Presentation and participation at the 1st International Symposium on grapevine roots in Rauscedo (Italy) and visits to the Universities of Bologna and Geisenheim



FINAL REPORT to

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1 Abstract

The visit of the University of Bologna allowed discussions on viticulture and grapevine nutrition with Prof. Adamo Rombolà and his research group and the visits of four wineries in the Emilia-Romagna wine region. Attending the International Symposium on grapevine roots provided the opportunity to gain knowledge of the current efforts in root research and to present a paper on recent research titled 'Effect of N and water supply on xylem composition in Semillon and Riesling'. At the Geisenheim University in Germany discussion and meetings were held with Prof. Manfred Stoll, Prof. Otmar Löhnertz and others in relation to plant nutrition and carbohydrate physiology.

2 Executive Summary

The travel included the participation in the 1st International Symposium on grapevine roots held near Udine in Italy. In addition, the University of Bologna (Italy) and Geisenheim University (Germany) were visited.

Prior to the symposium I visited the University of Bologna where I had a meeting with Prof. Rombolà and his research group. His research has a strong emphasis on the development of cultivation techniques in organic and biodynamic viticulture, which includes nutrition and soil management. At the end of the discussion with the group, I gave a presentation on our post-harvest and carbohydrate reserve research to the plant nutrition group and other researchers from the Department of Agricultural Sciences. I also visited the experimental vineyard close to the university with various training systems and four wineries in the Emilia-Romagna wine region in the vicinity of Bologna.

The research presented at the 1st International Symposium on grapevine roots was on our recently completed work on grapevine nutrition and was titled 'Effect of N and water supply on xylem composition in Semillon and Riesling'. The symposium also allowed further knowledge to be gained in relation to grapevine roots and nutrition through the various presentations and discussions with other scientists. The most relevant sections were on roots and vine mineral nutrition as well as on modern methods for vine root research. Two tours allowed further information to be gained on the operations and research of the Vivai Cooperative Rauscedo nursery were the symposium was held and on grape production in the Colli Orientali region.

The University Geisenheim was visited after the symposium where I had meetings and discussions at the Institute for Viticulture with Dr Manfred Stoll. Most of the research emphasis undertaken at the institute relates to source-sink relationships, water relations and vineyard managements systems. I also visited the free atmosphere enrichment facility that are planted with Riesling vines, being now fully operational. In addition, I met Prof. Löhnertz from the institute of plant nutrition and soil science and staff from the institute for breeding to discuss current research on nutrition and rootstocks. Current research in nutrition relates to N management systems to optimise the effectiveness of N application (timing and method) and the allocation of N in vines.

The participation at the symposium and the visits to the two universities provided an excellent opportunity to gain further knowledge in the field of root research and on grapevine nutrition. This information will contribute to current and future research undertaken in Australia and is being incorporated in seminars and lectures.

3 Project background

Vine nutrition and carbohydrate physiology are important issues for the Australian wine industry, since nutrient and carbohydrate management require significant input for grape production, influencing vine development and grape/wine composition. These issues were addressed at the international Symposium on grapevine roots near Udine and during the visits of the universities in Italy (Bologna) and Germany (Geisenheim). The presentation and participation at the symposium, together with meetings and discussions at the universities with key scientist working on roots, plant nutrition and carbohydrate physiology is expected to provide valuable information that will be beneficial for incorporating in industry presentations, lectures on viticulture/wine science and articles in the near future. In addition, the knowledge gained will contribute to current projects and will assist in developing a concept for a project on grapevine nutrition, for optimizing nutrient application and timing in relation to fruit/wine composition and perennial nutrient/carbohydrate reserves.

4 Project aims and outputs

The major objectives were to present and participate at the 1st International Symposium on grapevine roots and visit two important universities (Bologna and Geisenheim) in Europe. The visits to the universities were aimed to strengthen the outcomes of a number of current and future viticulture projects, particularly contributing to research on grapevine nutrition and carbohydrate physiology conducted at the NWGIC. A further objective was to incorporate the gained information and knowledge into education undertaken at the NWGIC and enhance the collaboration with Universities in Bologna and Geisenheim. The following lists the project outputs, performance targets and completion dates as indicated in the original application.

Output	Performance Targets	Date
A. Present recent research on grapevine nutrition and participate at the 1st International Symposium on grapevine roots (Rauscedo, Italy).	Presentation given titled 'Effect of N and water supply on xylem composition in Semillon and Riesling' as part of the 1st International Symposium on grapevine roots.	18/10/2014
B. Enhance scientific exchange in the area of grapevine nutrition and carbohydrate physiology with other scientists at the symposium and at the two universities in Europe (Bologna, Geisenheim).	Discussion and meetings held with key scientists at the symposium and the universities in the area of plant nutrition and carbohydrate physiology.	22/10/2014
C. Report back to the Australian wine industry on current advancements on grapevine nutrition in grower orientated journal and as part of industry presentations, including lectures in viticulture/wine science.	A publication on current advances in grapevine nutrition published in grower orientated journal and contribution to seminars to grape growers and lectures to students.	31/03/2015

D. Develop a concept of a project on grapevine nutrition management that incorporates recent research/advances and industry requirements.	Project concept developed in advanced grapevine nutrition management with industry consultation.	30/06/2015

A. Presentation was given titled 'Effect of N and water supply on xylem composition in Semillon and Riesling' as part of the 1st International Symposium on grapevine roots. Participation in all six session of the symposium, which was held over two days.

B. Discussion and meetings were held with scientists at the symposium and the universities (Bologna and Geisenheim) in the area of plant nutrition, rootstocks and carbohydrate physiology as outlined in the detailed travel report.

C. Two articles were published on grapevine nutrition in the grapevine management guide titled;' Winegrape nutrition and fertiliser application for sustainable production' and 'Nitrogen nutrition and grape and wine production'. The gained knowledge from participation of the symposium and associated travel is being incorporated in seminars and lectures.

D. A project concept has been developed on nutrition and is titled 'Optimising nutrition management to improve vineyard productivity and enhance wine quality'. The project concept will be further developed with knowledge gained from the travel and with further industry consultation.

5 Detailed travel report

5.1 University of Bologna

Bologna is the capital of the Emilia-Romagna wine region, which is one of most productive regions in Italy, with more than 55,000ha of vineyards. The region is located between Tuscany to the south, Lombardy and Veneto to the north and the Adriatic Sea to the east. The vineyards are present from the hills of Emilia (Apennines) to the plains of Romagna (Po valley), resulting in a variety of climates that produce a wide range of wines in different styles. The wine production in the Emilia-Romagna region is divided evenly between white and red varieties, the dominant vine varieties are Malvasia and Lambrusco, Trebbiano, Barbera, Bonarda and Sangiovese. A large percentage of these grapes are used to produce sparkling wines.

The University of Bologna is considered to be the oldest university in the Western world, being founded in 1088. Today the University has about 85,000 students in its 11 schools, with branch centres located in Imola, Ravenna, Forlì, Cesena and Rimini. The school of Agriculture and Veterinary Medicine includes teaching activities in viticulture and oenology, with the research undertaken in the Department of Agricultural Sciences.

On October 13 I met the professors Ilaria Filippetti and Cesare Intrieri together with Dr Everard Edwards (CSIRO) to visit the experimental vineyard of the university near Bologna. We were shown the various training systems and management techniques on which research is currently conducted (Figure 1). This research includes the evaluation of new prototype machines for winter pruning, cluster and shoot thinning that can be applied to different training systems. In the afternoon I visited with Prof. Rombolà the Orsi Vigneto San Vito winery (Figure 2) on the hillsides near Bologna, the vineyards are around 200m above sea level. The production follows the biodynamics principals, with the vines cultivated sustainably. In the cellar the winemaking is undertaken without the use of selected yeasts, clarification and filtration, using wild yeast for the fermentations process.



Figure 1. Training system in experimental vineyard of the University of Bologna.



Figure 2. Orsi Vigneto San Vito winery on hillsides near Bologna.

The second winery we visited in the afternoon on that day was the Corte d'Aibo winery, which is also located in the hills near Bologna. The estate produces organic wines, with the

grapes being produced from 75 ha of vineyards. The wine making procedure includes the use of terracotta containers, which have a capacity of up to 300L (Figure 3 and 4).



Figure 3. Vineyards of the Corte d'Aibo winery near Bologna.



Figure 4. Terracotta wine containers in the winery.

On October 14 I had a discussion with the research group of Prof. Rombolà, which included the Post-Doctoral Fellow Alejandra Ribera Fonseca (University of La Frontera, Chile), the Turkish Masters student Onur Sevindik and the PhD student Paola Tessarin. The PhD student works on a project that is concerned with organic viticulture, with an emphasis on innovative canopy management strategies and the bunchzone environment to reduce disease incidence and improve fruit and wine quality (Figure 8). In addition, the student Giuseppe Tumbarello is working on several sites in central (Tuscany) and southern Italy to study the organic and biodynamic viticulture under the climatic conditions in these regions. Onur Sevindik is working on the composition of grape seed oils. Dr. Alejandra Ribera is working on Highly Sustainable Viticultural Systems and on the use of portable non-destructive methods for assessing berry quality. Overall Prof. Rombola's research has a strong emphasis on the development of cultivation techniques in organic and biodynamic viticulture, which includes nutrition (e.g. silicon) and soil management. This research comprises the use of subterranean clover to control weeds under the vine row and to provide N to the vines, and the intercropping with graminaceous species (e.g. barley) to prevent micronutrient deficiencies and obtain an additional income, biodynamic preparations, composted manure and mineral salts to decrease the susceptibility to biotic and abiotic stresses and evaluation of organic composts and biochar to increase soil carbon fixation. The first two research areas would be of considerable interest to collaborate with Adamo, reducing inputs in weed control and fertiliser requirements is an important issue for grape production in Australia. Similarly, a reduction in the use of fungicide through the application of nutrients would be beneficial to the grape producers. There is considerable evidence that certain nutrients reduce or inhibit pathogen invasion and others have important roles in the plants defence reactions. In addition, the application of particular nutrients to reduce the impact of abiotic stress such as heat events would be another potential link for future collaboration. At the end of the discussion with the group, I gave a presentation titled 'Vine balance: Function, dynamics and management of carbohydrate reserves' to the plant nutrition group (plant stress physiology and highly sustainable agricultural systems), with other staff members from Department of Agricultural Sciences present.

In the afternoon the Campodelsole winery was visited, which is located in the Emilia-Romagna grape growing region (Figure 5 and 6). The 75 hectares of vineyards are just over 200m above sea level; the winery is constructed that it blends very well into the natural scenery.



Figure 5. View of Emilia-Romagna grape growing region near the Mediterranean sea.



Figure 6. The Campodelsole winery near the village Bertinoro.

Later in the afternoon the Condé winery was visited, the company owns 110 hectares of vineyards, which are between 150 and 350 metres above sea level (Figure 7). Ninety percent of the vines are Sangiovese, the remaining vineyard area is planted with Merlot in deeper soils. The vineyards consist of high density plantings with 5,000 to 6,000 vines per hectare, with relatively low yields of around one kg per vine.

On the last day in Bologna I gave a two hour lecture on grapevine carbohydrate reserves and nutrition to the bachelor students. The lecture needed to be translated simultaneously into Italian and was given as part of the course on vineyard management at Tebano, being 50 km from Bologna. After the lecture at midday I left immediately and travelled to Udine to the location were the International Symposium on grapevine roots was held.



Figure 7. Condé winery also located in the Emilia-Romagna grape growing region.



Figure 8. Field experiment in an organic vineyard near Tebano.

5.2 International Symposium on grapevine roots

The symposium was held in the Vivai Cooperative Rauscedo (VCR) near the town of Udine in the Friuli grape growing region (Figure 9). In this Italian region traditional varieties are grown such as Refosco and Tocai friulano, but also varieties that are not regional specific for the area. The main goal of the symposium was to bring together scientists from different disciplines that work on roots (eg. vine physiology, molecular biology and pathology). The topics included rootstocks, rootstock breeding, root genetics, root interactions with natural factors and agronomic practices, root diseases, roots and mineral nutrition, methods for root studies. Two tours were organized during the symposium to allow delegates to gain further information on the symposium topics and the regional viticulture and wines.

The symposium program started on 16 Thursday, October 2014 with an opening lecture titled ‘Grapevine root system: functions and reactions’, by Diego Tomasi (CRA-VIT Conegliano, Italy). A number of sessions followed, the first overview talk was presented by Nathalie Ollat (INRA, France) on Grapevine rootstocks: origins and future. Prior to lunch a poster session was held. The second session was on grapevine roots: interaction with natural factors and agronomic practices and the key note address was presented by Kobus Hunter (University of Stellenbosch, South Africa). The last session titled ‘Roots molecular biology’ was chaired by Luigi Cattivelli (CRA GPG, Fiorenzuola d’Arda, Italy), who also gave the introductory talk. Each section had a number of talks on the overall topic, after the last talk a visit of the VCR nursery followed.

VCR is one of the main and renowned vine nurseries in the world, with the capacity of producing 60 million grafted and own rooted vines in more than 4,000 combinations. These are produced on 1,100 hectares of nursery and 1,050 hectares of rootstock mother blocks. The VCR was founded 80 years ago, has today 250 cooperative members and is present in over 30 countries. The VCR continuously searches for new varieties, clones and crossings; the nursery also undertakes research for instance in propagation, grafting and health checks (Elisa test and PCR) and conducts microvinifications to evaluate crossings and new grape varieties (Figure 10).

On October 17 another three sessions were held on topics concerning grapevine roots at the VCR nursery. Session 4 was titled 'Roots and vine mineral nutrition' and was chaired by Roberto Pinton (University of Udine, Italy), who gave also the key note address. This session was particularly relevant, as our research conducted at the NWGIC was presented. An interesting talk was in this session was titled 'Implication of nutrition on root development'. Session V followed with the overview talk by David Eissenstat (Pennsylvania State University, USA) on modern methods for vine root research. This session, chaired by him also, had a number of very relevant presentations for our research at the NWGIC, for instance 'Screening root morphology traits in grafted grapevine using 2D digital images from rhizotron'. Prior to lunch another poster session followed, with the last session in the afternoon on the topic 'Vine root system diseases and compatibility problems'. Josep Armengol (Polytechnic University of Valencia, Spain) gave the key note speech and chaired the session; the conclusion of the symposium was drawn by Attilio Scienza (University of Milan, Italy).

A visit to a winery and vineyards in Colli Orientali area followed, the vineyards in this area are located in the hills in the eastern province of Udine, between 100 and 350 m above sea level (Figure 11 and 12). In the Felluga winery we had a wine tasting, the estate owns 155 hectares of vineyards.



Figure 9. Vivai Cooperative Rauscedo (VCR) where the symposium was held.



Figure 10. The experimental winery of the cooperative near Udine.



Figure 11. Vineyards Felluga estate in Colli Orientali area.



Figure 12. Wine tasting in the Felluga winery.

5.3 Geisenheim University

The Geisenheim University is situated on the Rhine river in a major grape growing region the Rhinegau in Hessen, an important grape growing state in Germany. Across this large European river the largest German wine region (Rhinehessen) is located as well as the smaller region of the Nahe river. At the University, general research is conducted on aspects of viticulture and oenology. The main purpose of this visit was to continue with the collaborative work in the area of carbohydrate physiology and grapevine nutrition.

I was based at the Institute for Viticulture and had several discussions with Dr Manfred Stoll allowed for a further insight of the research currently undertaken (Figure 13). Most of the emphasis undertaken at the institute relates to berry ripening and flavour development, by altering the leaf to fruit ratio, reducing photosynthesis and assimilate production. Other research conducted at the institute relates to minimal pruning on steep slope vineyards, remote sensing, vine water use and irrigation management, rootstock/scion interaction and organic/biodynamic viticulture. The project titled 'The implications of different leaf areas and the contribution of vine reserves on berry sugar accumulation in Riesling (Vitis Vinifera L.) grapevines in a changing climate' was discussed in great detail, particularly the work undertaken in the past season. The free atmosphere enrichment facility (FACE) that is comprised of six rings that are planted with Riesling vines is now being fully operational and studies have been undertaken in the past season (Figure 14).

I had a meeting with Prof. Joachim Schmid, Prof. Ernst Rühl and Dr Elvira Bleser (Institute for breeding) to discuss rootstock research, in particular in relation to nutrition. The institute undertakes rootstock breeding and selection of clones from varieties, with the aim to maintain and enhance the performance of rootstocks and varieties (Figure 15). The breeding program is aimed to produce rootstocks which are resistant to phylloxera, good grafting ability and adaption to locations, as well as positive influence on the grapes of the scion. This is achieved by investigating the rootstocks in different locations and with various varieties in the German grape growing regions. In addition, the institute has 11ha of vineyards for research and multiplication, an experimental cellar and laboratories (eg. ELISA and PCR methodologies). The later was visited with Dr Elvira Bleser, were research is undertaken using tissue culture and micro propagation (Figure 16). An important direction in the most recent years is to keep the genetic diversity of traditional German varieties.



Figure 13. The Institute for Viticulture is close to experimental and commercial vineyards.



Figure 14. One of the rings for grapevines of the FACE system.



Figure 15. The breeding institute is crucial for rootstock research.

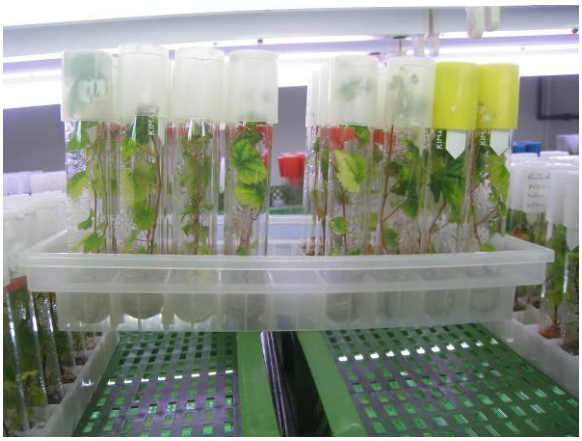


Figure 16. Micropropagation undertaken in the laboratory of the institute.

I met Prof. Löhnertz (Institute of plant nutrition and soil science) and discussed the progress of the PhD of Markus Müller, since some of his work was presented at the 1st international root symposium in Italy. The presentation was submitted as a full paper at the end of September (Acta Horticulturae), the student has conducted his research the NWGIC, but also at Geisenheim University and is close to completing his thesis. The research at the institute is water and N supply on grape composition and the issue of untypical aging of wines is continuing (Figure 17 and 18). Currently research undertaken at this institute relates to N management systems to optimise the effectiveness of N application, with both timing and method of application (foliar, soil and fertigation) being important considerations. Another important direction is to assess the N and C losses from the vineyard system, by assessing the nitrogenous gasses and carbon dioxide using gas chromatography. Further work is undertaken to determine the allocation of N during the season and the allocation to the various grape organs. Some of this research is undertaken in the FACE facility using stable isotopes (N15).



Figure 17. The institute of plant nutrition and soil science has various analytical capacities.



Figure 18. The nitrogen and irrigation large pot experiment with Sylvaner vines.

6 Conclusions

The participation at the 1st International Symposium on grapevine roots provided an excellent opportunity to gain further knowledge of the current efforts in root research and to present part of our recent work on grapevine nutrition. The most relevant sections were on roots and vine mineral nutrition as well as on modern methods for vine root research. The symposiums also allowed for invigorating international contacts and facilitated future collaboration and linkages.

The visits to the University of Bologna and Geisenheim University allowed for a number of discussion and meetings, which related to plant nutrition and carbohydrate physiology. These visits included observation of some of the facilities at the universities and wineries near Bologna. The observation obtained, particularly on grapevine roots and nutrition, will flow into current and future research in Australia.

7 Acknowledgements

The National Wine Grape Industry Centre and the AGWA scholar program have met the cost for the presentation and participation at the 1st International Symposium on grapevine roots in Italy, the visits to the University of Bologna and the wineries in Italy and the Geisenheim University in Germany. Some of the information provided in this report is from university and winery websites.

I greatly appreciate being given the opportunity to meet with Prof. Adamo Rombolà and other staff and students from the University of Bologna to discuss relevant past and current research. I would also like to thank Prof. Adamo Rombolà for organising the visits to four wineries in the Emilia-Romagna grape growing region. In addition, I would like to thank Dr Manfred Stoll for hosting me at the Institute for Viticulture (Geisenheim University), I also appreciate the discussion with him and Prof. Otmar Löhnertz as well as with staff from the Grapevine Breeding Institute.

8 Appendixes

8.1 Travel Itinerary

October 13 – 15; University of Bologna (Italy), discussions and meetings with Prof. Adamo Rombolà (Department of Agricultural Sciences), presentation to the plant nutrition group (plant stress physiology and highly sustainable agricultural systems).

October 16 - 18; 1st International Symposium on grapevine roots (Rauscedo, Italy) – presentation/participation and discussions with scientists that have research focuses on grapevine roots and nutrition.

October 20 - 22; Geisenheim University (Germany) - Discussions and meetings with Prof. Otmar Löhnertz (Institute of Plant Nutrition and Soil Science) and with Dr Manfred Stoll (Institute for Viticulture).

8.2 Budget reconciliation

This will be provided separately