EIP-AGRI Focus Group

Diseases and pests in viticulture

STARTING PAPER
Version 19 January 2017

Cristina Micheloni, EIP-AGRI Service Point

funded by European Commission

Table of contents

1. Introduction

Viticulture is a relevant sector of EU agriculture in terms of economic revenues and jobs creation, but also as landscape shaping and identity preservation. Wine is the main export item of the EU within the food sector[1] and an excellent witness of local traditions, skills and biodiversity. But at the same time viticulture is the area with the highest use of pesticides, as its specialization and intensification made it more and more susceptible to pests and diseases out-breaks as well as to climate change effects.

EIP-AGRI Focus Group (FG) on diseases and pests in viticulture was set up with the scope of identifying the precise features of the problem and address paths to solutions, based on scientific knowledge and practical experiences from vine-growers and advisers in the different EU wine producing Regions.

1.1 The role of the Focus Group

The basic question the FG is challenged to answer is "*How can we increase resilience of grape vines to pests and diseases and support the productivity of the sector in sustainable ways?".* The 19 experts composing the group will work together to share their knowledge and experiences and from them to produce practical suggestions and recommendations. The path of knowledge sharing starts with the meeting in Porto and is triggered by the commitment to fulfill the following tasks within the FG mandate:

- **Make an inventory of the main pests and diseases** affecting grape vines, including their distribution and economic impact. Where possible, **summarise** how expected climatic changes will impact the distribution and occurrence of pests and diseases.
- **Take stock of state of play** with regard to prevention practices, early detection, diagnostics and monitoring.
- **Take stock of main 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 resilience of grapevines to biotic stresses should deserve special attention.
- **Compile examples of 'good practice'**, 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.

---

1 European Commission, 2016. Agri-food trade in 2015: China boosts EU exports- in Monitoring Agri-trade policy. MAP 2016-1. http://ec.europa.eu/agriculture/trade-analysis/map/2016-1_en.pdf

funded by European Commission

1.2 Scope of the starting paper

The purpose of this starting paper is to set common basis for discussion at the first meeting, provide building blocks for the final outcome of the FG work, start the inventory of pests and diseases affecting European viticulture and the most promising and sustainable methods to manage them, summarize the initial contributions of Focus Group members and finally propose key questions to trigger discussion at the first Focus Group meeting.

1.3 Viticulture in EU, figures and trends

Most recent statistics from OIV[2] (Organisation Internationale de la Vigne et du Vin) quantify a surface of vineyards in the EU in 2015 of 3.362 kha, that is about half of the world vineyard (7534 kha). That includes grape for wine production (by far the majority) but also grape for fresh consumption and dried grapes. Most relevant countries for EU wine production are Italy, France and Spain (see table 1).

Tab.1 Number of hectares of vineyard per country in the EU (data from OIV refer to 2013 as final consolidated data and at 2015 as forecast, not complete for all countries).

Of course the average size, the management techniques, the wine types obtained and their values greatly vary not only within EU but also within each region. Nevertheless for all the countries and regions with strong viticulture tradition, wine production is among the most relevant agriculture activities in economic terms. Just as an example: export value of wines from Spain in 2015 are estimated in 2641 Mio€, from France 8244 Mio€, from Italy 5353 Mio€, from Germany 953 Mio€ and from Portugal 738 Mio€ (still from OIV).

Besides the economic relevance directly linked to the wine production, the value of viticulture landscapes and the link to traditional knowledge and skills increase the social relevance of viticulture in Europe.

But at the same time the intensification of viticulture practices led to a loss of biodiversity, the degradation of soils and and overall decrease of resilience of viticulture systems that pushed towards an increased use of pesticides that, in turn, further decreased biodiversity and increased the dependence on external inputs.

2 Elements de la conjoncture mondiale, Avril 2016. http://www.oiv.int/public/medias/4709/oiv-noteconjmars2016-fr.pdf

funded by European Commission

2. Pests and diseases incidence on viticulture

All viticulture areas are characterized by varieties grown, climate, soil and management practices and in all areas some pests and/or some diseases are constantly hampering the grape production and so requiring specific management. Pests and diseases impact on grape production both in terms of quantity and quality and they may also put at risk the longevity of vineyards (i.e. Esca complex). Grape varieties have low to high susceptibility to the different fungal diseases, that result in significant production costs and economic losses[3]. It has been calculated that in Piedmont the annual cost for controlling downy mildew (the most critical disease of the area) in all conventional vineyard ranges from 8 to 16 million Euros, including work, equipment and product costs[4]. In France, under medium downy mildew pressure, 12 treatments per season are necessary for traditional varieties grown under conventional management [5].

As already mentioned, besides the cost issue, the environmental and health impact is to be considered. The growing concern for a more sustainable vineyard management is among the reasons of the fast growth of the organic wine production (according to EC Reg. 834/07)[6] in all European wine regions and the issuing of the European Directive on Sustainable use of Pesticides (EC Dir. 2009/128)[7] that promotes Integrated Pest Management (IPM).

IPM is more broadly developed and implemented through the Integrated Production (IP) concept, as defined by the International Organization for Biological and Integrated Control (IOBC). The concept is based on the use of natural resources and regulating mechanisms to replace potentially polluting inputs.[8]

2.1 The main pests and diseases

2.1.1 The diseases

From literature and from the preliminary and not exhaustive information gathered from the FG experts it results that in the main European wine areas the diseases with higher impact that winegrowers have to manage are the following:

- **Downy mildew**, caused by *Plasmopara viticola,* may reach 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, discoloration including brown spotting and yellowish-green tips of the leaves;
- **Powdery mildew,** caused by *Erysiphe necator,* all European varieties are more or less susceptible. It infects all green tissue on the grapevine, including leaves and young berries and can cause relevant crop loss. Warmer and drier climates favor the attack. Main symptoms are easily identifiable: gray-white, dusty formation on the upper sides of the leaves, but it can also infect the bottom sides, buds, flowers, young fruit, and young stems;

---

3 Fuller, K.B., Alston, J.M., Sambucci, O.S., 2014. The value of powdery mildew resistance in grapes: evidence from California. Wine Econ. Pol. 3, 90–107, http://dx.doi.org/10.1016/j.wep.2014.09.001.

4 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.

5 Rousseau, J., Chanfreau, S., Bontemps, É., 2013. Les Cépages Résistants and Maladies Cryptogamiques. Groupe ICV, Bordeaux, pp. 228

6 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:189:0001:0023:EN:PDF

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

8 https://www.iobc-wprs.org/ip_ipm/IOBC_IP_principles.html

funded by European Commission

- **Botrytis** caused *Botrytis cinerea*. Its relevance highly 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 year climatic conditions and other pests and diseases level of damage.

Besides the main 3 diseases there is a growing concern on **Flavescence dorée** (FD), caused by the bateria *Candidatus Phytoplasma vitis* and transmitted by the vector *Scaphoideus titanus,* it develops in the phloem vessels of the host plants, and Grape Trunk Diseases (**GTD**s), including Eutypa, Esca and Black Dead Arm dieback. Each can be caused by different species of one fungus genus or by different geni. They may lead the plants to death (more or less rapidly), are only partly related to climatic conditions and mainly to variety sensitivity. FD arrived in Europe in the 80s, starting from France and rapidly spread to Italy and in now moving Eastern. GTDs are more complex to understand, are present in many European wine regions but not always leading to damage to plants or impacting production. FD and GTDs are the core topic of the on-going Thematic Network Winetwork[9].

Other pathogens mentioned by experts to be relevant in some specific areas are Black rot (caused by *Guignardia bidwellii*), Crown gall (caused by *Agrobacterium vitis*) and several viruses.

2.1.2 The pests

Concerning pests, the FG experts preliminary identified the following ones as the main problems vinegrowers have usually to manage, especially in warmer climates:

- **Grape moths**, European grape moth (*Lobesia botrana*) and Cochilis grape moth (*Eupocilia ambiguella*), two lepidoptera of Tortricidae family that cause direct damage to the bunch as they feed on the grape content and indirect damage as it opens wounds that consequently offer opportunity for attach of diseases such as Botrytis. They are common in Mediterranean climate;
- **Mites** (different species such as *Calepitrimerus vitis, Eriophyes vitis, Eotetranychus pruni, Panonychus ulmi*) more common in mild climates they attach leaves and shoots, decreasing the photosynthetic activity of the plant;
- **Smaller green leafhopper** (Empoasca vitis) a phloem-feeding leafhopper causing veinal browning, as well as marginal rolling and burning;
- **Grape mealybug,** an unarmored 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

Other pests relevant on a local level are **Trips** and **Phylloxera** and there is increasing concern on the risk of **Pierce's disease** (caused by the bacteria *Xylella fastidiosa*).

A non-exhaustive list of pests and their characteristics is reported in Annex 2. It is a work in progress and will be further elaborated during the FG work.

9 www.winetwork.eu

funded by European Commission

3. Which tools are available for pest and disease management?

Pest and disease management is nowadays based on the integration of several means and tools (i.e. combination of choice of training system, plus monitoring tools, early alert technologies and use of Plant Protection Products – PPPs- in precise quantities and moments) that together may allow to protect the vineyard efficaciously and efficiently with a limited environmental impact. Their implementation requires knowledge and often some technology, something that is not always available in all wine producing areas. Nevertheless professional wine sector probably is (or at least could be) the most advanced on this issues, thanks to the relatively high economic revenues obtained, on one hand, and due to the heavy environmental impact conventional management has, that put it under the spot of public opinion, with a negative influence on reputation and consumers/citizens acceptance.

The system approach that characterizes IP and IPM combines several of the following measures and tools:

3.1 The prevention practices

- Creation of an **ecological infrastructure**, at farm and at larger scale, with the aim of improving micro-climatic conditions and increase biodiversity, including beneficial timely presence and activity. In the vineyard it is implemented with flowering strips, alternate mowing between rows, creation of hedges and woodlots and other elements of agro-forestry systems;
- Choice of **varieties and root-stocks** adapted to the local conditions. Among "classical" varieties there is the possibility to select more resistant ones and better adapted clones. Several farmers run on-farm mass-selection programmes or multiply their own ecotypes to increase adaptation. Besides, last 10 years breeding of new resistant/tolerant varieties of grapevine have offered the availability of several quality materials that have high potential to reduce pesticides use. In France it was estimated that resistant varieties could cut production costs by two[10]. Nevertheless especially in traditional wine production areas the concern on wine quality is constraining/slowing down the producers from accepting them.
- Choice of **management/cultivation strategies** that mitigate the impact/development of pests and diseases. For example soil management that facilitate drainage, balanced nitrogen fertilization to avoid excess vigor of the plants that leads to high susceptibility to downy and powdery mildew, training and pruning systems that facilitate air circulation in the canopy or leaves removal to facilitate bunch ventilation and reduce Botrytis risk;
- **Sanitation measures** to prevent the spread of diseases. For example care for nursery healthy materials, pruning tools disinfection to avoid spreading of trunk diseases by workers, removal of diseased plants in the vineyard to reduce the inoculum of diseases and sources of infected materials for vectors.

---

10 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

funded by European Commission

3.2 The early detection/diagnostics/monitoring tools

- **Monitoring/scouting** of pest and diseases but also of beneficials. Good knowledge of physiology and morphology (of the plant, the pest/disease and of beneficials) is a basic requirement to plan and implement an efficient monitoring system. Monitoring can be implemented with simple visual inspections, for example of juvenile forms of *Scaphoideus titanus*, and/or with the support of traps (that catch insects, mites or spores). For example yellow traps with pheromones for grape moths, There are also more advanced systems that capture air samples to monitor spores or even fluorescence-based methods to detect molecules in the plant tissues whose production is induced by downy mildew infection;
- **Forecasting systems** to identify the risk level linked to the attack of a pest or a disease and to decide the tool and moment to act for plant protection. They have been developed for different diseases, but especially for downy and powdery mildew, and for several pests, such as moths. In last decades the availability of Information Technology (IT) tools, wireless sensors to constantly monitor climatic data and vegetation development as well as more developed and precise algorithms to forecast pest and diseases development cycles allowed to implement in many regions/farms IPM and precision plant protection techniques. IT tools are available in several EU regions and are used directly by the farmers or, more often, by the advisory service, that disseminate early alerts based on their outcome. 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 (if to spray, when to spray, what to spray). IT and Internet of Things (IoT) technologies implementation made available several tools (Apps, web-based services etc.) that facilitate their direct use by farmers and advisers (with no need of intermediate steps/actors). They rely on forecasting systems and constant monitoring, allowing high efficiency and savings.

3.3 Methods and tools for direct control/management

It includes:

- **Mechanical control systems**, they range for simple mass trapping (for example of chafers) or flame weeding (to reduce downy mildew inoculum) to more technologically advanced vibrational mating disruption (experimentally applied to *Scaphoideus t.*);
- **Biological control methods,** for example mating disruption applied to several *Lepidoptera* species and to *Planococcus ficus*, or the use of microorganism based products, such as *Bacillus thuringiensis* to control moths or *Ampelomices quisqualis* to control powdery mildew or other living organisms able to compete with (for space or for food) or to parasitize pests and diseases. There are successful examples against insects, mites, fungi and bacteria;
- **Use of pesticides.** It comes as a last resource and should be applied under guidance of monitoring and forecasting systems. It includes natural products, like botanicals, products of mineral origin (i.e. clays, some Sulphur formulates), low risk products (i.e. food-grade products like carbonates or plant oils or lecithins) and synthetic pesticides. They can act by contact of be systemic or cytotropic and their application mode changes accordingly;
- Also the tools used to spray should be chosen according to the “sustainable” principles, for example **sprayers** using reduced volumes of water or able to recycle the part of treatment not reaching the canopy. Besides their features, their regular control and fine-tuning is strategic (and compulsory for the Sustainable Pesticide use directive) for a more efficient and safer use.

funded by European Commission

3.4 Integrated Pest Management (IPM)

As defined by FAO, IPM "is 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 minimize risks to human health and environment. IPM emphasizes the growth of healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms"[11]

The increasing impact of pests and diseases and the parallel increased availability of plant protection products in the last 40 years, went hand in hand with the intensification of viticulture practices, that led to a simplification of the agro-eco-systems, the loss of soil fertility (chemical but also microbiological and physical), the reduction of vineyard life span. Now it is common perception and scientists' opinion, that in order to efficiently and safely manage vineyard health there is the need to review the whole farming system and reconsider all the operations in their connection with each other. That is summarized in the concept of Integrated Pest Management (IPM) and even more as part of Integrated Production (IP).

Viticulture is among the agriculture sectors where IPM concepts were firstly implemented and results of its translation into practice are already available in several wine producing regions.

IPM is nowadays widely used in the management of moths, where constant monitoring and mating disruption applied at large area scale (not only at farm scale) are applied in Trentino, Tuscany and other European regions.

In the control of Flavescence dorèe IPM approach is a must, as it requires a large scale implementation in prevention, monitoring, indirect control through inoculum and vector reduction and finally direct control of the vector in order to have some potential of success.

Downy mildew control is widely implemented through a combination of monitoring systems, forecast methods and finally timely and precise applications of PPPs.

Nevertheless, IP and IPM full potentials are still far from being achieved both in conventional and organic viticulture. Most recent scientific knowledge on pests and disease biology and the host/vector/pathogen interaction with their plants and the environment proved to have the potential to allow viticulture to make further steps towards sustainability. Besides recently developed technologies (including IT and IoT) could offer simpler and broadly available tools for IPM practices. But the implementation is not simple nor fast, as it requires some initial investments and, more important, large involvement and training of farmers and advisors.

11 http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/en/

funded by European Commission

4. How will pests and diseases evolve with climate change and what will be their impact?

What enhances the risk level, in viticulture as in other agriculture production systems, is the clear evidence that the changing climate will increase the risk and the damage linked to pest and diseases (besides several other problems related to water scarcity, high temperature and changes in the variety profiles). Salinari et al.[12] estimated that in Piedmont climate change will increase downy mildew incidence, requiring a higher number of treatments with a costs increase from 20 to 50% and a higher risk of environmental impact.

Several simulations[13] try to predict the evolution of the vineyard agro-eco-system with the changing climate and what will happen with pests and diseases. Even if there are no clear figures the overall forecast is for a) an increase of incidence of pests and diseases on viticulture; b) a change of pest species causing problematic sytuations; c) a change in pests and diseases biological cycles that will make more difficult their control; d) and increased difficulty in forecasting due to extreme variation in climatic conditions and, consequently, in the vine growth and in pests and diseases development. In any case viticulture will face a more complicated situation, rapidly changing, that requires production to be based on a more resilient system, since direct control methods will be less effective and probably not sufficient.

The FG experts started to identify the trends in pests and diseases development and which ones are becoming more and more relevant due to climate change. Among others and as a preliminary overview: **Mediterranean vine mealybug** seems to enlarge its presence and impact and several insects **cycles are changing**, making it more difficult to apply forecasting systems. Diseases such as **downy mildew**, in recent years, became problematic also in areas where they rarely appeared beforehand, i.e. Sicily and, vice versa, **powdery mildew** started to be problematic in more Northern areas.

---

12 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.

13 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. Bottlenecks and challenges

In the future scenario, knowledge availability and timely information will be the key. Practitioners will need better techniques for a continuous and detailed monitoring of their vineyard. The innovative techniques will probably be based on new tools combined with consolidated practices, locally developed skills, new technologies and products. Decision Support Systems (DSSs) can play a pivotal role and get mainstream if they become more user-friendly and less data hungry, so to be accepted by a large part of practitioners and become part of usual practices. This needs a shift in habits (of practitioners but also of researchers and technology providers) and in approach, where continuous learning and knowledge exchange among all actors is part of the working habits. Within the overall strategy botanicals, microbiological products and elicitors appear to be quite promising, even if their practical use is not easy to get to a reliable standard.

But the most critical phase will be the implementation. ENDURE project[14] identifies several causes or bottlenecks that prevent specific innovations in viticulture to become mainstream. These are:

- **Availability** (registration status for PPPs or market/technology availability). The issue pertains the legal authorization process at EU level, the National registration process of formulated products and the local availability on the market. The critical point for EU authorization is linked to procedures length and costs, that often prevent companies to apply if the market potential is not sure and fast, and in any case the time required for the procedure to be completed may phase out the innovation push. Further process is needed to authorize active ingredients in organic farming, ending up with 4-6 years delay compared to conventional farming. Also the National formulates registration may, for certain products and in certain Member States, be too expensive or complicate and that prevents vine-growers of the country from using the new product. Finally, local market availability plays a relevant role, even if the possibility of e-commerce partially solves the problem. Nevertheless some technology problems still remain, for example internet access quality in some rural areas makes impossible in practical terms remote sensing and monitoring, so complicating the implementation of remote sensing and precision techniques.

- **Legal framework** (not allowing some varieties or products). For example resistant grape varieties are authorized only in some countries, while in others (i.e. Italy and France) only few of them can be legally planted. As for PPPs, also the variety registration process requires time and funds, often not compatible with companies business, especially in innovative solutions were uncertainty is high. Another example is the use of drones for monitoring and also spraying. Its use requires authorizations of the civil aviation bureau (it varies among Member States) and it risks to delay their use and/or make it too complicate and expensive, while their technology is progressing very rapidly and could give already a significant help to practitioners.

- **Compatibility with production goals** (in quantity and quality). IP and IPM require a system approach and sometimes imply restrictions that may limit the quantity produced or its quality, mainly in the firt implementation years, while in the long run a balance is reached. For example to limit nitrogen fertilization reduces diseases risks but also the quantity produced and that can be difficult to accept for producers of mass wines. The same is true for training and management systems: the systems that facilitate ventilation and reduce fungi risks may also be less productive (i.e. pergola versus guyot). That should be taken into account by producers together with production costs, and has to be assessed within the market orientation and potentials.

  Other techniques may lead to different quality traits, for example more resistant varieties may be difficult to cope with the market segment a producer is referring to. That is the factor mainly refraining producers in typical wine regions and with AOC labels (*appellation d'origine contrôlée*) from trying resistant varieties.

14 www.endure-network.eu

funded by European Commission

- **Implementability in terms of farm size or technology available.** Efficient use of PPPs requires well equipped machines (sprayers) and timely interventions. That may be not so difficult in medium farms with good labour organization but more complicated in large farms, where spraying requires many hours or days, and that for examples makes more difficult to manage downy mildew only with copper. But it can also be a problem in small farms, where often the owner is the only worker, so requiting more time for spraying. Besides, investments in equipment and technology in small farms can be a limiting factor, as the production revenues may not pay them back in compatible time.

  In some Regions the constrains may be the lack of advisory services supplying technological and professional support or simply connections are not properly working or the needed network of sensors is not available and as a consequence any DSS system may not be implemented.

- **Economic sustainability** and the **initial investments** need. Economic sustainability is a key aspect that cannot be underestimated. Several preventive measures require investments (i.e. hedges planting, changing of varieties etc.) and also the monitoring system and all the bases for DSS use (wireless sensors, Apps etc.) require initial investments, alike a better sprayer. Even if they can be payed back in the following years not all producers may effort them or do not feel like running the risk.

- **Availability of knowledge and skills**. It is probably the most critical point and the most demanding. It requires a collective involvement of farmers, advisers, researchers, input and technology suppliers that continues in time, updating and adding/changing the information and skills accordingly to new knowledge available and combining it with traditional knowledge and locally adapted skills. But what is highlighted as more problematic is the cultural shift in paradigm: from “controlling a specific pest or disease” to “build a resilient system where pests and diseases cannot cause a significant damage”.

6. Questions for the Focus Group to debate:

1. Is there something missing in the inventory of pests and diseases?
2. What prevention practices are successful and why?
3. How are the early detection/diagnostic/monitoring tools working?
   Are you using them in practice?
4. What are the main methods and tools for direct control/management?
5. What is the role of functional biodiversity and what is the current practice?
6. What are potential solutions in the field of prevention/early detection/diagnosis/monitoring and control?
7. How to make IPM strategies and practices more applicable and cost effective?
8. Are there good practical examples of traditional knowledge or innovative technologies or a combination of the two delivering successful tools to vine-growers? Why are they successful? Why are they not mainstream?
9. Which role do biodiversity and system thinking play in viticulture? Are they sufficiently acknowledged by farmers, advisers and researchers?

funded by European Commission

7. A lot of knowledge

In last decades many research has been done on pests and diseases management in viticulture, at European, National, trans-national and regional level. Quite some knowledge became available out of them, but probably not all has been exploited by practitioners. The recently concluded projects and the running ones can help in identifying gaps or missing informations that can be addresses by future research, and in understanding what can be shared with practitioners for use, assessing as well if there are hindering factors preventing their implementation (i.e. costs, need for infrastructures etc.).

Most recent European and trans-national projects are listed here below:

PROJECT FUNDED UNDER the EUROPEAN Research FRAMEWORK Programmes (FP7 OR HORIZON 2020)

- BCA_GRAPE- New biocontrol agents for powdery mildew on grapevine. FP7 www.bca-grape.eu
- CO-Free - Reducing copper as a pesticide FP7 **www.co-free.eu**
- ENDURE- diversifying crop protection. FP7 www.endure-network.eu
- INNOVINE - Vineyard agronomic management and breeding for improved grape quality to reinforce competitiveness of the winegrowing sector – FP7 **www.innovine.eu**
- MODEM_IVM- a web-based system for real-time monitoring and decision making for integrated vineyard management. FP7 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 protecion. FP7 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. FP7 www.pure-ipm.eu
- VINEMAN – Innovative cropping systems for organic viticulture. Core Organic2 ERANET **www.vineman-org.eu**
- VINEROBOT – tools for precision viticulture. FP7 **www.vinerobot.eu**
- WINETWORK – a Thematic Network on Grape Trunk Diseases and Flavesence Dorée – H2020 **www.winetwork.eu**

Projects under other European funding (COST, LIFE, INTERREG etc.)

COST Actions

- Cost action FA 858 Viticulture: Biotic and abiotic stress - Grapevine Defence Mechanism and Grape Development **www.cost.eu/COST_Actions/fa/858**
- COST Action FA1303 Sustainable control of grapevine trunk diseases http://managtd.eu/en

LIFE PROJECTS

- BIODIVINE Demonstrating functional biodiversity in viticulture landscape **www.biodivine.eu**
- ADVICLIM Adaptation of viticulture to climate change **www.adviclim.eu**

LIFELONG LEARNING PROJECTS

- EVITICLIMATE climate change and European wine producers **www.eviticlimate.eu**
- **SUSVIT** plus Sustainable viticulture on farm

INTERREG PROJECTS

- **VISO** Viticulture and sustainable development of local resources in the wine industry
- **http://viso.appliedgenomics.org/en**
- **BACCHUS** pest and disease in viticulture **http://www.bacchus-science.eu/**
- **WINETECH PLUS** - Comunidad de Innovación y Nuevas Tecnologías en Viticultura y Elaboración de Vino **http://www.winetechplus.eu/index.php?lang=es**

funded by European Commission

ANNEX 1

Most common diseases, their characteristics and management practices

Regions/countries where it is reported as problematic	**Latin name**	**Common name in English**	**How relevant is the damage it causes to the plant?** *(0=no at all 5=extremely relevant)*	**How relevant can the damage be on the economic performance of the vineyard (in terms of quantity or quality of production)?** *(0=no at all 5=extremely relevant)*	**How frequently is it relevant?** *(0= rarely, 1= every 4-6 years; 2= every 2-3 years; 3= every year)*	**Which climatic conditions lead to higher impact? Please describe.**	**Which soil and location conditions lead to higher impact? Please describe.**	**Which viticulture management practices lead to higher impact/risk? Please describe.**
all countries	Erysiphe necator	Powdery mildew	1-5	3-4	2-3	dry and cold Springtime, dry summer if humidity is higher and temperatures favorable – NO COMMON POSITION	compacted soils	high N availability and high amount of new vegetation is results of low ventilation in the vineyard
all countries	Plasmopara viticola	Downy mildew	3-5	4-5	2-3	High humidity conditions, 4 hours of darkness, Tª higher than 12ºC. More impact in rainy and soft spring-summer periods	compacted and wet soils	wrong vineyard orientation,training system, low ventilation, inappropriate fertilization and disease prevention
all countries	Botrytis cinerea	Botrytis	1-4	3-4	2.-3	rainy season, in particular around flowering and during maturation	compacted soils	Vigor management, N fertilization, handmade defoliation previous the harvest period, avoid damages in the grape…
all countries but not all regions	Flavescence dorée	flavescence dorée of grapevine	1 or 5	5	3	Optimal temperature for the vectors.		Uncontrolled vineyards; skip protection against Scaphoideus titanus; infected vines
all countries	A very diverse fungal complex	GTDs	1-5	1-5	1-3	depends and not always clear	compacted soils, Cool and wet areas	stress caused by different factors, infected material
Italy, Spain, Hungary, Romania,	Guignardia bidwellii	Black rot	1-4	1-5	0-3	rainfall in spring, mild temperatures, rainy summer (rainy flowering)		High plant vigor, high fertility in soils, low ventilation exposition
Bulgaria and Spain	GFKV & ArMV GLRaV	Grapevine leafroll virus and other	1-2	1-3	0-3	low temperature during the winter		Plant material free of virus in new plantations
Bulgaria. Hungary and Romania	Agrobacterium vitis	Crown gall	2-4	3	2-3	Low temperatures during the dormant period (below -18°C)		low qualty planting material, wrong pruning, missing protection against frost

-Part 2-

Which prevention measures are advisable?	Is there a monitoring/forecasting system available? Please describe.	Which direct interventions (spraying or biological/physical systems) are used?	Are there more resistant varieties/ecotypes? Yes/No - if yes please name the main ones	Are there natural enemies that can keep control? Yes/No - if yes please name the main ones How efficient are they?	Which are the key elements that make the vineyard a high risk case?	Are there innovative approaches/solutions that may significantly contribute to its control? If yes - please describe.	Referring to previous point: And if there are, why are they not mainstreaming?	Is everything known about causes? If no - please eplain.	Which ideal conditions would make the grapevine sufficiently resistant?
correct fertilization, early leaves removal to facilitate ventilation	yes, based on climatic data elaboration	In conventional: several systemic PPPs. Risk of resistance in organic: S and Ampelomyces quisqualis (not so often used)	Not 100% resistant but there is a degree of resistance	yes, spatial competition (i.e. Ampelomices, but not sufficient to keep control)	Canopy with abundant vegetation, excess of N fertilization, infection from previous year	DSS, BCAs, breeding, Orange oil, KHCO3	lack of knowledge, high costs, still unclear efficacy	Not completely: we still have to understand the initiation of overwintering structure formation (this will help in the sanitation treatment application)	Good canopy structure, optimal ventilation.
Ventilation of the canopy (tru "green" operation: removal of watersprout and lateral shoots, controlling shoots' length, partial leaf removal); equilibrated application of fertilizers to avoid nitrogen excess	yes, based on climatic data elaboration	several PPPs with systemic activity. In organic mainly Copper	yes, several new varieties	yes, spatial competition, but not sufficient to keep control	high vigor vineyard - high density - reduced ventilation - compact canopy - variety with compact bunches	DSS, BCAs, Resistance breeding	Quite recent - highly innovative - changing the approach in treatment scheduling. Expensive, not yet 100% efficient	about resistance mechanisms and Not completely: we are still missing a good (and convenient) method to estimate the amount of overwintering inoculum (that rules the intensity of epidemic in the following season)	Good canopy structure, optimal ventilation.
good ventilation in the canopy, spraying after mechanical damages of the bunches, avoid crack of the berries; protection against pests and Powdery mildew, to save the surface of the berries	Yes, different tools are available: from empiric rules to most innovative decision support system based on mechanistic modelling and actual weather data analysis	chemical sprays - defoliation - ventilation after flowering to blow out infected debris	Not 100% resistant but tolerant	some fungi	Reduced ventilation. Damages by other pests and diseases.	DSS, BCAs, some tolerant varieties	lack of knowledge, inefficient, expensive	Not completely: we still have to understand the importance for the epidemic of early infection (and so of possible early treatments)	Timely nipping laterals and removing leaves around clusters also reduces the relative humidity, the cluster is more exposed to the sun so the grapes when spraying better protected
high quality planting material, regular plant observation and analyses of symptomatic plants Protection against Scaphoideus titanus	cromathic traps for the vector	Treatment with pesticide against the vectors.	NO	Natural enemies of cicada Dictyophora europea and Oncopsis alni	high vigor vineyard - high density - reduced ventilation - compact canopy – presence of vector	sterilization of pruning devices, thermoterapy		A lot to know about the relationship between the phytoplasma and the vector/s	not reliable yet

Which prevention measures are advisable?	**Is there a monitoring/forecasting system available? Please describe.**	**Which direct interventions (spraying or biological/physical systems) are used?**	**Are there more resistant varieties/ecotypes? Yes/No - if yes please name the main ones**	**Are there natural enemies that can keep control? Yes/No - if yes please name the main ones How efficient are they?**	**Which are the key elements that make the vineyard a high risk case?**	**Are there innovative approaches/solutions that may significantly contribute to its control? If yes - please describe.**	**Referring to previous point: And if there are, why are they not mainstreaming?**	**Is everything known about causes? If no - please eplain.**	**Which ideal conditions would make the grapevine sufficiently resistant?**
Decrease vigor and fertilization in vines mangement. High quality and fitosanitarity vines in new plantations Protection on wounds pruning Other issues about vine management related to period and conditions of pruning	yes for Euthipa and dead-arm, no for others	separate pruning, removal of syntomatic plants, PPPs for Euthipa and dead-arm, BCA for others. In nursery: hot water treatment	different sensitivity but not 100% resistance	Trichoderma spp. -	Diverse sources of stress: high yield, water stress, bad pruning, low quality planting material- big wounds	planting material, management, Bcas	not completely known, not clear results	No. There is a long way to go in this subject. We need to understand how we can manage the vineyards to increase their resilience and to cohabit with fungi that are and will be endemic	Removal of infected vines; disinfect tools; gentle pruning, with small wounds, springtime-pruning
Removal and burning of affected bunches and shoots from the previous year, balanced application of fertilizers, mummies removal	different tools available: from empiric rules to most innovative DSS based on mechanistic modelling and actual weather data analysis	PPPs as for downy mildew	less sensitive, not 100% resistant	no	high vigor vineyard - high density - reduced ventilation - compact canopy - variety with compact bunches	DSS		Yes, why are there so virulence some years, resistances to fungicides?	Good canopy structure, optimal ventilation, disease management in the early season
Plant material free of virus in new plantations	no	no	??	No	Plant material	sterilization of pruning devices, thermoterapy	not always sufficient results	no, needed knowledge plant-pathogen interaction	Plant material free of virus
Removing and destroying of plant residues who present bacterial tumors. High quality vines	no	no	less sensitive	Agrobacterium rhizogenes K84	Infected materials, wrong pruning and mechanization management	sterilization of pruning devices, thermoterapy	No 100% efficient	no, needed knowledge- soil- plant-pathogen interaction	

ANNEX 2

Most common pests, their characteristics and management practices

Regions/countries where it is reported as problematic	**Latin name**	**Common name in English**	**How relevant is the damage it causes to the plant?** *(0=no at all 5=extremely relevant)*	**How relevant can the damage be on the economic performance of the vineyard (in terms of quantity or quality of production)?** *(0=no at all 5=extremely relevant)*	**How frequently is it relevant?** *(0= rarely, 1= every 4-6 years; 2= every 2-3 years; 3= every year)*	**Which climatic conditions lead to higher impact? Please describe.**	**Which soil and location conditions lead to higher impact? Please describe.**	**Which viticulture management practices lead to higher impact/risk? Please describe.**
Hungary, Spain, Bulgaria and Romania	*Calepitrimerus vitis Eriophyes vitis Eotetranychus pruni, Panonychus ulmi*	Spider mites, leaf bllister mite, Grape leaf rust mite, prapeleaf bud mite, grapevine yellow mite, grape gall mite, red spider	3	2,5	2	cold Springs and hot Summers, , while for red mite, yellow and bud mite warm and wet Springs are favorable	not clear	N abundance, high moisture in soil, compacted soil, use of pesticides that reduce beneficials, grafting with material from infested vineyards. Management of pruning material
all countries	Lobesia botrana - Eupocilia ambiguella	Grapevine moth	1-5	3-4	3	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
Spain, Hungary, Greece	Empoasca vitis	Smaller green leafhopper	1-3	2, 4 in Greece	3	high temperatures in June,		high vigor
Italy, Hungary but all countries as FD	Scaphoideus titanus ball	American Grapevine leafhopper	as vector of FD, not per se	as vector of FD	3	Mediterranean climate	no impact	wild/unmanaged vineyards
Italy and Greece	*Planococus ficus*	Med. Mealy bag	depends, increasing	high	increasingly frequent	higher temperatures, humid summer	vigor of the plant	N availability, compacted soils
Greece and Spain	*Thrips Tabaci / Frankliniella sp.*	trips	depends	can be high	2-3	no specific	wild areas nearby	avoid wild areas, facilitate ventilation in the canopy, weed control less irrigation
Italy and Bulgaria	*Phylloxera vastatrix*	leaf form of phylloxera	in some areas			hot and wet springtime	unmanaged vineyards	

-part 2-

Which prevention measures are advisable?	Is there a monitoring/forecasting system available? Please describe.	Which direct interventions (spraying or biological/physical systems) are used?	Are there more resistant varieties/ecotypes? Yes/No - if yes please name the main ones	Are there natural enemies that can keep control? Yes/No - if yes please name the main ones How efficient are they?	Which are the key elements that make the vineyard a high risk case?	Are there innovative approaches/solutions that may significantly contribute to its control? If yes - please describe.	Referring to previous point: And if there are, why are they not mainstreaming?	Is everything known about causes? If no - please explain.	Which ideal conditions would make the grapevine sufficiently resistant?
preservation of natural enemies, removal of pruning material, reduction of overwintering population	visual monitoring	Typhlodromus pyri ando other predatory mite release/preservation or acaricides	no	Several predatory mites	intensive use of pesticides (destroy natural enemies) and non control materials that may introduce the pest	biocontrol in some areas	no	natural enemies	balanced population of natural enemies, reduced use of pesticides to avoid detrimental effects on biodiversity, canopy management
moderate vigor in the vineyards, monitoring, removal of pruning materials	pheromon traps	Mating disruption, Bacillus thuringiensis kurstaki (Btk) and other BCA, chemical PPPs.	no, different sensitivity depending on cluster compactness	no	Presence of late varieties presenting large and compact bunches. High vigor of the plants	Mating disruption	price, collaboration among vinegrowers of the area	insect cycle and what influences it	balanced vigor of the canopy
balance canopy, cleaning of shoots	chromatic traps	several chemical PPPs	No	yes but not always syncronized and efficient	High N availability- intensive pesticides use			still several aspects to know	balanced environment and less N
monitoring, cleaning of shoots and vineyard	chromotropic traps	insecticides (natural and synthetic)	no, but different sensitivity	no		Vibrational interference (experimental)			
balanced vigor, no excess N, good drainage	pheromones traps	synthetic PPPs and mineral oils	not clear	Cryptolemus mantrouzieri, Anagrus pseudococci, Leptomastidea abnormis, Leptomastix flavus,Leptomastix dactylopii Moderate to low efficacy	poor biodiversity, high N availability, water excess	antagonistic insects release, new PPPs		biology	
avoid wild areas, facilitate ventilation in the canopy, weed control less irrigation	chromotropic traps	several PPPs	no	Orius spp.	weeds management			about weeds and insect cycle	beneficials presence
	pheromone traps	PPPs		yes several, not always sufficient	simplified environment	BCAs			