EIP-AGRI Focus Group

Diseases and pests in viticulture

FINAL REPORT
MARCH 2019

funded by European Commission

Table of contents

Table of contents 2
1. Summary 3
2. Introduction 4
3. Brief description of the process 6
Inspiring farm visits 6
4. State of play: pests and diseases in viticulture, and management recommendations 7
4.1 Integrated Pest Management (IPM) 7
Prevention practices 8
Early detection/diagnostics/monitoring tools 9
Methods and tools for direct control/management 10
4.2 Functional biodiversity 11
4.3 Main pests and diseases and corresponding IPM recommendations 11
Diseases 12
Pests 16
4.4 The influence of climate change on vineyard pests and diseases 20
5. Recommendations 21
5.1 Ideas for local innovation projects, including EIP-AGRI Operational Groups (OGs) 21
5.2 Research needs from practice 21
5.3 Other recommendations, including knowledge and training needs 23
Annex A: Members of the EIP-AGRI Focus Group 25
Annex B. List of mini-papers 26
Annex C: Relevant recent and on-going research projects 63

funded by European Commission

1. Summary

`How can we increase the resilience of grapevines to pests and diseases and support the productivity of the sector in sustainable ways?` Nineteen Focus Group experts from different wine-growing regions in the EU discussed this question. They made an inventory of the main pests and diseases affecting grapevines, including their geographical distribution, and looked into Integrated Pest Management (IPM) strategies to combat them. The experts specifically considered how promoting functional biodiversity can help to create a more resilient vineyard system, as it can help to both prevent and fight pests and diseases. They also shared their ideas on how expected climatic changes will impact the distribution and occurrence of pests and diseases.

Viticulture is a relevant sector of EU agriculture in terms of economic revenues and job creation. It has also shaped the landscape, and is associated with regional culture and identity of wine growing regions. Wine is the main export item of the EU within the food sector. All the wine growing areas in the EU are characterised by specific varieties, climate, soil composition, and management practices. In each area, pests and/or diseases affect grape production and require specific management. Pests and diseases reduce grape quantity or quality and they may also threaten the longevity of vineyards. In conventional wine growing, an intensive pesticide schedule is usually required to meet qualitative and quantitative production standards. This is costly, and the environmental and health impacts of pesticides also need to be considered. The growing demand for more sustainable vineyard management is one of the reasons for the fast growth of organic wine production in all European wine regions and for the enacting of the European Directive on Sustainable use of Pesticides (Directive 2009/128/EC)1 that promotes Integrated Pest Management (IPM).

The Focus Group identified needs from the sector and possible gaps in knowledge on particular issues concerning the management of pests and diseases in grape production, which may be solved by further research, including, but not limited to:

- Selection and breeding of locally adapted grape varieties
- Developing ways to improve planting material health, including research on rootstocks and nursery management
- Adapting IPM and precision viticulture for small-sized and scattered vineyards
- Management strategies to control powdery mildew
- Methods to manage soil organic matter, soil fertility and the soil microbiome to improve plant health and reduce the impact of pest and diseases
- Effects of climate change on vine pests and diseases
- Develop strategies to manage Grapevine Trunk Diseases

They also proposed priorities for relevant innovative actions/ projects including practical ideas for EIP-AGRI Operational Groups, such as:

- Identify and test appropriate IPM and precision viticulture practices, with locally adapted strategies and specific regional implementation requirements
- Test and select locally adapted varieties and planting materials for local conditions and market demands.
- Develop local strategies for a proper use of cover-crops.
- Test ways to enhance both functional and vine biodiversity in vineyards to increase vineyard resilience
- Define strategies, based on local conditions and requirements, to increase vineyard resilience, to cope with climate change effects on pest and disease pressure

Other recommendations included:

- Knowledge exchange on plant, pests and diseases physiology and their interaction
- A "learning from failure - Platform" and an e-learning system with scientific validation, where farmers can upload a picture of an infection and get advice.

1 http://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/index_en.htm

funded by European Commission

2. Introduction

The Focus Group (FG) on diseases and pests in viticulture was launched by the European Commission in 2016 as a part of activities carried out under the European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI).

The main question for the Focus group was: "How can we increase the resilience of grapevines to pests and diseases and support the productivity of the sector in sustainable ways?".

The Focus Group brought together 19 experts from all over the EU (see annex B for the list of members) with the purpose to:

- **Make an inventory of the main pests and diseases** affecting grapevines, including their distribution and economic impacts. Where possible, **summarise** how expected climatic changes will impact the distribution and occurrence of pests and diseases.
- **Get an overview of current practices** in early detection, diagnostics, and monitoring.
- **Get an overview of current methods for control**. Particular care should be taken to highlight both existing problems and opportunities in pest/disease management.
- **Make an inventory of IPM (Integrated Pest Management) strategies** (including biological control) to control pests and diseases in grapevine. **Compare** these different management practices and strategies, having also practicability and costs in mind.
- In particular, **explore potential solutions to manage pests/diseases** based on agro-ecological principles such as biodiversity. The role of disease management in supporting the resilience of grapevines to biotic stresses should deserve special attention.
- **Compile examples of 'good practices'**, i.e. a number of case studies, from farm level in particular, across different regions in Europe.
- **Identify needs from practice (farming sector) and possible gaps in knowledge** on particular issues concerning the management of pests and diseases in grape production which may be solved by further research.
- **Propose priorities for relevant innovative actions/ projects** including practical ideas for EIP-AGRI Operational Groups.

According to the 2018 statistics from OIV[2] , referring to 2017 data, the vineyards in the EU-28 covered 3,312 thousand ha, representing about half of the vineyard plantings in the world (7,564 thousand ha). European vineyards include grapes for wine production (by far the majority) but also grapes for fresh consumption and dried grapes. The most relevant countries for EU wine production are Italy, France, and Spain (see table 1).

2 http://www.oiv.int/public/medias/5958/oiv-state-of-the-vitiviniculture-world-market-april-2018.pdf

funded by European Commission

Country	x 1000 ha	
	2016	**2017**
Spain	975	967
France	786	787
Italy	690	695
Portugal	195	194
Romania	191	191
Greece	105	106
Germany	102	102
Hungary	68	68
Bulgaria	64	64
Austria	46	46
Switzerland	15	15
Other European countries	683	681
Total Continenal Europe	**4007**	**4001**
Total EU-28	**3317**	**3312**

Tab.1 Number of hectares of vineyard per country in the EU (data from OIV refer to 2016 - 2017).

Within the EU, and also within each EU wine-growing region, there is wide variety in the size of wine estates and vineyards, vineyard management techniques, wine types and their values. Nevertheless, for all the countries and regions with a strong viticulture tradition, wine production is an economically important agricultural activity.

In addition to the economic importance of wine production, the value of viticultural landscapes and the link to traditional knowledge and skills increase the social relevance of viticulture in Europe. At the same time, the intensification of viticultural practices has led to a loss of biodiversity (with intensive use of few International varieties and declining use of local varieties), the degradation of soils, and an overall decrease of the resilience of viticulture systems.

funded by European Commission

3. Brief description of the process

The Focus group met twice. Their first meeting was held in Porto, Portugal on 25-26 October 2016 (Porto, Portugal). The `starting paper` served to catalyse the discussion. This starting paper had been prepared beforehand by the coordinating expert and took into account inputs from the 19 experts concerning the most relevant pests and diseases within the different areas.

At this first meeting, the group identified three core topics, which were further discussed in subgroups per topic.

- Prevention, early detection, diagnosis, monitoring, and control tools
- Good practices, traditional or innovative, or a combination of both
- The role of biodiversity in viticulture protection

The second meeting took place on 4-5 April 2017 in Cluj-Napoca, Romania. At this meeting, the participants:

- identified bottlenecks in the practical implementation of Integrated Pest Management in viticulture;
- gave recommendations and practical hints on how to overcome the bottlenecks;
- identified risks linked to climate change;
- gave recommendations for further research and innovation activities to be proposed at European, National, and Regional level.

The Focus Group produced five mini-papers. (complete list in **Annex B**).

Inspiring farm visits

Besides the meetings the experts visited local farms to see and discuss pest and disease management in practice. In Porto the group visited Quinta do Seixo farm in the Douro valley that applies several functional biodiversity measures with the support of ADVID (Association for the Development of Viticulture in the Douro Region). The farm is managed under specific Integrated Production rules since more than 10 years and still serves as a trial ground for research studies and innovative practices. The group discussed the following topics related to functional biodiversity:

- Ecological infrastructure and its role in pests and diseases prevention (example of inter-row management).
- the Project BIODIVINE (LIFE+) with the evaluation of biodiversity in vineyard landscape management, meaning flowering strips, an area with wild shrubs and trees within the vineyard etc., and the evaluation of the impact of biodiversity in decreasing pest pressure.
- The relevance of genetic material preservation (as a basis for innovation) and use of local varieties (Muscat à petits grains, Aragonêz, Touriga Nacional, Tinta Francisca).
- The impact of climate change on viticulture in the Douro valley area.
- Local automatic weather stations with data available online (part of a private network of 20 stations in vineyards).

An optional field visit was offered during the second Focus Group meeting to visit the Jidvei vineyards and cellar in Tarvavas valley, Transylvania (A very large farm with high technical level management) and to discuss the specific strategies implemented to combat pests and diseases in this area.

funded by European Commission

4. State of play: pests and diseases in viticulture, and management recommendations

All viticultural areas are characterised by specific varieties, climate, soil composition, and management practices. In each area, pests and/or diseases affect grape production and require specific management. Pests and diseases reduce grape quantity or quality and they may also threaten the longevity of vineyards. Fungal diseases can cause significant economic losses in traditional grape varieties, either by reducing production or through increased costs of antifungal treatments. It has for instance been calculated that in Piedmont, the annual costs for controlling downy mildew (the most critical disease in this area) in all conventional vineyards ranges from 8 to 16 million Euros, (including costs for work, equipment and fungicides[3]). In France, under medium downy mildew pressure, 12 treatments per season are necessary for traditional varieties grown under conventional management[4].

Besides the costs, the environmental and health impacts of pesticides have to be considered. The growing demand for more sustainable vineyard management is one of the reasons for the fast growth of organic wine production in all European wine regions and for the enacting of the European Directive on Sustainable use of Pesticides (Directive 2009/128/EC)[5] that promotes Integrated Pest Management (IPM).

The Focus Group experts discussed which pests and diseases are currently most relevant in EU viticulture, and which would be the most sustainable management approaches to counter the effects of these pests and diseases. They considered that for almost all of these pests and diseases, an integrated pest management approach would be required.

4.1 Integrated Pest Management (IPM)

The FAO defines IPM as the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and environment. IPM emphasises the growth of healthy crops with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. The Focus group experts considered this the most appropriate definition of IPM.

The Directive 2009/128/EC on sustainable use of pesticides also provides a definition of IPM which includes elements of the FAO definition. Integrated pest management is a broad-based approach.

A pest is any organism that damages or interferes with the crop plants. It can be a weed, an invertebrate (insects, mites, slugs, nematodes), a bird, rodent or other mammal, or a pathogenic microorganism (fungi, bacteria, phytoplasmas, viruses). NB In this report, a distinction has been made between pests and diseases, with the latter caused by fungi, bacteria, phytoplasmas and viruses.

IPM is based on accurate pest identification. It typically includes regular observation, crop monitoring and applying economic damage thresholds to determine if, when and what treatments are needed for effective control. Emphasis is given to preventive measures (for instance cultural practices, the use of pest-free and pathogen-free planting material, the use of resistant varieties, supporting functional biodiversity) to suppress or prevent pests. They should be exploited to the fullest extent to reduce the need for direct control measures.

Direct control measures should only be taken if they are economically justified. Preference is given to non-chemical control measures such as physical interference (nets or traps, mechanical weed control) and biological control (the use of natural enemies – predators, parasites, pathogens, and competitors – and pheromones to control pests and their damage) if they provide satisfactory pest control. Chemical control is only used when

3 Salinari, F., Giosue, S., Tubiello, F.N., Rettori, A., Rossi, V., Spanna, F., Rosenweig, C., Gullino, M.L., 2006. Downy mildew (*Plasmopara viticola*) epidemics on grapevine under climate change. Glob. Change Biol. 12, 1299–1307, http://dx.doi.org/10.1111/j.1365-2486.2006.01175.x.
4 Rousseau, J., Chanfreau, S., Bontemps, É., 2013. Les Cépages Résistants and Maladies Cryptogamiques. Groupe ICV, Bordeaux, pp. 228
5 http://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/index_en.htm

needed. Pesticides should be selected and applied in a way that minimises their possible harm to people and to the environment. Resistance management strategies are applied to prevent the development of resistance in pests, pathogens or weeds. The general principles of integrated pest management as formulated by the European Union can be found in Annex III of the Directive 2009/128/EC.

The Focus group experts considered that for the main pests and diseases, an IPM approach should be put into place in order to obtain a reliable level of plant protection. These IPM approaches include:

- prevention practices
- early detection and monitoring
- direct control and management

The experts identified the following tools and practices that could be useful for vineyard management, as well as factors that may limit their use.

Prevention practices

- Creating an **ecological infrastructure**, both at farm and at larger scale, with the aim of improving micro-climatic conditions, increasing biodiversity and timely presence and activity of beneficial insects, spiders, mites, microorganisms and pest predators. In the vineyard this infrastructure is characterised by flowering strips, alternate mowing between rows, creation of hedges and wood-lots and other elements of agro-forestry systems;
- Choice of **varieties and rootstocks** adapted to the local conditions. Among "traditional/international" varieties there is the possibility to select more tolerant ones and better-adapted clones. Several farmers run on-farm mass-selection programmes or multiply their own ecotypes to increase adaptation. In addition, efforts to breed new tolerant varieties of grapevine during the last 10 years have led to several quality varieties and rootstocks that have a high potential to reduce pesticide use. In France it was estimated that tolerant varieties could reduce production costs by half[6]. Nevertheless, and in particular in traditional wine production areas, the concern for maintaining wine quality and wine characteristics is slowing down the acceptance of tolerant varieties.
- **Crop management strategies** that prevent, suppress or at least mitigate the development/impact of pests and diseases. For instance, soil management that facilitates drainage, balanced nitrogen fertilisation to limit excess vigour of the plants leading to a reduced susceptibility to downy and powdery mildew, training and pruning systems to facilitate air circulation in the canopy or leaf removal to improve ventilation around the bunches of grapes and so reduce Botrytis risk, adoption of pruning techniques and trellising systems that reduce the trunk diseases` impact;
- **Sanitation measures** to prevent the spread of diseases. For example, care for healthy nursery materials and removal of diseased plants in the vineyard to reduce the inoculum of pathogens and sources of infected materials, which may cause vectors to spread diseases.

Factors currently limiting the use of IPM prevention strategies, and elements that could help vineyard managers to take up these strategies:

- generally the vineyard is not viewed or managed as a whole, integrated system. The move towards a systems approach in vineyard management requires time, training, and good examples;
- there is a need to create a resilient agro-ecosystem from the beginning, when the vines are first planted; these resilient agroecosystems generally avoid mono-cultures and prefer a complex system including flowering inter-rows, hedges, trees, and other ecological elements in the vineyard;
- pruning and canopy management should favour plant health, reducing disease outbreaks, and managing plant vigour;

6 Galbrun, C., 2008. Étude INRA: Comment Réduire ses Coûts de Production de 50%. Réussir Vigne, France (Online:) http://vigne.reussir.fr/actualites/etude-inra-comment-reduire-ses-couts-de-production-de-50:6ZKTI5TA.html

- soil is a key element. Proper management strategies are essential and a pause/rest before re-planting is needed to reduce problems during the life of the vineyard. The use of cover and catch crops to increase diversity and soil activity is very beneficial;
- the use of mycorrhiza and in general microorganisms can be beneficial but it requires proper management, with deep knowledge of species and mechanisms;
- mainly due to climate change, there is a need for different varieties, more adapted to local conditions (even within the same vineyard), including tolerant varieties. Concerning the latter, for some regions, there is still need for further breeding, while in some Member States, or for certain production areas, tolerant varieties are already available;
- healthy planting materials, which are free of pests and diseases are very important, and there is a need to cooperate with nurseries to set up best practice guidelines and quality control procedures;
- a good canopy structure improves air circulation, supporting the establishment of a positive microflora/microclimate. Cultural practices, such as fertilisation, trellising and pruning are the first tool for preventing diseases, but operations such as drastic or invasive pruning may also spread diseases, and should be avoided;
- region-wide weather forecasting tools and information about growing conditions (i.e. vegetation indexes) are needed to generate sufficient and appropriate local data for precision viticulture.

Early detection/diagnostics/monitoring tools

- **Monitoring/scouting** of pests and diseases but also of beneficial insects and other organisms, including pollinators and natural enemies of pests and diseases, is essential to Integrated Pest Management. Good knowledge of physiology and morphology (of the plant, the pest/disease and of beneficial organisms) is a basic requirement to plan and implement an efficient monitoring system. Monitoring can be done with simple visual inspections, for example to identify and count juvenile forms of *Scaphoideus titanus*. Traps that catch insects, mites or spores may also be used, for example, traps baited with pheromones for vine moths. There are also more advanced systems that capture air samples to monitor spores. There are even fluorescence-based methods to detect molecules in plant tissues which are produced when the plant is affected by a downy mildew infection;
- **Forecasting systems** are developed to identify the risk level linked to the attack of a pest or a disease and to decide if and when to start plant protection. Forecasting systems exist for different diseases, especially for downy and powdery mildew, and for several pests, such as vine moths and *Scaphoideus titanus*. In the last decades the availability of Information Technology (IT) tools, of wireless sensors (to constantly monitor climatic data and vegetation), of precise algorithms (to forecast pest and disease development cycles) has increased constantly. This has helped to advance the implementation of IPM and precision plant protection techniques in many regions and farms. IT tools, such as connected meteo stations or climatic sensors inside the canopy, are available in several EU regions and are used directly by the farmers or, more often, by the advisory services, that disseminate early alerts based on the results of these tools. Recent technology allows for very specific, timely and place-related forecasting;
- **Decision Support Systems** (DSS) to guide practitioners in the efficient implementation of plant protection schemes (whether to spray, when to spray and what to spray). IT and Internet of Things (IoT) technologies have allowed the development of several tools: apps, web-based services etc. can be used directly by farmers and advisers - with no need for intermediate steps/actors. These tools rely on forecasting systems and constant monitoring, allowing high efficiency and savings for the farmers.

Factors currently limiting the use of early detection and monitoring tools, and elements that could help vineyard managers to take up these tools:

- logistics for monitoring tools need to be developed (weather stations at farm or area level, where to situate them, how to read the data) as several small details influence the final efficacy;
- epidemiological models need to be site-specific in order to be reliable (i.e. validated) and able to provide useful information for decision-making about cropping techniques and/or interventions (i.e. treatment applications). More models should be put together to work simultaneously in order to provide better information about crop management to growers;

funded by European Commission

- in some cases, there is too much reliance on monitoring traps (i.e. moth pheromone traps) and the check of efficacy is missing. It is important to also verify post-treatment efficacy (i.e. yellow strips to verify leaf moisture);
- drones are still underused for monitoring;
- the most promising monitoring tools rely on:
  - Recovery panels
  - Electrolysed nozzles
  - Sensors (of different types)
  - Efficiency assessment
  - Risk mapping
  - Geographic Positioning System (GPS)
  - Decision Support Systems (DSS)

The group also discussed whether farmers are using these available tools in practice and if not (or not enough) why:

- vine-growers need to know how to use these diagnostic and monitoring tools, and be convinced that they will prove useful and economically viable before they will decide to implement them fully. Peer-to-peer knowledge exchange is needed as vine-growers tend to trust their colleagues. Researchers should be part of the learning process - or better, the knowledge creation and circulation process (no top down approaches). Demonstration farms/plots where the innovative approach is demonstrated in its complete implementation (no single practice) could speed up the adoption process;
- the traditional "calendar" approach is still preferred in certain areas because it has been used for decades and does not require specific observations or knowledge.

Methods and tools for direct control/management

These include:

- **mechanical control systems**, ranging from simple mass trapping (for example of chafers) or flame weeding (instead of chemical or mechanical weeding) to more technologically advanced vibrational mating disruption (experimentally applied to *Scaphoideus titanus*);
- **biological control methods, including for example**
  - mating disruption using pheromone dispensers applied to several *Lepidoptera* species and to *Planococcus ficus*,
  - the use of microorganism based products, such as *Bacillus thuringiensis* to control moths
  - *Ampelomyces quisqualis* to reduce formation of overwintering structures of powdery mildew
  - *Bacillus subtilis* to counteract Botrytis infections or other living organisms able to compete with (for space or for food)
  - to parasitise pests and pathogens. There are successful examples against insects, mites, fungi, and bacteria;
- **use of direct control, including pesticides.** This should be considered a last resource and should be applied under guidance of monitoring and forecasting systems. Pesticides include natural products, like botanicals, products of mineral origin (i.e. clays, some sulphur formulates), biocontrol agents (BCAs), pheromones, resistance inducers (often based on natural molecules or combination of molecules), low risk products (i.e. food-grade products like carbonates or plant oils or lecithin or weed extracts) and, as a very last resource, synthetic pesticides. Pesticides can act by contact or be systemic or cytotropic and their application mode changes accordingly. For example with contact pesticides the leaves should be permanently covered, while with systemic pesticides the active substance circulates inside the plant tissues and there is no need to repeat the treatment after rain;

funded by European Commission

- Machinery and sprayers used to apply treatments in the vineyard should be selected according to the "sustainable" principles: for instance, **sprayers** using reduced volumes of water or able to recycle the part of treatment not reaching the canopy. In addition, regular control and fine-tuning of sprayers and other treatment machinery is strategic (and compulsory according to the Sustainable Pesticide use directive) for a more efficient and safer use.

4.2 Functional biodiversity

The Focus Group experts specifically considered **functional biodiversity** and its role in vineyards.. Functional biodiversity is the diversity on microorganisms, insects, plants etc that live in the vineyard and can develop or not depending on the management of the vineyard, including pesticide use, soil management etc. Promoting functional biodiversity can help to create a more resilient vineyard system, as it can help to both prevent and fight pests and diseases. Healthy soils will for instance also contain beneficial microorganisms which limit the growth of pathogens and promote plant health in different ways. Functional biodiversity also includes pollinators, and predators of plant pests, such as spiders, ladybirds which eat plant lice, and insect-eating birds. The experts noted that there is often a lack of understanding of how functional biodiversity works. Action could be taken to improve on the following points/issues:

- a better understanding of the plant-pathogen interaction;
- a better understanding of how functional biodiversity works in general, and specifically considering the effects of climate change;
- more knowledge of agronomic practices contributing to resilience and good biodiversity.

Furthermore, the group identified some initial steps needed to trigger the adoption of **functional biodiversity**:

- to promote the advantages of a balance between the vineyard and the agro-ecosystem around it;
- to disseminate and promote the benefits of choosing local varieties as a tool to preserve biodiversity and an essential pool of characteristics that increase sustainability and resilience. Especially in the "newly developed" viticulture areas there is the need to increase the awareness on preservation and the use of local varieties;
- to map pests and diseases across Europe to monitor their spread and better understand their cycles and factors affecting their development;
- to create a good balance in the farm/area between the vineyards, other crops, and the ecological areas.

4.3 Main pests and diseases and corresponding IPM recommendations

The experts agreed that the following lists include the main pests and diseases currently affecting vineyards in Europe. They indicated their relevance in the different wine areas, and recommended practices to be integrated in an IPM approach, that can help to reduce their impact.
The experts emphasised that an Integrated Pest Management strategy is essential. It should consider:

- the whole life cycle of the vineyard;
- all the pests and diseases that may affect the vineyard;
- the combined use of different means and tools, starting from preventive measures (like soil fertility management to enhance plant health) up to the rational and smart use of pesticides, which should always be considered the last possible solution.

funded by European Commission

Diseases

Concerning diseases, the following list summarises opinions and experiences of the experts, including the recommended corresponding elements of IPM strategy.

Overview symbols

- Regions/countries where it is reported as problematic
- Climatic conditions that lead to higher impact
- Soil and location conditions that lead to higher impact
- Viticulture management practices that lead to higher impact/risk:
- General information
- Focus Group recommendations for Integrated Pest Management

Downy mildew
Plasmopara viticola

- Regions/countries: All countries
- Climatic conditions: High humidity conditions, Temperatures above 12ºC. More impact in rainy and mild spring-summer periods
- Soil and location: Compacted and wet soils
- Viticulture management: Wrong vineyard orientation, training system, low ventilation, inappropriate fertilisation and inappropriate disease prevention

General information: It is caused by *Plasmopara viticola,* may cause devastating effects in climates with relatively warm and humid summers. It attacks all European varieties, to different degrees and may cause large losses of production. Common symptoms include necrosis of the stem or shoot, discolouration including brown spotting and yellowish-green tips of the leaves;

Focus Group recommendations:

- the use of tolerant varieties and clones or at least of less sensitive varieties in areas with a high pressure of the pathogen;
- balanced fertilisation with reduced nitrogen to avoid excessive vigour and canopy development, and management practices to increase soil organic matter through appropriate fertilisation and cover cropping
- canopy management with removal of water-sprouts and lateral shoots, control of shoot length and partial leaf removal to facilitate air circulation in the canopy;
- proper soil management to enhance microbial activity, including the use of cover crops to reduce survival and sporangiospores dispersal via rain splashes and care for soil structure and reducing machine impact;
- the use of natural products to decrease pathogen pressure and to dry tissues surface (i.e. acid clays, proteins etc.);
- the use of elicitors to enhance plant self-defence;
- preventive application of control measures;.
- the use of Decision Support Systems to rationalise pesticide use.

funded by European Commission

Powdery mildew
Erysiphe necator

All countries

Dry and cold springtime, hilly, windy areas, dry summer if humidity is high and temperatures favourable – on this point, the experts had NO COMMON POSITION

Compacted soils

High N availability and abundant new growth on the vines resulting in low ventilation in the vineyard

It is caused by *Erysiphe necator*, all European varieties are more or less susceptible. It infects all green tissues on the grapevine, including leaves and young berries and can cause serious crop loss. Warmer and drier climates favour the attack. Main symptoms are easily identifiable: gray-white, dusty formation that is more evident on the upper side of the leaves; it can also infect buds, flowers, young fruit, and young stems;

- balanced fertilisation with reduced nitrogen availability. Soil organic matter management is especially important;
- structure of the canopy that allows ventilation;
- early symptoms scouting on lower leaves to monitor primary infections;
- removal of young infected shoots (flag shoots);
- choice of tolerant varieties, clones or heterogeneous materials;
- Decision Support Systems (DSS) use if available in the area;
- the use of low toxicity products such as Orange oil or $KHCO_3$;
- the use of preventive applications of control measures (i.e. chemical or proper BCAs (biological control agents) such as *Ampelomyces quisqualis* against the formation or to reduce vitality of the overwintering structures (*chasmothecia*) of the fungus;
- the use of elicitors to enhance plant self-defence.

Grey mould / Botrytis
Botrytis cinerea

All countries

Rainy season, in particular around flowering and during maturation

Compacted soils

High plant vigour, N fertilisation, heel or other damage to the grapes, including grape moth attacks

It is caused by *Botrytis cinerea*. Its relevance strongly depends on climatic conditions and canopy density, as air circulation prevents the pathogen development. Its impact, compared to downy and powdery mildew, is more related to specific yearly climatic conditions and to the level of damage caused by other pests and diseases.

- the use of tolerant varieties and clones or, at least, less susceptible ones in areas with high pathogen pressure;
- balanced fertilisation to control vigour;
- canopy management: removal of water-sprouts and lateral shoots, controlling shoots length and partial leaf removal to facilitate air circulation;
- defoliation of the cluster area;
- ventilation after flowering to blow out infected debris;
- removal of major source of inoculum;
- management of inter-row vegetation in order to facilitate air circulation;
- the use of biological control agents, dryers (such as clay), elicitors and skin hardener products;
- early and preventive application of control measures to properly protect bunches at flowering and avoid latent infections.;
- control of pests that increase the risk of Grey mould;
- the use of Decision Support Systems to rationalise pesticide use.

funded by European Commission

Flavescence dorée of grapevine
Flavescence dorée (FD)

Almost all countries, but not all regions; in Spain the vector is present, but the disease is not reported

Optimal temperature for the vectors.

no clear link

Uncontrolled vineyards; lack of protection against *Scaphoideus titanus*; infected vines

It is caused by a phytoplasma transmitted by the vector *Scaphoideus titanus*, it develops in the phloem vessels of the host plants. FD arrived in Europe in the 80s, starting from France and rapidly spreading to Italy and it is now moving Eastwards. FD and Grapevine Trunk Diseases are the core topics of the recently concluded Thematic Network Winetwork.[1]

- implementation of a territorial strategy: uprooting of unmanaged vineyards, large scale monitoring, monitoring of symptomatic plants, timing direct control etc.;
- use of controlled/certified planting material;
- precise monitoring and control of the vector (see *Scaphoideus titanus*);
- thermotherapy in nursery (no unanimous opinion on efficacy).

[1] www.winetwork.eu

Grapevine trunk diseases (GTDs)
--- (a very diverse fungal complex)

All countries

Depends, for instance rainy spring/early summer may favour esca complex; and for other GTDs not always clear.

Compacted soils, Cool and wet areas

Stress caused by different factors, infected material

GTDs include Eutypa, Esca and Botryospaeria (Black Dead Arm) dieback. Each can be caused by different species of one fungus belonging to one genus or different genera. They may cause the plants to die (more or less rapidly), are only partly related to climatic conditions and mainly to variety sensitivity. GTDs are present in many European wine regions but the symptoms may not always be visible. FD and GTDs are the core topic of the recently concluded Thematic Network Winetwork[1].

- balanced fertilisation and careful soil management to enhance plant health and correlated capacity to keep GTDs under control;
- pruning during dry weather to avoid inoculum dispersal;
- pruning wounds protection, soon after pruning, with *Trichoderma* spp. or other registered biological control agents or with chemical+physical barriers;
- use of high-quality vines in new plantations;
- removal of symptomatic plants;
- use of *Trichoderma* spp. and mycorrhizae or other biological control agents to support rooting during planting and other phases;
- specific attention to pruning management and techniques, especially in first years, avoiding pruning in wet conditions;
- removing/composting pruning debris if affected (or at risk of infection);
- trunk renewal of affected plants.

[1] www.winetwork.eu

funded by European Commission

Black rot
Guignardia bidwellii (syn. Phyllosticta ampelicida

Italy, Spain, Hungary, Romania,

Rainfall in spring, mild temperatures, rainy summer (rainy flowering)

No clear link

High plant vigour, high fertility in soils, low ventilation exposition

It is caused by *Guignardia bidwellii also known as Phyllosticta ampelicida,* and it can affect both European varieties and American hybrids. Main symptoms are pale brown spots surrounded by a darker boundary on the leaves, and berries heavily shrivel and mummify on bunches. On both types of organs a few days after the appearance of symptoms black pycnidia (fruiting bodies of the fungus) are formed, allowing a clear identification of the disease.

- balanced fertilisation to enhance plant health;
- canopy management to improve ventilation;
- removal and burning of affected bunches and shoots from the previous year, mummies removal to decrease inoculum;
- use of Decision Support Systems for a rational use of pesticides;
- removal of abandoned vineyards.

Crown gall
Agrobacterium vitis

Bulgaria, Hungary and Romania

Low temperatures during the dormant period (below -18°C)

no clear link

Low quality planting material, wrong pruning, missing protection against frost

It is caused by *Agrobacterium vitis* which causes typical tumour formation on the aerial plant parts and root necrosis. Because *A. vitis* persists systemically in symptomless grapevine plants, it can be efficiently disseminated to distant geographical areas via international trade in propagation material. In the vineyard it can be easily spread by mechanical and physical damage caused by vineyard management practices.

- correct pruning;
- sterilisation of pruning devices;
- removal of infected vines;
- use of clean/healthy propagating material;
- avoid/protect from mechanical and physical damages.

funded by European Commission

Pests

Concerning **Pests** the following list summarises opinions and experiences of the experts, including the recommended corresponding elements of IPM strategy.

Grape(vine) moths/ vine moth *Lobesia botrana, Eupoecilia ambiguella*

All countries

Mild winters; high temperatures and high atmospheric humidity during the vegetation period

No clear link

Variety sensitivity (bunch compactness) high N input, no weed control, compacted soils

European grape (vine) moth (*Lobesia botrana*) and Cochilis grape moth (*Eupoecilia ambiguella*), two *lepidoptera* of *Tortricidae* family that cause direct damage to the bunch as they feed on the grape content, and indirect damage as their feeding opens wounds that consequently offer opportunities for diseases such as the one caused by *Botrytis*. They are common in Mediterranean climate;

- appropriate variety choice for low sensitivity;
- balanced fertilisation with reduced nitrogen input;
- careful soil management to avoid compaction;
- removal of pruning debris;
- monitoring by pheromone traps and use of forecasting models (FM);
- application of mating disruption strategy;
- use of *Bacillus thuringiensis*;
- use of selective insecticides that do not harm beneficial insects, including pest predators.

Mites

Spider mites, leaf blister mite, grape leaf rust mite, grapeleaf bud mite, grapevine yellow mite, grape gall mite, red spider

Hungary, Spain, Bulgaria and Romania

Cold springs and hot summers, while for red mite, yellow and bud mite warm and wet Springs are favourable

Not clear

N abundance, high moisture in soil, compacted soil, use of pesticides that reduce beneficials, grafting with material from infested vineyards. Inappropriate management of pruning material

Different species (such as *Calepitrimerus vitis, Eriophyes vitis, Eotetranychus pruni, Panonychus ulmi),* more common in mild climates they attack leaves and shoots, decreasing the photosynthetic activity of the plant;

- avoid excessive use of pesticides that will harm beneficial insects and natural enemies of pests, and increase pest damage;
- balanced fertilisation with reduced nitrogen input;
- proper soil management to avoid compaction;
- avoid grafting with material from infested vineyards;
- management of pruning debris (removal or composting);
- control overwintering population;
- preservation of high biodiversity within the vineyard to enhance the presence of natural enemies;
- predatory mites release;
- visual monitoring to decide if there is the need to spray and when.

funded by European Commission

Smaller green leafhopper *Empoasca vitis*

Spain, Hungary, Greece

High temperatures in June

/

High vigour

A phloem-feeding leafhopper causing veinal browning, as well as marginal rolling and burning;

- balanced fertilisation with reduced nitrogen input;
- balanced management of the canopy;
- shoots removal;
- use of chromatic traps;
- use of selective insecticides that do not harm beneficial insects.

Grape mealybug / Med. Mealy bug *Planococcus ficus*

Italy and Greece, and northern Spain

Higher temperatures, humid summer

Vigour of the plant

N availability, compacted soils

An unarmoured scale insect of the *Pseudococcidae* family that damages grapes by contaminating clusters with cottony egg sacs, larvae, adults, and honeydew and can transmit grape viruses

- balanced fertilisation with reduced nitrogen input;
- accurate soil management to avoid compaction;
- use of pheromones traps;
- use of mineral oils;
- control of overwintering population;
- release of natural enemies (*Anagyrus vladimiri* and *Cryptolaemus montrouzieri*);
- visual monitoring to decide if there is the need to spray and when;
- use of selective insecticides to preserve beneficials.

funded by European Commission

Thrips
***Thrips Tabaci/ Frankliniella* sp.**

Italy and Greece

No specific

Wild areas nearby

Avoid wild areas, facilitate ventilation in the canopy, weed control, reduce irrigation

A very small yellowish thrips that sucks the sap. The sucking leaves silver wounds on the vines, so reducing the photosynthetic surface and increasing loss of water. It may also transmit viruses.

- care in case of wild vegetation (hosting thrips but also beneficials) close to the vineyard;
- facilitate ventilation in the canopy;
- reduced irrigation;
- use of chromotropic traps;
- accurate weed management;
- use of selective insecticides that do not harm beneficials.

Phylloxera - Leaf form of phylloxera, grape phylloxera
Phylloxera vastatrix

Italy and Bulgaria

Hot and wet springtime

Unmanaged vineyards

Non grafted vines

It is an old and well-known pest that caused huge damage to European viticulture when it arrived in the mid 1800s from North America. It completely changed the European vineyard, making practically impossible to avoid grafting on American root-stocks. In last years it appeared on grafted vines, showing symptoms on leaves.

the symptoms on leaves are still rare but emerging as a problem, probably due to climate change. Still under observation. The control in nursery is recommended.

funded by European Commission

American grapevine leafhopper
Scaphoideus titanus ball

Italy, Hungary but all countries as FD

Mediterranean climate

No impact

Wild/unmanaged vineyards

It is a leafhopper that feeds on *Vitaceae* plants, introduced in Europe from North America in the '70s.It has only a generation per year. It is the main vector of the phytoplasma inducing flavescence dorèe

- proper pruning and removing pruned materials from the vineyards ;
- monitoring with chromotropic traps;
- use of selective insecticides that do not harm beneficials;
- management at landscape scale (uprooting abandoned vineyards or wild areas as a reservoir of FD and leafhoppers);
- continuous monitoring of FD symptoms.

4.4 The influence of climate change on vineyard pests and diseases

Premium wine grape production occurs within very narrow climate ranges. In Europe the impact of global warming on wine regions will be large[7]. Salinari et al.[8] estimated that in Piedmont climate change will increase the downy mildew incidence, requiring a higher number of treatments leading to a cost increase of 20 to 50%, and a higher risk of environmental impact.

Several simulations[9] tried to predict the evolution of the vineyard agro-eco-systems with the changing climate, including the development of pests and diseases.

Even if there are no clear figures, the overall forecast is

- an increase of incidence of pests and diseases on viticulture;
- a change of pest species causing problematic situations;
- a change in the biological cycles of pests and diseases, making them more difficult to control;
- an increased difficulty in forecasting due to extreme variation in climatic conditions and, consequently, in the vine growth and development of pests and diseases.

In any case, viticulture will face a more complex situation, which will include more frequent and rapid changes in both weather and pest and disease cycles. This situation requires a more resilient wine and grape production system, since direct control methods will be less effective and probably not sufficient.

The FG experts identified trends in pest and disease development and also identified those pests and diseases that are becoming more and more relevant due to climate change. The Focus Group experts considered the following the most important:

- The **Mediterranean vine mealybug**: both its prevalence and impact are increasing, with significant damage to wine and table grapes;
- several insect **cycles are changing**, making it more difficult to apply forecasting systems;
- in recent years diseases such as **downy mildew**, also became problematic in areas where they rarely appeared before, i.e. Sicily or Sardinia and, vice versa, pesticide-resistant strains of pathogens are appearing in areas with long term presence of the specific pathogen.
- **powdery mildew** has started to become problematic in more Northern areas where it wasn't usually an issue in the past.

Practical examples of temperature change effects are already visible:

- *Lobesia botrana* males appear in early spring, 30 day earlier compared to 30 years ago;
- *Eupoecilia ambiguella* is affected by higher winter temperatures, it appears 30 days earlier;
- also the grapevine starts its cycle earlier, about 13 days in 2011 compared to previous 30 years average in Spain and about 12 days earlier in France.
- Insects seem to be showing a kind of adaptation towards increasing CO_2 concentrations. However, it will only be possible to draw conclusions about this after several generations of insects with higher pupae weight and shorter larval development. This would probably lead to a change in plant-insect interactions, but it is not yet clear what this change will look like, nor what it will mean for vine cultivation in Europe.

7 Mozell, M.R, Thach, L., 2014. The impact of climate change on the global wine industry: Challenges & solutions. Wine Economics and Policy 3 (2014) 81–89

8 Salinari, F., Giosue, S., Tubiello, F.N., Rettori, A., Rossi, V., Spanna, F., Rosenweig, C., Gullino, M.L., 2006. Downy mildew (*Plasmopara viticola*) epidemics on grapevine under climate change. Glob. Change Biol. 12, 1299–1307, http://dx.doi.org/10.1111/j.1365-2486.2006.01175.x.

9 Fraga, H., Malheiro, C.C., Mountinho-Pereira, J., Santos, J.A., 2012. An overview of climate change impacts on European viticulture. Food Energy and Securyty 2012; 1(2). 94-110

funded by European Commission

5. Recommendations

Taking into consideration the main challenges and bottlenecks in the protection of the vineyard, the experts listed a set of recommendations for:

- innovation projects, that can be implemented at local level, to make use of the knowledge and skills already available but often underexploited;
- research projects, on topics where the available knowledge is still missing

5.1 Ideas for local innovation projects, including EIP-AGRI Operational Groups (OGs)

The proposed topics and contents recommended by the experts for Operational Groups are:

- Working with owners and managers of small-scale and scattered vineyards to identify and test appropriate **IPM and precision viticulture practices**, with locally adapted strategies and specific regional implementation requirements. These may include for example: using local forecasting models, mating disruption systems (adapted to small scale or alternative methods), locally adapted varieties, the use of drones, etc.
- Involving local vineyard managers, owners, wine producers in the testing and selection of **locally adapted varieties and heterogeneous planting materials** fitting local conditions and market demands. The OG project could test and select locally adapted varieties/heterogeneous materials for their tolerance to pests and diseases, acceptability for the market and ease to grow in site-specific conditions, including small vineyards.
- Developing local strategies for a proper use of **cover-crops**. This will include vineyard managers identifying the best, locally adapted species (and mixtures), sowing time, mowing/terminating method and time for different cover-crops management.
- Testing ways **to enhance biodiversity in vineyards**, through the activation of local networks including gene banks, *in situ* conservation etc. to protect and enhance both functional biodiversity and vine biodiversity in vineyards. The project could list locally adapted good practices to maintain or increase biodiversity in vineyards.
- Impact of **climate change** on pests and diseases, incidence and definition of strategies, based on local conditions and requirements, to increase resilience. The project could work on specific local effects of climate change and locally adapted mitigation measures.
- Involving local vineyard owners and managers in testing site specific **GTDs management** through preventive and control strategies. These strategies should include monitoring of seasonal inoculum in order to guide management. Successful innovative practices should be shared widely.

5.2 Research needs from practice

Besides the ideas for local innovative projects (e. g. Operational Groups), the experts also identified topics where more research is needed and is recommended for consideration within a large framework, either national, transnational or European.

The list below summarises these recommendations:

- **Selection and breeding of grape varieties and heterogeneous planting materials** fitting local conditions and market demands. The research should include testing and selection of locally adapted varieties but also heterogeneous materials, tolerant to pests and diseases, but also acceptable for the market and easy to grow in site-specific conditions, including in small vineyards.
- To increase **health in planting materials** by improving nursery management. The research should focus on how to make viticulture more resilient, starting from planting materials and nursery methods. The aim

funded by European Commission

is to produce healthy plants (and also the definition of healthy plant is still to be completed), including research on rootstocks and their influence on resilience.

- A set of measures to **downscale IPM and precision viticulture** in order to make them applicable in small-sized and scattered vineyards and farms, which form a relevant part of European viticulture. The measures should help to identify or adapt IPM practices and precision technologies which will be useful for such small-scale vineyards. These may include for example: adoption of local forecasting models, mating disruption systems (adapted to small scale or alternative methods), locally adapted varieties, drone use on small scale, etc.
- **IPM overall strategy on table grapes and related labelling**: need for research on **overall IPM strategy** to efficiently manage pests and diseases and to reduce pesticide use on table grapes - and at the same time - reduce resistance risks. The research activity should include practical implementation of the strategies, which should be locally adapted, and demonstration/pilot farms to increase trust and peer-to-peer knowledge exchange.
- Management strategies to control **powdery mildew**, including the reduction/control of overwintering structures, fitting within a global strategy that can be adapted to local specific conditions, availabilities and needs.
- The **role of organic matter and soil fertility on plant health**. Research on methods to manage soil organic matter, soil fertility and the soil microbiome that will improve plant health and reduce the impact of pest and diseases.
- Effects of **climate change on pests and diseases**. The research should include the identification of specific changes in pest and disease life cycles, their impact on grape production, and resistance of pest and diseases under climate change scenarios. Also the emergence of new pests and diseases should be forecast.
- Understanding the main factors of **vine decline**, in different European regions/conditions. Research should aim to understand the reasons behind the vine decline and should propose strategies to halt this decline. These strategies should be adapted for different regions and for different types and structures of vineyards.
- Research to develop strategies to manage **Grapevine Trunk Diseases** (GTDs), which can be incorporated in overall vineyard management strategies covering the entire lifecycle of the vineyard. To improve their efficacy, these strategies should include the role of biocontrol agents, understanding their mode of action.

funded by European Commission

5.3 Other recommendations, including knowledge and training needs

The Focus group experts highlighted that knowledge sharing and training are essential to implement IPM measures and strategies successfully. They noted that there is much knowledge available on IPM strategies and on how to increase vineyard resilience, based on scientific activity and from advisory experience (**see Annex C**), but its practical implementation is extremely limited and slow, often due to a lack of trust from the growers` side. For this reason, the Focus Group considered that the most urgent needs are training and demonstration activities, supported by researchers, advisers and skilled farmers. As reported in **mini-papers 2 and 4** several efficient biocontrol methods are available but these are still not effectively used. Very often farm managers are aware that there are non-chemical alternatives to pesticides but they do not know their exact potential or how to practically insert them into an IPM strategy. The Focus Group experts also noted that the vine sector is quite traditional, with small size companies and a lot of regional rules and particularities. This means that it is difficult to establish a unique/general framework methodology for knowledge exchange (about viticulture topics) which is clear, efficient and useful for all the different regions or countries.
They therefore stressed the need to identify how the knowledge exchange chain works in each area in order to identify both the good points and the points for improvement.

Trentino-South Tyrol (Italy) hosts a good example of close cooperation between growers and research institutions, which allowed the establishment of IPM in the Region. Here the driving force for IPM implementation was the adoption, in the past 20 years, of pheromone mating disruption with an Area Wide approach against codling moth and leafrollers on apple crops and against the vine moths in the vineyards. Although the mountainous terrain of the area was not optimal for the efficacy of mating disruption, grower cooperatives and their field consultants were very influential in convincing growers to implement this technology. Public research institutions conducted extensive research and education, and provided credible assessments of various mating disruption technologies. Thus, the development and adoption of an area-wide mating disruption in Trentino-South Tyrol resulted from the merging of several favourable factors, which brought together researchers, advisors, cooperatives, growers, pheromone distributors, and related industries.

There are not many similar examples of large scale success but in Tuscany a pilot project on the implementation of mating disruption (to manage moths and mealy bugs; see mini-paper 4) demonstrates that IPM implementation can be taken up widely, when research scientists have an interest in and are encouraged to promote and adapt existing knowledge to practical implementation together with local winegrowers. Scientists must play a leading role in engaging all groups of stakeholders to work together with a common goal. This was probably the most important factor in the successes achieved in this project.

The specific needs can be summarised as follows:

- improved knowledge on **plant, pests and diseases physiology and their interaction**. A wide understanding of pest and disease development based on local historical data (forecasts, phenological stages etc.) and deep knowledge of physiological mechanisms are needed in order to make farmers confident and skilled in a systems approach.
- **The establishment of a European network of farms** where IPM strategies and practices are demonstrated in local environments. Links between similar initiatives in different wine regions would enhance the uptake. The topics in the demo farm network should include:
    - local genetic materials,
    - newly bred varieties with high tolerance and quality, fitting IPM and organic needs,
    - biodiversity management within the farm and at landscape level,
    - IPM strategies covering the whole vineyard production cycle from vineyard planting upto grape harvest. The demonstration network will increase trust and knowledge among practitioners as well as the interaction between farmers, researchers and advisors.

funded by European Commission

- There is an urgent need for knowledge (practical and scientific) and systems that use all available knowledge from science and practice. The experts propose a **"learning from failure - Platform"** and an e-learning system with scientific validation, where farmers can upload a picture of an infection and get advice.

  It can include an alert system for the spread of pests or diseases.

Finally the experts proposed to set up a traceability system in nurseries to trace the plant materials` origins. This could help to increase the sustainability of European viticulture.

funded by European Commission

Annex A: Members of the EIP-AGRI Focus Group

Name of the expert	Profession	Country
Ait Barka, Essaid	Scientist	France
Caffi, Tito	Scientist	Italy
Compant, Stéphane	Scientist	Austria
Csikós, Anett	Scientist	Hungary
Donkó, Ádám	Scientist	Hungary
Durán Pereira, Daniel	Farm advisor	Spain
Fabianek, Daniela	Farmer	Austria
Legas, Markos	Farmer	Greece
Lucchi, Andrea	Scientist	Italy
Majcenović, Irena	Farmer	Croatia
Mugnai, Laura	Scientist	Italy
Palacios Muruzábal, Julián	Farm advisor; Farmer	Spain
Popescu, Daniela	Scientist	Romania
Rapf, Klaus	Farmer	Austria
Rego, Cecilia	Scientist	Portugal
Santesteban, Luis Gonzaga	Farm advisor; Scientist	Spain
Zekri, Olivier	Expert from agricultural organisation, industry or manufacturing; Advisor; Scientist	France
Tsvetkov, Ivan	Scientist	Bulgaria
Vrbanek, Josip	Farm advisor; Farmer	Croatia

Facilitation team

Cristina Micheloni	Coordinating expert
Emilie Gaetje	Task manager
Sergiu Didicescu	Back-up Task manager

You can contact Focus Group members through the online EIP-AGRI Network.
Only registered users can access this area. If you already have an account, you can log in here
If you want to become part of the EIP-AGRI Network, please register to the website through this link

Annex B. List of mini-papers

.

	Title	Main author	Other authors
1	Practical ways to increase functional biodiversity to control pests and diseases, including soil pathogens	Luis Gonzaga Santesteban	Luis Gonzaga Santesteban*, Julián Palacios Muruzábal, Ivan Tsvetkov, Daniela Popescu, Ádám Donkó
2	How gain the interest and trust of vine growers: training, demonstration, capacity building & education.	Daniel Durán	Daniel Durán*, Ivan Tsvetkov, Daniela Fabianek, Josip Vrbanek, Irena Majcenović, Tito Caffi
3	How can winter pruning practices help to reduce the impact of Grapevine Trunk Diseases	Julián Palacios Muruzábal, Luis Gonzaga Santesteban	Julián Palacios Muruzábal*, Luis Gonzaga Santesteban*, Anett Csikós, Daniela Popescu, Stéphane Compant, Essaid Ait Barka, Cecilia Rego, Ivan Tsvetkov
4	SHARING NEEDS AND KNOWLEDGE PROMOTES IPM	Andrea Lucchi	
5	Strategies for a better use of copper-based fungicides in organic viticulture	Tito Caffi	

funded by European Commission

EIP-AGRI Focus Group

Disease and pests in viticulture

MINIPAPER: Practical ways to increase functional biodiversity to control pests and diseases, including soil pathogens

Luis Gonzaga Santesteban*, Julián Palacios Muruzábal, Ivan Tsvetkov, Daniela Popescu, Ádám Donkó

funded by European Commission

Introduction

The interaction between biodiversity and ecosystem services (ESS) plays a key role in sustainable agricultural systems which use as few external inputs as possible. Vineyards can provide high levels of biodiversity inside the cropped area, which cannot be found in annual cropping systems. Therefore, viticultural systems provide ideal conditions for analysing biodiversity and ESS relevant for the winegrower (Pingel et al., 2015). Biodiversity and associated ecosystem services in viticultural landscapes are primarily affected by human management regimes and natural characteristics (climate and soils) at different spatial scales.

Functional diversity is a component of biodiversity that generally concerns the range of things that organisms do in communities and ecosystems. In agricultural ecosystems, it refers to the ecosystem services that support sustainable agricultural production and can also have a positive spin-off to the regional and global environment and society as a whole.

1)Functional biodiversity within the vineyards

In the last decades intensification and mechanisation of vineyard management caused a separation of production and conservation areas. As a result of management intensification, including frequent tilling and/or use of pesticides, several ecosystem services are affected, leading to high rates of soil erosion, degradation of soil structure and fertility, contamination of groundwater and high levels of agricultural inputs (Zaller et al., 2015)

a) Diversity in plant material

In the design and planting of a new vineyard there are several scales of diversity depending on the plant material used. Ordered from lowest to highest degree of biological variability, the following types of vineyards can be found:

- Vineyard based on a single clone of one variety
- Vineyard based on one variety but multiclonal
- Vineyard based on one variety but with plants obtained by mass selection
- Vineyard based on one variety but without any selection (collection of buds from old vineyards)
- Vineyard based on several varieties and with no selection

Within this broad range of choice, for a project seeking functional diversity, one single-variety and one clone is not a sensible choice. However, in order to allow a reasonable operational management of the vineyard, options including many variables are difficult to justify, unless they provide additional value apart from the agronomic (wine-tourism, education...). For growers and institutions the main goal within this field should be to preserve intra-variety diversity. A similar reflection could be done for root-stocks, where basing all the production on a reduced set of genotypes can also be problematic.

b) Preserving and promoting biodiversity within the vineyard

b.1. Soil management implications for vineyard biodiversity

Vineyard management plays a crucial role in determining to which extent a vineyard is a simple, plain agroecosystem, or it becomes a more complex habitat that provides ecosystem services to growers and to humankind in a broader sense.

funded by European Commission

The first decision growers must make is how to manage soil, in order to deal with adventitious flora or `weeds`. Traditional vineyard management was characterised by frequent tilling to eradicate all adventitious plants to reduce competition for water and nutrients (Gago et al., 2007; Pardini et al., 2002). Later, herbicides became a key tool frequently used to remove `weeds`. Chemical control is particularly effective to control weeds in the vine rows, where it is difficult to operate mechanically, whereas vegetation can be easily controlled by mowing or disking in the work row (Ferrara et al., 2015). However, these management strategies are associated with ecosystem disservices linked to erosion, degradation of soil structure and fertility, contamination of groundwater, and cause a significant loss of biodiversity at both below and above ground levels.

Below ground, herbicides and tillage are known to negatively affect biodiversity. Two major examples of this effect are arbuscular mycorrhizal fungi (AMF) and earthworms. Herbicides affect AMF directly, through destruction of extraradical hyphae by soil disruption, or indirectly, through effects on populations of mycorrhizal weeds and cover crops (Baumgartner et al., 2005). Mycorrhizal fungi are important for the nutrient status of plants (Abbott and Robson, 1991), and are known to be bioprotective against soil-borne fungal pathogens (Tsvetkov et al., 2014). Concerning earthworms, they are known to be highly beneficial, as they usually improve soil structural stability and soil porosity and reduce runoff, and result in a better soil organic matter (SOM) and nutrient cycling, and induce the production of substances that improve plant growth and health (Bertrand et al., 2015). Several studies have shown that earthworm abundance and diversity are reduced in agricultural fields, compared to uncropped soils, and that herbicides and intensive tilling negatively affect earthworm populations (Bertrand et al., 2015; Vršič, 2011; Zarea and Karimi, 2012).

Aboveground, weed management practices also determine plant and arthropod diversity in vineyards, being increased when cover crops are used (Costello and Daane, 2003, 1998; Sanguankeo and León, 2011). This enhanced biodiversity can be highly beneficial for pest management (Altieri et al., 2005) and, in vineyards, it has been shown for instance to contribute to biological control of leafhoppers and thrips, by breaking the virtual monoculture that vineyards become in the summer after winter cover crops dry out or are ploughed under (Altieri et al., 2005).

Thus, cover crops in vineyards provide a large range of different ecosystem services, those regarding biodiversity and potential benefits for disease and pest control having been highlighted here. However, despite the large range of positive effects of cover crops and spontaneous vegetation in vineyards, the strong competition for water with the vines and the associated reduction of grape yields of up to 40% (Ruiz-Colmenero et al., 2011) limits their adoption in rainfed vineyards in semiarid or sub-humid climates. Therefore trade-offs exist between soil conservation, biodiversity conservation and production depending on climatic and pedological conditions. Consequently, optimum management practices have to be specifically sought for different regions.

Currently detailed studies on the effects of species-rich inter-row vegetation on a variety of ecosystem services in various viticultural landscapes are still missing. Even if cover crops are increasingly becoming the state of the art in vineyard management in areas with summer rain or irrigation, we need to better understand how diverse cover crops, with seed mixtures, can result in more beneficial effects than one-species cover crops (Boller et al., 1997). Apart from this, other alternatives for weed management under the vine row, or the potential benefits of applying natural products targeted to disfavour the development of aggressive spontaneous vegetation need to be identified. Besides cover crops, alternate mowing can be an option, depending on the climate. Also permanent cover with species that autoregulate in periods of drought are an option (i.e *Trifolium subterraneum*)

Moreover, growers and viticulturists need to have access to relatively cheap, readily usable tools allowing them to evaluate their vineyard biodiversity, in order to test to which extent any change in vineyard management is affecting it. This would be particularly relevant for estimating soil biological richness, the unseen part of terroir, which has implications not only for vineyard resilience, but also on wine typicity and potential quality (Gilbert et al., 2014; Probst et al., 2008).

Figure: Photo of different types of soil management in European vineyards (http://www.vinedivers.eu/)

b.2. Pest and disease control

In the different models of P&D control (IPM, Organic, low-input) the management should aim to increase diversity that, in turn, facilitates P&D control.

Concerning pests, it is evident that a complex ecosystem is more resilient than a simple ecosystem and that favourable conditions need to be promoted: avoiding aggressive practices (broad spectrum treatments) and/or encouraging populations of beneficial insects. An improved knowledge of natural predators and their interactions is needed and local specificity is not sufficiently studied.

Concerning diseases, it is not so evident that a complex ecosystem is more resilient, but it is likely to be so, as there will be greater competition for the ecological niches. There is, for instance, scientific evidence that *Trichoderma* sp. can act exactly like that, competing with the fungi causing GTDs.

b.3 Promotion of alternative habitats

Beyond the role cover crops can play in increasing diversity, growers can enhance diversity through the establishment of biodiversity hot spots within or near the vineyard. Biodiversity hot spots are areas providing biological diversity in the agro-ecosystem, which could contribute to vineyard resilience. However, it is not always easy to implement hot spots within the vineyard, as they can interfere with vineyard management, so for most growers it will be more practical to develop these areas around the vineyard.

2) Preserving and promoting functional biodiversity around the vineyard

Typical intensive agriculture has resulted in the simplification of the landscape, implying the expansion of monocultures, which has decreased abundance and activity of natural enemies due to the removal of critical food resources and overwintering sites (Corbett and Rosenheim, 1996). In viticulture, vegetation corridors have been shown to have a positive effect, as the complex of predators that circulate through the corridor move to the adjacent vine rows, and exert a regulatory impact on herbivores present in such rows (Nicholls et al., 2001). Growers should then understand that managing a vineyard means managing an ecosystem where grapevines are the dominant plant species. Vineyard landscapes are now the base for emerging research showing connections between ecosystem function, agricultural practices at multiple scales, and response of agroecosystems (Viers et al., 2013).

There are many ways to enhance plant diversity in viticultural areas. The first one, as highlighted before, is using (diverse) cover crops between vine rows. However, headlands, borders, riparian zones or areas

funded by European Commission

unsuitable for productive grape growing due to salinity, water logging or to any other cause have to be considered as part of the strategy for increasing vineyard resilience through enhanced biodiversity (Creek et al., 2011; Ponti et al., 2005).

Figure: Different landscape complexity (high structural diversity in left and low structural diversity in right) of European vineyards

Creating habitats on the least productive parts of the farm to concentrate natural enemies is another important strategy. This approach has been used satisfactorily in several vineyard areas, creating islands of flowering shrubs and herbs at the centre of the vineyard, which acts as a push-pull system for natural enemy species. The island provides pollen, nectar and neutral insects for a variety of predators and parasites (Altieri et al., 2006; Viers et al., 2013). It is important to establish a diversity of plants to attract an optimal number and mix of natural enemies. The size and shape of the flowers determine which insects are attracted, as only those who are able to access the flowers' pollen and nectar will make use of the food sources provided. The period during which the flowers are available is as important as the size and shape of the flowers. Many beneficial insects are only active as adults and for specific periods during the growing season; they need pollen and nectar during these active periods, particularly in the early season when prey is scarce (Altieri et al., 2006).

Apart from favouring arthropod presence in vineyards, we need to take into account the potential that birds and mammals can have on reducing pest pressure and rachieving a more resilient vineyard through biodiversity. Maintaining landscape heterogeneity in and around agricultural landscapes can thus help conserve biodiversity and potentially natural pest control (Kelly et al., 2016). Studies performed in vineyards in California indicate that natural trees and shrubs should be conserved and restored throughout the vineyard landscape to enhance bat abundance for a win-win agricultural production and conservation solution (Kelly et al., 2016; Tietje et al., 2014). Wetlands surrounding the agricultural landscape have also proved to be crucial to enhance bat presence and biodiversity (Sirami et al., 2013; Stahlschmidt et al., 2012). Regarding birds, avian conservation practices have been shown to strengthen ecosystem services in vineyards (Jedlicka et al., 2011), and how maintaining and promoting herbaceous corridors or other habitats can enhance their presence (Arlettaz et al., 2012; Duarte et al., 2014; Schaub et al., 2010).

Therefore, the conservation of old buildings, dead trees, surrounding vegetation and the creation or preservation of wetlands needs to be promoted as a good agricultural practice. From a research point of view, there is a need to increase the knowledge on the distribution and abundance of bat and insectivorous bird species across different types of agricultural landscapes and on how they can interact with vineyard resilience from a holistic point of view.

References

Abbott, L.K., Robson, A.D., 1991. Factors influencing the occurrence of vesicular-arbuscular mycorrhizas. Agric. Ecosyst. Environ. 35, 121–150. doi:10.1016/0167-8809(91)90048-3

Altieri, M.A., Ponti, L., Nicholls, C.I., 2006. Managing pests through plant diversification. Leisa Mag. 9–11.

Altieri, M., Ponti, L., Nicholls, C., 2005. Manipulating vineyard biodiversity for improved insect pest management: case studies from northern California. Int. J. Biodivers. Sci. Ecosyst. Serv. Manag. 1, 191–203. doi:10.1080/17451590509618092

Arlettaz, R., Maurer, M.L., Mosimann-Kampe, P., Nusslé, S., Abadi, F., Braunisch, V., Schaub, M., 2012. New vineyard cultivation practices create patchy ground vegetation, favouring Woodlarks. J. Ornithol. 153, 229–238. doi:10.1007/s10336-011-0737-7

Baumgartner, K., Smith, R.F., Bettiga, L., 2005. Weed control and cover crop management affect mycorrhizal colonization of grapevine roots and arbuscular mycorrhizal fungal spore populations in a California vineyard. Mycorrhiza 15, 111–119. doi:10.1007/s00572-004-0309-2

Bertrand, M., Barot, S., Blouin, M., Whalen, J., de Oliveira, T., Roger-Estrade, J., 2015. Earthworm services for cropping systems. A review. Agron. Sustain. Dev. 35, 553–567. doi:10.1007/s13593-014-0269-7

Boller, E.F., Gut, D., Remund, U., 1997. Biodiversity in Three Trophic Levels of the Vineyard Agro-Ecosystem in Northern Switzerland. Springer Berlin Heidelberg, pp. 299–318. doi:10.1007/978-3-642-60725-7_17

Corbett, R., Rosenheim, J.A., 1996. Impact of a natural enemy overwintering refuge and its interaction with the surrounding landscape. Ecol. Entomol. 21, 155–164. doi:10.1111/j.1365-2311.1996.tb01182.x

Costello, M.J., Daane, K.M., 1998. Influence of ground cover on spider populations in a table grape vineyard. Ecol. Entomol. 23, 33–40.

Costello, M.J., Daane, K.M., 2003. Spider and Leafhopper (Erythroneura spp.) response to vineyard ground cover. Environ. Entomol. 32, 1085–1098.

Creek, C., Island, K., Creek, L., Vale, M., Retallack, M., 2011. Vineyard biodiversity and insect interactions - Establishing and monitoring insectariums. Mary Retallack.

Duarte, J., Farfán, M.A., Fa, J.E., Vargas, J.M., 2014. Soil conservation techniques in vineyards increase passerine diversity and crop use by insectivorous birds. Bird Study 61, 193–203. doi:10.1080/00063657.2014.901294

Ferrara, G., Mazzeo, A., Matarrese, A.M.S., Pacifico, A., Fracchiolla, M., Al Chami, Z., Lasorella, C., Montemurro, P., Mondelli, D., 2015. Soil management systems: Effects on soil properties and weed flora. South African J. Enol. Vitic. 36, 11–20.

Gago, P., Cabaleiro, C., García, J., 2007. Preliminary study of the effect of soil management systems on the adventitious flora of a vineyard in northwestern Spain. Crop Prot. 26, 584–591. doi:10.1016/j.cropro.2006.05.012

Gilbert, J. a, van der Lelie, D., Zarraonaindia, I., 2014. Microbial terroir for wine grapes. Proc. Natl. Acad. Sci. U. S. A. 111, 5–6. doi:10.1073/pnas.1320471110

Jedlicka, J.A., Greenberg, R., Letourneau, D.K., 2011. Avian Conservation Practices Strengthen Ecosystem Services in California Vineyards. PLoS One 6, e27347. doi:10.1371/journal.pone.0027347

Kelly, R.M., Kitzes, J., Wilson, H., Merenlender, A., 2016. Habitat diversity promotes bat activity in a vineyard landscape. Agric. Ecosyst. Environ. 223, 175–181. doi:10.1016/j.agee.2016.03.010

Nicholls, C.I., Parrella, M.P., Altieri, M.A., 2001. The effects of a vegetational corridor on the abundance and dispersal of insect biodiversity within a northern California organic vineyard. Landsc. Ecol. 16, 133–146.

Pardini, A., Faiello, C., Longhi, F., Mancuso, S., Snowball, R., 2002. Cover crop species and their management in vineyards and olive groves. Adv. Hortic. Sci. 16, 225–234.

Ponti, L., Ricci, C., Veronesi, F., Torricelli, R., 2005. Natural hedges as an element of functional biodiversity in agroecosystems: The case of a Central Italy vineyard. Bull. Insectology 58, 19–23.

Probst, B., Schüler, C., Joergensen, R.G., 2008. Vineyard soils under organic and conventional management—microbial biomass and activity indices and their relation to soil chemical properties. Biol. Fertil. Soils 44, 443–450. doi:10.1007/s00374-007-0225-7

Ruiz-Colmenero, M., Bienes, R., Marques, M.J., 2011. Soil and water conservation dilemmas associated with the use of green cover in steep vineyards. Soil Tillage Res. 117, 211–223. doi:10.1016/j.still.2011.10.004

Sanguankeo, P.P., León, R.G., 2011. Weed management practices determine plant and arthropod diversity and seed predation in vineyards. Weed Res. 51, 404–412. doi:10.1111/j.1365-3180.2011.00853.x

Schaub, M., Martinez, N., Tagmann-Ioset, A., Weisshaupt, N., Maurer, M.L., Reichlin, T.S., Abadi, F., Zbinden,

funded by European Commission

N., Jenni, L., Arlettaz, R., 2010. Patches of Bare Ground as a Staple Commodity for Declining Ground-Foraging Insectivorous Farmland Birds. PLoS One 5, e13115. doi:10.1371/journal.pone.0013115
Sirami, C., Jacobs, D.S., Cumming, G.S., 2013. Artificial wetlands and surrounding habitats provide important foraging habitat for bats in agricultural landscapes in the Western Cape, South Africa. Biol. Conserv. 164, 30–38. doi:10.1016/j.biocon.2013.04.017
Stahlschmidt, P., Pätzold, A., Ressl, L., Schulz, R., Brühl, C.A., 2012. Constructed wetlands support bats in agricultural landscapes. Basic Appl. Ecol. 13, 196–203. doi:10.1016/j.baae.2012.02.001
Tietje, W.D., Weller, T.J., Yim, C.C., 2014. Bat Activity at Remnant Oak Trees in California Central Coast Vineyards 1. Gen. Tech. Rep. PSW-GTR-251 97–106.
Tsvetkov, I., Dzhambazova, T., Kondakova, V., Batchvarova, R., 2014. Mycorrhizal fungi Glomus spp. and Trichoderma spp. in viticulture (review). Bulg. J. Agric. Sci. 20, 849–855.
Viers, J.H., Williams, J.N., Nicholas, K.A., Barbosa, O., Kotzé, I., Spence, L., Webb, L.B., Merenlender, A., Reynolds, M., 2013. Vinecology: pairing wine with nature. Conserv. Lett. 6, n/a-n/a. doi:10.1111/conl.12011
Vršič, S., 2011. Soil erosion and earthworm population responses to soil management systems in steep-slope vineyards. Plant, Soil Environ. 2011, 258–263.
Zarea, M.J., Karimi, N., 2012. Effect of herbicides Earthworms. Dyn. Soil, Dyn. Plant 6, 5–13. doi:10.1146/annurev.py.15.090177.002045

EIP-AGRI Focus Group

Diseases and pests in viticulture

MINIPAPER: How gain the interest and trust of vine growers: training, demonstration, capacity building & education.

Daniel Durán*, Ivan Tsvetkov, Daniela Fabianek, Josip Vrbanek, Irena Majcenović, Tito Caffi

funded by European Commission

1. Introduction

Knowledge about best practices and recommendations on how to manage pests and diseases in viticulture, as well as other good cultural practices, traditional or innovative, to manage the vineyard as a whole are sometimes not accessible to end users or they are not sufficiently reliable.

The main objective of this mini-paper is to discuss how we could improve exchange of knowledge and use of this knowledge for the end user (i.e. vine-growers) through new training and education methods or practical field demonstrations for vine growers.

Vine growers need to get the knowledge, know how to apply it practically and evaluate if these new practices are worthwhile; if yes, this will increase their trust in these new approaches. Different approaches have been tried in the past to persuade vine growers but the results have not been that successful. The best way to convince vine growers to try a new approach is through a practical demonstration.

If the solutions (knowledge) exist but are not applied, the effort will be wasted. This is the reason why knowledge exchange through training, demonstration, capacity building & education is such an important contribution to increasing resilience of grape vines to pests and diseases and supporting the productivity and sustainability of the vine sector.

This minipaper was written on the basis of experience from different viticulture areas in Bulgaria, Croatia, Austria, Italy and Spain.

2. How is it organized and who are the agents involved in practical demonstration and training on viticulture issues? Differences among countries and regions

As mentioned above, knowledge exchange is very important to achieve changes in vineyard management, but the vine sector is a traditional sector, with small-sized companies and a lot of regional rules and particularities. This means that it is difficult to establish a unique framework methodology for knowledge exchange on viticulture topics that would be clear, efficient and useful for different regions or countries.

This is the reason why it is necessary to identify how this exchange chain works in each area in order to identify possible structural deficiencies and also the good points in the system.

Below an overview is presented, illustrating the situation in each region/country that has participated in this mini paper. Later, we will be able to contrast the differences among them, indentify the main problems and discover the best practices to be proposed.

Bulgarian case: In 2017 the total vineyard area was 63.952ha. Currently, approximately 33% of the vineyards are in a good condition, and the share of restored plantations is 52%. Total grape production for this year was 200.428 tons (186.131 tons- wine grapes, 14.297 tons- table grapes). Viticulture and wine production have a long history in Bulgaria, and they are traditional subsectors of agriculture that have always provided income and occupation to a part of the population.

In the past, the cultivar structure was comprised predominantly of local grapevine cultivars (Pamid, Gamza, Shiroka melnishka, Mavrud, Dimyat, Misket cherven, Rkatsiteli), but currently, introduced cultivars mainly from the Western Europe are more common. There are 5 regions into which the country's wine-lands can be roughly divided, although only 2 are Denomination of origin (DOC/DOCG/IGT).

The viticulture and wine production sector is one of the first economic sectors to be allowed, by legislation, a high degree of self-regulation, conducted by the National Viticulture and Wine Production Chamber.

The profile of a typical Bulgarian winegrower is: self-employed with middle-level qualification and professionalisation, and a tendency to improve.

The average size of a farm is about 1.0 hectares.

Currently there are no specific associations for vine growers. In the near past, there were a few of these associations but they did not work very well. Vine growers do not have specific and practical support from

funded by European Commission

governmental institutions; only phytosanitary suppliers (mainly big pesticide producers) have organised informative workshops, but these were limited to proper use of their own pesticides. There is a serious lack of demonstration and training on viticulture issues.

Croatian case: According to the vineyard register, there are 19.989 hectares of vineyards and 39.249 farms/companies that are managing them. Thus the average size of a farm is about 0.5 ha. There are 196 varieties that can be grown in Croatia. Vineyards in Croatia cover around 1,7 % of the total agricultural area, but the value of Wine in purchased and sold agricultural products is around 58 million Euro and it accounts for 6,2 % of all the trade in agricultural products.

In Croatia 4 % of the vine growers are younger than 35 years, and 59 % of them are older than 54 years. Only 5 % of the vine growers have some sort of agricultural education, 99% of the vine growers are registered as self-employed farmers; they own 68 % of the vineyards. This in contrast to the other 1% of vine growers, who are registered as legal entity (LTD. or similar forms), and own 6.289 hectares (32 %). Vineyards are mostly privately owned and in some regions there are big problems with land ownership, because the owners are not known, or ownership is divided among more than 10 people.

Vine growers are usually organised in the form of a not for profit association but these organisations don't fulfil their full potential. The role of these organisations is usually focused on checking the wine quality and and organising annual regional wine fairs. They do not organise demonstrations and training on the issue of viticulture; only suppliers and traders sometimes organise advisory meetings regarding plant protection, fertilisers, wine plants etc.

The only support that vine growers have in Croatia is provided by the Advisory service, organised by the government or by Phytosanitary suppliers who usually organise informative workshops for vine growers.

Italian case: In Italy there are 640.000 hectares of vineyards and 384.000 farms/companies managing them. Thus the average size of a farm is about 1,9 hectares and it means that the landscape is highly fragmented and to apply an innovative tool and/or strategy at field level it is necessary to involve a lot of people (in terms of growers) for a small area (in terms of hectares).

Moreover, 442 varieties are grown in Italy and more than 500 Denominations of origin (DOC/DOCG/IGT) are present, so it means that many different rules and regulations should be known and respected simultaneously by the same grower.

Austrian case: The wine-growing country of Austria is known for its diversity of grape varieties and the versatility of its wine producers. Around 20.000 vintners cultivate grapevines on 45.000 ha, it means an average of 2.25 ha per vine grower. These growers make their own wines at all levels of quality, and for all occasions. The total wine production is around 2.000.000 to 3.000.000 hl per year. The vine and wine sector is very important in this country in economic terms.

Regarding the profile of Austrian winegrowers, there are over 80-90% who work full-time in vine-growing and wine-making, most of them self-employed and owners of the land. Their qualification and professionalization level is usually higher than in the previous cases, and it is common to find young vine growers with a master's and high school degree. It should be highlighted that in the past few years many young people started working in the wine sector.

About the production structure, the most common are small-scale vine growers, there are only a few big ones. They were organised in associations, but they are not very innovative. Vine growers can be supported by the Plant protection products companies, but the phytosanitary suppliers have a small role organising informative workshops related to viticulture issues. We could say that only some innovative vine growers work together with universities and do some research.

Spanish case: For Spain we will focus on two regions: Galicia and La Rioja; two important regions in terms of viticulture but with important differences in their structure of production

In Galicia region there are over 16.100 vine growers and about 9,700 hectares dedicated to vine-growing.

In the past few years the Galician wine and vine sector showed strong growth, in terms of production and economic relevance. During 2015, the total production was 63,8 millions of liters, and 446 wineries were registered in the different qualified designations of origin. 17,500 people worked directly in the wine sector.

Regarding the Galician vine growers` profile, their average age is quite high (50-60) and there is an important problem of generational renewal. According to the Agricultural Census, 86% of the farmers just have practical training, 1.9% has professional training, 0.5% has any university degree and 13% have another type of training (this situation is comparable to vine growers). Most of the vine growers work part-time on vineyard management, and they are the owners of the vineyards. The number of employees is growing due to of the hiring done by the services companies and biggest wine cellars; however, the number of employees is lower than the number of owners.

There is a prevalence of small properties; this characteristic is emphasised for the small-scale farming of land property system in Galicia. Most vineyards are directly managed by the vine growers.

The Galician vineyards are young, an average of 20 years old, because of the restructuring with native varieties in the nineties.

Regarding vine growers` organisations, most vine growers are enrolled in a Regulatory Council Designation of Origin, but only looking for advantages in terms of distribution and wine commercialisation but not in terms of training and technical support.

The owners of big plantations and vine growers who are associated in Cooperatives have technical staff that offer technical support, the others look for advice from experts working at Agricultural Offices, Wine Advice Offices, phytosanitary suppliers … but the quality of advice and support could be improved.

Phytosanitary suppliers often organise workshops and conferences but only about their products for the technical staff and vine growers who buy their products.

In Galicia the innovation has been based on the equipment purchase and the technological modernisation in wineries over the 90’s decade. It is a traditional sector but very dynamic and open to new initiatives. In this sense, the innovation is conducted internally with own knowledge but only in big wineries. Collaborations are difficult, especially with the university or the researches centers. It is a sector very focused in the market and the sales. Only some big companies carried out R&D projects funded by public grants at regional or national level.

In La Rioja region there are over 16.706 vine growers and about 61,840 hectares dedicated to vineyards and a production of 368,42Mkg.

The wine sector is very important in the region in economic terms. Rioja is the most important wine region in Spain and it is internationally well known.

About the vine growers’ profile, their average age, as in the Galician region, is also quite high, and there is an important problem of generational renewal. However their qualification level is medium-high and their professionalisation level is high in to the case of important owners, but even in the case of complementary activity, the technical qualification is quite high. In most cases vineyard management is a complementary activity, but there is a large number of medium-big owners for whom wine production is a full-time activity.

Traditionally, the vineyard belonged to small vine growers who provided grapes or wine to large wineries. In figures, over 70% of the vineyard plots are between 0.25 and 2 ha and only 7% are plots of more than 5 hectares.

In recent years large wineries have started to buy their own vineyards. Nowadays, in Rioja, large wineries which have their own vineyards or buy grapes or wine coexist with "*cosecheros*" (small-scale wine producers)

In Rioja every winegrower is enrolled in the Regulatory Council of DOC (it is compulsory). Approximately, a 40% are associated in Cooperative Companies, and a large number belongs to agricultural trade unions. The most important organisation is the Regulatory Council of DOC, although they don’t organise informative activities about viticulture issues. Trade unions and, especially, cooperative companies occasionally organise activities regarding this matter.

Normally the vineyards are managed by the vine growers themselves, although they sometimes follow the guidelines set by the technical services of wineries to which they supply. Sometimes, services of independent consultants are also used, and even the guidelines set in a free way by the Public Administration.

Phytosanitary suppliers, in addition to their role as suppliers, act in most cases as consultants for vine growers, and some of them regularly organise informative workshops for the general public.

Innovation is important in the winegrowing sector of Rioja, because of its importance in the regional economy, and due to the competition. Innovations are implemented mainly by some wineries and technology providers, though all the agents are involved.

funded by European Commission

3. Which are main gaps, bottlenecks and lock-ins influencing knowledge exchange, outreach and trust of end users (vine-growers)? Identification and description of the problems and failures in exchange of knowledge.

Based on the experience of the experts and the conclusions from section 2, we will be able to extract the main gaps and problems in training and exchange of knowledge in the viticulture sector to get the attention and trust of practitioners and vine-growers about findings, advances and new practices (taking in account mainly the regions involved in this mini-paper).

Bulgarian case: The exchange of knowledge in viticulture issues is not efficient in Bulgaria and it has not solved common problems of the vine growers. The main reason is the lack of effective transfer of knowledge from research to test and apply its results in practical recommendations.

To bridge the gap that makes exchange of knowledge not effective in Bulgaria, the effectiveness of the exchange of knowledge (in both directions) in every link of the chain research-education- repository government administration-farmers should be improved.

Regarding the vine growers` perception of research results and how they could implement them in their daily work, sometimes they are not able to introduce findings, because of the small-scale profile of the most of the vine growers, their possibilities and ability to read scientific articles and its results, as well as cost of innovation products and technologies.

In addition, ways need to be found to promote the interests of the scientists to be involved in more joint activities with the end users.

Further practical training and clear practical demonstrations are needed for the end users because there are no "agents" to do this without any kind of support. There is also a lack of sufficient small and middle scale European and local project calls promoting these innovations.

Croatian case: The biggest problem is that there is a big gap between farmers and scientists. Scientists end experts should be more involved with farmers, but farmers should be more open-minded to new approaches. Other problems related to the exchange of knowledge looking for practical solutions is the lack of examples in practice, and expert people in the field that would stimulate development. In Croatia currently only the private sector can provide such training in the field. There is also a problem that farmers do not see or do not believe in the final benefit of new approaches, so scientists should focus more on demonstrating these types of benefits, with clear implementation of new technologies. Older vine growers tend to wait for instructions from the government institutions; meanwhile the rest of vine growers who live from agriculture are willing to pay for the changes that will give good results of their work. Also the focus of training should be addressed on few topics, not too many so farmers can adapt. Training must be financially accessible to farmers, and adjusted with regard to the age and current knowledge. More support for projects and trainings that will link scientists with farmers should be considered.

Italian case: Researchers often encounter difficulties in finding vineyards, farms or areas where to test and apply their findings. For instance in Italy, while in some EU Countries it is already a consolidated practice, researchers are experiencing a lack of dedicated farms for demonstration of the innovative techniques and tools.

Austrian case: Austrian case: Currently, in Austria, the younger vine growers are interested in the exchange of knowledge; however the elderly have difficulties in sharing their own experiences.

There is the perception that young vine growers trust results coming from recent scientific advances and that it is easy for them to implement these results in their daily routine in the vineyard.

In Austria the graduate associations of the schools offer further training courses which are also accepted.

In the opposite direction of knowledge exchange, there is a stream bottom-up from end users to the scientific community. The younger vine growers form communities in which they solve problems together and organise expert trainings themselves.

Spanish case: Regarding knowledge exchange issues, both regions presented in the previous section have more or less the same problems, so below the global vision for both regions and for the Spanish viticulture sector as a whole will be presented.

funded by European Commission

As in the other countries discussed, in Spain, the transfer of knowledge in viticulture issues is not too efficient. Vine growers do not have access to innovative results to solve common problems in their daily work; although these problems probably have been tackled by the scientific community.

Once again the main reason is the lack of effective exchange of knowledge between research and vine growers` practice.

Sometimes researchers focus their effort and research to obtain results and publish them, but not in order to make them practical and easily transferable to the field, and ready to apply these results in practical recommendations.

On the other hand it is common that the research community does not work in the main problems of the sector which are the main concern of end-user. Also it is a fact that it is not easy to involve vine growers interested in the exchange of knowledge and to participate in to promote ideas bottom-up. Probably the reason could be the lack of trust from end users in the research and the possibility to carry out innovations in their vineyards through the implementation of research results.

In Spain as in other European countries there are several regional and national research centres as well universities involved in vine with important prestige worldwide and exceptional research results. But the problem is that these research results regarding are not well connected with the productive sector neither trying to know their real needs nor transferring their results.

The main gap in knowledge exchange is a lack of efficient and effective intermediate agents to connect research results with the sector and to determine and share how to implement them in a practical way. And in cases when there are transfer agents they are not specific for viticulture issues and they are multi-sector transfer agents; as a result the transfer is not efficient.

It is common that the transfer tools used are limited to workshops or conferences, where researchers present their results, but not in a practical or useful way for the technical advisers and even less for the end users such as vine growers.

To bridge this gap, more viticultural technicians or advisers, who know the real problems of their region well, should be involved in knowledge exchange because they are the most efficient agents to spread innovation. For their work to be successful, demonstration fields and tools are also needed.

More multi- actor meetings are needed to make sure that the real needs of the end users such as vine growers will be addressed by the scientific community. This is also the best way to convince the practitioners, advisers and vine growers that they have an essential role in knowledge exchange to make the viticulture sector more sustainable.

4. Which are the main lacks of knowledge which could be solved through implementing tools and innovative strategies of transfer: focusing on the needs of vine-growers regarding pest and disease management, looking at the vineyard as a whole (integrated management system)

Several actions were identified that could help the end users in their daily work, and improve the impact of innovations in the vine sector and therefore on the resilience, provided that the vine growers would be involved correctly.

Some of these solutions were addressed in the first Focus Group meeting: varieties more adapted to local conditions; site-specific adaptation of epidemiological models; take care of, respect and promote biodiversity; balance between canopy, grape production and quality; planning before planting…

From the point of view of the experts involved in this mini-paper lack of knowledge and their effective implementation sometimes is due to the long period of vine growth, where growers need to wait several years to see final results. Another big problem is inadequate exchange of knowledge as well as resistance of farmers to new ideas and solutions. Some experts are convinced that only conversations that involve vine growers, their experiences and mistakes, and research outside buildings (near the field application) can give results in short or midterm.

But these problems regarding exchange and connection between multi-actors involved in chain value could be easily solved by improving the efficiency and working on innovative strategies of exchange.

We collected some concrete ideas from these FG experts that could improve the practical work of vine growers by improving the ways that knowledge is exchanged:

There are several easy recommendations regarding viticultural practices that sometimes are not clear for end users because there are different opinions from scientific community, agricultural officers, phytosanitary suppliers… for example, two very simple needs and common practices which are often not clear how to carry out while their real impact should be immediate: disinfection of scissors after every pruned plant as a prevention measure against spread of crown gall disease (*Agrobacterium vitis*) and protection treatment of plant pruning wounds with BCA´s (such as *Trichoderma sp.* or other suitable biological control agents).

On other occasions, problems come faster than solutions, even when there are previous experiences about this issue in other vineyard regions. As example, the *Flavescence dorée* disease in Croatia, which is already present, while wine growers do not yet have much knowledge about this disease. Some vine growers do not even report about this disease so as to avoid the Government cutting their vineyards. This situation is alarming because these infected vineyards are a source of new disease for other vineyards. There is obviously space for more training and informing growers about this problem and the Government should find ways to reimburse growers whose vineyards are affected by this disease. This example could be comparable to other threats, pests and diseases such as Grapevine Pinot gris Virus (GPGV) or *Xylella fastidiosa*.

Other problems are not new, but the sector is not sufficiently concerned about them. As example, the inadequate use of phytosanitary products, lack of clear information about the dosage, and how and when to spray… This has a direct impact on grape production, vine growers` revenues and the environment. It justifies a bigger effort to improve the way phytosanitary products are used. This is a big problem with older farmers but in some areas also with young farmers who have not been well trained. Wineries will buy grapes which have been treated with too much pesticides and they will have big problems throughout the wine-making process, and it is often very hard to find out which grapes caused the problem because farmers have very small areas and small quantities of grapes which are usually mixed with other vine growers` grapes. This is a serious threat to wine traceability.

We have discussed that it is necessary improve sharing of information and knowledge regarding simple practices, which are sometimes insufficiently clear, new and unknown threats, at least in some areas, or common practices with a big negative impact on viticulture of which the end users are insufficiently aware. But probably, we would also need to add more complex ideas which are more difficult to discuss and exchange, but which can have a big impact. These ideas include thinking of the vineyard as a complex productive system and as part of a whole ecosystem. It is important to keep in mind that it is necessary to move viticulture practices in the right direction, trying to improve the respect for the environment, the sustainability of the productive sector and its resilience. These concepts are more difficult to introduce, and more difficult for the sector to implement and to change their common practices. Once again demonstration and practical training will be necessary, as an important part of the exchange of knowledge.

Finally, vine growers, vineyard and winery managers, advisers should be involved in finding possible solutions in terms of exchange of knowledge. In fact, in some regions where younger vine growers have an open mind to new research, they have less problems to implement innovative results and practices and to promote ideas to the research community, and this is reflected in better results every year. We need to use these examples to show them to vine growers with less trust in innovative results or from other regions with less access to these types of results. Also, the cooperation between vine growers must be improved, and it should be promoted that young or less-experienced wine makers gain knowledge from older and more-experienced vine growers.

funded by European Commission

5. Identification of innovative methods to improve the exchange of knowledge and impact on vine-growers: Some ideas about innovative projects, best practices, and practical solutions to bridge the gaps

The contributions in this section of this minipaper, were created together by some experts involved in this FG, to find new proposals for training methods, practical demonstrations or specific educational tools about some topics identified as main lacks of knowledge related to increasing the resilience of grape vines to pests and diseases and how they could be implemented. Some interesting reflections and ideas proposed on the topic of this FG, pests and diseases, were:

Some innovative or good practices in pest and disease management as well as their results and effects in the vineyard need to demonstrated in practice to be convincing. With this aim **demo-farms** could be a possible solution where the innovative approach is shown in its complete implementation. These demo farms can also serve to bring together different actors involved in the exchange of knowledge: **for researchers**, who can apply the results from research on a large scale basis, **and for growers**, who can see the practical applications of the most recent innovation, it is a good way to let vine-growers improve and broaden their knowledge on good practices in pests and diseases management, and learn how to use them and start trusting them.

A good example is the demo farm Res Uvae that was recently created by Horta (https://www.horta-srl.it/sito/en/) a spin-off company of the Università del Sacro Cuore (https://www.unicatt.it/). It was set up to apply and show to growers, advisers and stakeholders the most advanced innovations in terms of sustainable management of vineyards such as scheduling fungicide applications on the basis of information provided by a Decision Support System, applying fertirrigation, managing the soil against erosion and conserving organic matter. All these techniques and tools are used during the season and demonstrated during specific events to the interested growers: for instance, over two seasons more than 400 people were involved in such demonstrations.

Regarding demonstration farms, the PLAID project "Peer-to-peer Learning: Accessing Innovation through Demonstration" (https://www.plaid-h2020.eu/) is especially relevant. It is a European Union funded project under Horizon 2020, which has been designed to encourage farmers and farm employees to embrace innovations in agriculture, leading to a greater sustainability of European Agriculture, by accessing high quality demonstration activities on commercial farms.

Figure 1: Demo farm Res Uvae - Horta

During the FG meetings, the need was also identified **to promote activities of exchange of "innovative" or simply "good practices" among actors**, because sometimes the gap in an effective management of any pest or diseases does not come from a lack of solutions or knowledge, since in some vineyards/farms they are well-managed. Thus sharing experiences among actors at similar level (growers to growers, advisers to advisers...) seems to be a good practice to spread the solutions and increase their impact, because **peer to peer knowledge exchange tends to increase the trust** in the solution if it comes from colleagues. So to sum up the idea: **"sharing knowledge and build trust".**

There were good examples with interesting results of initiatives or projects funded by the EC, such as the **Grundtvig Lifelong Learning Programme**, which from 2009 till 2012 allowed an **exchange of visits and**

funded by European Commission

experiences among groups of organic vine-growers from Italy, Germany, France, Switzerland and Spain. The programme set up 3 days visit programmes in the participating countries; in practice 2 visits per year took place during the 4 years of the project`s duration.

These activities allowed for a progressive improvement of the exchange. The opportunity to visit in turn each other`s farms was highly appreciated as it allowed showing the implementation of what was exchanged in the previous visits. What was highly appreciated was the practical approach and the peer to peer learning opportunity and even if some lectures or some visits of academic or research institutions were included in the tour, the main learning channel was the colleagues` experience and opinion. The overall cost was limited but the impact was very significant and some participants are still in contact.

Still, it is very difficult to maintain these types of initiatives in a sustainable way; in this case the initiative stopped due to the change in the EU programmes.

(More info: **https://eacea.ec.europa.eu/homepage_en**)

In Galicia (Spain), the regional government establishes **grants that fund various types of training, transfer and exchange activities organised by public or private entities** for the agricultural and forestry sectors, which can fit perfectly to cover some specific gaps of training and good practices exchange of the vine sector previously identified.

The activities funded are: demonstration activities and information actions lasting between 5 and 20 hours including visits, stays or exchanges of up to 1 month of duration and visits of up to 5 days to vineyards/farms (More info: **www.xunta.gal/dog/Publicados/2017/20170109/AnuncioG0426-261216-0004_es.html**)

Filling some gaps in the needs for training and culture building, that could be facilitated by a peer to peer exchange, where demonstration and interaction are central elements, are clearly necessary. Maybe through this funding model and taking advantage of the experience of previous initiatives such as the Grundtvig project, these training and demonstration activities could be upscaled at European level. Using public money (i.e. RDP) for implementation of these innovative methods of exchange or pilot farms as demonstration plots (*why not implement changes in policy guidelines to try to turn the common problem of vineyard abandonment into an opportunity to build a network of demonstration plots?*), and then spreading the model through the Rural Development Networks could assure a great impact in terms of spread in the vine-growing areas and maintenance in the mid & long-term.

Following a similar approach, FG experts agree that in these demonstration activities the importance of involving **key/leader farmers** should be considered (sometimes the big farms/wineries, but not always) and that also **"good" advisers**, are very important, and may be seen as **"lighthouses"** to change the perspective for all the other farmers/vine growers leading to a wide uptake and impact of the solutions.

There are several examples of the impact of these actors as "lighthouses" to become in the best demonstrators of the results of innovative and good practices in management of pests and diseases. One example could be the demonstration plot Pé Redondo of the Martín Códax cooperative winery in Galicia, where a 12ha experimental plot helps to spread the results of their innovative solutions not only to the vine-growers of the cooperative, but also to other cooperatives and vine growers of the region. Sharing not only demonstration, also building trust in the practices, it has permitted to shift the approach from "solving a pest/disease attack" to a "systems approach", testing at local level several tools or DSS (Decision Support System). These experiences have also increased local cooperation to solve common problems. A good example is for instance the Atlantic vineyards project, where the three biggest cooperatives "have cooperated" to improve a DSS tool on downy mildew management, with high success and impact in changing the common practices of spraying by calendar (**http://vinasatlanticas.depo.es/**)

Related to commercial farms that engage in demonstration activities, the AgriDemo-F2F project is noteworthy (**https://agridemo-h2020.eu/**). This project enhances peer-to-peer learning within the commercial farming community. The project utilises the experience of different actors and involves practitioner partners throughout the project to deepen understanding of effective on farm demonstration activities (multi-actor approach).

funded by European Commission

Figure 2: Pé Redondo vineyard an experimental and demonstration plot in the Salnés valley, Galicia

Another interesting way to improve the capacity building and training on vineyard management, and also specifically on pest and disease issues, could be developing **innovative training and demonstration practices related to specific issues** of vine production and sustainability through learning materials combined with practical training. This should allow the training to be time-flexible so vine growers could choose their own timeline, and it would be combined with practical demonstrations.

For example, an innovative training course has been developed under Erasmus + funds. Its name is PAThOGEN (**http://www.pathogen-project.eu/nqcontent.cfm?a_id=13020**) course, focusing on grapevine viruses and confronting the problem of viruses in the vine sector through education and demonstration, combining e-learning courses with field sessions. The most innovative feature of this project was the "demand-driven approach" adopted in the conception of the training (methodology, e-learning platform, training tools and contents...). PAThOGEN has achieved this by engaging partners with different profiles (multi-actor approach) throughout the whole life cycle of the project: from implementation phase of the methodology, through the building of the e-learning platform and development of the training content, until the final assessment with real-pilot-courses where more than 120 trainees tested PAThOGEN courses. This helped to assure that the contents and training were adapted to the target trainees such as farmers, advisers (there are several levels of training) and addressed the main problems and goals of this issue. Each training course was translated to the local language of each vine region and some adaptations to specific practices, local and legal specifications were necessary. The contents can also be updated regularly following future knowledge advances and development. As a result of this work, the PAThOGEN courses are now being exploited in common by PAThOGEN partners, therefore, the cooperation of this consortium is continuing after the Erasmus + funding period, achieving the challenge of a marketable training product which fills the worldwide training gap in this specific subject.. Once this methodology will prove successful in the virus topic, it could be developed for other pests and diseases.

Figure 3: PAThOGEN training in viruses combining e-learning contents with field training sessions

During their discussions, the members of the FG also highlighted that often different countries have made the same or similar mistakes throughout the evolution and maturation process of the sector. For example, the importance of conserving the local varieties (avoiding genetic erosion motivated by the massive spread of the most common "commercial" varieties) seems to be clear, but we found that frequently in different areas and countries not much attention has been paid to this. When the sector finally became aware of the problem, they had already lost a huge diversity and wealth of their local varieties. This has happened several years ago in some areas and it was identified as a severe problem, but this is still happening in the development of new wine areas in some countries with less viticulture tradition or experience. To avoid these kind of problems, **exchange of knowledge and collaborative actions among countries, at policymaking level** could give good results. Several projects with this aim were carried out in the past, such as the Twinning Projects for EU Enlargement. Some examples carried out with the support of Spanish partners: *Harmonization of legislation and strengthening the capacity to manage the aquis on wine in Romania (RO2000/IB/AG/04) 2002-2004, Support to further strengthening the wine sub-sector of Romania (RO2004/IB/AG 08) 2005-2007, Capacity building for the regulation of the Serbian wine sector (SR2005/IB/AG/03) 2004-2007*

In addition to the different activities discussed above dealing with education, training, demonstration, knowledge and good practices should be also permanently available to the end users to consult and take into account in their daily practice. For this objective it is very important to find the appropriate channels and formats for the materials to share the knowledge, in a way that will fit the end user needs. They must be clear, easy and ready to use. We must also be aware that different tools for the exchange of knowledge must take into account that some vine growers have limitations in the use of IT tools. So, similar contents must be available in different formats, and through different channels. (Print-out materials, videos, mobile applications, YouTube videos…)

Following this idea the Thematic Network WINETWORK (http://www.winetwork.eu/), funded by the H2020 programme, proposed several innovative paths and tools to transfer the results about best practices collected around Europe (Highlighting the important work carried out under the multi-actor approach and following an innovative methodology to finding and exchange innovative practices) to face two of the most important threats of the European vine sector: the Grapevine trunk diseases and Flavescence dorée. As result of this project important and diverse tools and a range of materials (end user fliers, training modules, technical data sheets, technical articles, video seminars, presentations…) were made available to the end users. In addition, a common space, called knowledge reservoir, was created with the ambition to host all worldwide existing knowledge on the topics, both developed by research or derived from practical experience. All stakeholders – such as scientists, advisers or vine growers – who would like to share their documented knowledge can contribute to this web archive by uploading their videos, images and documents in the site (More info: http://www.winetwork-data.eu/en/gb/default.asp#)

We would like to highlight another good example related to the importance of materials and demonstration channels, which shows how new technologies may be used to foster knowledge exchange and uptake of innovative practices, at least for those vine growers whose feel comfortable in using them. The example is a demonstration video showing biological control of *Panococcus ficus*. This video was developed by the Department of Agriculture Food and Environment (DAFE) of the University of Pisa, Italy: https://www.youtube.com/watch?v=ILa2ZawSBHc

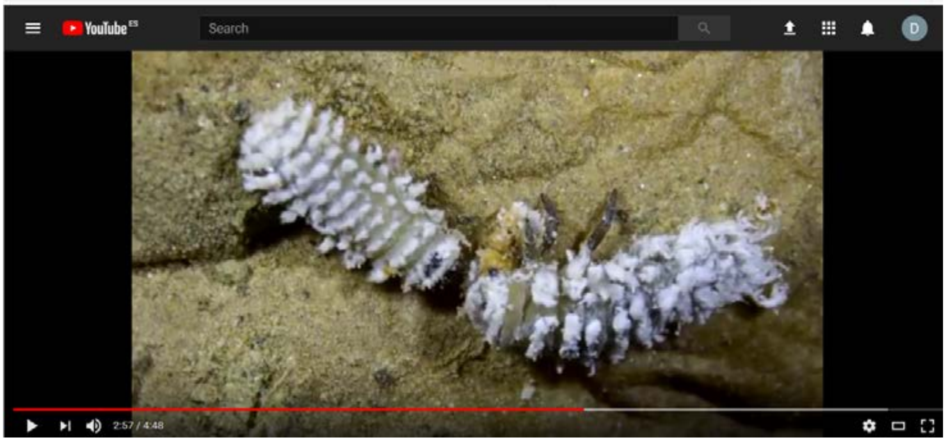

Figure 4: PAThOGEN training in viruses combining e-learning contents with field training sessions

So far, we have discussed different ways to learn and get knowledge about specific practices and recommendations in pest and disease management, but we should not forget that more deep and wide education and training may be necessary for different profiles of vine growers, sometimes to refresh or update their knowledge (e.g. of experienced farmers/vine growers) or to teach new skills (e.g. to young farmers).

To reach this objective the FG agreed that summer-schools and/or seasonal modules of education throughout the year-cycle of the vine could close the important gap in education and training that exists in some regions or countries where the viticulture sector is less professionalised, probably because vine growers did not have access to relevant education in their activity as vine growers.

This type of summer or seasonal school should directly address the common practices in vineyard management (also related to pests and diseases) in depth, and in a practical way. It is fundamental to adapt the training periods to the vine growers` times and availability and allow them to combine their professional activity as a farmer/vine grower with their education.

In this type of education, and coming back to the idea that the vine grower profile is diverse, with different interests and capabilities, we should think about the possibility of set up different types of summer or seasonal schools adapted to this diversity.

We could think of one model of school for older farmers, where practical training should predominate, held by experts who understand their challenges and needs, and who know how to focus the teaching to demonstrate the economic benefits that they can get by improving their common practices to manage pests and diseases. However, for younger farmers it could be proposed to complement the in-person training with the exchange of knowledge through some type of online platform, even at national or European level. In this model of school the main interest should not only be to demonstrate the economic benefits. It should also highlight other important benefits that they can get by improving their practices, thinking about pest and disease management in a holistic way, taking into account aspects such as organic farming, environmental protection, sustainability and much more.

6. Research needs

Research is needed about the main problems that must be dealt with by researchers but it is important to open calls at different levels to encourage all the agents to participate in exchange of knowledge. This is needed for all the actors involved in the value chain of the vine-sector in general, and specifically for questions on sustainable ways to deal with pests and diseases in viticulture.

Public funds can help to catalyse the development of these methodological and innovative approaches, and the contents for the training as well as some first actions to foster exchange of knowledge. In the future these activities could be maintained and further developed by different actors from public bodies and private companies, and also be paid by marketing incomes and maybe subscriptions paid by farmers. This business model would assure the quality of exchange and training actions to survive in the future.

References

Plaid project: *www.plaid-h2020.eu/projectoverview*

AgriDemoF2F project: *https://agridemo-h2020.eu/*

The Analytical Framework Demonstration Farms as Multi-Purpose Structures, providing Multi-Functional Processes to enhance Peer-to-Peer Learning in the context of innovation for Sustainable Agriculture: *https://agridemo-h2020.eu/docs/Rapport_AGRIDEMO_analytical%20framework.pdf*

BMEL (Federal Ministry of Food and Agriculture), 2016. Demonstration Farms for Integrated Pest Management: *www.nap-pflanzenschutz.de/en/practice/demonstration-farms*

Farmer field schools: From agricultural extension to adult education *- Waddington, H., White, H. and Anderson, J., 2014.*

ENDURE: *www.endure-network.eu/endure*

ENDURE IPM Training Guide: *www.endure-network.eu/content/download/5806/44460/file/IPM%20Training%20Guide%20Introduction.pdf*

Training in Integrated Pest Management Number One: Using experience groups to share knowledge and reduce pesticide use: *www.endure-network.eu/content/download/5016/40751/file/Number%20One%20-%20Using%20experience%20groups%20to%20share%20knowledge%20and%20reduce%20pesticide%20use.pdf*

Training in Integrated Pest Management – Participatory IPM training - principles, methods and experiences: *www.endure-network.eu/content/download/5223/41856/file/Number%20Two%20-%20Participatory%20training%20-%20principles,%20methods%20and%20experiences.pdf*

AgriSpin Network: *https://agrispin.eu/about/*

Innovative farmers: *www.innovativefarmers.org/*

Innov'Action: *www.innovaction-agriculture.fr/*

INNOVINE project: *http://www.innovine.eu/home.html*

PROMESSING project: *www.promessing.eu/*

WINETWORK Network: *www.winetwork.eu*

BIODIVINE project: *www.biodivine.eu*

PAThOGEN training: *www.pathogen-project.eu/nqcontent.cfm?a_id=13020*

TOPPS project: *www.topps-life.org/*

ATLANTIC VINEYARDS project: *http://vinasatlanticas.depo.es/web/vinas-atlanticas/home*

LIFEAGROINTEGRA project: *www.agrointegra.eu/en/*

Grundtvig Programme: https://eacea.ec.europa.eu/homepage_en

Stakeholder Engagement Handbook: *www.biodiversa.org/702*

Bioland: *www.biodiversa.org/702*

EIP-AGRI Focus Group

Disease and pests in viticulture

MINIPAPER: How can winter pruning practices help to reduce the impact of Grapevine Trunk Diseases

Julián Palacios Muruzábal*, Luis Gonzaga Santesteban*, Anett Csikós, Daniela Popescu, Stéphane Compant, Essaid Ait Barka, Cecilia Rego, Ivan Tsvetkov

1. Introduction

Modern vineyards hardly reach the longevity that used to be common for vineyards, and this is a serious concern for grape growers and winemakers. The reason behind this early decline is mainly linked to the presence of several fungi that, as a whole, are designated as grapevine trunk diseases (GTDs). However, GTDs have been present in vineyards for a long time, and some, such as esca, have been known for a long time, and are quoted in every treatise on viticulture written in the early 20th century around Europe (Brizi (1919) in Italy, Arnaud & Arnaud (1931) in France). Due to their increased incidence during the last two-three decades, much effort has been made to understand these diseases, learning which fungi are associated to each (about 100 species described), their interaction and their biology. Critical points for infection have also been studied, and relevant advances obtained. However, one of the main questions remains unsolved: why has GTD prevalence and severity increased so much in such a short time-span? Some growers point to the ban on the use of sodium arsenite as an agent to limit disease development, but the response to this question is probably much more complex. Many experts consider that the severity of GTDs is related to the dramatic changes experienced in viticulture during the last decades: mechanisation, cultural practices for increased productivity, using plants massively propagated in nurseries, bad pruning practices.

The main challenge is to widen the focus of research, going beyond the study of fungi, applying a holistic approach, learning how cultural practices, plant material and environmental conditions affect GTD presence and severity. It is necessary to remember that plants behave as an ecosystem, where there is an equilibrium between the plant and microorganisms. In fact, most endophytic microorganisms coexist in a harmonious way with grapevines, and only few of them under some circumstances affect them negatively (Stone et al. 2004).

Below, some key points on how pruning can contribute to improving vineyard resilience in the face of GTDs are detailed, and these can constitute a very valuable tool to minimise the impact of these diseases on vineyard productivity and longevity.

Winter pruning as a key factor to control GTDs

Fungal spores are known to be spread mainly by wind and rain, although arthropods and pruning tools can occasionally act as vectors, and pruning wounds are the main route for infection (OIV, 2016; Gramaje & Armengol, 2011). Moreover, pruning wood and dead grapevines are the main reservoir of spores, so a correct management of pruning, pruning wastes and dead vines plays a crucial role in GTD management.

b.1. Pruning wounds, sap preferential paths

First of all, growers need to know that the way they perform pruning and the way they treat the pruning wounds will highly determine the risk of infection by GTDs and damage of the vine vascular system. When we inflict a pruning wound to any part of the grapevine (shoot, spur, arm or trunk), the plant protects itself by healing the wound following an inwards cone-like pattern. The depth of the desiccation cone is proportional to the width of the pruning wound, and cones can be easily seen when wood is cut (Figure 1). Sap cannot flow through the desiccated area, as that area becomes dead matter. Therefore, pruning wounds should respect as long a distance in wood as possible (Figure 2). Thus, pruning should not imply aggressive cutting, especially avoiding pruning wounds close to the base of spurs or canes, arms or trunk, contrary to what is frequently observed in the field.

Pruning wounds are the main infection entrance for GTDs, and they are known to remain receptive for infection for a long time after pruning (Luque et al 2014). Greater attention needs to be paid to rapidly protecting wounds once pruning is done to create a physical barrier between the wound and the potentially arriving spores (Fig 3). It is a relatively inexpensive practice, and needs to be adopted as a good practice by every grower in areas with prevalence of GTDs.

Preferential flow paths also need to be respected, allowing sap to follow a trajectory as straight as possible. Modern pruning systems have forgotten what was traditionally done in many areas for grapevine pruning. It was frequent practice that pruning cuts were always done on the same side of the trunk/arm, which guaranteed that the flux would not be interrupted along the trunk/arm. Research is needed to determine to which extent these practices contributed to reducing GTDs incidence.

b.2. Managing pruning wastes and dead plants

As spores mostly generate in diseased or dead plants within the field or in surrounding areas, it is critical to remove and eliminate these infection sources as soon as possible. Spores can also come from other woody crops, so attention needs to be paid to them as potential sources of contamination.

Figure 1: Desiccation cone in a pruning wound

Figure 3: Pruning wound protection

Figure 2: Example of badly performed pruning (top), not leaving the necessary protection length, in comparison to a correctly performed pruning (bottom)

funded by European Commission

References

Arnaud G. et M. Arnaud, 1931. Esca, Polypores et Maladies fongiques diverses du tronc. Pages 428-444 in: Traité de Pathologie Végétale - Encyclopédie Mycologique III, Lechevalier et Fils ed., Paris.

Brizi U., 1919. Malattie delle Piante Agrarie. Stabilimento Grafico Gustavo Modiani & C., Milano, Italy, 418 pp

Gramaje, D. y Armengol, J., 2011. Fungal trunk pathogens in the grapevine propagation process: potential inoculums sources, detection, identification, and management strategies. Plant Disease 95: 1040-1055

Luque, J., Elena, G., Garcia-Figueres, F., Reyes, J., Barrios, G., & Legorburu, F. J. (2014). Natural infections of pruning wounds by fungal trunk pathogens in mature grapevines in Catalonia (Northeast Spain). Australian Journal of Grape and Wine Research, 20(1), 134-143.

OIV, 2016. Grapevine Trunk Diseases. A review. http://www.oiv.int/public/medias/4650/trunk-diseases-oiv-2016.pdf

Stone J.K.; Polishook J.; White J.F., 2004 Endophytic fungi. In Biodiversity of Fungi. Mueller G.M. Bills G.F. & Forster M.S. (eds) Elsevier Academic Press.

funded by European Commission

EIP-AGRI Focus Group

Disease and pests in viticulture

MINIPAPER: SHARING NEEDS AND KNOWLEDGE PROMOTES IPM

Andrea Lucchi

INTRODUCTION

In plant protection, several efficient non-insecticide methods are available but they are often not used by stakeholders for lack of knowledge and trust.

Very often farm managers are aware of the existence of alternatives to pesticides but they don't know exactly the potency of a given means or strategy.

funded by European Commission

In the USA this gap is filled by University Extension Services, which support farmers in implementing innovative methods to deal with pests and diseases.

Trentino South Tyrol (Italy) hosts a good example of close cooperation between growers and research Institutions, which allowed IPM to be established in the Region. The driving force for IPM implementation was the adoption of pheromone mating disruption (MD) over the past 20 years. This strongly reduced insecticide use in the Region. Since the nineties, MD has been applied in an Area Wide approach against codling moth and leafrollers on apple crops and against vine moths in the vineyards. Although the mountainous terrain of the area was not optimal for the efficacy of MD, grower cooperatives and their field consultants were very influential in convincing growers to accept MD technology. Public research institutions conducted extensive research and education, and provided credible assessments of various MD formulations. Thus, the development and adoption of area-wide mating disruption in Trentino-South Tyrol resulted from the combination of several favourable factors, which brought together researchers, advisers, cooperatives, growers, pheromone distributors, and related industries.

Unfortunately, this success in Trentino-South Tyrol has not been replicated in the rest of Italy, due in part to the lack of cooperation between research institutes, industry, and growers.

Here we report on a recent cooperative pilot experience put in place in the wine growing area of Bolgheri (Tuscany), which originated from a close partnership between University and growers, for the management of 2 feared grapevine pests.

ENVIRONMENTAL CONDITIONS:

Region/Area: Bolgheri - Tuscany – Italy (DMS: 43.233982, 10.614802), one of Italy's most prestigious areas for the production of wines of top quality (http://www.wine-searcher.com/regions-bolgheri).
Climate: Mild climate with medium-high rainfall (400-800 mm per year on average)
Terrain/Soil: Mostly sandy soil

Figure 1: A detail of a vineyard in the area of Bolgheri (Livorno – Italy)

IDENTIFICATION AND DESCRIPTION OF THE MAIN PROBLEM RELATED TO THE TOPIC.

The Bolgheri vineyards have historically been affected by heavy infestations of the European Grapevine Moth (EGVM) *Lobesia botrana* (Lepidoptera, Tortricidae) and the Vine Mealy Bug (VMB) *Planococcus ficus* (Hemiptera Pseudococcidae).

Insecticide strategies generally adopted by growers included 2-3 sprayings per year against Lobesia with IGRs or organophosphates and 1-2 treatments per year against *P. ficus* with systemic or neurotoxic insecticides).

Recently, one famous Winery located in Bolgheri, province of Livorno (Tuscany), asked for help to manage insect outbreaks.

Insecticides have been showing limited efficacy in the previous years, so that the manager would like to start adopting alternative and more sustainable strategies.

DESCRIPTION OF THE EXISTING BEST PRACTICES AND POSSIBLE SOLUTIONS TO SOLVE THE PROBLEM.

On our proposal the farm applied the Pheromone Mating disruption (MD) against *L. botrana* on one sixth (50 hectares) of the whole farm surface, to be able to compare the results obtained with the conventional insecticide strategy.

MD was applied with ShinEtsu Isonet L dispensers (Fig. 2) at a rate of about 500 units per hectare. The strategy for *P. ficus* included the release of two Biological Control Agents (BCAs), the Encyrtid parasitoid *Anagyrus vladimiri* in May (1,000 individuals per hectare on a total of 3.5 hectares) and the Coccinellid predator *Cryptolaemus montrouzieri* (about 500 individuals x hectare on a total of 4 hectares) in June and/or July (Fig. 3).

From the beginning, the management of the programme was in the hands of a technical working group (TWG) composed of University personnel and winery technicians. The monitoring of pest populations was carried out with pheromone traps and cluster sampling.

funded by European Commission

Figure 2: Dispenser Isonet L Shinetsu for mating disruption of L. botrana.

Field assessments were carried out both in MD and conventional vineyards with regard to EGVM and in the plots were BCAs were released.

Results were very promising: the farm did not spray against *Lobesia* in MD areas, with low infestation at harvest (less than 5% infested bunches), whereas they sprayed 2 times in the conventional areas, with a more limited efficacy.

Excellent results were obtained in the control of VMB too, so that other local farms joined the project: MD was then applied on about 300 hectares, and BCAs were efficiently released in new plots for a total of about 20 hectares.

Hence, the following year other farms joined the project; MD was applied on 700 hectares in Bolgheri area and BCAs were released on 400 hectares.

The substantial decrease in the amount of insecticides used, due to the implementation of MD and BCAs was perceived as the first major step forward:it improved the public perception that wine was produced with high environmental safety standards.

The action plan drastically reduced insect populations, so that other farms joined the programme and the area managed in IPM further increased this year (2017) (BCAs and MD on about 1,200 ha).

Figure 3: Anagyrus vladimiri female (top left), male (top right) and female during parasitizion of a mealy bug (bottom left). Adult of Cryptolaemus montrouzieri (bottom right).

KEYS OF SUCCESS

Sharing the problem: Limited efficacy of insecticides pushed growers to adopt alternative and more sustainable strategies;

Conditions: Vineyards were relatively young and well-managed;

Growers and technicians were well-trained and open to new experiences;

The University's support has been crucial to the success of the programme (see video at: **https://www.youtube.com/watch?v=ILa2ZawSBHc**).

Lesson learned: We believe that substantial increases in IPM implementation are possible in Italian vineyards, if interest among research scientists in promoting and transferring existing knowledge can be cultivated. Scientists must play a leading role in engaging all groups of stakeholders to work together towards a common goal, which probably has been the most important factor in the success achieved in this project.

EIP-AGRI Focus Group

Diseases and pests in viticulture

MINIPAPER: Strategies for a better use of copper-based fungicides in organic viticulture

Tito Caffi

funded by European Commission

Introduction

Copper-based fungicides are nowadays the most important fungicide in organic viticulture, mainly used to control downy mildew, but also, indirectly, other diseases such as black rot or phomopsis cane and leaf spot. Nevertheless, due to the long-term use and runoff from sprayed plants copper accumulation in soils is a risk, with the related environmental problems. Recently the European Commission confirmed the copper-based compounds as candidates for substitution (Reg. CE 2018/1981) and the European regulation on organic farming was just adjusted to a maximum limit of 4 kg Cu/ha per year with the possibility to choose for a cumulative maximum of 28 kg Cu/ha per 7 years (Reg. CE 354/2014). In some countries (e.g. Netherlands, Denmark), copper use in agriculture is forbidden, and in other countries there is a lower quantitative limit. Further quantitative limitations in the organic legislation are likely for the future and probably also for conventional viticulture, as EFSA is strongly supporting a copper ban or at least a strong reduction in use. On the other hand there are no real alternatives to copper that can completely replace it, despite many years of research at National and European level. Farmers and advisers engaged in the attempt to reduce copper use and even to avoid it when possible, for example in seasons with a low pathogen pressure, agreed that the most efficient way to manage grapevine pathogens successfully is to create, and progressively implement, an overall strategy to deal with them. This would also help in difficult years and in a changing climate. The elements of a successful strategy are very close to the elements of an Integrated Pest Management (IPM) strategy:

- choice of vineyard location;
- selection of varieties (different resistance/tolerance against downy mildew);
- rational management of fertilisation, trellis and pruning;
- use of monitoring systems and Decision Support Systems for timely intervention;
- choice of copper-based fungicides according to specific need;
- choice of appropriate sprayers, proper dose of fungicides and proper volume of water for each application.

funded by European Commission

A more efficient and timely use of copper is needed

Up to the beginning of the new millennium, *Plasmopara viticola* oospores were considered to be only important for initiating the disease early in the grapevine vegetative season, but not for subsequent disease development. A combination of research on epidemiology and population genetics has substantially altered our understanding of downy mildew epidemics (Rossi et al., 2012). Relationships between *P. viticola* and weather conditions are complex and have been studied extensively, showing that the risk of *P. viticola* infection and downy mildew epidemics is closely related to the weather conditions occurring before budbreak and during the grapevine-growing season. Variation in weather conditions is the main driver of variability in the severity of downy mildew among locations and years; for this reason, grapevine downy mildew is considered a case-study for evaluating the impact of climate change on plant diseases.

The influence of weather on downy mildew has been incorporated in mathematical models that are used to evaluate disease risk and to support decision-making in crop protection. Use of weather-driven, mathematical models is a key element of Integrated Pest Management (IPM) as stated in the Directive 128/2009 of the European Commission on the Sustainable Use of Pesticides. The results of a study on the effect of year-to-year variation of weather conditions on the dynamics of downy mildew epidemics on grapevine carried out on three sites in northern, central, and southern Italy for a 3-year-period, confirmed that there is great variability in downy mildew epidemics among areas and years, a variability that is closely related to the variability in weather conditions. The results also showed that severe epidemics can occur in areas where the disease has not been traditionally considered a key problem. This means that decisions about the use of plant protection products must be based on local conditions, disease monitoring, and risk assessment rather than on the calendar or on traditional practice (Caffi et al., 2014).

With the quality enhancement and computing power offered by computers and laptops, models have been consistently incorporated in decision support systems (DSSs), tools that assist users in tactical and operational decision-making in crop protection. Models can also be part of disease warning systems at local level (Rossi et al., 2012). In the past, DSSs have contributed little to practical agriculture because of the so-called 'problem of implementation', i.e., because of the ''lack of sustained use in a way that influences practice'' (Rossi et al., 2012). Nevertheless, a new DSS, named vite.net®, was developed by the Università Cattolica del Sacro Cuore (Piacenza, Italy) for sustainable management of vineyards and it is intended for the vineyard manager. The DSS was experimentally evaluated by researchers and practically evaluated by farmers in 21 farms across Italy, which were either organic, or in transition from conventional to organic. In these organic farms disease control and control costs were compared in those parts of the vineyards managed using the DSS vs those parts managed according to the usual practice over two seasons with low (2011) and high (2012) downy mildew severity in untreated plots. In both years, disease control obtained using vite.net® was not statistically different from that obtained with the usual farm practice, but vite.net® reduced the total amount of copper applied by an average of 37% because of both reduced doses and fewer applications; the DSS reduced the number of applications by an average of 24%. The use of vite.net® in organic farming saved the growers an average of 195 €/ha/year relative to the usual farm practice. (Rossi et al., 2014). These results were obtained when the copper limit was 6 kg/ha/year showing that a satisfactory downy mildew control can also be obtained with a low amount of copper per hectare per season.

Do we already know everything about copper properties and characteristics?

Control of grapevine downy mildew requires fungicide application and the optimisation of fungicide application requires knowledge of the physical mode of action (PhMoA) of each fungicide. PhMoA describes the effect of a fungicide with respect to the time of its application relative to the host-pathogen interaction (e.g., pre- or post-infection) and the duration and degree of fungicide activity. A work was recently carried out to characterise the PhMoAs of different copper-based fungicides formulated as water dispersable granules which release copper ions gradually (Caffi et al., 2012). One tested fungicide contained copper oxychloride and hydroxide (both at 14%), and another one contained only copper oxychloride (37.5%) in order to consider two different types of formulation: the former more ready-to-use copper ions, the latter with a slower release of active ingredients. Both fungicides were tested in a controlled environment at 100, 75, and 50% of the label dose and both products provided 100% control of infection, although efficacy differed depending on dose and timing. Overall, infection control was greater for the product containing both copper salts. Neither product efficiently reduced sporulation. Product rainfastness was measured on potted grapevines, and a model was developed to predict rainfastness based on rain events and plant growth (Caffi et al., 2012).

Such type of information is crucial for better understanding when a downy mildew control treatment should be applied, the type and dosage of the copper-based product to be sprayed for controlling *P. viticola* infection.

A 'during-infection' use of copper fungicides was also tested (Caffi et al., 2016) in order to 'replicate' the same strategy adopted for apple scab management that has been proven to reduce the amount of fungicides used in organic orchards by 70 % (Jamar et al. 2008). The idea is that this approach helps to reduce both the number of treatments compared to a calendar-based application, and the use of systemic fungicides, which frequently have a high risk of resistance (Brent and Hollomon 2007). The post-inoculation efficacy of two different copper fungicides decreased rapidly as application time after inoculation increased, and it was <20 % after 6 h at the optimal temperature for *P. viticola* development (20 °C) (Caffi et al., 2016). This means that there is a certain effect of the copper also during the rain event, because the active ingredient is affecting the spreading propagules of the pathogen, but of course it cannot be applied too late (more than 6 h) after the end of the rainfall causing the downy mildew infection. Nonetheless, this information is relevant in a proper organic management of grapevine downy mildew disease. Information about PhMoA of different copper-based compounds are relevant to properly include them in disease control strategies and provide the growers with more efficient tools for controlling the disease.

A silver bullet as alternatives to copper does not exist (yet)

An alternative to classical chemical fungicides is represented by biofungicides, where the active ingredient is a microorganism (or its derivate) or a botanical extract (botanicals). In contrast to US legislation, the European Union does not distinguish between the synthetic or natural origin of active ingredients, which follow the same rules in the registration process (Reg. CE 1107/2009). In spite of major research efforts during the past few decades, no satisfactory alternatives to synthetic chemicals and copper have been found against *P. viticola* yet (Dagostin et al., 2011). The reason for this failure can be found in the nature of the pathogen and the conditions in which infection occurs. Indeed, *P. viticola* penetrates tissues through the stomata very rapidly and, without a highly effective preventative substance, after penetration only systemic active ingredients can partially stop the disease. In addition, a single infection in early phenological stages can entirely destroy bunches, resulting in extreme yield losses (Pertot et al., 2016). Laminarin and chitosan (Garde-Cerdán, 2017) and potassium bicarbonate, calcium chloride and hydroxide (Lukas et al., 2016) provided good experimental results under environmental controlled conditions and in preliminary trials, but further studies need to confirm their effectiveness against downy mildew infection in order to include them in disease control strategies.

On the other side, different commercial products, such as fertilisers, were developed with collateral effects such as inducing resistance against downy mildew infection. For instance, a mineral organic fertilizer containing glucose, oligosaccharide and reducing sugars was recently used to verify on grapevine cv Merlot the ability to induce resistance to downy mildew infections either by foliar application or irrigation (Bove et al., 2018). The tested product showed an average efficacy of 35% by foliar applications across all the phenological stages tested, but with a high variability. The average protection provided by irrigation treatment was lower, on average 25% with the same variability, but also with a higher efficacy in the first development stages of the host (Bove et al., 2018). In such a case, when the tested products provided interesting results even if they cannot provide a complete protection against *Plasmopara viticola* infections alone, they could be successfully integrated in disease control strategies in order to help classical fungicides, in particular phenological phases. It is crucial that such products are tested by third parties like universities and research centres in order to provide information about their physical mode of action and practical proposals for integration in disease control strategies to the growers.

funded by European Commission

Nonetheless it is important to keep in mind that downy mildew infections can be further reduced, and copper treatment efficiency increased, if accompanied by other agronomical practices, especially leaf and bunch thinning, allowing a better circulation of air inside the vineyard creating unfavourable conditions for the development of downy mildew (Kullay, 2017) and allowing the fungicides to reach the bottom side of the leaf and to efficiently cover all the vegetation surface.

Crop-adapted fungicide application can increase the efficacy of the treatment

A key point in fungicide application is represented by properly reaching the target with the fungicide suspension. This goal can be achieved with a broad spectrum of different machinery and quantity of water. Also, the amount of the active ingredient used (fully respecting labels and national laws) should be adapted to the increasing volume of canopy to be sprayed across the season. Grapevines have no leaves at the start of each growing season and abundant leaves at the end. Consequently, the leaf area to be treated increases considerably during the growing season, from nearly zero at bud burst to over 23,000 m^2 ha^{-1} at fruit set (Siegfried et al., 2007). It follows that the application of a fungicide at a fixed rate per hectare will over-treat early season foliage but under-treat late season foliage. Fungicide dosages must therefore be adjusted according to the leaf area at the time of application. Crop-adapted spray application makes it possible to obtain constant quantities of active ingredient per unit of leaf area throughout the growing season (Caffi and Rossi, 2018). The vine row volume (VRV), the leaf wall area (PWA), and the unit canopy growth (UCR) have all been used in the last decade to determine the optimal volume for spraying in vineyards based on achieving the optimal coverage (impacts cm^{-2}) according to the characteristics of the crop canopy. Researchers have also developed methods to modify the volume of spray applied based on the type of sprayer used, nozzle types and sizes, operational parameters, and weather conditions (Caffi and Rossi, 2018). Crop-adapted spraying reduces the quantity of fungicide applied while achieving disease control equivalent to traditional spraying (Gil et al., 2011).

Resistant varieties as a new arrow in the organic growers' quiver

Since the introduction of *P. viticola* in Europe in the XIX century, efforts in breeding American *Vitis* species with the European *V. vinifera* led to interspecific hybrids. The large use of pesticides in XX century reduced the demand for cultivars with resistance to *P. viticola*, decreasing the efforts in breeding for resistance. In the 1980's, the increasing interest in production systems less dependent on pesticides led to again increasing interest in resistant varieties (Gessler et al., 2011). In fact, the cultivation of these varieties has the potential to reduce the overall fungicide application in viticulture, since they require reduced chemical input compared to traditional varieties (Pertot et al., 2016). A certain number of breeding programmes in Europe have continued crossing hybrids with *V. vinifera* varieties in order to obtain resistant varieties with the traditional flavours that consumers are used to. Breeding techniques have evolved radically over time and the new breeding techniques (i.e. marker assisted selection, gene mapping, in vitro-culture and genetic engineering and pyramiding of resistance, etc.) have become more and more important in recent years. Therefore, the current aim in resistance breeding is to pyramidise resistance genes of different origin (i.e. from *V. rotundifolia* and *V. amurensis*) into a single genotype and to cross them with V. vinifera in order to obtain both highly resistant genotypes and varieties for quality wine production (Pertot et al., 2016). These new resilient or resistant cultivars should be considered important tools to be integrated in the IPM framework, as well as in organic viticulture, rather than a stand-alone solution (Lamichane et al., 2015). In fact, other than planting a new "resistant vineyard" they should also be used to create buffer zones near to water bodies, houses or streets. Finally, if and where it is allowed by the National regulations, they can also be used in some percentage for preparing blends of wines.

funded by European Commission

Vineyard biodiversity represents a tool to increase the efficacy in controlling pest populations

Organic vineyards still rely on a large amount of external inputs to control harmful organisms. Natural solutions based on plant diversity can represent an interesting tool to control pests and reduce pesticide dependence. The capability of plants to increase the ecosystem resistance to pests and invasive species is a well-known ecosystem service. However, monocultures such as vineyards do not exploit the potential of plant diversity. New viticultural systems can be developed based on an increased plant diversity within (eg, cover crops) and/or around (e.g., hedges, vegetation spots, edgings) vineyards by planting selected plant species for the control of arthropods, soil-borne pests (oomycetes, fungi, nematodes), and foliar pathogens. There is an ongoing European project, funded by the ERA-net Core Organic, named BIOVINE (www.biovine.eu) that aims to identify candidate plants and test them under controlled environment or small-scale experiments. Such plants have been selected in order to investigate their ability to: i) attract or repel target arthropod pests; ii) conserve/promote beneficials; iii) control soil-borne pests by mean of biofumigation; iv) carry mycorrhizal fungi to vine root systems to increase plant health (growth and resistance); v) control foliar pathogens by reducing the inoculum spread from soil. Innovative viticultural systems should include improved ways to control pests in organic viticulture, meanwhile they should positively affect functional biodiversity and ecosystem services. New control strategies may provide financial opportunities to vine growers and lower their reliance on pesticides. Preliminary results obtained confirmed the importance of this approach and the possibility to retrieve interesting information from these experiments (Manstretta et al., 2018).

Further needs of research and demonstration

It is important to highlight the need of funding for further research projects, for instance, to confirm the preliminary results obtained by possible alternatives to copper such as bio-fungicides, biocontrol-agents and resistance inducers. Even in the case of resistant varieties it is clearly important to test them under different environments and, probably, also to help growers to build a specific market for the wine obtained from these varieties.

On the other side it is even more crucial to support demonstration projects, for instance, to show the organic growers the relevant support that an integrated approach, the proper use of ICT such as forecasting models and DSSs and the increased precision of intervention in the use of copper-based fungicides can provide, on the short time period, an improved capacity in controlling downy mildew epidemics even under a low amount of copper availability regime.

funded by European Commission

Cited references

Bove F., Caffi T., Poni S., Languasco L., Rossi V. 2018. Caratterizzazione dell'attività di un fertilizzante organo-minerale nei confronti di Plasmopara viticola. ATTI Giornate Fitopatologiche 2: 357-364.

Brent, K.J., & Hollomon, D.W. (2007). Fungicide resistance in crop pathogens: How can it be managed? (FRAC Monog.). Fungicide Resistance Action Committee

Caffi T., Legler S.E., Carini M., Rossi V. MODE OF ACTION AND RAINFASTNESS OF COPPER-BASED PRODUCTS AGAINST GRAPEVINE DOWNY MILDEW. Journal of Plant Pathology, Dec2012 Supplement, Vol. 94 Issue 4, pS4.59-S4.59. 1/4p.

Caffi et al., 2014. Year-to-year weather variability affects downy mildew epidemics in vineyards and should guide decisions regarding fungicide applications, Agrochimica vol. LVIII: 77-90

Caffi T., Legler S.E., González-Domínguez E., Rossi V. 2016. Effect of temperature and wetness duration on infection by Plasmopara viticola and on post-inoculation efficacy of copper. Eur J Plant Pathol (2016) 144:737–750 DOI 10.1007/s10658-015-0802-9

Caffi T., Rossi V., 2018. Fungicide models are key components of multiple modelling approaches for decision-making in crop protection. Phytopathologia Mediterranea (2018), 57, 1, 153−169 DOI: 10.14601/Phytopathol_Mediterr-22471.

Dagostin S, Scharer H-J, Pertot I., Tamm L. 2011. Are there alternatives to copper for controlling grapevine downy mildew in organic viticulture? Crop Protect. 30: 776-788.

Garde-Cerdán T., Mancini V., M. Carrasco-Quiroz, A. Servili, G. Gutiérrez-Gamboa, R. Foglia, E. P. Pérez-Álvarez, and G. Romanazzi. Chitosan and Laminarin as Alternatives to Copper for Plasmopara viticola Control: Effect on Grape Amino Acid. Journal of Agricultural and Food Chemistry 2017 65 (34), 7379-7386 DOI: 10.1021/acs.jafc.7b02352

Gessler, C., Pertot, I., & Perazzolli, M. (2011). Plasmopara viticola: a review of knowledge on downy mildew of grapevine and effective disease management. Phytopathologia Mediterranea, 50(1), 3-44.

Gil E., J. Llorens, A.J. Landers, J. Llop and L. Giralt, 2011. Field validation of dosaviña, a decision support system to deter- mine the optimal volume rate for pesticide application in vineyards. European Journal of Agronomy 35, 33–46.

Jamar L., Lefrancq B., Fassotte C., Lateur M. 2008. A during-infection spray strategy using sulphur compounds, copper, silicon and a new formulation ofpotassium bicarbon- ate for primary scab control in organic apple production. European Journal of Plant Pathology, 122: 481–493

Kullaj E., S. Shahini, S. Varaku & M. Çakalli 2017. Evaluation of the efficacy for reducing copper use against downy mildew control in organic Mediterranean viticulture, International Journal of Pest Management, 63:1, 3-9, DOI: 10.1080/09670874.2016.1209252

Lamichhane J.R., Dachbrodt-Saaydeh S.,Kudsk P.,Messean A., 2015. Toward a reduced reliance on conventional pesticides in European agriculture. Plant Dis. 100, 10-24.

Lukas, K., Innerebner, G., Kelderer, M. et al. J Plant Dis Prot (2016) 123: 171. https://doi.org/10.1007/s41348-016-0024-1

Manstretta V., Si Ammour M., Armengol Forti J., Kehrli P., Ranca A.M., Sirca S., Wipf D., Rossi V.. Exploit biodiversity in viticultural systems to reduce pest damage and pesticide use and increase ecosystems services provision: the BIOVINE Project. International Congress on Grapevine and Wine Sciences, 7-9 November 2018, Logrono (ES).

Pertot, I., et al., 2016. A critical review of plant protection tools for reducing pesticide use on grapevine and new perspectives for the implementation of IPM in viticulture, Crop Protection, http://dx.doi.org/10.1016/j.cropro.2016.11.025

Siegfried W., O. Viret, B. Huber and R. Wohlhauser, 2007. Dos- age of plant protection products adapted to leaf area index in viticulture. Crop Protection 26: 73–82.

Rossi et al., 2014. Addressing the implementation problem in agricultural decision support systems: the example of vite.net®, Computers and Electronics in Agriculture 100; 88–99

Rossi et al., 2012. Contribution of molecular studies to botanical epidemiology and disease modelling: grapevine downy mildew as a case-study, European Journal of Plant Pathology, DOI 10.1007/s10658-012-0114-2

Annex C: Relevant recent and on-going research projects

project name	main topic/characteristis	Frame work	web
BCA_GRAPE	New biocontrol agents for powdery mildew on grapevine	7FP	www.bca-grape.eu
CO-Free	Reducing copper as a pesticide	7FP	www.co-free.eu
Endure	Diversifying crop protection	7FP	www.endure-network.eu
INNOVINE	Vineyard agronomic management and breeding for improved grape quality to reinforce competitiveness of the winegrowing sector	7FP	www.innovine.eu
MODEM_IVM	A web-based system for real-time monitoring and decision making for integrated vineyard management	7FP	www.modem-ivm.eu
PLANT CT	Making plants healthier - development of monitoring tools	H2020 SMEs tool	
PROECOWINE	Development of bio-fungicides	7FP	www.proecowine.eu
PROLARIX	Botanicals for plant protection	7FP	www.prolarix.eu
PROMESSING	Promoting eco-system services in grapes	FACCEJPI ERANET	www.promessing.eu
PURE	Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management	7FP	www.pure-ipm.eu
VINEMAN	Innovative cropping systems for organic viticulture.	Core Organic2 ERANET	www.vineman-org.eu
VINEROBOT	Tools for precision viticulture	7FP	www.vinerobot.eu
WINETWORK	Thematic Network on Grape Trunk Diseases and Flavesence Dorée	H2020	www.winetwork.eu
Cost action FA 858	Viticulture: Biotic and abiotic stress - Grapevine Defence Mechanism and Grape Development	Cost action	www.cost.eu/COST_Actions/fa/858 www.cost.eu
COST Action FA1303	Sustainable control of grapevine trunk diseases	Cost action	http://managtd.eu/en
BIODIVINE	Demonstrating functional biodiversity in viticulture landscape	LIFE	www.biodivine.eu
ADVICLIM	Adaptation of viticulture to climate change	LIFE	www.adviclim.eu
EVITICLIMATE	Climate change and European wine producers	LLLP	www.eviticlimate.eu
SUSVIT	Sustainable viticulture on farm	Grundtvig	
SUSVIT PLUS	Sustainable viticulture on farm	Grundtvig	
VISO	Viticulture and sustainable development of local resources in the wine industry	Interreg	http://viso.appliedgenomics.org/en
BACCHUS	Pest and disease in viticulture	Interreg	http://www.bacchus-science.eu/
WINETECH PLUS	Comunidad de Innovación y Nuevas Tecnologías en Viticultura y Elaboración de Vino	Interreg	http://www.winetechplus.eu/index.php?lang=es
WINETECH	Promote the Innovation engagement int the vine and wine sector	Interreg SUDOE	http://www.winetech-sudoe.eu
PAThOGEN	Training programme to improve grapevine virus knowledge and management	Erasmus+	http://www.pathogen-project.eu/ngcontent.cfm?a_id=13020
VALOVITIS	Identification of unknown and ancestral varieties and preservation plant material in vine	Interreg-POCTEFA	http://www.valovitis.eu/senalar-un-pie-de-vid/?lang=es
VITISOM	Viticulture Innovative Soil Organic Matter management	LIFE	http://en.lifevitisom.com/objectives
PLAID	Access to innovation through demonstration	H2020	http://www.plaid-h2020.eu/
INBIOSOIL	Control of subterranean crop pests of global economic importance	FP7	http://inbiosoil.uni-goettingen.de/
MYCORRAY	Solution to help prevent fungal trunk diseases for the vine grower	FP7	http://www.mycorray.eu/
VINTAGE	A user friendly Decision Support System for an integrated vineyard management, for addressing quality and quantity production variability optimising the use of resources	FP7	www.vintage-project.eu.
FITOVID	Reduction of phytosanitary use in viticulture	LIFE	http://www.fitovid.eu/?lang=es
TOPPS	Train operators to promote best management practices and sustainability	LIFE	http://www.topps-life.org/
VINOVERT	To guarantee the long-term competitiveness of companies in the wine sector in south-west Europe, adapting them to a new type of demand for wines considered to be more "clean" from the point of view of health and the environment	Interreg SUDOE	https://www.interreg-sudoe.eu/proyectos/los-proyectos-aprobados/161-vinos-competitividad-politicas-medioambientales-y-sanitarias-de-las-empresas-acompanamiento-

project name	main topic/characteristis	Frame work	web
			hacia-la-puesta-en-marcha-de-metodologia
ATLANTIC VINEYARDS	Development & demonstration of a complete system to reduce the use of chemical products in the D.O. RIAS BAIXAS	LIFE	http://vinasatlanticas.depo.es/web/vinas-atlanticas/home
PRIORAT	Making compatible mountain viticulture development with European Landscape Convention objectives	LIFE	http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=2899
AWARE	Reducing pesticide-related water pollution by improving crop protection practices: The use of embedded ICT technologies	LIFE	http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=2860
LIFEAGROINTEGRA	DEMONSTRATION OF SUSTAINABLE ALTERNATIVES TO CHEMICAL PRODUCTS FOR EUROPEAN CROP PROTECTION (AGROINTEGRA)	LIFE	http://www.agrointegra.eu/en/
LIFE VinEcoS	Optimizing Ecosystem Services in Viniculture facing Climate Change	LIFE	http://www.life-vinecos.eu/en/news/index.html
LIFE+ SOIL4WINE	Innovative approach to soil management in viticultural landscapes	LIFE	http://dipartimenti.unicatt.it/diproves-progetti-di-ricerca-life-soil4wine
CENIT-DEMÉTER	Adaptation to the Climate change	Spain-CDTI	www.cenitdemeter.es
GLOBALVITI	Adaptation to the Climate change	Spain-CDTI	http://www.hispatec.es/globalviti-id-vitivinicola-participamos/
AGRISENSACT	New generation of wireless sensors for integrated precise agriculture	FP7-SME	www.agrisensact.eu
BROWSE	Bystanders, Residents, Operators and WorkerS Exposure models for plant protection products	FP7	www.browseproject.eu
VITISENS	COST-EFFECTIVE HAND-HELD DEVICE FOR RAPID IN-FIELD DETECTION OF FLAVENSCENCE DOREE PHYTOPLASMA IN GRAPEVINES	FP7-SME	www.vitisens.eu
SAFEGRAPE	Biosensor-based instrumentations to be used in vineyards and wineries for fast and sensitive detection of Botrytis cinerea, grey rot, in grapes	FP7-SME	http://www.safegrape.eu
SUSTAVINO	Integrated Approaches for Sustainable European Wine Production	FP7-SME	http://cordis.europa.eu/result/rcn/60432_en.html
BIOBIO	Indicators for biodiversity in organic and low-input farming systems	FP7 KBBE	http://cordis.europa.eu/result/rcn/54220_en.html
VITICAST	VITICAST: innovative solutions for fungal diseases prediction in vines». Objective: to develop site-specific DSS (Decision Support System) for monitoring fungal diseases, taking into account the phenological stages as well as climate data, inoculum pressure information and weather forecast Members: 2 wineries, 2 winegrowers associations, 1 ITC company, 1 research group	National OG	no website http://www.campogalego.com/es/vina-es/galicia-consolida-su-papel-en-la-investigacion-nacional-del-sector-vitivinicola/
RETMAVID	Project that seeks to minimize the incidence of GTD's	Spanish Ministry (MINECO Funds)	no website + info: http://www.martincodax.com/blog/es/noticia/retmavid/
EVID	EVID: Innovative practices to fight the grapevine trunk diseases». Objective: to monitor innovative practices on GTD´s management, identified in WINETWORK project, by implementing protocols and field trials that allow to obtain information about the viability and efficacy of those practices. Members: 1 winery, 1 research group, 1 administrative body. Regional project	Regional OG	no website
SISTEMIO	Downy mildew and powdery mildew remote sensing system	Regional Funds	no website http://www.innovi.cat/es/innovi-coordina-prova-pilot-sistema-teledeteccio-gestio-tractaments-fitosanitaris-vinya/

project name	main topic/characteristis	Frame work	web
VineDivers	Biodiversity-based ecosystem services in vineyards: analysing interlinkages between plants, pollinators, soil biota and soil erosion across Europe	FACCEJPI ERANET	http://www.vinedivers.eu/
ADER 521	Assessing the vulnerability of the viticultural ecosystem to the harmful impact of competing and antagonistic organisms	Romanian Ministry (ADER Funds)	http://www.madr.ro/cercetare-inovare/ader-2011-2014/ader-5-2011-2014/18-ader-5-2-1.html
ADER 116	Developing adapted wine technologies to mitigate the disruptive effect of climate change	Romanian Ministry (ADER Funds)	http://www.madr.ro/cercetare-inovare/ader-2011-2014/ader-1-2011-2014/57-ader-1-1-6.html
ADER 311	Technological system for the production of viticulture propagation material free from viruses in protected areas	Romanian Ministry (ADER Funds)	http://www.madr.ro/cercetare-inovare/ader-2011-2014/ader-2-2011-2014/15-ader-2-2-6.html
GTDfree	Management of grapevine trunk diseases	Hennessy/industrial chair ANR	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/contributions-de-recherche/lancement-de-la-chaire-industrielle-gtdfree
Euréka	Management of grapevine trunk diseases	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/eureka
CO-ACT	Flavescence dorée	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/co-act
LONGVI	Vineyard sustainability	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/longvi
ORIGINE	Vineyard sustainability	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/origine
PHYSIOPATH	Vineyard sustainability	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/physiopath
TOLEDE	Management of grapevine trunk diseases	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/tolede
TRADEVI	Vineyard sustainability	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/tradevi
VACCIVINE	Biocontrol of fanleaf virus	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/vaccivine
VITIMAGE	Management of grapevine trunk diseases	French Ministry	https://www.plan-deperissement-vigne.fr/travaux-de-recherche/programmes-de-recherche/vitimage
Plant signaling and Phytoplasma Response	Plant signaling and Phytoplasma Response	Austrian Science Fundation	https://www.fwf.ac.at/en/
GYBase	Phytoplasma understanding	Austrian Science Fundation	https://www.fwf.ac.at/en/
Obsphytoplasmosen	Phytoplasma understanding	Austrian Ministry	
FFOQSI_DownyMildew	Downy Mildew	Austrian Ministry	
SOIL4WINE	Innovative approach to soil management in viticultural landscapes	LIFE+	http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5780

project name	main topic/characteristis	Frame work	web
ValorInVitis	Valorisation of biodiversity towards a more sustainable viticulture in "Colli Piacentini" environment	RDP 2014-2020 (Rural Devolpment Program, Emilia-Romagna Region IT)	-
Nutrivigna	Innovation and new techniques of precision viticulture for vineyard nutrition	POR-FESR 2014-2020 (Rural Devolpment Program, Emilia-Romagna Region IT)	http://www.nutrivigna.it/ngcontent.cfm?a_id=13827
BIOCONVITO	"INTRODUCTION AND TESTING OF BIOLOGICAL CONTROL TECHNIQUES FOR EFFECTIVE AND SUSTAINABLE CONTROL OF INSECTS HARMFUL TO THE VINE IN TUSCANY"	EU programme of rural development f, funded by the regional government of tuscany	
RTA2010-00009-C03	Biology of pathogenic fungi causing wood diseases on grapevine and development of control methods.	Spanish Ministry (MINECO Funds)	http://p-rta2010-00009-c03-01.agripa.org/
RTA2015-00015- C02-01	Desarrollo de una tecnología para reforzar la resistencia de portainjertos y variedades a los patógenos fúngicos de la madera de la vid	Spanish Ministry (MINECO Funds)	
VIT-FOOT	Evaluation the impact of grafting methods on GTDs incidence	Regional Funds, Navarra region	no website
ViTHZ	Use of THz spectrometry to detect GTDs non-destructively	Regional Funds, Navarra region	no website
R-03-16	Characterization, epidemiology and control of fungal trunk pathogens of grapevine in La Rioja	Regional Funds, La Rioja region	no website
TROPICSAFE	Insect-borne prokaryote-associated diseases in tropical and subtropical perennial crops: facing, yellows in grapevines	H2020	http://www.tropicsafe.eu/
LIFE GREEN GRAPES	LIFE GREEN GRAPES - New approaches for protection in a modern sustainable viticulture: from nursery to harvesting	LIFE 2014-2020	http://www.lifegreengrapes.eu/

eip-agri
AGRICULTURE & INNOVATION

The European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI) is one of five EIPs launched by the European Commission to promote rapid modernisation by stepping up innovation efforts.

The **EIP-AGRI** aims to catalyse the innovation process in the **agricultural and forestry sectors** by bringing **research and practice closer together** – in research and innovation projects as well as through the EIP-AGRI network.

EIPs aim to streamline, simplify and better coordinate existing instruments and initiatives and complement them with actions where necessary. Two specific funding sources are particularly important for the EIP-AGRI:

- ✓ the EU Research and Innovation framework, Horizon 2020,
- ✓ the EU Rural Development Policy.

An EIP AGRI Focus Group* is one of several different building blocks of the EIP-AGRI network, which is funded under the EU Rural Development policy. Working on a narrowly defined issue, Focus Groups temporarily bring together around 20 experts (such as farmers, advisers, researchers, up- and downstream businesses and NGOs) to map and develop solutions within their field.

The concrete objectives of a Focus Group are:

- ✓ to take stock of the state of play of practice and research in its field, listing problems and opportunities;
- ✓ to identify needs from practice and propose directions for further research;
- ✓ to propose priorities for innovative actions by suggesting potential projects for Operational Groups working under Rural Development or other project formats to test solutions and opportunities, including ways to disseminate the practical knowledge gathered.

Results are normally published in a report within 12-18 months of the launch of a given Focus Group.

Experts are selected based on an open call for interest. Each expert is appointed based on his or her personal knowledge and experience in the particular field and therefore does not represent an organisation or a Member State.

*More details on EIP-AGRI Focus Group aims and process are given in its charter on: http://ec.europa.eu/agriculture/eip/focus-groups/charter_en.pdf

funded by European Commission

Join the EIP-AGRI network & register via www.eip-agri.eu

servicepoint@eip-agri.eu | +32 2 543 73 48 | Koning Albert II laan 15 | Conscience Building | 1210 Brussels | Belgium