitive papers (Syngenta, Bassel, Switzerland) placed in twelve different positions, 4 levels in height and 3 in depth. During the process, air characteristics for the selected sprayer's configurations were measured and characterized using a 2D anemometer at the outlet section of the sprayer. Results from the different experiments showed that, for the considered apple canopy characteristics, the best spray technologies were the Lechler IDK 90 02 at 10.9 bar and Lechler IDK 90 03 at 4.9 bar, both flat fan spray pattern. For the two tests, the optimal airflow settings were a large rotary speed of the fan with a blade angle of 30°, generating 26195m³/h. The main difference between both configurations was the generated droplet size, an important characteristic with a clear and direct influence on the environmental risk (spray drift), coverage and bio-efficacy. OPTIMA project will evaluate drift and bio-efficacy in future trials, to encounter the optimum technology for the orchard apple crop.

3.12 Development of artificial apple trees for laboratory trials

OPTIMA include a huge number of laboratory trials in order to select the optimal spraying configuration, among others, for apple crop. Apple crop is a deciduous tree, which does not permit to make trials all the year, because in some periods it does not present vegetation. For this reason, five artificial apple trees were designed with the aim of analyzing phytosanitary application techniques under laboratory conditions. The structures were build using as base iron tubes, where wooden cylindrical masts were inserted, and at the same time, main branches, also made of wood, were inserted into the masts. The artificial leaves branches, made of plastic, are composed of 42 leaves each one. Five structures were build following the same characteristics of the orchard apple trees in Spain, where the field trials will be carried out of the project. The height of each tree is 3,5 m and 1,64 m of width. The foliar branches were analyzed using a planimeter in order to evaluate the target vegetation area. In each artificial tree were placed a total of 110 leaf branches. The leaf branches can be modified in order to simulate different crop stages of the apple trees cobbering the whole range since an initial crop stage to the full vegetation that reaches at the ending of the season. The artificial vegetation has been validated to ensure its usefulness. No statistical differences were observed between the constructed vegetation and the previous tests carried out in the pilot zone, with the real vegetation, regarding the spray coverage under

the same treatment conditions. Different spraying configurations were tested in the artificial trees with the aim to evaluate the coverage and select the optimal spraying configuration for this crop.



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