



Del 7.7

Second batch of practice abstracts for end-users

June 30th, 2022



Document Summary

Deliverable Title: **Second batch of practice abstracts for end-users**

Version: **Version 1.**

Deliverable Lead: **CERTH-iBO**

Related Work package: **WP1, WP2, WP3, WP4, WP5, WP6**

Author(s): **Thanos Balafoutis, Michael Moraitis**

Contributor(s): **All Partners**

Communication level: **PU Public**

Project Number: **773718**

Grant Agreement Number: **773718**

Programme: **OPTIMA**

Start date of Project: **September, 2018**

Duration: **46* months**

Project coordinator: **Agricultural University of Athens (AUA)**

Abstract

This deliverable is supplementary to D7.6 “First batch of practice abstracts for end-users” and contains the resume and contents of 20 additional practice abstracts developed under the Project’s activity; achieving the initial target which was expecting a total of 30 practice abstracts to be delivered by the end of the Project. All 32 practice abstracts will be displayed on the OPTIMA webportal Library, and the EIP-AGRI website.

Table of contents

1.	Introduction.....	4
2.	Summary of Practice Abstracts	5
3.	Description of Practice Abstracts	7
3.1	Focus Group and end user assessment of OPTIMA IPM strategy in vineyards (Italy) ..	7
3.2	Focus Group and end user assessment of OPTIMA IPM strategy in apple orchards (Spain) 7	
3.3	Focus Group and end user assessment of OPTIMA IPM strategy in open field carrots (France) 8	
3.4	OPTIMA DSS for the detection of plant diseases in vineyards, carrots and apples	8
3.5	Description of OPTIMA EDS and results	9
3.6	Chemical control of apple scab	9
3.7	Biological control of apple scab.....	10
3.8	BMPs for Vineyard Downy Mildew control	10
3.9	BMPs for Apple Scab control.....	10
3.10	BMPs for Alternaria leaf blight in carrots.....	11
3.11	Best Management Practices for set-up and use of smart sprayers	11
3.12	Best Management Practices for spray applications in vineyards.....	12
3.13	Best Management Practices for spray applications in apple orchards	12
3.14	Best Management Practices for spray applications in bed-grown carrot fields	13
3.15	Field evaluation of the OPTIMA IPM system: Vineyard case	13
3.16	Field evaluation of the OPTIMA IPM system: Apple case	14
3.17	Field evaluation of the OPTIMA IPM system: Carrot case.....	14
3.18	Integrated Pest Management on vineyards: multi-criteria assessment addressing human health and environmental risks, impacts and costs	15
3.19	Integrated Pest Management for apple orchards: multi-criteria assessment addressing human health and environmental risks, impacts and costs	15
3.20	Integrated Pest Management for carrots: multi-criteria assessment addressing human health and environmental risks, impacts and costs	16

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 has been produced by the 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 was initially foreseen for the project. 12 were delivered in the first batch (D7.6 First batch of practice abstracts for end-users) and 20 more in this second batch, resulting in a total of 32. The first batch is already uploaded on the webportal Library (<https://optima-h2020.eu/library/>) and the EIP-AGRI website (<https://ec.europa.eu/eip/agriculture/en/find-connect/projects/optimised-pest-integrated-management-precisely>), and the second will soon be.

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

2. Summary of Practice Abstracts

Nº	Language	Partner	WP	Title
1	EN, IT	UNITO	1	Focus Group and end user assessment of OPTIMA IPM strategy in vineyards (Italy)
2	EN	UNITO	1	Focus Group and end user assessment of OPTIMA IPM strategy in apple orchards (Spain)
3	EN	UNITO	1	Focus Group and end user assessment of OPTIMA IPM strategy in open field carrots (France)
4	EN, GR	WUR, AGENSO	2	OPTIMA DSS for the detection of plant diseases in vineyards, carrots and apples
5	EN	WUR, AUA	2	Description of OPTIMA EDS and results
6	EN, IT	AUA, UNITO	3	BMPs for Vineyard Downy Mildew control
7	EN, IT	AUA, UNITO	3	BMPs for Apple Scab control
8	EN	AUA	3	BMPs for Alternaria leaf blight in carrots
9	EN	AUA, UNITO	3	Chemical control of apple scab
10	EN	AUA, UNITO	3	Biological control of apple scab
11	EN	ILVO	4	Best Management Practices for set-up and use of smart sprayers
12	EN	ILVO, UNITO	4	Best Management Practices for spray applications in vineyards
13	EN	ILVO, UPC	4	Best Management Practices for spray applications in apple orchards
14	EN	ILVO, INRAE	4	Best Management Practices for spray applications in bed-grown carrot fields
15	EN, ES	UPC, UNITO	5	Field evaluation of the OPTIMA IPM system: Vineyard case
16	EN, ES	UPC, FEDE	5	Field evaluation of the OPTIMA IPM system: Apple case
17	EN, ES	UPC, INRAE	5	Field evaluation of the OPTIMA IPM system: Carrot case
18	EN	UC	6	Integrated Pest Management on vineyards: multi-criteria

				assessment addressing human health and environmental risks, impacts and costs
19	EN	UC	6	Integrated Pest Management for apple orchards: multi-criteria assessment addressing human health and environmental risks, impacts and costs
20	EN	UC	6	Integrated Pest Management for carrots: multi-criteria assessment addressing human health and environmental risks, impacts and costs

3. Description of Practice Abstracts

3.1 Focus Group and end user assessment of OPTIMA IPM strategy in vineyards (Italy)

During OPTIMA, regular meetings with selected vineyard growers and advisers, a Focus Group (FG), were held in order to agree on the project developments, so to achieve tangible results applicable in the field on a broad scale. This regarding: 1) timing of application using the OPTIMA Decision Support System (DSS); 2) management of application using OPTIMA Early Detection System (EDS); 3) selection of crop protection strategy and PPP/bio-PPP; 4) use and set up of smart sprayers.

Three sessions of FG meetings were held from January 2020 to July 2021 and a questionnaire was submitted to further end users and advisers who took part in field demonstrations at the OPTIMA experimental vineyard plots. The feedback received, both from FG and end users, indicated that OPTIMA DSS was considered useful and well structured, even if still to be improved especially concerning the prediction downy disease model and concerning the spatial resolution. EDS was generally considered promising, but still not mature to be used in current field activities as it requires too much time for scouting. The introduction of alternative PPPs and bio-PPPs with respect to those typically applied was welcome as it would provide an added value to the grapes product, nevertheless there were still some doubts about their efficacy in comparison to conventional products. Finally, the OPTIMA smart sprayer for vineyards was very much appreciated, especially the electric fan able to modulate the air flow in function of the canopy density and the spray variable rate were rated as the main improvements enabling to reduce PPP consumption and spray drift. Growers however underlined the need to keep the final cost of such sprayers contained, in order to get an economical benefit from the achieved savings in PPPs and fuel.

3.2 Focus Group and end user assessment of OPTIMA IPM strategy in apple orchards (Spain)

During OPTIMA, regular meetings with selected apple orchard growers and advisers, a Focus Group (FG), were held in order to agree on the project developments, so to achieve tangible results applicable in the field on a broad scale. This regarding: 1) timing of application using the OPTIMA Decision Support System (DSS); 2) management of application using OPTIMA Early Detection System (EDS); 3) selection of crop protection strategy and PPP/bio-PPP; 4) use and set up of smart sprayers.

Three sessions of FG meetings were held from February 2020 to June 2021 and a questionnaire was submitted to further end users and advisers who took part in field demonstrations at the OPTIMA experimental apple orchard plots. The feedback received, both from FG and end users, indicated that OPTIMA DSS was considered useful and well structured, even if still to be improved especially concerning info on the spray volume suggested. EDS was considered an interesting option for the future, but at the moment it was rated still not sufficiently affordable to be trusted on its apple scab diagnosis and to improve in smartness for use in the field. The introduction of alternative PPPs and bio-PPPs with respect to those typically applied was moderately appreciated, especially more

evidence of their biological efficacy was required, as bio-PPPs are still not used at all in the apple orchard area of Epila. The OPTIMA smart sprayer for apple orchard was very appreciated, as it demonstrated to enable the reduction of spray volumes and PPP consumption, therefore mitigating the environmental impact. Some concerns were however pointed out about the cost of such advanced equipment, which could considerably affect its profitability.

3.3 Focus Group and end user assessment of OPTIMA IPM strategy in open field carrots (France)

During OPTIMA, regular meetings with selected carrot growers and advisers, a Focus Group (FG), were held in order to agree on the project developments, so to achieve tangible results applicable in the field on a broad scale. This regarding: 1) timing of application using the OPTIMA Decision Support System (DSS); 2) management of application using OPTIMA Early Detection System (EDS); 3) selection of crop protection strategy and PPP/bio-PPP; 4) use and set up of smart sprayers.

Three sessions of FG meetings were held from April 2020 to November 2021 and a questionnaire was submitted to further end users and advisers who took part in field demonstrations at the OPTIMA experimental carrot fields. The feedback received, both from FG and end users, indicated that OPTIMA DSS was appreciated but needed to include references to the crop stage and the irrigation scheme, EDS was judged very promising and raised the interest of growers, provided it could be managed automatically while operating in the field. The introduction of alternative PPPs and bio-PPPs was welcome and especially bio-PPPs were considered interesting, as already some of them are coming into practice. Finally, the OPTIMA smart sprayer for carrots was very appreciated, especially regarding the achieved benefits in reducing spray drift and losses, with the possibility to customize the nozzle spacing on the boom in function of the crop bed swaths.

3.4 OPTIMA DSS for the detection of plant diseases in vineyards, carrots and apples

OPTIMA DSS is a fully functional Decision Support System that operates as a valuable tool in the hands of European producers for predicting disease outbreaks (5-day prediction) regarding 3 main plant pathogens that cause severe economic losses to vineyards (Downy mildew), apples (Apple scab) orchards and carrots (Alternaria leaf blight) by generating qualitative and quantitative degradation of the agricultural goods produced. The DSS is freely accessible in <http://dss.optima-h2020.eu/> and functions by exploiting data from weather services' networks. The DSS allows a better understanding of the infection risk based on the optimum conditions for diseases' early symptoms occurrence in order to properly and timely control the potential outbreaks and finally lead to a significant reduction of chemical PPPs applied. The map presents several areas in different coloring, located in Spain (Zaragoza region), France (Bordeaux region), Italy (Piemonte region) and Greece (Thessaly, Evia and Attica regions). The color scale indicates the four risk levels: green for no risk; yellow for low risk; orange for medium risk; and red for maximum risk. Furthermore, users have the ability to select the "Ideal spraying" button for displaying the appropriateness of the meteorological conditions for spraying application (5-day prediction) on a specific selected time-point. This holistic IPM approach is targeting to lower chemical inflows in food

production chain, lower residues and reduce impacts on human health and the environment.

3.5 Description of OPTIMA EDS and results

OPTIMA EDS is a fully functional smart camera-based disease detection system. Although significant advances have been made in the field of image-based plant disease detection, it must be acknowledged that in studies found in literature the disease detection was performed on fixed-size datasets with limited variation, making them only partially relevant for a real-world field application. Within OPTIMA an integrated Early Detection System (EDS) that can be used in commercial orchards, vineyards and open fields is developed. Deep learning based disease detection using color RGB cameras for the detection of apple scab in orchards, downy mildew in vineyards and Alternaria in carrot fields are applied. The system consists of a smart camera, image processing pipeline, localization through a global navigation satellite system (GNSS) system and wireless connection to a decision support system (DSS). The system can be operated while mounted on a platform that drives through the orchard, vineyard, or field with a speed of 1.5 km/h. Final system performance was a detection score (F1) of 66% for downy mildew in grapes, 45% for scab in apple and 42% for Alternaria in carrot. These scores are on spot level, when translated to spraying resolution the measurements are higher. False color images extracted from multispectral data clearly identify the disease spots in carrot and apple. Nevertheless a multispectral based deep learning classifier does not outperform the RGB based classifier, presumably due to the fact RGB based pre-trained networks were used.

3.6 Chemical control of apple scab

Apple scab, caused by the fungus *Venturia inaequalis*, is a major disease in world-wide apple production. Apple growing environments usually characterized by cool and rainy summers, favor this disease which requires intense chemical control measures. The disease affects leaves, buds, flowers and fruits and sometimes twigs. Symptoms include twisted and puckered leaves that have black, circular scabby spots on the underside. On the upper surface the spots look velvety and have an olive-green, sooty appearance. As the disease progresses, the leaves get yellow and drop. The fruit develops scabby spots that are tan and sunken.

OPTIMA project searches alternative products to reduce the use of chemical PPPs and optimize their efficacy. The control strategy is based on the use of preventive action products, used immediately before any infectious rains, and integrated, if necessary, by curative treatments with retroactive products to block the infection within a certain number of hours since its inception. Currently preventive fungicides registered in EU include: anthraquinone (dithianon), dithiocarbamates (mancozeb, metiram), ftalimid (captan), pyridinamine (fluazinam), guanidine (dodine), SDHI (penthioopyrad, fluopyram, fluxapyroxad), strobilurin (trifloxystrobin, pyraclostrobin). Curative products include: anilino pyrimidine (cyprodinil, pyrimethalin) and azole (difenoconazole).

Resistance to strobilurin and IBE fungicides were reported therefore the use of different active ingredients and tank mix are recommended to prevent the spread of resistance.

3.7 Biological control of apple scab

Apple scab, caused by the fungus *Venturia inaequalis*, is a major disease in world-wide apple production. Apple growing environments usually characterized by cool and rainy summers, favor this disease, which requires intense chemical control measures. The disease affects leaves, buds, flowers and fruits and sometimes twigs. Symptoms include twisted and puckered leaves that have black, circular scabby spots on the underside. On the upper surface the spots look velvety and have an olive-green, sooty appearance. As the disease progresses, the leaves get yellow and drop. The fruit develops scabby spots that are tan and sunken.

In organic agriculture, copper and sulfur compounds are the most important fungicides allowed for the control of apple scab. The use of copper was reduced by the European Union Regulation 2018/1981 to 4kg/ha/year, because of its toxicity to soil and microorganisms.

OPTIMA project searches alternative products to reduce the use of copper-based formulations. Tests are in progress in Italy and Spain with biological plant protection products such as: *Trichoderma* spp., *Bacillus* spp., *Pythium oligandrum*, *Aureobasidium pullulans*, *Saccharomyces cerevisiae*, sweet orange essential oil.

Planting of resistance or tolerant varieties, elimination of crop residues (e.g. overwintering leaves), the use of natural products such as laminarin or potassium bicarbonate, the use of Decision Support Systems to optimize PPPs use and application timing are the recommendations suggested to farmers to reduce the number of copper based treatments.

3.8 BMPs for Vineyard Downy Mildew control

Grape downy mildew, caused by the obligate 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 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.

OPTIMA project developed best management practices for controlling this disease, after investigating the efficacy of novel plant protection products.

The control strategy is based on the use of a mixing route including bio-PPPs/PRIs (Cerevisane, Essential oil of sweet orange, *Bacillus pumilus* and *B. amyloliquefaciens*) alternated with the new generation PPPs oxathiapiprolin + zoxamide and mandipropamide + zoxamide with a normal dose. It is recommended to use the normal suggested dose of each PPP to prevent the development of *Plasmopara viticola* fungicide resistant isolates and to avoid the curative use of bio-PPPs/PRIs under high disease pressure. In organic farming it is recommended to combine multiple doses of the bio-PPPs/PRIs Cerevisane and Essential oil of sweet orange and resistant varieties where available, in order to reduce the use of copper fungicides.

3.9 BMPs for Apple Scab control

Apple scab, caused by the fungus *Venturia inaequalis*, is a major disease in world-wide apple production. Apple growing environments usually characterized by cool and rainy summers,

favor this disease, which requires intense chemical control measures. The disease affects leaves, buds, flowers and fruits and sometimes twigs. Symptoms include twisted and puckered leaves that have black, circular scabby spots on the underside. On the upper surface the spots look velvety and have an olive-green, sooty appearance. As the disease progresses, the leaves get yellow and drop. The fruit develops scabby spots that are tan and sunken.

OPTIMA project developed best management practices for controlling this disease, after investigating the efficacy of novel plant protection products.

The control strategy is based on the use of a mixing route including bio-PPPs /PRIs (Laminarin, potassium bicarbonate) alternated with the new generation PPPs fluxapyroxad and then dithianon with a normal dose. It is recommended to avoid using lower of the recommended dose of synthetic PPPs to prevent the development of *Venturia inaequalis* fungicide resistant isolates and the curative use of bio-PPPs/PRIs under high disease pressure. In organic farming it is recommended to combine multiple doses of the bio-PPPs/PRIs laminarin and potassium bicarbonate and resistant varieties where available.

3.10 BMPs for 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 stems, 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. OPTIMA project developed best management practices for controlling this disease, after evaluating the efficacy of novel plant protection products. The control strategy is based on the use of highly resistant varieties and a mixing route including the bio-PPPs/PRIs Sonata® (*Bacillus pumilus*), Heliosoufre® (Sulphur+co-formulant based on derivatives Terpenes from pine), LBG-01F34® (Potassium phosphonates) alternated with the new generation PPPs Luna Sensation® (fluopyram+ trifloxystrobin) and then Dagonis® (fluxapyroxad + difenoconazole). It is recommended to use the normal suggested dose of each PPP to prevent the development of *A. dauci* fungicide resistant isolates and to avoid the curative use of bio-PPPs/PRIs under high disease pressure. Other practical recommendations are the use of commercial treated seeds, no excess of nitrogen fertilization and avoid leaving crop residues in the field. It is highly recommended the use of disease forecast models to optimize PPPs use and application timing. In organic farming, it is recommended to combine multiple doses of the bio-PPPs/PRIs Sonata®, Heliosoufre®, LBG-01F34® (Potassium phosphonates) and varieties offering intermediate level of resistance or use varieties with a high level of resistance only.

3.11 Best Management Practices for set-up and use of smart sprayers

When spraying plant protection products (PPP), farmers have a responsibility to prevent it from drifting as well as harming the environment, human health, and food safety in other ways. One way to mitigate the impact of PPP is to improve the efficiency of spray applications through increasing depositions on the target crop and reducing losses to the

environment. Best Management Practices (BMPs) have been drafted to aid farmers in setting up and using their sprayer in an efficient manner. These BMPs are the following:

- 1) Consider the use of smart sprayers enabling to spray only where and when needed using sensors and advanced spray technologies to maximize target deposition with minimal losses and PPP use.
- 2) Be aware of the full and minimum spray volume settings. The minimum PPP dose prescribed on the label must be respected even when the spray volume is varied/reduced to match crop size, canopy density or disease conditions.
- 3) Select appropriate nozzles (such as flat fan, drift reducing, and off-center nozzles) and settings to avoid spray drift, run-off and direct losses to the ground.
- 4) Consider variable rate application systems. Variability in canopy characteristics and disease pressure typically result in over- and under-spraying when using a constant rate application.
- 5) Avoid too high tank mix temperatures (> 35 to 40°C) when using bio-PPPs. High temperatures in the spray mix may affect the vitality and effectiveness of bio-PPPs.

3.12 Best Management Practices for spray applications in vineyards

When spraying plant protection products (PPP), farmers have a responsibility to prevent it from drifting as well as harming the environment, human health, and food safety in other ways. One way to mitigate the impact of PPP is to improve the efficiency of spray applications through increasing depositions on the target crop and reducing losses to the environment. Best Management Practices (BMPs) have been drafted to aid the farmers in setting up and using their sprayer in an efficient manner. Besides more general BMPs, specific BMPs for vine growers and their vineyard sprayer are listed:

- 1) Match the air support to the canopy target and density. Inappropriate design and fan settings can have a negative effect on spray deposition and losses. Excessive air flow rates should be avoided and air deflectors (if present) should be adjusted to match the canopy and symmetry in air flow rate on both sprayer sides.
- 2) Consider the use of variable air flow rate systems. Adjusting the air flow with respect to the target characteristics (e.g. canopy density measured using ultrasonic sensors) on the go, allows increasing the canopy deposition, while reducing spray drift and losses.
- 3) Match the spray distribution to the canopy to avoid spray losses by adjusting the number of nozzles, spray angle, nozzle spacing and distance to the target. When appropriate, the use of off-center nozzles is encouraged.

3.13 Best Management Practices for spray applications in apple orchards

When spraying plant protection products (PPP), farmers have a responsibility to prevent it from drifting as well as harming the environment, human health, and food safety in other ways. One way to mitigate the impact of PPP is to improve the efficiency of spray applications through increasing depositions on the target crop and reducing losses to the environment. Best Management Practices (BMPs) have been drafted to aid the farmers in

setting up and using their sprayer in an efficient manner. Besides more general BMPs, specific BMPs for growers and their apple orchard sprayer are listed:

- 1) Match the air support to the canopy target and density. Air assistance is used to enhance transport of droplets in the canopy by moving and lifting the foliage and thus improving spray penetration, deposition and coverage, including the underside of the leaves. However, inappropriate design and fan settings can have a negative effect on spray deposition and losses. Excessive air flow rates should be avoided and air deflectors (if present) should be adjusted to match the canopy and symmetry in air flow rate on both sprayer sides.
- 2) Match the spray distribution to the canopy to avoid spray losses by adjusting the number of nozzles, spray angle, nozzle spacing and distance to the target. When appropriate, the use of off-center nozzles is encouraged.

3.14 Best Management Practices for spray applications in bed-grown carrot fields

When spraying plant protection products (PPP), farmers have a responsibility to prevent it from drifting as well as harming the environment, human health, and food safety in other ways. One way to mitigate the impact of PPP is to improve the efficiency of spray applications through increasing depositions on the target crop and reducing losses to the environment. Best Management Practices (BMPs) have been drafted to aid the farmers in setting up and using their sprayer in an efficient manner. Besides more general BMPs, an additional specific BMP for carrot growers and their boom sprayer is given. Main objective is to match the spray distribution to the canopy to avoid spray losses by adjusting the number of nozzles, spray angle, nozzle spacing and distance to the target. When appropriate, the use of off-center nozzles is encouraged. Bed spraying and the use of variable nozzle spacing to adjust the spray distribution to the target zone can also be considered.

3.15 Field evaluation of the OPTIMA IPM system: Vineyard case

The main objective of the European project OPTIMA, funded by the H2020 program, has been the development of tools for the implementation of Integrated Pest Management. A decision support system (DSS), a device for the early detection of diseases (EDS) and three variable application equipment (vines, carrots and apple trees) have been developed. In addition, a complete guide on the use of bio-PPPs has been prepared: what products to use, how to combine them and how to apply them. The developments have been evaluated in the wine-growing area of Canelli (Italy), in collaboration with farmers in the area.

Regarding the decision support system, the results have not shown improvements compared to other systems already used by producers. However, the proposed strategy for the use of bio-PPPs showed similar results to those obtained with the conventional application, being possible to reduce the amount of PPP. As for the variable application equipment (modification of the air flow and the amount of phytosanitary product), the results have made it possible to reduce the amount of product applied (18%) and reduce the amount of product lost due to drift (64%) in comparison with the technology used by farmers. And all of this while maintaining the same pest and disease control values. In line with what is established in the European strategy from the field to the table.

3.16 Field evaluation of the OPTIMA IPM system: Apple case

The main objective of the European project OPTIMA, funded by the H2020 program, has been the development of tools for the implementation of Integrated Pest Management. A decision support system (DSS), a device for the early detection of diseases (EDS) and three sprayers for Variable Rate Application (vines, carrots and apple trees) have been developed. In addition, a complete guide on the use of bio-PPPs has been designed: which products to use, how to combine them and how to apply them. The result has been evaluated in collaboration with the Épila Fruit Growers Association in Spain.

The results have shown the interest and benefits of both the decision support system and the device for early detection. Regarding the use and potential benefits of bio-PPPs, the results of the evaluation of the biological efficacy of the selected products show that the same efficacy values can be obtained as with products of synthetic origin, in this case for the control of mottled apple (*Venturia inaequalis*).

Regarding the results obtained with the variable application equipment, it should be noted that the system has worked perfectly. The implemented technology has allowed an adequate characterization of the vegetation that has resulted in a reduction of PPP of around 20%, with the same values of reduction of the amount of water applied. As a consequence, the work capacity of the equipment has been significantly improved, the application time has been reduced and, above all, drift reduction values close to 40% have been obtained compared to those obtained with the traditional technology used by the farmers in the area.

3.17 Field evaluation of the OPTIMA IPM system: Carrot case

The main objective of the European project OPTIMA, funded by the H2020 program, has been the development of tools for the implementation of Integrated Pest Management. A decision support system (DSS), a device for the early detection of diseases (EDS) and three variable application equipment (vines, carrots and apple trees) have been developed. In addition, a complete guide on the use of bio-PPPs has been prepared: what products to use, how to combine them and how to apply them. The developments have been evaluated in collaboration with carrot growers in south-western France.

The results highlight the need to continue with the development of the decision support system, making it more precise for carrot cultivation, especially in relation to the control of *Alternaria*. Similar conclusions have been obtained after field validation of the early detection system, although the results indicate that it is a very interesting device. Regarding the application of products based on the characteristics of the vegetation, this showed a double benefit in terms of deposition in the crop and a significant reduction in drift using low drift nozzles and aerial assistance. In addition, the data shows that there are no differences in terms of biological effectiveness, concentrating the sprays in the exact area of the crop, thus reducing soil loss and drift. The OPTIMA IPM system therefore provides solutions to reduce the use of plant protection products and the risk of environmental contamination by reducing product drift.

3.18 Integrated Pest Management on vineyards: multi-criteria assessment addressing human health and environmental risks, impacts and costs

Integrated Pest Management (IPM) practices for vineyards tested in the OPTIMA project were compared based on field trials (May-August 2021) in Piedmont, Italy. The OPTIMA IPM practices included different technological innovations: smart sprayers, biological plant protection products (bio-PPPs), EDS (Early Detection System) and DSS (Decision Support System). They were compared against a baseline representing current practice.

The choice of environmental, human health and costs indicators, as well as the definition of their importance, derives from literature, and consultation of stakeholders. The set of indicators encompassed climate change and photochemical ozone formation (Environmental Life Cycle Assessment), risk to pollinators, risk to other beneficial insects, and risk to soil organisms (Environmental Risk Assessment), risks to human health in the local community, namely for farmers (Human Risk Assessment), and operational costs for farmers.

The multi-criteria assessment clearly endorses the use of bio-PPPs, which originated a risk reduction to human (99% lower) and ecological (30-80% lower) receptors. IPM using the experimental EDS was hindered by the impacts of scouting, namely increased labor costs and environmental impacts of using diesel, calling for more sustainable scouting strategies.

3.19 Integrated Pest Management for apple orchards: multi-criteria assessment addressing human health and environmental risks, impacts and costs

Integrated Pest Management (IPM) practices for apple orchards tested in the OPTIMA project were compared based on field trials (February-July 2021), in three different farms in Zaragoza, Spain. The OPTIMA IPM practices included different technological innovations in smart sprayers and biological plant protection products (bio-PPPs), which were compared against a baseline representing current practice.

The choice of environmental, human health, and cost indicators, as well as the definition of their importance, derives from literature, and consultation of stakeholders. The set of indicators encompassed climate change and photochemical ozone formation (Environmental Life Cycle Assessment), risk to pollinators, risk to other beneficial insects, and risk to soil organisms (Environmental Risk Assessment), risks to human health in the local community, namely for farmers (Human Risk Assessment), and operational costs for farmers.

Comparing two IPM practices in the same farm, one using only synthetic PPPs and the other one using also some bio-PPPs, the multi-criteria assessment clearly endorses the latter, which minimized toxicity to human and ecological receptors (from 20% to honeybees to over 60% to soil organisms), as well as decreased life-cycle impacts.

3.20 Integrated Pest Management for carrots: multi-criteria assessment addressing human health and environmental risks, impacts and costs

Integrated Pest Management (IPM) practices for carrots in open field tested in the OPTIMA project were compared based on field trials (July-October 2021), in Aquitaine, France. The OPTIMA IPM practices included innovations in smart sprayers and the use of biological plant protection products (bio-PPPs), which were compared against a baseline representing current practice.

The choice of environmental, human health, and cost indicators, as well as the definition of their importance, derives from literature and consultation of stakeholders. The set of indicators encompassed climate change and photochemical ozone formation (Environmental Life Cycle Assessment), risk to pollinators, risk to other beneficial insects, and risk to soil organisms (Environmental Risk Assessment), risks to human health in the local community, namely for farmers (Human Risk Assessment), and operational costs for farmers.

The multi-criteria assessment clearly endorses the use of the smart sprayer configuration. This is particularly observed in the reduction of the risk to soil organisms (64%). Concerning bio-PPPs, results singled out the incorporation of Heliosoufre (a bio-PPP containing sulphur, causing chronic risk to bees), and a recommendation to be replaced in the future.



THIS PROJECT HAS RECEIVED FUNDING FROM
THE EUROPEAN UNION'S HORIZON 2020 RESEARCH
AND INNOVATION PROGRAMME UNDER GRANT
AGREEMENT N. 773718

