THE UNIVERSITY of ADELAIDE

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Australian Grape and Wine Authority

Participation in the 7th International Workshop on Grapevine Downy and Powdery Mildew, Vitoria-Gasteiz, Spain, 30 June - 4 July 2014

FINAL REPORT to

AUSTRALIAN GRAPE AND WINE AUTHORITY

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Contents

1. Abstract

Dr Eileen Scott attended the 7th International Workshop on Grapevine Downy and Powdery Mildew in Vitoria-Gasteiz, Spain, 30 June - 4 July 2014, and co-presented one oral paper and two posters. New information on the biology, epidemiology and management of the diseases was gained from the 34 papers and 19 posters presented. The program and selected presentations are available at http://gdpm2014.com/scientific-program. New information has been incorporated into current research projects and university lectures. An article has been prepared for publication in an industry journal.

Existing networks between Australian and international researchers were strengthened and new links were established.

2. Executive Summary

Improved management of powdery and downy mildew, two serious diseases that affect the Australian grape and wine industry, requires deeper understanding of the biology of the pathogens and the diseases. The International Grapevine Downy and Powdery Mildew Workshop, which is held every 3-4 years, is an important opportunity for Australian researchers to exchange information on these diseases and keep abreast of the latest research findings internationally. Most of the 75 delegates were from European countries. Six delegates were from Australia and two were from the USA, down from 10 and 7, respectively, at the 2010 workshop, whereas participation by Chinese researchers was strong. Three of the Australian delegates, Mrs Barbara Hall (SARDI), Dr Tijana Petrovic and Dr Eileen Scott (University of Adelaide) received travel support from AGWA to attend the workshop. Drs Bob Emmett (RW Emmett Pty Ltd) and Peter Magarey (Magarey Plant Pathology) were members of the workshop scientific committee.

Sessions at the workshop covered epidemiology (including detection and forecasting), plant-pathogen interactions, disease resistance and grape breeding, and disease management and control (including fungicides and biological control). In total, two invited lectures, 32 offered papers and 19 posters were presented, the latter accompanied by short verbal presentations, and social activities provided opportunity for networking. Participants visited the Basque Government agricultural research and development institute, Neiker-Tecnalia, on the outskirts of Vitoria-Gasteiz, and vineyards and wineries in the Rioja Alavesa and Gipuzkoa regions to the South and North of Vitoria-Gasteiz, respectively. Rioja Alavesa illustrated a hot, dry, inland region and Gipuzkoa, a cool, wet, maritime (Atlantic coast) region.

The workshop program and slides presented by the invited speakers and a few other presenters can be viewed at http://gdpm2014.com/scientific-program along with a gallery of photographs taken during the workshop. A report on the workshop has been prepared for the Australian and New Zealand Grapegrower and Winemaker magazine. Information from the workshop has been shared with colleagues in the AGWA projects Objective measures for powdery mildew (UA1202), Understanding fungicide resistance in powdery and downy mildew (SAR1204) and Relative sustainability of organic, biodynamic and conventional viticulture (UA1102). New information also has been incorporated into Eileen Scott's lectures on grapevine diseases presented to undergraduate and postgraduate coursework students at the University of Adelaide.

This visit was supported by funding from AGWA, the University of Adelaide and Dr Eileen Scott. Participation in the workshop strengthened links with international researchers and provided new opportunities for collaboration, particularly with European and Chinese

researchers. Benefits to the Australian grape and wine industry include knowledge of new research findings, which will enhance education and training and, ultimately, disease management.

3. 7th International Workshop on Grapevine Downy and Powdery Mildew

The workshop attracted approximately 75 delegates, six of whom were from Australia (Fig. 1). Sessions were held at the Europa Palacio de Congresos, Vitoria-Gasteiz, the capital of the Basque Region of Spain, with visits to Neiker-Tecnalia (1 July) and field trips inland to Rioja Alavesa (2 July) and to Gipuzkoa on the Atlantic coast (3 July). A summary of the key points of presentations in each session is provided below.

3.1 Invited lectures

Viticulture in Chile, with reference to downy and powdery mildews, by Bernardo Latorre (Pontifica Universidad Catolica de Chile).
Dr Latorre provided an overview of viticulture in Chile, where Cabernet Sauvignon and Sauvignon blanc are the most widely cultivated varieties. Annual rainfall ranges from about 10 mm in the north to 1000 mm in the south, and about 80% of vines are irrigated. Downy mildew first appeared in Chile in the early 1990s and there was an epidemic in 1997, but outbreaks have been sporadic and relatively minor since then. Powdery mildew has been the most important disease over the last decade. Temperature is the main driver of disease as rainfall is typically scarce, and risk is predicted the Californian Gubler-Thomas model. Powdery mildew is managed largely by cultural practices and conventional fungicide spray programs, although alternatives and biological agents are being used in drier regions where risk is reduced.

Assessment of spray application processes worldwide, by Emilio Gil (Universitat Polytecnica de Catalunya, Spain).
Dr Gil presented a summary of spray application practices and technologies in major viticultural regions of the world, including Australia. He discussed the importance of using appropriate rates of applications and minimising spray drift, and summarised approaches used, such as the ground area dose (used in the UK), tree row volume (used in some European countries) and the unit canopy row (Australia). 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 emphasised the need to standardise methods for calculating application rates. He also briefly mentioned the TOPPS (train operators to promote practices for sustainability) program (http://topps-drift.org).

3.2 Epidemiology, disease detection and forecasting

Epidemiology, detection and prediction of powdery mildew, downy mildew and, to a lesser extent, botrytis bunch rot were discussed in nine papers and eight posters (day 1, 30 June and day 4, 3 July).

3.2.1 Multiple diseases

Odile Carisse (Agriculture and Agri-Food, Canada) discussed the need for risk indicators and decision rules to guide fungicide application. She has collected data for experimental plots of five north American varieties in which downy mildew, powdery mildew and botrytis bunch rot were managed or not from 2008 to 2011. The proportion of area of leaves and berries affected was assessed and airborne inoculum monitored. Many variables were analysed using correlation analysis, discriminant analysis and principal component analysis. Variables that best described disease 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 noted that more reliable means of estimating the amount of airborne

inoculum during the growing season and disease severity at harvest are required. Her group has developed multiplex qPCR assays to quantify (i) sporangia of *Plasmopara viticola* and (ii) conidia of *Erysiphe necator* plus *Botrytis cinerea* caught in spore traps. Although working with multiple diseases simultaneously is complex, progress is being made towards developing models to estimate risk. Dr Carisse also presented a poster on the influence of covering vines with soil during winter to protect them from frost damage on subsequent risk of downy mildew development. Greater incidence of downy mildew in autumn was associated with earlier and more severe symptoms the following spring. Sequential sampling of vines for disease and complex mathematical analyses, including Monte Carlo simulations, were used to determine the probability of correctly estimating incidence of downy mildew.
Also in the poster session, Boso and colleagues (Mision Biologica de Galicia, Spain) reported concentrations of spores of *Plasmopara viticola*, *Erysiphe necator* and *Botrytis cinerea* in the warm, wet climate of Galicia, north-west Spain where susceptible varieties are common. Airborne spores were caught on sticky glass slides and identified by microscopy. Despite large variation in the data, spores of *B. cinerea* were most common, particularly during flowering and ripening, whereas those of *E. necator* were abundant between flowering and berry set. This group also reported preliminary studies on population variation amongst these three pathogens in north and northwest Spain; genetic diversity of *B. cinerea* and *E. necator* was low, whereas several races of *P. viticola* were detected.
Anna Maria Diaz-Navajas reported a protocol for multiplex end-point PCR to detect downy and powdery mildew spores in environmental samples captured on coated glass microscope slides 1 m above the grapevine canopy. The PCR assay was modified to overcome interference by fungicide residues appeared to interfere with the assay.

Laurent Deliere and colleagues (INRA, Bordeaux) provided an update on field evaluation of the Mildium prototype expert decision system for managing downy and powdery mildew at the plot scale. Use of Mildium over 4 years in various regions of France has allowed the number of fungicide treatments to be reduced. Gottfried Bleyer (State Institute for Viticulture and Oenology, Freiburg, Germany) then gave an update on the web-based forecasting tool, “Viti-Meteo Monitoring” (see www.vitimeteo.de), which is now in regular use in central Europe (Germany, Belgium, Switzerland, Italy and the Czech republic). It combines inputs from weather forecasts, advisors and local observers trained to assess the disease situation and provide monitoring data. Primary infections of downy and powdery mildew are assessed on a 1-4 scale, from none to heavy infestation, in each “wine village”. Ten well-trained local observers reporting every 10 days is considered the ideal.

3.2.2 Powdery mildew

Australian research on improving diagrammatic keys for assessing powdery mildew was presented by Bob Emmett and Eileen Scott. The process for developing keys with various increments at the lower end of the disease severity scale was outlined and the evaluation of six keys in workshops was described. Visual assessment of powdery mildew was confirmed to be very subjective and the researchers concluded that training to recognise powdery mildew in field conditions was important, as was development of objective measures. This aspect of the research was presented in a poster and short talk by Tijana Petrovic, who outlined development of qPCR and spectroscopic assays for powdery mildew (Fig. 2).

Agnes Calonnec (INRA Bordeaux, France) described modelling of the spread of powdery mildew in a spatially heterogeneous vineyard using simulations for many possible permutations of vine growth and vigour, management practices such as shoot topping, pathogen growth and dispersal, and other factors. Simulations predicted that reduced vigour, late bud break, heterogeneity in terms of vigour or resistance, and use of fungicides would lead to reduction of disease and such effects could be quantified for the parameters used. This group also used ROC statistical analysis to confirm that the earlier an epidemic begins, the more severe is powdery mildew at veraison and that bunch closure is a critical stage for

control of powdery mildew, so that vines should be sprayed from just before flowering to bunch closure.

Brianna McGuire, PhD student representing the Gubler lab at University of California at Davis, reported investigation of virtual weather networks to interpolate data from conventional weather stations to determine risk of powdery mildew as an alternative to expensive in-field weather stations. A weather algorithm was developed to average the output from conventional weather stations at 10 vineyard sites in Lodi, California. In most cases, the virtual model underestimated the risk and recommended fewer sprays, indicating that site-specific microclimate information was lost in the regional interpolated data.

3.2.3 Downy mildew

Hyperspectral imaging is being studied as a means of automated early detection of downy mildew, before symptoms appear. Sergio Rodriguez-Vaamonde and colleagues (Tecnalia Computer Vision, Spain) detected changes in spectra following injection of *P. viticola* mycelium into grapevine leaves. They presented a formula to classify each pixel according to presence or absence of mycelium, although what was being detected was unknown. Gwendal Latouche (Université Paris Sud, France) presented a poster on detection of downy mildew on foliage in the vineyard using a hand-held fluorescence sensor, the Multiplex 330, to detect stilbenes synthesised by the vine in response to infection. Diseased vines could be distinguished from healthy controls one day after inoculation, although the signal was weaker on the adaxial than the abaxial surface.

Researchers at Agroscope, Switzerland (Pierre-Henri Dubuis and colleagues) provided an update on the VitiMeteo-Plasmopara model, an expert system that uses weather data to simulate the main stages in development of downy mildew. In Changins, Switzerland, the system provided correct forecasts of primary infection in 7 of 11 years, was too early in 3 years and too late only in 1 year. Growers using VitiMeteo-Plasmopara were able to manage downy mildew with fewer fungicide applications (0-4 compared with 8-12). In Bulgaria, Zvedko Jelev has developed a forecasting model called RIMpro-Plasmopara by adapting the successful decision support system for apple scab, RIMpro-Scab. The model has, to date, predicted infection events and appearance of symptoms, and trials continue.

3.3 Plant-pathogen interactions, resistance and breeding

The biology of interactions between *Plasmopara viticola* (downy mildew) and the grapevine host was the focus of five papers. Resistance to both mildews and breeding comprised another five papers. Eight posters were assigned to this topic, of which all concerned downy mildew and two also included powdery mildew (days 1 and 2, 30 June and 1 July).

3.3.1 Host-pathogen interactions

Early cellular events in downy mildew infection as a means to improve understanding of disease development and control were eloquently described by Peter Nick (Karlsruhe Institute of Technology, Germany). Zoospores of *P. viticola* can locate stomata of susceptible vines within 10 minutes, but failed to do so on leaves of wild accessions of *Vitis* from China and Japan, and of German accessions of *V. vinifera* subspecies *sylvestris*. In detailed comparisons, an Asiatic genotype exuded small aldehyde compounds (nonanal and decanal) that suppressed infection. Breeding for fruit quality appears to have resulted in loss of this defence mechanism. Experiments using a transgenic actin marker line suggested that stomatal guard cells mediate response to infection and that breeding to modulate actin to induce a defence-related hypersensitive response might be a useful strategy. A poster by Viktoria Troster and Peter Nick complemented this talk, and reported abnormal behaviour of zoospores on leaves of some accessions.

Comparison of early events in the interaction between *P. viticola* and several-grapevine varieties showed that sporulation was most intense on the susceptible Muller Thurgau, less intense on the partially resistant Regent and was absent from the resistant *Vitis rupestris* (Malke Muller et al., DLR Rheinpfalz-Abteilung Phytomedezin, Germany). Transcription of WRKY factors (regulators of plant immunity) and expression of pathogenesis related proteins was greatest in the resistant genotype. As these features occurred in the susceptible and moderately resistant genotype but were less sustained, it may be that pathogen effector proteins play an important role.

Necrosis- and ethylene-inducing peptide-1 (NEP1)-like proteins (NLPs) can induce defence responses in plants. They may also act as cytolytic toxins. Stefan Schumacher, Hans Kassemeyer *et al*. (State Institute for Viticulture and Enology, Frieburg, Germany) examined a collection of *P. viticola* strains for polymorphisms in 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. Also in the Kassemeyer group, R Fuchs presented a paper on activation of resistance by pathogen-associated molecular patterns (PAMP) and damage-associated molecular patterns (DAMP). These are detected by specific membrane receptors in the grapevine host. Collaborative research involving nine European Union countries (VineMan.org) is investigating natural non-toxic compounds that induce PAMP-triggered immunity, to enhance resistance to downy mildew in organic vineyards. A plant extract shows promise but details are confidential. V Huerga then presented findings on expression of defence-related genes in leaf tissue of the resistant hybrid Solaris and the susceptible Petit Courbu during infection by *P. viticola*. Glucanase and chitinase appeared to be involved in resistance of Solaris to infection, as did callose synthesis, and a signalling element EDS1 may play a major role in conferring resistance.

3.3.2. Resistance and breeding (downy and powdery mildew)
Sabine Wiedemann-Merdinoglu and colleagues at INRA, Colmar, France, provided an update on breeding for resistance to downy and powdery mildews. Pyramiding of resistance genes is being used to reduce or delay the risk of breakdown of resistance, given that *P. viticola* has already overcome resistance in Bianca and Regent. The program began in 2000 and they expect to register the first varieties in 2016. German researchers (Tisch and colleagues, DLR Rheinpfalz) are examining wild European grapes (*V. vinifera* ssp. *sylvestris*) for resistance to downy and powdery mildew and black rot. Development of *P. viticola* was greatly reduced on leaf discs of Solaris 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 checks. These researchers also presented a paper on the course of infection events on grapevine genotypes resistant and susceptible to powdery mildew visualised using low temperature scanning electron microscopy (LTSEM). Conidia germinated on both resistant and susceptible genotypes but hyphal growth on the former was restricted, leading the authors to conclude that plant immunity was triggered during appressorium development, penetration and haustorium formation. Thus observations using LTSEM support findings reported previously by Australian researchers (N Scott, I Dry, D Godfrey and others). LTSEM was also used by Spanish researchers (V Huerga and colleagues) to compare the response of Cabernet Sauvignon and Tempranillo to downy mildew; the latter appeared to be more susceptible, having more stomata infected and more sporulation.

High throughput phenotyping for downy mildew resistance has been applied to nine segregating populations from a cross between *V. vinifera* and a *Vitis* hybrid. Peressotti and colleagues at the Fondazione Edmund Mach (San Michele all'Adige, Italy) have inoculated these populations with *P. viticola* and are using results on sporulation density and disease progress to generate data towards marker-assisted pre-breeding for downy mildew resistance. This group also presented a poster comparing methods to assess symptoms of

downy mildew. They reported good agreement when sporulation was assessed visually and using the free software program, Image J, to assess area on photographs. Another group at the same institution is searching for quantitative trait loci (QTLs) for use in marker-assisted selection to facilitate pyramiding of resistance to both downy and powdery mildews. It is hoped that the pyramiding of resistance genes will lead to improved and durable resistance. Ruiz-Garcia and colleagues at Instituto Murciano de Investigacion y Desarrollo Agraria y Alimentario, Spain, are also working towards marker assisted selection and pyramiding of resistance genes in crosses involving the Spanish variety Monastrell. Preliminary research on mechanisms involved in virulence showed differences between strains of *P. viticola* in terms of effector molecules but these did not explain differences in phenotype.

Francois Delmotte and colleagues at INRA, Villenave d'Ornon, France, presented a paper and poster on adaptation of *P. viticola* to partially resistant grapevine varieties. In cross-inoculation experiments, isolates from partially resistant varieties sporulated better on these hosts than did isolates from susceptible varieties but sporulated equally well on both types of host, indicating there was no fitness penalty associated with adaptation to the partially resistant varieties. Isolates from partially resistant varieties had smaller sporangia than those from susceptible varieties. 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 in resistance breeding programs. This group (Delmas et al) also reported quantification of sporangia and zoospores of *P. viticola* using an automatic particle analyser, a rapid technique that could be used to estimate infection potential of this and other zoosporic pathogens.

3.4 Disease management

Five papers in Oral Sessions 3 and 5 described research on reducing environmental impacts of disease control. Marianne Claverie (Institut Francais de le Vigne et du Vin (IFV), France) reported on a 3-year trial of the Optidose® method for pesticide dose adjustment to control powdery and downy mildew. The overall aim is to move French viticulture from fungicide application label rates based on hectares to a system that takes into account canopy structure and spray efficacy. The Optidose® rate was calculated based on intrinsic susceptibility of the vineyard patch, canopy characteristics, phenological stage and inoculum pressure, and was compared with standard spray application and untreated control. The Optidose® treatment, in all but a few cases, was as effective as the standard treatment, with reduced inputs. Marc Raynal, also of IFV, presented the next stage, the Optimised Treatment Plan® (PTO®), which synthesises information concerning the efficacy of treatment to optimise doses of fungicide. PTO® aims to improve on Optidose® by including information at the plot scale using geographic information systems (GIS) and precision viticulture. It uses radar to evaluate rainfall, records of spray deposition and drift, and water balance in the soil. Dose adjustments have led to 30% reduction in active ingredient sprayed on vineyards.

Low drift nozzles are another approach being evaluated to reduce environmental impacts, specifically EU directives aimed at reducing spray drift. Montsy Gallart, Emilio Gil and others (Universitat Polytecnica de Catalunya and BayerCrop Science Spain) reported that conventional cone nozzles, air induction cone nozzles and air induction flat fan nozzles were equally effective (>99%) for controlling powdery mildew. However, no data on spray drift were presented. David Lafond presented a proposal to use inter-row plantings to promote and propagate biological control agents for powdery mildew. These plants would be allowed to develop powdery mildew (caused by fungi other than *E. necator*) to promote growth of the mycoparasite *Ampelomyces quisqualis* and the mycophagous mite *Orthotydeus lambi*, which could then migrate to parasitise grapevine powdery mildew. Research has yet to begin. Also on biological control, Longxian Ran and colleagues (Agricultural University of Hebei, China) reported that strains of *Streptomyces* and *Pseudomonas* bacteria prevented development of downy mildew in a leaf disc assay.

Research on non-biological alternatives to conventional fungicides was presented in two oral papers and one poster. Schnee and colleagues (Agroscope, Switzerland) found that methanolic extracts of dried and powdered grapevine canes exhibited potent activity against the causal agents of powdery and downy mildew. Chitosan, a crabshell extract, was effective in controlling downy mildew in the vineyard (Romanazzi et al, Marche Polytechnic University, Italy). Ben Pike and colleagues (University of Adelaide) compared biodynamic, organic and conventional inputs for control of powdery mildew, and found that programs involving sulfur generally gave the best control, although alternative materials sometimes reduced disease severity also. Biodynamic programs resulted in smaller vines and reduced yield.

3.4.1 Fungicide efficacy against powdery mildew
Strobilurin resistance was detected in Israel in 2006/07, and tank mixes of fungicides that differ in mode of action applied from bloom to the early stages of bunch closure have improved control. Failure of strobilurins to control powdery mildew in Switzerland was first recorded in 2011 and resistance was widespread in 2012. In 2013, a mixture of strobilurin and metrafenone resulted in control similar to metrafenone alone. A novel fungicide for control of powdery mildew, pyriofenone, was described by Chantelot and colleagues (Belchim Crop Protection France). This benzoylpyridine compound has a vapour action, is translocated rapidly in plant tissue and is rainfast. It appears to have both preventative and curative efficacy. Application of the fungicide meptyldinocap to immature chasmothecia (cleistothecia) reduced maturation by 50% and reduced viability of ascospores by 30%. Application to mature chasmothecia after dispersal also reduced ascospore viability three-fold, although this was not statistically significant. Nevertheless, the authors believe that the fungicide has potential for use in sanitation.

Barbara Hall and colleagues (SARDI) summarised the challenges of testing fungicide resistance of the obligately biotrophic *E. necator*. Of numerous methods tested, inoculating leaf discs on tap water agar with conidia via a settling tower proved the most reproducible. Testing for quinoxyfen susceptibility in 34 vineyards over 5 years (2009-2013) in Italy (Turan et al) showed that EC_{50} values varied with vineyard but did not change with time, whereas minimum inhibitory concentrations were higher in 2012/13 than in 2009/2010. Results for disease severity on inoculated, fungicide-treated grape seedlings and conidial germination assays were in agreement.

3.4.2 Fungicide efficacy against downy mildew
The curative activity of several fungicides when applied 24 hours or 7-8 days after inoculation was assessed; all fungicides tested reduced sporulation when applied 24 hours post-infection, but only metalaxyl-M reduced oilspot formation. Ametoctradin (Initium), a new triazolopyrimidylamine fungicide with unique mode of action for downy mildew control, was described by Randy Gold and other BASF representatives. It inhibits zoospore formation, release, motility and germination and is not cross-resistant with QoI and QiI fungicides. It is being used in combination with chemicals with different modes of action (EBDC inhibitors, e.g. metiram, and CAA inhibitors, e.g. dimethomorph).

4 Field visits

4.1 Visit to Neiker-Tecnalia

Workshop participants visited Neiker-Tecnalia, an organisation funded by the Basque Government to conduct agricultural research and development. Founded in 1852, it has 182 staff across two sites, Bilbao and Vitoria-Gasteiz, and 72 ha of farmland. The head of Neiker-Tecnalia gave an overview of activities, which include R&D on animal husbandry and crops such as cereals, potato, vines, forestry, soil health and the environment and natural

resources. They also offer analytical services and conduct technology transfer. See http://www.tecnalia.es/en/proyectos-item/neiker-tecnalia

This overview was followed by a presentation from the head of viticulture at Organisation Internationale de la Vigne et du Vin (OIV). He explained the OIV charter, which influences 80% of the world production, including Australia, and outlined activities relating to climate change, plant protection, reduction of pesticides in viticulture using models such as Agrometeo and Optidose IFV, and updating resolution VITI 1/1991, the process for clonal selection of vines. He also noted the challenges of standardising fungicide application. See www.oiv.int

4.2 Visit to Rioja Alavesa

Participants travelled inland to La Guardia, where we heard a presentation from Antonio Remesal Villar on the history of the region and the influence of Bordeaux. La Rioja, comprising Rioja Alavesa, Basque and Navarre regions, has 64,000 ha of vineyards, of which 50,500 are planted with Tempranillo and grown without irrigation. Other red varieties are Garnacha (Grenache), Mazuelo (Carignan), and white varieties, Viura, white Garnacha and Malvasia, are minor. Carbonic maceration is common. Quality is classified according to the Denomination of Origin Calificada (DOCa) Rioja. After lunch at Eguren Ugarte, we had a short tour of the vineyard (Fig. 3). Leaf roll type 3 was common, spread by propagation in the warmer regions as the mealy bug vector is absent. We later visited Rioja Alta winery (ww.riojalta.com), where the head of viticulture explained operations. Teledetection is used to assess canopy vigour, and mildews and other diseases are predicted using weather-based models; there is no monitoring by humans. The head of winemaking described winemaking processes and, during a tour of the winery, we learned that grape consignments indicated by mid-infrared scanning to exceed 5 to 10% Botrytis bunch rot (via gluconic acid and glycerol content) are rejected.

4.3 Visit to Gipuzkoa

Workshop participants visited Gipuzkoa on the Atlantic coast, where the terrain is steeply sloping and the climate is wet (1000-2000 mm rain per year) and windy. Vines are grown on a traditional pergola trellis (Fig. 4). They are trimmed regularly and leaves are removed from the fruit zone to promote air movement and drying of bunches. Downy mildew is the most common disease problem and is managed by regular spraying from equipment small enough to navigate the steep terrain and overhanging trellis, and re-supplied from a tank at the end of the row.

5 Outcomes

5.1 Main outcomes

Australian researchers benefitted from taking part in the workshop. New knowledge about biology, epidemiology and management of downy and powdery mildew will enhance existing and future research projects. A summary of the workshop has been prepared for submission to the Australian and New Zealand Grapegrower and Winemaker and new findings have been included in lectures to undergraduate and postgraduate students. This will increase the knowledge base of the industry now and in the future and facilitate improved disease diagnosis and management.

Collaborative links with European researchers were strengthened and new links with researchers in China were established. Dr Eileen Scott was invited to visit Professor Longxian Ran at the Agricultural University of Hebei, China at a mutually convenient time in the future.

5.2 Communication

An article has been prepared for the Australian and New Zealand Grapegrower and Winemaker magazine.

New information has been incorporated into viticulture teaching at the University of Adelaide.

The program and selected presentations at the workshop are available at http://gdpm2014.com/scientific-program and the abstracts are published as: Diaz-Navajas, AM, Ortiz-Barredo, A, Menendez, C, Emmett R, Gadoury D, Gubler D, Kassemeyer H-H, Magarey P, Seem R (2014). Proceedings of the 7th International Workshop on Grapevine Downy and Powdery Mildew. Vitoria-Gasteiz, Spain, 30 June - 4 July (ISBN 978-84-7821-827-1).

6 Recommendations

That links established during the workshop be maintained and similar visits by scientists to international workshops be supported to

- keep Australian scientists abreast of developments elsewhere;
- promote collaborative work and exchange of ideas among researchers;
- ensure that the AGWA research providers contribute to and benefit from the international research community, so that they can provide the best outcomes for the Australian grape and wine industry.

7 Figures

Fig. 1. Conference delegates at the Europa Palacio de Congresos, Vitoria-Gasteiz, Spain (photograph from http://gdpm2014.com)

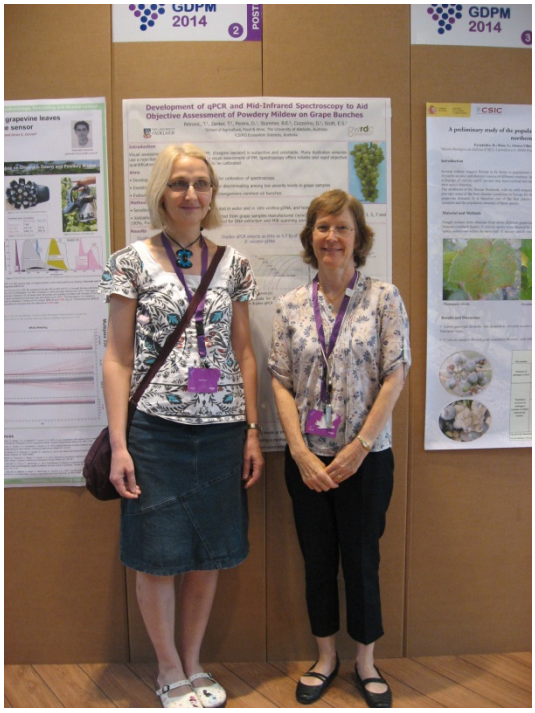

Fig. 2. Tijana Petrovic and Eileen Scott beside their poster

Fig. 3. Vines in Rioja Alavesa, Spain (photograph from http://gdpm2014.com)

Fig. 4. Vines at Gipuzkoa, Atlantic coast, Spain