# Abstracts

## Papers and Posters Presented at the Joint International Conference on Viticultural Zoning, 15 – 19 November 2004, Cape Town, South Africa

## PAPER PRESENTATIONS

### THEME I – A Worldwide Perspective on Viticultural Zoning

**E. Vaudour (Keynote Speaker)**

Institut National Agronomique Paris-Grignon, UMR INRA/INA P-G "Environnement et Grandes Cultures" – Equipe Sol-DMOS, Centre de Grignon BP 01, 78850 Thiverval-Grignon, France
[E-mail: Emmanuelle.Vaudour@grignon.inra.fr]

This article reviews viticultural zoning concerns and issues in a worldwide perspective. In every vineyard in the world, zoning is needed and corresponds to varied applications, definitions and approachs. Zoning aims have been changing together with the needs of the ever-expanding international wine market. There are more and more wine-producing regions and countries involved in zoning studies, and although many of the corresponding works were initiated in Europe, zoning needs go far beyond the countries endowed with centuries-old viticultural history. Demarcating registered designations of origin or protected geographical indications is one of the most obvious of all zoning aims, which originates from the XIX$^{th}$ century in Europe, and now addresses most recent wine-growing countries. Other important zoning aims, not necessarily related to demarcating operations, consist in segmentating a vineyard territory into homogeneous units that are likely to be consistent with either pest management, reparcelation, vineyard restructuring operations, grape harvest quality management, or site selection for new vineyards. The homogeneous units obtained through viticultural zoning are frequently referred to as '*terroirs*'; however their scale, characteristics, materials and methods may greatly vary depending on authors and vine-growing regions, making international zoning comparisons uneasy. Viticultural zoning can actually be separated into 2 main groups: on the one hand, that insisting on the geographical differentiation of wines, grapes, or plant characteristics; on the other hand, that focused on the geographical differentiation of land capabilities or vineyard suitabilities, for which soil and climate are mostly referred to as key variables, but with varied significations and the use of distinct soil classifications. Viticultural zoning is not always synonymous with mapping and spatial analysis: this is changing through the enhanced use of geomatics. Digital mapping methods and remote sensing techniques are renewing viticultural zoning at all scales, from plot to region. Suitabilities approaches at the field scale or local level, including precision viticulture, are mostly directed towards the understanding of plant ecophysiological functioning. At the global or regional scale, encompassing wider areas, suitabilities approaches are oriented towards the characterization of land geographical patterns and face the problem of relating these patterns to sample sites described at the field scale. Spatial analysis criteria, including spatial extent, resolution, map scale, sampling design, all together with duration criteria, tools, validation, plant varieties and training systems are likely to enable zoning comparisons at the international level. Some examples are given in this paper.

### The Role of the Landscape as a Component of the Terroir in Spain (Do Somontano, Ne Spain)

**V. Sotés** and V. Gómez Miguel

Universidad Politécnica de Madrid.- Ciudad Universitaria, s/n-E28040 Madrid, Spain
[E-mail: vsotes@pvf.etsia.upm.es]

The components and methodology for characterization of the terroir in Spain have been described by Gómez-Miguel et *al.* (2003), Sotés et *al.* (2003), taking into account the full range of environmental factors (i.e: climate, vegetation, topography, soils, altitude, etc.), landscape variables (derived from photo-interpretation and a digital elevation model), and variables specific to the country's viticulture (i.e: size and distribution of the vineyards, varieties, phenology, productivity, quality, designation regulations, etc.). This paper describes the integration of the resulting database in a Geographic Information System (G.I.S.) that allows the spatial and statistical analysis of all variables; the parametric system of variable quantification; the selection of main endogenous and exogenous variables for terroir characterization; and the role of the variables that describe the landscape in the final results. The analysis has been carried out on over 1.8 million ha. This paper presents the results of a case study in the county "Somontano" that covers an expanse of 142,000 ha and includes 4,173 ha of vineyards. The observed distribution of vineyards in this county is correlated to the integrated landscape-terrain classification and productivity but does not depend on the total available area for cultivation. It is significant that a subset of geologi-

**Bold type** indicates presenting author. Full-length oral presentations are available on CD and could be ordered from the SASEV office. Inquiries should be addressed to: SASEV, P.O. Box 2092, Dennesig 7601, South Africa. E-mail: sasev@arc.agric.za

cal formations that accounts for 45 percent of the total area sustains over 90 percent of the vineyards. The results of the study have general implications for landscape-terrain classification in Spain and define a set of methodological guidelines. These guidelines refer to: (a) Definition of the set of variables that define the landscape: characterization of the lithological and morphological components; homogenization of lithological units; cartography of the geological formations; integration of a digital elevation model to derive altitude, orientation, exposure, and slope. The spatial scale should be at least 1:25.000; (b) Definition of the Homogeneous Land Units (HLU): The parameter characterization was carried out from the units which were previously defined from the data of the environmental analysis; (c) Experimental design: Selection of Homogeneous Land Units and characterization within the units and (d) Final zoning: Integration of the Homogeneous Land Unit with the plant (variety and rootstock) and the product (must and wine).

### Viticultural Sites and their Valorisation in Istria (Croatia)

**B. Sladonja**, D. Peršuric, A. Milotic and A. Peršuric Ilak

Institute of Agriculture and Tourism, Porec, C. Huguesa 8, p.p. 31, 52 440 Porec, Croatia
[E-mail: barbara@iptpo.hr]

Almost the whole territory of Istria has suitable natural conditions and millenniums long tradition of vine growing. Viticulture was and stayed economically the most important branch of agricultural production. Viticultural locations in Istria are characterised by several factors as natural, productional, social and administrative. Last hundred years, sociopolitical circumstances were not supporting viticultural development. By the end of the 19. century vine stocks were planted on one third of whole arable land surface; by the cadastre in 1880. Istria had 33.847 hectares of mature vineyards (Vivoda, 2001). Regardless the wealth and importance of natural conditions, different states that crossed through Istria in time, had agrarian policies which caused a significant decrease in viticulture locations, so in 2001. Istria had 8.277 hectares of vineyards (Governmental Office for Statistics, 2001). Beside economical losses and non used resources, also the land devastation occurred – the land of vineyards and wine was left without pictures vineyard sites, and its known identity. Today intensive programs for vine stock planting and landscape renovation would be unfortunately stopped by Croatia entering the European Union. This paper presents possible administrative solutions for viticulture spreading and data on typical viticultural locations and wine from indigenous grape varieties in Istria. Beside returning historical characteristics in landscapes, it would possibly enable a strong revalorisation of viticulture as a unique socioeconomic and ecological branch of agriculture.

### Determining Sub-Appellations in Ontario's Wine Regions

**A.B. Shaw**

Department of Geography, Brock University, St. Catharines, Ontario, L2S 3A1, Canada
[E-mail: tshaw@brocku.ca]

Vintners Quality Alliance (VQA) Ontario is responsible for administering and enforcing standards in connection with wine quality, Appellation of Origin, grape varieties and production methods. Wines produced in accordance with VQA regulations are currently labelled under three distinct but broad viticultural areas (Niagara Peninsula, Lake Erie North Shore and Pelee Island. The present system of production permits a single grape variety to be grown in several highly dissimilar soils, topographies and mesoclimates, resulting in wines that are highly variable in their character. The objective of this project is to evaluate specific properties of the soil, geology and climate that are suitable for certain varieties, wine styles and consumer preferences. Furthermore, it aims to identify broad zones or sub-appellations that possess a combination of climatic, soil, geological and topographic elements that would enable the designated grape varieties to achieve optimum ripening potential, produce wine of consistent quality and avoid excessive freeze injury. Accordingly, this project uses several databases relating to the soil, topography, location, geology and climate of Ontario's wine regions along with GIS (Geographic Information System) tools to determine the spatial distribution and homogeneity related to several proposed sub-appellations. A composite index based on several key environmental variables was then constructed; the results were mapped for the region and the boundary of each sub-appellation was carefully defined.

### Climatic Potential to Produce Grapes for Wine-Making in the Tropical North Region of Minas Gerais State, Brazil

**M.A.F Conceição**[1] and J. Tonietto[2]

(1) Brazilian Agriculture Research Company (Embrapa), Grape and Wine National Research Center, Tropical Viticulture Experimental Station, PO Box 241, 15700-000, Jales, SP, Brazil

(2) Brazilian Agriculture Research Company (Embrapa), Grape and Wine National Research Center, PO Box 130, 95700-000, Bento Gonçalves, RS, Brazil

[E-mail: marcoafc@cnpuv.embrapa.br]

The tropical north region of Minas Gerais State is one of the least developed of Brazil and viticulture could be an alternative to develop its agriculture zone. The objective of this work was to evaluate the wine grape production climatic potential of that region. The evaluations were carried out employing the Multicriteria Climatic Classification System (Geoviticulture MCC System), that utilizes three reference climatic indexes (Dryness Index – DI, Heliothermal Index – HI and Cool Night Index – CNI). This study integrates the concept of viticultural climate with intra-annual variability, that corresponds to the regions that, under natural climate conditions, change viticultural climate class as a result of the time of the year at which grapes can be produced – a definition to be used for regions with a hot climate where it is possible to have more than one grape harvest per year. Three locations – Pirapora (17° 21'S, 44°56'W, 489m), Montes Claros (16°43'S, 43°52'W, 647m) and Diamantina (18°15'S, 43°36'W, 1297m) – and two potential production cycles along the year – October-March (summer period) and April-September (winter period) – were evaluated. The results showed that in the summer period Pirapora and Montes Claros presented monthly average maximum temperature values (Tmax) varying from 29,4 °C to 31,7 °C, average minimum temperatures (Tmin) between 17,7 °C and 20,4 °C, and precipitation (P) varying from 76,8 mm to 223,8 mm, representing a 'humid, very warm and with warm nights' class of viticultural climate, according to MCC System. This climatic condition is similar to the summer period condition of the Brazilian San Francisco Valley (9°23'S, 40°29'W, 371,7m)

grape-growing region, although with a higher DI. For the winter period, those two regions presented Tmax between 27,1°C and 31,7°C, Tmin between 12,1°C and 18,2°C, and P between 1,8 mm to 51,4 mm representing a 'moderately dry, warm and with temperate nights' according MCC System. Otherwise, the Diamantina summer period presented Tmax values between 24,4°C and 25,3°C, Tmin varying from 15,6°C to 17,3°C and P values between 99,2mm and 261,2mm, representing a 'humid, temperate warm and with temperate nights' viticultural climate. In the winter period, Diamantina Tmax values varied from 20,9°C to 24,0°C, Tmin varied between 11,8°C and 15,9°C and P varied between 7,8mm and 58,1mm. These values represent a 'subhumid, temperate and with cool nights' viticultural climate. Based on those results it can be concluded that the north region of Minas Gerais State has a great climatic potential to became a grape-growing for wine-making region, specially on the winter period, when the region viticultural climate presents conditions where vine will potentially face a certain level of dryness, an heliothermal global regime between temperate warm and warm, and with cool to temperate nights. The viticultural climate with intra-annual variability of the region, that offers a potential to produce grapes in the tropical winter period, represents a particular condition in relation to the world classic geoviticulture. The climatic groups of the regions with possibility to produce in the non classic periods of the year must be considered in the context of the tropical viticulture climate, presenting a distinct seasonal thermic evolution dynamic.

### Evaluation of the Site Index Model for Viticultural Zoning

**D. Tesic**[1] and G. Barbeau[2]

(1) National Wine and Grape Industry Centre, Charles Sturt University, Wagga Wagga, 2678 NSW, Australia
(2) Unite de recherches sur le vigne et le vin, INRA Centre d'Angers. 42, Rue Georges Morel BP57, 49071 Beaucouze CEDEX, France

[E-mail: dtesic@csu.edu.au]

A composite variable termed the Site Index (SI), integrating soil physical properties and mesoclimate, was previously proposed for characterisation of vineyard sites based on a three-year study of Cabernet Sauvignon vineyards in the Hawke's Bay region of New Zealand. In this paper, viticultural data collected from Chenin Blanc and Cabernet Franc vineyard sites in the Loire Valley (France) were analysed. These analyses provided an opportunity for validation and understanding of limitations of the SI model. The relationship between SI and Chenin Blanc fruit composition in Anjou was found to be similar to that determined in the New Zealand study. In this study, a modified SI that included winter rainfall was found to be a better predictor of grapevine vigour than original SI. In cases when the range of SI values between sites was small, no significant correlation between SI and viticultural variables was observed. Factor analysis extracted one factor best related to SI and fruit quality potential, and the second factor related to modified SI that included winter rainfall and vegetative vigour. It was determined that SI has the potential to be included as an additional indicator to the range of attributes available for vineyard site evaluation. It would be particularly useful where input variables (soil depth, texture, rockiness, water influx and air temperature) are considerably different between sites that are being compared.

## THEME II – Methodological Approach to Zoning

**V.A. Carey**[1] and **V. Bonnardot**[2] **(Keynote Speakers)**

(1) Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
[E-mail: vac@sun.ac.za]
(2) ARC Institute for Soil, Climate and Water, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: valbon@webmail.co.za]

An appellation or geographic indication should be based on the terroir concept in order to ensure its integrity. The delimitation of viticultural terroirs must include two consecutive or parallel steps, namely (a) the characterisation of the environment and identification of homogenous environmental units (basic terroir units, natural terroir units) taking all natural factors into account, as well as (b) the characterisation of the viticultural and oenological potential of these units over time.

### Soil Clay Mineralogy and Potassium Buffer Capacity as Potential Wine Quality Determining Factors in Western Cape Vineyards

**J. Wooldridge**

ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: wooldridgej@arc.agric.za]

The potassium (K) supply characteristics and clay mineralogies of a population of Western Cape soils were investigated to determine their potential effects on vine K uptake and wine quality. The total K contents of granite-, shale- and sandstone-derived soils varied, averaging 33.7, 26.1 and 4.5 cmol(+)/kg, respectively. Corresponding M $NH_4Cl$ exchangeable soil K levels were: 0.172, 0.042 and 0.035 cmol/kg. Ability to fix applied K also varied, decreasing from 0.350 in the shale-, to 0.188 in the sandstone- to -0.177 cmol/kg in the granite-derived soils. Potential buffering capacity for K was pH / liming dependent, particularly in the shale soils. Potassium uptake by Italian rye grass correlated negatively with K fixation. The K contents of Italian rye grass grown on the sandstone, shale and granite soils were, respectively, 2.32, 2.12 and 5.56 dry mass %. These results were explicable in terms of soil mineralogy. The presence of kaolinite in the clay fraction, with mica and K-rich feldspar cores in the silt fraction enabled the granite soils to release primary K, but conferred little power to fix, or to buffer K against luxury uptake or loss through leaching. In contrast, the shale soil clay fractions consistently contained vermiculite and interstratified 2:1 minerals. These conferred marked pH / liming dependent K buffer capabilities. The shale soils also contained K in micas in the non-clay fractions. The sandstone soils varied in terms of both mineralogy and clay content. Sandstone soils, in which the sand fractions were quartzitic were unable to deliver primary K. Similarly, sandstone soils having low clay contents had severely

limited K buffering capabilities. The observed differences in the abilities of sandstone-, shale- and granite-derived soils to supply and buffer K may be sufficient to affect grape vine performance and wine quality in Western Cape vineyards.

## The Use of Remote Sensing In South-African Terroir Research

**A.E. Strever**

Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
[E-mail: aestr@sun.ac.za]

The diversity of soil types in the Western Cape of South Africa leads to high levels of within-vineyard variability. Multispectral remote sensing has received a lot of attention recently in the South-African wine industry in an attempt to identify and deal with this variability. While this technology holds promise for precision vineyard management as well as segmented harvesting of grapes, its potential as a tool in research has not yet been fully utilised. It holds promise as a tool to study the interaction of the grapevine with its environment, especially with regards to differences in vine performance due to soil variability. One of the most important goals of this research is to determine how the information derived from the vegetation indices used in the imaging relates to grapevine performance. Another objective is to assess the effects of practices that could differ between vineyards, such as trellis systems or canopy management on the image signal. In a terroir study, aerial images were used to optimise plot layouts in the vineyards at different localities according to vineyard characteristics. Factors limiting or enhancing vine vigour were investigated using multispectral images. The use of hyperspectral satellite imagery from the hyperion imager was also investigated as an additional tool to monitor the effects of the environment on the performance of the grapevine. Terroir research focuses on identifying homogenous environmental units that have a specific viticultural and oenological potential. It is deemed necessary to investigate the "building blocks" of these "homogenous" units, which may encompass high levels of variability, in order to adapt them to a micro-scale for application on a vineyard level. Closer investigation of these "micro" terrroirs that exist within vineyards may enable us to utilise the full potential of our diverse natural environment.

## Characterization of Vine Performance Using Remote Sensing Tools

**J.P. Roby**, E. Marguerit, O. Schemel, C. Germain, G. Grenier and C. Van Leeuwen

ENITA de Bordeaux, 1 cours du Général de Gaulle BP 201, 33175 Gradignan Cedex
[E-mail: jp-roby@enitab.fr]

Today, a variety of remote sensing tools are used to characterise plant performance. However, the vine is rarely studied, as a major crop specificity is canopy discontinuity. Registered images of the vineyard are anisotropic, therefore difficult to analyse. All current plant performance evaluation technologies pick up and record the energy of emitted or reflected electromagnetic radiation, and analyse information for later interpretation. Most importantly, they allow the expression of information in terms of spacial location. Application of these technologies in the vineyard differ considerably according to the tools used. The different radiations recorded provide a wide range of information. The spectral behaviour of plant reflectance in the visible field (380 to 700 nm) is linked only to pigment composition. In this field, plants produce a low reflectance (around 15%) with a peak of 550 nm, mainly due to chlorophyll a and b pigments. These pigments do not interfere with spectral response in the near-infrared field (750 to 1300 nm). The internal structure of leaf cells induces variations of the reflectance value. Estimating the health of the vine plant can be carried out utilising the near-infrared reflectance value. It is therefore possible to define different leaf indicators such as the Normalized Difference Vegetation Index (NDVI). Thermal infrared radiation values indicate the energetic and hydrous status of the plant. Measures of thermal infrared radiation can be taken on the ground, close to the plant, by means of a thermal infrared gun or by airborne shooting. From these, it is then possible to construct a water stress index. These data can then be exploited to analyse vineyard intraparcel heterogeneity. Data require the use of high resolution remote sensing tools (pixel representing a ground distance inferior to 20 cm). Hyper-spectral bands, already used in cereal fields could reveal a spectral signature of diseases such as esca or eutypa before leaf symptoms are visible. Whatever the captor, information quality depends on picture resolution. Today, the main difficulty in working on the vine comes from the anisotropic aspect of photographs. Above all, the researcher must be able to automatically distinguish vine rows. This is possible for vines growing on flat ground without grass but difficult for sloping vineyards with inter-row grass. The main risk lies in uniformly interpreting pixel values from different sources such as ground, grass or vine. Different vehicles such as aeroplanes, satellites, helicopters and, of course, the vine grower's tractor can be used, although not all captors can adapt to these different vehicles. In term of development, each captor/ vehicle combination must be considered. Later, analysed and geo-referenced pictures will have to be integrated in the tractor onboard computer equipped with GPS. This is the way forward to allow tomorrow's vine growers to apply real precision viticulture.

## "Zonation": Interpretation and Estimation of "Great Zonation" (Gz) Following the Base Methodology of "Grande Filiera" (Gf) (Great Chain)

**G. Cargnello**

Directeur SOC Tecniche Colturali – Istituto Sperimentale per la Viticoltura – Via E. De Nicola, 41 – 31015 Conegliano (TV) Italy

[E-mail: cargnellogiovanni@libero.it]

In previous papers on zonation we investigated: so called "GRANDE FILIERA" (GF) ("Great chain"), "terroir", "Terra", "Small zonations or sub-zonations", "Great zonation", qualities (we have classified more than ninety), economy of qualities, as well as "GREAT OBJECTIVES" (GO) of vitivinicultural activity and means utilised for its achievement. In "GREAT ZONATION" (GZ) we have specified that in order to zonate, it is necessary to start from economic, social and existential aspects which in filiera from below to above represent "GREAT OBJECTIVES" (GO) also of vitivinicultural activity and thus of zonation, and not from "technical" aspects such as soil, climate, vineyard model and its management, etc. which represent "MEANS" for achievements of "great objectives" above mentioned (Cargnello G., 1995, 1997, 1999a-b-c-d-, 2000a-b and 2003a-c-d). Must be therefore said again that "great objectives" shouldn't be messed-up, as frequently happens in our

branch, with means utilised for achievement of such objectives. Consequently "Zonating" ("Great Zonation") comprised between interpretation and estimation of zonation, following the base methodology of "Great Chain" means, among other things, to operate in "globality" and in sustainable equal mode on tempistic, economic-social and realistically "qualitative" level, also in harmony (the best) with listed descriptors. In the present paper, zonation interpretation and estimation will be treated as explained above. Type of interpretation and estimation that after researches conducted by foreign researches have risen in importance and have stimulated us to intensify our investigations in that sense.

## Methodology for Application and Valorisation of "Terroir" Studies on Cooperative Wineries in the Côtes du Rhône Area (France)

**B. R. Lovelle**[1] and F. Fabre[2]

Syndicat Général des Vignerons des Côtes du Rhône
(1) Institut Rhodanien, 2260 Rte. du Grès, 84100 Orange, France
(2) Maison des Vins, 6 rue des Trois Faucons, 84000 Avignon, France
[E-mail: b.rodriguez@syndicat-cotesdurhone.com]

Most of the "Côtes du Rhône" controlled appellation wine is produced by cooperative wineries. In order to make the best use of the qualitative potential of their "terroirs", several cooperative wineries produce specific "cuvees terroir" with harvest selections from different districts. This work is an answer to professionals' needs to enhance the knowledge of their "terroirs" diversity, to evaluate their effects on grape berry composition and to work out a methodology to improve the management of harvest selections. The proposed methodology is developed in 3 stages : I. Characterisation of "terroirs" diversity of a cooperative winery area : maps of the soils. II. Evaluation of the way the most important soils function, essentially for water and of the influence on vine behaviour and on grape berries composition. The aim is to look for simple tests explaining this influence and III. Application to "terroir" harvest selections : the tests are then tried out to set up a harvest selection in the winery. The methodology is applied to different cooperative wineries. In this paper we will show, as an example, the results from the Rochefort du Gard winery. The proposed method starts off with a zoning study. It is then completed by an evaluation of potential quality of different kinds of soils and finally, it leads to practical application in order to enhance management of harvest selections in a quite precise professional context, which is that of cooperative wineries.

## A Multidisciplinary Approach to Grapevine Zoning G.I.S. Technology Based: An Example of Thermal Data Elaboration

**G. Scaglione**[1], C. Pasquarella[1], P.Manna[2] and A. Bonfante[2]

(1) Dipartimento d'Arboricoltura, Botanica e Patologia Vegetale, Università degli Studi di Napoli "Federico II". Via Alessandro Scarlatti 110, 80127 Napoli, Italia
(2) Dipartimento di Scienze del Suolo, Pianta, Ambiente. Università degli Studi di Napoli "Federico II". Via Università 100, 80055 Portici (Napoli) Italia
[E-mail: scaglion@unina.it]

A large number of studies have been devoted to the quantitative assessment of the climate effects upon the quality of vineyards in many different climatic contexts. Generally the grapevine vocation of a territory may be studied through mono or multidisciplinary approaches. Viticultural zoning approaches permit to increase our knowledge on the complex reality among grapevine and environment interactions, in order to evaluate the potentiality of an area necessary to obtain a data level of grape quality. In this study we will to suggest a multidisciplinary approach to zoning, G.I.S.-technology-based. The presented method permit possible combinations of "information layers", for example: climatic data (air temperature, rainfalls, wind direction and velocity, global and direct radiation), with grapevine informations (thermal needs necessary to obtain a data maturation level of the grape, daily potential evapotranspiration), or soil informations (slope, geology, topography), in order to analyse their correlations. According the method, is possible to present the obtained results clearly on builted computer maps. The method may consider different preliminary approaches to the data elaboration (maked with a specific computer program) on the basis of the type of data (for example: a climatic factor) considered. In the present contribute an example of thermal data elaboration (air temperature) combined with the information derived from the heat requirements of a group of 22 grapevines is presented, on the basis of an experience conducted in an area of the province of Benevento (Campania region, southern Italy). In the proposed example, the method combine the said thermal informations with the Amerine–Winkler bioclimatic index, permitting to obtain a subdivision of the considered territory in five areas, according their thermal suitability (from less than 1200 to 2000 degree-days). Through the model it was possible to elaborate a map of the thermal suitability of the considered grapevines, being possible to have an optimal placing of the grapevines in the various zones of the considered territory.

## Study and Valorization of Vineyards "Terroirs" of A.O.C. Cahors (Lot, France)

**F. Laffargue**[1], E. Besnard[1] and M. Garcia[2]

(1) Association d'Expérimentation, Ferme Départementale, 46140 Anglars-Juillac, France
(2) ENSAT, Centre de Viticulture-Œnologie de Midi-Pyrénées, Avenue de l'Agrobiopole, Auzeville-Tolosane, BP 107 F, 31320 Castanet-Tolosane Cedex, France
[E-mail: ferme-exp-cahors@wanadoo.fr]

In the current context of market competition and consumption evolution, it is necessary to produce wines of a genuine typicity. The Terroir represents an unique and irreproducible inheritance that can be valorized through the origin and the sensory characteristics of the wines. Since 1989, the Expérimental Association of « la Ferme Départementale d'Anglars-Juillac » has led research and experimentation on vineyard terroirs, aimed at direct valorization for the winegrowers. The objective is to know (1) the wine-producing potentials of each terroir of the Cahors Appellation, for the principal vine grape cultivars of the Appellation: Malbec N or Cot N or Auxerrois N, (2) the vine behaviour on these terroirs and (3) to valorize this knowledge through technology, agronomy and enological procedures adapted to each terroir. Cartography of the whole A.O.C. Cahors has been realized (22000ha). Nine terroirs have been identified according to the type of soil and the landscape situation: alluvial terraces of the Lot, "grèzes", calcareous hillsides, high calcareous plateaus (eventually with marl), and red clays from sidérolithique formations. Agronomic and enological studies of a representative parcel of each terroir have been done since 1994. Pedological pits have also been done with physical and chemical analyses of each described horizon. Each year, maturity controls are carried out on

these parcels; each is separately vinified with the same protocol. Wines are analyzed and tasted. Results show that qualitative terroirs exist on alluvial terraces of the Lot, as well as on high calcareous plateaus. It is not the chemical nature (acid or calcareous) of the soil but the thickness of the soil which determines the quality of a terroir, in relation with the regularity of vine hydrous nutrition. For all that, some terroirs seem well adapted to produce vintage wines, whereas other terroirs seem more adapted to produce regional wines or wines for blending. This study provides an agronomic and enological basis for advising wine-growers, in order to lead each terroir to its qualitative optimum: adaptation of the cultural practices, especially for new plantations (choice of the rootstock, soil management); adaptation of the method of vinification according to the terroir. The wine-grower has to take care of the terroir, the quality of the grape harvested and the wine. This study has led to a qualitative improvement of A.O.C. Cahors wines. The Cahors Appellation is now experiencing an infatuation for the most qualitative terroirs. In the future, the start-up of the hierarchical system of the A.O.C. Cahors terroirs and the creation of vintage wines, will allow a large communication on wine quality and typicity, favorable to the whole Appellation Cahors wine business.

## Atmospheric Modeling: A Tool to Identify Locations Best Suited for Vine Cultivation. Preliminary Results in the Stellenbosch Region

**V. Bonnardot**[1], S. Cautenet[2], H. Beukes[1] and J.J. Hunter[3]

(1) ARC Institute for Soil, Climate and Water, Private Bag X5026, 7599 Stellenbosch, South Africa
(2) Laboratoire de Météorologie Physique (UMR 6016-CNRS), Blaise Pascal University, 24 Avenue des Landais, 63177 Aubière, France
(3) ARC Infruitec-Nietvoorbij, Private Bag, X5026, 7599 Stellenbosch, South Africa
[E-mail: valbon@webmail.co.za]

The choice of sites for viticulture depends on natural environmental factors, particularly climate, as grapevines have specific climatic requirements for optimum physiological performance and berry quality achievement. In the Stellenbosch wine-producing region, the complex topography and the proximity of the ocean create a variety of topoclimates resulting in different growth conditions for vines within short distances. The Regional Atmospheric Modeling System (RAMS) was used to perform numerical simulations over the South Western Cape, for a period of 18 days during grape ripening (February 2000). Four 4 nested grids (25 km, 5 km, 1 km and 200 m of resolution) were used, the coarse grid being the computational domain (taking the large scale circulation into account), while the finest resolution (200m) focused on the vineyards south of Stellenbosch (taking the local circulations into account) in order to extrapolate climatic data at a fine scale. Data from the analysis file were extracted and remapped using the climatic thresholds for viticulture, thereby making the meso-scale atmospheric modeling system applicable to grapevine cultivation. Temperatures were grouped into different ranges that would affect the physiology of the vine. These preliminary results identified locations near Stellenbosch according to the thermal stresses for specific days as well as their potential to meet the climatic requirements for optimum physiological performance of the vine. Three typical weather situations are described at the peak of the photosynthetic performance period (12:00), using results of the two finest grid resolutions (1 km and 200 m). Modeled hourly data were extracted from the analysis file in order to calculate the mean hourly temperature fields for a 16-day period (1-16 Feb 2000) and the mean data were then reintegrated into a GIS as an additional descriptive variable useful for terroir identification.

## Climate and Mesoclimate Zonification in the Miño Valley (Galicia, Nw Spain)

D. Blanco, C. Alvarez, M.P. García and **J.M. Queijeiro**

Vigo University, Plant Biology and Soil Science Department, Ourense Science Faculty, As Lagoas s/n 32004 Ourense, Spain
[E-mail: dblancoward@uvigo.es]

Galicia is a region in Northwest Spain and has a long viticulture heritage. Today about 28,500 hectares are dedicated to vine growing and, of these, 8.100 has are protected under 5 distinct denominations of origin. Most of these zones are situated in the southern and central part of the region in and around the river Miño valley. Some high quality wines are also produced on the southwest coast and in the river Támega valley. The climate of this area is mild, fresh maritime with strong influences from the Atlantic which gradually give way to Mediterranean and continental inland tendencies as one goes inland to the East. The main aim of this article is to demonstrate the suitability of the classification of today's Galician AOCs given the latest information on the field of Climatic Zoning. For this purpose, standardized climate data provided by the Spanish and the Galician meteorological services have been utilized as well as data provided over the last five years by a new network of automatic weather posts that complete the previous network. These data were used to calculate as series of climatic indices according to various methodologies. This information was later processed statistically to identify the most relevant factors in the differentiation of the vine growing areas. Results confirmed the existence of four very clearly defined different viticulture climates. It was also shown that within the vine-growing zone of the Rías Baixas at least two sectors exist with quite distinct climatic conditions. Furthermore, the statistic processing of the information provided by the new automatic weather stations advanced research in climatic zoning permitting the identification of a series of typical mesoclimates that appear within the interior of the traditional viticulture zones.

## THEME III – Practical Application of Zoning

**J. Tonietto (Keynote Speaker)**

Embrapa – Centre National de Recherche de la Vigne et du Vin, Boite Postale 130 – 95700-000 Bento Gonçalves, Brésil
[E-mail: tonietto@cnpuv.embrapa.br]

Le zonage vitivinicole présente toute une série d'applications pratiques. Son importance est en train d'augmenter, soit en fonction des moyens techniques chaque fois plus performants, qui rendent possible le développement des zonages de plus en plus intégrées, consistants et utiles, soit en fonction d'un marché de plus en plus mondialisé. L'article situe la contribution du zonage au niveau de la production vitivinicole et du développement du territoire. Il montre également les contributions indirectes au niveau du marché du vin et de la valorisation du territoire. L'usage pratique du zonage est situé en fonction des différentes échelles, qui peut être la parcelle viticole, une région particulière, un pays ou être l'objet d'analyse à l'échelle géoviticole. Quelques aspects de la contribution du zonage sont particularisés : la gestion agroviticole et œnologique, la délimitation des territoires viticoles et le zonage des régions à potentiel viticole. Une analyse de l'importance pour l'avenir et du potentiel de contribution du zonage à l'échelle géoviticole est présentée dans le contexte du changement climatique et de ses impacts sur le zonage dans l'espace x temps, signalant également le besoin du développement des approches méthodologiques pour cette échelle d'analyse, comme est le cas du Système CCM Géoviticole. L'importance du zonage vitivinicole pour le développement territorial et pour le développement soutenible est signalée.

### Franciacorta Docg Sparkling Wine Interpretation in Relation to Wine Coming from Different Areas

**D. Porro**[1], M. Stefanini[1] and F. Iacono[2]

(1) Istituto Agrario S. Michele all'Adige, Italy
(2) Azienda Agricola Fratelli Muratori, Italy
[E-mail: duilio.porro@ismaa.it]

In the classical tradition the sparkling wines are a blend of wines with different origin. Likewise, the decision of the sparkling process typology "brut, extra brut, zero dosage" is defined from the sensorial results obtained at the end of bottle refinement. So, the choice of the "*liqueur de triage*" and of the "*liqueur de expedition*", is to be considered a way to characterize and affirm the company mark, more than valorize the peculiar characteristics of the production areas. In order to study the territorial differences of Franciacorta DOCG sparkling wines, in the period 2000-2002 a production protocol associated to the sensorial profile that blend different kind of wines produced in the same area was established. The dynamic concept of site evaluation was applied considering as a whole the system *terroir*-vine. The experience outlines a great constancy of the vineyards expressing its own characteristics, when its relative to same area, justifying a blending that increased the value of the peculiar characteristics. The results indicate that the expressed variability from the wines obtained from the vineyards in the same area, justify a way of producing that able to valorize the territory's importance in all different sparkling processes.

### Cartography of Viticultural Terroirs: Valorisation of the Results Through Software for Dynamic Consulation of Maps

**E. Goulet**[1], D. Rioux[1] and G. Barbeau[2]

(1) Cellule « Terroirs Viticoles », Confédération des Vignerons du Val de Loire, 42 rue Georges Morel, 49071 Beaucouzé Cédex
(2) Unité Vigne et Vin, INRA, 42 rue Georges Morel, 49071 Beaucouzé Cédex
[E-mail: goulet@angers.inra.fr]

For its routine work of characterisation and cartography of viticultural terroirs, the CVVL Terroir Cartography Unit uses the method developed by the INRA-Angers Research Unit on Grapevine and Wine. This method, of international recognition, is presently applied to the cartography of the Val de Loire vineyards (scale : 1/10 000) and valorised through the edition of viticultural atlases for the use of the vine-growers and technical institutes. These atlases propose precise maps of the Basic Terroir Units and soil characteristics as well as maps to assist in the choice of the planting material (variety, rootstock) and cultural practices (interrow grassing). The objective is to optimise the adaptation of the planting material and the cultural practices to the terroir conditions and, therefore, to improve the quality and the typicalness of the resulting wines. In order to facilitate this tool and make it more attractive, the Terroir Cartography Unit is now able to propose a computerised version of the cartographic bases. These are accessible through a software that allows for a dynamic consultation of all the thematic maps proposed in the atlases. In a concrete way, the vine-grower can, on his computer, surf and zoom on the maps or change the topic (Basic Terroir Unit, soil depth, soil water reserve, percentage of gravels, etc...). A simple click on a precise location of the pointer gives access to all the information relative to the site. All the plots of a given vine-grower can be digitalised, and superimposed to the different maps, which allows the user for a quicker and more precise localisation of his sites of interest. This computerised tool constitutes a real evolution both for the single vine-growers and the co-operatives, as a new and very technical card to elaborate specific terroir wines. It completes the viticultural and enological software proposed to the growers to improve the monitoring of the vine and elaboration of the wine, to better guarantee the authenticity and the traceability of the product.

### AOC Coteaux du Languedoc: An Example of Using Zoning for Highlighting "Terroir" Differences for Consumers

**J. Fanet**[1], J.C. Jacquinet[2] and J.P. Granier[3]

(1) Head of association of producers Coteaux du Languedoc Au Mas de Saporta – CS 30030 – 34875 Lattes
(2) INAO Expert
(3) Association of producers, Coteaux du Languedoc
[E-mail: j.fanet@fr.oleane.com]

The appellation Coteaux du Languedoc was created in 1960 by grouping 14 little basic appellations representing 55 villages in the Languedoc region. During the following years, more than one hundred villages were added. The appellation is now a vast area of 168 villages on a distance of 140 kilometers, from Narbonne to Nîmes. Until now it was possible to use the name of the basic appellations on the labels next to the name Coteaux du

Languedoc. After being recognized as AOC in 1985, the producers decided to put a system of sub-appellations in place inside the AOC Coteaux du Languedoc in order to designate the wines with the highest level of quality because the basic appellation were not homogeneous and coherent enough to be representative of these wines. The producers of the association Coteaux du Languedoc decided to establish a viticultural zoning on all of the Coteaux du Languedoc area in order to determine the different sub-appellations. This viticultural zoning was realized by Jean-Claude Jacquinet, specialist in botany and climatology, during the years 1996 and 1997. For this study, he used mainly climatical but also geological datas. The AOC Coteaux du Languedoc is located between the Mediterranean shore in the South and the first hills of the Massif Central in the North. The area is surrounded by two prominant and very windy valleys, viz. the Aude valley in the west and the Rhone valley in the east. Between these two valleys is located a very well sheltered region. M. Jacquinet highlighted two main variations in rainfall: one in a west-east direction (550 mm in Narbonne, 730 mm in Nîmes) and another in a south-north direction (580 mm along the sea, 1000 mm on the first hills of the Massif Central). On the other hand, the average temperatures are decreasing from south to north. To these temperature and rainfall data must be added the influence of the pronounced relief which. M. Jacquinet has also highlighted 5 main types of geological formations : alluvial terraces, hard calcareous rocks, soft calcareous rocks, conglomerates and schists. From these different data, 10 distincts subareas were demarcated. The wine producers validated this proposals because these subareas represent homogeneous natural and human units. The wine producers chose names for each area : from east to west : Terre de Sommières, Pic St Loup, Grés de Montpellier, Terrases du Larzac, Pézenas, Picpoul de Pinet, Terrasses de Béziers, La Clape, St Chinian, Faugères. From this study, the association of wine producers has organized meeting with the producers of each area, in order to choose the best varieties, to define the type of the wines and to organize themselves in sub-association. The results was immediately positive because, for each area, it was possible to define specific types of wines. St Chinian, Faugères and Pic St Loup were already recognized by INAO before this study. But from this zoning new designations were rapidly recognised: La Clape (1997), Grés de Montpellier (2003), Terrasses du Larzac will be recognized at the end of 2004. The files of Pézenas and Terres de Sommières are ready to be studied by the National Institute.

## Contribution of Very High Resolution Satellite Remote Sensing to the Mapping of Harvest Zones in the Maipo Valley (Chile)

P.P. Emilfork and **E. Vaudour**

Institut National Agronomique Paris-Grignon, UMR INRA/INA P-G "Environnement et Grandes Cultures" – Equipe Sol-DMOS, Centre de Grignon BP 01, 78850 Thiverval-Grignon, France
[E-mail: emmanuelle.vaudour@grignon.inra.fr]

Use of very high-resolution images, as a support to demarcating grape harvest zones, is recent in viticulture. Using very high resolution IKONOS (4 m-resolution) and supermode SPOT-5 (2.5 m-resolution) multispectral images, this paper here proposes an approach of segmentating a vineyard region into grape harvest zones. In addition to vine vegetation states, soil surface is characterized. This approach relies on a diachronic study at two significant dates of the vine cycle: March 2001 (IKONOS) and July 2002 (SPOT-5). The study is carried out over 134 ha, comprising 23 Cabernet-Sauvignon irrigated plots. Images are processed by successive maskings carried out on a Infrared Color (IRC) image, which alternately isolate vine vegetation or bare soils. The performing of Ascending Hierarchical Classifications result in defining 6 vine vegetation classes, which are ranked by chlorophyll biomass (and activity) qualitative level, and 4 bare soil classes. These results demonstrate that vine chlorophyll biomass qualitative levels are specifically related to some classes of bare soils. Results are discussed in relationship with viticultural data referring to variety, training system, row orientation, grass cover, irrigation, plant age, planting density.

## Contribution of Soil Electric Resistivity Measurements to the Study of Grapevine Behaviour and Spatial Land Distribution

**E. Goulet**[1] and G. Barbeau[2]

(1) Cellule « Terroirs Viticoles », Confédération des Vignerons du Val de Loire, 42 rue Georges Morel, 49071 Beaucouzé Cédex
(2) Unité Vigne et Vin, INRA, 42 rue Georges Morel, 49071 Beaucouzé Cédex
[E-mail: goulet@angers.inra.fr]

The measurement of soil electric resistivity, as a non destructive, spatially integrative technique, has recently been introduced into viticulture. The use of performing equipment and adapted software allows for rapid data processing and gives the possibility to visualise the variations of soil texture or humidity in two or three dimensions. Soil electric resistivity has been tested for the last two years at the Experimental Unit on Grapevine and Vine, INRA, Angers, France, to study the water supply to the vine in different "terroir" conditions. The classical techniques that allow to quantify the soil water status do not give access to the volume of soil explored by the root system. On the contrary, measurements of soil electric resistivity permit to visualise precisely the zones of preferential grapevine root activity. In some types of soil, available water may even be quantified. It is also possible to monitor in real time the effects of rain or drought through root solicitation, as well as the effects of soil management (inter-row grassing) or different rootstocks on the water supply to the vine. When applied to precision viticulture, electric resistivity can be used to refine the geo-pedological cartography of a given plot. The choice of sites for pedological studies or the assistance for selection of rootstocks are direct applications of this cartography. The use of geophysical techniques such as soil electric resistivity constitutes a tool for the use of both scientists and adepts of precision viticulture. Recent technological developments are now facilitating the use of these equipments.

## Viticultural Zoning in D.O.C. Ribeiro (Galicia, Nw Spain)

**D. Blanco,** C. Alvarez and J.M. Queijeiro

Vigo University, Departament of Plant Biological and Soil Science, Science Faculty, As Lagoas s/n 32004 Ourense, Spain
[E-mail: dblancoward@uvigo.es]

The 'Ribeiro' is the most historically renowned Denomination of Origin (D.O.) in Galicia and includes some 3,200 hectares. This region is situated in the central part of the river Miño valley in northwest Spain and has a temperate maritime climate corresponding to Winkler´s II zone. Although there are very productive varieties of vines e.g. Palomino or Garnacha, these have been recently substituted by more traditional varieties better suited to the production of higher quality wines. In the following article,

we identify prevailing mesoclimates, in this particular vine growing and wine producing area and characterize the most suitable conditions for these varieties concerned. In order to distinguish among mesoclimates, data provided by seven new automatic meteorological stations during 2003 was utilized. In addition to this, the wine-producing cooperative commercialising over 60% of the production in the area concerned, facilitated details corresponding to Brix degrees when grapes harvested entered the cellars. These data on Potential Alcohol Content (PAC) were introduced into a geographic information system (GIS) for integration with a Digital Terrain Model (DTM) in order to obtain a zonification where mention of the identified mesoclimates present appear together with the most suitable areas for the traditional varieties.

## Using GIS to Assess the Terroir Potential of an Oregon Viticultural Region

**G.V. Jones**[1], P. Nelson[2] and N. Snead[3]

(1) Department of Geography, Southern Oregon University, 1250 Siskiyou Blvd, Ashland, OR 97520, USA
(2) Environmental Education Program, Southern Oregon University, Ashland, OR, USA
(3) Department of Planning Public Policy & Management, University of Oregon, Eugene, OR, USA
[E-mail: gjones@sou.edu]

Deciding to grow grapes in Oregon is complex issue due to our diverse geography, climate, and relatively short history of grape growing. For any potential grape grower, vineyard site selection is the single most important decision they will face. Combined with matching the site to a grape variety, this decision will ultimately affect the vineyard's yield, the quality of the wine produced, and the vineyard's long-term profitability. This research facilitates the process by modeling the climate and landscape in a relatively young grape growing region in Oregon, the Umpqua Valley American Viticultural Area (AVA). The result is an inventory of land suitability that provides both existing and new growers greater insight into the best terroir of the region. A field survey using a Global Positioning System (GPS) and a varietal survey were conducted covering all of the vineyards in the Umpqua Valley AVA. The results have described the locational factors important for vineyard layout, training methods, soil types, irrigation and frost uses, and phenological variability across the region. Using the locational information from the surveys of existing vineyards as the baseline, a digital elevation model (10m resolution) was analyzed for topographical components of elevation, slope, and aspect, ultimately identifying those sites that have ideal conditions for growing grapes in the region. The topographical classifications are then combined with soil characteristics of drainage, depth to bedrock, water holding capacity, and pH to produce a composite landscape model of suitability which is then masked by zoning requirements to identify the best available sites. In addition, a composite climate model, derived from the PRISM gridded data, develops cool, intermediate, warm, and hot climate-maturity groupings based on ripening potential and multiple climate parameters important for winegrape production. Finally, the composite landscape and climate models are then combined to detail the best terroir for specific varietal groupings in the Umpqua Valley AVA. Combining topography, soil, and land use finds over 3000 acres of nearly ideal landscapes that are suitable for vineyard development. The results indicate that very good landscapes exist across all climate maturity types with strong potential for future development and production of quality fruit and wines. Through the use of GPS and GIS technologies, this research has helped to further define the terroir potential of grape growing in the Umpqua Valley AVA. The results provide existing and future growers with baseline knowledge of the region's grape growing potential relative to its topography, soil, land use, and climate. While not specifically addressing the cultural aspects of terroir (e.g., style-directed viticultural and enological practices), which typically take many years to become dominant, the results presented here should serve to initiate better decisions in the site selection process, thus leading to fewer and/or more efficient trial and error procedures. In addition, for most potential growers, site selection will involve compromises, in that few sites will possess ideal characteristics in every respect. While compromise in many cases has been the rule, this body of research presents one of the best tools yet to enhance the site selection process for future growers in the Umpqua Valley AVA. Finally, the process developed here theoretically can be applied to any area where adequate spatial data resources are available.

## Climatic Zoning of Viticultural Production Periods Over the Year in the Tropical Zone: Application of the Methodology of the Géoviticulture MCC System

**J. Tonietto**[1] and A.H. de C. Teixeira[2]

(1) Embrapa – Centre National de Recherche de la Vigne et du Vin – Cnpuv, Rua Livramento, 515 ; 95700-000 – Bento Gonçalves, Brésil
(2) Embrapa – Centre de Recherche du Tropique Semi-Aride – Cpatsa
[E-mail: tonietto@cnpuv.embrapa.br]

The objective of this research is the viticultural climatic zoning of the production periods over the year in the São Francisco Valley, a Brazilian grape-growing region located in semi-arid tropical climate. In this region, the production can be spread over all months of the year. The region is situated in climate with intra-annual variability, that corresponds to the regions which, under natural climatic conditions, change the class of viticultural climate according to the period of the year during which the grape is produced. The methodology adopted is that of the Géoviticulture Multicriteria Climatic Classification System (Géoviticulture MCC System) (Tonietto & Carbonneau, 2004), employing the modulation functions of the indices. The viticultural climatic indices of the System have been adapted to the biological conditions of the Syrah variety, which has an average cycle of 4 months from bud burst to harvest (d-r) in the region. The study is based on a daily climate database from 1976 through 2002, simulating 36 theoretic harvests per year (one theoretic harvest at every ten 10 days), amounting to a total of 972 harvests in the whole period covered by the study. In this way, the Heliothermal Index ($HI_{12d}$) was calculated over 4 months throughout the year. The Cool Night Index ($IF_{3d}$) was calculated over the 30 days that preceded the theoretic harvest (maturation period). The amount of rain ($P_{3d}$) in the maturation period was equally been taken into account according to the potential effect of the incidence of bunch rotting. The results have allowed to distinguish 3 climatic viticultural periods during the year: Period "a" – less warm during d-r cycle ($IH_{12d}$) and for night temperatures ($IF_{3d}$) and very dry ($P_{3d}$); Period "b" – intermediate climate between "a" and "c" period for

3, with no significant effect on the pH of the juice. Canopy management had no significant effect on wine pH. It appears to be possible to reduce the pH of juice in the case of Cabernet franc/99R, situated on granite soils, by means of Ca and Mg fertilisation. Because $Ca(OH)_2$ and $MgSO_4$ fertilisation increased the maturity of Cabernet Sauvignon/101-14 Mgt grapes, it was impossible to evaluate the effect of fertilisation on the pH of juice at Kersfontein. The general phenomenon that a high canopy density results in a high pH of juice and wine, was not observed in this field trial. The possible reasons for this were the low canopy density of the control plots (canopy 3), as well as the difference in maturity between canopy management treatments.

## Soil Management with Cover Crops in Irrigated Vineyards: Effects in Vine Microclimate (cv. Malbec) Grown in a Terroir of Agrelo (Luján De Cuyo)

**E.M. Uliarte**, R.F. del Monte, J.A. Prieto and S.E. Sari

EEA Mendoza INTA, San Martín 3853 Luján de Cuyo, Mendoza Argentina
[E-mail: agrimec@mendoza.inta.gov.ar]

The objective of this work was to study the influence of cover crops soil management in vine microclimate. For this aim, a research was conduced to compare five different species with diverse vegetative cycle against no tillage soil management through herbicides applications. The study was developed in a vineyard of cv. Malbec trellised in vertically positioned shoots (VPS) and located in a terroir of Agrelo, Luján de Cuyo, Mendoza, Argentine. Primarily, measures of microclimatic parameters were taken: temperature, relative humidity and radiation at bunches level; soil temperature (depth: 15 cm), quantity and quality of cover reflected radiation. We verified a significant diminution of cover crop reflected PAR and a significantly poorer Red/Far red ratio than bare soil (no cultivation). Those had no effects inside the canopy, because permanent cover crops of red clover (*Trifolium pratensis*) and tall wheatgrass (*Agropyron elongatum*) resulted in a restriction in vine vigour that translated in a greater direct PAR reception at bunches level. There were not a significant variation of: maximum and minimum temperatures and temperature amplitude, at bunches level. It was remarkable that the treatments with greater ground cover had a tendency to lightly reduce the minimum temperature (-0,5 °C for red clover and tall wheatgrass), which could be important for critical periods. Relative humidity in the canopy was not significantly affected. Red clover, tall wheatgrass, cereal rye-chess mix (*Secale cereale-Bromus catharticus*) and sudangrass (*Sorghum sudanensis*) notably decreased soil thermic amplitude. This effect was mainly due to a decrease in the maximum temperature. Cover crops species with difficulty to develop during their cycle had an intermediate behaviour or very similar to bare soil. The introduction of a permanent cover crop with a good invasion of inter row spacing modified microclimatic characteristics principally related to soil temperature and reception of radiation. It would be convenient to verify if the mentioned effects show a different intensity in a larger cover crop surface, modifying the vineyard mesoclimate.

## Shoot Heterogeneity Effects in a Shiraz/R99 Vineyard

**H. Cloete**[1], E. Archer[2], V. Novello[3] and J.J. Hunter[4]

(1) Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
(2) Lusan Premium Wines, P.O. Box 104, 7599 Stellenbosch, South Africa
(3) Dipartimento di Colture Arboree, I 10095 Grugliasco, Italy
(4) ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: hcloete@sun.ac.za]

The effect of shoot heterogeneity on vegetative and reproductive growth parameters, vine physiology and grape composition was investigated in a Shiraz/Richter 99 vineyard. Comparisons between underdeveloped (typically shorter and less ripened at véraison) and normally developed shoots in both shaded and well-exposed canopies were made. Compared to underdeveloped shoots, normal shoots had a larger total leaf area, due to the higher occurrence of secondary shoots as well as larger leaves on primary and secondary shoots. Since the physiological activity of the leaves from normal shoots was higher than that from underdeveloped shoots, higher levels of total carbohydrates were produced and stored in the former. Starch was more evenly distributed over the whole shoot length in the longer and thicker normally developed shoots compared to the underdeveloped shoots. The larger clusters of the normally developed shoots were evidence of their more favourable total leaf area per gram berry mass. Berries from the normally developed shoots were smaller at five weeks after véraison than those from underdeveloped shoots, displaying a higher skin to pulp ratio and therefore higher anthocyanin and total phenolic extraction potential for winemaking. The peculiar absence of large differences in grape composition between normally and underdeveloped shoots indicated that assimilates needed for berry ripening of the latter originated in organs other than the leaves [e.g. from adjacent normal shoots and the rest of the permanent structure of the vine (cordon, trunk, roots)]. The larger differences in berry size that occurred between shoot types in the shaded compared to the well-exposed canopies may be evidence for this. The photosynthetic activity of shoots was lower in shaded than in exposed canopies. The total carbohydrate production of the normal shoots in shaded canopies seemed insufficient to supply in the ripening needs of their own clusters and of the shoot itself as well as the ripening of stem tissue and clusters of the underdeveloped shoots in the canopy. This was illustrated by the lower levels of starch that accumulated in the normal shoots from shaded compared to that of exposed canopies. Vine shoot heterogeneity clearly led to visible and physiological imbalances that would impact negatively on grape and wine quality as well as production costs and should therefore be avoided on any terroir.

## Study of Wine-Growing Land ("Terroir") Characteristics in the Canton of Vaud, Switzerland: Ecophysiological Behaviour of the Vine (Cv. Chasselas)

**V. Zufferey** and F. Murisier

Agroscope RAC Changins, Federal Research Station for Plant Production Changins, Viticultural Centre Caudoz, CH-1009 Pully (Switzerland)
[E-mail: vivian.zufferey@rac.admin.ch]

A study of the physiological and agronomical behaviour of the vine (cv. Chasselas) was conducted between 2001 and 2003 by the Swiss Federal Research Station for Plant Production at Changins

(Agroscope RAC Changins) on various wine-growing farms (terroirs) in the Canton of Vaud (Switzerland), as part of a study project on Vaudois vines and vineyards in association with the firm I. Letessier (SIGALES) in Grenoble and the Federal Polytechnic School of Lausanne (EPFL). In order to identify the typical characteristics of Vaudois wine-growing plots or "terroirs", the chosen working method attempted to integrate all factors susceptible of influencing "terroir" functions : on the one hand, natural parameters (geology, soil and climate), and, on the other hand, vine response, the most important indicator of 'terroir" value. The study of vine behaviour was carried out over a region comprising about fifty Chasselas plots spread out over four pilot zones (1000 ha approximately). The defined pedological units, which are representative of vineyards, led to pertinent plant responses, in particular concerning hydrous plant reactions in the vine, its vegetative outgrowth, in addition to qualitative characteristics of the harvest. Conditions of water supply to the vine were closely linked to soil water reserves (useful reserve, RU) and to summer rainfall during the 2001-2003 growing seasons. The study of water supplies to the vine, measured by means of $Y_{base,}$ showed that the level of water stress was low in 2001. The 2002 season differed by its moderate water stress during the period of grape development on sites with low RU (sloping and compact moraines, sandy-stony soils, moraines covering conglomerates and sandstones, or limestone). In all other places, water supplies to the vine were not restricted. In 2003, water stress levels rose during the growing season as a result of a severe water deficit during the summer and heatwave temperatures recorded in June and August. Whatever the type of soil or site, water potential values continued to fall without exception from the time of flowering up until mid-August. The wine-growing region, as a whole, suffered from moderate water stress levels during grape development. In some vines (sloping and compact moraines or sandy-stony soils with low RU), high water stress levels were observed with natural leaf loss in the grape-bunch zone. Results from measurements of minimum stem water potential ($Y_{T\ MIN}$) have also demonstrated that temporary water stress on a daily basis is possible: thus, $Y_{TIGE}$ proves to be reliable indicator for studying the emergence of water deficits or persisting stress after rainfall in wine-growing "terroirs". Our observations indicate that there is a close correlation between the carbon isotope discrimination technique (DC13) in grape sugars and the water supply observed in grape-vines during ripening (sugar accumulation phase in berries). Early flowering and fruiting in "terroirs" and the speed of plant growth were mainly influenced by the thermic mesoclimate (altitude, angle and orientation of vineyard slopes). Encouraging results were obtained from the identification of distinct plant-growth stages (e.g. burst of budburst) and climatic units. Plant outgrowth of vines, as an expression of leaf biomass together with mass of pruned wood, were largely dependant on soil water reservoirs and conditions of plant water stress during the growing season. Trained vines on high RU land gave both greater pruning masses and greater individual vine-branch masses than vines established on restricted RU soils with limited root systems. The water supply system to plants, which was observed during grape development, had an important influence on the final berry size and the accumulation of their reduced sugars. Higher levels of sugar in berries were obtained from vines which had suffered from moderate water stress than from vines characterised by the absence of any water stress. The beneficial role of moderate water stress during grape development is thus proven for sugar accumulation and for early stunting of plant growth (around the time of ripening). However, situations of increased water restriction (high stress) penalised reduced must concentration. This was even more noticeable in the case of early water stress. Finally, in order to rationalise the relationship "vine water supply system – plant outgrowth – berry parameters", it is necessary to take into consideration a given situation of water stress, the time of its appearance, its duration and intensity. The ability to regulate the water supply system in a "terroir" appears to be its most important qualitative parameter.

## THEME VIII – The Role of Soil Water Holding Capacity and Plant Water Relations in Zone/Terroir Expression

**H. R. Schultz (Keynote Speaker)**

Institut für Weinbau und Rebenzüchtung, Forschungsanstalt Geisenheim, Germany

[E-mail: h.schultz@fa-gm.de]

The spatial variability in soil type and depth and water holding capacity is very high in many viticultural regions of the world. Differences in rooting depths and water extraction profiles and their seasonal dynamics add additional variability and it is extremely difficult to deduct direct causal relationships between these factors and fruit composition even within small units of climatic zones, and much less so over larger climatic trans-sects. The influence of water status on grape composition has been studied intensively for many years, yet indirect effects caused by changes in plant water status have been largely neglected. For example, vineyard sites with limited water supply will be more prone to early leaf drop causing substantial changes in the light environment of the fruit, which in itself will change fruit temperature. Additionally, there is almost certainly a different link between plant water status and fruit and wine composition for red and white cultivars and within each respective group between varieties of different geographic origin. Another unresolved problem is the coupling of soil to plant water status. Many plant water status indicators such as stem, or midday or pre-dawn ($\psi_{PD}$) leaf water potential are difficult to link to quantitative soil water data. We have recently started to use the concept of total transpirable soil water (TTSW) and the fraction thereof (FTSW), originally proposed for herbaceous plants, to evaluate the coupling between soil water availability and plant water status measurements for contrasting vineyard sites. Even for soil water holding capacities over the root profiles between 380 and 100 L/m$^2$, and a TTSW varying from 50 to 175 L/m$^2$, respectively, we found a single common relationship between $\psi_{PD}$ and FTSW for all vineyards, irrespective of water extraction profiles and canopy systems (Gruber and Schultz 2004 in press). This relationship has also been proven stable across different wine regions in Europe. This system may provide a platform to better link quality parameters

to plant and soil water status. Some recent results also suggest that indirect effects of changes in water supply may be more important than previously thought for fruit composition. These effects seem not restricted to changes in canopy microclimate or co-limiting factors such as nitrogen, but seem to extend to substances influencing micronutrient metabolism of yeasts, which may alter aromatic expression. It is clear and has been proven many times that water relations are important in quality formation and in the expression of terroir characters, yet it is still difficult to provide conclusive linkages between all the involved parameters.

## Diurnal Cycles of Grapevine Leaf Water Potential under Field Conditions

**M. Laker**[1], P.A. Myburgh[1] and E. Archer[2]

(1) ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
(2) LUSAN Premium Wines, Private Bag 104, 7599 Stellenbosch, South Africa
[E-mail: lakerm@arc.agric.za]

Diurnal cycles of leaf water potential ($\Psi_l$) were established on an hourly basis at various phenological stages at two localities with different air temperature and vapour pressure deficit (VPD). Lower air temperature and VPD values were recorded consistently throughout the season at the cooler locality. Leaf water potential measurements at flowering showed that Sauvignon blanc grapevines at this cooler locality were subjected to a higher degree of water stress throughout the day compared to grapevines at the warmer locality. At this phenological stage, soil water matric potential ($\Psi_m$) of the well-drained soil at the cooler locality was *ca* -0.03 MPa compared to *ca* -0.01 MPa at the warmer locality. This suggested that diurnal grapevine water status was primarily controlled by soil water content. The difference in grapevine water status between the two localities gradually diminished as the growth season progressed until the post harvest period when $\Psi_l$ in grapevines at the cooler locality tended to be higher compared to those at the warmer one. The relatively low pre-dawn $\Psi_l$ at the cooler locality during this measurement cycle indicated that the grapevines were exposed to excessive water stress as a result of the low soil water content (*i.e.* $\Psi_m$ = -0.77 MPa). Partial stomatal closure in grapevines at the cooler locality, however, prevented excessive water stress (*i.e.* $\Psi_l$ < -1.2 MPa) during the warmest part of the day compared to grapevines at the warmer terroir where almost no stomatal control occurred. It appears from these results that low pre-dawn $\Psi_l$ values do not necessarily imply that grapevines will experience more water stress during the warmest part of the day, or *vice versa*. Hence, determination of daily water status cycles, as well as the accumulated water stress over the full diurnal cycle at various phenological stages is invaluable in order to understand and quantify terroir effects on grapevine water status.

## Influence of Irrigation on Water Status, Productivity, Yield and Must Composition in Tempranillo Grapevine Under Duero Valley Zone Conditions

**J. Yuste**, J.L. Asenjo, H. Martín and R. Yuste

Instituto Tecnológico Agrario de Castilla y León, Valladolid, Spain
[E-mail: yusbomje@jcyl.es]

This study analyzes the influence of moderate irrigation on plant water status (leaf water potential), productivity (dry matter and yield) and fruit quality (berry size, °Brix, pH, titratable acidity, phenolic compounds) of Tempranillo grapevine in the Duero river Valley, at the A.O. Cigales. Irrigation treatments applied were: 0% and 20% ETo. The experimental trial was located in Valladolid (Castilla y León, Spain). The 12-year-old vines grafted onto 110 Richter rootstock were vertical trellis trained, through bilateral cordon, and spur pruned. Vine spacing was 2645 vines per ha (2.7 m x 1.4 m). The application of irrigation has increased the leaf water potential level and provoked an important increase of dry matter production as well as yield. The water stress caused by the lack of watering has increased sugar concentration, pH, titratable acidity and phenolic compounds concentration, through the berry size reduction. The application of moderate doses of irrigation causes an improvement of water status and an important increase of productivity and yield conditioned by the climatic characteristics of the zone (Valley of the Duero river) and the soil of the experimental trial. Nevertheless, a reduction of the must quality of Tempranillo grapevine can take place due to the irrigation.

## Contribution of Soil and Atmospheric Conditions to Leaf Water Potential in Grapevines

**P.A. Myburgh** and M. Laker

ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: myburghp@arc.agric.za]

Since grapevine water status, which is a function of soil and atmospheric conditions, affects grapevine physiology it will also play an important role in grape and wine quality. Water status in dry-land Sauvignon blanc was measured simultaneously both at a warm and a cool locality in the Stellenbosch region at different phenological stages during the growing season. Leaf water potential ($\Psi_l$) appeared to be a logarithmic function of soil matric potential ($\Psi_m$). Grapevine water stress tended to increase at a slower rate when $\Psi_m$ dropped below *ca* -0.3 MPa. Under the given conditions, vapour pressure deficit (VPD) did not seem to have an effect on pre-dawn $\Psi_l$, but in combination with $\Psi_m$ could explain 85% of the variation in $\Psi_l$ measured at 14:00. These results indicated that grapevine water status was a function of atmospheric conditions as well as soil water content. The non-linear response of $\Psi_l$ appeared to be the result of partial stomatal closure that increased $\Psi_l$ at certain stages during the day. Sap flow rates in grapevines cultivated on the drier soil (*i.e.* $\Psi_m$ = -0.75 MPa) showed pronounced reductions during the day at the cooler locality compared to those at the warmer one where $\Psi_m$ was *ca* -0.12 MPa. This confirmed that grapevine water status was regulated via partial stomatal closure at the cooler locality, despite the lower VPD that was recorded at this particular locality. In studies with irrigated grapevines, where $\Psi_m$ was higher than -0.08 MPa, absence of significant stomatal control was probably the reason for the reported linear response between $\Psi_l$ and $\Psi_m$. However, measuring $\Psi_l$ at 15 minute intervals revealed that stomatal closure occurred in irrigated grapevines under semi-arid conditions where VPD increased from 1.0 kPa pre-dawn to 4.6 kPa in the afternoon despite soil water content being near field capacity (*i.e.* $\Psi_m$ = *ca* -0.01 MPa). Due to stomatal control, the relationship between $\Psi_l$ and VPD was also non-linear. Under these specific conditions, minimum $\Psi_l$ was *ca* -1.6 MPa. These results showed that even where soil water content was not a limiting factor, harsh meteorological conditions were able to cause partial stomatal clo-

sure, thus preventing the evolution of extremely low $\Psi_l$ values in grapevines. From the foregoing, it is suggested that $\Psi_m$ as well as VPD should be considered for the quantification of terroir effects on grapevine water stress.

### Hierarchy of the Role of Climate, Soil and Cultivar in Terroir Effect can Largely be Explained by Vine Water Status

**C. van Leeuwen,** P. Friant, M.-E. Jaeck, S. Kuhn and O. Lavialle

ENITA de Bordeaux, 1, Crs du Général de Gaulle, BP 201, 33175 Gradignan-cedex, France

[E-mail: k-van-leeuwen@enitab.fr]

Terroir can be defined as an interactive ecosystem, in a given place, including climate, soil and the vine. The three main components of terroir effect, soil, climate and cultivar, have been studied simultaneously. Vine development and berry composition of non-irrigated *Vitis vinifera* L. cv Merlot, Cabernet franc and Cabernet-Sauvignon were compared on a gravely soil (G), a soil with a heavy clay sub soil (C) and a sandy soil with a water table within the reach of the roots (S). The influence of climate was assessed with year-to-year climatic variations (vintage effect) over the period 1996 to 2003. Effects of climate, soil and cultivar on vine behaviour and berry ripening were highly significant. On most variables, the impact of climate was greater than the effect of soil and cultivar. Most variables were correlated with the intensity of vine water stress, which was assessed by measurements of pre-dawn leaf water potential and carbon isotope discrimination measured on grape sugar ($\delta^{13}C$). It is likely that the effect of climate and soil on fruit quality is mediated through their influence on vine water status.

### Effect of Irrigation and Soil Type on Root Growth and Distribution of *Vitis vinifera* L. cv. Nero D'avola Grown in Sicily

M.G. Barbagallo, P. Costanza, **R. Di Lorenzo**, E. Gugliotta, A. Pisciotta, S. Raimondi and T. Santangelo

Dipartimento di Colture Arboree – Università degli Studi di Palermo – Viale delle Scienze, 11 – 90128 Palermo – Italy

[E-mail: rdiloren@unipa.it]

The trial was carried out in a Nero d'Avola vineyard, grafted onto 1103Paulsen, and located in Alcamo D.O.C. area (Sicily). Vines were trained to a vertical trellis system, spur pruned and drip irrigated. Three treatments were applied: A) vines grown without irrigation water; B) vines irrigated when the pre-dawn leaf water potential was above -0.7 MPa and to maintain pre-dawn leaf water potential at value below -0.4 MPa until harvest; C) vines irrigated in order to maintain pre-dawn leaf water potential at value below -0.4 MPa, from budbreak to harvest. Three clay soil types were present in the vineyard: Entisol, on the top of the hill, Inceptisol, halfway down the hill and Vertisol, at the bottom of the hill. The distribution of the root system in the different soil types and in relation to the different irrigation treatments was determined by using the contact method. Irrigation was the most important factor in determining the quantity and distribution of roots, even if it was also noted that the irrigation strategy must be calculated in relation to the type of soil or vice-versa, so that the type of soil determines the most suitable irrigation strategy. For the study of the relationships between root systems and area, it is necessary to take the efficiency of the root systems into account, especially in conditions in which the various limiting effects are reduced, as happens in the dry environments where irrigation is used.

## THEME IX – Role of Harvesting Time/Optimal Ripeness in Zone/Terroir Expression

### J.J. Hunter (Keynote Speaker)

ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa

[E-mail: kobush@infruit.agric.za]

Optimal ripeness is defined according to the style of wine that is required. The latter is ultimately dictated by the market. Soil and climate may have a dictating effect on typical expression of wine. The level of grape and wine quality achieved and the potential for obtaining different styles of wine are determined by the integrated effect of the natural characteristics of the terroir and technological intervention (long and short term cultivation practices). The growth conditions that the grapevine is subjected to should allow optimal metabolic activity in roots, permanent structure, canopy and grapes and the potential for these organs to develop and support each other until the desired grape quality and style is reached. Monitoring of morphological and physiological parameters in the canopy and grapes, ultimately displaying the integrated effect of the growth environment, is critical in our quest for finding indicators that may be associated with a particular grape and wine style. This has not been systematically investigated. Results of collaborative research done on a Shiraz/R99 vineyard in the Stellenbosch region, South Africa, with the purpose of defining environmental, canopy and grape parameters that may be suitable as eventual practical indicators for obtaining particular styles of grapes and wine, are presented. Vines were vertically trellised and spaced 2.75 x 1.5 m in north-south orientated rows on a Glenrosa soil and a west-facing slope. Microsprinkler-irrigation was applied at pea berry size and at vèraison stages. The 1.4 m canopies were shoot-positioned and topped. Fortnightly sampling was done from berry set up to two weeks post-véraison, after which harvesting for wine making was done approximately every four days. Microclimate, vegetative, reproductive and physiological parameters were investigated and changes during alcoholic fermentation monitored at each harvesting stage. Wines were made and analysed. Similarities in patterns as well as various ratios between the different parameters were investigated. Results are argued against canopy performance, carbon allocation, water relations, production level, and sugar, acidity, anthocyanin, phenolic and tannin contents of the grapes as well as wine quality and composition. Ratios for potential practical use in determining optimal grape quality, time of harvesting and expected wine style are discussed.

## Phenolic Extraction During Fermentation as Affected by Ripeness Level of Syrah/R99 Grapes

**M. Nadal**[1], N. Volschenk[2] and J.J. Hunter[2]

(1) Departament de Bioquimica i Biotecnologia, Facultat d'Enologia de Tarragona, CerTA, Ramón y Cajal 70, 43003 Tarragona

(2) ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa

[E-mail: mnrj@fe.urv.es]

Phenolic (tannin and anthocyanin) extraction during fermentation of Syrah grapes was investigated as part of an elaborate study to determine parameters that would indicate high grape quality and different grape and wine styles. A Syrah/R99 vineyard, situated in the Stellenbosch region (South Africa), was used. Vines are vertically trained and spaced 2.75 x 1.5 m in north-south orientated rows on a Glenrosa soil and a west-facing slope. Microsprinkler-irrigation was applied at pea berry size and at vèraison stages. Canopies were suckered, shoot-positioned and topped, whereas leaves were removed at two stages. Fortnightly sampling was done from berry set up to two weeks post-véraison, after which grapes were harvested for analyses and winemaking approximately every four days. Six wines were made per ripeness level. Results obtained during the ripening period of the 2002/2003 growth season (from 17 February to 24 March) are reported. Whole berries, skins, seeds, pomace and wine were analysed for each ripeness level. Grapes of all harvests were cooled to the same temperature (20 °C) before processing. Grapes were destemmed, crushed and the pomace inoculated with commercial yeast (VIN 13). Alcoholic fermentation took place at a controlled temperature of 24 °C (di-ammonium phosphate and $SO_2$ were added). The skins were pushed through three times per day. Fermentation on the skins averaged five days, after which the pomace was pressed. Skins and juice were analysed on the first, second and fourth day during fermentation. On the fifth day after crushing (at pressing), skins, juice and seeds were analysed. Total soluble solids, titratable acidity, pH, anthocyanins, tannins and phenolics were analysed in the whole berries. Evolution of colour density ($A_{520+420}$) and total phenolic content (absorbance at 280nm) was monitored in the pomace and skins. Proanthocyanidin content (DMAC analysis) was determined in the seeds from intact berries and in the seeds after pressing. The degree of alcohol, phenolics, colour intensity and colour density were determined in the different wines. The °Balling of the berries reached a high at approximately 11 March (178 days after bud burst). This pattern was similar to that of the anthocyanin, tannin and total phenolic contents of the berry (whole berry extraction) and coincided with the reduction in berry size due to water loss. After 11 March extraction of the different phenolic compounds seemed not to be affected by the decrease in berry size. From 17 March no further extraction from the skins (skin extraction after 5 days of fermentation) occurred, hence the stable colour density and total phenolic patterns of the skins during this period. The colour density and total phenolic content of the skins during fermentation showed a clear distinction between harvest dates with higher extraction occurring from 11 March to the last harvest date, resulting in low remaining values in the skins after five days of fermentation. The proanthocyanidin content of the seeds only slightly decreased during the course of ripening. However, the seeds were heavily depleted during fermentation of the harvests following that at approximately 6 weeks after véraison, a trend which is completely opposite to the sugar content of the berries. The colour density and total phenolic content of the wine followed similar patterns to those of the berries.

## Determination of the Maturity Status of White Grape Berries (*Vitis vinifera* L. cv. Chenin blanc) Through Physical Measurements. Example on Two Terroirs in the Coteaux Du Layon Area (France)

**G. Barbeau**, Y. Cadot and F. Neau

INRA, Unité Expérimentale Vigne et Vin, 42, rue Georges Morel, BP 57, 49071 Beaucouzé cedex, France

[E-mail: barbeau@angers.inra.fr]

Veraison represents an intermediate stage in development of grape berries, coinciding with the onset of the maturation process. The change in skin coloration is associated with a loss of firmness, a reduction of acidity and an increase in sugar and pigment contents, as well as berry size. For white berries, veraison is difficult to determine on a visual basis. Its evaluation through finger pressure is too subjective to be used as a routine technique. In a previous work, compression tests realized with Cabernet franc berries allowed to develop a non destructive method to analyse the firmness of the berries in relation with their chemical composition ; this method is now extended to the Chenin variety. Samples of berries were taken from two experimental plots for compression tests and chemical analyses, at ten picking dates, from two weeks before veraison until two weeks after. The plots were chosen according to their geo-pedological characterisation and its consequences on the behaviour of the vine. Results indicated that the compression ratio of 20% of the berry diameter and the pressure classes determined for Cabernet franc were also accurate for Chenin. The method allowed to determine with precision the physical mid-veraison stage (loss of firmness for 50% of the berries) and brought to the fore the level of heterogeneity of berries and the differences between plots in terms of earliness. High correlations between berry firmness and both sugar and malic acid contents were obtained as soon as the veraison process initiated. These results will enable to follow in situ the evolution of the grape berry maturation, on a dynamic non destructive way.

## Investigation on Harvesting Period Choices for Correct Interpretation of Experimental Results

**C. Giovanni**, R. Attilio and P. Luciano

SOC Tecniche Colturali – Istituto Sperimentale per la Viticoltura, Viale XXVIII Aprile 26 – 31015 Conegliano (TV) Italy

[E-mail: cargnellogiovanni@libero.it]

Happens too often in scientific papers to find the same harvesting period of a cultivar, although the used treatment influence a maturity curve of investigated thesis. This inevitably leads to wrong conclusions when comparing the treatment effects, since obtained on maturity stages more or less far from those technologically correct. The present paper has the aim to enhance the sensibility of our environment, and not only, this fundamental aspect in the framework of a larger project, has the aim to enhance various aspects of "quality" (for example organoleptic, economic, social and existential) and of its "economies" (Cargnello G. (1996): *La qualite economique, l'economie de la qualite et la qualite economique des preferences: differentes considerations.* Compte-rendu n°9 GESCO, Budapest (Hongrie), 21 -23 Août, pp.379-384.). It was conducted on *cv.* Prosecco in "Terra della Valle del Piave" in collaboration with respected Casa vitivinicola Carpenè – Malvolti di Conegliano. Particularly, the research about short cut (Spur Pruned Cordon of Conegliano) and long (precisely of

training form "Prosecco Alta Marca"), showed that production of the last one is penalised if harvesting time is judged on thesis of Pruned Cordon, and inversely, in function of product typology we want to obtain and of enterprise objectives we want to achieve.

### Flanan-3-OL Compositional Changes in Red Grape Berries (*Vitis vinifera* L. cv Cabernet franc) from Two Terroirs of the Loire Valley (France)

**Y. Cadot**[1], M.T. Miñana[1], R. Champenois[1], M. Chevalier[2] and G. Barbeau[1]

(1) Unité Vigne et Vin, Institut National de la Recherche Agronomique, Centre de Recherches d'Angers, 42 rue Georges Morel, 49071 Beaucouzé Cedex, France
(2) Unité Mixte de Recherche Génétique et Horticulture (GenHort), Institut National de la Recherche Agronomique, Centre de Recherches d'Angers, 42 rue Georges Morel, 49071 Beaucouzé Cedex, France
[E-mail: yves.cadot@angers.inra.fr]

The quantity and the quality of flavonoïds are important parts of the global quality of the grape berries. Especially, the tannins are responsible of some majors flavour properties of the red wines including colour, bitterness and astringency. Nevertheless, their synthesis and properties are still misunderstood. Thus, the comprehension of the relations between environment and setting of this tannic pool, up to the harvest of the grapes, is not sufficient. The tannin composition was monitored since the middle of the first growth period (30 days after the onset of flowering) to the average maturity, for two plots. The study the stage of the berries, and not the average value of the parameters. Thus, the contribution of a more functional relation between composition and physiological stage of the grape constitutes a powerful lever for interpretation. The composition in flavan-3-ols and in proanthocyanidins of skins were determined by HPLC reversed phase and by histochemistry. The linking of these two analytical techniques allowed the association of quantitative and spatial data. This original approach pointed out the importance of the period previous maturation in relation with the stage of maturation but also others factors, such as the number of seeds. There was little evolution of the tannins after veraison. It is suggested that the tannic pool is set before veraison. More, a relation between the number of seeds and the quality of the berries was shown.

### Contribution of Glycosidic Potential to the Aroma of Grenache noir and Shiraz Wines in the French Rhone Valley

M. Ségurel[1,2], R. Baumes[1], **C. Riou**[2], A. Razungles[1]

(1) UMR Sciences pour l'œnologie, INRA, 2 place Viala, 34060 Montpellier Cedex 1
(2) INTER RHONE, Interprofession des vins AOC Côtes-du-Rhône et vallée du Rhône, 2260 route du Grès, 84100 Orange
[E-mail: criou@inter-rhone.com]

Grenache noir and Syrah are the predominant grape varieties in the French Rhone valley vineyard, and produce wines with well differentiated aromatic notes. This study aimed at investigating the contribution of glycoconjugated precursors to these aromatic specificities, through their analytical profiles and the sensory influence of the odorant compounds they release during wine aging. The aglycones released by enzymatic hydrolysis of glycosidic extracts from grape were quantified using GC-MS analysis, and the profiles of both varieties were compared for different geographical sites of the French Rhone valley vineyard, and for three consecutive years. Moreover, the wines elaborated with different grapes were added with their own glycosides, then submitted to aging treatments prior to sensory descriptive analysis. The results showed that addition with glycosidic precursors enhanced the initial aromatic notes of the wines, depending on grape variety and vine site. The aglycone profiles of the grapes of the two varieties showed significant differences for half of the quantified compounds, and were influenced by vintage and vine site. It therefore appeared that glycosidic precursors could actually contribute to the aging aromas of Grenache noir and Syrah wines, and to the complex interactions between variety and terroir.

## THEME X – Role of Molecular Ecophysiology in Terroir Expression

### A. Deloire (Keynote Speaker)

AGRO Montpellier, UMR 1083 « Sciences pour l'Oenologie et la Viticulture », 2 place P.Viala, F-34060 Montpellier cedex 1
[E-mail: deloire@ensam.inrfa.fr]

Terroir is a complex concept which associates soil, climate, grape variety and cultural practices that include the training system and oenological techniques. It is a type of social construction with man at its centre. The typicality of a wine is also a social construction which is the result of an agreement among specialists vis à vis a given quality of the wine whose references are the wine's origins (e.g. terroir) and taste. The wines' 'origins' refer both to its physical place of origin and to a historical continuity. Taste results from the interaction of several factors. The blending of wines from several different grape varieties grown either in the same terroir or in different terroirs in order to arrive at a 'typical' wine, identifiable as such by specialists or even the consumer illustrates the degree of complexity of the terroir concept and of the identification of typicality. In the context of a molecular approach to viticultural terroirs associated with physiological and biochemical approaches, one of our current major priorities is to develop a deeper understanding of the influence of certain primary environmental factors (water and temperature) in conjunction with vine architecture (training system, plant bunch micro-climate) on the development and maturation of grapeberries. The mechanisms that enable the vine to elicit an appropriate response to a given environmental signal depend on the ability of the grape variety in question to detect and decode the applied stimulus in order to activate the appropriate genetic stimuli. Molecular biology techniques that are used to dissect the regulatory networks activated when a grape variety is exposed to different stresses involve the identification and functional characterisation of so-called 'initiator' or 'early-response' genes. Activation of the genes that code for proteins involved in signal pathways and the regulation of genetic expression, results in the activation of so-called 'secondary response' genes that are responsible for the vine's ability to adapt to its environment. New data obtained on the role of these genes in integrated approaches would appear to be of fundamental importance and opens the way to applied solutions, such as the treatment of vines with elicitor-type molecules or the development of genetically modified organisms.

## THEME XI – The Role of Mechanization in Zone/Terroir Expression

**S. Poni**

Istituto di Frutti-viticoltura, Università Cattolica del Sacro Cuore di Piacenza. Italy
[E-mail: stefano.poni@unicatt.it]

The relationship between mechanization and terroir is analyzed in this review paper with special emphasis on harvesting and winter and summer pruning. Besides a brief overview of equipment available for different site conditions, there will be special emphasis on mechanization interacts with vine vigor, canopy efficiency and grape quality, and a discussion of the crucial issue of adapting the machine to the vine supporting frame and to canopy architecture. Mechanical harvesting will be primarily addressed in term of advantages and disadvantages of vertical and horizontal shaking principles and latest developments for adapting hedgerow, VSP canopies to vertical impactors. Physiological effects of mechanical harvesting will be briefly addressed as well. Winter mechanical pruning will be tackled in term of degree of suitability of a given cultivar to light pruning as well as yield compensation mechanisms which are triggered at high levels of retained nodes. Recent achievements in the adaptability of pruning machines to traditional VSP trellises will be considered. Mechanical summer pruning will be addressed mainly as shoot trimming and leaf removal. Results from experiments with mechanical shoot trimming carried at different severities and its impact on yield and grape quality will be briefly presented. Early mechanical leaf removal as a tool for yield control through decreased fruit set and berry size and for improved grape quality will be also discussed. Finally, new machinery available to combine grass cutting and sward build up under the row will be presented.

## THEME XII – Tools for Optimizing Grape and Wine Quality

### Applications of Infrared Spectroscopy from Laboratory to Industry

**H. Nieuwoudt** and F. Bauer

Institute for Wine Biotechnology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa

[E-mail : hhn@sun.ac.za]

The grape and wine industries have long sought rapid, reliable and cost-effective methods to screen and monitor all the stages of the winemaking process, which include grape ripening in the vineyard, harvest and grape reception at the weighbridge, the fermentation stage and the bottling of the final product. Primary requirements of effective quality control in this environment would include the handling of complex sample matrices, a high degree of automation, precision, accuracy and where relevant, good agreement with the reference methods conventionally used for grape and wine analysis. Although conventional chemical methods still remain the workhorse of the wine analytical laboratory, some disadvantages such as lengthy assay times, unsuitability for automation, labour-intensive activities and the generation of large amounts of chemical waste, place an obstacle in their use for rapid quality control purposes. Infrared (IR) spectroscopy is not a new application in the field of analytical chemistry. Recent improvements in IR instrumentation and the development of innovative and powerful software applications have optimised this technology. Currently, multi-component analytical instruments with impressive performance data in terms of simple sample handling, accuracy, precision and speed of analysis, are commercially available. The technology is based on the measurement of vibrational frequencies of covalent bonds in functional groups such as C-C, C-H, O-H, C=O and N-H, upon absorption of radiation in the IR region of the electromagnetic spectrum. Since IR spectroscopy is an indirect method employing empirical correlations between compositional and/or functional quality attributes and the IR spectra of samples, multivariate data analytical techniques are used to establish these correlations. This presentation highlights the use of near infrared (700-2500 nm) and mid infrared (2500 – 5 x $10^4$ nm) spectroscopy for quantitative and qualitative applications in the grape and wine industries. These include the measurement of colour, sugar and acidity in grapes, as well as the quantification of routine wine parameters such as pH, volatile acidity, titratable acidity, alcohol and sugar in wine. Industrial applications include the streaming of grape juice based on colour measurement. Future directions in IR spectroscopy regarding wine flavour analysis and product authentication are discussed.

### Screening of Different Commercial Wine Yeast Strains: The Effect of Sugar and Copper Additions on Fermentation and Volatile Acidity Production

**W.J. du Toit**, J. Ferreira and M. du Toit

Department of Viticulture and Oenology and Institute for Wine Biotechnology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
[E-mail: wdutoit@sun.ac.za]

The aims of this study were to examine the effect of high sugar concentrations of must and copper residues on different commercial wine yeasts. Copper originating from pesticides has been known to inhibit yeast, but it's effect on fermentation performance and VA production of different yeast strains had not been investigated in detail. Fermentation performance was monitored through mass loss and growth as measured at OD600. VA, glucose and fructose concentrations were monitored after 21 days of fermentation with the FOSS 2000 Grape Scan. Certain strains were initially less affected by high sugar concentrations than others, but only musts fermented with strains VIN13, WE372, N96 and L2056 contained less than 11 g/L fructose after 21 days. VIN13 and RJ11 produced the lowest VA in the 21°B, 25°B and 28°B musts. Higher VA concentrations were also produced in higher sugar containing musts. It must, however, be kept in mind that the nutrient requirements of yeast stains differ which can affect this, although these must all received sufficient DAP. The fermentation ability of six trains was also monitored in must containing Cu concentrations close to the legal limit in SA. Strains NT50, Collection Cépage Cabernet (CC)

and D80 were not significantly affected, whereas musts fermented with strains VIN13, NT112 and RJ11 contained significantly more glucose and fructose after fermentation. The utilization of fructose was also more affected by the copper than that of glucose, which might further had contributed to a sluggish fermentation. This inhibition was also reflected in the growth of the different yeast strains. Copper also increased the VA production by yeast strains with certain strains being affected more than others.

### Contribution of Phenolic Compounds to the Total Antioxidant Capacity of Pinotage Wine

**D. de Beer**[1], E. Joubert[2], J. Marais[2], M. Manley[1]

(1) Department of Food Science, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
(2) Post-Harvest and Wine Technology, ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: dalene@infruit.agric.za]

The South African wine industry is taking an interest in the enhancement of red wine total antioxidant capacity (TAC) with retention of sensory quality to satisfy the demands of increasingly discerning consumers. The focus is especially on the unique South African red wine cultivar, Pinotage. Pinotage has a unique phenolic composition and commercial Pinotage wines (1998 vintage) has an average TAC of 15.3 mM Trolox equivalents which compares well with that of Cabernet Sauvignon. Knowledge of wine phenolic composition, the antioxidant activity of individual phenolic compounds and their respective contribution to the TAC of wines are needed to evaluate the importance of individual phenolic compounds. The TAC of wines could then be manipulated optimally by using viticultural and enological practices to enhance the content of compounds contributing significantly to the TAC. The aim of the study was to determine the antioxidant activity of individual phenolic compounds in Pinotage wines and their contribution to TAC. A series of 20 young Pinotage wines were analysed to determine their phenolic composition (reversed-phase HPLC) and TAC (ABTS radical cation scavenging assay). Compounds identified include gallic acid, caftaric acid, caffeic acid, coutaric acid, catechin, procyanidin B1, myricetin-3-glucoside (glc), quercetin-3-glc, kaempferol-3-glc, quercetin-3-rhamnoside, myricetin, quercetin, kaempferol, isorhamnetin, delphinidin-3-glc, peonidin-3-glc, petunidin-3-glc, malvidin-3-glc, delphinidin-3-glc-acetate, vitisinA, petunidin-3-glc-acetate, peonidin-3-glc-acetate, malvidin-3-glc-acetate and malvidin-3-glc-coumarate. The polymeric content of each wine was also estimated as mg catechin equivalents/L. Individual phenolic compounds, available as pure standards (gallic acid, caffeic acid, catechin, procyanidin B1, myricetin-3-glc, quercetin-3-glc, kaempferol-3-glc, quercetin-3-rhamnoside, myricetin, quercetin, kaempferol, isorhamnetin, delphinidin-3-glc, peonidin-3-glc, petunidin-3-glc, malvidin-3-glc), were tested at a range of concentrations and their Trolox equivalent antioxidant capacity (TEAC) values calculated. Taking the concentration and TEAC values of 24 monomeric phenolic compounds which could be quantified, into account, only 14% of the TAC of the wines could be explained. Possible synergism was ruled out, as the measured and calculated TAC of a mixture of phenolic standards was within the experimental error. Sulphur dioxide additions to the phenolic mixtures at two concentrations had no effect on their TAC. To estimate the contribution of polymeric compounds ultrafiltration was performed in an attempt to separate monomers and polymers in 3 wines. The polymeric compounds, and possibly proteins, isolated using ultrafiltration (50000 dalton nominal molecular weight cut-off), contribute about 30% of their TAC values. A large fraction (59%) of the TAC of a wine is due to unknown compounds which may or may not be phenolic.

### Analytical and Chemometric Investigation of Phenolic Content of South African Red Wines

A. de Villiers[1], **A. Crouch[1]**, Th. Heidemann[1], P. Majek[2], P. Sandra[1]

(1) Department of Chemistry, Stellenbosch University, CENSSUS, Private Bag X1, 7602 Matieland, South Africa
(2) Slovak University of Technology, Department of Analytical Chemistry, 812 37 Bratislava 1, Slovak Republic
[E-mail: pat.sandra@richrom.com]

Phenolic compounds have been the focus of a lot of research in recent years for their important contribution to sensory characteristics of wine, their beneficial health effects, as well as the possibility they offer of characterising wines. In this contribution, a method is developed that allows the direct injection of wine samples followed by liquid chromatography-diode array-electrospray ionisation-ion trap mass spectroscopy (MS) for the quantitative and qualitative analysis of a wide range of non-coloured phenolics. Diode array detection was found to be more suitable for quantitative purposes, while on-line UV spectra in combination with mass spectra greatly facilitate the identification of phenolics. Although MS detection was characterised by relatively poor sensitivity (full scan mode) and linear response, this form of detection proved to be an exceedingly powerful identification tool, allowing identification of 20 non-standard compounds in wine. These include procyanidins, epigallocatechin, prodelphinidins (only the second time these compounds are identified in wine), tartaric acid esters of p-coumaric acid and caffeic acid, 3 resveratrol derivatives, myricetin and flavonol-glucosides. It is concluded LC-UV-MS currently represents the state-of-the art in analysis methods for wine polyphenols, combining quantitative and identification capabilities. The LC-diode array method was subsequently used to quantify 16 phenolic compounds in 55 South African red wines. Values are compared to those reported in the literature for these compounds in wines from other countries. These data were used together with chemometric methods for the characterisation of these wines according to variety. Discriminant analysis allowed a 100% correct recognition of the 5 cultivars studied, independent of the vintage or geographical origin, based on non-coloured phenolic content.

### The Use of Epifluorescence Versus Plating to Monitor the Effect of Different Parameters on Micro-organisms in Wine

**W.J. du Toit[1]**, I.S. Pretorius[1,2] and A. Lonvaud-Funel[3]

(1) Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
(2) The Australian Wine Research Institute, Waite Road, Urrbrae, SA 5064 Adealide, Australia
(3) Faculté d'Oenologie, 351, Cours de la Libération, 33405 Talence, France
[E-mail: wdutoit@sun.ac.za]

The monitoring of the number of micro-orgranisms in wine is crucial for the wine producer. Traditional counting methods include microscopic enumeration and plating on selective media, which measures the culturability of the cells. The use of epifluorescence microscopy is, however, a method, which can measure both cul-

turability and viability in wine. This method distinguishes between live and dead cells. Research showed that little difference existed between plating and epifluorescence numbers to enumerate lactic acid bacteria in wine. However, a difference exists between these two methods to distinguish between acetic acid bacteria numbers in wine. Plating counting numbers were lower than plate numbers for *Acetobacter pasteurianus* in wine under anaerobic conditions. This difference was, however, negated by the addition of oxygen to the wine. $SO_2$ additions lowered the culturability of *A. pasteurianus* at dosages higher than 0.35mg/L molecular $SO_2$, but higher dosages were required to lower epifluorescence intensity, which is an indication of viability. *Brettanomyces bruxellensis* culturability was inhibited at lower dosages, but total cell numbers according to epifluorescence microscopy were affected at higher molecular $SO_2$ dosages. Epifluorescence microscopy and plating also showed that *B. bruxellensis* was drastically affected after 120 min after molecular $SO_2$ addition and it's culturability after only 30 min. An exposure time of 5 min to molecular $SO_2$ reduced the cell's viability drastically and 45 min completely inhibiting the viability after two days. The bonded form of sulphur dioxide did not affect both micro-organisms.

Epifluorescence microscopy can thus be used as a quick alternative to assess micro-organisms numbers and culturability in wine. This technique has both advantages and disadvantages over traditional enumeration methods, which will also be discussed.

## TCA – A Status Report on South African Cork Closures

**J.A. Minnaar**

Department of Viticulture and Oenology and Institute for Wine Biotechnology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
[E-mail: jminnaar@sun.ac.za.]

Cork taint decreases the commercial value of wine as tainted wines are rejected by consumers. Although other compounds in wine and cork can also be responsible for causing a taint, 2,4,6-trichloroanisole (TCA) is regarded as the primary cause of cork taint. As cork taint is often used in marketing campaigns against natural cork closures, manufacturers extended their overall quality control to monitoring TCA levels. Since August 2004 a representative sample of all batches of cork closures that are imported by members of the South African Cork Quality Council (SACQC) are tested for TCA before release into the market. Quality control on TCA is conducted by an independent laboratory, established by the Institute for Wine Biotechnology (Department of Viticulture and Oenology, University of Stellenbosch) and Thalès Wine Cellar Services (Pty) Ltd. In this contribution we report on the current status of TCA in cork closures in South Africa. The analytical methodologies as well as the quality control program that is currently implemented are also outlined.

## Distribution and Associated Symptoms of Grapevine Trunk Pathogens in South Africa

**J.M. van Niekerk**[1], P.H. Fourie[1] and F. Halleen[2]

(1) Department of Plant Pathology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
(2) Disease Management, ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: jvanniek@sun.ac.za]

In recent studies, several grapevine trunk pathogen complexes have been identified from grapevines in South Africa. These pathogens include *Eutypa lata, Phaeomoniella chlamydospora, Phaeoacremonium* sp., *Botryosphaeria* sp. and *Phomopsis* sp. Trunk diseases lead to reduced yield, and grape quality as well as a decline and premature dieback of grapevines. Infection occurs as early as the propagation processes, or during the subsequent vineyard development. As these pathogens infect mainly through wounds, most research has focussed on the protection of pruning wounds. However, climatic differences between different grape growing regions would likely affect the demographics of regional pathogen populations. In order to develop management strategies for specific regions, it was therefore necessary to determine the distribution of grapevine trunk disease pathogens in different grape growing regions of South Africa. During October 2003 – April 2004, a survey of visually healthy grapevines was conducted in 10+ year-old Cabernet Sauvignon vineyards in Stellenbosch, Malmesbury, Vredendal, and Robertson (3 vineyards from each region). In the fifth region, Upington, Ruby Cabernet vineyards were sampled. Samples consisting of the two distel cordon pieces (including the last spurs on each side) were collected from twenty grapevines in each vineyard. The occurrence of trunk disease pathogens was determined by doing isolations onto potato dextrose agar from all the different wood decay symptom types that were observed in cross sections of the samples. Plates were incubated for 2 – 4 weeks before the isolated fungi were identified based on morphological or molecular characteristics. Internal wood symptoms ranged from black and brown vascular streaking, brown V-shaped lesions, brown watery lesions, brown internal necrosis and Esca associated symptoms. The isolations clearly showed that specific symptom types could not be attributed to one single pathogen but that overlap of symptoms occurred between pathogens. The dominating pathogens across the five surveyed areas were *Pa. chlamydospora* and *Botryosphaeria* sp., which were isolated two to four times more frequently than *Phaeoacremonium* sp. and *Phomopsis* sp. In the cooler regions of Stellenbosch and Malmesbury, the dominating pathogens were *Pa. chlamydospora* and *Phaeoacremonium* sp., while *Botryosphaeria* sp. occurred more frequently in the hotter regions of Robertson, Vredendal and Upington. Relatively low numbers of *Eutypa lata* were recorded with the Stellenbosch area having the highest occurrence of the fungus. These results therefore indicate that the demographics of trunk disease pathogen populations differ between climatically different areas. Pruning wound protection strategies should consequently be adjusted accordingly.

## Pro-Active Management of Grapevine Trunk Diseases by Means of Sanitation in Nurseries

**P.H. Fourie**[1] and F Halleen[2]

(1) Department of Plant Pathology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
(2) Disease Management, ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
[E-mail: phfourie@sun.ac.za]

Several trunk diseases cause decline and premature dieback of grapevines. In vineyards, these pathogens gain entry into plants through unprotected wounds. Wounds are also frequently infected during the propagation stages. The pathogens survive in infected plants in a latent form and cause disease in older grapevines or in plants that are subjected to stress. No curative management strategies are known and disease prevention strategies focus on the pro-

tection of wounds in nurseries and vineyards. The aim of this study was to determine the effect of different chemical and biological sanitising treatments of propagation material on infection of trunk disease pathogens. Rootstocks (101-14 Mgt) and grafts (Shiraz) were drench-treated in captan, benomyl, bronocide, Sporekill, Bio-sterilizer, chinosol and Trichoflow prior to cold storage (1 h drench), prior to grafting (10 min drench) and prior to planting (5 s dip). Vines were bench-grafted by hand or Omega machine and cold or hot callused, respectively. For the hand-grafted treatment, half the number of plants was grafted with sterilised hands on sterilised tables, while the other half was grafted under standard conditions (dirty hands and tables). The treated, grafted rootstocks were planted in a field nursery in Wellington and grown for 7-8 months before it was uprooted. Take percentages, root and shoot mass, as well as the incidence of *Botryosphaeria*, *Cylindrocarpon*, *Phomopsis*, *Phaeomoniella* + *Phaeoacremonium* spp., total pathogen and *Trichoderma* in graft unions and basal ends of rootstocks of uprooted vines were determined. Take percentages for most treatments did not differ significantly. None of the treatments impacted negatively on vine growth. Benomyl, Sporekill, captan and bronocide were consistently most effective in reducing the incidence of pathogens in the graft union and in the basal end of the rootstock. Bronocide did, however, cause a reduction in take percentage. Trichoflow, chinosol and Bio-sterilizer were not as effective and marginal to no reductions were observed. Significantly more Petri disease causing pathogens were isolated from the graft unions of cold callus vines, compared to the hot callus vines. This might be attributed to the bigger grafting wounds (hand grafted *vs.* Omega bench grafted), and might also indicate that these pathogens infect graft union wounds during the propagation process. By isolating important trunk disease causing pathogens from the graft unions and basal ends of rootstocks of certified nursery vines, this study has clearly showed that sanitation practices during the propagation process is of utmost importance. Benomyl, Sporekill and captan provided the best protection against trunk disease pathogens. However, integrated treatment strategies with environmentally safe products should be considered in order to comply with environmental laws.

## Black Foot Disease in South African Vineyards and Grapevine Nurseries

**F. Halleen**[1], P.H. Fourie[2] and P.W. Crous[3]

(1) ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch, South Africa
(2) Department of Plant Pathology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
(3) Centraalbureau voor Schimmelcultures, P.O. Box 85167, NL-3508 AD Utrecht, The Netherlands
[E-mail: halleenf@arc.agric.za]

The survival rate of grapevine cuttings in nurseries, and young grapevine plants in newly established vineyards in South Africa is increasingly compromised by root and trunk pathogens. *Cylindrocarpon* spp., which cause black foot disease of grapevine, were associated with 52%, 22% and 29% of diseased grapevines during 1999-2002, 2002-2003 and 2003-2004, respectively. However, very little information is available regarding the aetiology and epidemiology of the pathogens believed to be involved in black foot disease. The primary aims of research have been (1) to conduct nursery surveys in order to determine which fungi are involved in the decline phenomenon, (2) to identify the organisms believed to be the causal organisms of black foot disease, and (3) the development of management strategies to prevent or eradicate these infections. The diversity of species associated with black foot disease has been confirmed by this study and four *Cylindrocarpon*-like species were identified: *Cylindrocarpon destructans*, *C. macrodidymum*, *Campylocarpon fasciculare* and *Campyl. pseudofasciculare*. The observation that these species infect grapevine cuttings in nursery soils has clearly placed the emphasis on the importance of suitable measures to prevent or eradicate these infections. However, none of the chemical and biological treatments evaluated in this study prevented infection of nursery grapevines. The reduction of infection in uprooted dormant nursery grapevines caused by the hot water treatment clearly demonstrated the potential of this control measure. Apart from these pro-active management strategies in grapevine nurseries, no curative strategy is known for declining grapevines in vineyards. Producers are therefore urged to prevent or correct predisposing stress situations, such as unbalanced root development, soil compaction and poor drainage.

## Partial Rootzone Drying (PRD): Strategic Irrigation Management as Viticultural Tool Affecting Plant Physiology and Berry Quality

**P.G. du Toit**

Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
[E-mail: pgdt@sun.ac.za]

Partial rootzone drying (PRD) is an irrigation management technique designed to reduce water use in grapevines without a decline in yield, thereby increasing water use efficiency (WUE). The principle of PRD is to keep part of the root system at a constant drying rate to produce soil derived signals to above-ground plant organs to induce a physiological response resulting in viticultural effects. Major PRD effects include a reduced canopy size and greatly increased WUE with possible improvements in fruit quality. Experiments conducted under Australian conditions consisted of field-grown grapevines irrigated at variable rates to elucidate a true PRD effect. The effects of PRD on the assimilation and partitioning of C and N in grapevines are reported and the sustainability and economic potential of the PRD system are discussed. Major findings include the effects of PRD on grapevine physiology on the biochemical level where the source:sink relationship between plant organs influences dry matter accumulation and nitrogen assimilation that will influence fertilization needs. Finally, the effects of PRD on berry growth and quality are discussed, especially the accumulation of hexose, amino acids and inorganic ions such as $K^+$, that may have an influence on wine quality.

## Influence of Partial Rootzone Drying on Grape And Wine Anthocyanin Composition

**K. Bindon**

Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa
[E-mail: bindonk@sun.ac.za]

The effect of Partial Rootzone Drying (PRD) on fruit and wine composition has been investigated. At harvest, total anthocyanin and phenolic concentration of Shiraz and Cabernet Sauvignon

fruit was either unaltered or increased by PRD relative to control irrigation over two seasons. Where there was an increase in anthocyanin concentration with PRD, this was independent of berry size. In the 2002 season, total colour of Cabernet Sauvignon wine was enhanced by 10% in response to the PRD treatment although total anthocyanin concentration was unaltered in either fruit or wine. This colour enhancement was maintained after a year's ageing in the bottle and was due to an increase in coloured pigments in co-pigmented or polymeric form, that is, in association with other anthocyanins or phenolic compounds. In both fruit and wine samples, PRD caused a decrease in the contribution of malvidin-glucosides to total anthocyanins. Thus, levels of non-malvidin glucosides, namely delphinidin and cyanidin were increased by PRD. This effect was investigated as fruit matured post-veraison, and was evident from early in berry development. Preliminary results indicate that this response requires the presence of high incident light levels to the bunch zone during development, but it is not mediated by increased bunch exposure alone. Shading of fruit led to a significant decrease in all anthocyanin types, and caused a shift in the ratio of acetyl- and 3p-coumaryl-glucosides to mono-glucosides. The PRD treatment, however, did not lead to changes in the proportions of acetyl-, 3p-coumaryl- and mono-glucoside anthocyanins. These results show that the response of the anthocyanin pathway to the PRD is most likely mediated by physiological signals within the fruit and vine, rather than due to a change in bunch microclimate.