Participation in the X International Symposium on Grapevine Physiology and Biotechnology



FINAL REPORT to

AUSTRALIAN GRAPE AND WINE AUTHORITY

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Principal Investigator: **Dylan Grigg**

Research Organisation: **University of Adelaide**

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Executive summary

This Australian Grape and Wine Authority travel bursary was used to fund participation and attendance at the 10th International Symposium on Grapevine Physiology and Biotechnology (10thGPB) in Verona, Italy. Personal funds were used to finance further travel and educational visits during and after this conference in both Italy and Spain.

Aim of the travel

The principal aim of this travel was to attend the 10thGPB and present a poster entitled "Does vine age influence vine performance and grape quality?" in the poster session Topic 2: *Yield, berry ripening, grape and wine quality*.

Further to the above aim while travelling to Europe the opportunity was taken to broaden my knowledge and understanding of viticulture practices and production systems in different environments via a self-funded brief study tour including:

- Technical visits in Italy in the Langhe region of Piemonte, specifically in and around the world famous areas of Barolo and Barbaresco. Meeting with scientists, researchers and wine producers.
- Technical visits to the Emporda region in North East Spain to observe vineyard practices and production in a hot dry climate, especially to observe 'old' vines over 100 years in age.

Travel itinerary and activities outline

The following is a brief summary of the itineraries and locations of travel.

Location	Activity	Dates
Verona (Italy)	Attend and present poster at 10th GPB conference.	13th-18th June
Alto Adige, Sud Tirol (Italy)	Visit J Hofstatter winery and vineyard	17th June
Cascina Belmonte, Muscoline (Italy)	Visit winery and vineyard	19th June
Piemonte (Italy)	Vineyard and winery visits multiple sites and producers	20th – 22nd June
Alt Emporda (Spain)	Vineyard and winery visits	22nd - 24th June

Project outputs

Brief summary of project outputs and opportunities for dissemination of knowledge gained.

Output	Performance Target	Date
Improved understanding of current research in Grapevine Physiology	Attendance at the 10th ISGPB conference Verona, Italy	Completed
Increase awareness of my project and discussion of project with colleges and researchers.	Present poster, attend poster session and discussion with fellow scientists and researchers.	Completed
Creation of research links with international researchers.	Meeting with Giorgio Gambino – Institute for Sustainable Plant Protection, National Research Council (IPSP-CNR) Meeting with Simone Lavezzaro from Vit.En consultancy.	Completed
Disseminate new knowledge to students and peers	Present and communicate material through my role as demonstrator in University of Adelaide practical viticulture course. Viticulture methods and procedures. Especially practicals and field trips.	July-August 2016

Overview of conference and industry visits

10th International Symposium on Grapevine Physiology and Biotechnology.

- This is the most important conference in the field that covers physiology and biotechnology of grapevines, it is run under the frame of the International Society of Horticultural Science (ISHS).
- More than 30 countries of the world were represented.
- 64 oral presentations and over 200 posters.
- A unique initiative of 'cross-contamination' through invitation of scientists from different disciplines and fields of expertise such as tomato research.
- Key papers/talks relevant to my research and of interest to the Australian wine industry are listed below.
- Full papers cane be supplied to anyone interested, for information please contact me.

Developmental changes in grape composition and the implications for wine volatile profiles

P.K. Boss *- E.L. Nicholson - S.M. Maffei - C. Böttcher - C. Davies*

CSIRO Agriculture, Wine Innovation West Building, Waite Campus, Urrbrae, SA 5064, Australia

Grape composition exerts a primary influence on wine flavour and aroma profiles. However, compounds we can measure in grapes are rarely found in the same form in wine. More often, grape metabolites are used by the yeast to produce a range of volatile compounds, in particular, esters, alcohols and acids. Our incomplete knowledge of those grape metabolites that are precursors of wine flavour components, or stimulatory to their production, hinders our ability to predict wine sensory properties from measures of grape composition. Nevertheless, progress is being made, and part of our improved understanding comes from experiments that explore how wine composition is influenced by berry development changes and harvest timing. It is important to remember that while the accumulation of compounds that have a positive effect on wine attributes is an essential part of fruit ripening, the depletion of compounds with negative wine sensory impacts is also occurring. These processes may not necessarily be controlled in a similar manner and may be influenced differently by viticultural practices and environmental factors. We will present an overview of our research into the influence of grape composition on wine volatile composition and sensory attributes with a focus on the changes that occur during berry development.

Affecting yield components and grape composition through manipulations of the source-sink balance

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Department of Sustainable Crop Production, Università Cattolica del Sacro Cuore, Piacenza, Italy[(1)]

Manipulation of the source-sink balance in the grapevine through cultural practices such winter or summer pruning is a long-to-date investigated subject. Though, more recent findings have disclosed the possibility that some specific and targeted operations can be profitably used to pilot dynamic of ripening, induce desired grape composition and replace other costly manual interventions.

The best case in point is leaf removal that when applied pre-flowering (i.e. well ahead traditional usage scheduled between fruit set and veraison) has proven to be effective under a wide range of cultivars and environmental conditions to control yield by reducing fruit set and/or berry size, induce looser cluster less susceptible to bunch rot and promote ripening as a result of increased availability of assimilate per unit of crop post-veraison. This operation can be fully mechanized and, if needed, replaced by the use of anti-transpirants, i.e. a different tool to impose the required source limitation.

A more recent example of a physiological use of leaf removal is given by late (post-veraison) apical to the cluster leaf removal, consisting in having a leaf plucker machine opening a window in the upper two-third of the vine canopy. When applied in environments where, under the pressure of global warming, too fast ripening and unbalanced grape composition is becoming a quite common feature, the technique is viable to slow down the sugaring process, retain higher acidity and, at the same time, total anthocyanins and phenolics do not seem to be either delayed or reduced.

The most recent research line on the subject is represented by recurring to a very late winter spur pruning under the aim of delaying the annual cycle so as the final stage of ripening occurs in a cooler period. Though, preliminary trials have shown that a late winter pruning performed when apical shoots on top of the unpruned canes are at the two-unfolded leaf stage, leads to a yield reduction of about 20% as compared to standard winter pruning, while ripening is not at all retarded, rather enhanced especially in term of berry pigmentation. Once confirmed under a broader array of conditions, the technique might turn out to be a very competitive alternative of the standard and expensive cluster thinning.

Unraveling the impact of crop load on the genetic regulation of fruit quality pathways in Pinot noir and Cabernet Sauvignon grapevines

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The impact of yield on fruit and wine quality has been studied extensively; vine response to increased yield is well known, but responsible mechanisms – including the regulation of pathways responsible for color, aroma and mouthfeel – have not been characterized at the level of genetic regulation. To examine the impact of crop load on transcriptomic and metabolomic changes during grape berry maturation vines from two cluster thinning treatments (50% or 75% of clusters removed following fruit set) were compared to control vines (no cluster thinning). Treatments were applied to mature Cabernet Sauvignon and Pinot noir grapevines, varieties believed to respond differently to varying crop loads, over three consecutive vintages. Agronomic parameters, including yield per vine and the yield to pruning weight ratio, as well as fruit and wine composition, were determined at harvest. Fruit transcriptomic and metabolomic changes were measured in berry samples collected from each treatment in both cultivars at 7 to 10 day intervals from fruit set to harvest. The patterns of berry development by weight, sugar accumulation, and malic acid degradation indicated that both cultivars responded differentially to crop load reduction by accelerating berry maturation progress. RNA-Seq analysis, and untargeted GC-MS and UHPLC-QTOF-MS -based metabolomic approaches were used. The indication of the acceleration of maturation transcriptional programs and of metabolite accumulation in the treated vines was suggested by multivariate analyses. To identify the transcriptional key triggers of this response we applied a two-regression step statistical approach, which identified genes modulated over development dependent on the crop load. Comparing vintages and varieties we were able to estimate the environmental influence on the crop load treatments among years and determine the specificity of varietal responses. The application of this multifaceted approach allowed the construction of robust models describing the impact of crop load on the genetic regulation of grape maturation.

Environmental interaction and climate change – some open questions with respect to grapevine physiology

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The changes in environmental factors such as temperature and precipitation over the last 40+ years have been shown for many viticultural regions and the global increase in CO_2 concentration has now been directly measured for almost 70 years. Certainly, over this time span, grapevines have already adapted to these changes at various degrees but the difficult question is how physiological traits may respond to the predicted further changes and how the wine industry can adapt. Several key issues such as possible changes in plant water relations including genotypic differences of both scion and rootstock in water use efficiency have been studied more than others. Yet there are many physiological responses which have attracted limited attention or hardly any attention at all:

- If Carbon and Water relations change under a future climate – do phloem and xylem capacities change to react to possible changes in sink- source capacities?
- Stomatal conductance should decrease as a response to an increase in CO_2 concentration. But can possible patchy stomatal conductance as a response to CO_2 and stress (i.e. water deficit) modify the overall reaction – and why have studies on this phenomenon disappeared from the literature since the late 90ies?
- Early versus late – how does CO_2 affect early development right after bud break and how are varieties with different seasonal cycle responding?
- Grapevines and associated vegetation in a vineyard – do we need to have a look at comparative adaptation?
- Climate change underground – how do soils respond and how is the grapevine responding? How can altered temperature regimes and precipitation patterns affect organic matter decay and soil nutrient release?
- If soils are warming, what are the effects on hydraulics, on transpiration, on nutrient transport?
- Observed changes in night temperature are stronger than for day temperatures – how does this affect night transpiration and whole-vine water balance in the future – and is evaporative demand increasing or decreasing (both during the day and during the night)?

There are many more detailed research challenges in the context of climate evolvement and specifically responses at the gene and metabolite level will provide some mechanistic answers on varietal responses and resilience capacity.

Remote sensing tools for monitoring vineyard water requirements and vine water status

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The main agricultural areas of Chile will face a significant reduction of rainfall (between 20-40%) due to the global climate change. Also, Chile is periodically affected by the climatic phenomenon of "La Niña" (ENSO), which has produced important droughts and economical losses in most of agricultural areas. Under these conditions, sophisticated irrigation water management will be required to optimize water productivity (kg m^{-3}) and to maintain sufficient levels of yield and wine quality. In this regard, the objective of this paper is to describe remote sensing tools for monitoring vineyard water requirements (or evapotranspiration, ET) and vine water status. The description includes the evaluation of METRIC (mapping evapotranspiration at high resolution with internalized calibration) model to generate maps with spatial distribution of crop coefficients (Kc) and ET of vineyards using satellite images. In this case, validation indicated that METRIC was able to estimate ET and Kc with errors of 9 and 10%, respectively. Also, the presentation includes the validation of a remote sensing energy balance (RSEB) algorithm for estimating vine ET using multispectral and thermal sensors placed aboard an Unmanned Aerial Vehicle (UAV). Results indicated that RSEB algorithm overestimated ET by about 13% with a root mean squared error (RMSE) and mean absolute error (MAE) of 0.43 and 0.29 mm d^{-1}. Finally, the presentation will describe a preliminary study about the estimation of vineyard water status using spectral indices obtained from a six-band multispectral camera placed aboard an UAV.

Genomics of the grapevine and its associated microorganisms enables systems biology studies of grape-microbe interactions in the vineyard

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Many microorganisms, including viruses, bacteria and fungi are capable of infecting grapevines causing important damage if left uncontrolled. Many more microorganisms, endophytic or epiphytic, are not pathogenic and may play a positive role in wine grape production. Although recent reports have shown that composition of microbial communities correlates with quality characteristics and regional variation among wine grapes, our understanding of the interactions between microbial communities and grapevines is still limited. Deep sequencing of rRNA and metagenomes allowed us to describe the composition of the microbial communities in the vineyard, while whole-genome shotgun sequencing provided us with the references necessary to apply metatranscriptomics and profile gene expression of all interacting organisms simultaneously, including the grapevine host. The highly heterozygous genome of Cabernet Sauvignon was sequenced at 140x coverage with the PacBio RSII using a combination of 20kb and 30kb DNA libraries. Reads were assembled into 788 contigs of total length of 590Mb, achieving a contig N50 and N90 of 2.1Mb and 1Mb, respectively. Genetic and optical maps are being used to improve contig scaffolding. The same approach was used to sequence the genomes of some of the most common and economically important grape pathogens. For most fungal species, single molecule sequencing yielded the reconstruction of entire chromosomes in individual contigs from telomore-to-telomere. Short read sequencing of multiple isolates and metatranscriptomic sequencing of vineyard samples has given us the opportunity to associate microbial activity, gene expression with genetic diversity. To study the impact of microbial activity on grape metabolism we have been integrating transcriptomics, metabolomics, and enzyme activity assays. Integrative systems-level analysis of grape berries during the interaction with biotrophic and necrotrophic pathogens is shading light on how microbial activities can reprogram berry development and metabolism.

Clonal fingerprinting in grapevine (*Vitis vinifera* L.) by the identification of somatic variation using Next Generation Sequencing

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Somatic variation in the shoot apical meristem is a cause of intravarietal diversity in grapevine (*Vitis vinifera L.*). The selection of these somatic mutants and the certification of clonal identity have important commercial implications for nurseries. The signatures of somatic mutations are difficult to detect at the DNA level because mutated and wild-type cells coexist in most of the organs, therefore the mutation is diluted in the extracted DNA. For this reason, we developed a reliable system for whole-genome scanning of chimeric variants based on next generation sequencing (NGS) of leaf DNA. *Vitis vinifera* is a model for fruit crops for this issue because there are many clones with accumulated somatic mutations and a high quality reference genome sequence is available. We resequenced (Illumina technology) twenty-three individuals of *Vitis vinifera* derived from two different seedlings: thirteen clones of 'Pinot' and ten clones of 'Sangiovese'. The bioinformatics pipeline for variants detection was calibrated on quality scores of two known chimeric mutations in 'Pinot' family. The comparison between 'Sangiovese' clones revealed a lower level of genetic variation than the comparison between 'Pinot' clones: this reflects little phenotypic diversity among Sangiovese clones and the short history of vegetative propagation of 'Sangiovese'. Through the power of the NGS technology we have produced a sufficient depth and breadth of sequence coverage to comprehensively discover somatic mutations within varieties that distinguish clones at the genotypic level. The study provides the first whole-genome estimation of the rate of somatic mutation in grapevine varieties.

The dissection of GxE interactions using a novel data mining approach uncovers the plasticity of the grapevine berry transcriptome

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Paola Zuccolotto [3] - *Marianna Fasoli* [1] - *Lucio Brancadoro* [2] - *Attilio Scienza* [2]
Giovanni Battista Tornielli [1] - *Mario Pezzotti* [1]

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Grapevine, the most widely-cultivated perennial fruit crop, is also considered a very environmentally sensitive crop. It is characterized by remarkable phenotypic plasticity which in turn is believed to effectively buffer environmental extremes especially through transcriptomic and epigenomic reprogramming. Thus, the final phenotype (P) of a given vine is the result of the close interaction between its genetic composition (G) and the environment (E).

Here we analyzed Genotype x Environment (GxE) interactions in two grapevine varieties by characterizing their transcriptome plasticity when cultivated in different environments. Specifically, two genotypes (Sangiovese and Cabernet Sauvignon) were cultivated in three different locations in Italy (Bolgheri -littoral Tuscany-, Montalcino – Appennine Tuscany- and Romagna -foothill area-), trained in an almost identical manner, and sampled at four developmental stages over two grapevine growing seasons, 2011 and 2012, for a total of 144 samples that were analyzed by hybridization to a whole-genome microarray.

In order to study the relationships among differential gene expression profiles and environmental cues, we have developed a new statistical data mining tool based on data reduction approaches which allowed a dissection of the transcriptomic data into stage-specific, cultivar-related and GxE important clusters of gene expression. This deep inspection of inner relationships between the different dataset variables allowed the identification of several candidate genes that could represent putative markers of berry quality traits in grapevine GxE interactions. Moreover, the methods used to establish our model provide a framework for the analysis of transcriptome plasticity in other crops as they respond to diverse environments.

Industry visits

Conference field day…

Site 1. Visit far eastern Veneto region near the south coast of lake Garda, known as Lugana. Figure 1.

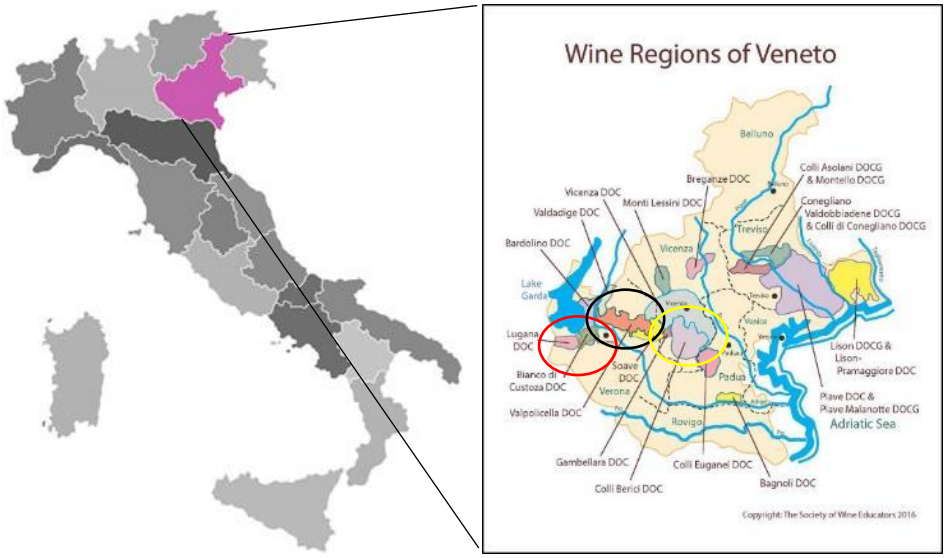


Figure 1. Location within Italy and Veneto wine region, stop one is highlighted in red, stop 3 is highlighted in black with our final destination highlighted in yellow. Image: http://batwine.uk/italian-wine/veneto/

This visit was to the family winery and vineyards of Le Morette, this was in the Lugana DOC which is located between the Lombardy and the Veneto regions. Lugana is a relatively small region in Veneto covering approximately 1500ha, as compared to Soave which is 7000+ha. This visit was very comprehensive in terms of viticultural information, the owner and host was clearly aware that we were from a viticultural conference and was very open to discuss many aspects of produciton. Some key information on viticulture in the region and specifically at Le Morette is supplied is as follows:

- Vineyards are flat, generally 40-45% clay.
- Clay content is claimed to assist in limiting summer growth later in the season.
- Young vines are ripped pre planting and irrigated for the first 10 years to ‘soften’ the clay and allow root penetration.
- The region is mainly planted to Trebbiano using a Guyot trellis system, this is often a modified system to have an arched cane as Trebbiano is not fruitful on nodes 1-3.
- Vineyards are planted at 0.8m spacing and 2.5m to 2.8m rows. Row width is wide for the VSP but required to allow light and airflow.
- Vineyards are usually planted North to South for best light capture and airflow.
- It has been seen that vineyards planted East West can have a 2^{o} Brix difference at the same point at harvest.
- Fruit prices are around €2/kg which is a significant rise from just several years ago when €1/kg was more common.
- Sites are run in a ‘generally organic’ standard ie. Copper and Sulphur and pheremones for mating disruption of pests.
- Further questions revealed that systemic spraying is used routinely and required to minimise rot and disease.

- Spraying is undertaken 12-14 times in a 'normal' season, this season (2016) is far from normal and has seen more sprays at this time than at the same time in the past.
- Sprays in this region represent around 20% of the total vineyard production costs. Trebbiano has large bunches and will crop very high, this can be achieved outside of DOC regulation however within limits are applied to keep crops below 12 t/ha.
- Due to Phylloxera, rootstocks are nessecary. Kober is now preferred as it can handle waterlogging where S04, which was widely planted, does not.
- Some vines are up to 50 years old, but due to constant re-planting the average age is much lower.
- Experince suggests 25 year old vines make the best wines, that are more suited to aging, while younger vines make wines that are less suited to aging.

Le Morette are champions of the variety Turbiana, this is not widely known, but is suggested to be distinct from Trebbiano. As with many Italian varieties, there are often synonyms and local clones that appear to differ morphologically. A paper by Imazio et al. (2002) found that Trebbiano di Soave and Trebbiano di Lugana (often labelled as Turbiana) are actually 97% genetically similar.

Le Morette have a source of 100 year old Turbiana which they use as source scion material to graft in their own semi commercial nursery. This was established to maintain the genetic individuality of their vineyards under a program of constant re-working.

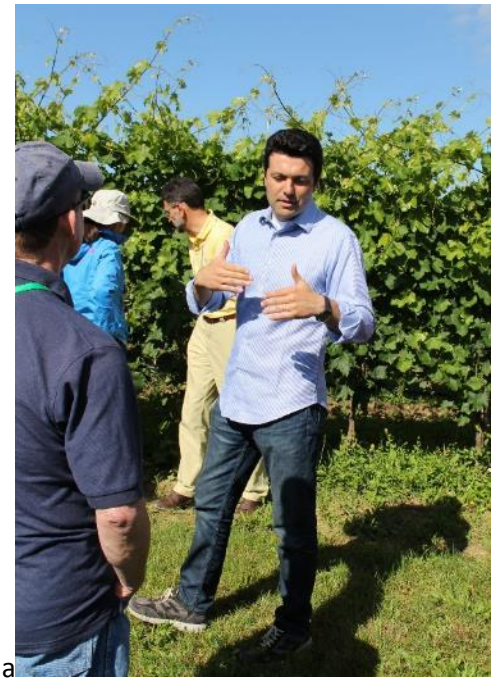
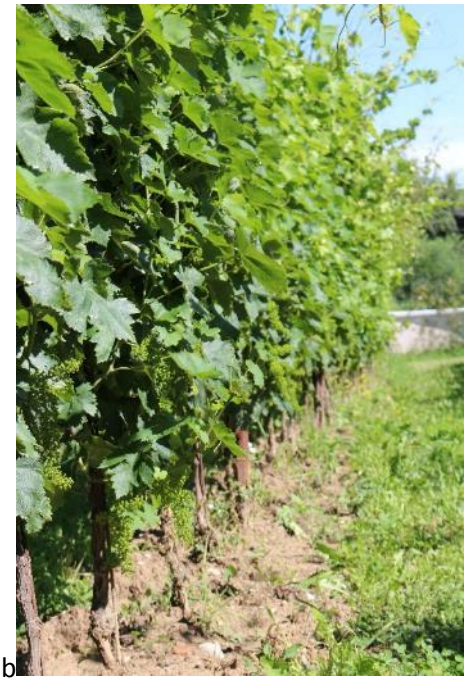
a  b 

Figure 2. Fabio explaining the viticulture of the region (a) and example of strict VSP canopy (b).

The extensive viticultural session was followed by a brief tour into the underground cellar and a tasting of wine.

Site 2. The second stop was at a producer specifically for lunch, we were given a tour of the wine warehousing space and guided to the tables for food. This stop was not well accommodated for viticultural or wine related education, however the food was abundant and high quality.

Site 3. The second to last stop was on the western shore of Lake Garda, at the winery 'Zeni' in Bardolino (Figure 1). This winery was established in 1870 and the same family still own it and have a long history of wine production. Firstly we were taken to look at an uncommon vineyard for the region, cabernet sauvignon. This was on the winery site but not indicative of the viticulture or varieties common to the region, it was somewhat of a curio planted by Fausto's father.

a  b 

Figure 3. Fifth Generation winemaker at Zeni, Fausto talking about viticulture (a) cordon pruned Cabernet Sauvignon showing severe wood disease and dieback (b).

The vineyard inspection, while not informative for the region, for this early career researcher was a fantastic opportunity to identify and talk about current management and the challenges it faces. Specifically discussing the trunk disease (Eutypa like symptoms) and excessive vegetative growth with well published research peers such as Prof. Markus Keller was very much a highlight.

While still in the Veneto region (Figure 1) Zeni procures grapes from four DOC recognised areas allowing several wine styles to be produced. DOC wines produced are labelled, Lugana, Bardolino, Valpolicella and Soave. Following this vineyard visit a tour was conducted through the Zeni wine museum which showed pictures and examples of antique winemaking equipment and practices. A small tasting was arranged in the underground cellar of Zeni where we tried several wines.

Stop 4. The final destination was in the historic town of Soave, at Cantina di Soave. A guided tour of the cellar and underground barrel storage was undertaken briefly before the evening meal was served. Highlights here were the large array of soil samples presented (Figure 4) to show the vast range of influences possible on wine style.

Figure 4. Underground cellar (a) and examples of typical soil types which are found in various regions and sites (b)

Alto Adige (Sudtirol)

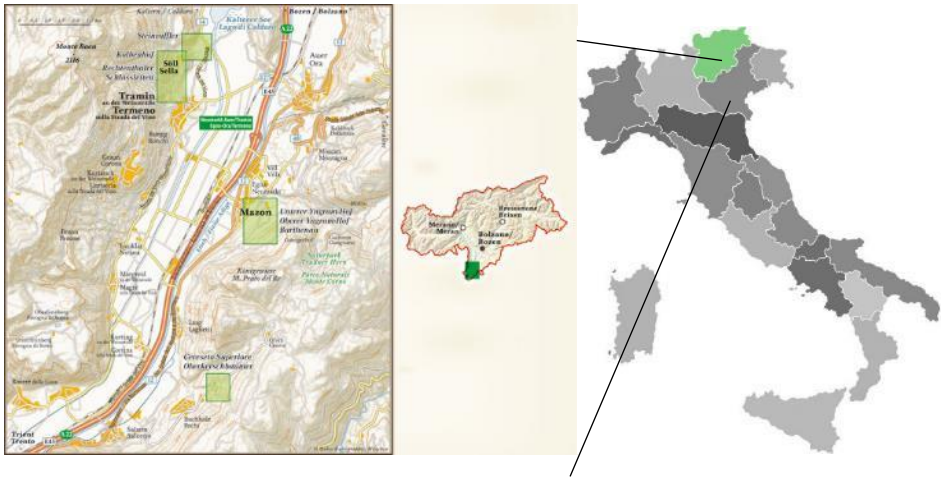


Figure 5.Location of Alto Adige wine region in Italy and inset showing location of J Hofstatter vineyards and winery near Tramin. Image: http://batwine.uk/italian-wine/sudtirol/

This visit was arranged to visit the cellar and vineyards of one of the most well established and recognised wine businesses in the region. The visit to J. Hofstatter was very interesting, the winery and cellar door is state of the art. From a viticultural point of view, behind the winery is a small vineyard planted with a large array of native, and not so native wine grape varieties (Figure 6a). This planting includes one row (sometimes only 12-20 vines) of an impressive array of varieties and clones, mainly the most important ones to the area such as; Gewurztraminer and Pinot Bianco. There were also several very peculiar varieties that I was not familiar with such as the Hungarian Gewurztraminer cross Cserszegi Fuszeres Neoplanta.

The small varietal vineyard contained many informative signposts labelling each planting and covering topics from clones, climate to pruning and training in the region. This was the first identification of the Simonit and Sirch pruning method I observed while travelling (Figure 6b). Having heard and read of this method in Australia I was interested to learn more of its practical application. This pruning method is touted as being the future of pruning, it is based on decades of research into sap-flow, die-back and technique. The Simonit and Sirch method was developed in Friuli and is now being exported around the world, a later visit in Piemonte has been arranged to learn more about its application.

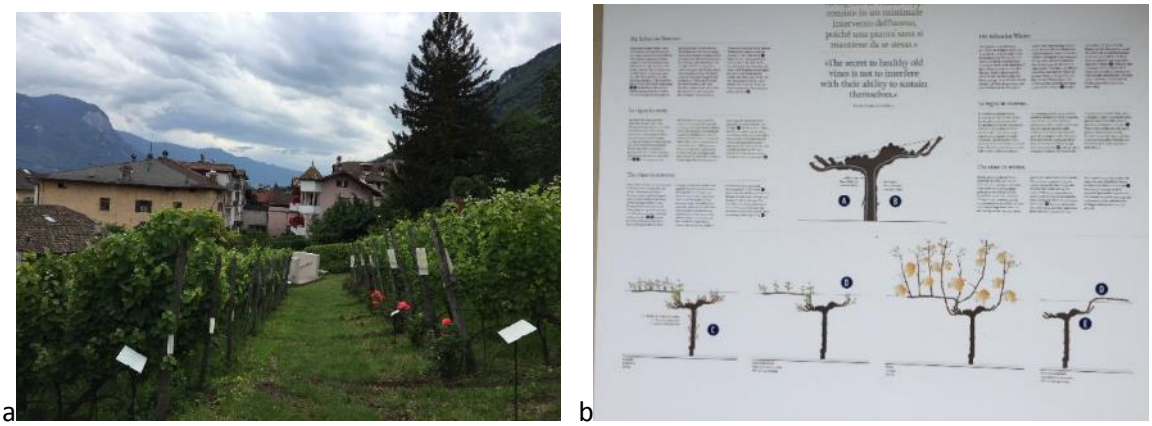


Figure 6. Varietal and informative vineyard (a) details of Simonit and Sirch pruning and training method (b)

In the cellar the winery was small but new and well designed, one on the most striking features was the shape and material used for fermentation, they were like a stemless wine glass, such as Riedel

(Figure 7a). Interestingly, the round fermenters were custom designed to contain cooling jackets and had flat bottoms for ease of use, unlike many other producers that use an 'egg' shaped vessel which anecdotally allows convection and passive circulation within the vessel.

Markus the winemaker at J Hoffstatter explained the entire winemaking process including the relationship they have with a specific cooper to make barrels and analytically benchmark and test them for specific compounds and concentrations prior to use. The cooper is Francois Ferrer from Mersault in France (Figure 7b). Equally impressive was the room of Austrian oak from famed cooper Stockinger (Figure 7b inset).

a  b 

Figure 7 (a) Wine glass shaped concrete fermenters and storage vats. (b) underground barrel storage and trial set-up.

Muscoline

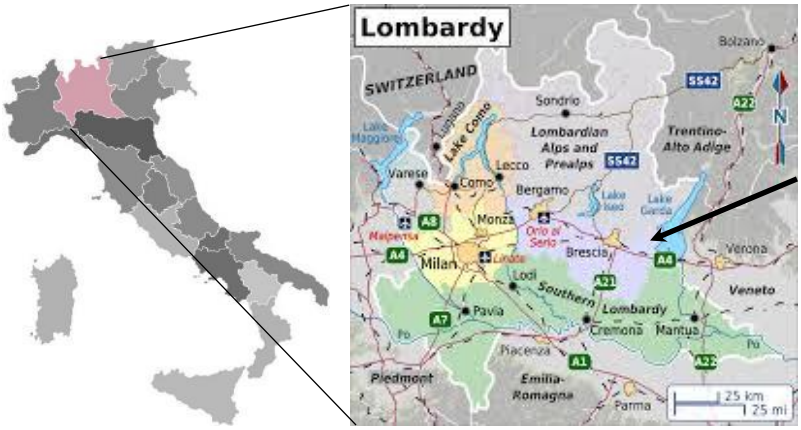


Figure 8 Location of region of Lombardy within Italy also showing provence of Brescia and arrow indicating approximate location of Cascina Belmonte. Image: http://batwine.uk/italian-wine/lombardia/

On the route to Piemonte a brief stop was made at Cascina Belmonte. Cascina Belmonte is located near the town of Muscoline which is a small town in the south east corner of the province of Brescia in Lombardy. This visit was intended to observe organic viticulture and integrated pest management techniques. Unfortunately this field visit was cancelled due to dangerous storms at the time. We did still get a tour of the winemaking facility, which is quite small and a tasting of several wines. Interesting to note was the practice of grape washing; this is undertaken to remove any spray residues, dust, bugs or other non-grape material. In addition to the above reasons, the area is

suggested to be quite polluted so washing was seen as a method for removal of pollutants prior to vinification. A custom washing and drying conveyor is used which can be seen in Figure 9.

A wine tasting was held with several wines one of which was unheard of for me. The wine was made from the grape called Rebo, this is unique to this area and appears to perform well, due to this, it is hoped to be a very successful variety for the region. Rebo was an accidental import to the region and planted by mistake, later this was seen as a potentially useful variety as it outperformed the other varieties that were intentionally planted. Rebo is a cross between Merlot and Teroldego, that was made in the 1940's.



Figure 9. Custom made grape washing and drying conveyor and our host and winemaker Enrico.

Piemonte

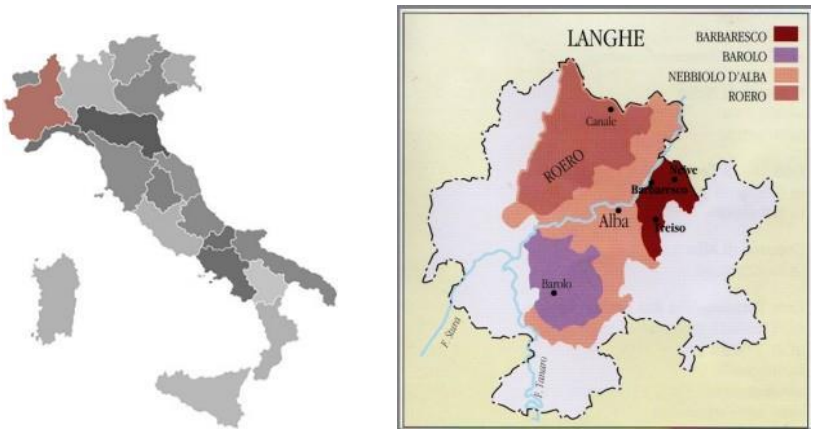


Figure 10. Map of Italy showing location of Piemonte region, inset showing Langhe region home to Barolo, Barbaresco. Image: www.vinissima.net and http://batwine.uk/italian-wine/piemonte/ .

The trip to Piemonte was made to visit the world famous vineyards of Barolo and Barbaresco (Figure 10). Much like the Barossa Valley (and Australia) this region is most recognised for one variety, Nebbiolo. Like Shiraz this variety can produce very different wines from nearby locations and has a wide range of clones available. A very detailed vineyard tour was arranged in the Langhe region, this was a chance to learn more and see vineyard practices first hand. This tour was also attended by Giorgio Gambino, a researcher specialising in epigenetic and genetic diversity of Nebbiolo and Nebbiolo clones. This provided a unique opportunity to discuss research topics and potential collaborations in relation to future Shiraz clonal studies in Australia.

Giorgio is involved in researching epigenetic responses to environment, which is currently also being investigated in our University of Adelaide research group. Simone Lavezzaro, from the consultancy firm vit.en was also present to bring management and research experience regarding pests and

diseases of grapevines. The tour was run by Davide Pellizzari and David Fletcher, both from Ceretto winery in Alba.

Ceretto winery owns 140 ha of vineyards in the Langhe, including holdings in cru's of Barolo, Barbaresco and Roero. Ceretto vineyards are all certified organic and are largely biodynamic, mainly in Barolo. Some highlights of interest to report are listed below in point form:

- Cover cropping was a much used practice, however cultivation is now preferred to be kept to a minimum.
- Any grass growth in the mid-row (which is quite a lot) is preferred to be rolled with a ribbed roller rather than mown or cultivated.
- Older clones of Nebbiolo are cane pruned while newer selections are able to be spur pruned due to greater basal fruitfulness.
- Yields are controlled to be below 7.5t/ha to maintain classification by authority.
- Spraying is undertaken frequently as organic preparations are only protective
- Frequency of spraying can be as high as 18 per season due to organic requirements.
- Long shoots were observed in the vineyard and wrapped around top foliage wire in place of trimming, this practice is called pallisage and thought to promote balance reducing lateral growth.

Cannubi was the first Cru vineyard visited to see the oldest vines Ceretto own. Here we saw 80 year old Nebbiolo. The old vines were inter-planted with newer vines and also featured many layered vines. Layering in a region known to have Phylloxera is uncommon but appears to work in this situation.

Following the visit to Cannubi, the oldest known vineyard in the area was visited, near La Morra. This is greater than 80 years old and had very large trunks and poorly managed structure. The vine training method here results in long sections of non-bearing wood above ground. These vines were still productive but appeared to not be in the greatest health.

We visited a young vineyard to observe where the Simonit and Sirch pruning method had been implemented since planting, this was approximately 5 years ago. Key points from this are:

- Make small cuts only
- Keep all terminating cuts above the cordon, so sap flow is unimpeded below the cordon
- Don't ever cut a shoot close to the point of origin, maintain a 'portion of respect'
- This 'portion of respect' can be removed once dried
- When taking a can to lay always must be from inside the spur
- When leaving spurs not the lower bud must be on the outside, therefore cannot prune to a definitive number but more to position.
- This method is aimed to prolong health, balance and vigour in the vines.

Further visits were made to the cellars of Giuseppe Rinaldi and Brezza. Enzo Brezza was very accommodating and happy to give a tour of the vineyard, compost and machinery shed. Here I observed several unique customised machines, which may have application in Australian viticulture, specifically lightweight ATV towed machines.



Figure 11.(a) Cannubi vineyard with Georgio, David, Davide and Simone. (b) 80 year old Nebbiolo vine in Cannubi, note younger vine planted between.(c) Oldest reported vines in region. (d) Pruning method detail on young vines. (e) Pallisage; wrapping of growing canes around top foliage wire in place of trimming. (f) Vast biodynamic composting piles >3000 tonnes of raw compost creates ~1000 tonnes of usable material which is spread annually.

Emporda region in Spain



The Emporda wine region is located approximately 160km north of Barcelona, it is at the base of the Pyrenees and close to the French town of Perpignan and regions of Banyuls. Emporda has been a viticultural production region since Roman times. During the early infection of French vineyards with Phylloxera in the 1860's plantings increased to supply failing French vineyards. After the discovery of grafting to rootstocks for Phylloxera, demand was reduced for Emporda's grapes and Phylloxera too began to cause decline on vineyards in Emporda in 1879, the region has never recovered all the land they occupied prior to this.

My visit was arranged to see one of the larger producers in the region that have both young and old vines across the region. Espelt viticultors have been involved in grape production for at least 6 generations. The tour began in the national park of Mas Mares (Figure 12a), above the town of Roses. Here I saw plantings of Grenache, Shiraz, Carignan, Cabernet, Merlot, this site is very exposed to the Tramontana which is a strong wind (up to 120kph) that comes from the North.

In this region water is in very limited supply and vines must be managed in a manner that best conserves the low growing season rainfall. This region, like many, faces uncertainty from climate variability and must take steps to ensure production can continue, as it is important for employment and tourism.

Of the vineyards visited, some were noted as being 116 year old Grenache (Figure 12b), these were planted on rootstocks. As with in Italy, some of these old vines were supporting layered younger vines growing on their own roots via vegetative propagation.

The growing season of 2016 will be recorded as one of very high disease pressure, Downy mildew (Plasmopara viticola) is not often a problem due to the dry spring and summer. This season repeated warm wet weather events, produced significant outbreaks of mildew that infected not only leaves but flowers and bunches (Figure 12c,d), this leads to very high crop loss.



Figure 12.(a) Typical vista from Mas Mares vineyards above the town of Roses, low shrubs and arid dry landscape. (b) Old vine Grenache reported to be 116 years old. (c) Bunch and leaves showing severe Downy Mildew (Plasmopara viticola) infection the fruit not infected by Downy Mildew is infected with Powdery Mildew (oidium). (d) Shoot showing symptoms of Esca dieback, this was not uncommon to see in vigorous vineyards.

Outcomes and conclusions

Participation at this conference was a great privilege and opportunity, listening and meeting some of the best researchers and most highly respected leaders in grapevine research was very inspiring. This conference, being my first as a PhD candidate and student, was an invaluable opportunity to make contacts and mingle amongst not just peers of vine research but the potential future leaders also. I took the opportunity to talk about not only my research but the research questions and methodologies of other researchers too. This was very informative and thought provoking seeing the many ideas for data presentation and analysis, which can be incorporated into my research and communication immediately. Having my research displayed at such a large conference certainly helped to raise my profile as a researcher in viticulture.

I would like to thank Wine Australia and the University of Adelaide for giving me this opportunity to meet new people, broaden my knowledge and skills in this part of the world.

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