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The use of images of selected posters (p. 14) was approved by all first authors of posters via e-mail and Dr Latouche provided web link of his paper (p. 5).

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Contents

1. Abstract 4
2. Executive Summary 4
3. Summary of Workshop Sessions 5
   - 3.1 Invited lectures 5
   - 3.2 Epidemiology, disease detection and forecasting 6
   - 3.3 Plant-pathogen interactions, resistance and breeding 9
   - 3.4 Disease management 11
4. Field Visits 12
5. Outcome 13
   - 5.1 Main outcomes 13
   - 5.2 Communication 13
6. Recommendations 13
7. Figures 14

1. Abstract

Dr Tijana Petrovic attended the 7th International Workshop on Grapevine Downy and Powdery Mildew in Vitoria-Gasteiz, Spain, 30 June - 4 July 2014. Workshop was held in the Europa Palacio de Congresos, Vitoria-Gasteiz. She presented a poster and co-presented an oral paper. New information on the epidemiology, disease detection and forecasting, plant-pathogen interaction, resistance and breeding, and disease management of the diseases was presented in 34 papers and 19 posters. New information on qPCR (limits of detection and quantification) and hyperspectral imaging has been incorporated into current research project. The article "International research on downy and powdery mildew" (Scott *et al.* 2015) has been prepared for publication in The Australian & New Zealand Grapegrower & Winemaker Magazine.

2. Executive Summary

Downy and powdery mildew are the most threatening diseases of grapevine around the world, and better understanding of pathogens and their interactions with hosts lead to improved disease management. The International Grapevine Downy and Powdery Mildew Workshop is an opportunity for Australian researchers to exchange information on these diseases, to learn about the latest projects and the most recent international research developments. Seventy five delegates from 11 countries attended workshop, with most of them from Spain, France, Germany and Italy, one from Bulgaria, two from Israel, three from China, two from North and one from South America, and six delegates from Australia: Mrs Barbara Hall, Dr Trevor Wicks, Dr Eileen Scott, Dr Tijana Petrovic, Dr Bob Emmett and Dr Peter Magarey.

Sessions at the workshop covered epidemiology, detection and forecasting, plant-pathogen interactions, disease resistance and breeding, and disease management and control. In total, two invited lectures, 32 papers and 19 posters were presented, the latter supplemented with 2 min verbal presentations. Participants visited the Basque Institute for Agricultural Research and Development Neiker-Tecnalia (Day 2) located 6 km from Vitoria-Gasteiz, and vineyards and wineries in the Rioja Alavesa (Day 3) and Gipuzkoa (Day 4) regions. Rioja Alavesa is a hot, dry, inland region suitable for development of powdery mildew and Gipuzkoa is a cool, wet, maritime (Atlantic coast) region suitable for development of downy mildew. Participants also visited Laguardia, medieval city in the province Alava, the site of the 10th-century castle.

The workshop program, two invited lectures, slides for three oral presentations and two short talks that complemented posters can be viewed at http://gdpm2014.com/scientific-program. A report on the workshop has been prepared by Scott and co-authors for the Australian and New Zealand Grapegrower & Winemaker magazine. Information from the workshop has been shared with colleagues in the AGWA project "Objective measures for powdery mildew" (UA1202) and Dr Belinda Stummer (CSIRO). New information on qPCR (limits of detection and quantification) and hyperspectral imaging have been incorporated into the project "Objective measures for powdery mildew".

This visit was supported by funding from AGWA and Dr Tijana Petrovic. Participation in the workshop strengthened links with Italian and Israeli researchers and provided opportunities for collaboration on powdery and downy mildew. Benefits to the Australian grape and wine industry include knowledge of new research developments and findings, especially in the area of disease monitoring, forecasting and quantification of pathogen which will increase knowledge, improve training and consequently, disease management.

3. Summary of Workshop Sessions

The key points of selected presentations in each session which were of particular interest to me are summarized below. All oral and poster presentations have been summarized in detail in reports written by Dr Eileen Scott (project number GWT 1325) and Mrs Barbara Hall (project number GWT 1328).
Several presentations gave me an opportunity to interact and share knowledge with presenters. Some of those presentations were given by:

Odile Carisse
Highlights: (a) developed SYBR Green multiplex qPCR to improve quantification of airborne inoculum of *E. necator, P. viticola* and *B. cinerea,* and
(b) difficulty to recognize downy and powdery mildew on the same berry (pepper-corn and pea-size) and/or bunch under cool and humid conditions in Canada, mainly when observations are done in the morning instead of noon.
Impact on me: The quantification of three pathogens using multiplex qPCR prompted me to think that it may be important to develop multiplex qPCR to quantify *E. necator* and *B. cinerea* simultaneously in cooler and wetter areas of South Australia where wineries use low severity levels of both diseases, powdery mildew and botrytis bunch rot, as crop rejection thresholds.
Difficulty to recognize downy and powdery mildew on the same berry/bunch put my data on spectroscopic difference between *E. necator* and *P. viticola* into perspective.

Gwendal Latouche
Highlights: (a) detection and monitoring of downy mildew, and discrimination of disease from other biotic and abiotic stresses using a sensor for stilbene violet-blue fluorescence (Mx-330) and sensor for leaf chlorosis (Multiplex 3) (http://max2.ese.u-psud.fr/publications/Latouche_2014_Proceedings.pdf).
Impact on me: Possibility to explore similar approach that can complement and expand NIR/MIR spectral data of powdery mildew in the current project.

Sergio Rodriguez-Vaamonde
Highlights: (a) use of hyperspectral imagining to detect structural and functional changes in early stage of downy mildew development.
Impact on me: Same as Gwendal's presentation.

Emilio Gil
Highlights: (a) development of training tools to help farmers to select right nozzles and to use sprayer calibration software, and
(b) implementation of training system for sustainable use of plant protection products and application of phytosanitary equipment in developing countries of Eastern Europe (ISO standards).
More details on (ISO) standards were obtained from Claudia Ortugno (Syngeta, Italy) during question time and in the casual communication.
Impact on me: Updated knowledge on implementation of ISO standards.

3.1 Invited lectures

(A) Present situation of viticulture in Chile with special references to powdery and downy mildews - Latorre B.
Bernardo Latorre (Pontifica Universidad Catolica de Chile, Chile) provided an overview of the history of viticulture in South America, focusing on Chilean viticulture and wine production. Cabernet Sauvignon and Sauvignon Blanc are the most important cultivars in wine production, whereas the old French cultivar Carménere that was thought to be extinct, was re-identified in Chile. Powdery mildew (PM) and gray mould are the most important

diseases of grapevines. Downy mildew (DM) first appeared in southern Chile (Mediterranean climatic conditions) in 1992 and a few economically important outbreaks have since occurred. Wet winters followed by abundant rainfalls early in the growing season play a role in DM development. Powdery mildew has been the most important disease over the last decade. Sexual stage was discovered in 2004 in northern Chile (desert climatic conditions) and more aggressive isolates were introduced and established. The disease is controlled by application of protective fungicide after bud break until veraison, with warnings based on the Californian Gubler-Thomas model. The disease is managed largely by cultural practices, conventional fungicide spray programs, although biological alternatives (e.g. *Bacillus subtilis*) and other contact materials (e.g. $KHCO_3$, mineral oils) are being used in the vineyards that are subject to a low risk of disease.

(B) Assessment of spray application processes in vineyards around the world - Gil E.
Emilio Gil (Universitat Polytecnica de Catalunya, Spain) gave an overview of spray application practices and technologies in EU countries, Chile, Argentina, Australia and USA. He discussed the importance of using appropriate doses of applications and minimising spray drift by choosing different types of sprayers and nozzles. He highlighted the importance and difficulties to select the most suitable crop parameter for dose expression which is the product quantity in relation to the treated area. Live sensors are being used to determine canopy characteristics (height, width, volume) and allow variable rate application that takes into account the canopy volume. He summarised approaches used in various countries, *e.g.* the ground area dose (UK), tree row volume (some EU countries) and the unit canopy row (Australia). He explained the Leaf Wall Area (LWA) concept proposed by the European agrochemical manufacturing industry based on which the efficacy evaluation stage of pesticide registration will be harmonized across Europe. He emphasised the need to standardise methods for calculating application rates.

3.2 Epidemiology, disease detection and forecasting

Oral presentations

(A) Quantitative analysis of grape multi-diseases development: the ground work for improved management - Carrise O.
Odile Carrise (Agriculture and Agri-Food, Canada) discussed the implementation of integrated disease management programs in light of the organization and resulting yield losses of multiple pathosystems (PM, DM, Botrytis Bunch Rot-BBR). She applied the analytical approach to describe the development of PM, DM and BBR, and collected data from 2008 to 2011. Each pathogen was characterized based on the influence of weather conditions on each sub-processes of the infection cycles (e.g. inoculum potential from last year, survival potential, production of initial inoculum and nine more). Variables describing the cultivar and age-related susceptibility of both vegetative and berry growth were developed. The amount of airborne inoculum, disease severity and yield losses were used to estimate risk of each disease. Pathogen-, host- and weather-related variables were selected using correlation analysis, discriminant analysis and principal component analysis to discriminate among risk of PM, DM and BBR. Variables that best described combined diseases risk were: phenological stage of the vine, amount of inoculum, disease severity at harvest in the previous year and weather conditions at particular times. She pointed out that rapid and reliable methods of estimating disease severity at harvest and airborne inoculum during the growing seasons are required. Thus, her group has developed two qPCR assays using fluorescent hydrolysis probes: one to quantify sporangia of *Plasmopara viticola* and the multiplex assay to quantify conidia of *Erysiphe necator* and *Borytis cinerea* on spore traps.

(B) Inhibitor-free multiplex PCR for the simultaneous detection of *Plasmopara viticola* and *Erysiphe necator* spores in environmental samples - Huerga *et al.*

Anna Maria Díaz-Navajas (NEIKER-Tecnalia, Vitoria-Gasteiz, Spain) reported an improved protocol for multiplex end-point PCR used for detection and identification of *P. viticola* and *E. necator* airborne spores captured on coated glass slides 1m above the grape canopy. Fungicide residues and inhibitory compounds adhered to glass slides were eliminated by washing steps prior to spore lysis and DNA release using buffers containing EDTA-BSA and diethyldithiocarbamate. This method allows monitoring the presence and the severity of an infection in the vineyard, before the symptoms appear.

(C) The web module "VitiMeteo Monitoring": A valuable addition to the downy and powdery mildew forecasting models - Bleyer *et al.*
Bleyer *et al.* (State Institute for Viticulture and Oenology, Freiburg, Germany) gave an update on a platform for forecasting models and weather data (VitiMeteo) (www.vitimeteo.de), which is now in regular use in central Europe (Germany, Belgium, Switzerland, Italy and the Czech Republic). The web module "VitiMeteo Monitoring" is developed for the wine observers to enter their field assessments online. The field observations currently include diseases and pests in five damage classes (0-4), phenology stage according to the BBCH scale, plant protection treatments, lack of nutrients, vineyard works and weather conditions. An important input is the primary infection of DM and PM. With this information an early warning system has been established. The advantage of "VitiMeteo Monitoring" is that the field observations are immediately available for advisors and wine growers on the internet. The interaction between the model platform "VitiMeteo" and observation platform "VitiMeteo Monitoring" will enable a continuous validation and improvement of "VM models".

(D) Modelling of powdery mildew spread over a spatially heterogeneous growing grapevine - Calonnec *et al.*
Agnes Calonnec (INRA Bordeaux, France) presented results on development of a coupled PDEs-SEIRT model (Partial Differential Equations model including spore dispersal and Susceptible, Exposed, Infections, Removed, Ontogenic resistance model). This model includes biological parameters for pathogen development and plant growth taking into account the evolution of crop susceptibility (e.g. age-related resistance) and agricultural practices (e.g. shoot topping, fungicide). Authors tested if PDEs-SEIRT model is able to generate and explore the influence of host heterogeneities on epidemics spread control at the plot scale: heterogeneities within plot and between plots (e.g. phenology, vigour, plant resistance, spatial organization). The efficacy of spatial disease management strategies appears to be higher when heterogeneities in host population increase. Disease reduction increases when plant heterogeneities are distributed in rows rather than in patches. Simulations predicted that epidemic speed can be significantly reduced for both, mixture of resistant and susceptible plants and, remote susceptible plats scattered among resistant plots when short distance dispersal is combined with stochastic long range dispersal. Preliminary approach of simulations with fungicide use, authors showed that one fungicide applied early at flowering can reduce approx. 81% the diseased area at the end of the season by delaying the epidemic onset. It can also maintain a low level of disease at a key period when the dispersion of the pathogen from leaves to bunches can be detrimental.

(E) Early detection of downy mildew in vineyards based on hyperspectral imaging - Picon *et al.*
Sergio Rodriguez-Vaamonde and colleagues (Tecnalia Computer Vision, Spain) proposed using near-infrared (NIR) (970-2500nm) hyperspectral imaging that allows early detection of DM. Authors showed that, in a DM inoculated leaves, the infected areas present a distinctive appearance but this appearance was not discriminative enough to properly distinguish among early staged diseases. The use of spatial and spectral discriminative features make possible to extract the subtle structural (e.g. growth of the fungal mycelia inside the leaf) and functional (e.g. spectral component) information that allow the detection of DM at early stages. Authors examined 16 inoculated leaves with *P. viticola*. The database was divided

into training and test subsets, where 16% of the images were selected as training and 86% as testing. At each image pixel, the proposed spectral-spatial descriptors were extracted. The overall accuracy, measured in terms of number of pixels evaluated correctly, was 97.98%.

Poster presentations

(A) Multi-seasonal mildew development: potential mildew risk and sampling for fall mildew incidence - Carrise O.

Dr Carisse discussed the relationship between DM incidence in the fall and disease development the following spring, especially the amount of initial inoculum and the time of disease onset. Sequential sampling procedure (SSP) was one of four sampling procedures developed and chosen for evaluation based on the Monte-Carlo simulations. It provided the appropriate classification in 95% of the simulations when validation was done with no data used for construction of the model. The SSP could be used to provide early warning about risk of DM and as a tool to evaluate the efficacy of DM management. This information could be used to determine the most appropriate strategy to manage DM the following spring.

(B) Detection of downy mildew in the field on grapevine leaves using a new portable fluorescence sensor - Latouche *et al.*

Gwendal Latouche (Universite Paris Sud, France) presented results on verifying whether portable sensor for stilbene VBF, Multiplex 330 (Mx-330) (FORCE-A, Orsay, France) could be used in the vineyard to detect DM (Fig. 1). Stilbenes (phytoalexin of grapevine) are not present in healthy leaves and their synthesis and accumulation is induced by *P. viticola*. They display violet-blue fluorescence under UV-light. Fluorescence signals remained constant on control leaves, whereas a statistically significant transient increase in VBF was detected on infected leaves starting at 6 day after inoculation with a maximum between 9 and 20 day after inoculation. The signal was weaker on the adaxial than the abaxial surface.

(C) A preliminary study of the populational variability of determined fungal pathogens in northern and northwestern Spain - Fernández *et al.*

Fernández *et al.* (Misión Biológica de Galicia, Pontevedra, Spain) presented preliminary results on different populations and races of *P. viticola, E. necator* and *B. cinerea* in different winemaking areas of northern Spain, and whether the same races predominate year after year. Different populations of *P. viticola* and *B. cinerea* were studied by PCR of the microsatellites and the Boty and Flippe transposable elements, respectively. The primer pair mO3E11 was used to identify *E. necator* groups A and B in PCR. Genetic diversity of *B. cinerea* and *E. necator* was low, whereas several races of *P. viticola* were detected. *E. necator* samples were homogenous and belonged to group B that is associated with later symptoms.

(D) Concentration of airborne spores of *Plasmopara viticola, Erysiphe necator* and *Botrytis cinerea* in different regions of Galicia (Northwestern Spain) - Boso *et al.*

Boso *et al.* (Mision Biologica de Galicia, Spain) discussed the type and concentration of airborne spores of *P. viticola, E. necator* and *B. cinerea* in different areas of warm and humid Galicia where susceptible varieties are grown (Fig. 2, left). Knowledge about type and concentration of spores may allow better assessments of the risk of the DM, PM and BBR, and therefore the more rational use of crop protection treatments. Combining those information with meteorological data may allow treatment calendars to be appropriately adjusted. Authors reported that spores of *B. cinerea* were most common, particularly during flowering and ripening, followed by the *E. necator* spores that were abundant between flowering and budset, and the least abundant were spores of *P. viticola* with slight increase in number at flowering and *verasion*. Large differences were seen between airborne spore concentrations, depending on the topography of the area where traps were located.

(E) VitiMeteo-Plasmopara a valuable tool to better control downy mildew in grape - Dubuls *et al.*
Pierre-Henri Dubuis and colleagues (Agroscope, Switzerland) provided validation results of VM-Plasmopara model that simulate the main developmental steps of *P. viticola* in Switzerland, showing that model has been highly reliability during last 11 years. Outputs of the model were compared to observations made in the lab and in a small untreated experimental plot. Predicted DM development was in accordance with disease appearance and progression in the experimental plot. For the primary infection forecasting the model was right 7 out of the 11 years, too early 3 years and too late only 1 year. However, improvement will only be possible if the conditions required to have oospores maturation and germination in spring is better understood. Growers using VitiMeteo were able to manage downy mildew with fewer fungicide applications (0-4 compared with 8-12).

Delegates from the USA (e.g. Oregon State University & University of California) who developed LAMP PCR for detection-based management programs for powdery mildew in vineyards were not present. Their latest findings on LAMP method were available at http://www.oregonwine.org/media/131209/mahaffee_2014-1398.pdf (Mahaffee & Thiessen, 2014) and manuscript for journal Phytopathology is in press.

3.3 Plant-pathogen interactions, resistance and breeding

Oral presentations

(A) Early cellular events during grapevine downy mildew infection – Nick P.
Peter Nick (Karlsruhe Institute of Technology, Germany) gave an overview on early cellular events in host-pathogen interaction where specific host receptors are able to recognize pathogen effectors and to trigger defence (effector-triggered immunity). He highlighted two targets in host-pathogen interaction: (a) divert the pathogen and (b) activate the actin cytoskeleton. A novel pattern was observed on wild *Vitis* from China and Japan and German accessions of *V. vinifera* subsp. s*ylvestris* when the pathogen is diverted – zoospores failed to locate the guard cells and then formed an aberrant mycelium on the surface of the leaf. This happens because of emission of small aldehydes (nonanal and decanal) and consequently, the infection by *P. viticola* is supressed. As a result, this trait can be inserted into cultivated grapevine by marker-assisted breeding. Activating the actin cytoskeleton (early cellular factor for plant defence) provides a strategy to engineer defence-related hypersensitive response in otherwise susceptible genotypes of grapevine. Research group has generated a transgenic actin marker line for grapevine. Upon inoculation with fluorescently labelled strains of phytopathogenic bacteria, actin responses were confined to the guard cells. In contrast, upon contact with zoospores of *P. viticola*, the guard cells dominated the responses of the remaining epidermal cells, responding by formation of a perinuclear actin basket.

(B) Early events in the interaction between grapevine (*Vitis vinifera*) and downy mildew (*Plasmopara viticola*) - Müller *et al.*
Malke Müller (RLP AgroScience/AlPlanta-Institute for Plant Research, Germany) established tests for early events to analyse molecular and physiological parameters of the host and the pathogen, and consequently, developed host molecular markers. The time courses of expression of VvWRKY33 (transcription factor) and the promoter of the gene coding for VvPR10.1 were analyzed after infecting leaf tissue from potted vines with different susceptibility using qRTPCR. Comparison of early events showed that sporulation of *P. viticola* was most intense on the susceptible Muller Thurgau, less intense on Regent due to the inherited resistance locus from American wild *Vitis rupestris* ancestors and was absent from the resistant *V. rupestris*. The gene activity of *WRKY33* in the resistant *V. riparia* was induced early and reached a maximum early, in the tolerant 'Regent' lagged a little bit and in the susceptible 'Mueller-Thurgau' was induced quickly, but did not reach the levels of the tolerant or resistant varieties. The expression of *PR10.1* followed a similar pattern. As these

features occurred in the susceptible and moderately resistant genotype, but were less sustained, it may be that pathogen effectors play an important role.

(C) Role of necrosis and ethylene inducing proteins in early infection stages of the obligate biotrophic oomycete *Plasmopara viticola* - Schumacher *et al.*
Stefan Schumacher and colleagues (State Institute for Viticulture and Enology, Germany) examined the role of necrosis- and ethylene-inducing peptide 1 (NEP1)-like proteins (NLPs) in *P. viticola* given that their role is unknown in obligate biotrophs unlike in many necrotrophic and hemibiotrophic pathogens. NLPs may contribute to pathogenicity and virulence. Three potential coding regions of NEP1-like proteins were indentified in *P. viticola*. Molecular- and bioinformatic analysis revealed differences in DNA and subsequent amino acid sequence of these three genes. Natural mutations were identified which led to collecting different *P. viticola* cultivars from resistant and susceptible vines and their analysis for polymorphisms inside *NLP* coding genes. Studies of gene expression suggested that NLPs may have a role early in infection, but they do not induce a hypersensitive response.

(D) Breeding for durable resistance to downy and powdery mildewsin grapevine - Wiedemann-Merdinoglu *et al.*
Sabine Wiedemann-Merdinoglu (INRA, Colmar, France) provided an update on breeding for durable resistance to DM and PM. Pyramiding resistance genes is a strategy which can be used to monitor the risk of resistance breakdown. Consequently, authors have chosen to use multiple sources of resistance as genitors. They have also analyzed the genetic determinism of most of the employed sources. The overall process of selection is organized into three steps and takes sixteen years. Authors will propose first varieties for registration in 2016.

(E) Rescue to be rescued: European wild grape as genetic resources of resistance towards fungal diseases? - Tisch *et al.*
Christine Tisch (DLR Rheinpfalz, Germany) has been examining the European wild grape (*Vitis vinifera* subsp. *silvestris*) that survived only in a small population (100 individuals) on the peninsula “Ketsch” at the Rhine river, south-west of Germany. The genetic identity of these individuals is endangered by introgression from its cultivated descendant. After validation based on SSR markers to avoid genotypes that are not autochthonous or are the result of hybridisation with cultured grapes or rootstocks, wild grapes were characterised based on their potential resistance towards fungal pathogens. All genotypes with a sufficient amount of propagated plants were screened for resistance towards DM, PM and black rot (*Guignardia bidwellii*). The variety Müller-Thurgau was fully susceptible to all pathogens tested. The variety Regent was resistant to DM and PM but was susceptible to black rot. The new resistant variety Solaris had reduced development of DM on leaf discs compared with the susceptible check Muller-Thurgau. This was associated with accumulation of phenolic compounds around the stomata of the resistant genotype(s). The response of selected *V. vinifera* ssp. *sylvestris* to *P. viticola* and *E. necator* was intermediate between the resistant and susceptible varieties.

(F) Insights in the temporal and spatial course of infection events of grapevine powdery mildew reveal resistant and susceptible grapevine genotypes - Tisch *et al.*
Christine Tisch examined the response of different grapevine genotypes to infections by *E. necator*. She presented results on the temporal and spatial development of the pathogen from germinated conidia up to the start of the host surface colonization. She has used the Low-Temperature-Scanning-Electron-Microscopy (LTSEM) to illustrate the pathogen structure during the specific stages of conidia germination, infection and colonization. Leaf disks of *Vitis vinifera* cv. Müller-Thurgau and *Vitis riparia* were inoculated with *E. necator* conidia and hourly sampled over a time period of 19 h after inoculation. Afterwards the sampling was carried out every 12 h. *E. necator* conidia were able to germinate on both genotypes and to develop appressoria at a simultaneous time course. However, the frequently observed abnormal appressorium shape on *V. riparia* indicated differences in the

interaction with the host plant. Differences between *V. vinifera* and *V. riparia* became evident at the development and growth of the primary and secondary hyphae. On the genotype *V. vinifera* which is designated as susceptible to PM, *E. necator* colonized the host surface by rapid tip growth and branching of the hyphae. The wild *Vitis* species, *V. riparia* seemed to be able to respond to an infection with resistance mechanisms which restrain the spread of PM and the formation of an extended mycelium.

(G) Evolution of grapevine downy mildew (Plasmopara viticola) aggressiveness in response to host partial resistance – Delmotte *et al.*
Francoise Delmotte and colleagues (INRA, Villenave d'Ornon, France) presented results on aggressiveness in grapevine DM in a cross inoculation experiment using quantitative traits (e.g. disease severity, sporangia production and size, latent period, rate of zoospore liberation). They found that (1) most of the *P. viticola* isolates collected on different resistant varieties exhibited significantly higher sporulation than isolates from susceptible varieties; (2) isolates from resistant and susceptible varieties had similar levels of aggressiveness in terms of sporulation on the susceptible Cabernet Sauvignon; (3) increase in sporangia number was correlated with a reduction in their size. Authors highlighted that *P. viticola* aggressive isolates from various resistant varieties exhibit a high level of sporulation on partially resistant genotypes but there was no significant cost of virulence. They concluded that *P. viticola* populations may rapidly evolve to adapt to partially resistant grapevine varieties and the quantity of sporangia produced and their size are the key traits involved in the adaptation process.

Poster presentations
(A) Early cellular events during grapevine downy mildew infection - Tröster V.
Viktoria Tröster (Karlsruhe Institute of Technology, Germany) presented results on using different *Vitis* genotypes to identify unique and specific resistance mechanisms, and using a cell culture system to examine early cellular events of pathogen perception and signaling in response to pathogens (Fig. 2, right). Her results complemented Peter Nick's talk.

(B) Rapid and multiregional adaptation of grapevine resistance in European populations of *Plasmopara viticola* - Delmotte *et al.*
Delmotte presented a poster that complemented his talk. He assessed the level of adaptation of *P. viticola* to partially resistant grapevine varieties by combining phenotypic and genetic data (Fig. 3, left). Author determined whether populations of *P. viticola* infecting resistant varieties have adapted to their hosts, and whether the deployment of these resistances can modify the genetic architecture of *P. viticola* populations. Adaptation to overcome partial resistance of Regent has occurred independently in three wine regions in France within 5 years of planting the variety, which is a cause for concern to resistance breeding programs.
Paper written by Delmotte at al. is in press in journal Infection, Genetics and Evolution

(C) Quantification of sporangia and zoospore production in a plat pathogen oomycete using an automatic particle analyser – Delmas *et al.*
Chloe Delmas (INRA, Villenave d'Ornon, France) presented a quick-and-easy method, using an automatic particle analyser, to simultaneously quantity sporangia and zoospore production (Fig. 3, right). Author determined two well separated peaks for sporangia and zoospore particle number in two different size ranges. Method can be used to estimate infection potential of *P. viticola* and other zoosporic pathogens.
Paper written by Delmas et al. is in press in Journal of Microbiological Methods

3.4 Disease management (biological control)

Oral presentations
(A) Is using intercrops as source of biological agents against grapevine powdery mildew pressure a promising hypothesis? Lafond D. and Cantin C.

David Lafond (IFV Val de Loire Centre, France) presented a concept of using an intercrop to provide an abundant population of mycoparasite *Ampelomyces* and microphagous mite *Orthotydeus lambi* in the vineyard to control PM. The use of *Ampelomyces* to control PM can be limited by several factors, e.g. the necessity to time the *Ampelomyces* applications with the beginning of PM epidemic, adequate humidity since *Ampelomyces* requires a high humidity etc. Intercrop plants need to be infected by another PM fungus before the vine, to let population of *Ampelomyces* to build up. The concept is that *E. necator* will infect grapevine and an immediate parasitism by *Ampelomyces* will be possible. The author hypothesized that the similar approach can be applied for mite *Orthotydeus lambi*. This approach of PM control can be alternative to the use of sulphur in 5% of certified organic vineyards in France.

(B) Effectiveness of alternative compounds in the control of grape downy mildew caused by *Plasmopara viticola* - Romanazzi *et al.*
Gianfranco Romanazii and colleagues (Marche Polytechnic University, Ancona, Italy) explored possibility to use natural products (chitosan, laminarin, bentonite, earthworm humus, extract of *Saccharomyces* spp. and rhizosphere microorganisms) to control DM due to the restrictions to use copper in organic agriculture in European countries. Authors tested and compared effectiveness of chitosan (biopolymer; oligosaccharide elicitor) with copper based products and untreated control in a vineyard of the var. Montepulciano. In total, there were 11 applications and treatments were repeated weekly from mid May to late July in 2012 and 2013. In an unfavorable year for DM (2012), good protection of grapes was achieved by chitosan, laminarin plus low copper rates, and the alternation of the later combination with the mixture of laminarin and *Saccharomyces* spp. extracts. In a favorable year for DM (2013), good protection of grapes was achieved by copper along with chitosan, laminarin plus copper rates and with *Saccharomyces* spp. extracts. Consequently, chitosan can be a good alternative to copper and can contribute to an integrate management of DM in conventional agriculture.

4 Field Visits

Neiker-Tecnalia (1 July)

Workshop participants visited Neiker-Tecnalia, the Basque Institute for Agricultural Research and Development, which is a non-profit state-owned company assigned to the Department of Environment, Regional Planning, Agriculture and Fisheries of the Basque Government. It was founded in 1852 and it has 182 staff in two sites, Bilbao and Vitoria-Gasteiz, and owns 72 ha of farmland to conduct agricultural research and development. The head of Neiker-Tecnalia gave an overview of R&D on animal husbandry and crops such as cereals, potato, vines, forest and forestry, soil health and the environment and natural resources. They provide analytical services and organize technology transfer.
This overview was followed by a presentation from the head of viticulture at Organisation International de la Vigne et du Vin (OIV) (www.oiv.int). He outlined activities relating to climate change, plant protection, reduction of pesticides in viticulture using models, the process for clonal selection of vines and the challenges of standardising fungicide application, as was discussed by Emilio Gil in the invited lecture.

Rioja Alavesa (2 July)

Participants travelled inland to Rioja Alavesa, the province of Alava (Fig. 4, left). Mr Antonio Remesal Villar presented the history of the region and the influence of Bordeaux. He gave an overview of viticulture and wine production in La Rioja that comprises Rioja Alavesa, Basque and Navarre regions. La Rioja is surrounded by 64 000 ha of vineyards and predominant variety is Tempranillo, grown on 50 500 ha without irrigation, followed by Garnacha and Mazuelo. White varieties Viura, white Garnacha and Malvasia are grown sporadically. Carbonic maceration is common and those vines have short shelf-life.

Participants visited Eguren Ugarte winery that owns 130 ha of vineyards in the foothills of the Sierra Cantabria (Fig. 4, left). After lunch at Eguren Ugarte, participants had a short tour in the vineyard (Fig. 4, right).
Participants visited Laguardia, medieval city in the province Alava, the site of the 10th-century castle. The visit of Rioja Alta winery followed, where the head of viticulture explained operations. Monitoring of diseases by humans is eliminated and teledetection and remote sensing are used to assess canopy vigour, whereas PM, DM and other diseases are predicted using weather-based models. The head of winemaking mentioned the use of mid-infrared spectral scanning (WineScan FT 120 Foss Electric) to assess contamination by Botrytis, and consignments containing gluconic acid and glycerol due to 5-10% contamination are rejected.

Gipuzkoa (3 July)

Participants visited Gipuzkoa on the Atlantic coast, where the topography is steeply sloping and the climate is wet (1000-2000 mm rain per year) and windy (Fig. 5, left). Vines are grown on a traditional pergola trellis and they are trimmed regularly, leaves are removed from the fruit zone to promote air movement and drying of bunches (Fig. 5, right). Downy mildew is the most common disease problem and is managed by regular spraying from equipment small enough to navigate the steep topography (Fig. 6).

5 Outcome

5.1 Main outcomes

Knowledge about new research developments and findings, especially in the area of disease monitoring and forecasting, will improve education, training and consequently, disease management. The article "International research on downy and powdery mildew" (Scott *et al.* 2015) has been prepared for publication in The Australian & New Zealand Grapegrower & Winemaker Magazine. Information from the workshop has been shared with colleagues in the AGWA project "Objective measures for powdery mildew" (UA1202) and with Dr Belinda Stummer (CSIRO).
New information on qPCR detection and quantification levels and hyperspectral imaging also has been incorporated into the project "Objective measures for powdery mildew".

Participation in the workshop strengthened links with Italian and Israeli researchers and provided opportunities for collaboration. If opportunity arises, collaborative project can be initiated between Israeli (Dr Mery Dafny-Yelin, Golan Research Institute, Haifa University; Dr Tirtza Zahavi, Shaham, Ministry of Agriculture, Northern Region) and Italian scientists (Dr Gianfranco Romanazii) to test natural products (e.g. laminarin, chitosan, bentonite etc.) to control PM and gray mold in Australian organic vineyards and/or to control PM and DM in vineyards in the Golan region, Israel.

5.2 Communication

The article "International research on downy and powdery mildew" (Scott et al. 2015) has been prepared for the Australian and New Zealand Grapegrower & Winemaker magazine. The program and selected presentations at the workshop are available at http://gdpm2014.com/scientific-program

6 Recommendations

That links established during the workshop be maintained and that Australian and overseas scientists mutually keep abreast of developments and findings. That AGWA continues to support early career researchers to attend conferences to aid professional development and establishment of networks in the research community.

7 Figures

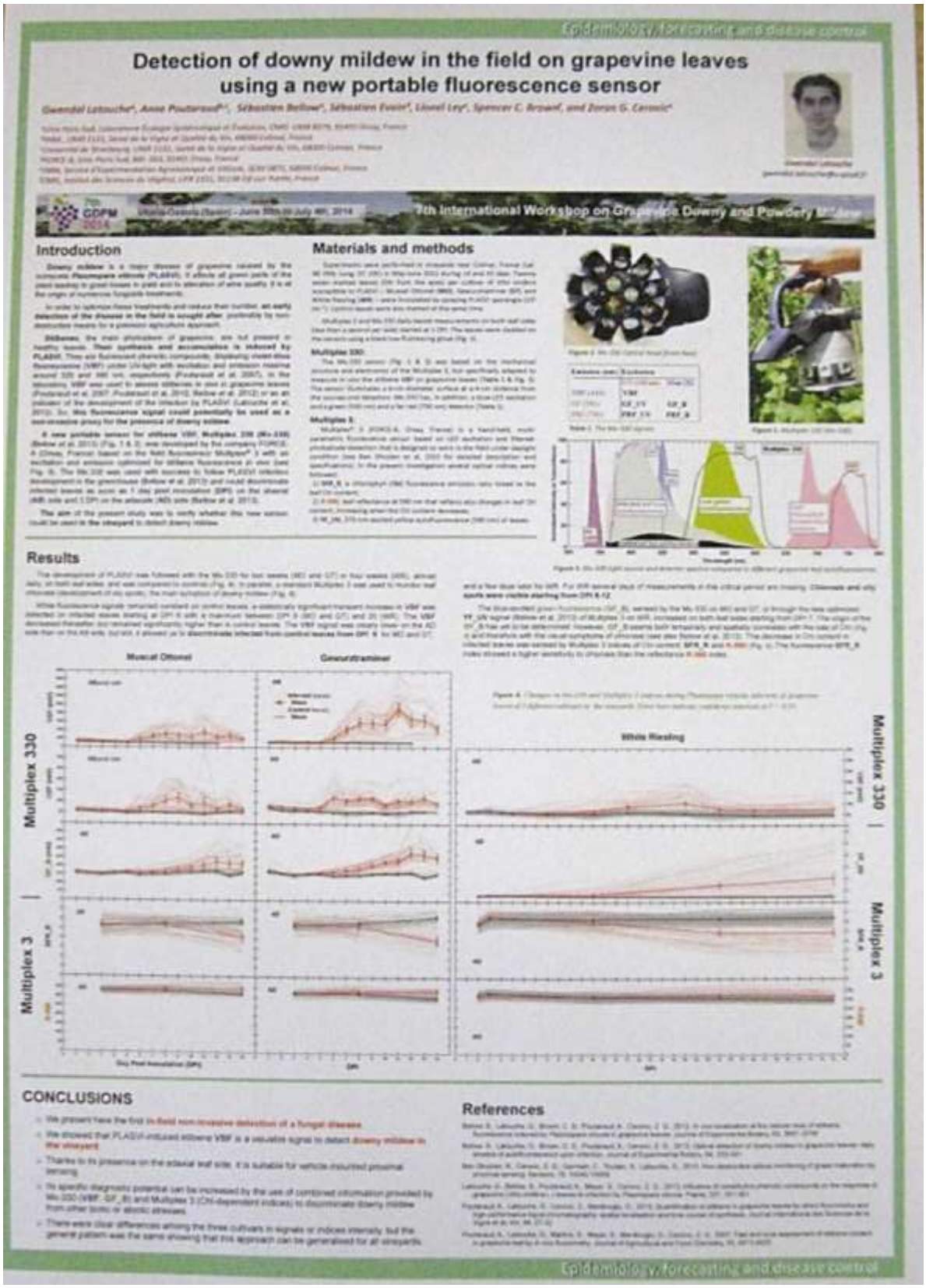
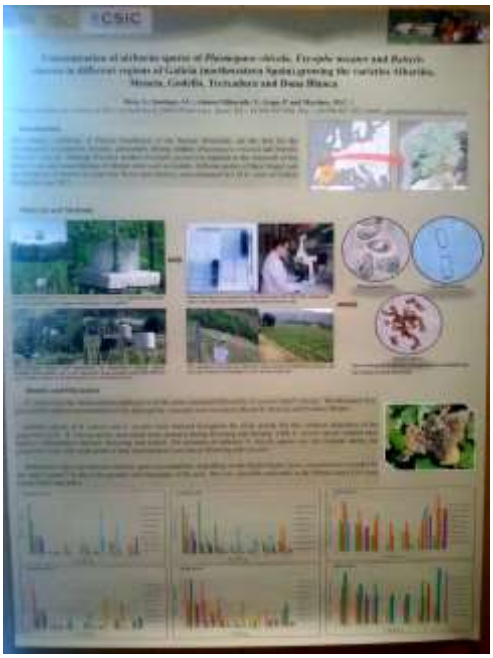


Fig. 1 Latouche et al. Detection of downy mildew in the field on grapevine leaves using a new portable fluorescence sensor



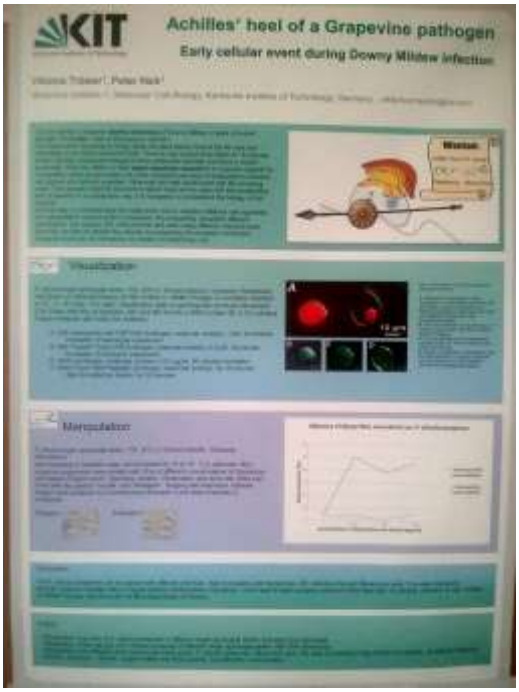
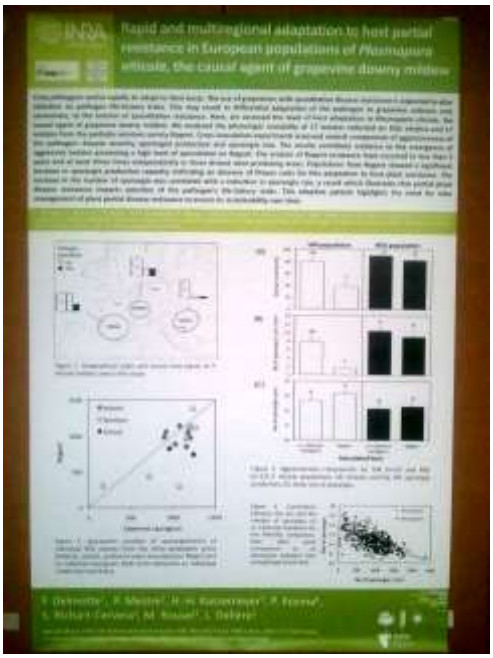


Fig. 2. Boso *et al.* Concentration of airborne spores of *P. viticola, E. neactor* and *B. cinerea* in different region of Galicia (Spain) (left) and Tröster V. Early cellular events during grapevine downy mildew infection (right)



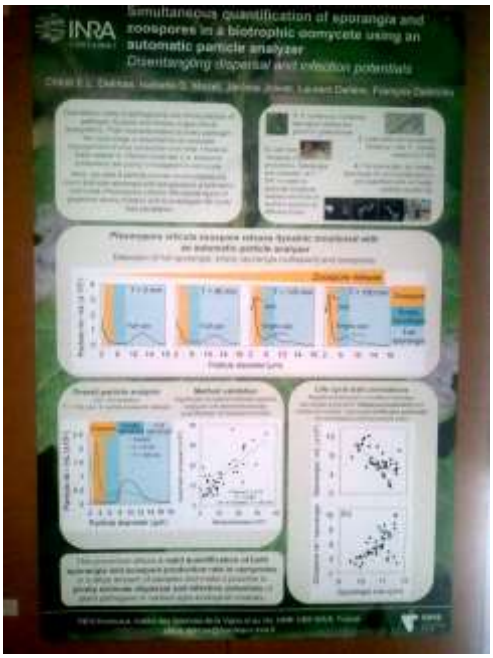


Fig. 3. Delmotte *et al.* Rapid and multiregional adaptation to grapevine resistance in European populations of *P. viticola* (left) and Delmas *et al.* Quantification of sporangia and zoospore production in plant pathogen oomycetes using an automatic particle analyser (right)





Fig. 4. Vines in Rioja Alavesa, inland, south of Vitoria-Gasteiz (left) and vineyard in Eguren Ugarte winery (right)





Fig. 5 Vines in Gipuzkoa, Atlantic coast, north of Vitoria-Gasteiz (left) and pergola type of vineyard (right)



Fig. 6 Sprayer used in a pergola trellis on steep terrain