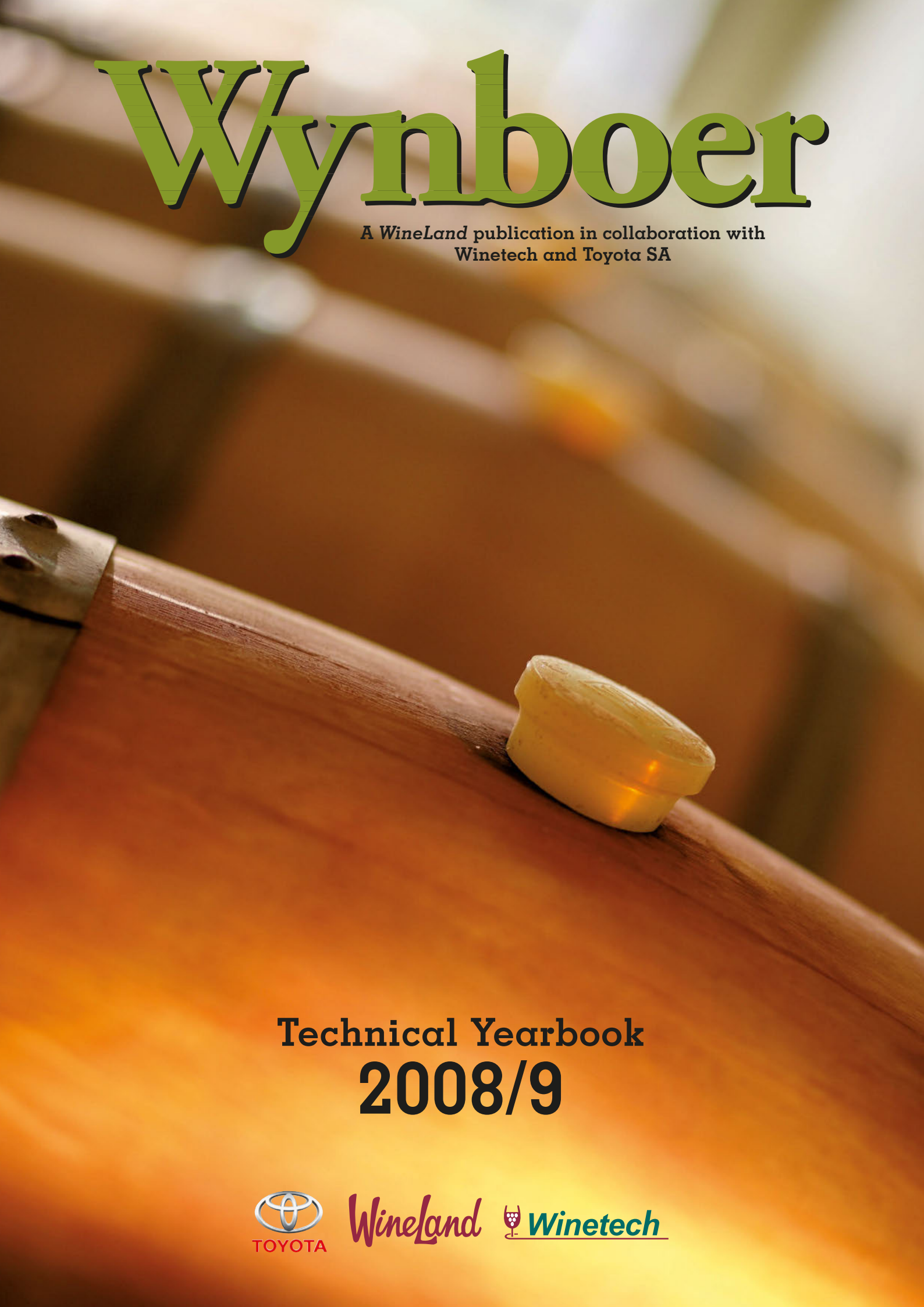

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Technical Yearbook
2008/9

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Foreword

Balancing healthy vines and a healthy environment

Viticulturists will need to be even more alert in future to carefully monitor a national asset, the Cape's more than 100 000 hectares of grape vines from the threat of alien pests and diseases.

With research now being conducted on, among others, Aster Yellows Phytoplasma and the harlequin ladybird (Harmonia axyridis Pallas), it is clear that South Africa's vineyards need to be protected against attack.

Ongoing research is being conducted at various levels by scientists in different fields at Nietvoorbij, Stellenbosch University and Elsenburg, to ensure that the country's vines do not fall foul to these diseases and pests. This, while trying to find ways of fighting age-old foes such as leafroll and downy mildew to name a few.

The main thrust is to also find ways of countering these problems in an environmentally friendly way, while preventing them from getting into the country's vineyards in the first place.

This juggling act must also include not hindering the growth of the industry, particularly in international markets where there is an ever growing need for higher quality wines and brandies.

Viticultural scientists in the next decade will probably be faced with other challenges coming to the fore as diseases mutate and change their line of attack on vineyards and the fruit industry in general.

Funding and maintaining the high research standards until now, will continue to be a major challenge for the wine industry, while its resources face growing constraints.

Arnold Kirkby

The articles in this publication have appeared in Afrikaans in *WineLand/Wynboer* during 2008.

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5TH ANNUAL EDITION, JANUARY 2009

UNDER THE AUSPICES VinPro VIR KAAPSE WYNPRODUSENTE

Winetech

Winetech News

Authenticity of South African brandy

Francois van Jaarsveld, senior researcher, ARC Infruitec-Nietvoorbij

Francois van Jaarsveld

South African brandy is a quality product produced in accordance with strict legal requirements. Various forms of adulteration have been reported internationally. European Union (E.U.) regulations monitoring the authenticity of products, is already in place. In the future European Union regulations may require full authentication of imported wines and spirits before sale. To be prepared, and to protect the South African producers and consumers, a database of isotopic ratios [$(D/H)_I$, $(D/H)_{II}$, $\delta^{13}C$ and $\delta^{18}O$] for South African brandies (and non-grape ethanol sources) was constructed against which all South African brandies will be compared to determine whether or not the brandy has been adulterated with other botanical or synthetic sources of ethanol. Stable isotope ratio analysis supply information regarding the origin of the ethanol component of spirits and can effectively be used to differentiate between the different spirits types and prove the authenticity of brandy.

The most common form of adulteration is where the botanical origin of the alcohol does not correspond to the product definition. Examples are the addition of alcohol/spirits from various raw materials such as synthetic alcohol or alcohol from sugar beet, grain or sugarcane. By law South African brandy can only be produced from grape alcohol. The adulteration of brandy must be controlled as it represents a severe danger for the consumer, state and the industry. Food adulteration can lead to (1) food poisoning due to lack of control of adulterants by the perpetrators, (2) monetary damage to the consumer who is sold an inferior product, (3) lack of confidence in food and company brands by the consumer, (4) elimination of honest producers from the market as their products can not compete with cheaper adulterated ones, and (5) deterioration of overall quality of products on the market as most producers must adjust to the lower standards in order to survive.

Due to sophisticated modern techniques such as SNIF-NMR (Site-specific Natural Isotope Fractionation Nuclear Magnetic Resonance) spectroscopy and IRMS (Isotope Ratio Mass Spectroscopy) all forms of adulteration regarding botanical origin can be determined. With NMR the deuterium/hydrogen of the methyl group [$(D/H)_I$] and methylene [$(D/H)_{II}$] groups of ethanol are measured. δ^{13}C-IRMS gives an average value for the whole ethanol molecule. Comparison of the Natural Stable Isotope Ratios for the ethanol of a commercial brandy with that of the authentic dataset will point out discrepancies such as the possible addition of non-grape alcohol, and give an indication as to the botanical origin of the ethanol. An authoratative database of deuterium[D]/hydrogen[H] and carbon-13/12 ratios, inclusive of all variations caused by grape cultivar, geographic location, still design and vintage, was compiled over five years and made available to the regulatory authorities.

Discrimination between the various sources of ethanol was possible (Fig. 1). With IRMS as method and measured δ^{13}C values, clear distinction between C_3- and C_4-sources of ethanol was possible (Fig. 1). With SNIF-NMR as method and measured $(D/H)_I$ values, C_3-sources of ethanol, i.e. aerial (apricot, plum, apple, etc.) and underground plants (i.e. sugar beet), as well as grape and non-grape sources, could clearly be differentiated from one another (Fig. 1). Synthetic ethanol in particular is enriched in deuterium as compared to fermentation ethanol, with significantly higher $(D/H)_I$ values than any of the C_3- or C_4-sources. Blending of the three different populations, i.e. C_3, C_4 and synthetic, will give values between those of the pure forms of C_3, C_4 and synthetic ethanol.

Both the SNIF-NMR and IRMS methods can, therefore, effectively be used for the characterisation of brandies and identification of illegally added non-grape alcohol sources.

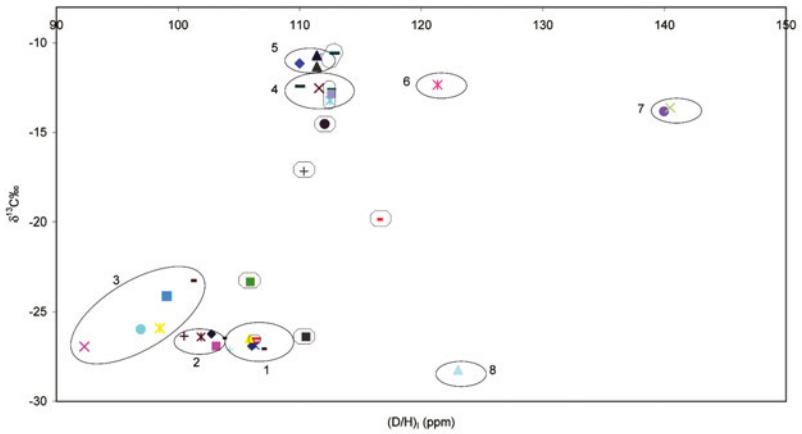

FIGURE 1: $(D/H)_I$ plotted as a function against $\delta^{13}C‰$ for various botanical sources of ethanol. 1, Authentic South African dataset (include brandy basewine, distilling wine, crude spirits, matured and unmatured pot-still brandy and neutral wine spirits); 2, C_3 grape alcohol sources (non South African); 3, C_3 non-grape alcohol sources (i.e. apple, apricot, plum, strawberry and sugarbeet); 4, sugarcane alcohol/-spirits sources (C_4); 5, grain spirits/-alcohol sources (C_4); 6, 1:1:1 mixture of cane:flavoured grain:synthetic spirits; 7 and 8, synthetic sources. Symbols encircled with stippled lines indicate commercial brandies.

For further information: Dr. Francois van Jaarsveld, e-mail: vanjaarsveldf@arc.agric.za

Soil publication for the Western Cape

Katena – Soil associations for the Breede River Valley, was published in December 2007, the first of a series of soil publications specifically for the wine producing areas of the Western Cape.

A mass of information already exists about soils and their characteristics, especially regarding wine grapes. All this information exists in cultivar guides, journals and research reports, individual soil data on farms and other publications. The Katena series is the first of its publication of its kind to incorporate all this information in one book.

The Breede River publication provides the typical soil association (Katenas) of the wine producing areas, particularly around Worcester and Robertson. It includes colour templates (photographs) of the dominant soils, each with its distinctive characteristics, restrictions yield potential with regard to viticulture, as well as cultivation methods. Included with the publication is a CD, with maps giving higher definition for easier viewing. A KML file can also be visited on Google Earth website.

Braham Oberholzer, VinPro's soil expert and co-ordinator of the Katena series said it would serve as a handy regional guide for the wine marketer, as well as for the regional viticulturist, the trained farm manager or a student. All would benefit by learning more about their environment.

VinPro is already working on the second Katena publication for the coastal region, which incorporates Tulbagh, Swartland, Paarl, Stellenbosch and Cape Point, which should be published in November 2008. Thereafter the finale book in the series will deal with the Little Karoo, Olifants River, and the Northern Cape in 2009. The Katena series forms part of Winetech's Technology Transfer Programme.

Braham Oberholzer (right), soil expert who compiled the first of three Katena publications on soils of the wine grape production areas of the Western Capes, presents the first edition to Jan Booysen, executive manager of Winetech.

Katena – Soil Associations for the Breede River Valley is available in Afrikaans and English from VinPro's offices in Paarl at R200 (VAT included).

For further information: Annemarie van Onselen,
Tel: (021) 807-3027, e-mail: vanonselen@vinpro.co.za

WRAP-presentation

Jacques Rossouw from IPW, with Nicola Jenkin from WRAP and Anel Andrag from Winetech.

"Bottling in a changing climate" was presented by Nicola Jenkin from WRAP (Waste & Resources Action Group) in conjunction with IPW and Winetech on 16 April 2008.

WRAP is a non-profit organisation established by the British government to specifically look at technical, practical and economic aspects regarding decreasing the weight of glass bottles, the promotion of mass importation of wine into the UK and improving the use of recycled glass. The presentation on their research showed that there are still numerous opportunities to reduce the weight of bottles from South Africa. The presentation is available from Winetech's offices.

For further information: Anel Andrag,
e-mail: andraga@winetech.co.za.

Viticulture and oenology: The current and future impact of biotechnology in the wine sciences

Photo: Anel Andrag

Presenters: Dr Graham Reid (Anchor Biotechnology), Albert Strever (DWO, US), Dr Maret du Toit (DWO, US), Prof Melané Vivier (IWBT, US), Dr Wessel du Toit (DWO, US), Dr Neil Jolly (ARC Infruitec-Nietvoorbij), Prof Florian Bauer (IWBT, US), Marianne McKay (DWO, US) and Marinda Swanepoel (Namaqua Wines). In front: Prof Alain DeLoire (SupAgro-Montpellier, France) and Dr Hélène Nieuwoudt (IWBT, US).

The SASEV / Winetech forum took place on 18 April at Infruitec in Stellenbosch. More than 100 registered participants enjoyed a morning of presentations that highlighted the role of biotechnology in the vineyard and the cellars, as well as its role as an enabler of the broader wine sciences. Presenters included Prof Alain Deloire, world-renowned viticulturist from SupAgro in Montpellier, France, Dr Neil Jolly from ARC Infruitec-Nietvoorbij, Dr Graham Reid from Anchor Biotechnology and Marinda Swanepoel from Namaqua Wines, as well as several academics from the Department of Viticulture and Oenology and the Institute for Wine Biotechnology (Proff Melané Vivier, Maret du Toit and Florian Bauer; Drs Wessel du Toit and Hélène Nieuwoudt; Albert Strever and Marianne McKay).

The presentations covered a wide range of topics, from providing a global perspective on SA wine sciences and biotechnology to the practical implications of biotechnology in viticulture and oenology in the South African context and the future of wine research in this country. Vine growing and winemaking are biotechnological practices, and the presentations made clear that biotechnological research has already had significant impacts on many practical aspects of these processes. These impacts include for example DNA-based diagnostic tools for plant diseases and spoilage organisms, new yeast and bacterial strains and the development of many enzymes. The issue of the public perception of biotechnology, and in particular consumer resistance to Genetically Modified Organisms, was highlighted. However, GMO's are not the main output or focus of the Biotechnology Research Programme.

Finally, several presentations showed how the Biotechnology Research Programme has played a very significant role in integrating cutting-edge approaches and research tools from the core fundamental sciences of chemistry and biology into the Viticulture and Oenology Research Programme. As a cross-cutting technology with significant support from public research funding bodies such as the NRF and THRIP, biotechnology has indeed opened new avenues for research collaborations and research funding, and enlarged the scope and vision of the wine sciences in South Africa.

Prof Florian Bauer
Winetech Biotechnology Programme Co-ordinator

Confronting climate change – developing a comprehensive response to climate change for the South African fruit and wine industry

Jan Booysen
Executive Manager Winetech.

Jacques Rossouw
Manager IPW.

South Africa's fruit and wine industry goes greener by

- Measuring the carbon footprint of the South African fruit and wine industry.
- Establishing how it fares against international carbon emissions standards.
- Formulating a carbon reduction plan with effective mitigation and adaptation strategies to meet the challenge of climate change.

South Africa's fruit and wine industry is to launch an innovative research programme to measure the carbon footprint of the industry. The project will also establish how the industry measures up, in terms of its carbon emissions, internationally.

The study will take three years to complete but initial results will be released in October this year.

The focus areas of the project will be to

- **Confront and address the reality of climate change –**
  The growing awareness of human-driven climate change and the corresponding demand to lower the carbon intensity of doing business and the emergence of carbon as a tradable commodity has a significant implication on the SA fruit and wine export industry. These include the perception around 'food miles', the comparative 'carbon footprint' of competing countries, the impact of climate change at a regional level (changing rainfall patterns and ambient temperature) and the opportunity of carbon offset projects. The need was identified to be able to position the SA industry to effectively deal with climate change and its implications.
- **Developing an industry wide response –**
  A successful response to the challenge of climate change demands a concerted and synchronised response at the industry or "country of origin" level rather than at an individual business level.
- **Responding from a position of knowledge –**
  Currently, there is no single reputable information resource available to industry leaders, decision makers and stakeholders on the subject of climate change in relation to the SA fruit and wine industry.
- **Building a consistent and comparable information base –**
  There has been a proliferation of 'carbon calculators' being developed making it difficult to compare "apples with apples". There is a need to have a carbon calculator that is compliant with one accepted international Life Cycle Analysis (LCA) standard that is comparable, both intra-industry and inter-industry.

Given the challenges outlined, there is a need for a credible, impartial, relevant and accurate information source for the industry that

- Provides and supports an industry wide perspective.
- Serves to highlight the issues, trends, opportunities and threats related to climate change.
- Benchmarks the industry's carbon-intensity and related performance.
- Enables informed and authoritative comment, debate and negotiation by industry stakeholders and policy-makers.
- Enables the standardised measurement, calculation, reporting and comparison of individual entity emissions base-lines the emission reductions across the industry.
- Is credible, transparent and scientifically sound while still being simple and easily understood by all users.
- Guides short-and long-term strategy formulation by leaders and decision-makers across the industry and the fruit and wine marketing supply chain.

Funders

The £200,000 (±R3,0 m) carbon footprint research scheme is jointly funded by DFID (Department of International Development) through ComMark (±R1,5 m) and the fruit (table grape, pome fruit, stone fruit, citrus, sub tropicals) and wine (Winetech) industries in South Africa (±R1,5 m).

Management

Hugh Campbell, General Manager of Deciduous Fruit Producers Trust Research, will co-ordinate the project. The project will be managed through a steering committee on which Jan Booysen, Executive Manager Winetech and Jacques Rossouw, Manager IPW will represent the wine industry.

Winetech/Consol bottling, packaging and distribution workshop

The Winetech bottling, packaging and distribution committee, in conjunction with the SASEV, presented a half-day report back/information session at the Olive Grove, Infruitec – which was sponsored by Consol glass.

The technical sub-committee, bottling, packaging and distribution, under chairmanship of Delana Green, gave feedback on the committee's activities of the past year.

- Ongoing discussions with Trade Metrology about the use of templates.
- Finalising the Bag-in-Box Protocol
- Standardising of bore control points. The same measuring points are used by both Nampak and Consol and comply with international standards
- Extraction tests on synthetic corks
- Discussions with Nampak and Consol about the possible rationalisation of general trade bottles.
- Date codes will in future be introduced on bottles by the glass manufacturers.

Photos: Anel Andrag

Speakers: Johan Visser (Nampak R+D), J Cilliers (chairman Bottling Committee/Distell), Delana Green (chairperson Technical Bottling Committee), Jacques Rossouw (IPW), Anton Eccles (Extradex), Louise Wigget (Extradex), John Bexley (Consol) and Gerard Martin (Winetech). André Matthee (W&SB) and Dr Gert Loubser were absent for the photo call.

The following subjects were also discussed on the day.

- The filling of bottles according to SANS 1841standards (Dr G Loubser)
- Compulsory labelling of wine bottles (A Matthee)
- International co-operation agreements for the determining of a carbon footprint calculator (J Rossouw)
- Feedback from Consol regarding the company's carbon footprint (J Bexley)
- New trends in packaging (J Visser)
- Feedback on the Agro-logistics initiative by the Department of Agriculture (G Martin)
- Feedback on the Wine-on-Line system (AEccles/LWigget)

Prof Vaudour visits ARC Infruitec-Nietvoorbij

Dr Victoria Carey (Stellenbosch University), Reckson Mulidzi (LNR Infruitec-Nietvoorbij) and Prof Emmanuelle Vaudour.

Prof Emmanuelle Vaudour visited ARC Infruitec-Nietvoorbij and Department of Viticulture and Oenology, Stellenbosch University for a period of two weeks during July 2008. Her visit was sponsored by Winetech in order to extend the current collaboration. Prof Vaudour is Assistant Professor at AgroParisTech where she teaches remote sensing and soil science, terroirs and the geography of wines. She performs research with the soil science team of the Department of Environment and Arable Crops at UMR INRA/AgroParisTech. Prof Vaudour completed her PhD thesis in 2001 on "*Viticultural terroirs. Spatial analysis and relationship with grape harvest quality. Application to the Southern Côtes-du-Rhône Appellation vineyard (France)*", for which she received a silver medal from the French Academy of Agriculture. Prof Vaudour's current

research focus is on the spatial modelling of soil landscapes and terroirs using visible-near-mid infrared remote sensing, with a particular focus on viticultural terroirs, the remote sensing of soils and soil spectroscopy. Her collaboration with Stellenbosch started in 2005, together with Dr Victoria Carey, Department of Viticulture and Oenology, on a NRF Thuthuka funded project entitled "Viticultural zoning in South Africa: spatial analysis and characterisation of soil landscapes". Ways of extending this collaboration to ARC Infruitec-Nietvoorbij are currently being investigated.

Prof Vaudour presented a lecture to the South African wine industry on "Terroir and the Geography of Wines" on 8 July 2008. In this lecture, she reflected on how the understanding of the geography of wine is based on four types of knowledge, i e Environmental Sciences, Human or Social Sciences, Regional Studies and Spatial Modelling. Prof Vaudour defined the different notions of the terroir concept and described the current scientific understanding of this word. Reasons for viticultural zoning or terroir studies were discussed. She described the human aspects that determined the development and current position of the current French wine regions. With regards to terroir and zoning studies, Prof Vaudour emphasised that the main limitations are with regards to spatial resolution and temporal validity. Many different methods have been used at different spatial levels. Prof Vaudour completed her presentation by describing the current project where SPOT images and digital topographic data are being used to identify soil-landscapes in the Simonsberg area and suggested some future applications of this technology.

– Dr Victoria Carey, Department of Viticulture and Oenology, Stellenbosch University

VinPro/Winetech Information Day: Worcester/Breedekloof

About 80 producers attended the first Worcester/Breedekloof region VinPro Information Day of the year. Various speakers discussed a number of topics, especially issues centred on the past season.

The day was opened by Neil Hamman, VinPro Director for Worcester, who warned that further interest rate increases and price hikes were imminent. He made a plea to say that the time had arrived when all role players in that region had to learn to work together, so that producers at farm level could survive.

Dirk ven Eeden from Terason, dealt with and discussed sicknesses and diseases and possible reasons and faults in programmes which resulted in outbreaks. He emphasised the so-called rot-complex and the best control mechanisms to combat it.

He concluded with an overview of the major reasons for the dramatic price hikes in chemicals. It appears as that the phenomenal increase in maize plantings for bio-fuel and the closing of chemical factories to counter air pollution with the upcoming Olympic Games in China, were major contributing factors.

He warned that producers were going to battle to get certain chemicals and where possible orders and purchases should be made as early as possible.

Christo Spies from WineMS illustrated the pooling of block and production statistics from WineMS data. From this producers can process and compare their information on the farm, in the cellar and regionally. It will provide a producer with the opportunity to evaluate and position himself in terms of the viability of each vineyard block on his farm.

Roleen Carstens from ARC Infruitec-Nietvoorbij provided a good introduction and theoretical overview about phytoplasmas. Aster yellowing is a new sickness in the South African wine industry and phytoplasma is a bacteria without a cell wall and there is no chemical control for it at present.

Jeff Joubert from VinPro (Vredendal) made a presentation about the future of phytoplasmas as he has experienced it over the past period of time in the Olifants River area. The symptoms of the viruses and phytoplasmas can at first glance appear to be the same, but the differences can be determined using photographs.

Viruses attack the entire vine, phytoplasma in most cases only affect parts of the vine. The vector is probably a plant sucking insect with the known leaf hoppers at the top of the list of "suspects". There is at present no official control strategy in place but where large sections of a vineyard are infected, it must probably be pulled out. Furthermore the vectors (leaf hoppers) and possible host plants such as weeds, must be controlled. Winetech has already registered a major research project in this regard.

– Pierre Snyman – VinPro vineyard consultant, Worcester

Photo: Edo Heyns

Roleen Carstens (ARC Infruitec-Nietvoorbij) and Jeff Joubert (VinPro).

Researchers meet for the 8th annual Grapevine Virus Workshop

Since the establishment of Winetech's Grapevine Virus Programme in 2000, local grapevine virologists, entomologists and viticulturists have met every year for their annual Grapevine Virus Workshop to discuss research findings and to prioritise future projects.

The 8th workshop was held at the "Olive Grove" on the ARC-Nietvoorbij/Infruitec campus on Tuesday, 19 August. The workshop was well attended by researchers as well as a number of industry representatives. This year, the regular sessions on molecular approaches to virus resistance in grapevine, the characterisation of known and new viruses, virus diagnostics and several aspects of insect vectors were supplemented by reports on the recently discovered Aster Yellows Phytoplasma disease in our vineyards.

The main virus problem in our industry remains Leafroll Disease and two researchers reported progress with unravelling the genome structure and genetic diversity of this virus. The emerging disease, Shiraz Decline in certain Shiraz clones, as well as the presence of grapevine fanleaf virus in a few Stellenbosch vineyards was reported. The first transgenic grapevines that contain resistance constructs have been established and their molecular characterisation was reported on. Whilst the characterisation of the Aster Yellows Phytoplasma is well under way, and a reliable detection method for this pathogen has been developed, the search for it's biological vector is one of the new tasks for the entomologists working on the vectors of the different virus diseases.

Earlier this year, the Virus Research Programme was reviewed and the structure of the new programme was presented and discussed at the workshop. The emphasis of the revised programme is the "disease triangle" of the Virus(es), the Vitis host and the Vector(s). Future projects will address one or more of these aspects in a direct and specific way. The day was concluded with informal discussions, accompanied by delicious snacks and some of the Cape's finest.

Photo: Anel Andrag

Speakers: Back: Nicoleen Smit, Dr Kerstin Krüger, Dr Johan Fourie (back), N Mgocheki and Hano Maree. Middle: Dr Dariuz Goszczynski, Dr Michael-John Freeborough, Stefanie Malan and Mandi Engelbrecht. Front: Dr Michael Stiller, Elize Jooste, Casper Nyamukondiwa, Roleen Carstens, Prof Johan Burger and Prof Dirk Bellstedt.

Prof Johan Burger – Programme co-ordinator

Winetech Terroir Programme Meeting 2008

Photo: Anel Andrag

Dr Kobus Conradie (ARC Infruitec-Nietvoorbij), Dr Victoria Carey (Department of Viticulture & Oenology, US/Programme co-ordinator), Irene Waller (Graham Beck Robertson/Chair Vinification Technology Committee), Dr Koos Eloff (ISCW) and Christien Potgieter (ISCW).

The annual Winetech Terroir Programme Meeting was held on 14 August 2008. At this meeting brief presentations regarding the main aims and progress of the 10 research projects resorting under this programme were made by the project leaders. These project leaders represented ARC Infruitec-Nietvoorbij, ARC Institute for Soils, Climate and Water, Department of Viticulture and Oenology at Stellenbosch University and VinPro. This annual meeting provides an important occasion during which researchers and industry representatives can discuss the programme and individual project aims, to ensure a co-ordinated and scientific approach towards terroir studies in the South African wine industry.

General

photo: Edo Heyns

Effect of ozone on distillery wastewater treatment in wetlands

Keith du Plessis[1], Jeff Green[2], Gunnar Sigge[2], Trevor Brits[2] and John Wooldridge[1]

[1]ARC Infruitec-Nietvoorbij, Stellenbosch
[2]Department of Food Science, Stellenbosch University

Key words: Chemical oxygen demand, constructed wetlands, distillery wastewater, ozone, polyphenol.

Keith du Plessis

INTRODUCTION

The discharge of wastewaters from wineries and distilleries is becoming increasingly restricted as pressures from environmental regulations increase (Van Schoor, 2005), and as awareness of the negative impacts of seasonal discharges of waters containing high nutrient and organic loadings into water courses spreads (Masi *et al.*, 2002). Disposal of such waters by irrigation, as investigated by Mulidzi (2001), is also regulated, notably by the National Water Act (No. 36 of 1998).

Of the currently availably wastewater disposal strategies, none are entirely satisfactory, cost usually being the most significant constraint. Constructed wetlands have nevertheless been found to be an effective way of treating wastewaters from a number of industries (Hammer & Bastian, 1989; Gale *et al.*, 1993; IWA Specialist Group, 2000; Ibekwe *et al.*, 2003; Du Plessis, 2007 and others). However, constructed wetlands are easily overwhelmed, and should not be supplied with winery wastewater having chemical oxygen demands (COD, a measure of the oxygen needed to decompose the organic material in the wastewater) above 5000 mg O2 / litre if the death of plants growing near the wetland inlet is to be avoided (Shepherd *et al.*, 2001). Distillery wastewater has a complex character and is difficult to treat (Yeoh, 1997; Sangave & Pandit, 2004), even where volumes are low. A medium-sized ethanol distillery producing 10 million litres of ethanol per year may generate up to 20 litres of wastewater per litre of ethanol produced (Van Haandel & Catunda, 1994). This means that treatment facilities must be able to handle high rates of throughput while retaining their effectiveness. According to Mulidzi (2005), one way in which effectiveness can be improved is to pre-treat the wastewater before it enters the wetland, the wetland thus becoming a secondary, as opposed to the sole treatment facility. Of the possible pre-treatments for distillery effluents, ozone, a powerful oxidising agent capable of increasing rate of biodegradation, appears to have potential. Studies by Benitez *et al.* (1999) and Martín *et al.* (2002), in which ozone was applied to winery and distillery wastewaters prior to anaerobic digestion, decreased COD whilst simultaneously increasing the rate at which anaerobic digestion proceeded in both effluent types.

The primary aim of the present study was to investigate the effects of treating distillery wastewater with ozone before it entered the wetland on the quality of the water after it drained from the wetland. A secondary aim was to determine whether further benefits could be derived by subjecting the water that drained from the wetland to a second ozone treatment.

MATERIALS AND METHODS

Two laboratory-scale artificial wetlands were constructed in a greenhouse at Nietvoorbij Research Farm, Stellenbosch. Each wetland consisted of a 0.06 cubic metre rectangular Perspex tank, with a base that sloped downwards at a low angle (1%) toward an outlet. Each tank was filled to 0.1 m from the top with irregularly fragmented dolomitic limestone gravel that had passed through a 25 mm square mesh grid. Nine Phragmytes spp. wetland plants (macrophytes) (IWA Specialist Group, 2000; Zingelwa, 2003) were planted in a regular grid pattern in each tank. Each tank, together with its gravel and plants constituted a single wetland system similar to the vertical flow design described by the IWA Specialist Group (2000). Using this pair of tanks, three trials were carried out consecutively. The purpose of these trials was to enable the effects of the ozone treatments to be tested at different combinations of COD and retention time (RT: the time taken for the wastewater to move through the wetland).

TABLE 1. Summary of trials and treatment parameters. Each trial consisted of an ozone pre-treated and a control (not ozone pre-treated) wetland treatment. In all cases acclimatisation was carried out using wastewater that was not pre-treated with ozone.

Trial	Retention Time (days)	Acclimatisation period (days)	Chemical oxygen demand (COD) during acclimatisation (mg O_2/ L)	Inflow COD during trial (mg O_2/ L)	Post-wetland ozonation on Day 72
1	9	1-27	2200	2200	No
2	9	1-9	3750	7100	Yes
		10-18	5500		
		19-27	7100		
3	12	1-12	3750	7100	Yes
		13-24	5500		
		25-36	7100		

Trial 1:

The objective of Trial 1 was to determine the effect of ozone pre-treatment where COD was low and RT reasonably short.

Before Trial 1 commenced, both wetlands were operated for an initial period of 27 days on raw wastewater with an initial (inflow) COD of 2200 mg O2 / litre. This wastewater was obtained in bulk from the final settlement dam at Distell's Goudini distillery near Worcester. The purpose of this pre-trial period, during which new wastewater was pumped into the wetlands each day at a rate adjusted to allow a total retention time (RT) within the wetland of nine days, after which the wastewater drained under gravity into collector tanks, was to allow the wetlands to acclimatise (or stabilise). Thereafter, one randomly selected wetland was designated as the control, and the other as the pre-ozonated wetland. After the 27-day acclimatisation period the control continued to receive none ozone treated wastewater with a COD at the inflow of 2200 mg O2 / litre at an RT of nine days. In contrast, the ozone pre-treated wetland received wastewater (also with an inflow COD of 2200 mg O2 / litre at an RT of nine days) that had been pre-treated with ozone by passing the wastewater through a venturi system into which ozone from a 4.8 g / hour generator was introduced at a flow rate of 4 litres / minute. The ozonated wastewater was collected in plastic drums, frozen, stored and thawed out as required.

After the 72-day evaluation (trial) period, freshly drained samples of the control and ozone pre-treated wastewaters were analysed to determine COD, alkalinity, phosphate and polyphenol concentrations, as well as conductivity, solids and colour. Wastewater colour (absorbance) was measured at 254 nm and 475 nm. Absorbance at these wavelengths is indicative of the presence of the precursors of such toxic substances as humic acids and dopachrome. Alkalinity, total solids (TS) and total suspended solids (TSS) were monitored according to standard methods (APHA, 1998). Conductivity was measured with a standard conductivity meter, whilst COD and phosphorous (PO43-) were determined colourimetrically. Total polyphenol content was determined using the Folin-Ciocalteau method (Singleton & Rossi, 1965). Each analysis was repeated three times.

Trial 2:

The purpose of Trial 2 was to determine the effect of ozone pre-treatment on wetland performance at a higher COD, but the same RT, as in Trial 1. In addition, a post-wetland ozone treatment was added.

As in Trial 1 the wetlands were subjected to a 27-day acclimatisation period. During this period the COD of the wastewater increased step-wise from 3750 mg/L in days 1 to 9, to 5500 mg /L in days 10 to 18 and, finally, to 7100 mg/L in days 19 to 27. As in Trial 1, the wastewaters were collected in bulk from Distell's Goudini distillery, though at different times, ozonated, and stored until required. Also as in Trial 1, the RT was nine days and the trial period 72 days. During this period the control and pre-ozonated wetlands received wastewater with an inflow COD of 7100 mg O2 / litre (3.23-fold the COD in Trial 1).

Samples of the wastewater that drained from the control and ozone pre-treated wetlands on Day 72 were collected and divided into two. One set of subsamples were analysed as in Trial 1. The second set of subsamples received ozone at a concentration of 400 mg / L, then analysed.

Trial 3:

Trial 3 was carried out to determine the effect of ozone pre-treatment on wetland performance at the same COD, but a longer RT, than in Trial 2. The trial procedure used in Trial 3 was the same as in Trial 2, excepting that the rate of inflow was reduced so that one pore volume was replaced over a 12-day period (as opposed to the nine day period used in Trials 1 and 2). Because of the extended RT, the acclimatisation period was increased to 36 days, to allow time for three changes of wastewater to take place, each taking 12 days.

The parameters used in the three trials are summarized in Table 1.

RESULTS AND DISCUSSION

In all three trials the wastewater COD decreased during its passage through the wetland (Table 2). Relative to the controls, ozone pre-treatment improved (reduced) COD by 11% in Trial 1, 6% in Trial 2 and 1% in Trial 3. Since it is likely that the ozone content of the wastewater declined rapidly during

TABLE 2. Percentage change in wastewater characteristics due to passage through an artificial wetland, and the effects of withholding (control) or applying an ozone pre-treatment.

Wastewater parameters	Trial 1		Trial 2		Trial 3	
	Control	Ozone pre-treated	Control	Ozone pre-treated	Control	Ozone pre-treated
COD (mg O_2 / L)	-62	-73	-78	-84	-92	-93
Alkalinity (mg $CaCO_3$ / L)	24	6	7	-3	49	34
Phosphates (mg PO_4^{3-} / L)	-38	-62	-53	-62	-51	-58
Conductivity (mS / m)	27	14	0	-6	28	33
Polyphenols (mg / L)	-31	-40	-72	-76	-67	-58
Total solids (mg / L)	-1	-10	-27	19	-13	57
Total suspended solids (g / L)						
Colour (254 nm)	-21	-56	-78	-91	-87	-93
Colour (475 nm)	1	-19	-8	-21	-9	-10
	-46	-68	-67	-80	-78	-85

Negative figures indicate that the parameter decreased in magnitude or severity (ie. the water improved in quality) as the wastewater passed through the wetland.

storage (ozone content was not measured at the wetland inflow), the observed improvements in post-wetland COD must have been due to oxidation which took place soon after the ozone was introduced. If this were the case then the ozone pre-treated wetland received wastewater in which the organic compounds had already been partly degraded. That the ozone-induced decrease in post wetland COD in Trial 2 was less than in Trial 1 probably indicated that the 9-day RT was too short to permit the Trial 2 wastewater, with its 323% greater inflow COD, to be processed with the same efficiency as in Trial 1. The highest percentage reductions in COD during wetland transit were observed in Trial 3. That the reduction in COD was greater in Trial 3 than in Trial 2, even though the inflow COD was the same in both trials, can only have been due to the 33% (3-day) longer RT used in Trial 3. Since ozone pre-treatment only resulted in a 1% improvement in COD over the control in Trial 3, it seems possibly that ozone pre-treatment can be dispensed with where 7100 mg O2 / litre COD wastewater is allowed a 12-day RT, although this possibility can only be applied with confidence to a wetland of the type used in this trial.

Wastewater phosphate concentrations also decreased during passage through the wetlands and, in all three trials, decreased to a greater extent in the ozone pre-treated than in the control treatments. Differences due to ozone pre-treatment decreased from 24% to 9% to 7% in trials 1, 2 and 3, respectively. Ozone pre-treatment improved polyphenol elimination by 9% in Trial 1, and by 4% in Trial 2, compared to the control. Despite the longer RT used in Trial 3, polyphenols were reduced less effectively in Trial 3 than in Trial 2. Total suspended solids concentrations in the three trials followed much the same pattern as COD, except that the effects of ozone pre-treatment were more marked (35%, 13% and 6%, respectively, in Trials 1, 2 and 3), also relative to the control.

In both the control and ozone pre-treatments, colour at 475 nm improved to a greater extent in Trial 3 than in Trial 2 which in turn showed a better improvement than that observed in Trial 1. The colour difference between control and ozone pre-treated wastewaters decreased from 24% in Trial 1 to 13% in Trial 2 to 7% in Trial 3, following much the same response pattern as was observed for COD, phosphates and polyphenols. Colour at 254 nm was less effectively reduced during passage through the wetland than at 475 nm, particularly in the control.

The effects of the treatments on TSS (that part of the TS that can be removed by filtration, as compared with the dissolved solids which pass through a filter, but appear as residue after a sample of wastewater has been slowly evaporated to dryness) was greater, and more consistent than were their effects on TS. Passage through the wetlands decreased TSS in all three trials, and in the control, as well as in the ozonated treatments. The extent to which TSS was lower in the ozone pre-treated than the control treatment was greatest in Trial 1 (35%), intermediate in Trial 2 (13%) and low in Trial 3 (6%).

The total (suspended + dissolved) solids (TS) content of the control wastewater was barely affected by passage through the wetland in Trial 1, though some reduction was observed in the ozone pre-treatment. In trials 2 and 3, in which the inflow COD was much higher than in Trial 1, limited reductions in TS were also observed in the control wastewaters following their passage through the wetlands. In contrast the effect of ozone pre-treatment in Trial 2 and Trial 3 was to bring about an increase in TS content. This increase was ascribed to partial breakdown of the organic residues coating the roots and gravel under the oxidizing influence of the ozone pre-treated wastewater, and release of the resultant fragments into the wastewater flow. That the treatments were generally able to bring about appreciable decreases in TSS, but only promoted relatively small decreases in TS, is explicable if it is assumed that the treatments converted solids from the suspended to the dissolved form, without bringing about their complete elimination from the TS category. This assumption is in line with the findings of Verma *et al*. (2007) who, while investigating the biodegradation of wastewater sludge, found that concentrations of dissolved solids increased linearly with total solids.

Conductivity (electrolyte or salt content) was not reduced by passage through the wetland in Trials 1 and 3 (the results for Trial 2 were inconclusive). Salt removal in wetlands is dependent on root uptake. The failure of the Phragmytes species to reduce the wastewater salt content in Trials 1 and 3 may either be due to inability on the part of the Phragmytes species concerned to remove the salts in the forms in which they were present in the wastewater, or to poor root function stemming from inhibited growth.

Alkalinity levels tended to increase as the wastewater passed through the wetland, notably in the control treatments. These increases were attributed to breakdown of the

TABLE 3. Percentage change in wastewater parameters due to the application of a post-ozonation treatment to the control and ozone pre-treated wastewaters after they had passed through the wetlands in Trial 2 and Trial 3.

Parameter	Trial 2		Trial 2	
	Control	Ozone pre-treated	Control	Ozone pre-treated
COD (mg O_2 / L)	-24	-29	-10	-19
Polyphenols (mg / L)	-68	-65	-36	-35
Total solids (mg / L)				
Total suspended solids (mg / L)	-1	4	13	18
	-9	-19	-54	-44
Colour 254 nm	-9	-52	-47	-62
Colour 475 nm	-59	-76	-85	-90

Negative figures indicate that the parameter decreased in magnitude or severity during post ozonation, relative to the non post ozonated controls.

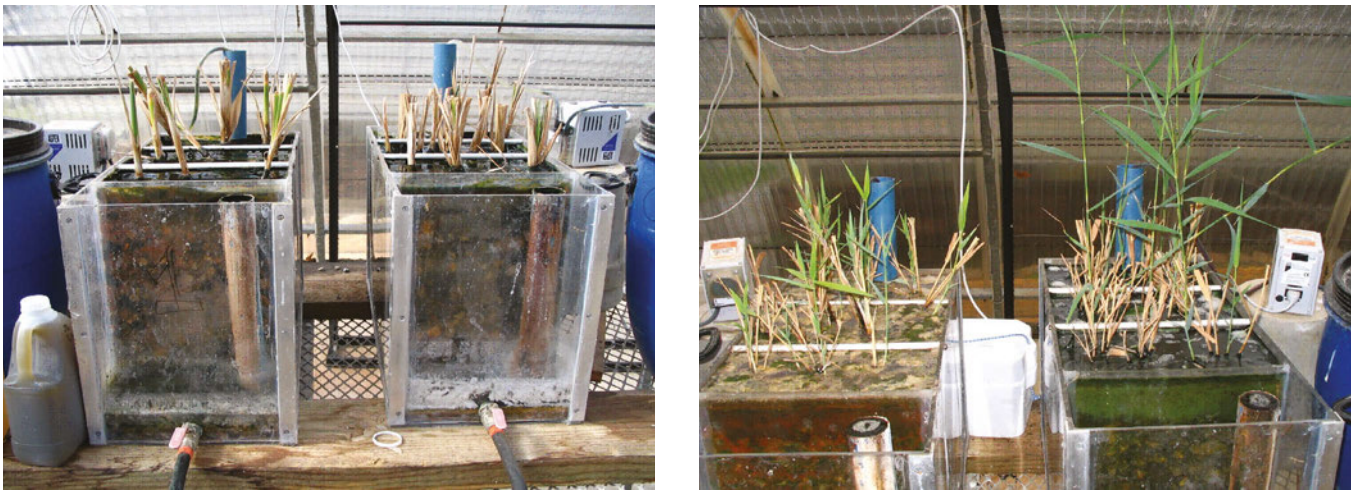

FIGURE 1. The experimental wetland systems at the start (left image) and end (right image) of Trial 3. In each image, the control wetland is on the left and the ozone pre-treated wetland on the right. Note the greater height of the Phragmytes spp. in the ozone pre-treated wetland.

dolomitic limestone as the wastewater passed through the pores in the gravel.

During Trial 3 the plants in the wetland which received ozone pre-treated wastewater grew appreciably better than those in the control wetland (Figure 1), reaching average heights of 118 cm and 95 cm, respectively. Since both wetlands were subjected to similar conditions of temperature, light intensity and flow rate, the difference in growth can only be ascribed to neutralization by the ozone pre-treatment process of certain of the phyto-inhibitory (toxic) components of the wastewater and, perhaps, their conversion into more readily biodegradable forms. The positive effects of ozone pre-treatment were sufficient to over-ride or mask any negative effects on the biological system operating within the wetland that may have been caused by the presence of any residual ozone in the wastewater. Because wetlands rely heavily on their macro plant components (IWA Specialist Group, 2000; Zingelwa, 2003), pre-treatments that improves the health and growth potential of the wetland plants should lead to greater removal efficiencies in the long term.

In the control and ozone pre-treated wastewaters that passed through the wetlands in Trials 2 and 3, post wetland ozonation increased the effectiveness with which COD, polyphenols, TSS and colour were controlled, relative to their concentrations in the post wetland wastewaters that did not receive the supplementary ozone treatment. In contrast, post ozonation increased TS, probably by converting suspended solids into the dissolved component of the TS. Wastewater parameters after passage through the wetland and the post-ozonation treatment did not show a consistent response to the ozone status (ie. control or ozone pre-treated) of the wastewater that entered the wetland. With the exception of polyphenols and colour (Figure 2), the benefits conferred by post-ozonation were small. Thus, although post wetland ozonation contributes to wastewater quality improvement, it is not a substitute for ozone pre-treatment.

CONCLUSIONS

A laboratory scale wetland trial showed that pre-treatment of the wastewater with ozone may have the potential to improve

FIGURE 2. Effect of passage through the wetland, and of post-wetland ozonation on ozone pre-treated distillery wastewater. Left, wastewater prior to entry into the wetland. Centre, the same wastewater after it had passed through the wetland. Right, wastewater after it had passed through the wetland and undergone post-wetland ozonation.

the quality of the wastewater that drains from wetlands. Criteria that proved amenable to ozone pre-treatment were COD, polyphenols and TSS contents, and colour, notably at 475 nm. Retention time within the wetland system is a critical factor and must be adjusted to suite the COD of the wastewater flowing into the system, high COD wastewaters requiring longer RT's than low COD wastewaters. Conceivably, if RT's could be sufficiently extended, the benefits associated with ozone pre-treatment could decrease, possibly to the point where such pre-treatment may no longer be considered necessary. Where an additional, post-wetland ozone treatment was applied, further improvements in waste water quality were obtained. Although ozone may thus improve the effectiveness of distillery and, by inference, winery wastewater purification in artificial wetlands, the question of whether ozonation will be viable in full-scale commercial settings is likely to be one of cost effectiveness; cost effectiveness being dependent on the efficiency of the apparatus used. Since data from a laboratory scale trial can not be reliably extrapolated to predict what will happen in a full scale wetland, and since investigation of the methods by which the efficiency of the ozonation process could be determined lay outside the scope of this trial, it is recommended that a further study should be

carried out. The aim of this new study should be to compare ozone application systems and application rates and determine how ozone use in conjunction with wetland systems can be rendered most cost effective.

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Summary

To facilitate an investigation concerning the possible benefits of ozone in wetland wastewater treatment, two laboratory-scale artificial wetland systems (0.06 m3 Perspex tanks filled with gravel and wetland plants) were constructed in a glasshouse. Distillery wastewater quality was assessed before it entered, and after it left the wetlands. Comparisons were made between wastewaters that were treated with ozone before they entered the wetland, and those that were not (the controls). Relative to the controls ozone pre-treatment reduced chemical oxygen demand (COD) by 6% to 11% and polyphenols by 4% to 10%. Factors which affected treatment efficiency were the COD of the inflowing wastewater, and the length of time taken for the wastewater to move through the wetland. The main effect of a supplementary ozone treatment, applied after the wastewaters drained from the wetlands, was to improve colour.

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Cost of a constructed wetland at Goudini Distillery

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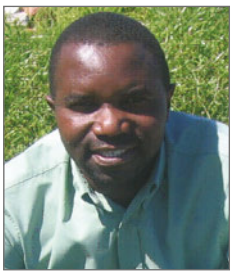

Reckson Mulidzi

INTRODUCTION

The wine industry produces wastewater during the washing, racking and filtration processes, as well as during pressing and the first fermentation phases of wine processing. Such wastewaters have the potential to cause considerable environmental damage (Van Schoor, 2002). To offset this possibility, international requirements as well as national legislation exert pressure on wine producers to manage their wastewater responsibly. In fact, wastewater management has been part of winery management for many years. Constructed wetlands nevertheless offer a relatively new approach to the treatment of winery wastewater, an approach that has been extensively tested over the past decade (Mulidzi, 2005).

The rationale for using constructed wetlands as winery wastewater treatment facilities is that wetlands are most biologically active natural ecosystems on earth (Shepherd & Grismer, 1997). Several types of constructed wetlands have been developed for use in wastewater treatment. Of these, free water surface wetlands, in which the water surface is exposed, and subsurface flow wetlands, where the water table lies below the top of the material filling the wetland, are the most common (Shepherd, 2002). In constructed wetlands, vegetation growing on a thick bed of coarse gravel provides a substrate (roots, stems and leaves) upon which micro organisms can proliferate (Figure 1). Treatment occurs when the wastewater passes over the prolific root structures to which the bacteria are attached.

Apart from environmental friendliness and effectiveness, the main advantages of constructed wetlands are low construction and operating costs. As an example, this article provides a breakdown of the estimated costs of the construction of a wetland for the treatment of wastewater at Distell's Goudini distillery (Figure 1).

CONSTRUCTION AND MATERIALS

The wetland is 45 meters long, 4 meters wide and 1.2 meters deep. It is filled to a depth of 0.9 meters with dolomitic gravel having a particle size range of 20 to 30mm). The porosity of the gravel bed was 35%, giving a total wetland volume of 162 cubic metres, and a pore volume (accessible to roots and wastewater) of 56.7 cubic metres.

The materials to be considered include the bed liner (floor and sides of the constructed wetland must be lined with an impermeable membrane to prevent leakage into the ground water), rooting substrate (sand or gravel), piping, pumps (varies with situation) and vegetation. Construction considerations include excavation of the bed and the structures needed to apply the wastewater and collect the processed outflow.

Selection of plants for constructed wetland

Plants in the wetland must be able to survive in a saturated medium. Plants which produce hard tissues are better than those having soft tissue, mainly because their root structures tend to remain more porous. High substrate porosity facilitates the inflow of oxygen, which is an essential requirement for odour-free operation, and which is also associated with reduced plant maintenance. Ideally, only native plants species should be used. Wherever possible, these should, in addition, be endemic to the locality in which the wetland is located. Avoid plants that could spread into the surrounding area as weeds. When selecting plants for constructed wetlands, the main factors to be considered are their pH and temperature tolerances. Worldwide, the most commonly used wetland plants are cattails (Scirpus spp.), bulrush (Typha spp.) and reeds (Phragmites spp.).

Plants suitable for use in constructed wetlands must possess certain characteristics. These include an ability to adapt

Materials	Costs
Dolomitic gravel	540 tons @ R108,21 per ton = R 26 295
Dam liner (6.8m x 50m), 1000µm	R26,50 per m^2 = R9 010
Excavation and construction	R 8 000
Sand (transport costs)	R 1 000
Drainage pipes	R 2 000
Other fittings	R 1 000
Water pump	R 3 000
Plants	R 1 000 (using local plants, where possible)
Total	**R51 305 (excluding VAT)**

FIGURE 1: Constructed wetland at Goudini with liquid capacity of 56.7 cubic metres used to treat 4.05 cubic metres of wastewater per day at a retention time of 14 days.

to the local climate and to variations in that climate, tolerance to high concentrations of nutrients and pollutants and resistance to pests and diseases. The plants should also have deeply penetration root systems. Wherever possible the system should be flushed with clean water before planting. The aim of this process is to remove fine material from between the gravel fragments, thereby maximising pore volume and hydraulic conductivity. Planting density should be six to 10 plants per square meter. During the immediate post planting period, continuing until the plants are established only clean water should be applied.

How much did the wetland system cost?

Approximate costs associated with the construction of a 56.7 cubic metre pore volume wetland at Goudini distillery are tabulated below:

The cost of R51 305 is considerably lower than that of alternative treatment systems, such as aerators. Constructed wetlands also have considerably greater aesthetic appeal than other forms of wastewater processing facility.

Capacity

Since the Goudini wetland has a liquid capacity of 56.7 cubic metres, it is able to process 4.05 cubic metres of wastewater per day at a retention time of 14 days. Where the quality of the wastewater is not heavily polluted, with a fairly low chemical oxygen demand, it may be possible to decrease the retention time to seven days, with a corresponding processing rate of 8.1 cubic metres per day.

CONCLUSIONS

The costs of constructed wetlands are low in comparison to those of other types of treatment system for winery and distillery wastewaters. Because wetlands do not require extensive maintenance, other than occasional cleaning and maintenance, their running costs are extremely low.

Information concerning the performance of constructed wetland will be published in a subsequent article.

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Analysing possible future scenarios: Introducing a tool for strategic decision making

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Sanri Reynolds

Wine businesses operate in a fast moving and constant changing environment. Anticipating potential changes and being informed on the possible impact of these changes provide businesses with a competitive edge to survive in a highly competitive market. To assist in this, Winetech, among others, has funded a project for the development of a system of models simulating the wine sector in South Africa. The models, developed by the Bureau for Food and Agricultural Policy (BFAP, website: www.bfap.co.za), should be used in analysing different possible scenarios and used by decision makers as one of the tools in the strategic decision making process.

The BFAP models simulate future trends and levels of prices, production, consumption and trade, as well as farm profitability in different wine grape producing regions. The projections are based on historical relationships between variables, perceptions of market structures and price formation and also future expectations. Table 2 and Figures 1 to 4 show the so-called baseline simulations for the wine industry. These simulations do not constitute a forecast, but rather a benchmark of what could happen under a certain set of assumptions. The baseline assumes that all current policies, international and domestic, will prevail. The baseline also assumes normal weather patterns and do not take into account the possible impact of climate change. Finally, the baseline projections are based on important macro-economic assumptions. Selected assumptions which proved to be crucial in driving the agricultural industry are presented in Table 1. Other variables taken into account includes the US dollar/Euro exchange rate, volumes and prices of other wine producing countries, input costs, domestic interest rates and prices of alternative products.

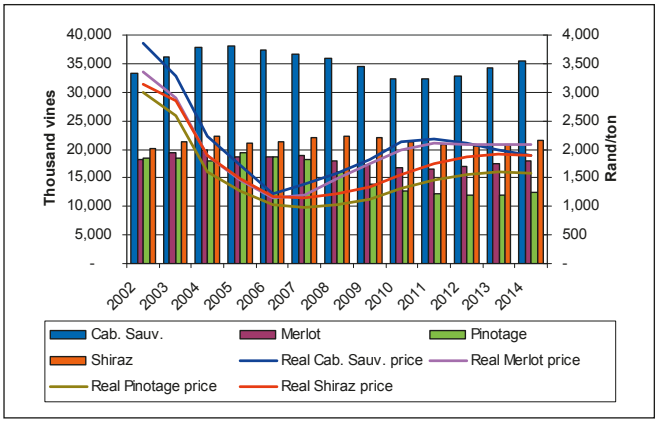

FIGURE 1: Vines in production of selected red varieties.
Source: 2004 - 2006 SAWIS, 2007 - 2014 model simulations.

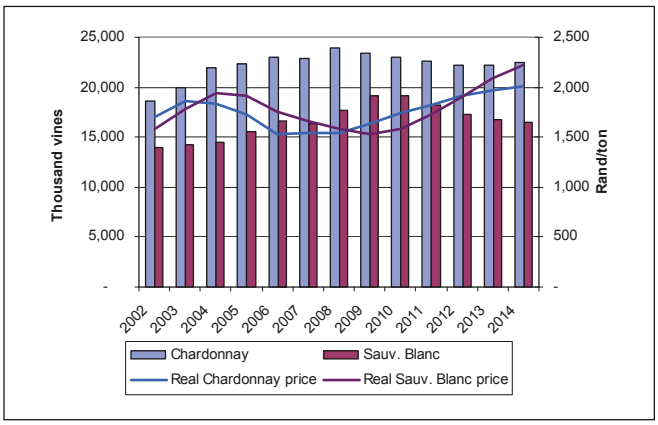

FIGURE 2: Vines in production of selected white varieties.
Source: 2004 - 2006 SAWIS, 2007 - 2014 model simulations.

TABLE 1: Macro-economic assumptions for baseline projections.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
People (Millions)											
Total population of SA	46.50	46.80	47.30	47.45	47.63	47.79	47.96	48.13	48.31	48.51	48.74
SA cent/US $											
Exchange rate	644.99	636.23	676.72	747.01	792.85	845.28	894.39	938.10	983.95	1,032.59	1,083.05
Rand (constant 2000)											
Real GDP per capita	15,500	16,069	16,654	17,329	18,179	19,127	20,171	21,305	22,510	23,819	25,270
Index (2000 = 100)											
GDP deflator	131.68	137.94	147.39	155.51	161.77	168.24	175.18	182.64	190.57	198.69	206.58

Source: Global Insight.

Based on these assumptions and following the decline in prices over the past four to five years, total vines in production is projected to increase marginally in 2007, decline in 2008 up to 2012, before it recovers to some extent in 2013 and 2014. Wine production is projected to follow a similar trend. On the demand side, exports are projected to resume its upward trend in 2007 and to continue this increasing trend over the baseline period. Domestic demand for wine is also projected to increase over the baseline period. The increase in demand and decline in supply is projected to put upward pressure on drinking wine prices, as well as prices of rebate wine and distilling wine and grape juice. Wine stocks are projected to increase over the next two to three years, where after it is projected to decline over the remainder of the baseline period.

Figures 1 and 2 present the baseline projections for vines in production and grape prices for selected red and white varieties. Note that the prices are constant 2000 prices, i.e., the prices are adjusted for inflation. The prices of red wine grape varieties are projected to turn upwards in 2007 and 2008 and will remain on this upward trend until 2011 for Cabernet Sauvignon and Merlot and 2013 for Pinotage and Shiraz. Thereafter prices are projected to come under pressure as supply increases. Note that prices of red varieties are projected not to reach the same price levels as before. The price of Chardonnay grapes is projected to stabilise over the next two years, strengthen from 2010 to 2012 and then level off as supply increases. The price of Sauvignon Blanc grapes are projected to follow a similar trend, though the turning points are a few years later. The tendency to plant reactive to price trends and the resultant commodity cycle are evident in the graphs.

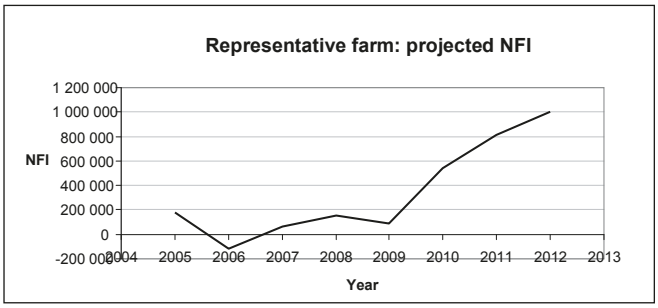

FIGURE 3: Projected net farm income (NFI) for a representative farm.

How will these price projections for different varieties impact on the profitability (in nominal terms) of wine grape farms in the various regions of South Africa? The possible effect of these price projections is simulated stochastically for representative wine grape farms in the different VinPro regions, and the average net farm income for one such region is illustrated in Figure 3. One way of presenting the possible effect of price risk on profitability, is illustrated in Figure 4 where the probability of various levels of projected net farm incomes are listed. Other performance measures like gross margin, net cash farm income, cash farm profit, ending cash surplus and net worth can also be simulated for a wine grape farm consisting of up to twelve grape varieties of three blocks each with variable age distributions of the vineyards.

However, as mentioned before, the environment is changing constantly and there are inherent uncertainties around policies, weather, financial markets, etc. For this reason, it is important to analyse different future scenarios. What if the

TABLE 2: Baseline projections.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vines (millions)											
Total vine in production	274.797	275.969	275.783	277.222	272.420	263.356	256.353	252.716	252.149	253.817	257.181
Litre (millions)											
Wine production	696.788	628.483	709.717	709.253	698.712	679.629	665.580	657.700	657.448	660.945	669.057
Rebate wine	85.357	82.928	82.116	84.195	84.374	84.381	84.476	84.440	84.486	84.567	84.732
Distilling wine	145.775	129.239	147.945	143.637	144.182	143.673	143.581	143.213	143.135	143.191	143.501
Non-alcoholic	87.777	64.578	73.201	90.798	84.951	76.009	68.882	64.251	62.603	62.377	63.945
Domestic sales	347.33	359.10	358.41	363.38	372.86	381.96	393.37	407.56	424.18	443.28	465.72
Exports	265.69	280.65	271.15	275.45	276.14	276.57	282.99	291.50	300.88	309.32	316.28
Stock changes	58.47	-6.28	77.03	47.38	27.51	1.60	-26.69	-54.44	-78.73	-101.67	-122.46
Rand/litre (nominal prices)											
Good wine price	3.54	3.38	3.34	3.68	3.96	4.30	4.65	5.01	5.36	5.72	6.06
Rebate wine price	1.98	2.07	2.10	2.20	2.35	2.55	2.75	2.95	3.16	3.36	3.56
Distilling wine and fruit juice price	0.97	0.98	0.94	1.00	1.13	1.21	1.30	1.42	1.53	1.64	1.74
Rand/litre (constant 2000 prices)											
Good wine price	2.70	2.45	2.27	2.37	2.45	2.56	2.66	2.74	2.81	2.88	2.93
Rebate wine price	1.51	1.50	1.43	1.41	1.46	1.52	1.57	1.62	1.66	1.69	1.72
Distilling wine and fruit juice price	0.74	0.71	0.64	0.64	0.70	0.72	0.74	0.78	0.80	0.83	0.84

Source: 2004 - 2006 SAWIS, 2007 - 2014 model simulations.

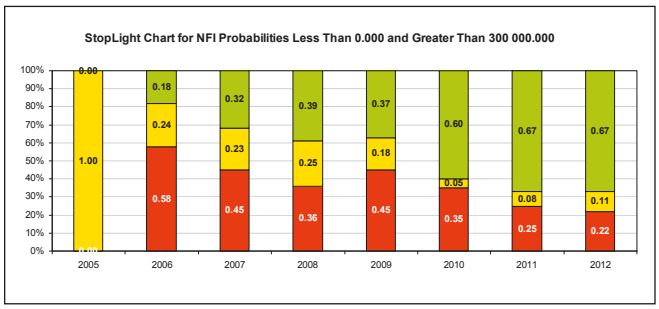

FIGURE 4: Stoplight chart showing the risk of various levels of net farm income (NFI) for a representative farm.

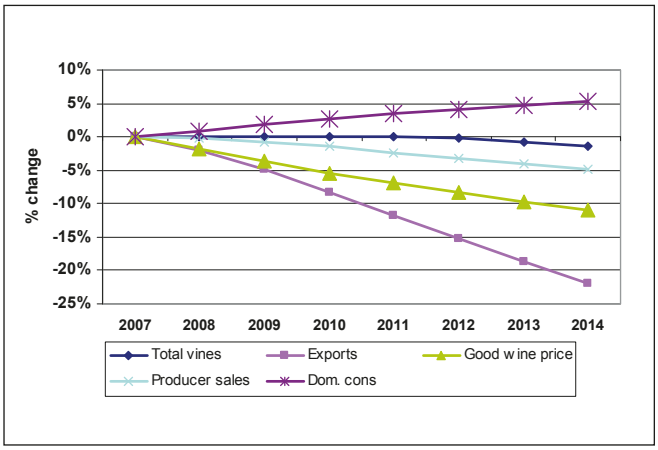

FIGURE 5: Wine industry overview – % changes from baseline.

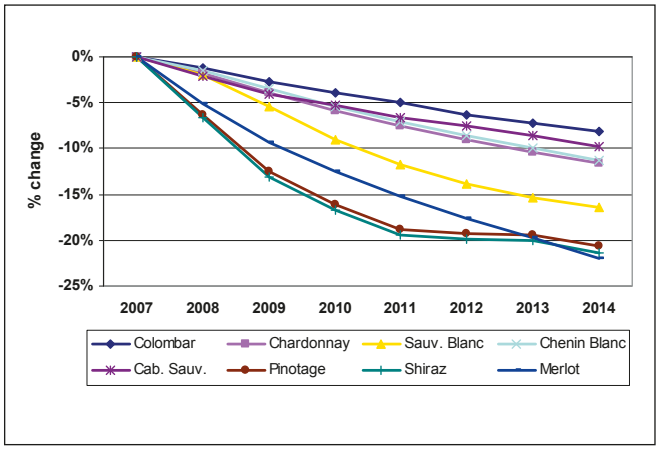

FIGURE 6: Grape prices – % changes from baseline.

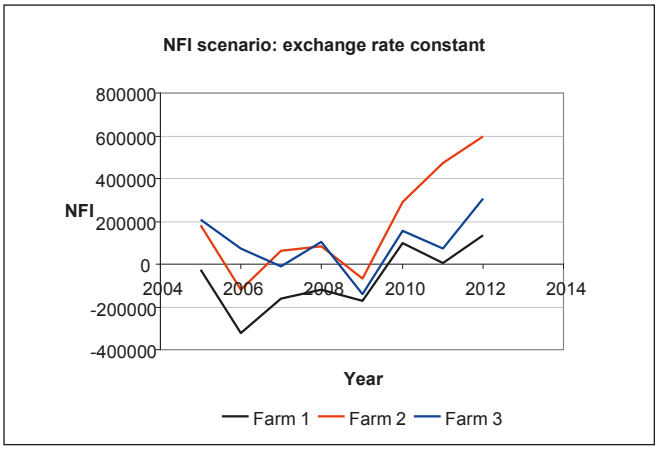

FIGURE 7: Net farm income (NFI) for three different representative farms for a scenario where the exchange rate remains constant.

exchange rate does not depreciate over time or what if the South African economy does not experience growth of between 4% and 6% per annum over the next seven years? For illustrative purposes, consider the possible impact should the exchange rate remain at R7,47/USD over the baseline period. How will this impact on supply, demand and prices and how will it impact on farm profitability?

Model results show that by 2014 exports will decline by almost 22% relative to the baseline; the decline in demand will push prices down with the real good wine price at R2.61/litre (constant 2000 prices), 11% below the baseline price (see Figure 5). Domestic consumption is expected to increase slightly, due to the lower prices. The impact on prices of red wine grape varieties is projected to exceed that of white wine grapes (see Figure 6), reflecting that prices of red wine grapes are more sensitive to changes in export demand than prices of white wine grapes. Finally, area under vines will decline the most in the Paarl region and least in the Robertson area (not shown in the figures).

The impact of the above mentioned exchange rate scenario on a representative wine grape farm in three VinPro regions is illustrated in Figure 7. Farm 2 in Figure 7 is the same representative farm as in Figure 3 and the effect of the exchange rate scenario is clear. The prices of different varieties in the different regions, as well as the relative composition of varieties and the age distribution of different vineyards will impact differently on the profitability and the effect that the exchange rate scenario will have on a specific representative farm.

The BFAP sector and farm level models of the wine grape industry give quantitative analyses and projections of how various policy options and a range of macro-economic variables can affect the supply of wine grapes and wine, as well as the demand for wine. The models are designed to address some of the most pressing information needs facing agribusinesses, farmers and policy makers. This management tool is available for evaluating strategic planning scenarios at various levels of decision making by different role players in the wine industry.

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Land reform farms in Bonnievale benefit from ARC Infruitec-Nietvoorbij vineyard training and technology transfer

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Key words: Previously disadvantaged farmers, wine grapes, technology transfer, training, Bonnievale.

Danie van Schalkwyk

A significant number of previously disadvantaged farmers now participate in the commercial cultivation of wine grapes. Many of these new farmers purchased farms from existing commercial farmers. Although these farms are situated in high potential viticultural regions, hardly any noteworthy progress has been made since the farms were acquired.

A survey to identify these farms was subsequently conducted by ARC Infruitec-Nietvoorbij in collaboration with the Provincial Departments of Agriculture of the Northern and Western Cape respectively. The purpose of the investigation was furthermore to point out and address possible limitations and shortcomings likely to restrict the development of these farms, so that they might develop into successful businesses.

Thirteen farms were identified and surveyed. The findings showed that certain factors such as a lack of bridging capital, healthy cash flow, business management skills, viticultural knowledge and management skills, as well as the participation of the trustees in the management of these farms, hampered the success of these farms.

Between 35 and 40 and more families joined forces to apply for funding by the Land Reform Programme (LRAD programme) in order to purchase the farms. Business plans drawn up by private consultants served as the basis for the purchase of these farms. Although some of the beneficiaries were familiar with certain aspects of agriculture, the survey showed that a large percentage of the beneficiaries had little knowledge of the cultivation of wine grapes. The farms were purchased in good faith in the belief that they would generate sufficient income to improve the beneficiaries' financial position. However, most of these parties were unaware of the need to make provision for operational capital to manage these farms once the purchase had gone through. Consequently there was a lack of funds for the necessary operational expenses and many of the farms were doomed right from the start.

Researchers from ARC Infruitec-Nietvoorbij decided to assist two of these farms, namely Gelukshoop and Nooitgedacht Kleinboere, both of which are situated in the Bonnievale/Swellendam area.

Gelukshoop is situated in the Bonnievale area, directly alongside the Gelukshoop road to Drew. It is a commercial farm that produces wine grapes and was purchased by a group of 40 families (with 160 potential beneficiaries), with funding by LRAD. The farm is managed by two of these trustees, Henrik Fortuin and Monde Xanywa, assisted by six shareholders (as permanent labourers). Additional labour is hired at peak times. The farm has 16,8 ha of vines and the grapes are delivered to Bonnievale Cellar.

The farm Nooitgedacht Kleinboere is situated directly alongside the road from Ashton to Swellendam, at the foot

1

Odette Beukes and Dr Johan van Zyl (research and technology manager of ARC Infruitec-Nietvoorbij) with personnel from Gelukshoop and Nooitgedacht Kleinboere at the diploma ceremony.

2

Personnel at Gelukshoop Kleinboere busy pruning a vineyard in the course of the training.

of the Langeberg. The farming activities focus on viticulture and milk production. Vines have been established on 6,5 ha and the remaining portions of the farm consist of both irrigated and natural grazing for the dairy stud. Altogether 35 families (approximately 175 potential beneficiaries) are shareholders in the trust. Of the initial five persons who were permanently resident on the farm, only two remain. Seasonal labour has to be hired regularly for essential viticultural actions such as pruning and suckering.

In the course of 2004 researchers from ARC Infruitec-Nietvoorbij, with financial assistance from Winetech, launched a project to enable the beneficiaries to manage the farms efficiently and profitably through technology transfer of viticultural knowledge and research results as well as practical training. In order to ascertain which viticultural practices had to be addressed, the current condition of the vineyards had to be investigated.

The first step was to conduct a survey among all parties concerned so as to determine their socio-economic circumstances as well as to survey the workers' levels of expertise in order to determine which information had to be conveyed and which skills had to be learnt. Results obtained from the surveys indicated that a large percentage of the beneficiaries did have experience of farming and to a certain extent they also had a limited background knowledge of viticulture. Knowledge of financial management was lacking. This problem was addressed by Odette Beukes of ARC Infruitec-Nietvoorbij, who presented a training course in basic business skills in 2006. All personnel on both farms underwent the training and diplomas were issued on completion of the course (Photo 1). These skills thus learnt are now being implemented with great success by the farm manager of Gelukshoop.

As a further step towards the success of these two farms, a meeting was held with all interested parties in 2006 to sensibly coordinate technology transfer and training. Johan Carstens (ARC Institute for Soil, Climate and Water), Prof Daan Louw (Optimal Agriculture Business Solutions) and Gert van Wyk (VinPro) were co-opted to evaluate and adapt the initial business plans, on the basis of which the LRAD funding for the purchase of the farms had been approved. To draw up more realistic business plans for each farm, complete surveys of farm costs and income were conducted and the data fed into a farm planning model. The results with regard to the effectiveness of the farming business plans, together with recommendations regarding the necessary adjustments, are provided annually to participating farm managements. The implementation and monitoring of affirmative action in each of the farming operations also receive attention.

The project leader, Danie van Schalkwyk, initiated the transfer of vineyard technology and training in the course of 2005. It was quite clear that pruning practices and canopy management on both farms were some of the biggest reasons for the farms' low production volumes and that these aspects had to be addressed urgently. To improve this situation, theoretical as well as practical training in pruning and canopy management have been offered on both farms since 2005 and the personnel's knowledge and skills in this regard have improved considerably (Photo 2 & 3).


4a


3

Personnel at Nooitgedacht Kleinboere busy pruning a Sauvignon blanc vineyard during training.


4b

Cover crops were sown in two blocks on Gelukshoop to demonstrate the effect of cover crop cultivation.

Nooitgedacht busy establishing a block of Chardonnay aided by a group of contractors from Bredasdorp.

After the purchase of Gelukshoop the vines' production initially decreased due to incorrect vineyard management practices and ineffective management. This situation has been reversed since the involvement of ARC Infruitec-Nietvoorbij, in collaboration with the Western Cape Department of Agriculture, VinPro, Bonnievale Cellar and OABS and a dramatic increase in production has taken place. This may be ascribed to the fact that pruning practices have improved and both canopy management and weed control have been implemented. Since 2004 production has increased by 66 tons with a considerable improvement in grape quality, which contributed to improved grading and remuneration. Gelukshoop works closely with the cellar and the VinPro's viticultural consultant to ensure that they implement the correct viticultural practices with a view to producing high quality grapes. As a result the grapes from one of their blocks were used to make a winemaker's class wine in 2007.

Weed control was one of the biggest problems that impacted negatively on both LRAD farms. The weed control expert from ARC Infruitec-Nietvoorbij, Dr Johan Fourie, was enlisted to address this problem. In the 2006/2007 production year he gave a lecture and practical demonstration on the identification of the various weeds and chemical control thereof. The influence of cover crop cultivation to control weeds, inter alia, was also covered in depth. Since the Trustee management of Gelukshoop opposed the use of cover crops, the project manager saw fit to have various cover crops established in two vineyards for demonstration purposes. Excellent growth was obtained and the effectiveness as cover crop was very obvious (Photo 4). As a result of this demonstration cover crops will probably be established in all the vineyards on Gelukshoop in 2008.

The managers of Gelukshoop Boerdery regularly attend information sessions presented by the cellar and other agricultural bodies and the manager, Mr Fortuin, stays abreast of the latest IPW guidelines. Thanks to good bookkeeping and improved viticultural practices, the farm's financial status and production compared very well with the 2006 average of the vineyard study group for the Robertson/Bonnievale area which is run by Gert van Wyk of VinPro. They have drawn up a long-term cultivar replacement programme in collaboration with their cellar and it is clear that this LRAD farm under the present management has the potential to compete with other commercial farms in the area.

The Rural Development Division of the Western Cape Department of Agriculture supports these LRAD farms by means of financial aid from CASP funds and also assisted Nooitgedacht to establish an additional 1 ha of Chardonnay (Photo 5). Although Nooitgedacht has the potential to manage their vineyards profitably, financial decision-making remains a problem. At this stage there is good collaboration with Gelukshoop, whose people helped to prune the vineyards on Nooitgedacht last season and also assisted with spraying of weeds in the vine row. Aid is mutual, in fact, since Nooitgedacht made one of their tractors and a trailer with a harvesting bin, as well as their truck, available to Gelukshoop during the pressing season. This enabled Gelukshoop to deliver all their grapes to their cellar on time. It is heartening to see this kind of collaboration among LRAD farms and goes to show that the owners of these farms are committed to making a success of these projects.

At this stage it is clear that the success of these LRAD farms depends largely on the Trust management's understanding of farming and the realisation that financial investment in vital viticultural actions (also in other branches of farming) is absolutely essential to improve production, quality and income.

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Vineyard

photo: Edo Heyns

Certified plant material: What guarantees are there? (Part I)

Francois Viljoen[1] & Nico van Rensburg[2]

[1]VinPro
[2]Vine Improvement Association

Francois Viljoen

Nico van Rensburg

SA wine farmers, when establishing a new vineyard, are aware of the importance of using the right scion, clone and rootstock combination for a specific locality / soil type as well as the best plant material if the vineyard has to stand any chance of being sustainable and profitable in the course of its lifetime.

South Africa also boasts one of the best plant improvement schemes in the world, managed and controlled by the Vine Improvement Association (VIA). The VIA is composed of representatives from producers, nurseries and plant improvement organisations.

Even so there are annual complaints about the quality of the vines and accusations by producers on the one hand and nurseries on the other hand about who is to blame if the vines do not take properly or if they display virus symptoms at an early stage. The producers accuse / suspect the nurseries of supplying poor quality plant material and infection in nurseries, while the nurseries contend that the producers' handling of the vines and establishment practices are still not up to scratch.

The question is therefore: "Are there really problems in our industry with regard to the availability and quality of our plant material, is it an erroneous perception, or merely a matter of being poorly informed?"

To find out more and get some answers, Francois Viljoen, Manager of VinPro : Consultation Service asked Nico van Rensburg, secretary of the VIA, to comment on the most common questions with regard to plant material that have to be dealt with by VinPro's viticultural consultants. In Part I of two articles the focus is on the VIA and the certification scheme, inter alia the guarantees.

Question 1: What guarantees are there if I order certified material?

Certification is a process and certified plant material means that plant material was propagated, following prescribed processes, from a nucleus plant with known virus status and viticultural characteristics, that it is true to varietal type, complies with the requirements of the scheme and has been inspected. Certified plant material therefore means that plant material with a known virus status and from a known source was handled and controlled in accordance with a prescribed process.

Question 2: For what do you test?

Plant material within the Scheme is subject to various tests.

- Varietal authenticity - Ampelographic controls are conducted to ensure that the nucleus plant complies with the typical characteristics of the variety.
- Viticultural - New clones are compared with existing clones of the same variety on a scientific basis to ensure that a new clone will perform better or at least as well as existing clones.
- Phytosanitary - During the candidate clone phase, nucleus plants are subjected to ELISA tests for Fanleaf and Leafroll, while ISEM and PCR tests are also used as optional tests.

Nucleus plants from registered clones are subjected to hard wood indicator tests, namely:

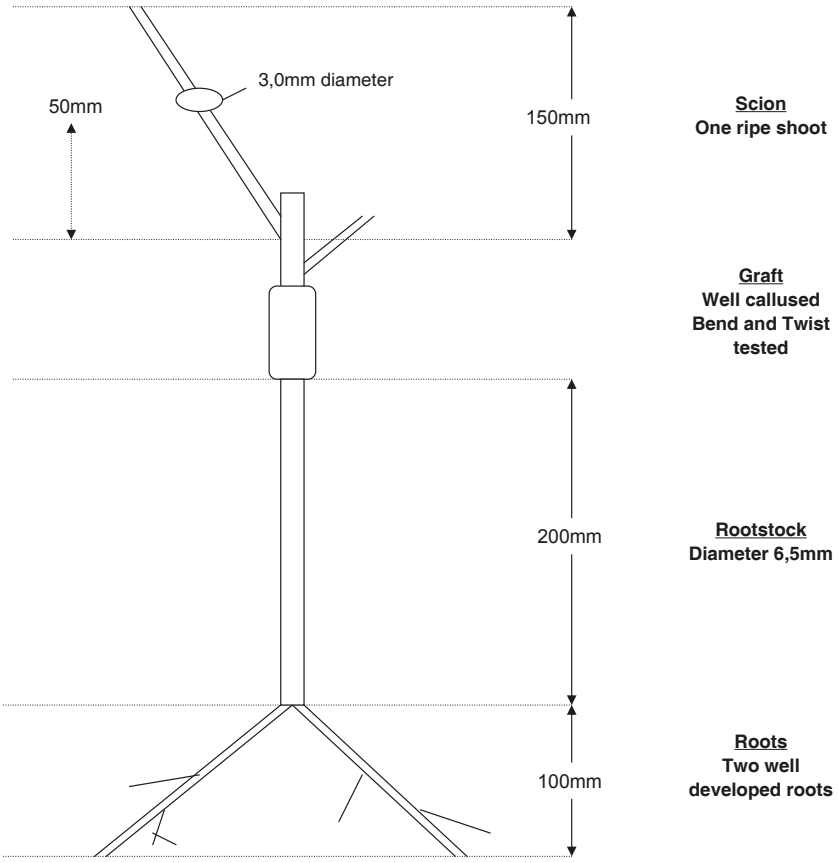
Scions	Rootstocks
Leafroll	Leafroll
Stemgrooving	Stemgrooving
Corky bark	Corky bark
Shiraz disease	Shiraz disease
Fleck	Fleck
	Vein necrosis
	Vein mosaic

Question 3: What is meant by: Material has been tested for all harmful viruses? – It sounds like there are many other viruses?

So far 54 viruses and/or virus-like diseases have been identified in vines throughout the world, although the causative organism has not yet been identified in all instances. With the annual expansion of scientific knowledge and the development of new testing techniques, new discoveries are being made each year or new strains of existing viruses identified. In terms of our Scheme testing takes place for 8 viruses/virus-like diseases that are of the biggest economic importance in South Africa at this stage. Consequently only those viruses that cause symptoms on grapevines and are of economic importance, are considered as pathogens. Although viruses are super-parasitic and always harmful, the greatest dangers are where viruses occur in varieties that are symptomless carriers and where complexes of viruses result from the grafting of scions and rootstocks of unknown status.

Question 4: How does the VIA ensure that nurseries comply with the certification requirements?

By comparing the quantity of plant material received by nurseries from the PIOs (Plant Improvement Organisations) to the quantity of vines grafted for each clone; and the nurseries themselves are subject to 3 annual inspections, namely summer, autumn and winter inspection. During the winter



Physical requirements of grafted wine grape material: 2007

inspection the vines are checked and finally certified as presented in bundles.

Question 5: What action does the VIA take, or is the VIA able to take, in the case of non-compliance?

Nursery vines that do not comply with the requirements of the scheme are provisionally rejected and if the shortcoming can be rectified through reselection of the vines, they may be presented again for certification. If the shortcoming is such that it cannot be rectified, or does not comply with the scheme requirements at the second submission, the vines are finally rejected.

Question 6: What does a vine that complies with the certification requirements look like (physical standards)?

Nursery vines should comply with the requirements of the scheme according to the following schematic representation:

Question 7: What should I, as a farmer, do to make sure I obtain the best plant material in our wine industry?

Due to reinfection and the presence of latent viruses, the best practice is to start with the cleanest possible plant material and keep it clean for as long as possible in order to achieve the maximum productive lifetime of the vineyard.

Nursery vines with the highest possible phytosanitary status should be ordered from a registered nursery at least 18 months prior to planting. Two years ago a system was implemented whereby plant material in foundation and mother units is graded according to the phytosanitary status of the nucleus plant and the risk profile of the unit.

- 3 star plant material comes from a nucleus plant that tests clean of all the prescribed viruses, has been planted in a low risk unit and is tested for leafroll every three years on an individual vine basis.
- 2 star plant material comes from a nucleus plant that tests clean of all the prescribed viruses, has been planted in a risk unit and is tested for leafroll every year on an individual vine basis.
- 1 star plant material comes from a nucleus plant that does not yet test clean of all the prescribed viruses, but is free of fanleaf and leafroll, and the unit is only visually clean of the prescribed viruses.

Question 8: Why is it still allowed to propagate and plant uncertified material in our wine industry?

Uncertified plant material may be propagated and planted in terms of the Plant Improvement Act, seeing that the scheme is voluntary and that the proclamation of the scheme did not prohibit the use of uncertified plant material. Although it is not recommended, the producer and nursery

are free to use uncertified plant material from untested and uncontrolled sources and run the risk themselves.

Question 9: Can I import my own material/clones?

Any person or body is free to import plant material. However, any import application should comply with rules in terms of the Plant Improvement Act as well as the Agricultural Diseases Act. Import requirements differ from country to country and depending on the risk profile of the plant material, as well as the area from which the plant material derives, additional requirements may have to be complied with. Some grapevine diseases such as "Pierce disease" and Flavesence Dorée do not occur in South Africa yet. Consequently it is absolutely essential for all imported plant material to be subjected to strict quarantine measures. Importation of large quantities of grafted or rooted plant material is generally not recommended due to the inherent risks. If it is allowed on special conditions in cases with merit, the vines may only be planted on the importer's premises and not propagated or distributed in the industry. Improved plant material should preferably be imported as unrooted shoots from a nucleus unit at recognised overseas instances and be further propagated and distributed by a Plant Improvement Organisation under the controls of the scheme.

Question 10: Can we still lay claim to having one of the world's best schemes? – In which ways are the other countries better than us?

Our Scheme is considered to be one of the best in the world because it is very dynamic in the sense that it makes provision for the continuous upgrading of clones and units, while clones and units that have become obsolete are phased out when new improved clones become available.

Our Scheme is also unique in that it is administered by an industry organisation which is managed according to strict guidelines that are controlled on an ongoing basis. Over the past 14 years, since the proclamation of the Scheme in the Government Gazette, it has shown that it is able to keep up with current demands and that the principles on which it is based are as valid as in the past.

Conditions differ from country to country and each country's Scheme is written according to its own particular requirements and risks. Consequently it is difficult to compare the Schemes of different countries directly with each other. The International Virus Congress held in South Africa in 2006 revealed that our requirements for nucleus plants are much higher than in the European Union and better than most other countries.

Our biggest problems, however, are that our new vineyards become reinfected due to the high risk of mealybug from old vines, especially the white varieties that are symptomless carriers of the leafroll virus and act as a source of infection.

Question 11: Is the material from all nurseries equally good as long as they comply with the certification requirements?

Nurseries receive the certified scion and rootstock plant material from mother units of the Plant Improvement Organisations. Consequently the nurserymen have no control over the quality of the plant material, except that they can decide on the category of plant material that is ordered in terms of the grading system i.e. 1 star, 2 star or 3 star plant material.

Plant material within the Scheme should comply with the prescribed requirements and there are differences between the status of the various clones and sources. Consequently one may expect plant material to perform differently depending on the clone and the source.

Differences in grafted vines from different nurseries may be ascribed mainly to the cultivation and care of the nursery vines, especially in the first year of the vineyard's lifetime. Thereafter grapevines from the same clones in the same area that have been properly taken care of, should perform the same.

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Certified plant material: What guarantees are there? (Part II)

Francois Viljoen[1] & Nico van Rensburg[2]

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Nico van Rensburg

In Part II Nico van Rensburg, secretary of the VIA, answers questions about possible reasons for reinfection of newly planted vines and steps producers can take to ensure that their plant material remains "clean" for as long as possible.

Question 1: Why are there so many red vines (virus vines) in my young vineyard despite having planted certified material?

Red leaves in a vineyard are not always due to Leafroll infection. Consequently experts should first ascertain whether there might not be other causes such as ringulation or potassium deficits. Leafroll symptoms might still occur due to reinfections by mealybug which could take place in the mother units, nurseries and the vineyard. Moreover the ELISA tests used in the case of 2 star and 3 star plant material have a threshold value, just like any other test, which means that a positive reading will only be obtained above a certain level of virus concentration and low concentrations cannot be detected. In the case of 1 star plant material the mother units are inspected visually only and the concentration of the virus particles may be so low that no symptoms are displayed.

Question 2: Is it always the farmer's fault if vines die or if virus symptoms appear?

No. Vines may die and develop virus symptoms after planting due to several factors. Low concentration of viruses and latent viruses can start accumulating in the vines after planting and cause symptoms especially in vineyards that experience stress conditions. In the case of Shiraz disease, where the causative organism is not yet known, vines can die within two to three years.

Drying out is the main reason why young vines die. Consequently the handling of the nursery vines is very important after lifting and transportation to cold storage and subsequent care after planting of the vineyard. Other pathogens such as fungi, bacteria and nematodes could also make the establishment of young vines more difficult. Consequently warm water treatment is strongly recommended to limit these pathogens to the minimum.

Question 3: What can I do to prevent the reinfection of new vines on old vineyard soils, e.g. how long should the soil be allowed to rest?

Reinfection can be limited by removing as many roots as possible from the previous vines during soil preparation and leaving the soil to rest for at least one year by sowing and ploughing a cover crop into the soil. A practice that is increasingly common is to give the soil an application of a systemic insecticide a year before the vineyard is due to be uprooted, to try and eliminate any mealybug population that occurs on the roots. Research is currently being done to spray vines with a herbicide after the last harvest, so that the roots may also die. Once the vines have been planted, preventative mealybug and ant control must be strict. Movement of labourers and implements should always occur from the youngest to the older vineyards. Labourers should preferably wear clean overalls and tractors and implements must be sprayed clean with water when moving from one vineyard to the next. Vines that display leafroll symptoms in the first two years must be removed and replaced with certified vines of the same clone.

Question 4: Is affinity still a problem?

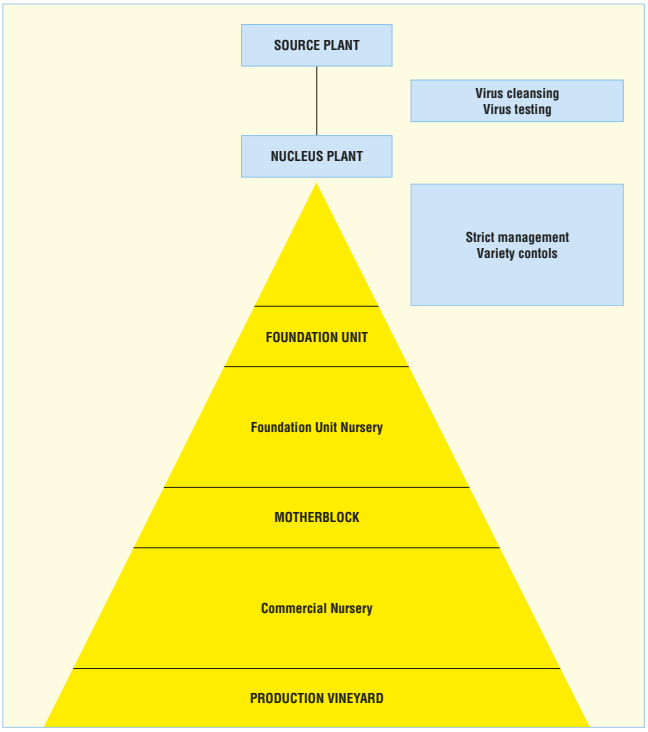
In the past affinity problems were caused mainly by virus complexes that result from the grafting of scions and rootstocks that are still heavily infected with viruses. Since the implementation of the Certification Scheme and the resulting improvement of plant material, the problem of affinity has largely disappeared. A new problem, however, known as Shiraz decline, induces the scion to callus very strongly and causes the rootstock to ringulate. One Shiraz clone that displays serious symptoms of this relatively unknown disease has already been withdrawn from the scheme.

Question 5: Why don't I always get what I ordered?

In order to ensure that a producer receives the right scion and rootstock clone, orders must be placed with the nursery at least 18 months before the vineyard is due to be planted. It is also recommended that producers visit the nursery so that they may check on the development of the vines in the nursery and whether the right clones for their purposes have been grafted. In instances where varieties are required that are not common, the orders should be placed with the nursery at least 36 months before the vines are due to be planted so that the PIO can propagate the plant material. If the full complement of vines ordered cannot be supplied, due to a poor take percentage in the nursery, the nursery will purchase the vines from another nursery or inform the producer in good time to make other arrangements.

Question 6: What is the difference between a nucleus, foundation; mother and commercial block?

One of the core principles on which the scheme is based, is that plant material should move from a nucleus plant, to foundation units, to mother units and then to the nursery unit. Nursery vines that have followed this route and comply with the physical and phytosanitary requirements of the scheme are certified and then planted in production vineyards by



producers. Although production vineyards are established using certified nursery vines, production vineyards cannot be used for further propagation under the scheme.

A nucleus plant derives from a local selection, breeding programme or an imported plant ex quarantine that is subject to strict virus tests and virus cleansing processes. Nucleus plants that test clean of the prescribed viruses and virus-like diseases are kept in a sterile soil medium in an insect-proof greenhouse with an impenetrable floor surface and tested regularly to ensure that the plants retain their status.

Plant material from the nucleus plants is gathered and propagated to establish foundation plants. Foundation plants may be kept in greenhouses or planted in open sites. Sites for foundation units must be 25 metres from other vineyards and the soil must be virgin soil and test clean of the vector X index that transmits fanleaf.

Plant material from the foundation plants are gathered and further propagated in a foundation nursery to establish mother units. Sites for mother units must be 3 metres from other vineyards and the soil should be virgin soil or test clean of the vector X index that transmits fanleaf.

Plant material from the mother units is collected and further propagated in nurseries to establish production vineyards. Sites for nurseries must be 3 metres from other vineyards and the soil should be virgin soil or test clean of the vector X index that transmits fanleaf.

Question 7: Where are the "clean" nucleus plants kept?

Nucleus plants that have been tested are kept in a nucleus unit, in sterile growth mediums, and that is insect-proof so that the nucleus plants cannot be reinfected.

Question 8: What is being done by the VIA, PIOs and nurseries to ensure that our plant material tests ever cleaner of pathogens each year?

Winetech has various research projects on viruses and plant improvement under way; the results are evaluated annually and incorporated in the protocols where possible.

Clones that have become obsolete as well as foundation and mother units that no longer comply with the requirements of the Scheme are scrapped annually and replaced with new, improved clones and planted in new foundation and mother units in areas with the lowest possible risk of reinfection.

Foundation and mother units are inspected annually and in some instances tested for leafroll. Units that have been tested on an individual vine basis in risk areas receive a 2 star grading and units in low risk areas receive a 3 star grading, whereas units that are only inspected visually receive a 1 star grading. As the status of the units is improved over time, the industry is continuously being provided with plant material of a higher standard.

In the case of nurseries the soil is left fallow for at least one year and sowed with a cover crop, while fungicides are used to limit fungal infections. Warm water treatment is strongly recommended, as it produced the best results in the research trials to eliminate a wide range of pathogens.

Question 9: Are grapevine viruses harmful to humans?

No. Grapevine viruses are very specific and only occur in live grapevine plant material. Consequently there are no health risks for humans. According to the latest research the leafroll virus does not occur in the grape berry.

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Effect of organic and integrated soil cultivation practices on the weed population in a Sauvignon blanc vineyard situated in the Paarl wine district

Johan Fourie

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Key words: Grapevine, organic production, integrated production, weed control, weed spectrum.

INTRODUCTION

According to Cousens & Mortimer (1995), the ability of weeds to increase rapidly in abundance after introduction into a habitat, and tolerate a wide range of habitat conditions, commands human attention. Uncontrolled weeds may reduce crop yield by as much as 80%. Effective and sustainable weed control is, therefore, essential. Producers are, however, being subjected to mounting pressure to reduce their usage of herbicides. Reasons include the widespread appearance of herbicide-resistant weeds (Darmency & Gasquez, 1990; LeBaron & McFarland, 1990; LeBaron, 1991; Henkes, 1997; Powles *et al.*, 1997), the risk of environmental contamination (Carter *et al.*, 1991), and negative public perceptions of agrochemicals (Major, 1992). A reduction in herbicide use, nevertheless place the economic viability of crop production at increased risk (Zoschke, 1994).

Soil cultivation practices act as a selective force in the development of a weed flora, because certain species are adapted to survive intermittent habitat disturbances (Smith, 1970) and will quickly fill the vacated niches created by such practices (Putnam, 1990). The species composition of a weed community is, therefore, linked to the agronomic practices applied (Buhler *et al.*, 1997). In consequence, situations where the weed population is dominated by a small number of species are indicative of a weed management system that provides opportunities that these species can exploit (Cousens & Mortimer, 1995).

This study was conducted to determine the effect of three minimum soil cultivation practices on cover crop performance, weed control efficiency and weed spectrum in a vineyard over a six year period. The aim was to improve our understanding of long-term weed population dynamics in perennial crops.

MATERIALS AND METHODS

Trial layout

The trial was carried out over a period of six years (April 2000 to March 2006) in a four year old non-irrigated Sauvignon blanc/99 Richter vineyard trained on a four strand extended Peroldt trellis system (Booysen *et al.*, 1992). The grapevines were established on a sandy clay loam soil (Table 1) at Plaisir de Merle farm situated near Paarl (33°44'S, 18°57'E), Coastal wine grape region, Western Cape. Mean annual rainfall during this period was 1033 mm, of which approximately 75% fell during autumn and winter. Vines were spaced 1 m in the row and 2.5 m between rows.

Three soil management practices were applied as described in Table 2. Treatments were replicated four times in a randomised block design. Each plot (replication) consisted of 21 grapevines and the two adjacent work rows, resulting in a surface area of 105 m2. From seasons 2000/2001 to 2004/2005, rye (*Secale cereale L. v. Henog*) was used as cover crop in the IP and Organic treatments. In 2005/2006 the cover crop was 'Pallinup' oats (*Avena sativa L. v. Pallinup*). The cover crop was sown annually (seeding dates varying between 14 April and 10 May) at 100 kg/ha (Fourie *et al.*, 2001). Seedbed preparation was carried out using a disc harrow approximately six weeks before the seeding date. After sowing (broadcasted by hand), the seeds were covered with a disc harrow. In the treatments managed according to

TABLE 1: Analyses of the sandy clay loam determined before the treatments commenced (sampled March 2000.)

Soil depth (mm)	Clay (%)	Silt (%)	Sand (%)	pH (KCl)	Electrical conductivity (mS/m)	Organic C (%)	P (mg/kg)	K (mg/kg)	Exchangeable cations (cmol(+)/kg)			
									Ca	Mg	K	Na
0-300	22.4	15.1	62.5	6.7	16	0.60	15	67	5.38	0.55	0.19	0.06
300-600	23.6	13.3	63.1	6.5	11	0.41	12	59	4.56	0.52	0.17	0.08

TABLE 2: Explanation of the three treatments applied to the work row.

Treatment	Soil management practices applied in the work row.
Conventional	No cover crop, full surface, post-emergence chemical control applied from bud break with glyphosate (380g/L formulation) at recommended rates. Inorganic nitrogen broadcasted.
Integrated production	Cover crop, full surface post-emergence chemical control from mid-October with glyphosate (380g/L formulation) at recommended rates. Inorganic nitrogen broadcasted.
Organic	Cover crop, flatten cover crop after completion of life cycle, slash weeds during grapevine growing season. No nitrogen applied to work row.

TABLE 3: Effect of three soil cultivation practices on cover crop performance and weed stand as determined before bud break in the non-irrigated Sauvignon blanc/99 Richter vineyard at Plaisir de Merle near Paarl.

Treatment	Dry matter production in tons/ha[1]									
	Cover crop					Weeds				
	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Conventional	0a	0a	0a	0a	0a	2.87a	1.54a	1.38a	0.98a	0.55a
Integrated production	3.77c	2.00c	3.05c	3.78b	1.21c	0.23b	0.23b	0.38b	0.27a	0.28a
Organic	1.17b	0.69b	1.23b	2.47b	0.52b	0.28b	0.41b	0.89ab	0.65a	0.78a

[1] Values in columns followed by different letters differ signifantly at the 5% level..

integrated production of wine (IP) guidelines (Anonymous, 2006), the cover crops received limestone ammonium nitrate (LAN) at a rate of 100 kg/ha (28 kg/ha of N) at the two- to four-leaf development phases as proposed by Van Huyssteen & Van Zyl (1984).

Measurements

Dry matter production (DMP) by both the cover crops and the associated weeds was determined at the end of August, according to the procedure described by Fourie *et al*. (2001). To determine the weed species in the work row, an area of 14 m2 was evaluated visually. The total surface area covered by weeds was estimated visually by only one person to avoid the inherent variance of multiple assessors (Olmstead *et al*., 2004). Percentage surface area covered by a weed species was estimated visually and expressed as a percentage of the total surface area covered by weeds.

RESULTS AND DISCUSSION

Cover crop performance and weed control efficacy

Dry matter production by the cover crops as measured at the end of August was, with the exception of 2004, significantly higher in the IP than in the Organic treatment (Table 3). The result achieved in 2001 illustrated the importance of nitrogenous fertiliser, when applied at the two to four leaf growing stage, in maximising the DMP of a grain species. The cover crops in the IP treatment and the treatment in which no chemicals were applied (Organic) suppressed the winter growing weeds significantly compared to that of the IP treatment in which no cover crop was sown (Conventional) during 2001 and 2002, while only the IP treatment suppressed the winter growing weeds significantly compared to the Conventional treatment in 2003. Thereafter no significant differences could be detected between treatments. Although not significant, the stand of winter growing weeds in the Organic treatment exceeded that of the Conventional treatment in which no cover crop was sown during 2005. This was attributed to poor cover crop growth as a result of the cover crops being established as late as 10 May, as well as the weeds producing seeds as a result of no chemical control being applied during the grapevine growing season.

Changes in the spectrum of winter growing weeds

The different soil management practices impacted on the species composition of the winter growing weeds (Tables 4 & 5). The percentage perennial weeds in the total winter weed spectrum declined in the Conventional treatment over the five year period, while it increased in the IP and Organic treatments (Table 4). The decrease in perennial species observed in the Conventional treatment was due to a sharp decline in the percentage yellow sorrel, while the increase in the IP treatment was due to yellow sorrel becoming one of the two dominant winter growing species. This increase is not of economic importance, because yellow sorrel is not difficult to control chemically. The increase in the perennial winter-growing weeds observed in the Organic treatment was due to an increase in both yellow sorrel (*Oxalis pes-caprae* L.) and narrow-leaf ribwort (*Plantago lanceolata* L.). This latter species is not readily controlled chemically and

TABLE 4: Effect of different soil management practices on the spectrum of winter growing perennial weeds in the vineyards at Plaisir de Merle near Paarl, as observed end of August.

Treatment	Weed stand (percentage of total weed spectrum)[1]							
	Narrow-leaf ribwort		Hairy wild lettuce		Yellow sorrel		Total	
	2000	2005	2000	2005	2000	2005	2000	2005
Conventional	3a	4a	0a	6a	31a	5a	34a	15a
Integrated production	0a	1a	6a	0b	5b	35a	11a	36a
Organic	3a	18a	4a	3a	5b	21a	12a	42a

[1] Values in columns followed by different letters differ signifantly at the 5% level..

TABLE 5: Effect of different soil management practices on the spectrum of winter growing annual weeds in the vineyards at Plaisir de Merle near Paarl, as observed end of August.

Treatment	Weed stand (percentage of total weed spectrum)[1]													
	Bristly ox-tongue		Broadleaf purple vetch		Wild radish		Bur clover		Winter grass		Other		Total	
	2000	2005	2000	2005	2000	2005	2000	2005	2000	2005	2000	2005	2000	2005
Conventional	0a	15a	8a	5a	45a	18a	13a	39a	0a	5a	0a	3a	66a	85a
Integrated production	4a	6a	11a	18a	56a	34b	5a	4b	9a	1a	4a	1a	89a	64a
Organic	5a	9a	6a	26a	55a	19ab	0a	1b	19a	0a	3a	3a	88a	58a

[1] Values in columns followed by different letters differ signifantly at the 5% level.

may, in consequence, come to have a negative economic impact in the long-term. Despite the increase in the percentage perennial species observed in the IP and Organic treatments, the annual species nevertheless remained dominant in these treatments (Table 5).

The weed population observed in the Conventional treatment changed from yellow sorrel and wild radish (*Raphanus raphanistrum* L.) being the dominant species (Table 4) to bur clover (*Medicago polymorpha* L.) becoming the dominant species (Table 5). Bristly ox-tongue (*Picris echioides* L.) appeared in the Conventional treatment at some point after 2000 and by 2005 had become one of the three prominent species. Bur clover and bristly ox-tongue are more difficult to control chemically than yellow sorrel and wild radish and may, therefore, have a negative economic impact in the long-term. The 'other' winter growing species observed in the Conventional treatment during 2005 consisted of ryegrass (Lolium species), flax-leaf fleabane (*Conyza bonariensis* (L.) Cronq) and Cape marigold (*Arctotheca calendula* L.) (Table 5). Inclusion of these species increased the biodiversity of the Conventional treatment to 11 winter growing species (Tables 4 & 5). Unfortunately one of the two indigenous species, yellow sorrel, diminished from being one of the two dominant species to only 5% of the total weed stand. The Conventional soil management practice, therefore, promotes invasion by exotic species over a period of approximately five years.

In the IP treatment, wild radish gave way as dominant species to yellow sorrel and wild radish, both of which are easy to control chemically. Hairy wild lettuce (*Hypochperis radicata* L.), a species that is more difficult to control chemically than yellow sorrel and wild radish, was not observed in this treatment after five years. This may be beneficial in the long-term. The 'other' winter growing species observed in the IP treatment during 2001 were musk herons bill (*Erodium moschatum* (L.) L'Herit. ex Ait) and chickweed (*Stellaria media* (L.) Vill.). These species disappeared so that by 2005, the only species present in the 'other' category was ryegrass. The exotic species present in the IP treatment decreased by one species, to give a total of eight winter growing species (Tables 4 & 5), while the only indigenous species, yellow sorrel, became one of the two dominant species. This soil management practice, therefore, creates conditions that favour the species endemic to the region.

The weed population observed in the Organic treatment changed from one in which wild radish was dominant to one in which broadleaf purple vetch (*Vicia sativa* L.), wild radish, yellow sorrel, and narrow-leaf ribwort were all prominent. Since broadleaf purple vetch and narrow-leaf ribwort are more difficult to control chemically than wild radish, a forced reversion to chemical weed control could have negative long-term economic implications. The 'other' winter growing species observed in the Organic treatment during 2001 consisted of musk herons bill and chickweed. By 2005 the chickweed was replaced by flax-leaf fleabane. The winter growing weed biodiversity of this treatment did not change and remained a total of nine winter growing species (Tables 4 & 5). This soil

TABLE 6: Effect of different soil management practices on the spectrum of perennial weeds growing during summer in the vineyard at Plaisir de Merle near Paarl, as observed end of January.

Treatment	Weed stand (percentage of total weed spectrum)[1]							
	Narrow-leaf ribwort		Hairy wild lettuce		Wild lettuce		Total	
	2001	2006	2001	2006	2001	2006	2001	2006
Conventional	1	0	13	5	8	19	22	24
Integrated production	22	10	62	10	6	0	90	20
Organic	20	30	48	20	0	16	68	66

[1] Values did not differ significantly at the 5% level.

TABLE 7: Effect of different soil management practices on the spectrum of annual weeds growing during summer in the vineyard at Plaisir de Merle near Paarl, as observed end of January.

Treatment	Weed stand (percentage of total weed spectrum)[1]																	
	Bristly ox-tongue		Flaxleaf Fleabone		Spanish blackjack		Painted milkweed		Withonde-bossie		Common dubbeltjie		Thorn apple		Other		Total	
	'01[2]	'06[3]	'01	'06	'01	'06	'01	'06	'01	'06	'01	'06	'01	'06	'01	'06	'01	'06
Conventional	52a	8a	3a	11a	0a	50a	0a	7a	6a	0a	5a	0a	12a	0a	0a	0a	78a	76a
Integrated production	10a	20a	0a	50a	0a	0b	0a	0a	0a	0a	0a	0a	0a	0a	0a	1a	10a	80a
Organic	25a	34a	0a	0a	0a	0b	0a	0a	0a	0a	0a	0a	2a	0a	5a	0a	32a	34a

[1] Valued in columns followed by different letter differ significantly at the 5% level. [2] '01 = 2001. [3] '06 = 2006.

cultivation practice has the advantage that it creates conditions that favour the development of species that are endemic to the region.

Changes in the spectrum of summer growing weeds

The different soil management practices affected the species composition of the summer growing weeds (Tables 6 & 7). The percentage of perennial weeds in the total summer weed spectrum declined drastically over the five year period in the IP treatment, but remained much the same in the Conventional and Organic treatments (Table 6). This decline in the perennial species observed in the IP treatment was attributed to hairy wild lettuce and narrow-leaf ribwort being prevented from producing seeds, despite the fact that chemical weed control was applied late (mid-October). Flax-leaf fleabane, a very hardy species that is difficult to control chemically, nevertheless filled the vacated niche and became the dominant species in the IP treatment (Tables 6 & 7). Despite a decline in the percentage of hairy wild lettuce in the Conventional treatment, the percentage of perennials present in the weed population remained the same (Table 6). This lack of change was attributed to an increase in the percentage wild lettuce (*Lactuca serriola* L.). The same phenomenon was observed in the Organic treatment with narrow-leaf ribwort and wild lettuce filling the niche vacated by hairy wild lettuce. As far as the annuals in the Conventional treatment are concerned, a definite population shift occurred, with Spanish black jack (*Bidens bipinnata* L.) replacing bristly ox-tongue as the dominant species (Table 7). The 'other' summer growing species observed in the Organic treatment during 2001 consisted of sowthistle (*Sonchus oleraceus* L.) and wild radish, while that observed in the IP treatment during 2006 was sowthistle. The exotic species present in the Organic treatment decreased by two over the five year period, while that in the IP treatment increased by one (Tables 6 & 7). The exotic species observed in the Conventional treatment was reduced by one over the five year period, while the only endemic summer growing species, namely common dubbeltjie (*Tribulus terrestris* L.), also disappeared.

CONCLUSIONS

A grain cover crop established annually, combined with either chemical weed control or slashing during the grapevine growing season prevents an increase in the percentage non-indigenous species. The absence of a cover crop in the working row during winter creates conditions which promote an increased variety of exotic weeds. This is not desirable and should be avoided at all cost. The importance of nitrogenous fertiliser (LAN, 28% N), applied at the two to four leaf growing stage, in maximising the DMP of a grain species was illustrated.

All soil cultivation practices cause greater or lesser changes in the weed spectrum, species dominance shifting with time. This is an aspect of weed control that should be studied more extensively in future, since it may be a useful way of determining whether a soil cultivation practice will promote biodiversity and be sustainable in the long term.

Such studies also create a better understanding of the weed population dynamics in the vineyards of the Western Cape, and enable guidelines regarding future soil management decisions to be formulated with greater confidence.

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Acknowledgements Financial support by Winetech and ARC, technical support by Isabella Van Huyssteen, Karen Freitag and the staff of Soil Science ARC Infruitec-Nietvoorbij.

Summary

Three soil management practices (treatments) in a non-irrigated Sauvignon blanc/99 Richter vineyard on a sandy clay loam soil near Paarl were evaluated over a period of six years, commencing four seasons after planting. Dry matter production of the cover crops was, with the exception of 2004, significantly higher under integrated production (IP) than when under organic production. The cover crops in the IP and Organic treatments suppressed winter weed growth significantly during 2001 and 2002 compared to a treatment in which no cover crop was sown and chemical control was applied during the growing season of the grapevines (Conventional). The perennial weed component of the total winter weed spectrum declined in the Conventional treatment over the trial period, but increased in the IP and Organic treatments. In contrast, the perennial weed component of the total summer weed spectrum declined steeply with time in the IP treatment, but remained unchanged in the Conventional and Organic treatments. The IP and Organic treatments prevented an increase in the percentage exotic species present.

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The contribution of atmospheric humidity in winter to yield fluctuations of Sultanina in the Lower Orange River region

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Key words: Growth arrest, delayed budding, yield, relative humidity, water deficit.

Philip Myburgh

INTRODUCTION

About 90% of South Africa's Sultanina vineyards used for drying grapes and wine production are situated along the Lower Orange River in the Northern Cape. The region has a summer rainfall climate characterised by exceptionally hot summers and cold, dry winters. The annual rainfall is approximately 200mm and precipitation occurs mostly in February and March. At that stage most Sultanina vineyards have been harvested. Seasonal variation in Sultanina yield is a phenomenon that occurs not only in the Lower Orange River region (Smit, 1970), but also in other regions such as the Murray River valley in Australia (May & Antcliff, 1963). Sultanina plantings in the Lower Orange River region gradually increased until 2001, thereafter they started to decline (Fig. 1). The total production of fresh grapes did not follow suit, however. The fluctuations in yield occurring from one season to the next may be ascribed to natural factors, such as frost and hail damage, as well as rain during ripening which causes berry shed. Damage due to flooding could also have reduced yields. The so-called growth arrest disease is also considered to be one of the important causes of low yields in some seasons. Such seasons are generally called "skip years". The typical symptoms of growth arrest disease are buds that appear at the beginning of the growing season but do not continue to grow - or perhaps don't even bud at all. When shoots start growing from these buds later in the season, they either have small or no bunches whatsoever. Various factors such as abnormalities in the winter dormancy physiology, large temperature fluctuations in summer and winter, low soil temperatures in winter, limited nutritional uptake from dry soil, certain rootstocks and diseases such as downy mildew may play a role in the occurrence of the growth arrest phenomenon (Van der Westhuizen *et al*., 2001).

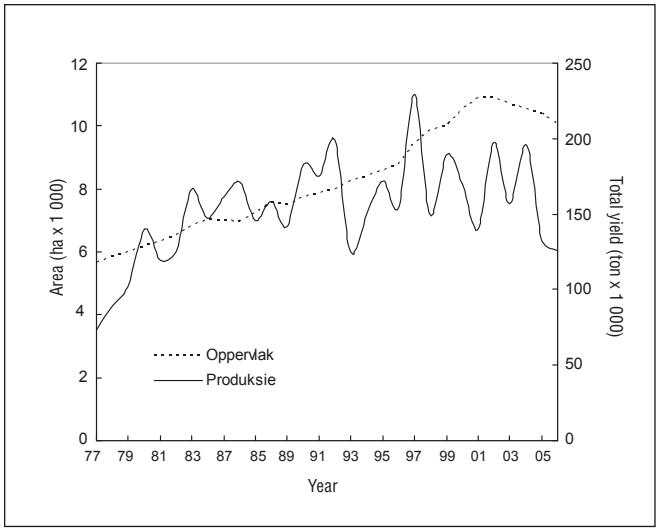

FIGURE 1: Change in Sultanina plantings and total yield in the Lower Orange River region from 1977 to 2006. Information supplied by DTS and SAWIS.

Observations in the Lower Orange River region indicated that water deficits during the dormant period are detrimental to shoot growth of Sultanina at the beginning of the season, and may also reduce yield (Goosen, 1956). More recently irrigation trials in the Upington area indicated that low atmospheric humidity, or low relative humidity, during the preceding winter also impacts on low yields (Myburgh, 2003a). It has been confirmed that low soil water content may aggravate this effect. During the 1992/93 season when the total yield in the Lower Orange River region was generally low (Fig. 1), a combination of these factors caused non-clone Sultanina in the alluvial soils of the irrigation scheme to produce less than 2 ton/ha compared to the 14 ton/ha of a control that was irrigated during the winter (Myburgh, 2003a). A subsequent study showed a similar drastic decline in fertility and yield in line with a decrease in relative humidity (Fig. 2). In this instance Sultanina (Clone H4) in sandy soil further away from the river was deliberately exposed to water deficits (Myburgh, 2003b). It was also found that dry soil conditions before budding reduced cane water content, and that there was a close correlation between yield and cane water content. A further field trial was subsequently undertaken to increase the cane water content by means of overhead pulse irrigation during the winter (Myburgh & Van der Walt, 2005). Cane water content and yield of Sultanina (Clone 14/2) in sandy soil further away from the river that received normal, as well as overhead irrigation, was higher compared to a control that did not receive any irrigation (Table 1). These results confirmed, to a certain extent, that soil water content and atmospheric humidity in winter influence the yield of Sultanina. During the irrigation trials low relative humidity and dry soil conditions in winter also caused the typical growth arrest or delayed budbreak symptoms that resulted in extremely low yields (Myburgh, 2003b; Myburgh & Van der Walt, 2005).

In view of the fact that the above-mentioned trials were all conducted under a specific set of conditions and cultivation

TABLE 1: The effect of overhead irrigation in July and August as well as dry soil conditions in winter on cane moisture content (CMC) and yield of Sultanina in sandy soil near Upington during the 2001/02 season (Myburgh & Van der Walt, 2005).

Irrigation	CMC (%)	Yield (t/ha)
Normal under-vine irrigation	*50.8ab**	*12.6ab*
Normal under-vine and overhead irrigation in July/August	*53.1a*	*18.4a*
Overhead irrigation only in August	*52.1ab*	*14.4ab*
No irrigation	*50.1b*	*7.6b*

* Figures followed by the same letter do not differ significantly ($p \leq 0.1$).

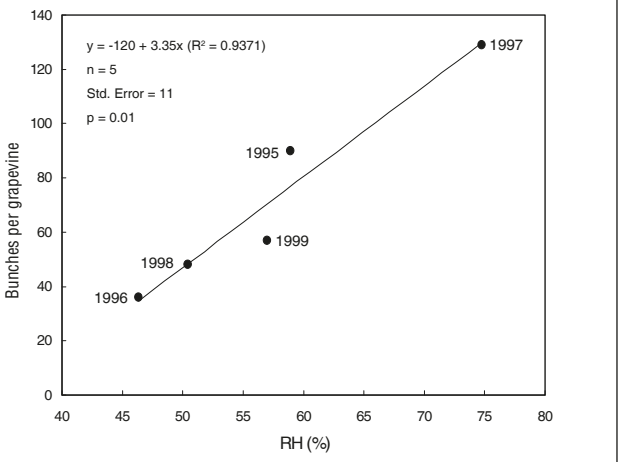

FIGURE 2: Effect of relative humidity (RH) in August and September on the fertility of Sultanina over five seasons in the Lower Orange River region (Myburgh, 2003b).

practices, the results are not necessarily representative of the entire Lower Orange River region. The purpose of this study was therefore to determine the extent to which the yield of Sultanina vineyards is influenced by relative humidity in winter on a regional basis.

MATERIAL AND METHODS

The annual total yield figures of Sultanina that is produced for raisins and wine were obtained from Dried Fruit Technical Services (DTS) and the South African Wine Industry Information and Systems (SAWIS) respectively. Until 1976 the yield figures for raisins along the Lower Orange River were reported as part of the national yield. Consequently the study had to be restricted to the 29-year period from 1977 to 2006. Seeing that the table grape crop is usually artificially reduced by producers to improve quality, the amount of table grapes produced annually is not necessarily a true reflection of the fertility of those vineyards. Consequently Sultanina vineyards that are cultivated for table grapes were not taken into account in this study. The surface area of Sultanina vineyards for drying and wine grapes was obtained from SAWIS. The average production (ton/ha) in a particular year was calculated by dividing the total yield by the number of hectares as determined by the previous year's survey. Average monthly maximum and minimum relative humidity, as well as total monthly rainfall for eight weather stations along the Lower Orange River, were obtained from the ARC Institute for Soil Climate and Water (ISCW) in Pretoria. The weather stations in question, as well as the years for which data were obtained, are indicated in Table 2. The correlation between the average yield of a specific season and the relative humidity the previous winter was calculated by means of linear regression. The average yield was plotted individually against the maximum, minimum and average relative humidity for June, July and August. Average yield was also plotted against various combinations of the three months' humidity figures.

RESULTS AND DISCUSSION

Over the 29-year period the average yield in the Lower Orange River region was 18.8±3.8 ton/ha. The highest yield (24.9 ton/ha) and the lowest (12.7 ton/ha) were obtained in 1992 and 2005 respectively. The lowest average relative minimum humidity for June and July was 23.9% in 2000 while the highest, i.e. 35.5%, was measured in 1976. The best correlation between the average yield and the average minimum relative humidity was obtained during those two months. There was a rectilinear increase in average yield with an increase in average relative minimum humidity (data not shown). The regression analyses showed that approximately 50% of the variation in average yield could be ascribed to the differences in minimum relative humidity between seasons.

Closer investigation revealed that in certain years yield did not follow the general trend with regard to the minimum relative humidity. In 1977 the yields were below average as a result of flood damage caused by flooding in 1976 (data not shown). Although flooding also occurred in 1988, the 1989 yield was not drastically reduced. In 1991 and 1994 the yield did not meet expectations either. In these years the average rainfall in January was 91 mm and 49 mm respectively in the Lower Orange River region. This was considerably more than the average January rainfall of 22 mm for the 29-year period. Seeing that Sultanina bunches easily shed berries during ripening as a result of rain, large-scale berry shed as a result of the abnormally high rainfall could therefore have reduced the average yield in the region. The rain could also have damaged raisins on the drying racks to such an extent that they could not be marketed. Although more than 40 mm rainfall also occurred in January 1995, 1996 and 2004, the yields were not influenced negatively. In 2004 the average yield even exceeded expectations. A possible explanation is that table grapes damaged by the rain were delivered to the wine cellars. If one does not take the above-mentioned "extraordinary" years due to flood damage and abnormal rainfall into account, 75% of the variation in average yield

TABLE 2: Weather stations where the relative humidity in the Lower Orange River region were measured.

Weather station	District	Years for which data were available
Boegoebergdam	Prieska	1976 to 1996
Groblershoop	Groblershoop	1998 to 2004
Opwag	Groblershoop	1976 to 2004
Upington Research Station	Upington	1976 to 2004
Keimoes	Keimoes	1976 to 2004
Kakamas	Kakamas	1976 to 2003
Kromhout Boerdery	Kakamas	1998 to 2004
Witklip Boerdery	Augrabies	1998 to 2004

TABLE 3: Average daily maximum and minimum relative humidity in June and July in various viticultural regions in South Africa.

Region	Weather station(s)	Relative humidity (%)	
		Maximum	Minimum
Lower Orange River	As indicated in Table 2	78.5	27.8
Olifants River*	Lutzville (NIWW)	83.5	32.5
Klein Karoo*	Roodeheuwel (WRS)	95.0	36.5
Breede River Valley*	Robertson (NIVV)	95.0	43.0
Stellenbosch*	Welgevallen 1	95.5	56.5

* (Anonymous, 1989).

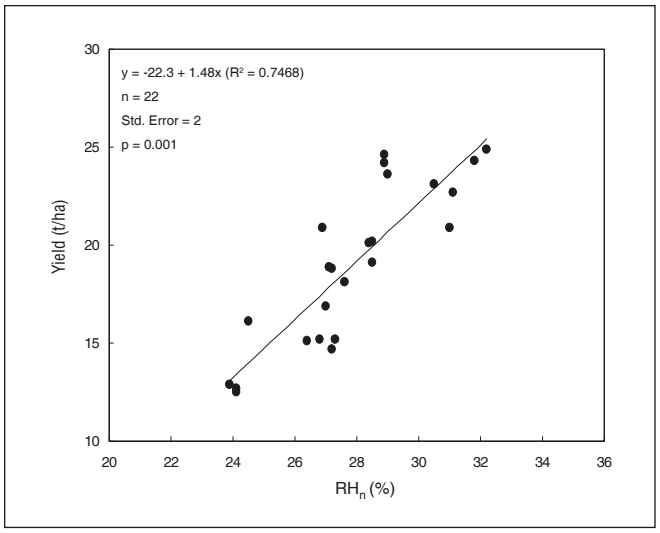

FIGURE 3: Effect of minimum relative humidity (RHn) in June and July of the preceding winter on average Sultanina yield in the Lower Orange River region.

may be explained by the variation in minimum relative humidity from one season to the next over the remaining 22 years (Fig. 3). In statistical terms this means there was a "moderately strong" relationship between average yield and the minimum relative humidity in the preceding June and July. The remainder of the variation in yield from one year to the next was probably due to frost and hail damage, or some of the other factors as discussed by Van der Westhuizen *et al*. (2001).

The relative humidity in the Lower Orange River region in June and July is considerably lower than the long term figures for the Winter Rainfall region (Table 3). During the day the minimum relative humidity in the Lower Orange River region is approximately half of that at Stellenbosch. This could explain why yield fluctuations occur more regularly and more extensively in the Lower Orange River region than in other regions in South Africa. There is a possibility, however, that in some seasons, low atmospheric humidity during winter could have contributed to low yields in regions such as the Olifants River Valley and the Little Karoo, where the atmospheric humidity is also fairly low.

CONCLUSIONS

The study showed that low minimum relative humidity during the preceding winter could play a significant role in the low yields of some seasons. Considering that existing data were used, these findings illustrate the importance of comprehensive and accurate record keeping, not only with regard to yield, but also with regard to weather data. It has been proven that the low atmospheric humidity also plays an important role in the occurrence of the growth arrest phenomenon. Seeing that the effect of atmospheric humidity is all-encompassing, this explains why (i) the problem occurs in vineyards on sandy as well as heavier soils, (ii) both scion and grafted grapevines are affected and (iii) the phenomenon occurs in clonal and non-clonal grapevines. Although the effect of atmospheric humidity offers a relatively simple explanation for a great deal of the fluctuating yields, it will unfortunately not be quite as simple to prevent the problem. It will be just about impossible to control the atmospheric humidity on a regional basis. Overhead pulse irrigation during winter may reduce yield losses, but this means that drip and flood irrigated vineyards require double irrigation systems. This will not necessarily be justifiable economically, especially if water tariffs are to be increased in future. Additional irrigation will also put more pressure on limited water resources. Another approach might be to treat the canes to prevent drying. To confirm such a possibility, the physiological processes involved in the crop reduc-

tion first have to be investigated to determine exactly how dry air reduces fertility. One also has to determine whether it is a cumulative effect of the dry air, and/or whether the negative effects are induced when the relative humidity drops below critical levels. As relative humidity is based on relationships, one has to investigate whether atmospheric humidity should not instead be quantified in terms of a more accurate representation of the actual atmospheric humidity such as vapour pressure deficit if further research is to be undertaken.

RECOMMENDATIONS

- The negative effect of low atmospheric humidity may be reduced by preventing severe soil water deficits in winter by means of irrigation.
- During winter the water consumption of vineyards is less than 1 mm/day. On gravel and sandy soils one irrigation per month will suffice. If the roots are deeper than 60 cm, two or three irrigations during winter may prevent serious drying of alluvial soils.
- Ground water content should preferably also be measured in winter to prevent excessive irrigation of vineyards.
- The relationship between yield and minimum relative humidity during the preceding winter may be used by producers as an aid to estimate yield in order to adapt their yield strategies for a particular season.
- It is important that complete and reliable weather data be made available to producers easily and quickly.

ACKNOWLEDGEMENTS

Dried Fruit Technical Services, SAWIS and ISCW for making data available, as well as the Soil Science personnel at ARC Infruitec-Nietvoorbij for technical assistance.

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Groeistilstandverskynsel by wingerd. ARC Infruitec-Nietvoorbij, Private Bag X5026, 7599 Stellenbosch.

Summary

Yield fluctuations are common in Sultanina grown in the Lower Orange River region. Previous research carried out in the region provided evidence that low Sultanina yields could be due to low atmospheric humidity during the preceding winter. Dry soil conditions during winter aggravated the effect of low humidity, and the combination of dry atmospheric and soil conditions induced stunted spring growth. To validate the contribution of humidity to the yield fluctuations on a regional scale, mean yield was calculated for the period from 1977 to 2006. Yield was correlated to mean relative humidity as determined at eight weather stations in the region. The variation in annual minimum relative humidity in June and July explained 75% of the yield fluctuations that occurred during 22 years of the 29-year period. Factors such as frost, hail or rain during ripening probably contributed to the remainder of the yield variation. Unfortunately, it would be almost impossible to control humidity on a regional scale. To reduce the negative effect of low humidity, growers should take care to prevent severe drying of soils during winter.

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Eksteenskuil farmers receive training and technology from the ARC and the wine and drying grape industries

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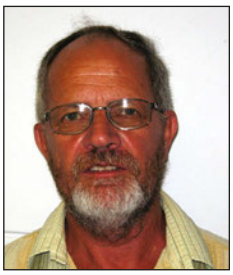
Key words: Eksteenskuil, technology transfer, vine, farmers' days and workshops.



Danie van Schalkwyk

Since 2003 Danie van Schalkwyk of ARC Infruitec-Nietvoorbij has been involved in an empowerment project aimed at the previously disadvantaged farmers of the Eksteenskuil community in the Northern Cape near Keimoes. These producers receive training related to viticultural management practices as well as technology transfer with regard to the latest research results. Each year training and technology transfer are addressed by a series of workshops and farmers' days. Experts from other organisations such as VinPro, SAD, SAWIT, Stellenbosch University, Oranjerivier Wine Cellars (OWC), private viticultural consultants, chemical spray companies such as Terason, Wenkem, etc., fertiliser companies and commercial financial institutions such as ABSA, are co-opted to participate in the transfer of new technology. The objective of this project is to empower these farmers with the necessary viticultural and financial know-how, as well as management skills so that they may become self-sustaining, and to improve their yields and grape quality through the application of this technology, to help them farm profitably. The project also aims to put the producers in touch with organisations that are able to assist them with the expansion of their plantings, thereby creating new job opportunities for the community.

To achieve this objective a number of workshops and farmers' days were again held at Eksteenskuil and in Upington in the course of 2006 and 2007, under the aegis of ARC Infruitec-Nietvoorbij.

One of the important aspects of a profitable farming concern is the application of sound business management practices. In order to equip the Eksteenskuil farmers with the necessary know-how and skills, Odette Beukes presented a course in basic business skills at Sandeiland in May 2006. This course was attended by 13 people from the farming community over a period of two weeks. Delegates received diplomas for modules that were successfully completed. The course is extremely practical and delegates are already applying their new know-how with great success on the farms. Twenty people, mostly students from the community, have completed the course in the past. Due to the practical applicability of the course, the community requested that another be presented in 2008.

In a survey about the establishment of new vineyards 66 farmers indicated that they were planning to expand. On 20 June 2006 a workshop was presented at Sandeiland, Eksteenskuil, where the entire value chain was discussed, from establishment of the vineyard to marketing of the wine on both the domestic and international markets. The Eksteens-

PHOTO 1. Speakers at the June 2006 workshop pictured with Mr J van Wyk (right) of the Eksteenskuil Farmers' Association; ltr. Herman Cruywagen (OWC), Elleunorah Allsopp (ARC Infruitec-Nietvoorbij), Dirk Malan (independent viticulturist), Louis Barkhuysen (on behalf of SAWIT) and Gert van Wyk (VinPro).

PHOTO 2. Eddie le Grange from ARC Infruitec-Nietvoorbij on the Upington Experiment Farm discussing and demonstrating the results of rootstocks on the viticultural performance of Sultana.

PHOTO 3. Neels Volschenk of ARC Infruitec-Nietvoorbij presents the results of his alternative cultivation methods on the Upington Experiment Farm to the Eksteenskuil farmers.

PHOTO 4. An SAD employee (left front) guided the tour through the factory, explaining and demonstrating the processing and packaging procedures to the Eksteenskuil farmers.

kuil Farmers' Association had drawn up several business plans for the expansion of their vineyard plantings, in particular wine grapes, and the purpose of this workshop was to familiarise then with the cost aspects of the establishment of new vineyards and an own cellar. It was also pointed out that there were other options besides an own cellar whereby they would be able to market their wine under their own brand until sufficient wine grapes had been planted to justify an own cellar. The workshop was attended by 62 farmers from the community. Herman Cruywagen, executive manager of OWC, used this opportunity to introduce his cellar's programme in support of previously disadvantaged wine farmers in the Northern Cape. The cellar has several systems in place with regard to training of students and producers from the community. The cellar also made shares available to emerging farmers and undertook to support the establishment of new vineyards.

Louis Barkhuysen was co-opted by the South African Wine Industry Trust (SAWIT) to become involved in drawing up a business plan for the establishment of wine grapes at Eksteenskuil and gave feedback about the progress of the business plan. He also confirmed that an own cellar for Eksteenskuil would not be a viable proposition at this stage. This recommendation was supported by Gert van Wyk of VinPro in the course of his detailed presentation on the entire economical value chain of vineyard establishment. He also discussed the cost implications of erecting an own cellar. Dirk Malan (independent viticulturist) then explained the current position of South Africa in the international wine industry.

Elleunorah Allsopp of ARC Infruitec-Nietvoorbij discussed and demonstrated the necessity of accurate record keeping of chemical sprays and the completion of the IPW forms, based on the spraying records of a few Eksteenskuil producers. It is important for the Eksteenskuil farmers to understand the importance of proper record keeping and the completion of the IPW forms seeing that they deliver grapes to both OWC and SAD and compete with commercial producers.

Fertilisation is a major viticultural expense and the Eksteenskuil farmers do not always have the necessary funds to follow the recommended fertilisation programmes. To address this problem a brainstorming session, directed by the project leader, Danie van Schalkwyk (ARC Infruitec-Nietvoorbij), was held with fertiliser experts in June 2006. A more affordable fertilisation programme was drawn up based on soil analyses of all the vineyard blocks and Leon Laubscher of SAD discussed this programme with the grapevine producers during small workshops on each of the five main islands in August 2006.

The biggest percentage of the drying grapes cultivated at Eksteenskuil is still established on scion roots and many of the vineyards' yields are not up to scratch. ARC Infruitec-Nietvoorbij has been engaged in several trials on Upington Experiment Farm in which the influence of rootstocks on the yields of Merbein Seedless and Sultana was evaluated. To demonstrate the results of these and other trials first hand, a farmers' day was held at the Upington Experiment Farm on 23 November 2006 and attended by 32 Eksteenskuil farmers. Three researchers from ARC Infruitec-Nietvoorbij, Eddie le Grange, Danie van Schalkwyk and Neels Volschenk presented and discussed research results in the actual trial sites.

Mr Le Grange discussed the importance of rootstocks and their effect on the yield of Merbein Seedless and Sultana (Photo 2). The farmers were given the opportunity to observe the difference in bearing as well as the trunk thickness of the various rootstocks. Most of these farmers' vines are established on the same type of soil and also tend to salinity with high water tables. These trials indicated that 143B MGT was the most suitable rootstock for both Merbein Seedless and Sultana and also well adjusted to the given soil conditions. Producers are advised to use 143B MGT as rootstock for their soil conditions.

Relatively high yields are important to the Eksteenskuil farmers seeing that they farm on relatively small units. Mr Van Schalkwyk presented the results of a trellis trial for wine and raisin grapes on the experiment farm and demonstrated

their construction as well as vine development on the various trellis systems. Although some of the systems such as the Factory and Gable are expensive, considerably bigger yields may be realised because these systems are able to accommodate larger cordons than the T-system, which is used predominantly in the Lower Orange River.

Mr Volschenk also demonstrated at the farmers' day that alternative and "cheaper" cultivation methods are being investigated and presented and demonstrated the results of his trial on the experiment farm (Photo 3). Scion plant shoots were established to reduce the establishment cost and the vines were established in narrow rows, 100 cm by various plant widths in the rows. It has already been proven that yields of up to 12 t/ha were realised in the second and 39 t/ha in the third year with Villard blanc. However, several adjustments had to be made to the usual management procedure of a vineyard.

The farmers' day on the experiment farm was followed by a visit to the SAD factory to familiarise them with the processing and packaging of their raisins once they had delivered them to SAD (Photo 4). This was most instructive and the quality of the raisins and the hygiene involved in handling the raisins during drying and processing were emphasised.

Next followed a visit to OWC's cellar in Upington to familiarise the farmers with the procedures during the handling of their grapes following delivery to the cellar (Photo 5). For most of the farmers it was their first ever visit to a cellar. A short explanation was given of the kind of wines vinified at the cellar and how the grapes are graded in the various classes according to grape quality. The bottling plant of the cellar was also visited and the farmers could see for themselves how the wines are bottled and packaged.

The farmers' day on the experiment farm and the visits to SAD and OWC gave the Eksteenskuil farmers the opportunity to look at research, vineyard management and the processing of their product from a broader perspective and gain more insight into why the correct cultivation practices are extremely important.

During 2007 additional workshops and farmers' days were held to convey important viticultural technology and research results to the Eksteenskuil farming community. In June 2007 yet another farmers' day was held at Sandeiland in Eksteenskuil which was attended by 59 people, including representatives from the Northern Cape Department of Agriculture, as well as representatives from Riemvasmaak and Blocuso Trust. The Eksteenskuil farmers have indicated that they would like to expand their vineyard plantings considerably and therefore it is important for them to establish only certified vines, consequently Nico van Rensburg of the Vine Improvement Association (VIA) was requested to explain the plant improvement scheme and the importance of correct record keeping procedures to the farmers.

Salinity occurs on soils in the flood plain along the Orange River and is a major cause of concern for some Eksteenskuil farmers. Theresa Volschenk of ARC Infruitec-Nietvoorbij is an expert on salinity and has studied its occurrence along the Lower Orange River. During the workshop she discussed the results of her investigation as well as the management of salinity. Jan Avenant of ARC Infruitec-Nietvoorbij presented the results of his rootstock trials for drying grapes on the soils inside and outside the Upington irrigation scheme and indicated which rootstocks were saline resistant. He also discussed the effect of rootstocks on the yield and sugar content of drying grapes. Sugar content is extremely important in the quality and grading of raisins, which is why Leon Laubscher of SAD discussed and emphasised its importance.

Increased production through the use of trellis systems bigger than the traditional T-system, that is predominantly used in the area, was discussed by Mr Van Schalkwyk of ARC Infruitec-Nietvoorbij. He discussed the vine development methods for the various trellis systems which was followed by a practical demonstration about the erection of a Gable system by André Schmidt (ARC Infruitec-Nietvoorbij), Leon Laubscher (SAD) and Dirk Malan (independent viticulturist). Mr Schmidt created a demonstration model and the farmers had to help assemble it. Practical alternatives to the erection of a Gable were also demonstrated. Although the Gable is considerably more expensive than a T-system, it has the option of producing much higher yields if the system is managed correctly, especially seeing that some of the vineyard blocks in the community are fairly small. It is also suitable for wine grapes, with a view to mass production for rebate or distilling wine.

These farmers' days and workshops empower the Eksteenskuil farmers with the necessary know-how and expertise that will enable them to manage their vineyards effectively and profitably. Continued efforts will be made to address this community's needs through similar events.

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The effect of alternative pruning methods on viticultural and oenological performance (Part 1): Cabernet Sauvignon in the Stellenbosch area

Danie van Schalkwyk

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Key words: Alternative pruning, wine grapes, grape quality, wine quality.

INTRODUCTION

The enormous increase in production costs, inter alia expensive labour, in the national and international wine industries necessitated an investigation into alternative grape production methods to keep these costs as low as possible. In South Africa 60% of the annual total wine grape production cost consists of labour and the development of labour saving techniques is therefore of cardinal importance to the wine industry. Most vines in the Western Cape are pruned by hand and constitute thirty per cent of the annual labour costs. It is therefore important to investigate alternative pruning methods. Examples of such alternative pruning methods are mechanical pruning (May & Clingeleffer, 1977; Clingeleffer, 1988), minimal pruning (Clingeleffer, 1993) and no pruning (Bakonyi, 1987).

Mechanical pruning may increase yield (Morris *et al*., 1975; Archer, 1999). On the other hand it results in a reduction in bunch and berry mass (Reynolds, 1988; Archer & Van Schalkwyk, 2007), and sugar concentration (Shaulis *et al*., 1973; Anderson *et al*., 1996). Combined with a loss in colour, these factors are mainly responsible for the evident decrease in wine quality (Reynolds & Wardle, 1993). According to McCarthy & Cirami (1990) different cultivars reacted differently to mechanical pruning.

Research showed that minimal pruning, compared to normal manual pruning, caused crop mass, number of bunches and number of shoots per vine to increase (Cirami, McCarthy & Furkaliev, 1985; Clingeleffer, 1993). Most of these reports showed that minimal pruning caused sugar concentration and pH of the must to decrease, while total acid concentration increased. The results in respect of wine colour, aroma and wine quality differed depending on climate and vigour.

Little information is available about no pruning. Research on seven cultivars conducted by Bakonyi (1987) showed that no pruning caused crop mass to increase without a decrease in quality. Research by Martinez de Toda & Sancha (1988) on unirrigated Grenache showed that no pruning caused crop mass, dry material and sugar production per vine to increase. This was ascribed to the significant increase in the total leaf surface per vine.

Although general trends were observed in the effect of alternative pruning methods on the performance of the vine in the above-mentioned research, pertinent questions remain with regard to specific vine conditions in South Africa: 1) Can these alternative pruning methods be used to produce high quality red wines from noble cultivars? 2) Are these methods applicable to different climatic conditions? 3) Does the reaction to the various pruning methods differ among cultivars? A research project to address these questions was launched in 1996.

The project consisted of three field trials at three different venues (Elsenburg, Nietvoorbij and Robertson). This article discusses the results of the Nietvoorbij trial in the Stellenbosch area and will be followed by articles about the other two trials.

PHOTO 1: Vines in the first year before switching to alternative pruning methods.

PHOTO 2: In the first year one of the cordon arms is trimmed back to the closest bud on either side of the split and the straightest cane is used to form the new cordon.

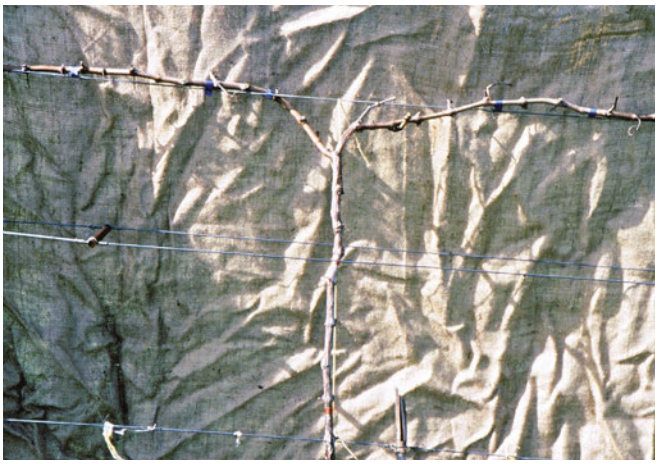


PHOTO 3: The new vine after the final pruning in the second winter.

PHOTO 4: The mechanical pruning treatment was simulated with mechanical hedge cutters.

TABLE 1: Labour input for the various pruning methods for Cabernet Sauvignon grafted on Richter 99 at Nietvoorbij (2000 - 2005).

Parameter	Labour (man hours/ha)			
	Hand	Mechanical **	Minimal **	No **
Prune	91.4 a*	20.4 b	0.7 c	0 c
Canopy management	123.2 a	10.2 b	11.4 b	6.4 c
Harvest	97.5 a	1.5 b	1.5 b	1.5 b
Total labour input	312.a	32.1 b	13.6 c	7.9 c

* Figures followed by the same letter of a parameter do not differ significantly from each other at p≤0.05.

** Grapes from the alternative pruning treatment were harvested mechanically.

MATERIAL AND METHODS

The trial was conducted in an existing four-year-old Cabernet Sauvignon X 99 Richter vineyard established on an Avalon soil type at Nietvoorbij (Soil Classification Work Group, 1991). Before planting the soil was criss-crossed with a shift delve plough to a depth of 1.30 m after 12 t/ha calcitic lime was broadcasted on the soil surface (eventual pH = 5.9). The plant spacing was 2.75 m x 1.5 m and the vines were trellised on an existing five wire extended Perold. The trellis system (Photo 1) as well as the vines (except for the control sites) were converted to a 1.2 m high single wire trellis system (Photo 2 & 3) according to the procedures described by Archer & Van Schalkwyk (1998). The following treatments were applied:

- **Control** - hand pruning to 12 two-bud spurs per vine, 24 buds per vine.
- **Mechanical pruning** - vines were pruned using mechanical hedge cutters (Photo 4) to approximately 10 cm above the cordon, no thinning of spurs was done.
- **Minimal pruning** - there was no winter pruning, but vines were mechanical skirted approximately 30 cm above ground level during December.

  The sides of the mechanical and minimal pruning treatments were trimmed with mechanical hedge cutters to keep the rows open for spraying. The tops were untouched.
- **No pruning** - no pruning or trimming was applied.

The pruning treatments were randomised in blocks and consisted of five replicates. Thirty vines with uniform vigour per trial site were used for data collection. Vines from the control treatments were split-cordon trained 70 cm above the soil surface on a five-wire extended Perold with moveable foliage wires (Zeeman, 1981). The alternative pruning treatments were split-cordon trained on a single wire hedge 1.20 m above the soil surface (Zeeman, 1981). Depending on soil moisture measurements, supplementary irrigation was given using microjets, up to a maximum of three irrigations depending on the season.

MEASUREMENTS

Time studies

Time studies to determine man hours needed for each operation were done during pruning, canopy management (suckering, positioning of shoots, tipping, topping and leaf removal) and harvesting and from these the labour needed to manage the vines of each of the pruning systems was calculated (machine and machine operator costs not included).

Yield, bunch mass, peduncle mass, berry mass and berry volume

During harvest, the physical condition of the grapes was visually evaluated and the percentage rot, millerandage, etc. noted by the same person. Thirty vines per plot were harvested in crates, weighed, and the average yield per vine calculated. One crate per plot was randomly selected, weighed, and the number of bunches counted to calculate the average bunch mass. Five bunches from each of those crates were randomly selected and stored at -20°C until after harvest whereafter the peduncle mass, berry mass and volume were determined according to the method described by Van Schalkwyk (2004). Five vines from each of the alternative pruning treatments were also harvested by hand and used to determined the above-mentioned information. The alternative treatments were subsequently harvested using mechanical harvesters. Grapes from all treatments were harvested at between 23°B and 24°B.

TABLE 2: Effect of pruning methods on the physical condition of Cabernet Sauvignon grapes at Nietvoorbij (2000 - 2005).

Parameter	Hand	Mechanical	Minimal	No
Dry rot (%)	0 a*	0.2 a	0.2 a	0.3 a
Sunburn (%)	2.2 c	6.6 b	9.7 a	9.9 a
Run-off (%)	0.3 c	1.6 c	4.6 a	3.2 b
Millerandage (%)	0.2 a	0.3 a	0.5 a	0.4 a
Bunch compactness	Well filled	Well filled	Well filled	Loose

*Figures followed by the same letter of a parameter do not differ significantly from each other at p≤0.05.

PHOTO 5: On the left, a hand pruning and on the right a no pruning treatment. Grapes from the no pruning treatment hang from the surface to approximately 1.8 m above the surface.

PHOTO 6: Grapes from the alternative pruning treatments were largely exposed to direct sunlight.

PHOTO 7: Grapes from the hand pruning treatment were far more protected by the canopy in the bunch zone.

Berry skin, wine colour and phenols

Berry skin (Hunter, *et al.*, 1991) and wine colour (Ribéreau-Gayon, *et al.*, 2000) were analysed using a spectrophotometer. Total phenolic compounds were quantified using a HPLC (Ribéreau-Gayon, *et al.*, 2000).

Wines

A total of 80kg of grapes from all treatments and replicates were harvested and used to make experimental wines. Wines were made according to the standard Nietvoorbij procedure for small-scale winemaking at the ARC Infruitec-Nietvoorbij Research Institute. The wines were stored at 14°C until sensorial evaluation. The wine quality was evaluated for aroma intensity and quality based on a descriptive sensorial analysis (10-point line scale method), 6 and 18 months after bottling each season's wine.

Cane mass and number of buds

During winter, the number of shoots per vine and internodes per shoot were counted. Cane length was measured using all the canes of five vines per replicate and the average internode length was calculated. The same vines were used each year. To calculate the average cane mass per vine, 30 vines of each replicate of the hand and mechanically pruned treatments were weighed. In one year the number of winter buds were counted on five randomly selected vines per plot. The same vines were used to count the shoots during spring and from this percentage bud burst was calculated.

Statistical analysis

The data were subjected to an analysis of variance. Student's least significant difference (LSD) values were calculated to facilitate comparison between treatment means.

RESULTS AND DISCUSSION

All three alternative pruning methods significantly reduced labour costs compared to hand pruning (Table 1). Not only was labour input for pruning reduced, but also for canopy management and harvest. Minimal and no pruning also required significantly less labour than mechanical pruning. It is imperative that mechanical harvesting is used when any one of the alternative pruning methods are employed as it is extremely labour intensive and costly to harvest these systems by hand.

Hand pruning, together with the necessary canopy management as well as harvest, require 273.6 man hours/ha

TABLE 3: Effect of pruning methods on the viticultural performance of Cabernet Sauvignon at Nietvoorbij (2000 - 2005).

Parameter	Hand	Mechanical	Minimal	No
Average cane length (cm) Nu	99.9 a*	70.9 b	19.7 c	18.6 c
Number of canes/vines	26 d	43 c	93 b	108 a
Average internode length (cm)	6.24 a	5.45 b	3.28 c	3.10 c
Cane mass (t/ha)	3.3 a	1.4 b	ngn	ngn
Crop mass (t/ha)	10.1 c	18.0 b	16.4 b	20.1 a
Number of bunches/vine	33.8 d	83.4 c	106.6 b	140.9 a
Bunch mass (g)	130.0 a	87.5 b	64.6 c	61.3 c
Berry mass (g)	1.54 a	1.42 b	1.18 c	1.19 c
Berry volume (mL)	1.44 a	1.40 a	1.14 b	1.16 b
Grape composition				
Sugar content (°B)	24.0 a	24.0 a	22.9 b	22.8 b
Total acid concentration (g/L)	7.7 a	7.4 b	7.4 b	7.5 ab
pH	3.66 a	3.32 b	3.27 c	3.24 c
Sugar:acid	3.2 b	3.3 a	3.1 b	3.1 b
Must composition (after skin contact)				
Sugar content (°B)	24.2 a	24.6 a	23.4 b	22.8 c
Total acid concentration (g/L)	6.9 a	6.1 b	6.8 a	6.7 a
pH	3.47 b	3.58 a	3.47 b	3.45 b
Sugar:acid	3.6 b	3.9 a	3.5 b	3.6 b

* Figures followed by the same letter of a parameter do not differ significantly from each other at p≤0.05.
nm = not measured

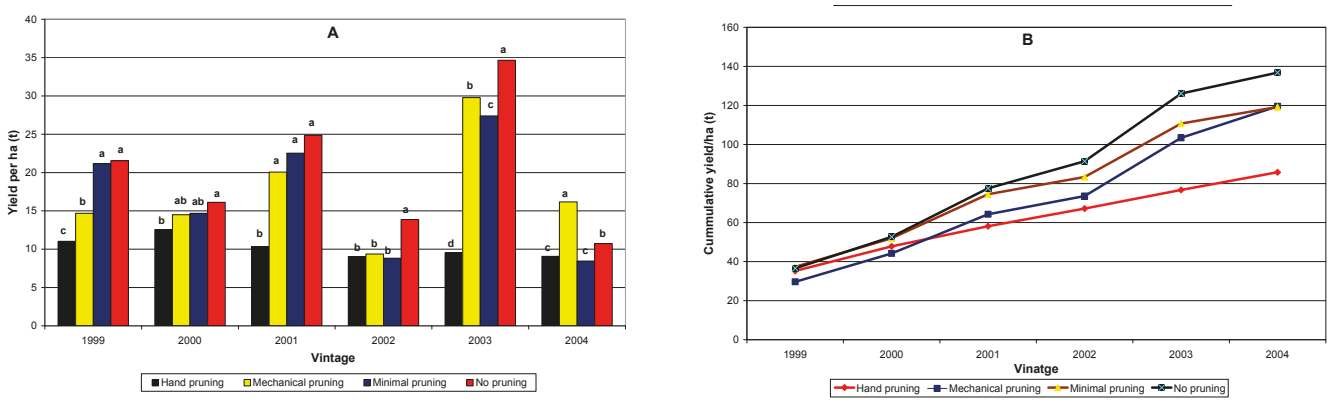


FIGURE 1. The influence of alternative pruning methods on the seasonal (A) and cumulative (B) yield per ha of Cabernet Sauvignon at Nietvoorbij (1999 - 2004).

compared to 43.8 and 14.4 man hours/ha for mechanical and minimal pruning respectively (Table 6). This saving in man hours was true for all the varieties and there is a clear economic advantage to use anyone of the alternative pruning methods. During this trial, time studies showed that it is not viable to harvest any of the alternatively pruned plots by hand (data not shown). A mechanical harvester is a prerequisite when these methods are used.

Time studies showed that harvesting by hand of the mechanical and no pruning treatments took 189 and 575 man hours per hectare compared to 98 man hours for the hand pruning treatments. Grapes from the no pruning treatment hang from soil surface to approximately 1.8 m above the surface of the soil, thereby complicating harvesting and mechanical harvesters have to be adjusted accordingly (Photo 5).

TABLE 4: Effect of pruning methods on the oenological performance of Cabernet Sauvignon at Nietvoorbij (2000 - 2005).

Parameter	Hand	Mechanical	Minimal	No
Alcohol (vol %)	14.6 b*	15.1 a	14.9 a	13.8 c
Sugar content (g/L)	1.7 b	2.0 a	1.7 b	1.7 b
Total acid concentration (g/L)	6.5 c	7.0 b	7.0 b	7.3 a
pH	3.86 a	3.74 b	3.61 b	3.58 b
Skin colour (420nm)	0.227 c	0.267 b	0.292 a	0.280 a
Skin colour (520nm)	1.000 c	1.235 b	1.358 ab	1.328 a
Wine colour (420nm)	0.562 b	0.701 a	0.583 c	0.626 b
Wine colour (520nm)	0.858 b	1.083 a	0.897 b	0.999 ab

* Figures followed by the same letter of a parameter do not differ significantly from each other at p≤0.05.

TABLE 5: Effect of pruning methods on the oenological performance of 6 and 18 month bottle matured Cabernet Sauvignon at Nietvoorbij (2000 - 2004).

Parameter	Hand	Meganies	Minimum	Geen
Overall wine quality after 6 months (%)	56.5 a*	54.8 ab	52.1 b	52.3 b
Overall wine quality after 18 months (%)	61.0 a	61.0 a	48.3 b	52.4 b
Overall cultivar intensity after 6 months (%)	66.5 a	65.4 a	59.0 b	58.1 b
Overall cultivar intensity after 18 months	67.4 a	64.5 ab	61.5 b	61.0 b

* Figures followed by the same letter of a parameter do not differ significantly from each other at p≤0.05.

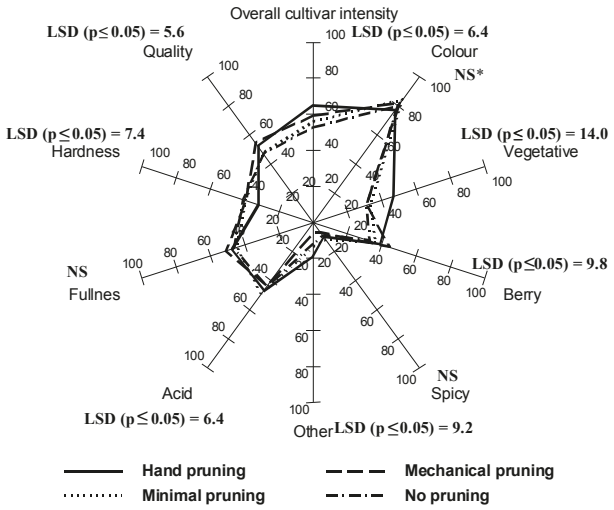
PHOTO 8A: Hand pruning yielded the longest canes and internodes.

PHOTO 8B: Mechanical pruning yielded shorter canes and internodes.

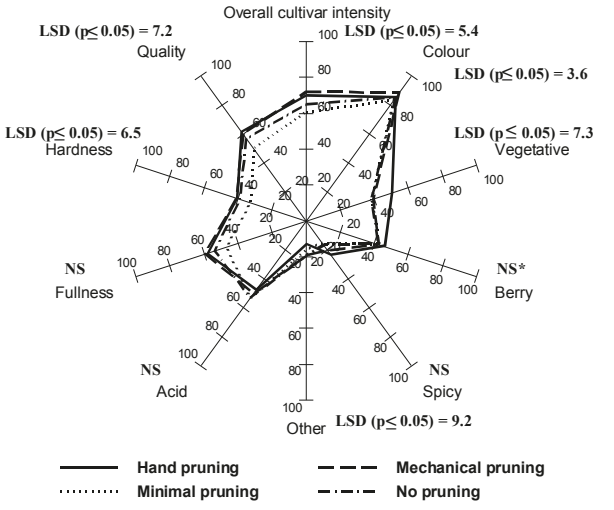
Viticultural performance

Bunches from the minimal and no pruning treatments were more exposed to direct sunlight with the result that more sunburn occurred than with the hand pruning treatment (Table 2). The bunches were significantly smaller and a high percentage of runoff occurred. Windy conditions during flowering probably contributed to the higher percentage of runoff in the alternative pruning treatments due to greater bunch exposure. The canes of the alternative prune treatment were more open and resulted in greater bunch exposure and were more subject to sunburn in abnormally warm seasons (Photo 6). The bunches of the no pruning treatments were much looser compared to the other pruning treatments (Table 2). In the hand pruning treatment canes were positioned vertically in the canopy thereby protecting the bunches against direct sunlight (Photo 7).

The alternative pruning methods produced more shoots, but decreased shoot length significantly compared to the hand pruned control (Table 3), although more bearer buds occurred. This can be ascribed to the shorter internode length (Photo 8). Mechanically pruned canes had the longest shoots of all the alternative prune treatments. This can be related to the fact that the capacity of alternatively pruned vines was expressed in significantly more shoots per vine



2000 Vintage



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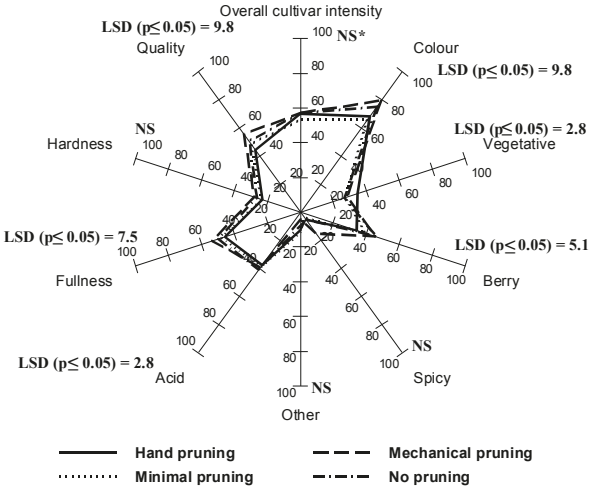
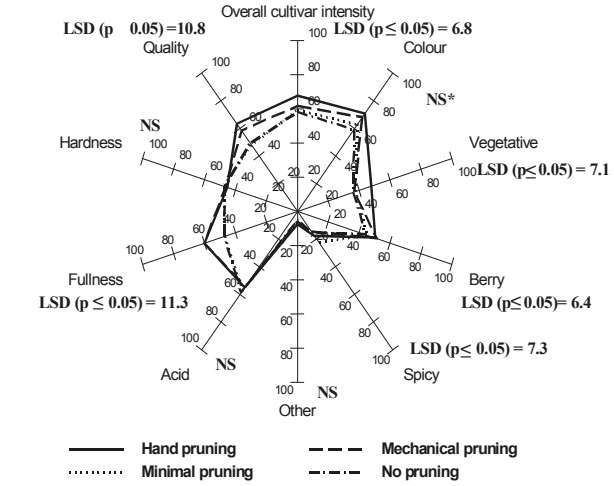
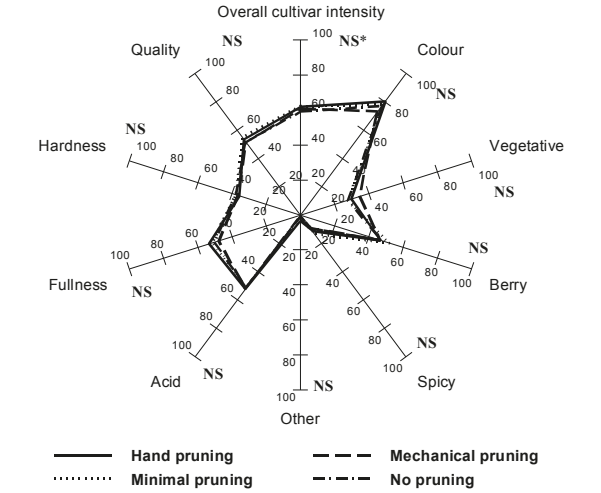


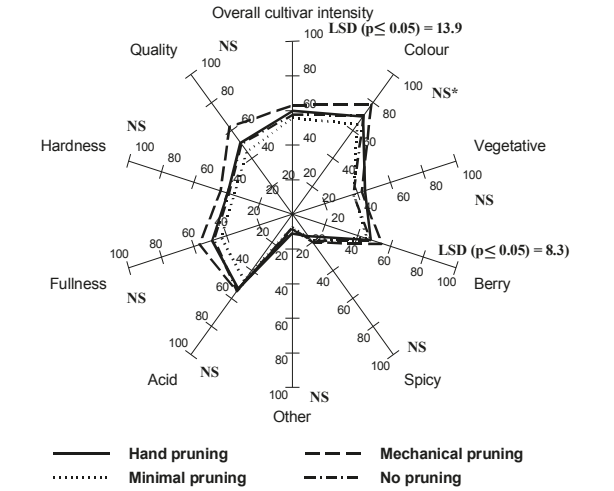
2002 Vintage



2003 Vintage

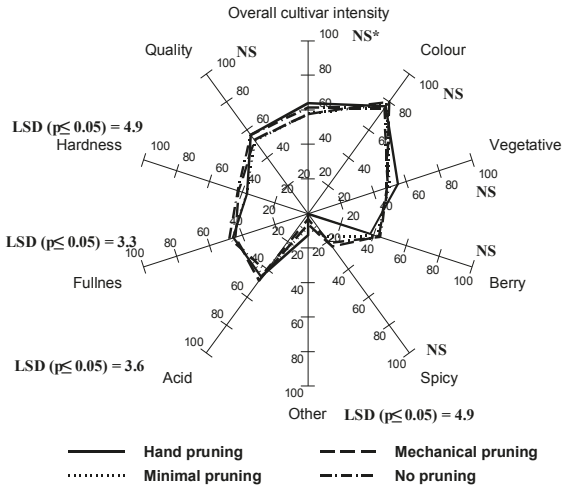


2004 Vintage

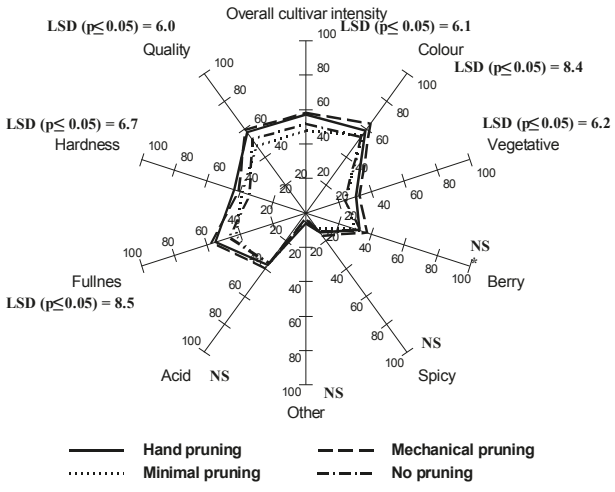


2005 Vintage

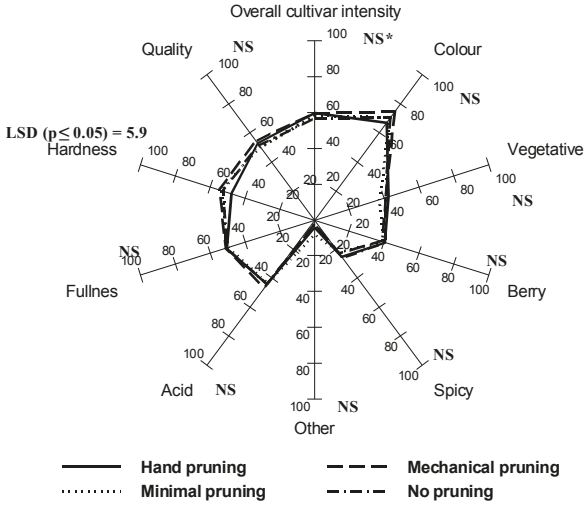
FIGURE 2. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Cabernet Sauvignon at Nietvoorbij 2000 - 2005.
* NS = Not Significant



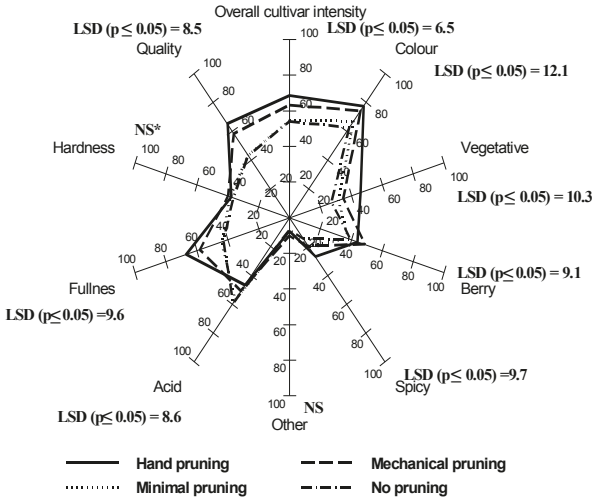
2000 Vintage



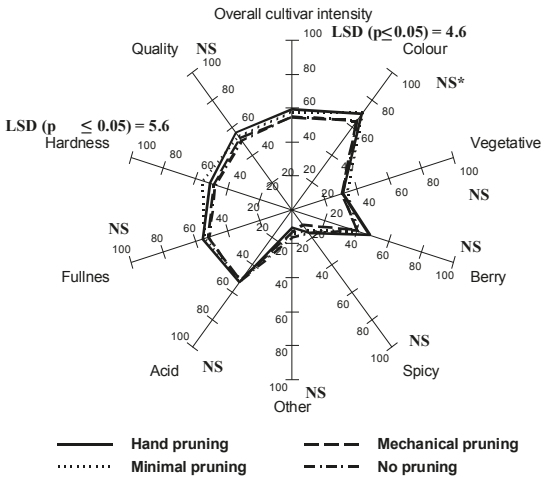
2001 Vintage



2002 Vintage



2003 Vintage



2004 Vintage

FIGURE 3. The effect of alternative pruning methods on the aroma profiles and wine quality of 18-month-old Cabernet Sauvignon at Nietvoorbij 2000 - 2004.
* NS = Not Significant

than in the case of the hand pruned control. The eventual result was that the highest cane mass was obtained from the hand pruned control vines.

Bud counts made during one data year showed that 24, 72, 191 and 227 buds per vine were left with hand, mechanical, minimal and no pruning respectively. This resulted in percentage budburst of 108%, 60%, 49% and 47% respectively.

A significantly lower yield was obtained from the hand pruned control vines (Table 3). Climatic differences such as temperatures during bunch initiation, bud, windy conditions during flowering (2004) as well as the occurrence of downy mildew (2002) had a negative impact on production (Fig. 1A). In most years the hand pruned plots yielded less but at least it was relatively consistent from year to year, while the alternative pruning treatments varied much more. The 2003 season was extremely favourable for high yields for alternatively pruned treatments (Fig. 1B). The hand pruned treatments accumulatively produced fewer grapes than the other treatments, while the accumulated yields of mechanical and minimal pruning over eight years were practically the same.

Despite the reduction in bunch mass, the increase in the number of bunches per vine caused the yields of the alternative pruning treatments to increase significantly (Table 3). Hand pruning also produced significantly larger berries than the other pruning treatments.

Must and wine

Vines that had minimal and no pruning treatments produced grapes that did not reach the required ripeness of 23°B to 24°B in some seasons due to their high yields (2003 & 2004). In those years the average sugar concentration of the grapes from the hand and mechanical pruning treatments was significantly higher than minimally and non-pruned vines (Table 3). The grapes from the alternative pruning treatments had a lower pH and this tendency was carried forward into the must (Table 4). The higher pH of the hand pruning treatment can largely be ascribed to the higher shade levels in the bunch zone of these trellis treatments.

In general, the alternative pruning methods induced better colour in the skins and wines (Table 4) and this is ascribed to better sunlight penetration into the bunch zone of these vines (data not shown). These results are in accordance with those reported by Clingeleffer (1983 & 1988). During the mechanical harvest of the alternative pruning treatments it was noted that the free run juice was pink to light red even at that stage.

Mechanical pruning produced the best wine quality in 6-month-old Cabernet Sauvignon during three of the six seasons (2000, 2002 & 2005) (Fig. 2). In three of the six seasons (2001, 2003 & 2004), however, hand pruned vines nevertheless yielded similar wine quality. Similar trends occurred in the 18-month-old vines in two seasons (2001 & 2002).

The aroma profiles and overall quality of 6- and 18-month old Cabernet Sauvignon wines are indicated in Figs. 2 & 3. Vintage played an important role and over years succeeded in blanketing the treatment effects in the case of 6-month-old wines (Fig. 2). In spite of this, the wines from the hand pruned vines consistently showed the most pronounced vegetative character. This is expected due to a higher canopy density (more shade) in the bunch zone. This tendency also held true in most vintages for the 18-month-old wines (Fig. 3). These results are in accordance with those of numerous other researchers who found a better expression of fruitiness in wines from alternatively prunes vines. In spite of this, an evaluation of overall quality showed that the trained panel of judges had a preference for wines from the hand pruned vines (Table 5). Both the minimal and no pruning treatments displayed less intense cultivar character over the period of the trial and also produced wines of significantly less quality.

CONCLUSION AND RECOMMENDATION

Compared to hand pruning, alternative pruning methods are hugely labour saving and contribute greatly to reducing production costs of wine grapes. A prerequisite for these methods is the availability of mechanical harvest machines because hand harvesting the resultant numerous small bunches by hand, is not viable (up to 60% more labour).

Alternative pruning methods induced shorter canes with shorter internodes and consequently lower cane mass. Although berry mass and volume as well as physical bunch size were reduced by alternative pruning methods, the increased number of bunches not only prevented a yield decrease, it was responsible for considerable yield increases compared to hand pruning. In general hand and mechanically pruned Cabernet Sauvignon produced wines with a more intense cultivar character and higher quality than minimal and no pruning. Hand pruning yields dense canopies in the bunch zone and therefore less bunch exposure, resulting in a more vegetative character in the wine, while alternative pruning methods produce wines with a more fruity (berry) character due to a larger percentage of bunch exposure. Minimal and no pruning are therefore not recommended for the vinification of high quality Cabernet Sauvignon in the Stellenbosch area. The difference in the canopies of the mechanical and hand pruning treatments induced different aromas, consequently grapes from these two treatments have to be used for different wine styles, although there were no quality differences.

Fertilisation and irrigation of alternative pruning methods have to be adjusted as a result of the dense canopy and higher yields. To accommodate the dense canopies of the alternative pruning methods, plant rows should not be narrower than 3 m. Sturdy poles should be used and planted closer to each other. A strong cordon wire that is properly attached to the poles should be used to prevent the trellis system from collapsing under the increased weight.

ACKNOWLEDGEMENTS

The Viticulture personnel of ARC Infruitec-Nietvoorbij for technical assistance. Thanks also to Winetech and ARC Infruitec-Nietvoorbij for financial support. Thanks to New Holland South Africa and Unique Agri Trade respectively for making available their mechanical harvesters and the mechanical harvesting of the alternative pruning treatments in the Nietvoorbij trial.

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Summary

To evaluate the effects of pruning methods on such parameters as growth response, grape composition and morphology and wine quality, as well as labour requirements, a trial was carried out in a four-year-old Cabernet Sauvignon vineyard on the Nietvoorbij, Stellenbosch research farm of ARC Infruitec-Nietvoorbij. Treatments included hand, mechanical, minimal and no pruning. Relative to hand pruning the alternative pruning methods resulted in considerable savings in labour. A reduction in vigour and increase in yield were evident. Minimal and no pruning decreased the overall cultivar intensity and quality of Cabernet Sauvignon wine at Nietvoorbij, Stellenbosch. Alternative pruning methods to hand pruning proved to be viable, especially for the production of medium and low cost wines.

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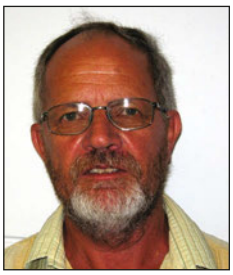
The effect of alternative pruning methods on viticultural and oenological performance (Part 2): Six cultivars in the Robertson area



Danie van Schalkwyk

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Key words: Alternative pruning, grape quality, Robertson, wine grape cultivars, wine quality.

INTRODUCTION

This article is a sequel to the one about "The effect of alternative pruning methods on viticultural and enological performance: 1. Cabernet Sauvignon in the Stellenbosch area" by the same authors. Research abroad (McCarthy & Cirami, 1990) has shown that cultivars and even clones of the same cultivar (Clingeleffer, 1988; McCarthy & Cirami, 1990) react differently to the application of mechanical pruning.

MATERIAL AND METHODS

Six cultivars i.e. Chardonnay (CY 277 B), Chenin blanc (SN 1064 B), Colombar (CO 2 A), Sauvignon blanc (SB 316 D), Ruby Cabernet (RC 1 A) and Shiraz (SH 5 C) grafted on Richter 99 (RY 13) were established on Hutton soil (Soil Classification Work Group, 1991) on Robertson Experiment Farm in the course of 1997. Before planting the soil was criss-crossed with a shift delve plough to a depth of 1.30 m after 6.5 t/ha calcitic lime was broadcasted on the soil surface to adjust the pH to 6.3. The plant spacing was 3.0 m x 1.5 m. The vines of the hand pruning treatment were trellised on a split cordon 70 cm above the soil surface on an existing five wire extended Perold and the mechanical pruning and minimum pruning treatments were trellised according to a split cordon on a 1.2 m high single wire trellis system (Zeeman, 1981). Irrigation was scheduled with microjets following a Class A evaporation span and crop factors were scheduled.

The following treatments were applied:

- **Control** – hand pruning to 14 two-bud spurs per vine, 28 buds per vine

PHOTO 1: Hand pruned cultivars in Robertson.

PHOTO 2: Mechanical pruning in Robertson using mechanical hedge cutters.

- **Mechanical pruning** – vines were pruned using mechanical hedge cutters to approximately 10 cm above the cordon, no thinning of spurs was done (Photo 2)
- **Minimal pruning** – there was no winter pruning, but vines were mechanical skirted approximately 30 cm above ground level during December (Photo 3)

In November/December the sides of the mechanical and minimal pruning treatments were trimmed with mechanical hedge cutters to keep the rows open for spraying. The tops were untouched.

The cultivars and the pruning treatments were randomised in blocks and consisted of six replicates per cultivar per treatment with a buffer row between treatments. Forty vines with uniform vigour per trial site were used for data collection.

MEASUREMENTS

Time studies

Time studies to determine man hours needed for each operation were done during pruning and canopy management (suckering, positioning of shoots, tipping, topping and leaf removal) and from these the labour needed to manage the vines of each of the pruning systems was calculated (machine and machine operator costs not included).

Yield, bunch mass, peduncle mass, berry mass and berry volume

During harvest, the physical condition of the grapes was visually evaluated and the percentage rot, millerandage, etc. noted by the same person. Forty vines per plot were harvested in crates, weighed, and the average yield per vine calculated. One crate per plot was randomly selected, weighed, and the number of bunches counted to calculate the average bunch mass. Five bunches from each of those crates were randomly selected and stored at -20°C until after harvest whereafter the peduncle mass, berry mass and volume were determined according to the method described by Van Schalkwyk (2004). Grapes from each of the pruning treatments were also harvested by hand, white cultivars at between 21°B and 22°B and red cultivars at between 24°B and 25°B.

PHOTO 3: In November/December minimal pruning treatments entailed pruning skirting canes with a mechanical hedgecutter to just above the irrigation line, approximately 30cm above the soil.

Berry skin, wine colour and phenols

Berry skin (Hunter, *et al.*, 1991) and wine colour (Ribéreau-Gayon, *et al.*, 2000) were analysed using a spectrophotometer. Total phenolic compounds were quantified using a HPLC (Ribéreau-Gayon, *et al.*, 2000).

Wines

A total of 80kg of grapes from each cultivar/treatment combination were harvested and used to make experimental wines. Wines were made according to the standard Nietvoorbij procedure for small-scale winemaking at the ARC Infruitec-Nietvoorbij Research Institute. The wines were stored at 14°C until sensorial evaluation. The wine quality was evaluated for aroma intensity and quality based on a descriptive sensorial analysis (10-point line scale method), 6 months after bottling each season's wine.

Cane mass and number of buds

During winter, the number of shoots per vine and internodes per shoot were counted. Cane length was measured using all the canes of five vines per replicate and the average internode length was calculated. The same vines were used each year. To calculate the average cane mass per vine, 40 vines of each replicate of the hand and mechanically pruned treatments were weighed.

Statistical analysis

The data were subjected to an analysis of variance. Student's least significant difference (LSD) values were calculated to facilitate comparison between treatment means.

RESULTS AND DISCUSSION

Labour input

Both alternative pruning methods significantly reduced labour costs compared to hand pruning. Not only was labour input for pruning reduced, but also for canopy management and harvest (Table 1). Minimal pruning also required significantly less labour than mechanical pruning as no pruning took place during winter and skirting canes were pruned with mechanical hedge cutters to just above the irrigation line (approximately 30cm above the soil) in summer.

Hand pruning, together with the necessary canopy management as well as harvest, required 193.8 man hours/ha compared to 46.6 and 22.0 man hours/ha for mechanical and minimal pruning respectively. This saving in man hours for the winter pruning of the mechanical pruning method and for the minimal pruning method could probably be reduced even further if tractor driven pruning/topping machines are used. It is imperative that a mechanical harvester

TABLE 1. Labour input for the various pruning methods for six different cultivars grafted on Richter 99 at Robertson (2001 – 2006).

Cultivar	Labour input (man hours/ha)											
	Hand pruning				Mechanical pruning				Minimal pruning			
	Pruning	Canopy manage-ment	Harvest	Total	Pruning	Canopy mange-ment	Harvest**	Total	Pruning	Canopy mange-ment	Harvest**	Total
Chardonnay	52.4 a*	54.5 a	86.5 a	193.4 a	19.6 b	18.9 b	1.4 b	39.9 b	0 c	17.4 c	1.5 b	18.9 c
Chenin blanc	61.9 a	51.1 a	90.5 a	203.4 a	22.7 b	21.9 b	1.4 b	46.0 b	0 c	20.1 c	1.5 b	21.5 c
Colombar	57.3 a	34.0 a	76.8 a	168.1 a	22.2 b	17.0 b	1.4 b	40.7 b	0 c	16.2 b	1.5 b	17.7 c
Sauvignon blanc	67.5 a	38.6 a	89.5 a	195.6 a	22.9 b	31.5 b	1.4 b	55.8 b	0 c	27.5 c	1.5 b	29.0 c
Ruby Cabernet	66.2 a	27.5 a	111.4 a	205.2 a	25.1 b	17.4 b	1.4 b	43.9 b	0 c	15.9 c	1.5 b	17.4 c
Shiraz	63.1 a	47.4 a	86.5 a	196.9 a	22.2 b	29.4 b	1.4 b	53.0 b	0 c	25.7 c	1.5 b	27.2 c
Average	**61.4 a**	**41.9 a**	**90.2 a**	**193.8 a**	**22.5 a**	**19.9 b**	**1.4 b**	**46.6 b**	**0 c**	**20.5 b**	**1.5 b**	**22.0 c**

* Figures for the different pruning treatments per cultivar followed by the same letter do not differ significantly from each other at $p \leq 0.05$.
** Labour input for the mechanical harvesting of the Cabernet Sauvignon trial at Nietvoorbij was used to harvest the various cultivars.

is used when any one of the alternative pruning methods are employed as it is extremely labour intensive and costly to harvest these systems by hand.

Time studies showed that depending on the cultivar and yield harvesting by hand of the mechanical and no pruning treatments took 135 and 790 man hours per hectare compared to 92.3 man hours for the hand pruning treatments. Using a mechanical harvester in a similar trial with Cabernet Sauvignon in Stellenbosch took 1.5 man hours per hectare. With minimal pruning on Sauvignon blanc a much larger percentage of the bunches hang on the inside of the canopy, while those of the other cultivars hang mainly on the outside of the canopy (Photo 4). Grapes from the no pruning treatment hang from soil surface to approximately 1.8 m above the surface of the soil, thereby complicating harvesting and mechanical harvesters have to be adjusted accordingly.

PHOTO 4: With minimal pruning treatment a large percentage of Ruby Cabernet bunches hang on the outside of the canopy.

Viticultural performance

The alternative pruning methods decreased shoot length significantly (Table 2). Minimal pruning had the shortest internodes. Mechanical pruning reduced shoot length by 18% in all cultivars and minimal pruning by 60% compared to hand pruning. At the same time internode lengths were reduced by 10% and 40% respectively. The average number of nodes per shoot of the minimal pruning treatment was significantly less in all cultivars compared to the hand pruning treatment. Alternative pruning methods also caused the number of bearer shoots to increase significantly, mechanical pruning by 113% and minimal pruning by 400%. The reduction in shoot length and increase in the number of shoots due to the application of mechanical pruning did not cause any change in shoot mass/ha in the case of Ruby Cabernet and Shiraz compared to hand pruning.

The increased yield obtained with the alternative pruning methods was partially responsible for the decrease in vigour compared to hand pruning (Table 2). In the case of Chardonnay minimal pruning resulted in a significantly higher yield than mechanical pruning. In Shiraz on the other hand mechanical pruning resulted in a higher yield than minimal pruning. In the four remaining cultivars the two pruning methods resulted in more or less the same yields. This indicates that cultivars differ from each other with regard to their yield reaction to alternative pruning methods and

TABLE 2. Viticultural performance of six cultivars at Robertson (2001 - 2006).

Parameters	Chardonnay			Chenin blanc			Colombar		
	Hand pruning	Mechanical pruning	Minimal pruning	Hand pruning	Mechanical pruning	Minimal pruning	Hand pruning	Mechanical pruning	Minimal pruning
Average shoot length (cm)	69.8 a*	54.3 b	26.2 c	79.0 a	59.8 b	28.3 c	75.0 a	63.7 b	35.2 c
Number of shoots/vine	22 c	47 b	118 a	24 c	55 b	115 a	21 c	49 b	128 a
Average internode length (cm)	4.6 a	4.5 a	3.1 b	5.3 a	5.0 a	3.5 b	5.2 a	5.0 a	4.0 b
Number of nodes per shoot	14.8 a	12.3 a	8.3 b	16.2 a	13.1 b	8.8 c	15.7 a	13.6 b	8.5 c
Shoot mass (t/ha)	2.4 a	2.0 b	ngn**	2.0 a	1.4 b	ngn	2.3 a	2.3 a	ngn
Crop mass (t/ha)	12.2 c	17.6 b	22.0 a	16.7 b	26.8 a	25.5 a	15.8 b	23.3 a	22.1 a
Number of bunches/vine	37 c	93 b	113 a	33 c	84 b	141 a	37 c	90 b	161 c
Bunch mass (g)	149.5 a	106.4 b	70.1 c	225.8 a	143.9 b	81.7 c	206.1 a	120.5 b	73.6 c
Peduncle mass (g)	36.1 a	20.1 b	17.6 b	42.7 a	31.7 b	22.5 c	56.1 a	42.3 b	27.4 c
Berry mass (g)	1.42 a	1.23 b	1.04 c	1.75 a	1.48 b	1.21 c	1.88 a	1.56 b	1.22 c
Berry volume (mL)	1.32 a	1.14 b	1. 04 c	1.62 a	1.36 b	1.13 c	1.74 a	1.42 b	1.12 c
	Sauvignon blanc			Ruby Cabernet			Shiraz		
Average shoot length (cm)	77.6 a	65.3 b	29.3 c	74.6 a	63.0 b	27.1 c	87.7 a	63.6 a	32.5 c
Number of shoots/vine	23. c	43 b	96 a	23 c	45 b	120 a	22 c	48 b	105 a
Average internode length (cm)	5.0 a	4.1 b	1.7 c	5.2 a	4.6 b	3.7 c	7.8 a	4.4 b	2.9 c
Number of nodes per shoot	16.6 a	17.1 a	9.1 b	15.3 a	14.6 a	8.5 b	14.4 a	11.9 b	8.6 c
Shoot mass (t/ha)	1.6 a	1.6 a	ngn	1.9 a	1.8 a	ngn	2.1 a	1.9 a	ngn
Crop mass (t/ha)	12.0 b	23.4 a	24.5 a	15.5 b	19.6 a	20.6 a	14.7 c	22.6 a	20.5 b
Number of bunches/vine	33 c	95 b	188 a	43 c	88 b	181 a	41 c	100 b	156 a
Bunch mass (g)	165.8 a	110.8 b	67.9 c	165.7 a	105.6 b	61.8 c	165.7 a	111.0 b	71.9 c
Peduncle mass (g)	35.1 a	25.5 b	17.5 c	57.1 a	48.2 b	28.7 c	37.1 a	36.0 a	23.6 b
Berry mass (g)	1.83 a	1.60 b	1.29 c	1.73 a	1.55 b	1.14 c	1.48 a	1.17 b	1.02 c
Berry volume (mL)	1.72 a	1.53 b	1.22 c	1.56 a	1.40 b	1.02 c	1.34 a	1.12 b	0.93 c

* Figures for the different pruning treatments per cultivar followed by the same letter do not differ significantly from each other at $p \leq 0.05$.
** nm = not measured

emphasises that one should not generalise.

The larger number of bunches produced by the alternative pruning methods resulted in a significant decrease in bunch and berry mass and berry volume in all six cultivars, especially in the case of the minimal pruning treatment. Mechanical pruning caused the average number of bunches per vine across all cultivars to increase by 166%, and minimal pruning by 360%. This caused the physical size of bunches to be significantly smaller due to smaller bunch peduncles (Table 2).

The cumulative production of the six seasons showed that Chardonnay and Shiraz benefited from the application of mechanical pruning, whereas Sauvignon blanc and Ruby Cabernet benefited from the application of minimal pruning (Fig.1). There was little benefit in the case of Chenin blanc and Colombar. Although the yields of the various cultivars differed significantly from one season to the next, there is no obvious pattern when the cultivars' yields across seasons are compared to each other (Fig. 2).

Must and wine

The application of the alternative pruning methods enabled much later harvesting of grapes that had received the minimal pruning treatment, especially Chenin blanc, Sauvignon blanc and Shiraz, compared to the other two treatments (Table 3). In the case of Sauvignon blanc harvesting was as much as three weeks later in some seasons compared to the hand pruning treatment. Sometimes grapes from the mechanically pruned vines ripened before those from hand pruned vines. Alternative pruning resulted in reduced acid concentration (Table 4). Alternative pruning methods did not have an obvious effect on the pH of the different cultivars. Further investigations are necessary to determine the

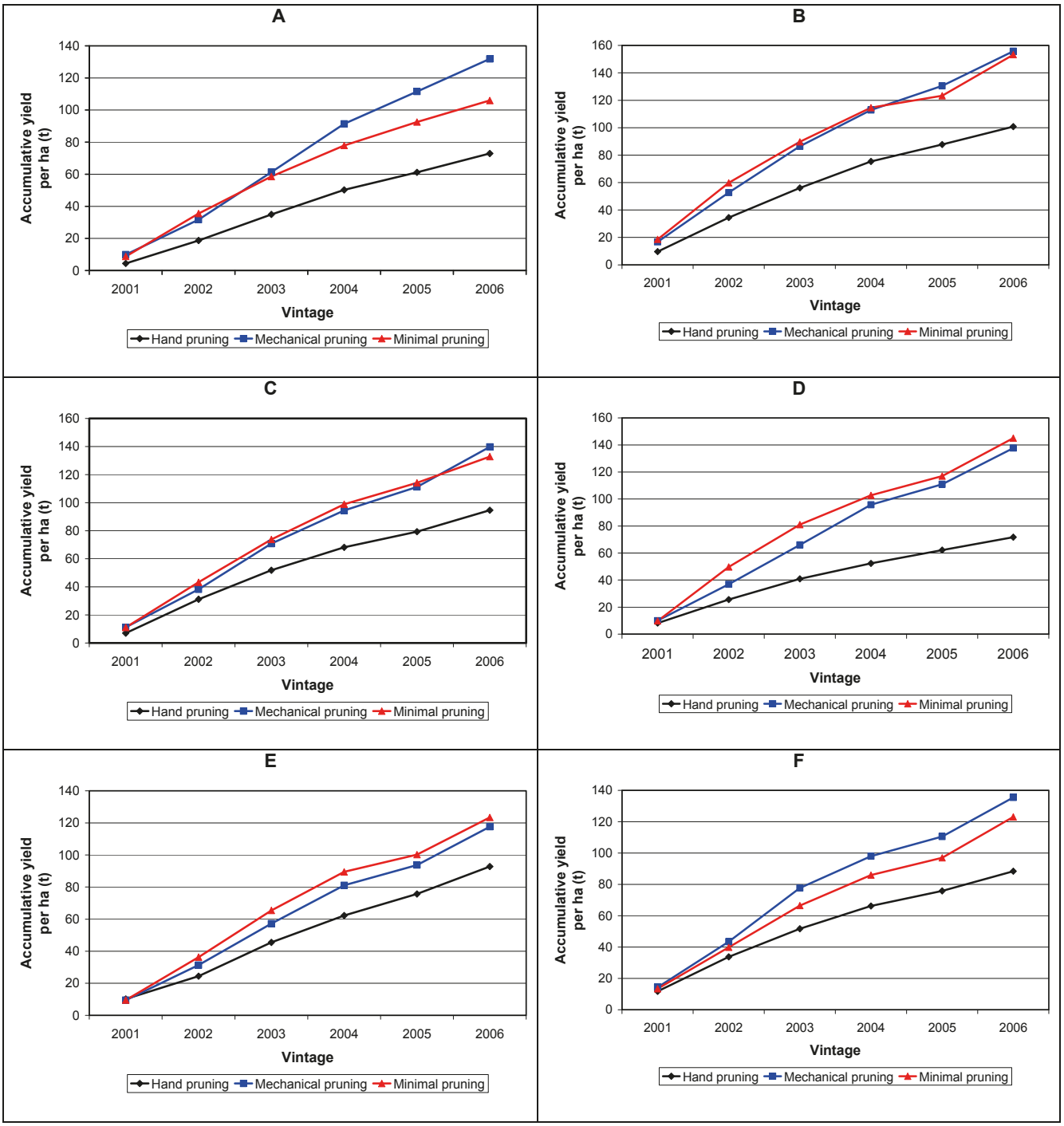


FIGURE 1. The effect of alternative pruning methods on the cumulative production of six different cultivars at Robertson (2001-2006). A = Chardonnay; B = Chenin blanc; C = Colombar; D = Sauvignon blanc; E = Ruby Cabernet and F = Shiraz.

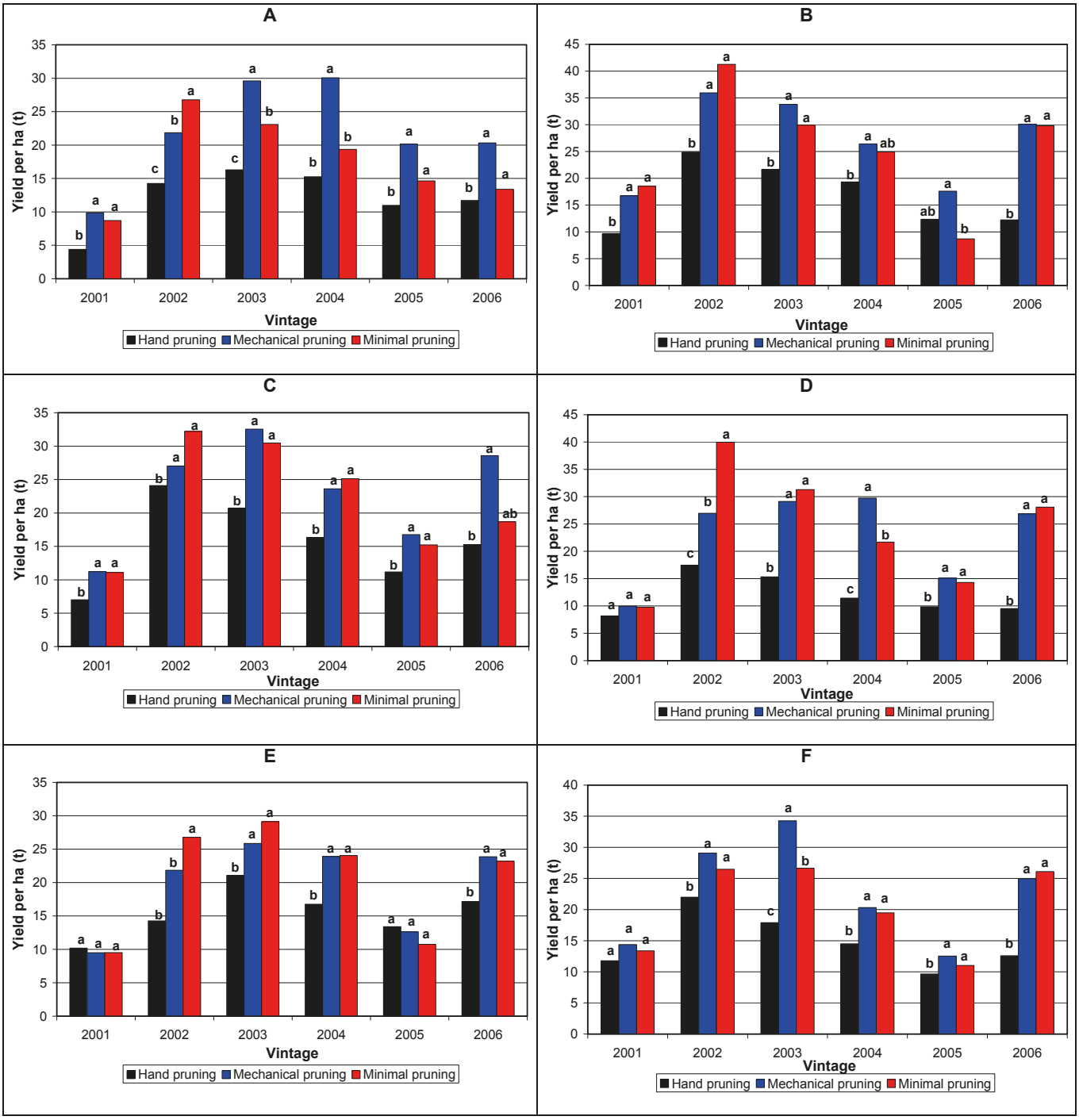


FIGURE 2. The effect of alternative pruning methods on the production of six different cultivars at Robertson (2001-2006).
A = Chardonnay; B = Chenin blanc; C = Colombar; D = Sauvignon blanc; E = Ruby Cabernet and F = Shiraz.

TABLE 3. The effect of alternative pruning methods on the general physical condition of the grapes during the harvest of six cultivars at Roberston (2001 - 2006).

Parameters	Chardonnay			Chenin blanc			Colombar		
	Hand pruning	Mechanical pruning	Minimal pruning	Hand pruning	Mechanical pruning	Minimal pruning	Hand pruning	Mechanical pruning	Minimal pruning
Harvest date across seasons	25 Jan – 11 Feb	25 Jan – 13 Feb	25 Jan – 25 Feb	9 Feb – 5 March	9 Feb – 5 March	9 Feb- 15 March	19 Feb- 13 March	19 Feb- 13 March	19 Feb- 13 March
Dry rot	1.9	0.3	0.4	4.3	1.4	4.3	0.8	0.5	0.6
Acid rot	0.1	0.2	0.0	0.8	1.6	0.3	0.1	0.0	0.1
Bird eating	0.2	0.2	0.1	0.2	0.4	0.3	0.5	0.6	1.6
Sunburn	0.7	0.6	1.4	1.3	1.6	4.1	1.6	2.0	5.3
Run-off	0.1	1.7	5.1	0.0	0.9	3.9	0.0	5.7	8.6
Millerandage	0.4	0.6	4.3	1.6	1.4	4.8	0.7	2.0	6.2
	Sauvignon blanc			Ruby Cabernet			Shiraz		
Harvest date across seasons	2 – 19 Feb	2 – 27 Feb	9 Feb – 5 March	24 Feb – 16 March	24 Feb – 12 March	24 Feb – 19 March	16 Feb – 22 March	16 Feb – 13 March	22 Feb – 20 March
Dry rot	2.6	2.1	4.1	0.1	0.1	0.0	0.1	0.0	0.0
Acid rot	1.4	2.7	1.6	0.2	0.0	0.0	0.0	0.0	0.0
Bird eating	0.0	0.1	0.3	0.1	0.3	0.4	0.5	0.4	0.0
Sunburn	0.1	1.2	2.3	3.2	2.7	8.9	2.8	3.9	9.6
Run-off	0.0	0.0	1.5	1.8	10.5	12.9	1.8	5.8	8.5
Millerandage	0.0	0.1	1.7	0.1	0.6	0.9	0.3	0.8	1.1

TABLE 4. The effect of alternative pruning methods on the grape and must composition of six cultivars at Roberston (2001 - 2006).

Parameters	Chardonnay			Chenin blanc			Colombar		
	Hand pruning	Mechanical pruning	Minimal pruning	Hand pruning	Mechanical pruning	Minimal pruning	Hand pruning	Mechanical pruning	Minimal pruning
Grape composition during the harvest									
Sugar content (°B)	22.2 a	22.2 a	22.6 a	21.8 a	21.8 a	21.7 a	21.8 ab	22.0 a	21.4 b
Total acid concentration (g/L)	8.4 a	7.4 b	7.0 c	7.5 a	7.2 a	7.2 a	9.6 a	9.4 a	9.6 a
pH	3.27 b	3.27 b	3.32 a	3.33 a	3.32 a	3.23 b	3.22 a	3.23 a	3.17 b
Sugar:acid	2.7 c	3.0 c	3.4 a	3.0 a	3.1 a	3.2 a	2.3 a	2.4 a	2.2 a
	Sauvignon blanc			Ruby Cabernet			Shiraz		
Sugar content (°B)	21.4 b	22.4 a	21.1 b	24.6 b	25.4 a	23.9 c	24.3 a	24.3 a	24.3 a
Total acid concentration (g/L)	9.6 a	7.3 b	6.4 c	7.1 a	6.5 b	6.4 b	6.5 a	6.4 a	6.3 a
pH	3.17 b	3.27 a	3.27 a	3.47 c	3.61 a	3.52 b	3.54 a	3.55 a	3.57 a
Sugar:acid	2.3 c	3.2 b	3.4 a	3.5 c	4.0 a	3.8 b	3.8 a	3.9 a	3.9 a
Must composition (after skin contact)									
Sugar content (°B)	**			24.5 b	25.1 a	24.0 b	24.3 a	24.5 a	24.2 a
Total acid concentration (g/L)				6.5 a	6.0 b	6.2 ab	5.9 a	5.4 b	5.5 b
pH				3.62 a	3.78 a	3.62 a	4.10 b	4.19 a	4.14 ab

* Figures for the different pruning treatments per cultivar followed by the same letter do not differ significantly from each other at p≤*0.05*.

** No skin contact applied

TABLE 5. The effect of alternative pruning methods on the enological performance of six cultivars at Robertson (2001 - 2006).

Parameters	Chardonnay			Chenin blanc			Colombar			Sauvignon blanc			Ruby Cabernet			Shiraz		
	Hand	Mechan-ical	Mini-mal	Hand	Mechan-ical	Mini-mal	Hand	Mechan-ical	Mini-mal	Hand	Mechan-ical	Mini-mal	Hand	Mechan-ical	Mini-mal	Hand	Mechan-ical	Mini-mal
Alkohol (vol %)	13.8 ab	13.6 b	14..0 a	13.3 a	13.4 a	12.8 a	13.2 a	13.4 a	13.0 a	13.4 a	13.9 a	13.8 a	14.7 ab	15.1 a	14.2 b	14.8 a	14.7 a	14.7 a
Extract (g/L)	22.6 a	20.8 b	20.9 b	20.6 a	18.6 b	20.0 a	21.2 a	21.6 a	21.9 a	21.5 a	20.9 ab	20.5 b	35.0 a	35.5 a	32.7 b	33.8 a	33.1 a	33.2 a
Sugar content (g/L)	1.8 a	2.1 a	1.8 a	1.8 b	1.7 b	2.7 a	2.3 ab	2.4 a	2.0 b	1.8 a	1.8 a	2.0 a	1.6 a	1.6 a	1.6 a	1.8 b	1.7 b	2.1 a
Total acid concentration (g/L)	5.4 a	4.8 b	4.5 c	5.6 a	5.1 b	5.2 b	6.5 a	6.1 b	6.3 ab	6.3 a	5.4 b	5.0 c	5.8 a	5.9 a	5.9 a	5.6 ab	5.5 b	5.9 a
pH	3.67 b	3.69 b	3.74 a	3.48 a	3.47 a	3.51 a	3.34 a	3.36 a	3.34 a	3.39 b	3.51 a	3.48 a	4.11 a	4.15 a	3.99 b	4.06 a	4.06 a	3.93 b
Skin colour (420nm)													0.849 b	1.023 a	0.886 b	0.552 b	0.624 a	0.638 a
Skin colour (520nm)													1.067 b	1.279 a	1.147 b	0.670 b	0.736 ab	0.768 a
Wine colour (420nm)													0.572 a	0.496 b	0.597 a	0.467 b	0.513 b	0.563 a
Wine colour (520nm)													2.635 ab	2.506 b	2.856 a	2.003 c	2.322 b	2.605 a

* Figures for the different pruning treatments per cultivar followed by the same letter do not differ significantly from each other at $p \leq 0.05$.

effect of alternative pruning methods on grape composition.

Apart from improved wine colour in Ruby Cabernet and Shiraz, alternative pruning methods did not have any obvious effect on the wine composition of the various cultivars (Table 5). Improved wine colour in the above two cultivars may be ascribed to improved skin colour (possibly better skin:pulp ration of the smaller berries).

Alternative pruning methods appear to improve the intensity of the tree fruit and citrus aromas in Chardonnay (Fig. 3). In 2001 mechanical pruning produced the best wine quality, whereas the wine quality of the hand pruning treatment was significantly better in 2004 and 2006. In 2004 and 2005 alternative pruning methods resulted in a more intense tropical fruit aroma in Chenin blanc, and also produced the best quality wines in 2005 (Fig. 4). Hand pruning produced higher quality wine only in 2006. Colombar, which is also a neutral cultivar, showed little reaction to the application of alternative pruning methods, although the tree fruit (guava) aroma was more intense in 2003 (Fig. 5).

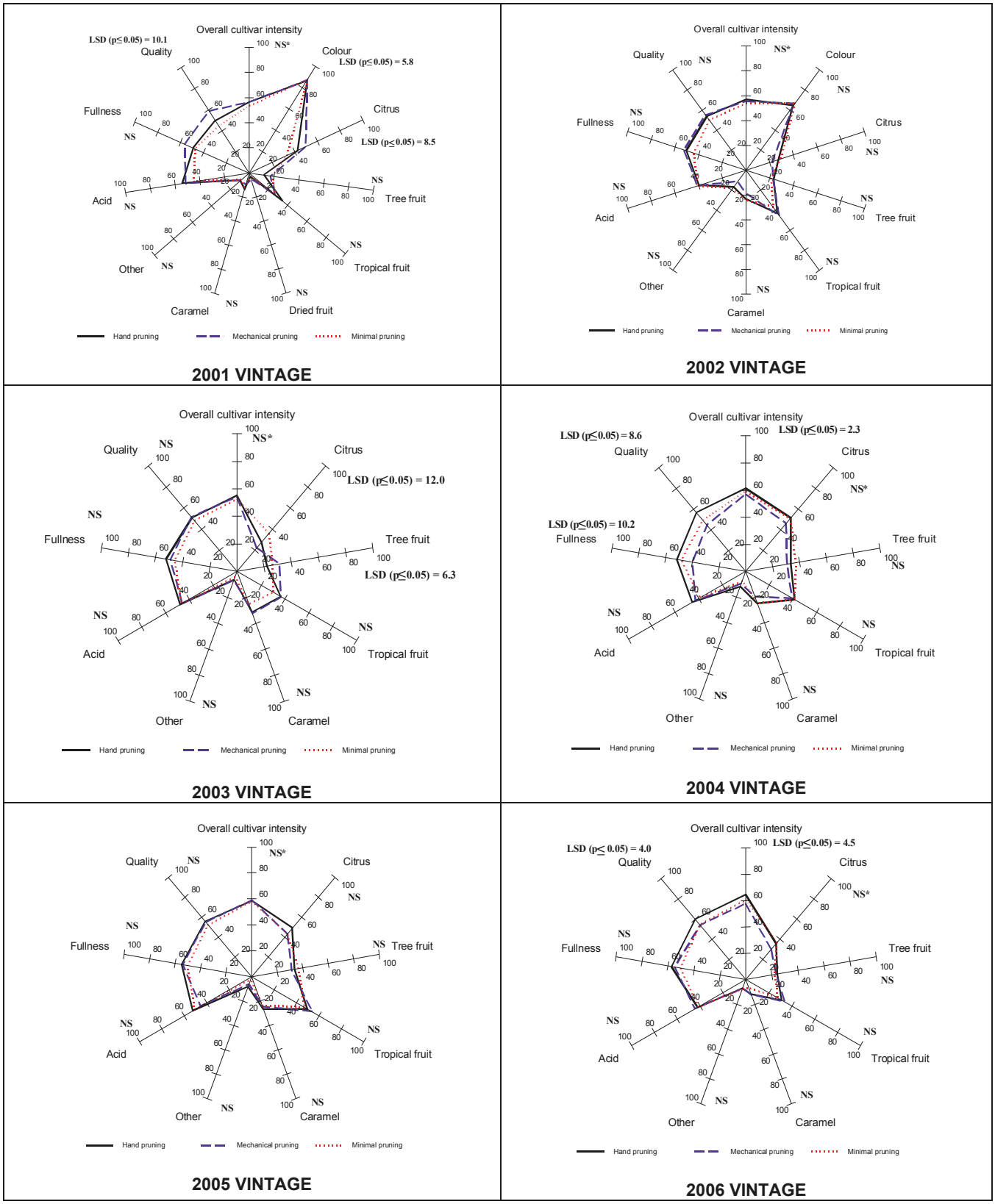
In 2001 en 2003 minimal pruning increased the vegetative aroma of Sauvignon blanc, contrary to the common belief, while reducing the tropical aroma in 2002 and 2003 (Fig. 6). The improvement in the intensity of the vegetative aroma in Sauvignon blanc is probably due to the increased number of bunches occurring inside the canopy and therefore ripening in the shade. Wine from the hand pruning treatment was more full-bodied, but there were no differences in wine quality.

Shiraz wines from the alternative pruning methods had more intense wine colour in 2002 and 2005 (Fig. 7). Although the wine quality, general cultivar intensity, fruity and spicy aromas tended to be higher with the application of alternative pruning methods, there was no obvious pattern in wine complexity.

The application of alternative pruning methods caused more intense colour in Ruby Cabernet in 2002, 2005 and 2006 (Fig. 8), the reason being that minimal pruning in particular causes bunches to hang on the outside of the canopy, resulting in more exposure to direct sunlight (Photo 4). The vegetative aroma of the wines from the hand pruning treatment was more intense in four of the six seasons. The application of alternative pruning methods improved the wine quality of Ruby Cabernet in three of the six seasons and in 2006 the wines had more body and the quality was significantly better than with the hand pruning treatment.

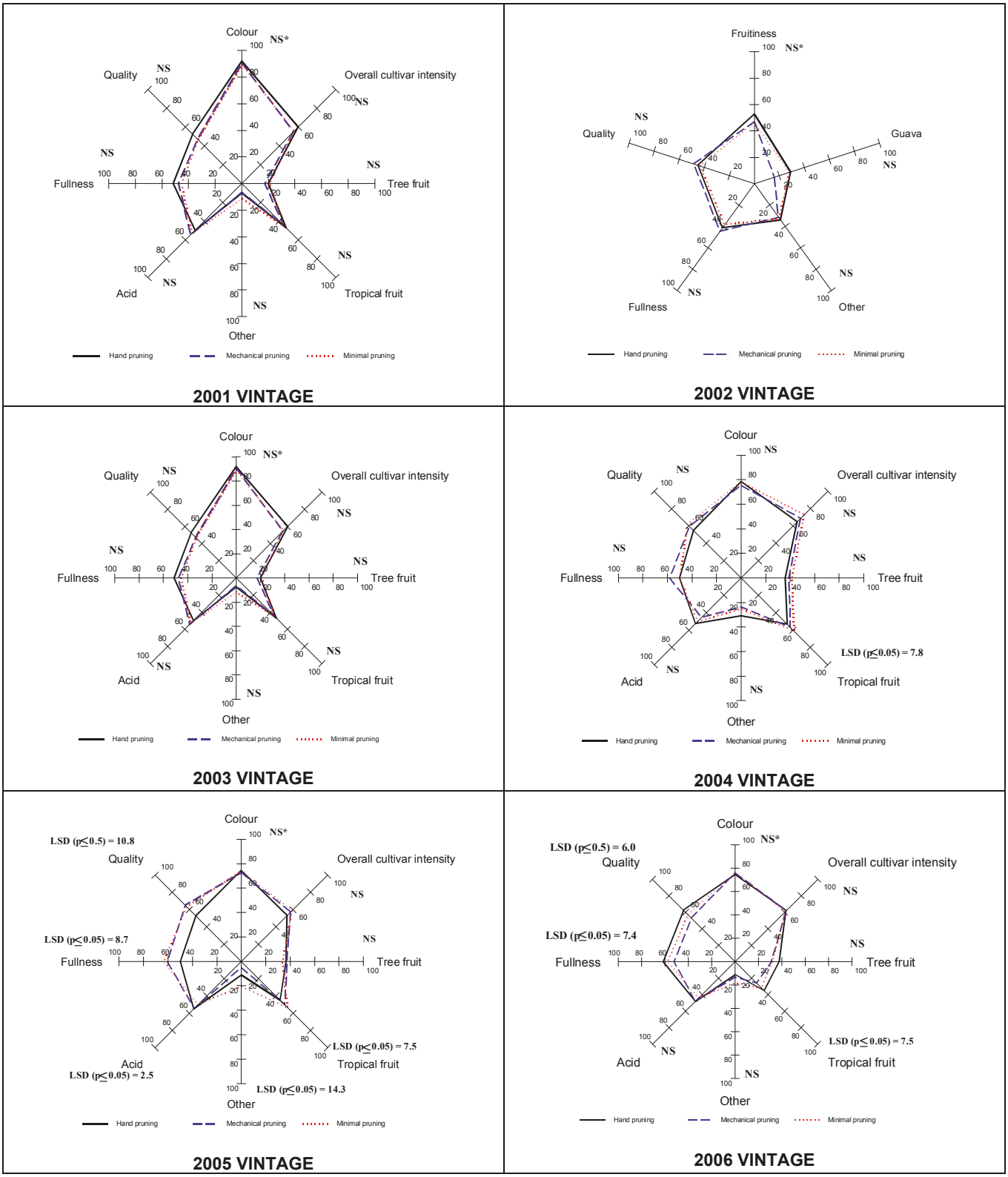
Contrary to findings by Reynolds & Wardle (1993) regarding alternative pruning methods, Ruby Cabernet and Shiraz had improved wine colour and wine quality was not compromised.

Alternative pruning methods increased the percentage sunburn in all cultivars, especially red



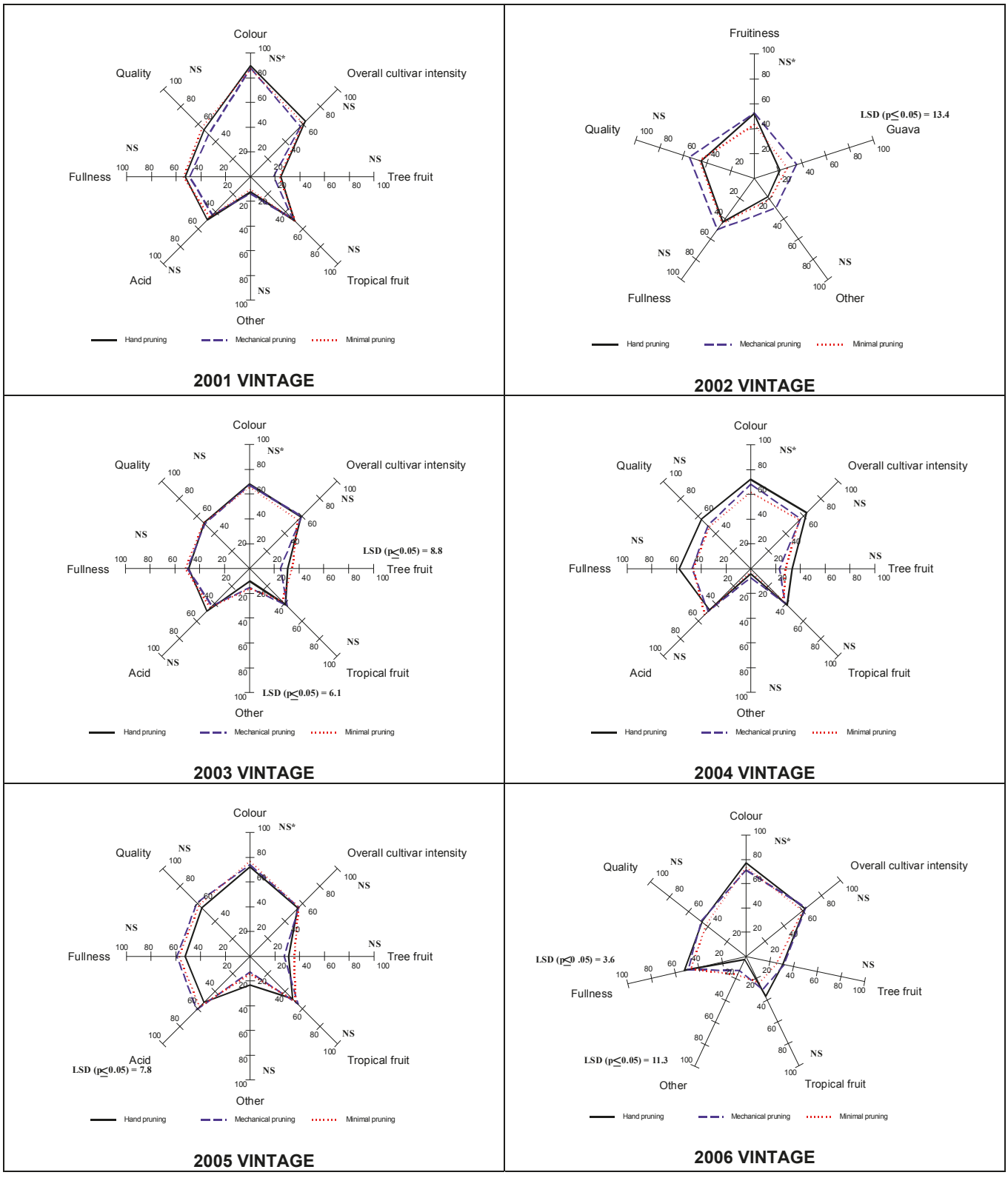
*NS - not significant

FIGURE 3. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Chardonnay wines at Robertson (2001 – 2006).



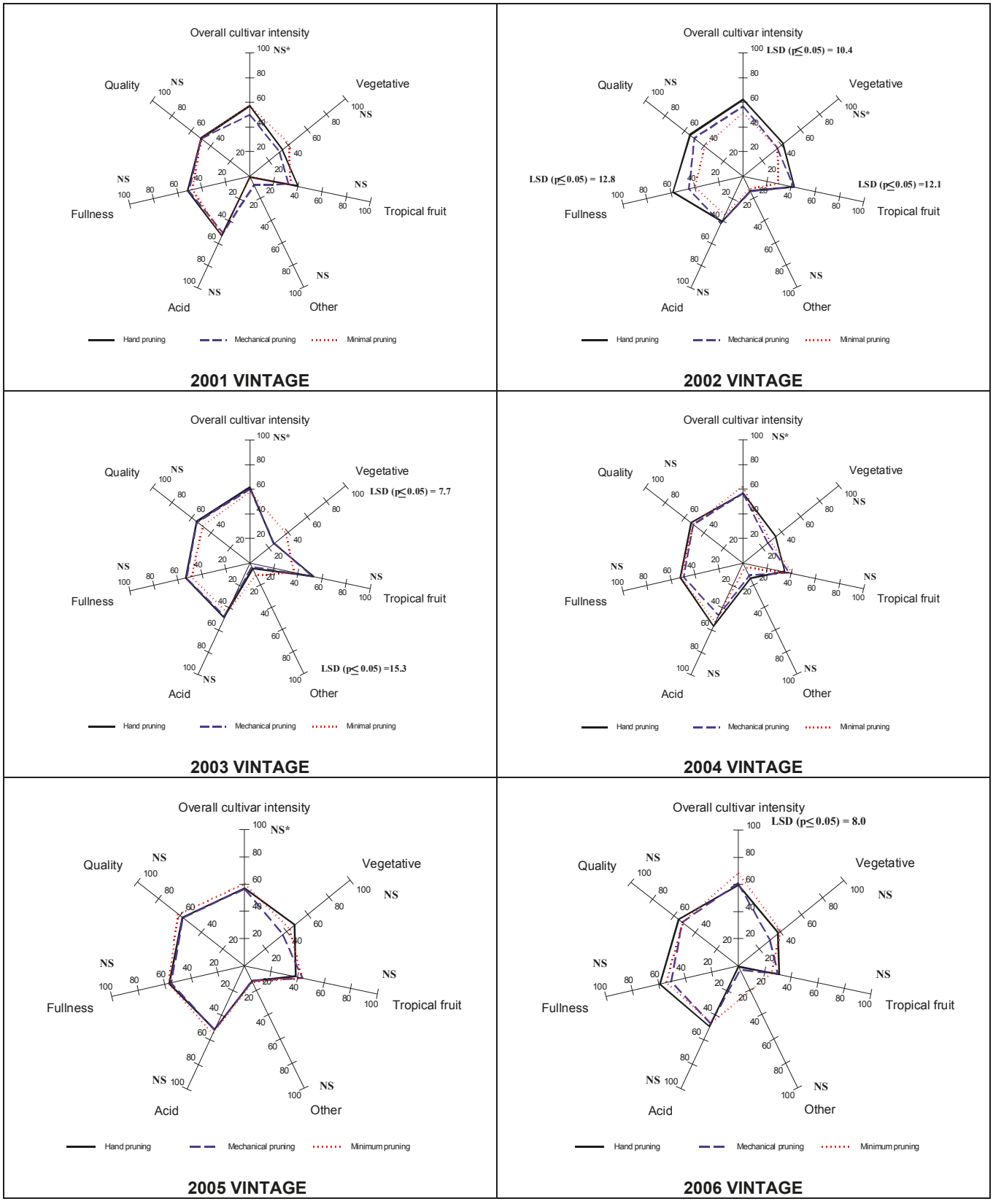
*NS - not significant

FIGURE 4. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Chenin blanc wines at Robertson (2001 – 2006).



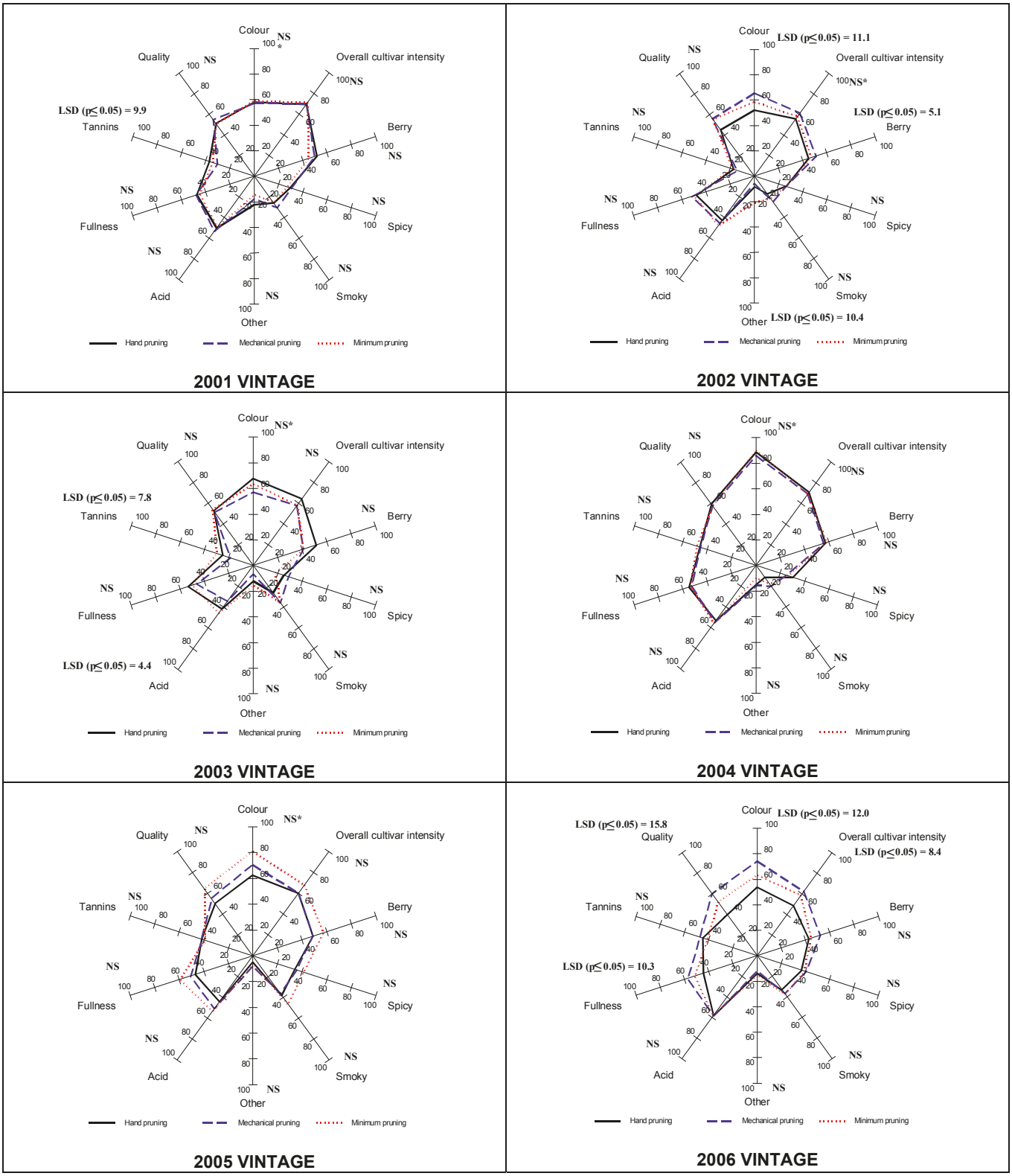
*NS - not significant

FIGURE 5. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Colombar wines at Robertson (2001 – 2006).



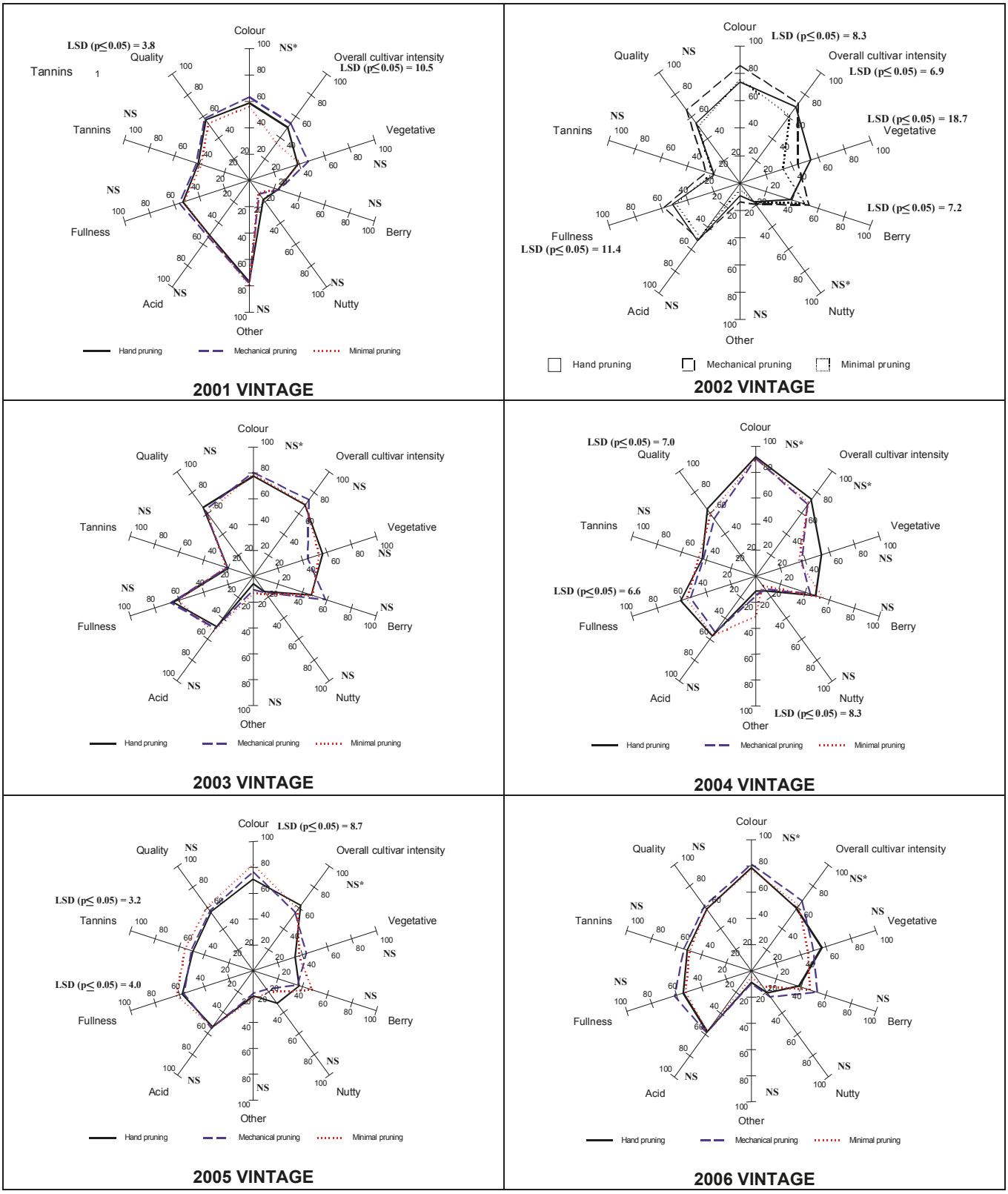
*NS - not significant

FIGURE 6. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Sauvignon blanc wines at Robertson (2001 – 2006).



*NS - not significant

FIGURE 7. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Shiraz wines at Robertson (2001 – 2006).



*NS - not significant

FIGURE 8. The effect of alternative pruning methods on the aroma profiles and wine quality of 6-month-old Ruby Cabernet wines at Robertson (2001 – 2006).

cultivars (Photo 5), as well as millerandage and reduced bunch compaction.

CONCLUSIONS AND RECOMMENDATION

As with the Cabernet Sauvignon trial at Nietvoorbij (Van Schalkwyk & Archer, 2008), alternative pruning methods were definitely labour saving on all six cultivars at Robertson compared to hand pruning and made a huge contribution to reducing production costs of wine grapes. In the case of minimal pruning 780% less labour is required on average. A prerequisite for these methods is the availability of mechanical harvest machines because hand harvesting the resultant numerous small bunches by hand, is incredibly labour intensive.

Regardless of cultivar differences, alternative pruning methods induced shorter canes with shorter internodes and consequently lower cane mass. Although berry mass and volume as well as physical bunch size were reduced by alternative pruning methods, the increased number of bunches not only prevented a yield decrease, it was responsible for considerable yield increases compared to hand pruning. The investigation proved that the different alternative pruning methods impact on vigour and that each of the different methods and cultivars impacts differently on the effect and degree of decreased yield. Contrary to the commonly held opinion that alternative pruning methods reduce wine quality, the various cultivars displayed little difference in wine quality. At times wine quality was even improved by the application of alternative pruning methods.

The performance of Chardonnay, Chenin blanc, Colombar, Ruby Cabernet and Shiraz with mechanical and minimal pruning was acceptable thus making some of these cultivars suitable for alternative pruning methods when taking the economy into account. The bigger crops and decrease in shoot mass when applying alternative pruning methods require additional fertilisation and irrigation as a result of the greater number of demand points.

PHOTO 5: In some cultivars, with minimal pruning treatment, a large percentage of bunches hang on the outside of the canopy.

ACKNOWLEDGEMENTS

The viticulture and Robertson experiment farm personnel of ARC Infruitec-Nietvoorbij for technical assistance. Thanks also to Winetech and ARC Infruitec-Nietvoorbij for financial support.

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SUMMARY

Different pruning methods were evaluated on four white and two red cultivars to determine the effect on parameters such as growth response, grape composition and morphology and wine quality, as well as labour requirements, in a vineyard that was established during 1997 at the Robertson Research Farm of ARC Infruitec-Nietvoorbij. Treatments included hand, mechanical and minimal pruning. Relative to hand pruning the alternative pruning methods resulted in considerable labour savings in all six cultivars. A reduction in vigour and increase in yield was evident for all cultivars. Wine quality was not decreased and in some cases quality even increased. Cultivars differed in their adaptability to alternative pruning methods with Chardonnay performing well and Sauvignon blanc poorly. Chenin blanc, Colombar, Ruby Cabernet and Shiraz, performed acceptably. Alternative pruning methods proved to be viable, especially for the production of medium and low cost wines.

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Aster Yellows disease in vineyards in South Africa

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Roleen Carstens

PHOTO 1. Delayed budding happens on certain posts of the vine.

PHOTO 2. Leaves have a wrinkled appearance.

PHOTO 3. Leaves on white cultivars are thicker than normal, are crisp and roll under.

PHOTO 4. Chardonnay shoots remain green.

(Photos: Jeff Joubert and Roleen Carstens)

GENERAL

Grapevine Yellows disease was detected for the first time in France in 1955 and can be found worldwide on several Vitis vinifera varieties. Yellows disease is a collective name for diseases like Flavescence dorée (France), Bois noir (Switzerland), Vergilbungskrankheit (Germany), Australian Grapevine Yellows (Australia) and North American Grapevine Yellows (North America). Yellows symptoms were also detected in Italy, Romania, Hungary, Chile, Israel, Greece, Portugal, Nieu-Zealand, Albania, Croatia, Lebanon, Serbia, Slovenia, Spain, Tunisia, Ukraine and Bulgaria. All Yellows diseases show similar symptoms and the diseases can therefore not be distinguished on symptoms only.

Grapevine Yellows disease is caused by a wide variety of phytoplasmas. The Yellows disease detected in the Western Cape is caused by Aster Yellows phytoplasma. Yellows diseases caused by this specific phytoplasma can also be found in Europe, Israel, North America, Chile and Tunisia. A phytoplasma is a small primitive bacterium without a cell wall that is systemic in the phloem of the plant. All organs can be infected namely the roots, trunks, shoots, buds, flowers and berries but phytoplasmas cannot be found in seed.

Grapevine Yellows disease affects a wide variety of cultivars. Chardonnay is very sensitive but it can also be found on Chenin blanc, Colombar, Pinotage, Cabernet Sauvignon, Cabernet franc, Shiraz, Merlot, Sauvignon blanc, Ruby Cabernet, Pinot noir, Pinot gris and Riesling. Rootstocks do not show symptoms but can act as carriers. Yellows disease was detected in the following table grape cultivars in Greece and Israel: Waltham Cross, Italia, Queen of the Vineyard, Muscat d'Alexandrie and Alphonse Lavallee.

Aster Yellows phytoplasma has a wide range of host plants (about 200) like weeds, cover crops, vegetables and flowers.

PHOTO 5. Bunches abort.

SYMPTOMS

Signs of delayed budding occur on parts of the vine while the rest buds and grows normally. Leaves are crisp with a wrinkled appearance. Shoots stay green and on Chardonnay it has a lead gray colour that can be rubbed off. Shoots have shortened internodes and tips, and young bunches abort.

Later in the season the leaves of white cultivars turn yellow and a reddening of the leaves of red cultivars occurs. Affected leaves are thicker than normal, crisp and they roll downwards. Shoots lignify only partially or not at all. Dieback of shoots takes place from the growth tips as well as partial dieback of fully developed bunches. Water shoots that seem unaffected develop on the trunk and arms of affected vines (especially young vines). Infected vines decline and die eventually.

TRANSMISSION

Leaf and plant hoppers (phloem feeders of the Hemiptera) primarily transmit the Aster Yellows in South Africa, but no vector has yet been identified. The phytoplasma is not carried from the infected insect to the next generation. The nymphs need to feed on an infected vine or on an infected host plant in order to transmit the disease.

The phytoplasma can also be transmitted by infected plant material.

DETECTION

The disease-causing organism can be detected and identified by the very sensitive polimerase chain reaction (PCR) method. The uneven spread of the phytoplasma in the plant and seasonal variation in concentration makes the detection of the disease-causing organism problematic.

CONTROL

When a plant is infected with the phytoplasma there is no control strategy to cure that specific plant. Control must therefore be aimed at the prevention of spreading of the disease:

- Infected vines serving as a source of infection should be eradicated.
- Weed control should be applied strictly to prevent vectors using the weeds as host plants for over wintering or as host source for the phytoplasma.
- When new vineyards are established certified planting material free of phytoplasmas should be used. Heat therapy and tissue culture produce clean planting material as well as hot water treatment of dormant planting material (50°C for 45 minutes) kills the phytoplasmas effectively.
- When specific insects are identified as vectors, those insects can be chemically controlled.

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Multi-coloured Asian ladybird beetle – Wolf in sheep's clothing?

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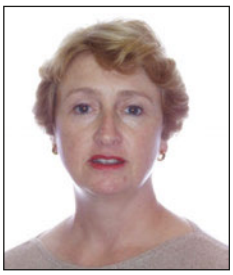

Elleunorah Allsopp

The establishment of an invasive ladybird beetle, the multi-coloured Asian ladybird or harlequin ladybird, in South Africa has been widely reported in the media. The beetle has been described as an "invasive monster beetle that gobbles up practically everything in its way".

The scientific name of the harlequin ladybird is *Harmonia axyridis Pallas*. It is a member of the ladybird family, which includes mainly predatory species, but also several plant-eating species. The common names "harlequin ladybird" and "multi-coloured Asian ladybird" are derived from the fact that the colour and spotting pattern of the beetle shows considerable variation. When threatened harlequin ladybirds secrete a yellowish fluid with a vile smell and taste to deter birds and other potential predators. This secretion taints wine when the ladybirds are crushed with the grapes. To date no method has been found that can rid wine of "ladybird taint".

The harlequin ladybird originates from Central and East Asia, and feeds mainly on aphids. It was imported into Western Europe and the USA as a biological control agent for aphids. Producers and scientists were shocked to discover that the beetle does not feed exclusively on aphids. When insufficient aphids are available, they eat just about any soft-bodied insects, for example mealybugs, psyllids, eggs of lacewings, eggs and larvae of moths and butterflies, immature stages of other beetles, including larvae of other predatory ladybirds, as well as pollen and damaged fruit (e.g. grapes that were damaged by birds or that burst because of fungal disease or rain). Cannibalism also occurs among harlequin ladybirds when other food is not available.

The consequence of their insatiable appetite is that harlequin ladybirds are able to seriously disrupt the biological balance in the ecosystems of the areas they invade. They compete with the indigenous predators for food and may even cause indigenous predators in a specific environment to become extinct. During autumn and winter harlequin ladybirds congregate in large numbers to hibernate. Clusters of these ladybirds often amass in houses and other buildings. The fluid secreted for defence can stain walls and curtains.

HOW DOES ONE RECOGNISE THE HARLEQUIN LADYBIRD?

The colour of harlequin ladybirds' elytra (shield wings) may range from pumpkin yellow or orange to bright red, while the number of black spots may range from none to as many as 19 (Fig. 1).

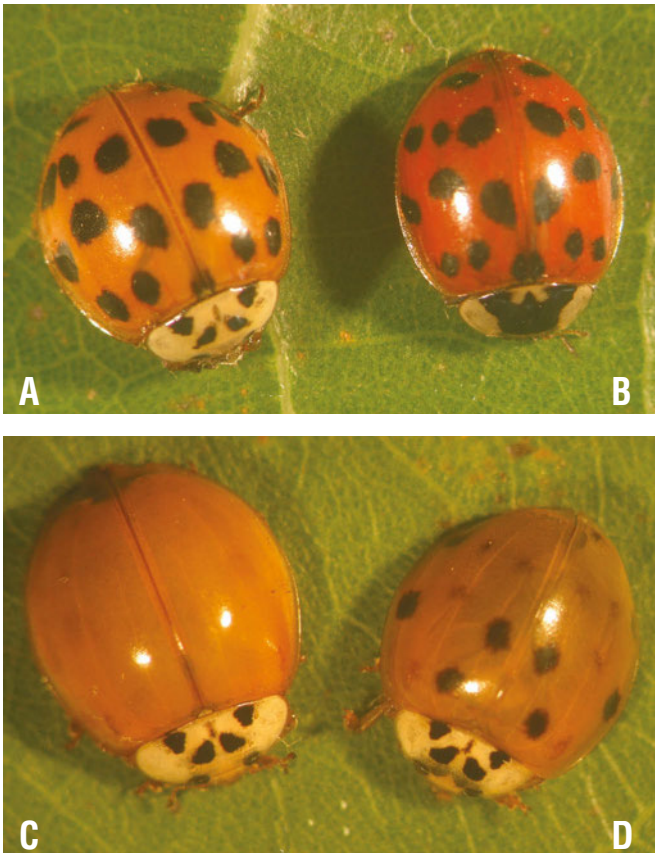

FIGURE 1. Different colours and spotted patterns of the harlequin ladybird beetle *(Harmonia axyridis)*.

FIGURE 2. *Hippodamia variegata*, a local ladybird that eats aphids and mealybug (left) and the harlequin ladybird beetle (right).

FIGURE 3. Red and orange versions of *Cheilomenes lunata*, an indigenous ladybird that eats aphids (left and middle) and the harlequin ladybird beetle (right).

The most important characteristic that distinguishes harlequin ladybirds from indigenous species, is the large, yellowish-white "cheek patches" occurring on both sides on the pronotum. In some instances the pronotum is almost entirely white with small black spots (Fig. 1 A, C & D), while in other instances the black patches look like the letter "W" with prominent white spots on both sides (Fig. 1 B).

Hippodamia variegata is an indigenous ladybird that eats aphids as well as mealybugs. It does not have the white "cheek patches", is smaller and the elytra are not as shiny smooth as those of the harlequin ladybird (Fig. 2).

Cheilomenes lunata, another local aphid predator, is about the same size and the elytra are as shiny smooth and hairless as those of the harleqiun ladybird, but the background colour of the elytra is black with red or yellow to orange patches (Fig. 3).

Besides being considerably smaller, *Chnootriba similis*, another local ladybird species, can be distinguished from the harlequin ladybird by the fact that its elytra are not smooth and shiny, but have a dusty, hairy appearance (Fig. 4). The elytra of many other ladybirds appear smooth, even though they are covered in fine hairs that are visible under magnification.

DOES THIS REALLY POSE A THREAT TO THE WINE INDUSTRY?

Harlequin ladybirds were identified in South Africa in 2002 and have since become prevalent throughout the country. They were recently found on farms in the Stellenbosch and Helderberg vicinity. Until now harlequin ladybirds have not caused any problems on grapes or taints in wine, but this does not mean it will never happen. To this end, ARC Infruitec-Nietvoorbij launched a research project to investigate the extent of the distribution of the beetles in wine-growing regions, as well as the possible impact on biological control of mealybug and other vineyard pests, and the possibility that local parasites that attack indigenous ladybirds, might also parasitise harlequin ladybirds.

FIGURE 4. *Chnootriba similis*, an indigenous ladybird that eats aphids (left) and the harlequin ladybird beetle (right).

Producers, extension officers and consultants can assist with the gathering of information about the distribution of the ladybird. If in doubt about the identity of the beetle(s), please send photo's or beetles to Elleunorah Allsopp or Kwaku Achiano at ARC Infruitec-Nietvoorbij. Please also let us know if the presence of the beetle on your farm has been confirmed. Contact details: Tel (021) 809-3007, fax (021) 809-3584, email allsoppe@arc.agric.za or achianok@arc.agric.za.

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Arbuscular mycorrhizal fungi in Western Cape grapevine nurseries (Part 1): varieties and distribution

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Key words: Grapevine, nursery soils.

André Meyer

INTRODUCTION

It is essential that young grafted vines recover quickly after being planted in the nursery and, after subsequent transplanting, in the vineyard. However, recovery after replanting is often hampered by stress. Stress, the symptoms of which may resemble nutrient deficiencies or drought, is often caused by poor root establishment and function, a condition that may be in duced, or exacerbated, by microbiological factors. Since grapevines are naturally dependent upon mycorrhizal associations for their normal growth and development, it is possible that stress symptoms could be alleviated by treating young vines with AM fungi, preferably of varieties that are known to be beneficial to grapevines. In practice, AM fungi are already commercially available and are sometimes marketed as bioregulators, biofertilisers or bioprotectors (Lovato *et al*., 1996). Arbuscular mycorrhizal fungi are widely acknowledged as being helpful, mainly because of the interchange of water and nutrients that takes place between the vine root and the fungus, which acts as a greatly extended root system (Figure 1). Nevertheless, little is known about how AM fungi function under field conditions, or how they are naturally distributed across soils and landscapes. What has been established is that the diversity of naturally-occurring AM species is considerable. Approximately 160 AM fungal taxa of the order Glomales (*Glomeromycota*) have been described to date, and molecular analysis indicates that the actual number of AM taxa is even higher. It is also reasonably well accepted that AM fungi compete for colonisation sites on the roots. If true, this implies that the common practice of adding commercial AM inoculants to soils that already contain populations of indigenous AM species, or to plants that became colonised with AM fungi in the nursery, is likely to be of debatable value. This article presents the results of a survey of the AM fungal populations in the soils of Western Cape grapevine nurseries. Relationships between the AM fungi, colonisation rates and soil char-

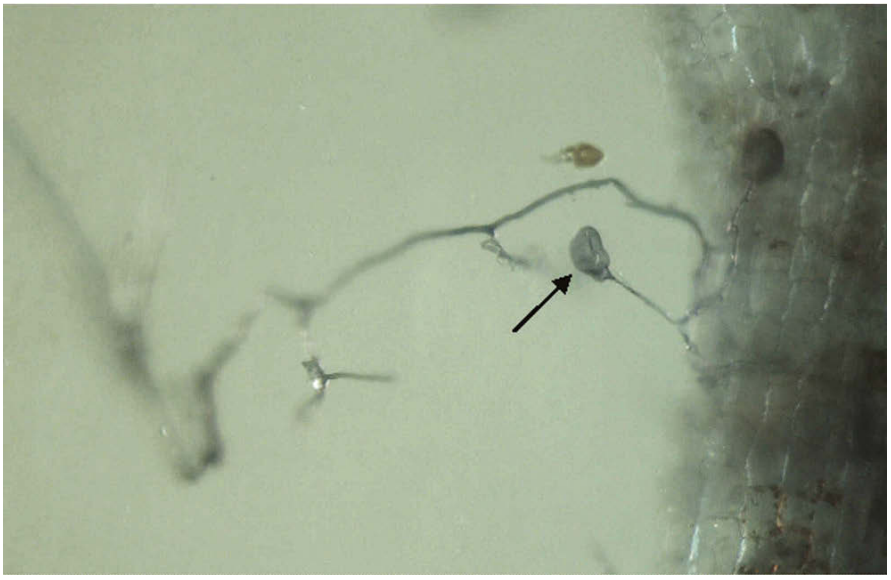

FIGURE 1. Root colonised by the AM fungus S*cutellospora calospora*. External hypha with auxiliary cell arrowed.

TABLE 1. Participating Western Cape grapevine nurseries. In all cases soil containing Chenin blanc/Richter 99 was sampled.

	Area	Nursery	Clone
1	Wellington	Lelienfontein	SN 1064 B / RY 251 A
2	Wellington	Patatskloof	SN 220 A / RY 30 B
3	Wellington	Nabygelegen	SN 24 B / RY 179
4	Wellington	Groenvlei	SN 220 A / RY 13 C
5	Paarl	Valencia	SN 220 A / RY 30 B
6	Paarl	Keerweder	SN 426 Q / RY 30 C
7	Malmesbury	Jakkalsfontein	SN 220 C / RY 13 A
8	Malmesbury	Nooitgedacht	SN 550 / RY 179
9	Malmesbury	Babylonstoren	SN 422 A / RY 179 B
10	Rawsonville	Nuutbegin	SN 9 / RY 30 B
11	Bonnievale	Mervespont	SN 1064 B / RY 251 A
12	Montagu	Nuweland	* / RY 30 C
13	Piketberg	Duikerfontein	SN 1064 B / RY 141 B
14	Klawer	Witkop	SN 220 / RY 30 B
15	Hermanus	Babilonstoren	SN 481 E / RY 30 B

* Data not available.

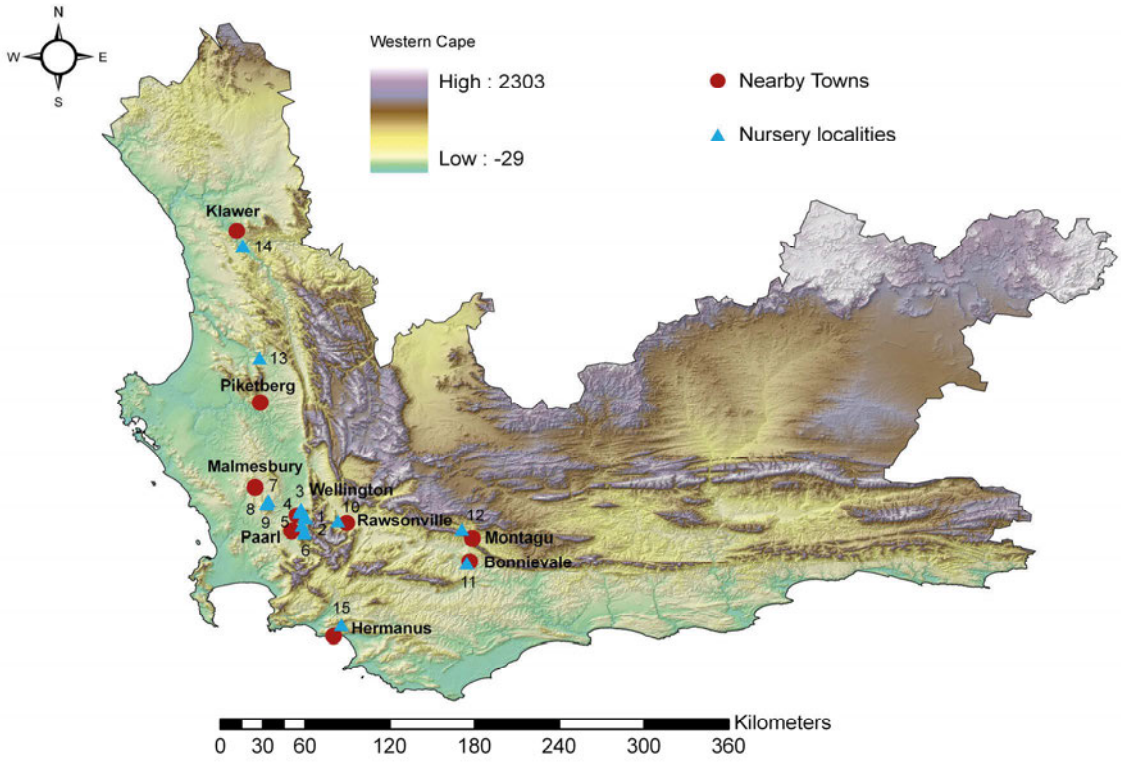

Figure 2. Locations of participating Western Cape nurseries.

acteristics will be discussed in the second of this series of two articles.

MATERIALS AND METHODS

Fifteen grapevine nurseries in various parts of the Western Cape were selected for this survey (Figure 2). Each of these nurseries produced Chenin blanc on Richter 99, though of differing clones (Table 1). Root and soil samples were collected from two depth intervals (0-150 mm; 150-300 mm) in February 2006, 16 -18 weeks after planting, and again in June 2006, shortly before lifting. Each sample was examined and the AM fungi were identified, mainly on the basis of spore morphology (Brundrett *et al.*, 1996).

RESULTS AND DISCUSSION

A total of 12 AM species were identified at the 15 nurseries. These are listed in Table 2. Four of these species: (*Glomus mossae*, *Scutellospora calospore*, *Glomus spp. and Acaulaspora spp.*) were present in all of the nursery soils, regardless of geographic location or soil conditions. The widespread occurrence of these AM fungi suggests that they are ubiquitous in the Western Cape or, at least to those parts of it that have similar soils, climatic conditions and cultural histories to those included in this survey.

The occurrence of the remaining eight AM species was sporadic. Of these, *Gigaspora decipens*, *Scutellospora fulgida*, *Scutellospora persica*, *Scutellospore spp.*, *Gigaspora albida*, *Glomus tortuosum*. *Gigaspora spp.* and *Gigaspora gigantea* were identified at six, four, three, three, two, one, one and one nurseries, respectively. Whether or not the more sparsely represented AM species were more widely spread in earlier times could not be established. That *Glomus tortuosumm*, *Gigaspora spp. and Gigaspora gigantea* occurred at single nurseries, whereas *Glomus mossae*, *Scutellospora calospore*, *Glomus spp.* and *Acaulaspora spp.* were present in all nurseries suggests that the latter group is more tolerant of factors that might lead to loss of species diversity than the former. It is conceivable that the species list might have been longer had molecular techniques, in addition to morphological identification criteria, been employed. Arbuscular mycorrhizal species that were in the resting stage at the time of sampling could have been overlooked during the present investigation (Vimard *et al.*, 1999).

The finding that three nurseries harboured four species of AM, four harboured five, seven harboured six and one nursery harboured seven may indicate that six AM species is not only the most commonly observed number, but is also the optimum number that can co-exist in Western Cape nursery soils producing Chenin blanc on Richter 99. Wider testing is required to find out if this is the case, and if there is an upper limit to the number of AM species that can co-exist in any given soil / plant combination.

That eight of the nurseries (53% of total) were hosts to either six or seven AM species (50% and 58% of total species, respectively) bodes well for the state of AM species diversity in Western Cape grapevine nurseries, and for their future sustainability (Baumgartner, 2003). Precisely how replanted grafted rootstocks from sites containing different numbers and combinations of indigenous AM fungi would react to inoculant AM species is unclear, since

TABLE 2. Presence (denoted by x) of arbuscular mycorrhizal fungal species at participating Western Cape grapevine nurseries.

Mycorrhizal species	Nurseries*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Scutellospora calospora	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Glomus mosseae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Glomus spp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Acaulospora spp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Gigaspora decipiens							x	x	x	x		x		x	
Scutellospora fulgida	x			x				x	x						
Scutellospora persica					x					x			x		
Scutellospora spp.	x						x					x			
Gigaspora albida			x									x			
Glomus tortuosum													x		
Gigaspora spp.		x													
Gigaspora gigantea		x													

*Nurseries: (1) Lelienfontein; (2) Patatskloof; (3) Nabygelegen; (4) Groenvlei; (5) Valencia; (6) Keerweder; (7) Jakkalsfontein; (8) Nooitgedacht; (9) Babylonstoren; (10) Nuutbegin; (11) Mervespont; (12) Nuweland; (13) Duikerfontein; (14) Witkop; (15) Babilonstoren.

much would depend on the vigour and effectiveness of the different indigenous and applied AM species, and the receptivity of the rootstock to colonisation by those species.

CONCLUSIONS

The survey data presented in this first article on the natural occurrence of AM fungi in Western Cape grapevine nurseries confirms that the nursery soils contain AM fungi from several genera. Four of these were present in all 15 nurseries, implying wide distribution and perhaps indigenous status. Others were represented at only one, or a very few nurseries. Whether or not the absence of specific AM fungi represents loss of mycorrhizal diversity under the conditions which prevail at specific nurseries, is unclear.

ACKNOWLEDGEMENTS

The authors wish to thank Winetech and the ARC for jointly funding this research, and Ansie du Toit for preparing Figure 2.

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SUMMARY

Soils of Western Cape nurseries producing Chenin blanc on Richter 99 were found to harbour *arbuscular mycorrhizal* (AM) fungi of the genera *Glomus, Acaulospora, Gigaspora and Scutellospora*. A total of 12 AM species were identified, four of which were found at all of the nurseries. The remaining eight species occurred sporadically. None of the nursery soils contained less than four or more than seven species.

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Arbuscular mycorrhizal fungi in Western Cape grapevine nurseries (Part II). Spore counts, root colonisation and soil factors

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Key words: Organic carbon, pH, phosphorus.

André Meyer

INTRODUCTION

Arbuscular mycorrhizal (AM) fungi are natural soil fungi capable of interacting with the roots of most plants, trees and vines to form what is, in effect, a vastly extended root system, the fungal component exchanging minerals and water for carbohydrates. These fungal associations (mycorrhizas) are beneficial since they seem to facilitate establishment of the grafted vines in the nursery beds, and their subsequent establishment in the vineyard, mainly by reducing post-plant stress. The survey of 15 Western Cape winegrape nurseries described in the first of this series of two articles (Meyer & Wooldridge, 2008) identified 12 AM species, of which four were present at all of the participating nurseries. The occurrence of the remaining species was sporadic. Since seven of the nursery soils contained six AM species, whereas only one soil contained seven, and none contained more than seven, it is possible that there is an upper limit to the number of species or isolates that can cohabit in a given soil, although why this should be the case is not known. Neither is it known why some AM species occur widely, whilst others occur in a few nursery soils only. Of equal importance is the present lack of information concerning those factors that facilitate or inhibit root colonisation and the establishment of a mutually beneficial relationship between vine root and fungus. This article discusses the relationships between AM spore count, root AM colonisation and soil parameters in the nurseries described in the previous article.

MATERIALS AND METHODS

At each of the 15 Western Cape grapevine nurseries that participated in this survey, root and soil samples were collected from two depth intervals (0-150mm; 150-300mm) in February 2006, 16-18 weeks after planting, and again in June 2006, shortly before lifting. In all cases the vines were Chenin blanc grafted onto Richter 99. The soil samples were analysed for pH, phosphorus (P) and organic carbon (OC) by a commercial laboratory (Bemlab, Strand) using standard techniques (pH, 1M KCl; P, Bray II; organic carbon, Walkley Black). Total soil AM spore counts were carried out and the rates of mycorrhizal root colonisation were determined as described by Brundrett *et al*. (1994). The data were statistically analysed and presented.

RESULTS AND DISCUSSION

Root colonisation and season

In February, the vines at only nine of the 15 nurseries were colonised. Among these the average root colonisation rate was 56% (Figure 1). By June all of the nurseries contained colonised vines and the average all-nurseries colonisation rate had increased to 63% with a minimum colonisation rate of 37% at Patatskloof and a maximum of 89% at Nuutbegin. In those nurseries where colonisation took place early in the season (February), the June colonisation rate was 66%. This figure was 8% higher than in those nurseries where colonisation took place after February. This result implies that factors that promote early colonisation lead to higher rates of colonisation being observed at lifting. Statistically, 86% of the variability in colonisation rate in June was explained by the February colonisation data.

AM Spore count and colonisation

Spores were present in the soils of all of the participating nurseries. The February spore count averaged 520 spores /100g air dry soil, and ranged from 150 at Babylonstoren (Malmesbury) to 1000 spores /100g air dry soil at Babilonstoren (Hermanus) and Groenvlei (Figure 1). The June spore counts were appreciably higher, averaging 860 and ranging from 200 at Mervespont to 1600 spores /100g air dry soil at Groenvlei. Spore count thus increases in winegrape nurseries as the time after planting increases. At the six nurseries where the vines were not colonised in February the average February spore count was 308, as compared with 661 spores /100g air dry soil in the nurseries where colonisation had taken place. These averages suggest that the likelihood of early (pre February) AM colonisation improves where the number of spores in the soil at planting is large. However, in neither February nor June was there a statistically significant (at the 95% confidence interval) relationship between spore count and colonisation rate. Less than 1% of the variability in colonisation rate was explained by spore count. In February, spore counts at Groenvlei and Babilonstoren (Hermanus) significantly (at $P = 0.05$) exceeded those at Babylonstoren (Malmesbury). In June, however, spore counts at Groenvlei exceeded those at Witkop, Nabygelegen and Mervespont. Counts at Patatskloof exceeded those at Mervespont. Differences in spore count were therefore apparent between some nurseries. Precisely what factors lead to these differences could not be determined from the available survey data.

AM Spore count and species diversity

Spore count did not reflect AM species diversity (refer to Part One). Only 3% of the variability in species was accounted for by spore count in February, and 5% in June.

Effects of soil P on AM spore count and root colonisation

At the February sampling, soil P concentrations ranged from

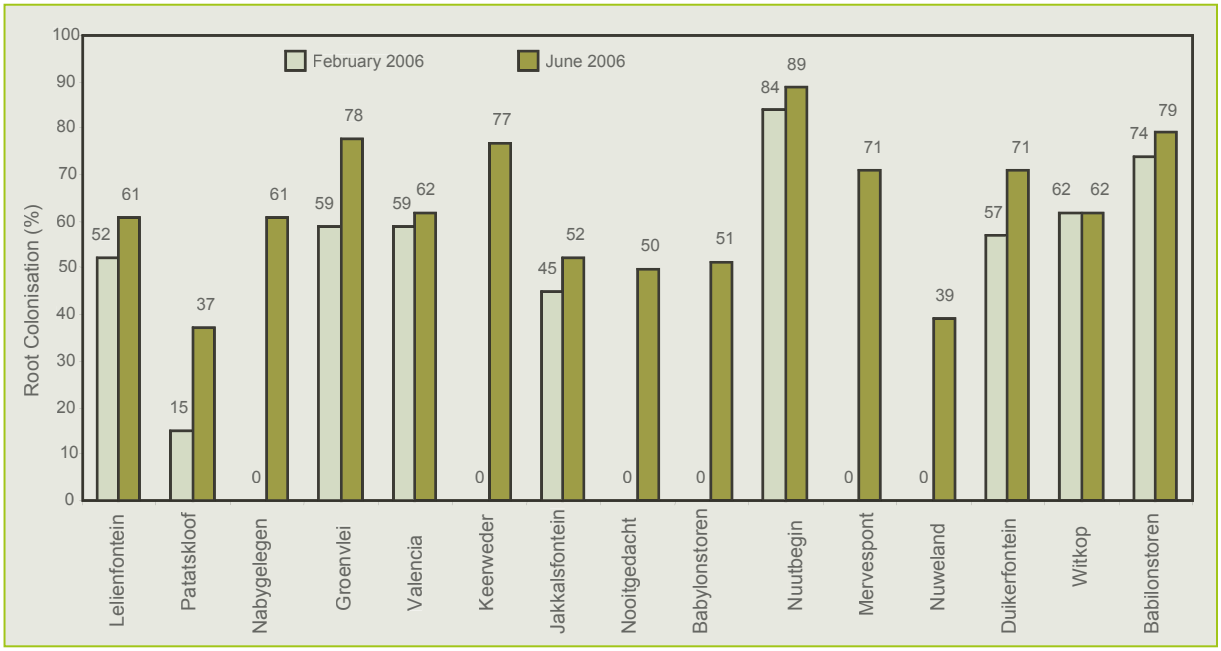

FIGURE 1. Colonisation (%) by arbuscular mycorrhizal fungi of Chenin blanc / Richter 99 vines in Western Cape nurseries as assessed in February and June, 2006.

28 to 226 mg/kg (0-150 mm, data not shown) and from 24 to 215 mg/kg (150-300 mm, Table 1). In the June samples, concentrations ranged from 60 to 196 mg P/kg (0-150 mm, data not shown) and from 17 to 197 mg P/kg (150-300 mm, Table 1). Since fruiting perennials such as grapevines perform well at soil P concentrations around 30 mg/kg, or as low as 20 mg/kg on low-clay soils (Conradie, 1994) both horizons were, with one exception, adequately to abundantly supplied with P. The four highest, and four lowest, 150-300 mm soil P concentrations were associated with average counts of 438 and 613 spores /100g air dry soil in February, and with 975 and 725 spores /100g in June, which was inconsistent. Neither was there a significant relationship between soil P concentration and spore count in either month, soil P explaining 9% of the variability in spore count in February and 13% in June.

At Patatskloof and Nuutbegin, where the lowest (37%) and highest (89%) June colonisation rates were respectively observed, the 150-300 mm soil P concentrations were both considerably higher than the requirement of about 30 mg P/kg, but not greatly different from each other (137 and 153 mg P/kg, respectively, in June). This finding supports Meyer *et al.* (2005) who found that AM fungi showed tolerance to P in vineyards, but is counter to Menge *et al.* (1978) and Brundrett *et al.* (1996) who maintain that root colonisation is inhibited by high soil P concentrations.

Although the spore counts were unaffected by the generally high (relative to the requirements of deciduous fruit trees and vines) soil P concentrations, the AM spore counts in this survey were lower than those that are commonly observed in vineyard soils, where spore concentrations range between 1000 and 3779 spores /100g air dry soil (Meyer *et al.*, 2005).

Effects of soil pH on AM spore count and root colonisation

Soil pH's in February ranged from 4.1 to 6.4 (0-150 mm, data not shown) and from 4.2 to 6.3 (150-300 mm, Table 1). June soil pH's ranged from 5.3 to 6.9 (0-150 mm, data not shown) and from 4.5 to 6.5 (150-300 mm). Since fruiting perennials perform best at around pH 5.5, the pH's observed in this trial were generally reasonable. Spore counts were not significantly related to pH in either February or June, in which months pH explained around 24% of the variability in spore count. Only 7% of the variability in colonisation in June could be explained by pH.

Effects of OC on AM spore count and root colonisation

In both February and June the OC contents of the nursery soils were below 1% at all except two nurseries (Keerweder and Babilonstoren (Hermanus)). However, no significant relationship could be established between OC and spore count; OC accounting for only 16% of the variability in spore count in February and 10% in June. This result does not support the view that adding organic amendments promotes the production of AM spores (Douds *et al.*, 1997; Muthukumar & Udaiyan, 2000). Colonisation rate in June was only 21% explained by the OC content. This relationship was not significant.

CONCLUSIONS

Results from a survey of AM populations in Western Cape grapevine nurseries producing Chenin blanc on Richter 99 indicate that AM fungal spore counts vary from nursery to nursery, but are generally lower after planting (February) than before lifting in June. High spore counts in the nursery soils tend to promote early colonisation which, in turn, is associated with higher spore counts and higher colonisation rates at lifting. This, positive, effect of high spore count, allied with the observation that AM spore counts in nurseries are lower than in vineyards, suggests that supplementation of spore numbers with commercial AM inocula at planting could facilitate early colonisation. By implication, a threshold spore count may exist below which supplementation is considered advisable. If so, this value has yet to be determined. Such a value would be likely to depend not only on the total

TABLE 1. Arbuscular mycorrhizal spore counts, soil pH, phosphorus and organic carbon in the rootzone (150-300 mm) of Chenin blanc / Richter 99 winegrape vines in Western Cape nurseries, assessed in February and June, 2006.

Nursery	February 2006				June 2006			
	Spore count (100 g dry ground)	pH (KCl)	P Bray II mg/kg	Carbon (%K)	Spore count (100 g dry ground)	pH (KCl)	P Bray II mg/kg	Carbon (%K)
Lelienfontein	850 ab	5.0	150	0.71	1 050 abc	5.2	197	0.83
Patatskloof	500 ab	5.3	152	0.75	1 200 ab	5.4	137	0.59
Nabygelegen	400 ab	6.0	115	0.46	500 bc	*	*	*
Groenvlei	1 000 a	5.8	123	0.58	1 600 a	5.7	109	0.52
Valencia	800 ab	5.6	41	0.75	900 abc	5.4	32	0.90
Keerweerder	350 ab	5.4	89	1.42	800 abc	5.3	42	1.25
Jakkalsfontein	550 ab	6.3	93	0.42	850 abc	6.2	72	0.29
Nooitgedacht	300 ab	5.9	134	0.71	700 abc	6.3	96	0.40
Babylonstoren	150 b	5.1	185	0.65	950 abc	5.4	183	0.40
Nuutbegin	250 ab	6.1	215	0.67	700 abc	6.0	153	0.84
Mervespont	200 ab	6.3	77	0.33	200 c	6.5	23	0.11
Nuweland	450 ab	5.8	24	0.17	1 000 abc	6.4	17	0.16
Duikerfontein	600 ab	5.5	92	0.17	750 abc	5.4	80	1.14
Witkop	400 ab	5.9	101	0.37	600 bc	6.2	79	0.20
Babilonstoren	1 000 a	4.2	77	2.45	1 100 abc	4.5	98	1.65

Values in the same column, that are followed by the same letter, do not differ at P = 0.05.

* Data not available.

soil spore count, but also on the indigenous species present, their relative abundance, the species present in the inoculum and the relative effectiveness of all the species concerned. Conceivably, the effectiveness of different species of AM fungi could vary with crop type and soil conditions. Spore count was not related to AM species diversity. Neither were spore count and AM colonisation affected by soil P concentrations above those needed by vines, pH, or by the organic carbon content of the nursery soil.

ACKNOWLEDGEMENTS

The authors wish to thank the ARC and Winetech for funding this research, and Isabella van Huyssteen for carrying out the statistical analysis.

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ABSTRACT

Surveys of naturally-occurring arbuscular mycorrhizal (AM) fungi were carried out during February and June 2006 in 15 Western Cape grapevine nurseries containing Chenin blanc on Richter 99. Spore counts varied between nurseries but were generally lower in February than before lifting in June. Most of the February spore counts were lower than those that commonly occur in vineyard soils. High February spore counts were associated with early colonisation, which was, in turn, associated with higher spore counts, and higher colonisation rates at lifting. Spore counts and colonisation rates were not significantly affected by soil pH, or by the organic carbon content of the nursery soil. Neither was the AM fungi inhibited by soil P concentrations in excess of those which are regarded as adequate for grapevines, or by other soil factors.

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OIV Sustainable Vitiviniculture Guide: Environmental Issues

INTRODUCTION

Sustainable vitiviniculture is defined by the OIV as a *"Global strategy on the scale of the grape production and processing systems, incorporating at the same time the economic sustainability of structures and territories, producing quality products, considering requirements of precision in sustainable viticulture, risks to the environment, products safety and consumer health and valuing of heritage, historical, cultural, ecological and landscape aspects."*

In order to comply with this definition, this document constitutes an implementation guide for environmentally sustainable production in the world vitiviniculture (specifically production, the processing of grapes, in addition to packaging of products) sector, while acknowledging the broader considerations for sustainable production.

1. GENERAL PRINCIPLES

Activities in the vine and wine sector are highly dependent on natural resources: solar energy, climate, water, soils and the successful integration of these elements with ecological processes. Therefore, protection, and preservation of these natural assets through environmentally sustainable practices are imperative for the long-term viability of vitiviniculturel activities.

The following principles constitute a base from which to promote a coordinated and efficient approach to the international vine and wine sector's commitment to environmental sustainability.

1. The selection of an appropriate environmental sustainability programme should be based on the programme's ability to satisfy three aspects of sustainable development: economic, environmental and social sustainability. It is acknowledged that the triple bottom line balance will vary between individual enterprises and that enterprises will require flexibility in establishing programmes of environmental sustainability in their individual operating environments.
2. The development of sustainable activities is based on an environmental risk assessment. Priority should be given to risks of significance in individual geographic regions where wineries and vineyards are located.
3. Environmental risk assessment should consider, but not be limited to:

a) Site selection (for new vineyards/wineries)	b) Biodiversity
c) Variety selection (for new vineyards)	d) Solid waste
e) Soil management	f) Energy use
g) Water management	h) Air quality
i) Wastewater	j) Neighbouring land use
k) Human Resource Management	l) Agrochemical use

4. A process of planning for environmental sustainability activities, implementation of the activities, assessment of their effectiveness and modification of the activity for application in the future should be established to ensure continuous control and improvement.
5. Vine and wine sector environmental sustainability programmes should incorporate 'self-assessment' and other forms of evaluation to gauge deficiencies and improvements in environmental performance.
6. The improvement of information and education opportunities linked with challenges facing sustainable development should be undertaken to build overall awareness of the international vine and wine sector.
7. The international vine and wine sector should recognise the importance of intra and inter-sectorial cooperation for natural resource management for sound ecological and social management, including inputs and equipment.

2. ORGANISATIONAL ISSUES

In compliance with regional, national and international regulations applicable to the vine and wine sector and to agricultural practices, the management of vineyards and wineries (or production/ transformation facilities) should at least include the following steps:

- identification of areas to be protected because of their environmental and landscaping interest and in addition to, if necessary, implementation of improvement measures at the level of the vineyard, wineries, its buildings and facilities;
- regular updating of information on techniques which contribute to sustainable

development;

- provision of in-house or external training for personnel in the application of sustainable development techniques relating to environmental issues;
- traceability of interventions and the use of inputs at the various production stages;

- adaptation of work in order to optimise energy use;
- production of a diagnosis, a quantitative inventory and a management plan for effluents and waste, focussing on their reduction, recycling or reuse.

3. SITE AND INFRASTRUCTURE

All infrastructure, equipment, and services related to vineyard, processing and packaging facility functions should be selected in accordance with continual improvement principles which take into account issues such as the environmental performance of the supplier and optimal use of energy and water, durability of service and item in addition to recycling possibilities.

a) Conception

- Buildings and associated infrastructures should be designed and constructed with due regard to visual and functional compatibility with the local environment, the optimal use of water and the need to minimise pollution and degradation of the environment.
- The fitting out of cellar, building and installations should integrate, if necessary, effluent and waste management.
- Loading and unloading bays and wash-down areas are planned. Sealing materials and fitting out of those impermeable areas should be appropriate for the degree of wear and for occasional risks.

b) Selection of the site

- Vineyard, and product processing and packaging should be established in full recognition of the adverse aspects linked to proximity to high density housing, and risks linked to mining activity and heavy industry. Likewise, sites which are in regions with hydrographically sensitive drainage basins, high water-table level or risk of flood should be avoided as far as possible.

c) Construction

- During soil preparation/cultivation for vineyards preparation and processing and packaging infrastructure, the damage and harmful effects caused to the landscape and environment should be limited insofar as possible.
- The choice of construction material should take into account thermal inertia and insulation in view of optimal energy management.

4. INPUTS AND PRODUCTION EQUIPMENT

Input reduction is a fundamental principle of environmentally sustainable production.

Materials and viticultural inputs such as plant protection products and soil conditioners and wine production inputs such as additives, processing aids and packaging materials as mentioned in the Oenological CODEX, should limit environmental impact to a minimum and favour renewable resources. Their use should be restricted to the minimum quantities necessary to achieve the desired outcomes.

Management of processing aid usage, both pre- and post-treatment, is a significant practical issue and should take into account issues of waste reduction, waste storage and its disposal.

a) Water and energy

- Water and energy required for cultivation, wine production operations and packaging should be limited to the lowest possible consumption through optimisation of infrastructure, equipment and processes with the most water and energy efficiency. In this manner, we limit wastewater generation and reduce energy use and chemical inputs.

b) Equipment

- Vineyard, processing, and product packaging equipment should be designed with due regard to: respect for the product, safety, and operational efficiency, particularly with regard to energy, water, hygiene management, noise and environmental pollution reduction.
- Refrigerants should be selected for their low impact potential on the environment (ozone layer, greenhouse gas).

5. EFFLUENT AND WASTE

Management of effluent, by-products and waste is a fundamental consideration in environmentally sustainable winemaking. Emphasis should be placed on initiatives for waste reduction at the source and on recovering useful and active materials from waste products, recycling waste components as part of selective management by appropriate supply channels. In general, the elimination of waste and effluents should minimise its impact on the environment and the local community.

The end use of effluents should determine the treatment and the choice of chemicals to be used as disinfectants and cleaning agents.

A regular quantitative and qualitative inventory of by-products and waste facilitates, the adaptation of vitivinicultural practices and equipment and the choice of management methods should be undertaken. This inventory is especially important for specific waste (batteries, drainage oil, hydraulic oil).

Emphasis should be placed on limiting the presence of solid matter, separation of by-products of crushing and fermentation such as stalks, skins, seeds and yeast lees, which are important imperatives for sustainability. In order to facilitate waste recovery or purification and to minimise the quantity of residual waste or pollutants, it is important to limit the presence of solid matter and reduce the use of chemicals.

The quantitative and qualitative characterisation of effluents should be based on analytical parameters such as Biological Oxygen Demand (BOD) or Chemical Oxygen Demand (COD), pH and possibly electrical conductivity and Sodium Adsorption Ratio (SAR). This characterisation enables the identification of the treatment required and the optimisation of the choice and capacity of the treatment device or process.

Emphasis should be placed on ensuring optimum waste and by-product management or water treatment and notably suspended particles and sludge.

Areas should be set up downstream for equipment and machine wash-down (tractors, harvesting machines, sprays), as well as fuel separation and water treatment systems in compliance with local environmental regulations.

Handling or washing of mobile equipment near a watercourse or sampling site should be avoided.

5.1 Waste storage and conservation

- Storage and treatment of effluent and solid waste should be carried out in dedicated areas which minimise the risk of their alteration or contamination, either of or by other materials. These areas should be located in a manner which also minimises their sensory impact and pollution potential with respect to the community and landscape.
- Solid waste should be selectively sorted and stored to facilitate its reprocessing, recycling or adapted, low environmental impact disposal.
- Store non-useable or out-of-date phytosanitary products in their original packaging separate from useable products; dispose of them via a supply channel that avoids any risk for the environment.
- Store empty phytosanitary and fertiliser packaging, if necessary rinsed and drained, in a sheltered area limiting the risks to the environment. Packaging must be eliminated in accordance with local regulations.
- Waste soiled by phytosanitary products must be kept in storage facilities for phytosanitary products, or in a sheltered place, limiting the risks to humans and the environment.

5.2 Treatment and recovering

- Separation of contaminated and uncontaminated liquid waste is an essential consideration at all sites. Ideally, design should be adapted to facilitate liquid waste separation and to minimise potential air-borne contamination.
- Effluent treatment systems should be adapted to the size of the processing plant and its peak effluent generation periods. Treatment systems should favour agronomical or biological processes with an efficient use of energy.
- Application of treated waste in vineyards, orchards and fields should take into account the characteristics of the soil and crops.
- Monitoring of treatment provisions should be carried out based notably on the following criteria: BOD or COD and pH. On the basis of specific local risks, the monitoring may be complemented by analyses such as: electrical conductivity, sodium absorption ratio.

6. SUSTAINABLE PRODUCTION APPLIED TO VITICULTURE PRODUCTION OPERATIONS

6.1 Establishing a vineyard

The following criteria must be followed when establishing a vineyard:

- Determine the viticultural aptitude and potential of the site
- Before any soil preparation/cultivation, carry out a soil study, taking into account pedological issues
- Take into account water availability and water protection requirements
- Ensure, by appropriate installations:
- Biodiversity maintenance
- Surface water management in order to limit the risks from run-off and erosion
- Surface and subsoil drainage
- Eliminate vine stumps and other plant remains likely to contaminate the soil with pathogens.
- If necessary, leave the soil fallow or establish a cover crop for a certain time before replanting always adapted to the local context.
- When required (and permitted), limit to a strict minimum any chemical disinfection of the soil and adapt it to local environmental requirements.
- Establish initial and amended fertilisation methods based on, in particular, representative soil and sub-soil analyses and carry them out according to regional requirements
- Use plant material (vine type and rootstock) free from serious viral diseases and suitable for the local conditions and the required type of production.
- Choose a vine training system compatible with sustainable production, taking into account the following items:
  - water requirement
  - grape quality
  - soil protection
  - soil potential
  - vine vigour
  - reducing risks of disease
  - application of phytosanitary products
  - density and layout of the vines
  - protection of landscape values

6.2 Nutrition

Nutrition should be based on the nutrients exported via the vine and the mineral and organic reserves of the soil:

- fertiliser input should be compatible with the production of quality grapes, the health of the vine, the maintenance of balanced soil fertility and be mindful of the extent of soil exploitation by the root system;
- the quantity and the nature of input should be minimised where possible and be based in particular on a soil and/or plant tissue analysis (basic analysis and regular fertility controls) and observation of plant vigour;
- nitrogen input and the times of application should be evaluated in relation to the needs of the vine, the quality of the grapes, the green covering or cover cropping technique, the type of soil and the risks of leaching;
- fertilisation should be applied according to regional references if they exist, to vine exports and the risks of deficiencies;
- preference should be given to recycling organic nutrients;
- fertilisers or soil conditioners contaminated by substances toxic or dangerous to the environment, such as trace metals, organic micro-pollutants or pathogenic microorganisms, should be fully controlled;
- foliar top-dressing should be used only to prevent or treat clearly established or clearly anticipated deficiencies.

6.3 Soil maintenance

Soil maintenance is designed to create optimum conditions for the plant, to prevent erosion, soil compaction, and leaching of nutrients, while promoting biological diversity.

All the appropriate measures to protect the soil against erosion should be taken: green covering, cover cropping,

ground coverage or mulches (straw, compost etc), site adaptation, terrace maintenance.

Green covering must be evaluated on the basis of the following items:

- level of precipitation and soil water reserves
- risks of erosion, leaching and soil compaction
- vine training system
- age of the vine
- grape quality and output, in particular the nitrogen content of musts
- frost risk.

Preference should be given to plant coverage of the soil in winter in order to fix nitrogen and prevent losses by leaching and winter erosion.

The technique and timing of mechanical cultivation should take into account environmental concerns and the prevailing and forecast weather conditions.

The introduction of mulch should take into account the timely release of nutrients, the risk of fire spreading and the possible presence of potentially toxic elements (trace metals, organic micro-pollutants).

The use of herbicides should be limited to the absolute minimum and their implementation optimised, while emphasising foliar weed control.

Weeding the entire soil surface area should be limited to specific situations (e.g. very low and narrow vines rows, terrace vineyards).

The type of weeding should be chosen on the basis of effective control, taking into account the energy impact and environmental impact (risk of residue build-up in the soil, soil degradation and contamination of water resources).

6.4. Irrigation

Recognising OIV Resolution VITI 2/2003 (see Annex 1) for vineyard water management and irrigation programmes, it is recommended that the following aspects be taken into account:

- all the techniques for limiting water requirements (tolerance to water stress, farming techniques etc.) should be implemented first and foremost
- water input should be based on needs related to production objectives (wine grapes, table grapes, raisins) for the vine at the various stages of its development, the type and specific nature of the grape and the requisite wine, taking into account the water balance of each vineyard
- the risks of environmental impact, in particular in terms of soil salinity and underground water, should be avoided in order to ensure sustainable viticulture
- preference should be given to irrigation techniques designed to optimise water efficiency, such as micro or drip irrigation, and to considering their effects on the distribution of the root system
- Similarly, over time evaluation of measures of soil water reserves and vine water status should be prioritised as the basis for determining volume and timing of irrigation water supply.

6.5 Vine training and canopy management

The best time for winter pruning should be selected according to local climatologic conditions in order to:

- limit contamination risk
- limit pruning wounds and thus reduce the risk of wood rotting diseases. (Resolution VITI 02/2006)

The vine should be pruned, formed and trained, through canopy management, in order to ensure a good balance between plant development and production.

Canopy management, in particular tying and debudding operations, should enable satisfactory ventilation of the grapes as well as good penetration of light and phytosanitary products.

6.6 Pest and disease management

a/ Basic strategy

The purpose of phytosanitary protection is to effectively protect the vine against pests and diseases, while respecting the environment.

All preventative measures are to be implemented in priority before using direct control methods.

When direct pest control is required, priority should be given to biological or biotechnical control methods. This control should be based on tolerance thresholds, risk assessment and information provided by regional technical services.

Risk assessment should be based on the following items:

- Monitoring (records to be kept)
- The indications of warning services
- Disease forecasting models and risk assessment
- The biological follow-up of diseases and pests

Preventative treatments should be evaluated according to risk potential for developing diseases and pests.

The following preventative measures are invaluable in aiding vine protection (these are also identified by Resolution VITI-OENO 1/2005):

- The use of suitable vine types and rootstocks
- The use of suitable vine training systems
- The choice of crop cultivation methods, in order to limit the pressure of diseases and pests (balanced top-dressing, irrigation, canopy management, etc.)
- Soil maintenance (green covering, soil cultivation period)
- Preserving beneficial organisms.

Annual and updated regional information documents, as well as fungal disease forecasting models, if they exist, should be used as the basis for a protection strategy.

Products should be used within the regulatory framework. For the uses mentioned, the licensed dosage and the indicated withholding period (prior to the harvest) should be respected.

The strategy for use of phytosanitary products should be dependent upon the classification ofproducts on the basis of their toxicity and environmental impact.

The products and quantities used should be those which are compliant with legal restrictions, label guidance and which ensure effective control of pests and diseases, taking into account the following issues:

- The phenological stage and the surface area of the plant to be protected
- Unintended effects on beneficial fauna and non-target organisms
- Toxicity in particular for bees and other beneficial organisms

- Risks of developing resistance
- Risks of water or soil pollution
- Risks of residues in the grapes and wines
- Possible effects on vinification

b/ Handling and application of phytosanitary products

The application technique, the choice and setting of the appliance and the weather conditions should enable optimum and targeted distribution of the plant protection products.

It is recommended that spraying equipment which reduces the level remaining in the tank and is easy to clean be used.

During the handling and application of phytosanitary products, the following is recommended:

- Have available a filling area with a system which avoids possible network contamination and limits the risk of accidental overflows or spillage
- If topographic conditions so allow, rinse the tanks of the spray onto the parcel, then spray the vine with the diluted rinsing water
- Forbid any handling or washing of the spray equipment near a water-course or sampling site.

Maintenance and calibration of the spray plant equipment should be carried out regularly by the user and, if necessary, it should be tested periodically by an approved procedure.

Techniques and suitable protective equipment should be used by the spray operator in order to avoid any risk of intoxication/contamination associated with the preparation of the mixture and with spraying.

c / Storage of phytosanitary products

The management of phytosanitary products should at least comply with the following recommendations:

- Store products in a clearly identified area specifically reserved for this purpose, aired or ventilated, locked with a key and organised to avoid any contamination or accidents and in compliance with local regulations
- Keep phytosanitary products in their original packaging with the label
- Store non-useable or out-of-date phytosanitary products in their original packaging separate from useable products
- Retain safety factsheets for products used.

6.7 Harvesting

Noting Resolution VITI-OENO 1/2005 vintage operations present some specific challenges with respect to inputs, pollution management of by-products and effluents.

As the vintage is a period of intense physical activity, operation of machinery, entry into confined spaces and chemical handling, extra vigilance is required.

a) Harvesting operations

- The picking temperature and the transport timeframe must take into account limiting energy consumption for transport, heating or cooling of the harvest.

b) Contamination risks

- Physical cleaning of machine harvesters and other grape handling equipment should be favoured over the use of chemical cleaning agents. Consideration should, however, be given to the optimum use of water, as part of the decision making process.
- Solid and liquid by-products of vintage operations should be stored in a manner which minimises the risk of their alteration or contamination and reduction of their environmental impact pending management or treatment.

7. SUSTAINABLE MANAGEMENT APPLIED TO PRODUCTION, TRANSFORMATION AND PACKAGING OPERATIONS

7.1 Elaboration, clarification and stabilisation

- Temperature and nutrient regimes during processing of grapes should be adapted taking into account fermentation control, product quality and energy input.
- Operations involving physical processes, such as centrifugation, filtration and heating/cooling or oenological processes should be implemented taking into account hygiene, energy use, and management of by-products.
- Solid or liquid residues from clarification or stabilisation operations, such as spent filter aid, fining deposits and tartrates should be re-processed whenever possible to recover useful and active materials. Any residues unable to be re-processed should be disposed of in a manner which minimises the impact on the environment and the local community.

7.2 Conservation and production

- Maturation and aging are generally carried out in either inert containers or wooden vessels. Consideration should be given principally to durability, integrity and possibility of recyclability of material in contact with wine.
- Wooden containers demand particular vigilance with respect to hygiene, due to the porous nature of the surfaces in contact with product. Cleaning and sterilisation should favour the use of hot water or steam, rather than chemical cleaning or sterilising agents.
- Consideration should be given to ensuring an optimal management of wine conservation materials when their life has ended.

7.3 Packaging and warehousing

- Special effort should be made to efficiently manage packaging materials when they are no longer usable.
- The possibility of recycling packaging elements should be the first option.
- The following materials are recyclable and efforts should be made to efficiently manage this waste:
- packaging containers made of glass, plastic, or plastic-lined paper or metal products
- container seals made of cork, plastic or plastic-coated metal products
- outer packaging, such as capsules, labels and cartons made of plastic, metal or a paper-base
- Packaging materials should be minimised while still permitting an optimal conservation and presentation of the product.
- Cleaning and sterilisation of packaging equipment surfaces which come into contact with product should favour physical treatments, such as hot water or steam, rather than utilising chemical cleaning or sterilising agents while taking into account energy consumption and water availability.

Cellar

photo: Arnold Kirkby

The use of non-Saccharomyces fructophilic yeasts for efficient fermentation of grape juice

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Key words: Glucose:fructose ratio, non-Saccharomyces yeasts.

Neil Jolly

In South Africa, the glucose to fructose ratio (GFR) in grapes at harvest may vary from 0.96 to as low as 0.77. Wine fermentation with glucophilic yeast, starting at a GFR of less than one, has a greater chance of reaching a critical imbalance (GFR ≤ 0.1), with its accompanying fermentation problems. In this study the effect of GFR on fermentation was investigated in fructose spiked musts during laboratory-scale fermentations. This was followed by an investigation into the use of fructophilic yeasts to change the GFR at the onset of fermentation in a proactive approach to prevent stuck fermentations during small-scale wine production trials. Preliminary results indicate that a combination of non-*Saccharomyces* and *S. cerevisiae* yeasts leads to more efficient utilisation of grape sugars.

INTRODUCTION

The glucose to fructose ratio (GFR) in grapes at harvest can vary, but is generally accepted to be close to one (Amerine & Thoukis, 1958; Amerine *et al.* 1972; Bisson, 1993). During fermentation, the glucophilic wine yeast, *Saccharomyces cerevisiae*, can preferentially utilise glucose above fructose. Should the GFR decrease to 0.1, it can result in a stuck fermentation with a higher residual fructose than glucose concentration (Gafner *et al.*, 2000). Inoculation at this stage with fructophilic non-*Saccharomyces* yeast can rectify the imbalance, whereupon *S. cerevisiae* can start fermenting again (Sütterlin *et al.*, 2004).

In South Africa, the GFR of some grapes at commercial harvest can vary between 0.96 to as low as 0.77 (Snyman, 2006; Jolly, unpublished data, 2006). This appears to be related to cultivar and area of production (G. Baumgarten, personal communication, 2005). The resultant fermentations with the glucophilic *S. cerevisiae* could therefore be at a greater risk of having their GFR dropping to below 0.1 with the accompanying risks of a stuck fermentation. Correction of this GFR imbalance with selected non-*Saccharomyces* yeasts as demonstrated by Sütterlin *et al.* (2004) requires that the yeast be ethanol tolerant, as well as be able to grow in an environment where nutrients other than sugar may be limiting.

In a proactive approach the GFR could be altered at the start of fermentation by fructophilic yeast. Here ethanol tolerance would not be required, but osmo-tolerance would be an added bonus, especially for the high sugar concentration in South African musts. Suppression of the fructophilic yeast by the fast growing *S. cerevisiae* is also of less importance. Therefore, in this study the effect of a lower GFR on the subsequent fermentation was investigated in fructose-spiked musts during laboratory-scale fermentations. This was followed by an investigation into the use of fructophilic non-*Saccharomyces* yeasts to change the GFR at the onset of fermentation in a proactive approach to prevent stuck fermentations during small-scale wine production trials.

MATERIAL AND METHODS

Yeast strains

The yeast strains used in this study are shown in Table 1.

Laboratory-scale fermentations

A previously frozen, clarified base must was used to prepare two sets of four fermentation mediums, i.e. a normal must

TABLE 1: Yeast strains used in this study.

Species	Strain no.	Origin
Saccharomyces cerevisiae	NT 112[1]	Anchor Bio-Technologies
S. cerevisiae	BDX[1]	Lallemand
S. cerevisiae	Fermichamp[1]	DSM
S. cerevisiae	VIN 13[1]	Anchor Bio-Technologies
Candida stellata	46	LNR Infruitec-Nietvoorbij yeast culture collection
Candida stellata	45	LNR Infruitec-Nietvoorbij yeast culture collection
Zygosaccharomyces bailii	48	LNR Infruitec-Nietvoorbij yeast culture collection
Candida pulcherrima	74	LNR Infruitec-Nietvoorbij yeast culture collection
S. cerevisiae	110	LNR Infruitec-Nietvoorbij yeast culture collection
Candida zemplinina	UCD	University of California
Candida pulcherrima	C1-15[2]	Anchor Bio-Technologies
Candida pulcherrima	825[2]	Anchor Bio-Technologies

[1]Commercial active dried wine yeast.
[2]Experimental active dried wine yeast.

TABLE 2: Glucose and fructose analyses of normal and fructose spiked musts after fermentation by Fermichamp, NT 112 en BDX yeasts without addition of a nitrogen source.

Must type[1]	Start GFR	Yeast[2]	End analyses			End GFR
			Res. sugar (glucose + fructose) (g/L)	Glucose[3] (g/L)	Fructose[3] (g/L)	
N2	1.06	Fermichamp BDX NT 112	0.64 3.21 1.31	0.04 0[4] 0.02	0.60 3.21 1.29	0.07 0 0.02
N2 + 10	0.95	Fermichamp BDX NT 112	40.14 13.12 15.64	10.71 0.49 1.42	29.43 12.63 14.22	0.36 0.04 0.10
N2 + 20	0.86	Fermichamp BDX NT 112	30.81 22.14 32.74	7.69 2.26 4.53	23.12 19.88 28.21	0.33 0.11 0.16
N2 + 30	0.78	Fermichamp BDX NT 112	29.90 50.79 39.63	7.24 3.62 6.34	22.66 47.17 33.29	0.32 0.08 0.19

[1]N2 = normal must (22.5°B) plus indicated g/L fructose addition.
[2]Fermichamp (DSM), BDX (Lallemand) & NT 112 (Anchor Bio-Technologies) = *Saccharomyces cerevisiae.*
[3]Analyses of single fermentation.
[4]Detection limit is 0.004 g/L. This value is used for the calculation of the GFR.

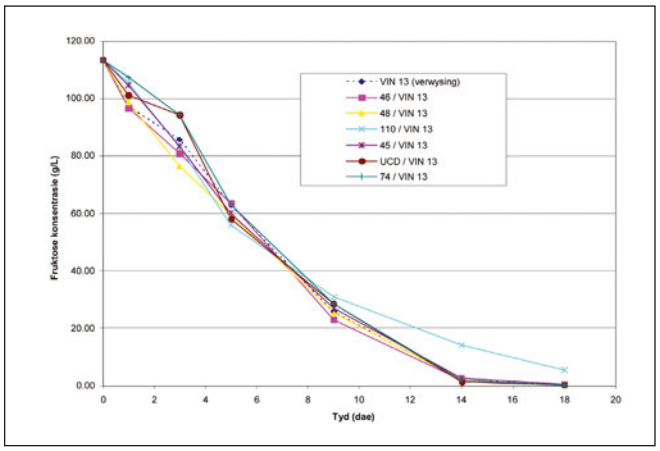

FIGURE 1. Decline in fructose concentration (average of two fermentations) in a 2006 Chardonnay must fermented by different yeast combinations.

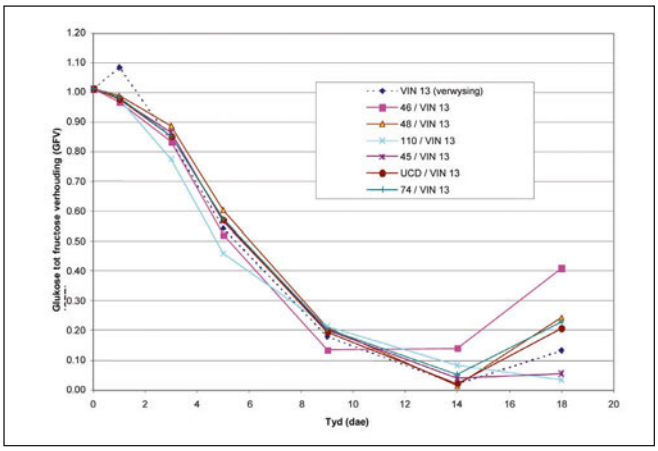

FIGURE 2. Change in glucose-fructose ratio (GFR) during the fermentation of Chardonnay 2006 must by different yeast combinations.

and three with increasing concentrations of added fructose as shown in Tables 2 and 3. A nitrogen source (*Nutrivin Super*, Anchor Bio-Technologies, South Africa) was added at a concentration of 0.5 g/L to the second set of fermentation mediums. The individual musts were aliquoted into 250 mL lots and sterilised by autoclaving. A selection of yeasts (Table 1) was used (2% inoculum, 24h culture, YPD broth [Biolab, Merck]) and the fermentation vessels were closed by tightly fitting fermentation caps. The fermentations were all done in duplicate at 20°C. Residual glucose and fructose concentrations were determined at completion of fermentation by the enzymatic method (Vinlab, Stellenbosch; and Koelenhof Wynlaboratoriumdienste (Wine laboratory services), Stellenbosch).

Small-scale wine production

Non-*Saccharomyces* yeasts (Table 1) were investigated in combination with a commercial *S. cerevisiae* (strain VIN 13, Anchor Bio-Technologies, South Africa) yeast for small-scale production of wine in aliquots of 18 L of freshly prepared Chardonnay and Chenin blanc must from the 2006 vintage (adjusted to 50 mg/L SO_2). All the trials were done in duplicate. For the Chardonnay must, six non-*Saccharomyces* yeast cultures i.e. 46, 45, 48, 74, 110 and UCD, (propagated in YPD broth) were inoculated individually at 1 x 10^6 cells/mL. This was followed within one hour by active dried wine yeast (VIN 13) at 30 g/hL. Other wine-production treatments were according to the standard Nietvoorbij procedures for small-scale white wine production (Jolly *et al.*, 2003a). During fermentation, 20 mL aliquots were removed under CO_2 gas for glucose and fructose analyses (enzymatic method). Chenin blanc wine production followed the same method, with the exception that experimental active dried non-*Saccharomyces* yeasts i.e. C1-15 and 825 were used at 25 g/hL instead of wet cultures. Reference fermentations were inoculated with VIN 13 only.

The wines were subjected to a descriptive sensory analysis five months after production as previously described (Jolly *et al.*, 2003b). The judging criteria were "fruity aroma", "butter aroma", "body" and "general quality"; and "fruity aroma", "guava aroma" and "general quality" for the Chardonnay and Chenin blanc wines, respectively.

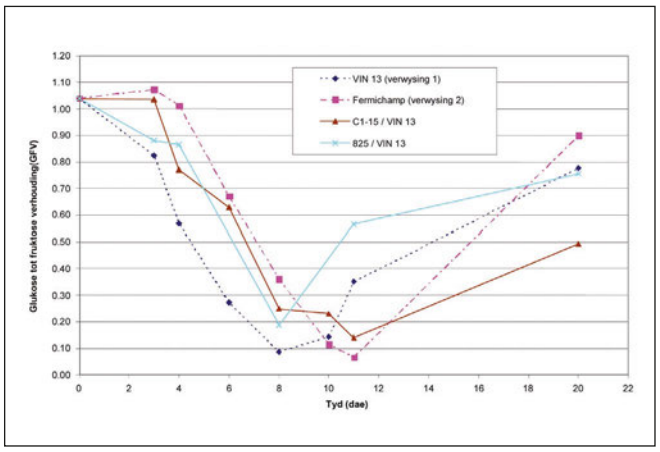

FIGURE 3. Change in glucose-fructose ratio (GFR) during the fermentation of Chenin blanc 2006 must by different combinations of active dried non-*Saccharomyces* and *Saccharomyces cerevisiae* yeast species.

RESULTS AND DISCUSSION

Sourcing of grape must with a specific low GFR is not practical for laboratory trials, therefore a laboratory protocol was needed whereby stuck fermentations due to GFR imbalances could be induced by using fructose-spiked grape must inoculated with *S. cerevisiae* references yeasts. Table 2 shows that the lower the GFR at the start of fermentation, the higher the total residual sugar (glucose + fructose) at the end of fermentation. As was expected, the fructose fraction was always higher than the glucose. The reference yeast Fermichamp, marketed as a "fructophilic" *S. cerevisiae*, did not perform very well in this evaluation. However, it did appear to utilise fructose better in the lower GFR musts. It also appeared that the cut-off GFR of 0.1, as shown by Gafner *et al*. (2000), does not always hold true, as some of the fermentations went to dryness even with a GFR below 0.1. From this experiment it appears that in some cases BDX is better able to utilise fructose than NT 112, although in South Africa NT 112 is generally considered to be a stronger fermenter than BDX.

When the experiment was repeated in a second must, but with the addition of a complex nitrogen source i.e. Nutrivin super (containing inactivated yeast, di-ammonium phosphate and thiamine), the *S. cerevisiae* yeasts were better able to ferment to dryness (Table 3). Here NT 112 generally out performed BDX and Fermichamp, and it was only in the 0.80 GFR must (i.e. N3 + 30) that NT 112 was unable to utilise all the fructose. From this data it therefore appears that some of the problems regarding residual fructose may, in some instances, be prevented by the judicious use of complex nitrogen sources.

Cellar-scale evaluation of fructophilic yeasts

An initial screening of yeasts found in the ARC Infruitec-Nietvoorbij microbiology culture collection resulted in the selection of five yeasts that showed faster fructose utilisation than *S. cerevisiae* reference yeast strains NT 112 and BDX (data not shown). This selection consisted of two *Candida stellata* strains and one strain each of *Zygosaccharomyces bailii*, *Candida pulcherrima* and *S. cerevisiae* (strain 110) (Table 1). A sixth yeast, a *Candida zemplinina* strain, was also included. This is a newly described species that has been designated an extreme fructophilic yeast (Sipiczki, 2003; D. Mills, personal communication, 2005). The strain used in this investigation was originally isolated from fermentations of *Botrytis*-affected Semillon grapes (Mills *et al.*, 2002).

During the small-scale (18 L) wine production trials using Chardonnay must, the six selected yeasts were co-inoculated individually with the commercial *S. cerevisiae* strain VIN 13. This was necessary as the fructophilic yeasts were only expected to play a role in the initial phase of fermentation, while the commercial *S. cerevisiae* wine yeast was desired for completion of fermentation and production of a specific wine style.

The Chardonnay grape must had an initial GFR of 1.01 and was therefore not expected to present any fermentation problems. With one exception, all the glucose and fructose was utilised (data not shown). The exception was the *S. cerevisiae* strain 110 / *S. cerevisiae* strain VIN 13 combination

TABLE 3: Glucose and fructose analyses of normal and fructose spiked musts after fermentation by Fermichamp, NT 112 and BDX yeasts with addition of a nitrogen source[1].

Must type[2]	Start GFR	Yeast[3]	End analyses			End GFR
			Res. sugar (glucose + fructose) (g/L)	Glucose[4] (g/L)	Fructose[4] (g/L)	
N3	1.02	Fermichamp BDX NT 112	3.63 0.59 0.56	2.07 0.22 0.17	1.56 0.37 0.39	1.33 0.59 0.44
N3 + 10	0.93	Fermichamp BDX NT 112	1.17 8.92 0.89	0.33 3.23 0.13	0.84 5.69 0.76	0.39 0.57 0.17
N3 + 20	0.86	Fermichamp BDX NT 112	0.50 33.35 0.79	0.13 3.71 0.15	0.37 29.64 0.64	0.35 0.13 0.23
N3 + 30	0.80	Fermichamp BDX NT 112	10.00 23.37 6.05	1.30 1.81 1.73	8.70 21.56 4.32	0.15 0.08 0.40

[1]0.5 g/L Nutrivin Super (Anchor Bio-Technologies, South Africa).
[2]N3 = 21°B + indicated g/L fructose addition.
[3]Fermichamp (DSM), BDX (Lallemand) & NT 112 (Anchor Bio-Technologies) = *Saccharomyces cerevisiae.*
[4]Analyses of single fermentation.

TABLE 4: Sensory analyses of 2006 Chardonnay produced by combinations of fructophilic and commercial wine yeasts.

Yeast strain	Wyneienskap (%)[2]			
	Fruity aroma intensity	Butter aroma intensity	Body	General quality
VIN 13[1] (reference)	53.88a	14.63b	44.13a	47.63a
46 / VIN 13	49.31a	19.56ab	41.87a	48.13a
45 / VIN 13	49.06a	25.25a	47.81a	49.69a
48 / VIN 13	56.06a	21.69ab	51.56a	48.25a
74 / VIN 13	52.50a	21.06ab	48.50a	43.94a
110 / VIN 13	47.00a	18.13ab	45.56a	48.50a
UCD / VIN 13	56.19a	17.06ab	49.06a	54.25a

[1]VIN 13 = active dried commercial *S. cerevisiae* wine yeast.
[2]Average value of duplicate wines judged by a panel of seven judges. Values within columns followed by the same letter do not differ significantly ($p \leq 0.05$).

where some residual fructose remained (Fig. 1). However, when the same data was presented in the form of GFR (Fig. 2), it appears that there were three types of fermentation. The first is the already mentioned *S. cerevisiae* / *S. cerevisiae* fermentation, where the GFR dropped to 0.1 (the ratio where fermentations are expected to cease) and then further to 0.03. This GFR pattern therefore represents an inefficient fermentation i.e. with residual fructose (Fig. 1). The second type of fermentation was the *C. stellata* strain 46 / *S. cerevisiae* fermentation where the GFR decreased to 0.14 and then started increasing again, in other words, the 0.1 mark was never reached. This GFR pattern can therefore be equated to an efficient fermentation. The third group, comprising the remaining five fermentations, all had their GFRs decreasing to below 0.1 before increasing again. However, as they all went to fructose dryness, these could be viewed as marginal fermentations. In this instance they were efficient, but it can be speculated that should other fermentation conditions have been stressful to the yeast e.g. nitrogen status of must, incorrect fermentation temperatures, etc. then these fermentations may have finished with residual fructose.

The *C. stellata* strain 46 / *S. cerevisiae* strain VIN 13 combination, representing the most efficient fermentation, produced wine of a similar quality to the reference fermentation (Table 4). This supports the findings of Jolly *et al.* (2003b), who showed that although their *C. stellata* strain could produce unacceptably high levels of volatile acidity when fermenting on its own, it did not do so in co-inoculated fermentations with *S. cerevisiae*.

The Chenin blanc must with an initial GFR of 1.04 was also not expected to present any fermentation problems. The two non-*Saccharomyces* yeasts used for these trials, *C. pulcherrima* strains 825 and C1-15, were originally selected for improved sensory quality in co-inoculated fermentations (Jolly *et al.*, 2003a). During the small-scale wine fermentations the GFR (Fig. 3) followed the same pattern of change for an efficient fermentation as previously discussed (GFR did not drop below 0.1). In contrast, the *S. cerevisiae* only fermentations with VIN 13 and Fermichamp were less efficient (marginal), as their respective GFR's dropped to below 0.1 before increasing. These experimentally dried non-*Saccharomyces* yeasts therefore not only enhance the sensory profile of the wine (Jolly *et al.*, 2003a), but also contribute to an efficient utilisation of sugars.

CONCLUSIONS

From the data presented it appears that a grape must with a GFR below one can, in some instances, lead to incomplete fermentation. The judicious use of a complex nitrogen source may, in some instances, help to prevent this. However, the use of selected fructophilic, non-*Saccharomyces* yeasts co-inoculated with the standard wine yeast, at the start of fermentation, can lead to more efficient utilisation of sugars, ensuring a problem free fermentation.

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Colour and phenolic characteristics of different clones from Pinot noir, Pinotage, Merlot, Shiraz, Cabernet franc and Cabernet Sauvignon

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INTRODUCTION

Different red grape cultivars are currently available to the wine grower in South Africa. These include Cabernet franc, Cabernet Sauvignon, Merlot, Shiraz, Pinot noir and Pinotage, with a number of different clones also being available to the producer.

Phenolic compounds, such as anthocyanins and tannins play a critical role in the colour, flavour and taste of red wines (Monagas *et al*., 2006). For a number of years KWV and the Department of Viticulture and Oenology has done very good research to establish which clones are optimal for South African conditions.

How these clones compare in terms of certain winemaking parameters in SA conditions is however not fully understood. One of these parameters includes the colour and phenolic composition of the different clones and how they compare to each other under the same growing conditions. How these differences are reflected in the corresponding wines is also not fully clear. The main aim of this project was thus to harvest different clones from some major red varieties which were grown under the same conditions and analyse some viticultural and winemaking parameters, especially colour and phenolics, in the grapes and corresponding wines.

MATERIAL AND METHODS

Suitable clones for Cabernet Sauvignon, Merlot, Shiraz, Pinot noir and Pinotage in the Grondves block of KWV in Stellenbosch were selected in terms of where they are situated, soil type and virus status, to make it as homogeneous as possible and harvested at roughly the same sugar level (23-25 degree Balling). Sugar levels between clones of a cultivar did not differ more than 1.3 Balling. The different clones selected of a cultivar grew in the same row with the same root stock. Fruit were harvested randomly from different vines for each clone at roughly the same sugar level (Table 1). Some of the berries were frozen for phenolic analyses at a later stage.

TABLE 1: Clones investigated in this study with rootstock.

Block	Cultivar	Clone	Rootstock	No of vines included
A	Pinotage	PI 45M	RQ36	25
A	Pinotage	PI 48H	RQ36	25
B	Cab franc	CF212C	RQ26	20
B	Cab franc	CF213B	RQ36	20
B	Cab franc	CF214B	RQ28	15
B	Cab franc	CF623B	RQ28	15
B	Cab Sauv	CS37C	RQ28	20
B	Cab Sauv	CS163O	RQ28	15
B	Cab Sauv	CS191B	RQ28	20
B	Cab Sauv	CS338B	RQ28	20
B	Merlot	MO45B	RQ28	20
B	Merlot	MO184C	RQ28	15
B	Merlot	MO346B	RG28	20
D	Shiraz	SH1C	RQ28	20
D	Shiraz	SH12B	RQ28	20
D	Shiraz	SH470B	RQ28	20
M1	Pinot noir	PN459	RG28	20
M1	Pinot noir	PN667A	RQ28	20
M1	Pinot noir	PN777A	RQ28	20
M1	Pinot noir	PN52C	RQ28	20

The following analyses were conducted on the grapes: sugar, pH, acid, total skin anthocyanins, total phenolic, total tannins and berry mass (Iland *et al* 2000, Sarneckis *et al*., 2006; Nieuwoudt *et al*, 2004).

The grapes were mixed homogenously and divided equally into three fermentation containers. The wine were made on small scale according to standard winemaking techniques and fermented with the Saccharomyces cerevisiae strain WE372 (Anchor yeast) and the skins and juice mixed twice a day by pressing trough until the end of fermentation. After fermentation the skins were pressed with the same press to the same pressure (2 Bars). The wine was then inoculated with Oenococcus oenos for malolactic fermentation and the malic acid concentration degradation followed.

After malolactic fermentation the following analyses were conducted on the wines: standard: alcohol, pH, different types of organic acids, sugar concentration. Phenolic analyses at this stage included colour density, modified colour density, total red pigments, total phenolics, total tannins, total anthocyanins, colour due to free anthocyanins, colour due to co-pigmentation and colour due to polymeric pigment with a spectrophotometer (Iland *et al*, 2000, Boulton *et al*, 2001;

Ribereau-Gayon *et al*. 2000, Sarneckis *et al*., 2006). Colour density is the sum of the absorbance value at 420 (brown), 520 (red) and 620 (blue) nm. This measurement thus measures the colour density at actual wine pH with the bleaching effect of SO_2, in other words how it would be observed with the naked eye. Modified colour density is measured at the same wavelengths, but acetaldehyde is added to a sample of the wine and the pH adjusted to 3.6 to negate the effect of SO_2 and pH on colour. This is necessary when one wants to compare the colour of different wines with different pH and SO_2 levels. Wine colour hue expresses the hue, tint or shade of the colour rather than its intensity, with young wine having lower values and older wines higher values. SO_2 resistant pigments measures the percentage of red coloured pigments (as a result of polymerisation reactions) which are resistant to the bleaching effect of wine. This could thus serve as in indication of colour polymerisation. Total red pigments are an estimate of the concentration of the total pigments in the wine. Total phenols are an estimate of the total phenolic compounds in wine. Co-pigments, free anthocyanins and polymeric pigments were analysed according to Boulton *et al*., 2000.

RESULTS AND DISCUSSION

In Table 2 the phenolics composition of the different clones at harvest can be seen. Merlot, Shiraz and Cabernet Sauvignon clones showed the largest differences regarding the mg anthocyanins per berry. Concentrations varied between 0.82-1.30 for Merlot, 1.22-1.43 for Shiraz and 0.66-0.97 mg/berry for Cabernet Sauvignon clones respectively. However, one should also measure the mg anthocyanins per g berry, as the size of the berry can obviously also plays a role here. Here Merlot and Shiraz showed the largest variances. Under these conditions Pinotage showed to had the highest amount of anthocyanins of the cultivars tested. Differences were also observed between the total phenol content of the different cultivars and clones, with certain clones having a total phenol content of more than 0.9 mg/g berry. Average anthocyanins values of 1.03 mg/berry and 0.79 mg/g berry and average total phenol values of 1.3 mg/berry and 0.98 mg/g berry has been found in a large survey of anthocyanin and phenol values of red grapes in the Robertson area. Surprisingly enough certain Cabernet Sauvignon clones showed lower values than some of the other cultivars in this study.

TABLE 2: Certain grape phenolic analyses performed on the different clones at the time of harvest.

Cultivar	Clone number	A mg/ berry	A mg/g berry	TP mg/ berry	TP mg/g berry	Total tannins (mg/L)
Pinotage	PI45M	1.3	1.16	1.3	1.16	502
	PI48H	1.35	1.17	1.25	1.09	538
Merlot	MO45B	0.82	0.66	1.09	0.88	460
	MO184C	1.04	0.71	1.31	0.9	509
	MO346B	1.03	0.8	1.17	0.9	472
Shiraz	SH1C	1.43	0.97	1.41	0.96	521
	SH12C	1.22	0.84	1.23	0.85	431
	SH470C	1.38	0.87	1.42	0.9	439
Cabernet franc	CF212C	0.81	0.58	1.21	0.86	539
	CF213B	0.78	0.57	1.1	0.81	561
	CF214B	0.85	0.65	1.13	0.85	506
	CF623B	0.85	0.62	1.24	0.91	529
Cabernet Sauvignon	CS37C	0.66	0.52	0.83	0.65	369
	CS163O	0.77	0.64	0.94	0.78	510
	CS191B	0.97	0.65	1.22	0.81	479
	CS338B	0.95	0.66	1.16	0.8	458

Regarding the tannin concentrations Merlot, Cabernet Sauvignon and Shiraz clones showed the largest differences, with certain clones having much lower total tannin concentrations than others. We also used a novel method to determine the total tannin concentrations in the grapes, which was recently published. In an Australian study, using this method, tannin levels of red grapes were 350-600 mg/L, which correlates with those that we found in this study.

In certain cases lower or higher concentrations of grape anthocyanins and grape tannins were reflected in the corresponding wines as well (Table 3). This led to certain clonal wines having different colour densities, which was especially the case in the Shiraz and Cabernet Sauvignon clonal wines. Generally colour density values of 0 to 6 OD units would described a light colour wine, between 6 to 10 OD units are described as medium red colour and > 10 OD units as deep red. Certain Shiraz and Cabernet Sauvignon clones had the highest colour densities, with Pinot noir having the lowest. Sometimes the colour density of SA young wines can range between 7-20 OD units.

Colour hue did not differ dramatically between the cultivars, with the Pinot noir wines having the highest hues. This could be due to these wines having lower red colour, which led to a higher hue value (420/520nm). The colour hue of young wines is normally 0.5-0.7 and those of older wines 1.2-1.3.

This colour density measurement negates the bleaching effect of SO_2 and differences in pH. This is achieved by adjusting the pH of the wine to 3.6 and adding acetaldehyde to the sample for analyses. The two Pinotage clones tested did not yield large differences regarding the phenolic composition of the grape and corresponding wines. The Pinot noir clones also differed in terms of their colour and phenolic composition. Pinotage, some Shiraz clones

TABLE 3: Different colour and phenolic analyses performed on the different clonal wines.

Cultivar	Clone	Total phenols (wine) (OD)	Anthocyanins (mg/L)	Colour density (OD)	Mod. wine colour density (OD)	Wine hue	Wine tannins (mg/L)
Pinotage	PI45M	44	544	7.0	11.5	0.57	2016
	PI48H	44	563	7.1	11.8	0.57	1852
Merlot	MO45B	32	373	8.6	10.9	0.65	1426
	MO184C	33	344	9.1	11.0	0.61	1564
	MO346B	32	336	10.4	10.5	0.54	1385
Shiraz	SH1C	47	454	11.6	14.5	0.57	2134
	SH12C	33	340	9.6	11.4	0.53	1750
	SH470C	44	410	7.5	11.0	0.63	1746
Cabernet franc	CF212C	32	394	5.5	7.9	0.67	1206
	CF213B	29	348	5.3	7.0	0.65	887
	CF214B	32	383	6.6	8.3	0.60	1172
	CF623B	33	378	6.2	8.4	0.63	1176
Cabernet Sauvignon	CS37C	37	450	6.7	9.7	0.72	1556
	CS163O	41	436	9.4	11.5	0.62	2229
	CS191B	42	466	7.6	11.2	0.73	2138
	CS338B	41	458	7.7	11.0	0.71	2065
Pinot noir	PN 459	36	244	5.8	7.7	0.78	1411
	PN 667 A	37	256	6.5	8.2	0.74	1693
	PN 777 A	38	261	7.7	9.1	0.73	1674
	PN 52 C	35	265	5.9	7.8	0.74	1263

and Cabernet Sauvignon wines had the highest total phenol levels. Cabernet Sauvignon and Pinotage wines had the highest anthocyanin levels. The largest clonal differences regarding anthocyanin concentrations in the wines were found in Merlot, Cabernet franc and especially Shiraz.

The wine tannin concentrations were found to be the highest in certain Pinotage, Shiraz and Cabernet Sauvignon clones. Average values for Australian wines were observed to be 1540 mg/L, 1850 mg/L, 1970 mg/L and for Merlot, Shiraz, Cabernet Sauvignon, respectively. This correlates well with values obtained by us in this study (average values of 1458 mg/L for Merlot, 1876 mg/L for Shiraz and 1997 mg/L for Cabernet Sauvignon).

In Table 4 additional phenolic and colour analyses that were performed on the grapes can be seen. In Shiraz clone SH1C had a higher level of SO_2 resistant pigments, which is an indication of polymerization of colour pigments, which also corresponded with a higher colour density and levels of anthocyanins and tannins in the grapes and wine. Tannins can act as co-pigments, which is important for the colour of young red wine. In the Cabernet Sauvignon the SO_2 resistant pigments differed the most between clones CS37 and CS163O, with the latter clone having had the highest levels of tannins in the grapes and wine, indicating the importance of tannins in colour development. The largest difference between the fractions of CP, FA and PP (Table 4) were observed with the Merlot and Shiraz clones, with the other cultivars not showing large differences. Co-pigmentation is especially important for the colour of a young red wine. Total red wine pigments were the highest in certain Shiraz clones and in Cabernet Sauvignon. Under our conditions, more of the colour was in the red form (% of colour in the red form) in the Merlot, Shiraz and Pinot noir wines than in the Cabernet franc and Cabernet Sauvignon wines. This means that wines from the latter two cultivars had a larger "pool" of potential colour, which can probably develop further during ageing. Regarding clonal differences in of % of colour in the red form, the largest differences were observed with Shiraz and Pinot noir.

There was not always a direct correlation between the phenolic composition and the grapes and that of the wine, but in certain cases higher grape phenolics led to higher concentrations in the wine. This is probably due to extractabilities that differ between grapes, leading to different phenolic composition of the resulting wines. These wine values obtained are normal under SA winemaking conditions. These analyses were also only per-

TABLE 4: Colour and certain phenolic characteristics of grapes and corresponding wines of different clones (average of 5 grape samples and 3 wines for each clone).

Cultivar	Clone	SO_2 resist (OD)	CP	FA	PP	Total red wine pigments (OD)	% colour in the red form	Mod % of colour in the red form
Pinotage	PI45M	1.52	0.47	0.32	0.21	20	20	36
	PI48H	1.56	0.44	0.35	0.21	19	21	38
Merlot	MO45B	2.26	0.29	0.35	0.35	18	26	36
	MO184C	2.18	0.24	0.41	0.35	16	32	39
	MO346B	2.17	0.16	0.47	0.36	19	32	32
Shiraz	SH1C	2.88	0.30	0.38	0.33	23	28	39
	SH12C	2.42	0.21	0.44	0.35	17	33	40
	SH470C	2.19	0.24	0.42	0.34	24	17	27
Cabernet franc	CF212C	1.23	0.22	0.51	0.27	16	18	28
	CF213B	1.13	0.23	0.50	0.27	19	15	22
	CF214B	1.31	0.24	0.49	0.27	25	15	20
	CF623B	1.27	0.24	0.48	0.28	21	16	22
Cabernet Sauvignon	CS37C	1.78	0.27	0.41	0.32	26	13	21
	CS163O	2.38	0.22	0.42	0.36	34	15	19
	CS191B	2.05	0.25	0.40	0.34	28	14	21
	CS338B	2.03	0.27	0.40	0.34	33	12	18
Pinot noir	PN 459	1.57	0.31	0.31	0.38	9	32	46
	PN 667 A	1.72	0.29	0.32	0.39	9	37	50
	PN 777 A	1.8	0.24	0.39	0.37	9	44	54
	PN 52 C	1.31	0.34	0.35	0.31	12	25	36

SO_2 resist: SO_2 resistant pigments, CP: Fraction of colour due to co-pigmentation, Fraction of colour due to free anthocyanins, Fraction of colour due to polymeric pigments. Mod.: modified.

formed after malolactic fermentation, which also lead to lower phenolics concentrations in wine. This raises the need of additional research that must be conducted regarding the concentration of anthocyanins and tannins in wine and how this reflects in the wine.

It is thus clear that the phenolic and colour composition of clones of the same cultivar can differ. However, it must be stressed that these are preliminary results and differences between clones can be due to factors other than genetic ones, such as terroir and viticultural practices. It must also be kept in mind that other characteristics, such as yield, resistance to diseases and aroma compounds should also be kept in mind when choosing a specific clone.

ACKNOWLEDGEMENTS

Wintech for financial support and Johan Jordaan and Charles Visser for technical inputs

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Influence of the wine yeast NT 202 on the progress of malolactic fermentation

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Key words: Pinotage, Merlot, yeast, lactic acid bacteria.

Heinrich du Plessis

INTRODUCTION

In winemaking there are two important fermentation processes, firstly the alcoholic fermentation, conducted using yeast and secondly the malolactic fermentation (MLF), conducted using lactic acid bacteria (LAB). During malolactic fermentation, L-malic acid is converted to L-lactic acid and CO_2 (Lonvaud-Funel, 1995). Malolactic fermentation can occur spontaneously as a result of LAB that occur naturally, or it can be induced with commercial starter cultures. The most important reasons why MLF is required in South African wines, is the contribution it makes to the flavour complexity and microbiological stability of the wine. There are many factors that influence the growth of LAB in wine and therefore the progress of MLF; one of those factors being the wine yeasts used to perform the alcoholic fermentation, which may have an inhibiting or stimulating effect on MLF. Yeasts produce compounds i.e. ethanol, SO_2 and medium chain fatty acids that inhibit the growth of LAB. Both yeasts and LAB compete with each other for nutrients. Other yeasts produce compounds which may promote the growth of LAB and nutrients are also released during yeast autolysis (Wibowo *et al.*, 1985; Ribéreau-Gayon *et al.*, 2000).

The wine yeast, NT 202, is a product of the yeast development programme at ARC Infruitec-Nietvoorbij. It is not genetically modified and was initially released for the production of Pinotage wines. Since its recent commercialisation it has also been used for red wine production from other grape cultivars. The effect of NT 202 on MLF is not generally known, so the aim of this study was to determine what effect NT 202 has on the progress of MLF in red wine.

EXPERIMENTAL PROCEDURE

Wine was made from Pinotage and/or Merlot grapes from the Nietvoorbij experimental farm for three consecutive vintages. Nietvoorbij's standard, small-scale vinification techniques were used (Experimental Wine Judging Committee, 2003, 2004, 2005). NT 202 was compared with two other commercial red wine yeasts that are commonly used by South African winemakers (yeasts coded as A and B). The analyses of the wines after alcoholic fermentation are given in Table 1. These wines were used for the MLF trials. A variety of commercial LAB cultures, i.e. Viniflora oenos, Viniflora CH 35, Viniflora CH 16 (Lake International Products), Lalvin 41 (Lallemand) and a treatment where MLF occurred spontaneously, were investigated. The progress of MLF was monitored using paper chromatography and chemical analyses confirmed that it was completed.

RESULTS AND DISCUSSION

In 2003 the progress of MLF was tested in Pinotage wines only. From Table 2 it is clear that the wines fermented with NT 202 completed MLF in a much shorter period than wines fermented with Yeasts A and B, respectively. Even the NT 202 wines that underwent spontaneous MLF completed MLF in a shorter period than the Yeast A and B wines that had been inoculated with commercial MLF cultures. The alcohol content of these wines was very high (Table 1) and may be the reason for the slow progress of MLF in the wines that had been fermented with Yeast A or B. Surprisingly, MLF was completed more quickly in the NT 202 wines which had a higher alcohol concentration than the Yeast A and B wines. Yeasts A and B are both established and often used in red wine production. Yeast A is known to inhibit MLF and Yeast B is considered to be a "neutral yeast", i.e. it neither inhibits nor stimulates MLF.

In 2004 the progress of MLF in both Pinotage and Merlot was investigated (Table 2). Yeast B was left out of the investigation because despite its "neutral" status, it produced results similar to Yeast A in 2003. As in 2003, MLF was completed in a much shorter period in both Pinotage and Merlot wines fermented with NT 202, regardless of the MLF treatment. The only exception was the Viniflora oenos treatment which completed MLF in 21 days in Pinotage wines produced with NT 202 and Yeast A, respectively.

In 2005 the focus was on Merlot exclusively, which is considered a difficult cultivar due to worldwide problems with successful induction and progress of MLF. Once again MLF was completed much more rapidly in NT 202 wines than in Yeast A wines. The spontaneous MLF treatment of the wines produced using NT 202 completed MLF at the same time as the wines that had been inoculated with commercial MLF cultures.

It is still unclear if NT 202 produced compounds that stimulated MLF or was just less inhibiting than the other yeasts. This matter requires further investigation. Winemakers should also note that the use of NT 202 may encourage the occurrence of spontaneous MLF, which could have a negative effect on wine quality.

RECOMMENDATIONS

If MLF is required in a red wine, a yeast strain such as NT 202, which is not inhibiting, should be used. NT 202 is especially recommended for alcoholic fermentation where the induction of MLF may be problematic, e.g. Merlot. For more information about the influence of other yeasts on MLF, the relevant yeast suppliers should be contacted.

ACKNOWLEDGEMENTS

Our gratitude to MLF culture suppliers (Lallemand and Lake International Technologies), the technicians at Wine Microbiology at ARC Infruitec-Nietvoorbij, as well as ARC and Winetech for financial support.

TABLE 1. Chemical analyses of Pinotage and Merlot base wines used in the MLF trials.

Yeast strain	Cultivar	Vintage	pH	Ethanol % (v/v)	Volatile acid (g/L)
NT 202	Pinotage	2003	3.98	15.9	0.57
Yeast A			3.92	15.7	0.48
Yeast B			3.84	15.7	0.47
NT 202	Pinotage	2004	3.86	14.5	0.38
Yeast A			3.84	14.8	0.32
NT 202	Merlot	2004	3.78	13.7	0.37
Yeast A			3.76	13.4	0.33
NT 202	Merlot	2005	3.51	12.5	0.19
Yeast B			3.57	12.7	0.19

TABLE 2. The progress of malolactic fermentation (MLF) in Pinotage and Merlot wines produced using different yeast strains.

MLF treatment	Vintage	Progress of MLF (days)					
		NT 202		Yeast A		Yeast B	
		Pinotage	Merlot	Pinotage	Merlot	Pinotage	Merlot
Viniflora CH 35	2003	35	ng*	74	ng	61	ng
Lalvin 41		35	ng	61	ng	61	ng
Viniflora oenos		35	ng	61	ng	64	ng
Spontaneous MLF		44	ng	>74	ng	>74	ng
Viniflora CH 35	2004	32	20	50	40	ng	ng
Lalvin 41		32	20	50	40	ng	ng
Viniflora oenos		21	20	21	40	ng	ng
Spontaneous MLF		35	39	58	47	ng	ng
Viniflora CH 16	2005	ng	27	ng	39	ng	ng
Lalvin 41		ng	27	ng	39	ng	ng
Spontaneous MLF		ng	27	ng	46	ng	ng

* nt – not tested.

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Summary

In winemaking there are two important fermentation processes, firstly the alcoholic fermentation, conducted by yeast and secondly the malolactic fermentation (MLF), conducted by lactic acid bacteria (LAB). During malolactic fermentation, L-malic acid is converted to L-lactic acid and CO_2. Malolactic fermentation can occur naturally or can be induced with imported commercial starter cultures. Malolactic fermentation contributes to the flavour complexity and microbiological stability of the wine. There are many factors that influence the growth of LAB in wine, one of those being the wine yeasts used to perform the alcoholic fermentation. Yeast produce compounds i.e. ethanol, SO_2 and medium chain fatty acids that inhibit the growth of LAB. Other yeasts can stimulate the growth of LAB by releasing nutrients during yeast autolysis. The wine yeast, NT 202 was originally selected for the production of Pinotage wines, but since its recent commercialisation it has also been used for red wine production from other grape cultivars. The effect of NT 202 on MLF is not generally known. The aim of this study was to determine what effect NT 202 had on the progress of MLF in red wine.

Results show that wines fermented with NT 202 completed MLF in a much shorter period than wines fermented with reference commercial red wine yeasts. This result was confirmed in both Pinotage and Merlot. The use of NT 202 also resulted in faster completion of spontaneous MLF. It is unclear if NT 202 produced compounds that stimulated MLF or was just less inhibiting than the other yeasts. This matter requires further investigation. Winemakers should also note that the use of NT 202 may encourage the occurrence of spontaneous MLF, which could have a negative effect on wine quality.

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Fructose utilisation by Anchor red wine yeast strains

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Key words: Fructose, wine yeast, glucose-fructose ratio.

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INTRODUCTION

Stuck and lagging fermentations are found periodically in wine industries. There are numerous causes, including incorrect choice of yeast strain, incorrect yeast rehydration procedures, incorrect temperature control during fermentation, inadequate yeast nutrition and high ethanol levels during the latter part of fermentation. Another reason may be an imbalance between glucose and fructose, especially near the completion of high sugar fermentations. During fermentation the glucophilic *Saccharomyces cerevisiae* preferentially uses glucose above fructose (Reed & Peppler, 1973; Margalith, 1981; Cason & Reid, 1987; Cason *et al.*, 1987) and if the glucose-fructose ratio (GFR) drops to below 0.1, fermentation can stop (Gafner *et al.*, 2000).

At veraison, glucose concentrations in grapes are normally higher than fructose concentrations (Boulton *et al.*, 1996). As grapes ripen, the fructose levels increase, with a concomitant decrease in GFR and overripe grapes have higher fructose than glucose concentrations (Amerine & Thoukis, 1958; Kliewer, 1965; Kliewer, 1966; Snyman, 2006). According to Kliewer (1965) ripe grapes are defined as being between 20° and 24°B. Above 24°B is considered overripe. However, today's modern winemakers in pursuit of optimal ripeness and fruity styled wines are redefining ripeness and often harvest grapes at higher degrees of Balling. The locality of the vineyard (terroir), viticultural practices and grape cultivar obviously play an important role in determining at what sugar level the grapes are ripe. Harvesting at high sugar concentrations presents additional challenges for yeasts with regard to osmotolerance at the start and ethanol tolerance at the end of fermentation. Higher ripeness in most cases translates to a lower GFR (Amerine & Thoukis, 1958; Ough & Amerine, 1963; Kliewer, 1965; Kliewer, 1966; Jolly, unpublished data, 2007). The GFR of grapes at harvest can range from 1.07 to 0.78 in the range of 16.4 to 27.0°B (Amerine & Thoukis, 1958; Snyman, 2006).

It was shown that fermentations starting with an initial lower GRF (*ca.* < 0.8) are at a higher risk of leading to a stuck fermentation (Jolly, 2007). Fortunately, strains of the wine yeast *S. cerevisiae* differ in their ability to utilise glucose and fructose (Cason *et al.*, 1987; Berthels *et al.*, 2004), so the correct choice of yeast will limit this risk.

The aim of this study was to evaluate a range of *Anchor Yeast* red wine yeasts for their ability to utilise high and low GFR musts at normal and high fermentation temperatures.

MATERIALS & METHODS

Laboratory-scale fermentations were carried out in 500 ml aliquots of previously frozen, non-sterile white grape must (21.5°B, 0.39 g/L volatile acidity, 3.17 g/L total acidity, pH 4.07) at an ambient temperature of 22° and 28°C, respectively. A yeast nutrient (*Nutrivin Super*, Anchor Bio-Technologies, Cape Town) was added at 0.5 g/L to all the must samples. Fructose (30 g/L) was added to a portion of the must to decrease the GFR from approximately one to below 0.8. The *Anchor Yeast* red wine yeasts (Table 1), one French red wine yeast (reference 1) and an *Anchor Yeast* white wine yeast, N 96 (reference 2) were rehydrated as per manufacturer's recommendations and inoculated at 20 g/hL. All the fermentations were done in duplicate and the fermentation vessels with tightly fitting fermentation caps were placed on an orbital shaker. Glucose and fructose analyses for determination of the GFR were done by Koelenhof Wynlaboratorium, Stellenbosch using an enzymatic technique. Residual sugar analyses were done according to the Rebelein method (SAWLA, 2002).

RESULTS & DISCUSSION

In this study the laboratory-scale fermentations mimicked commercial-scale fermentations. The placement of the fermentation vessels on an orbital shaker emulated the natural turbulence found in large fermentations as a result of the generation of CO_2 (Henschke, 1990). The tightly sealed fermentation caps ensured that no oxygen entered the fermentation vessels. The data presented in Table 2 shows that at 22°C the yeasts were able to ferment the normal GFR must to dryness (< 3 g/L sugar), but a few yeasts appeared to struggle in the low GFR must.

The yeasts were also able to ferment the normal must at 28°C. However, the yeasts were generally less efficient in fermenting the higher Balling/low GFR (fructose-added) must to dryness at 28°C. The higher fermentation temperature puts greater stress on the yeasts. In addition, it is most likely that ethanol also plays a role, as ethanol is more toxic at higher than lower temperatures (Casey & Ingledew, 1986; Van Uden, 1989). At 28°C the *Anchor Yeast* hybrid red wine strains (prefixed NT) generally showed better utilisation of sugar than the two natural isolates (WE 372 and the French reference yeast). The most suitable yeasts (with the least g/L residual sugar) for low GFR must at 28°C were NT 112 and NT 202. In these experiments, the low GFR was on average 0.77, which is a fairly extreme situation. Similar ratios have none the less previously been reported, particularly when grapes are harvested at higher Ballings (Snyman, 2006; Jolly, unpublished data, 2007).

It is also known that NT 112 can produce SO_2 under stress conditions (data not shown), which can possibly delay the onset of malolactic fermentation. This is an added bonus for situations where temporary inhibition of MLF is desired (e.g. micro/macro-oxygenation). On the contrary, caution should

TABLE 1. Yeasts used in this study.

Yeast strain	Yeast type	Application
NT 112	Hybrid yeast – *S. cerevisiae*	Red wine fermentation
NT 116	Hybrid yeast – *S. cerevisiae*	Red wine fermentation
NT 202	Hybrid yeast – *S. cerevisiae*	Red wine fermentation
NT 50	Hybrid yeast – *S. cerevisiae*	Red wine fermentation
WE 372	Natural isolate – *S. cerevisiae*	Red wine fermentation
French yeast[1]	Natural isolate – *S. cerevisiae*	Red wine fermentation
N 96[1]	Natural isolate – *S. cerevisiae*	White wine fermentation

[1] Reference yeasts

TABLE 2. Residual sugar concentrations after fermentation of normal[1] and fructose-added[2] grape musts at two different fermentation temperatures by a range of wine yeasts.

Yeast	Residual sugar (g/L)			
	22°C		28°C	
	Normal GFR (1.02)	Low GFR (0.78)	Normal GFR (0.94)	Low GFR (0.75)
NT 112	1.55	2.70	0.53	5.04
NT 116	1.04	4.73	0.90	15.05
NT 202	1.14	1.06	0.70	6.06
NT 50	1.21	1.54	1.09	10.47
WE 372	1.00	1.06	0.58	23.55
French yeast[3]	1.16	1.56	0.63	23.65
N 96[3]	2.63	7.11	0.77	16.07

[1] Normal must = 21.5°B.
[2] Fructose-added must = 23.6°B.
[3] Reference yeasts.

be taken when NT 112 is used for fermentations where a quick onset of MLF is desired. The NT 202 yeast, on the other hand, has been shown to stimulate MLF (H. du Plessis, personal communication, 2007) and this yeast is therefore recommended for grape varieties where MLF can be problematic, e.g. Merlot.

RECOMMENDATIONS

Based on the results of this study, it is recommended that for high sugar musts (above 24°B) and where a low GFR may be expected, fermentation temperatures should be lowered to limit the toxic effect of the alcohol on the yeast. For additional security the use of an *Anchor Yeast* NT hybrid strain is recommended.

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Summary

There are numerous causes of stuck wine fermentation. One of these is the imbalance between glucose and fructose (more fructose than glucose). A selection of *Anchor Yeast* red wine yeasts was therefore evaluated at two different temperatures to determine their ability to ferment musts with normal and a low glucose-fructose ratio (more fructose than glucose). It was shown that the normal must could be fermented at both temperatures, but the low glucose-fructose ratio must at the higher temperature led to incidents of stuck fermentation. Two of the yeasts i.e. NT 112 and NT 202 could ferment well under all conditions tested and are therefore recommended for use in situations where a low glucose-fructose ratio may be expected.

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New wine yeasts for South African winemakers

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Key words: Wine, yeast selection, yeast breeding, yeast evaluation.

Rodney Hart

INTRODUCTION

This project was started during a period when the local wine industry experienced a variety of serious fermentation problems. Problems with the locally selected yeasts could not be solved by turning to imported yeasts as many of these were not well adapted to local conditions. This Winetech/ARC funded project continues in spite of the fact that an extensive range of active dried wine yeasts (ADY) yeasts (local and imported) are currently available in South Africa. The ever-changing requirements of the dynamic wine industry cause many of the yeasts to fall short of the specific requirements of the winemaker thereby creating a need for new and better adapted yeasts. In the initial phases a comprehensive grape sampling and *Saccharomyces cerevisiae* yeast isolation strategy from different viticultural areas of the Western Cape was undertaken (Khan *et al*., 2000; Van der Westhuizen *et al*., 2000). Concurrent with this, the natural isolates, together with commercial strains, were used in a yeast breeding program resulting in 460 hybrid yeasts (Farmer, 2001). All the yeasts are currently in storage in the ARC Infruitec-Nietvoorbij yeast culture collection and gene-bank.

Ongoing consultations with the wine industry identified specific criteria for yeast development and seven yeasts (NT range) were developed and commercialised under licence agreement to Anchor Bio-Technologies. The yeast development program is still ongoing to satisfy the ever changing needs of winemakers who are continually striving to improve wine quality in an era of increasing competition. Changing market trends and new production technologies also dictate different wine styles and yeast development must keep pace with this.

Some of the areas currently receiving attention include yeasts suitable for the production of 1) aromatic white wines; 2) lower alcohol wines from grapes with high sugar content; 3) Stellenbosch region Chardonnay; and 4) brandy base wine. Current strategy is to select yeasts from the culture collection, evaluate them on laboratory-scale followed by evaluation during small-scale experimental wine production. This article highlights some of the progress made during the 2006 and 2007 vintages.

TABLE 1. *Saccharomyces cerevisiae* yeast strains used in this study.

Strain no.	Origin	Purpose
VIN 13[1]	Commercial strain (Anchor Bio-Technologies)	White wine
NT 116[1]	Commercial strain (Anchor Bio-Technologies)[2]	White & red wine
VIN 7[1]	Commercial strain (Anchor Bio-Technologies)	White wine
NT 50[1]	Commercial strain (Anchor Bio-Technologies)[2]	Red wine
D 47[1]	Commercial strain (Lallemand)	White & red wine
NT 2	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
NT 40	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
NT 51	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
NT 53	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
NT 54	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
NT 55	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
NI 5	Natural yeast isolate (ARC Infruitec-Nietvoorbij culture collection)	Red wine
NI 7	Natural yeast isolate (ARC Infruitec-Nietvoorbij culture collection)	Red wine
NT 239	Hybrid yeast (ARC Infruitec-Nietvoorbij culture collection)	White & red wine
JV 23	Natural yeast isolate (ARC Infruitec-Nietvoorbij culture collection)	White wine
HR 5	Active dried experimental yeast (Anchor Bio-Technologies)[2]	White wine
NT 117	Active dried experimental yeast (Anchor Bio-Technologies)[2]	Brandy base wine

[1]Active dried wine yeast.
[2]Developed by ARC Infruitec-Nietvoorbij.

MATERIALS AND METHODS

The yeast strains used in this study are shown in Table 1. The commercial yeasts served as reference yeasts in the respective sections of the study.

Laboratory-scale evaluations

The fermentation potential of the experimental yeasts strains were investigated in laboratory-scale (500 mL) fermentation trials. A previously frozen grape must was mixed thoroughly and aliquoted into fermentation vessels (750 mL glass bottles). After sterilisation (121°C for 20 minutes) 24 hour yeast cultures in YPD broth (Biolab, Merck) were inoculated (1% inoculum). Commercial yeast strains were included in the trials as references. Fermentations were conducted at an ambient temperature of *ca.* 15°C, and the CO_2 weight loss was measured and used to monitor the fermentations. The residual glucose was also periodically checked, by using ClinistixÒ (Bayer Corporation, USA), until the fermentation went to dryness (total residual sugar < 5 mg/L). All fermentations were done in duplicate and strains meeting the specific selection criteria were used in subsequent small-scale (20 L) winemaking trials.

Small-scale winemaking

The grapes used for vinification originated from the ARC Infruitec-Nietvoorbij Farm vineyards and the chemical analyses of the base must are shown in Table 2. The wines were made in duplicate according to the standard Nietvoorbij cellar method (Eksperimentele Wynbeoordelingskomitee, 2006, 2007) with the exception that the yeasts were inoculated as wet cultures (24 h cultures in YPD medium at 2%) after the respective yeast suspensions were allowed to acclimatise. The active dried experimental yeasts (ADEY) were rehydrated in the way specified for VIN 13 commercially. Fermentations were conducted at an ambient temperature of 14°C and 24°C for the white and red wines, respectively.

Chemical and sensory evaluation

The wines were subjected to sensory and chemical analyses upon completion of fermentation trials. Chemical analyses included total SO_2 (Ripper method, Cape Winelab [Pty] Ltd., Stellenbosch; Integral Bio-Tech Laboratory [Pty] Ltd., Paarl); volatile acidity, residual sugar and alcohol (Winescan method, The Institute for Wine Biotechnology, Stellenbosch University). Descriptive sensory evaluation was done by different panels consisting of seven trained wine tasters five months after production. A ten centimetre unstructured line scale was used and the judges were asked to rate "fruity" and "vegetative"; "berry" and "plum"; "citrus/limey" aroma intensity (undetectable to prominent) for Sauvignon blanc, Pinotage and Chardonnay, respectively. All wines were also rated on general quality (unacceptable to excellent). The average values of the duplicate wines are reported.

Drying of experimental yeasts

Promising experimental yeasts were dried by Anchor Bio-Technologies, Cape Town in their pilot plant. These yeasts were subsequently evaluated in laboratory-scale fermentation trials and small-scale winemaking as ADEY.

RESULTS AND DISCUSSION

The process of developing yeasts by natural selection and breeding is time consuming. It starts with identification of industry needs and culminates with production of an experimental dried yeast that is then subjected to further evaluation (small-scale and/or commercial-scale). Feedback is received from various industry sources, including industry committees, yeast suppliers and representatives, as well as one on one visits with winemakers.

Screening of yeasts for the production of aromatic white wines

Yeast strains suitable for production of aromatic white wines from grapes of non-aromatic cultivars were identified as an industry priority (Karien Lourens, personal communication, 2004). As VIN 7 was previously recommended for use in neutral cultivars (Marais, 2005) and was also shown to have thiol releasing abilities (Swiegers *et al.*, 2006), the potential of hybrid yeasts descended from VIN 7 in this regard was investigated. Fermentation trials were conducted in Sauvignon blanc as this cultivar has been shown to produce grapes with aroma-inactive, non-volatile, bound thiols (imparts guava aromas) that can only be released by wine yeast during fermentation (Swiegers *et al.*, 2007).

The eight selected VIN 7 descendants i.e. NT 2, NT 40, NT 46, NT 51, NT 52, NT 53, NT 54 and NT 55 represent the most promising based on standard chemical analyses following laboratory-scale screenings in 2005 (data not shown). The small-scale wine production trials done in 2006 were with Sauvignon blanc grapes from a vineyard that did not historically deliver grapes with strong cultivar characteristics. These grapes were chosen so that the impact of the yeast on the wine aroma could be more clearly noted. Indications were that only NT 54 and NT 55 were able to produce wine equal or better than that of the references based on chemical analyses (Table 3). Sensory evaluation indicated that, although these wines were judged to be of a similar general quality to the reference wines, the NT 54 wine was more vegetative, but less fruity than the VIN 13 and NT 116 reference wines, whilst the NT 55 wine was more fruity than the reference wines. The wines produced by the remaining experimental yeasts were regarded as being of lower quality (data not shown).

The trials were repeated in the 2007 vintage with the same eight yeasts and an additional two wine yeasts i.e. KC/7 and KC/9. The Sauvignon blanc grapes and reference yeasts used were as for the 2006 trials. The new yeasts (KC/7, KC/9) were previously isolated from the Constantia region known for good quality Sauvignon blanc wine.

The experimental yeasts NT 40 and NT 55 were able to produce wine equal to that of the references based on chemical analyses (Table 4). These results were complemented by the sensory evaluation results that showed that the NT 40 wine was more vegetative, but less fruity than the VIN 13, VIN 7 and NT 116 reference wines. In support of the 2006 results, the NT 55 wine was again fruitier than the reference wines. The wines produced by the remaining experimental yeasts were regarded as lower in quality (data not shown). As NT 55 showed potential for two consecutive vin-

TABLE 2. Chemical analyses of base must used for small-scale wine production trials.

Vintage	Cultivar	Analyses[1]		
		Sugar (°B)	pH	Total acidity (g/L)
2006	Sauvignon blanc	22.6	3.07	8.60
	Chardonnay	22.3	3.23	6.00
	Pinotage	27.1	3.27	7.60
2007	Sauvignon blanc	23.1	2.57	8.80
	Chardonnay	21.5	3.03	8.05
	Pinotage	25.8	3.70	4.50

[1]Analyses done by Cellar Laboratory, Nietvoorbij Experimental Cellar, Stellenbosch.

TABLE 3. Chemical and sensory analyses of 2006 Sauvignon blanc wine following fermentation by yeasts selected for the production of aromatic white wines.

Yeast strain	Chemical analyses[1]				Sensory analyses[1]		
	Total SO_2 (mg/L)	Volatile acidity (g/L)	Residual sugar (g/L)	Alcohol (%)	Fruity (%)	Vege-tative (%)	General quality (%)
VIN 13 (Reference)	80	0.34	3.57	14.19	44.93	37.64	45.57
NT 116 (Reference)	75	0.38	1.99	14.16	47.26	35.09	51.17
NT 54	58	0.31	2.59	14.10	40.92	42.17	48.00
NT 55	70	0.29	2.36	14.22	50.36	37.43	48.43

[1]Average values of duplicate fermentations.

TABLE 4. Chemical and sensory analyses of 2007 Sauvignon blanc wine following fermentation by yeasts selected for the production of aromatic white wines.

Yeast strain	Chemical analyses[1]				Sensory analyses[1]		
	Total SO_2 (mg/L)	Volatile acidity (g/L)	Residual sugar (g/L)	Alcohol (%)	Fruity (%)	Vege-tative (%)	General quality (%)
VIN 13 (Reference)	25	0.35	4.12	13.65	47.75	38.81	52.44
NT 116 (Reference)	27	0.42	1.92	13.73	52.49	48.38	58.24
VIN 7 (Reference)	44	0.63	2.39	13.73	50.06	37.69	44.44
NT 40	44	0.46	3.27	13.60	45.50	41.13	53.63
NT 55	36	0.36	2.03	13.73	49.81	37.31	50.94

[1]Average values of duplicate fermentations.

TABLE 5. Chemical analyses of wine following fermentation by yeasts selected for the production of lower alcohol Pinotage from higher sugar content grapes during the 2007 vintage.

Yeast strain	Chemical analyses[1]			
	Tot SO_2 (mg/L)	Volatile acidity (g/L)	Residual sugar (g/L)	Alcohol (%)
VIN 7 (Reference)	80	0.59	2.38	14.72
NT 50 (Reference)	71	0.43	1.92	14.61
D 47 (Reference)	58	0.45	2.08	14.67
NT 2	63	0.74	2.04	14.74
NT 51	75	0.53	2.16	14.73
NT 53	67	0.62	1.82	14.58
NI 5	62	0.46	2.08	14.67
NI 7	60	0.59	2.10	14.80
KC/7	50	0.47	2.02	14.86
KC/9	63	0.59	1.90	14.37

[1]Average values of duplicate fermentations.

tages this yeast is a good a candidate for further evaluations.

Screening of wet culture yeasts suitable for lower alcohol wine (< 14%) production

Climate change, together with issues of optimum ripeness and consumer preferences for lower alcohol wines presents challenges to the winemaker regarding wines, produced from grapes harvested at optimal maturity. These wines, usually produced from grapes with higher sugar content, have high alcohol levels (14% and above). Therefore, yeast strains suitable for the production of lower alcohol level wine from grapes with higher sugar content were identified as an industry priority. Low alcohol producing yeasts are also an international priority as was emphasised by a keynote speaker (Dr Vladimir Jiranek) at the recent 8th International Symposium on Innovations in Enology, Stuttgart (Gardner *et al*., 2007).

Genetic modification has the potential to create yeasts with lower alcohol production (Malherbe & van Rensburg, 2004). However, the South African wine industry will not easily use genetically modified (GM) yeasts due to the negative public opinion and the highly sensitive European export market that is largely against GM food products (Cape Winemakers Guild, 2006). The natural selection and breeding of yeast with lower sugar to alcohol conversion rates is therefore the only viable alternative. Simultaneously it will also enhance the natural, green image of wine. However, this path of yeast development will be difficult, since alcohol reduction might only be achieved in very small increments.

During a 2005 investigation into slow fermenters during small-scale Colombar wine production it was observed that three yeasts i.e. NT 2, NT 51 and NT 53 all produced wine with marginally less alcohol than the reference yeasts (D 47; CY 3097 [Lalvin, Lallemand] and VIN 13). In another investigation in 2006 a further four naturally isolated yeasts were also shown to produce wines with marginally lower alcohol than the reference yeasts. To investigate whether this observed lower alcohol could be repeated or was perhaps due to experimental error the yeasts were re-evaluated in 2007. Pinotage was again chosen for the trial and the resultant wines from 26°B grapes all had alcohol content below 15%. Unfortunately, only two yeasts showed promise i.e. KC/9 and NT 53 (Table 5).

As the experimental yeasts NT 53 and KC/9 both produced wines that were slightly lower in alcohol than the reference yeasts on two occasions, further investigation should be done. Although the reduction may be marginal, additional hybrid breeding and selective screening will now be conducted in an attempt to decrease the sugar to alcohol conversion rate in subsequent generations.

Stellenbosch region Chardonnay

Three yeasts i.e. JV 23, MCB C6, and TV 21 all natural isolates from Chardonnay grapes, were previously evaluated as wet cultures and shown to have potential for non-wooded Chardonnay production. They were subsequently dried by Anchor Bio-Technologies in their pilot plant. These yeasts together with three other ADEY i.e. NT 239, NW 3 and HR5 were used for small-scale winemaking during 2006. The chemical analyses of the wine making trials showed that only NT 239 and JV 23 produced wine equal to that of the reference yeasts (data not shown).

Sensory evaluation of the wines indicated that only HR5 of above-mentioned three ADEY produced a wine with a better Chardonnay (limey and/or citrus) character and more body than that of wine fermented by the reference yeast VIN 7 (data not shown). The ADEY i.e MCB C6, NT 239, JV 23 and HR 5 were re-evaluated in small-scale wine making trials during the 2007 vintage. NT 239, JV 23 and HR 5 produced wine equal to that of the VIN 7 reference (Table 6). The wine produced by MCB C6 was regarded as of lower quality (data not shown). As JV 23 has consistently been producing good quality wine in the active dried form over two vintages (2006 and 2007), the wine making trials were scaled up to pilot-scale (100 L) in 2008.

Brandy base wine yeast

Starting in 1996 twenty-two yeast strains developed by ARC Infruitec-Nietvoorbij were evaluated as potential brandy yeasts. Subsequent small-scale and large-scale fermentations, followed by small-scale, pilot-scale and large-scale distillations with accompanying chemical analyses identified one yeast with potential for the preparation of a good quality brandy. This yeast strain i.e. NT 117 was dried by Anchor Bio-Technologies and evaluated on commercial scale in fermentations and distillations carried out in 1999 and 2000 by a commercial brandy producer.

The distillates were matured in barrels and evaluated annually for three years. The outcome lead to a recommendation that this yeast receive further attention as an alternative to the existing brandy base wine fermenting yeast strains (Du Toit, 2004). The yeast was subsequently dried

TABLE 6. Chemical analyses of 2007 wine following fermentation by yeasts selected for non-wooded Chardonnay production.

Yeast strain	Chemical analyses[1]				Sensory analyses[1]		
	Total SO_2 (mg/L)	Volatile acidity (g/L)	Residual sugar (g/L)	Alcohol (%)	Lime/ citrus (%)	Body (%)	General quality (%)
VIN 7 (Reference)	47	0.51	4.08	13.00	46.75	52.69	48.38
NT 239	82	0.41	2.93	13.04	50.63	54.31	52.63
JV 23	76	0.45	1.49	13.04	57.94	57.63	59.50
HR 5	89	0.50	2.68	13.09	56.19	57.31	56.00

[1] Average values of duplicate fermentations.

again and evaluated in the 2005 season. A decision against commercialisation was taken, since NT 117 was found to be no better than VIN 13 and WE 372, respectively (G. Reid, personal communication, 2008).

GENERAL COMMENTS AND CONCLUSIONS

As discussed above, the different sections of the yeast development program are at different stages in reaching their specific targets. Some are far advanced e.g. brandy yeast and yeast for the production of aromatic wine, while others are only at the beginning stages e.g. low alcohol yeasts. Since 2004, seven experimental yeasts (JV 23, MCB C6, NT 239, NW 3, T 19, W 2 and NT 117) have been dried by Anchor Bio-Technologies. It is envisioned that NT 55 will be the next so that it can be evaluated on a larger scale in the near future. The evaluation of the yeast in the dried form is integral to the overall yeast development project. Promising yeasts in the wet form do not always dry successfully, or may not perform the same way once dried. Evaluations over vintages are also important to eliminate vintage differences in grape must composition.

Once an active dried yeast has shown its merit in the dried form during small-scale wine production, it needs to be evaluated by industry on a commercial scale. Here the willingness of the South African winemakers to test and evaluate new strains must be commended. Without this valuable input, no relevant decision on further development can be made. A decision on commercialisation will only be taken once feedback is obtained from industry. In the meanwhile, ongoing consultations with the wine industry will keep identifying new areas for yeast development so that the South African wine industry remains at the forefront regarding the most suitable yeast per application.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge:

- The Agricultural Research Council (ARC) and Winetech for financial support.
- The participants of the ARC Infruitec-Nietvoorbij experimental wine tasting panels.
- Anchor Bio-Technologies for pilot-scale drying of experimental yeasts.
- The winemakers of South Africa for input regarding wine yeast selection criteria.

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SUMMARY

This project was started during a period when the local wine industry experienced a variety of serious fermentation problems. Many of the local and imported active dried wine yeasts that were available to South African winemakers at the time fell short of the specific requirements. Consequently, a wine yeast development program was initiated at ARC Infruitec-Nietvoorbij that resulted in seven yeasts (NT range) being developed and commercialised between 1997 and 2004. This program is ongoing and currently various avenues of yeast development, as determined by the wine industry, are receiving attention. These include yeasts suitable for the production of aromatic white wines, lower alcohol wines from grapes harvested at high levels of ripeness, regional Chardonnay and a brandy base wine. Yeasts for each of these aspects are at different developmental stages and this article conveys some of the progress that was made during the 2006 and 2007 vintages.

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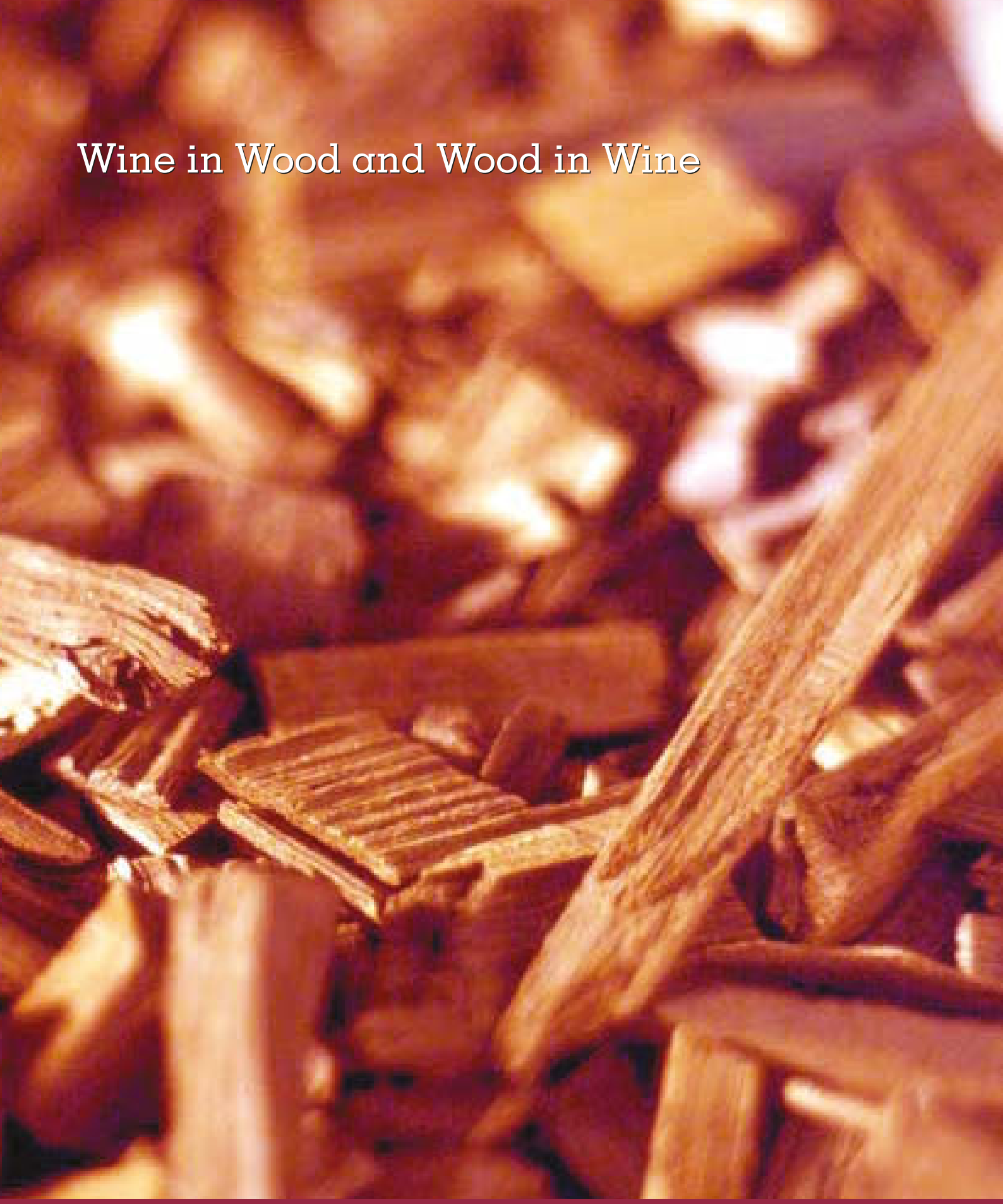
Wine in Wood and Wood in Wine



Series by: Charl Theron, Consulting Oenologist
Tim Rypstra, Professor in Wood Science
Jan Swart, Director, Wood and Fibre Institutute

Stellenbosch University

Selecting the right wood for a wine style

Charl Theron

The use of wood in vinification is like the use of spices in food. Both components play a role in the final product, some combinations don't work at all, while other combinations are complementary and produce a better product. Winemakers sometimes have to be prophetic in their predictions of what to expect from the final product, without being surprised by the eventual result.

As a consequence of the decisive role played by wood in the flavour and taste of wine, winemakers have to be very circumspect in the use of wood. To ensure that the desired result is obtained, the following steps may be taken:

1 The winemaker should decide which wine style is required. This decision will also be influenced by the policy of the cellar as regards wine price, target market, etcetera. Once this decision has been taken, the winemaker can decide which wood products if any have to be used for vinification, and whether it should be barrels or alternative wood products. Traditionally oak barrels are the source of wood flavours and tastes in wine, with oxygenation, wood extraction and concentration occurring in one container, which is moreover integral to the romance of wine. All the benefits of using barrels are seriously hampered, however, by the cost of barrels and limited use of space. In fact, the development of wood alternatives derived from these constraints. The alternative products are not only cheaper, they also reduce labour costs, wine losses and potential wine spoilage. The availability of different toasting levels in various wood alternatives enabled winemakers to manage the wood extraction from such products, however, despite being exposed to a wide range of products, winemakers encountered other problems. Few cooperages have the expertise or inclination to produce wood alternatives with the same dedication as barrels, the result being that several unreliable suppliers hope to serve the market on a price basis. Since it is a new technology, winemakers do not always have the expertise to use it correctly and moreover, wooden barrels still benefit from the romantic connotation.

2 Once a winemaker has decided whether to use barrels or wood alternatives, the detail specifications of the wood must be finalised. The origin of the oak, species, physical dimensions of the wood, grain density, particular cooperage, wood ageing and the toasting procedure are specifications that merit attention. All these specifications play an important role in the eventual quality or style of the wine, which is probably the most important factor to consider. It is therefore extremely important to evaluate wine sensorially on an experimental basis before finalising purchases of wood alternatives or barrels.

The reliability of the supplier is not negotiable. Only suppliers with a reputation of quality, sustainability, integrity and good client service should be considered. The establishment of a good relationship between the cellar and the cooperage is therefore essential.

Sensorial evaluation confirms desired or projected aims at the time of purchasing the wood alternatives, including the detail specifications mentioned above. The winemaker(s)' sensorial judgment is the decisive yardstick in this regard. The truth is that each wine has different wood requirements and there is no such thing as a universal product that is suitable for all wines (Murrell, 2007).

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The different alternative wood products

Ever since alternative wood products first saw the light a few years ago, various suppliers have shown great initiative in the development of new products and concepts. The more efficient use of wood has enjoyed high priority in this regard. StaVin is one of the brands offering an extensive range of products.

Although wood chips are generally held to be synonymous with alternative wood products, there are many other kinds of alternative products to consider for reasons such as capital outlay, logistics, labour or repeated use. StaVin's approach to alternative wood products confirms this approach because through a range of products they try to offer barrel alternatives without the disadvantages of using barrels. The StaVin range of products may be used for any stage of vinification from alcoholic fermentation to storage in wood. It consists mainly of staves, wooden chips, grains and barrel replicas. Different combinations of origin and toasting levels of the various products are possible. In order to keep the alternative products as close as possible to barrels, they are also committed to 3 years' drying in open air and the use of an open fire for toasting purposes. The dimensions of the staves have been optimised and a thickness of 10 mm offers the best toasting results. All products are packed in laminated foil bags to keep the wood fresh and prevent contamination from external sources.

Tank systems

Staves, chips or wood grains may be used in tanks. Staves may be used in various modular shapes in tanks to ensure optimal wood extraction. Chips or grains are usually packed in nylon gauze bags for easy handling and application. As a result of the bigger effective surface of the latter products, extraction also takes place more rapidly.

Barrel replicas

This product is basically a ministave system intended to extend the lifespan of barrels, provided the condition of the barrel is still good. It consists of a range of small staves in groups of three, bound together using nylon thread, and suspended from a stainless steel hook through the bung-hole in the barrel. Winemakers decide for themselves how much wood is required and the number of staves per barrel is determined accordingly. This barrel replica product compares favourably to the practice of shaving the insides of barrels for new wood exposure.

Micro-oxygenation

Since wooden barrels are porous, it follows that mixro-oxygenation should be used in conjunction with alternative wood products. More detail may be obtained on the website www.stavin.com.

Impact on colour tint and intensity

The tint (ratio of brown to red colour) and colour density of all wines treated with micro-oxygenation increased. On the other hand the tint and colour intensity of wines that underwent wood treatment without micro-oxygenation did not increase.

Colour stabilisation

Toasted oak products contain different aldehydes, which may promote the polymerisation of colourants, resulting in greater colour stability. Wood treatment on its own does not have such a marked influence as when it occurs in conjunction with micro-oxygenation (Boyer & McCord, 2007).

The various wood products discussed above are supplied by practically all suppliers of alternative wood products in similar or slightly amended versions.

REFERENCE

Bowyer, P.K. & McCord, J. 2007. StaVin - the alternative barrel alternative. The Australian & New Zealand Grapegrower & Winemaker, July 2007: 73 - 78.

This article is also available on www.winebiz.com.au.

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Using American oak of different origin

Winemakers have long been aware of the fact that French oak barrels of varying origins have a different influence on the wine that matures in them. When purchasing French oak it is mostly specified whether it should be Nevers, Vosges, etcetera and with coopers' transparency about the use of Russian or Eastern European oak, these have been added to the spectrum of origin. When using American oak, however, few winemakers specify the specific origin of the wood.

The South Australian winery, Step Road at Langhorne Creek, in collaboration with the Nadalié Cooperage, investigated the influence on wine of American oak from different origins, as well as different combinations. Hogsheads from Pennsylvania, Minnesota, Virginia and a combination thereof were used for the maturation of 2007 McLaren Vale Shiraz and 2007 Langhorne Creek Shiraz. The winemaker's observations of the different wood origins started at 6 weeks' maturation and the particular characteristics remained the same during maturation, but obviously became more prominent. The observations of the winemaker may be summarised as follows:

Pennsylvania barrels
- Prominent coconut character on the nose.
- Sweetness on the front palate.
- The wines become more full-bodied during maturation.

Virginia barrels
- Spiciness on the nose, with more prominent fruitiness.
- The taste is more structured and tends to make the tannins appear more dry.
- Will be beneficial in fruity wines, which require more body. Consequently it fared better with the Langhorne Creek wine, which is fruitier.

Minnesota barrels
- A more neutral wood character with spicy nuances on the nose.
- Smokey wood character on the palate.

Barrels of mixed origin
- Spice, cloves and coconut on the nose.
- The taste is more structured and sweet.
- It improves the middle palate with some sweetness on the front palate.
- It produced good results in both wines.

Except in the case of the Minnesota barrels, medium and medium plus toasted barrels were evaluated. In general the medium plus toasted barrels displayed a more prominent toast character, as could be expected, and consequently the winemaker preferred the medium toasted barrels, since the barrels showed up the wood differences. The different origins of the wood did not appear to have an influence on the toasting effect.

Upon completion of the investigation, the winemaker was convinced that he could be more specific in his wood requirements for different wines. Nadalié contends that their long, natural ageing process of the wood in America, before construction and shipping of the barrels to Australia, is a decisive quality factor. The wood is matured in high rainfall areas near the original plantations for 30 to 36 months. The leaching of the wood is therefore very intensive. They are also of the opinion that it makes sense for the entire manufacturing process to take place in America so as to have more control over the quality of the barrels delivered by them (Osborne, 2007).

Winemakers should note, therefore, that the purchase specifications of American oak products could be more detailed.

REFERENCE

Osborne, M. 2007. Oak trials instigated to create the right balance. The Australian & New Zealand Grapegrower & Winemaker, November 2007: 20 - 21.

Micro-oxygenation (Part 1)

The replacement of wooden barrels with alternative wood products, regardless of which kind, all have the same shortcoming, namely that unlike barrels, they do not make provision for slow oxygen uptake and consequently only enable the extraction of wood character. Micro-oxygenation addresses this shortcoming and will be discussed in a series of articles.

The following three aspects relevant to micro-oxygenation were studied in a research project in New Zealand:

1. The chemical and sensorial changes that take place during micro-oxygenation of wine at various dosages.
2. The influence of sulphur dioxide on tannin changes during micro-oxygenation of wine.
3. A better understanding of the micro-oxygenation process with regard to the influence of lees on oxygen uptake of wine and the relationship between oxygen particle size and the effectiveness of oxygenation.

Micro-oxygenation may be defined as the deliberate continuous, measured oxygen dosage of wine at various stages after alcohol fermentation until bottling of the wine. It was formally developed in France in 1995. The primary purpose of micro-oxygenation is the improvement of the sensorial qualities in a particular wine. Suppliers of the technology contend that it is able to soften the taste of the wine, improve the wine's colour, reduce the so-called green vegetative character of wine, remove reductive character from a wine and improve the mouthfeel of white wines that are left on the lees. Practice has shown that the sensorial development of wine goes through various stages during micro-oxygenation. The first stage is usually before the addition of sulphur dioxide and lasts from 3 days to 6 weeks with oxygen additions of 20 - 90 mg oxygen/litre wine/month. It is characterised by an improvement in the tannin structure of the wine. It usually goes hand in hand with a decrease in the yeast and cultivar aromas of the wine and the impression is created that the wine's quality has in fact deteriorated. The second stage is where the tannin structure of the wine reaches a peak and softens, while the cultivar aromas get stronger. The wine structure eventually decreases to a point where micro-oxygenation has to be stopped. Dosage during this phase which may last 3 weeks to 6 months, depending on the wine, is 1 - 10 mg oxygen/litre wine/month. The third phase, which should in fact be prevented, represents excessive treatment of the wine, which may result in the so-called dry tannins and oxidative character. Winemakers should take care to prevent this stage.

For the successful application of micro-oxygenation it is important that the tempo and dosage of oxygen application do not allow the accumulated oxygen concentration in the wine to increase. Should this be the case, it may be detrimental to the quality and long term potential of the wine. Depending on the type of wine and stage of treatment it may range from 1 - 90 mg/litre wine/month (refer to the original article for a table with detailed particulars).

It is generally accepted that wine polyphenols are the most important substrate for oxidation. Current research focuses on the nature of the tannin-anthocyanin interactions and the influence on the sensorial qualities of the wine.

Micro-oxygenation differs from normal aeration practices such as racking or aeration in that the dosage may be measured and controlled. Two methods are currently being used commercially for micro-oxygenation. Most common is the use of a micro-porous diffuser placed near the bottom in the middle of the tank. Oxygen bubbles moving upwards from below are dissolved in the wine. The dissolution of the oxygen is determined by the bubble size and density of the wine surface through which it moves. The use of high density polymer membranes as an alternative method has the advantage that bubbles do not have to be formed for the oxygen to dissolve in the wine. Large containers are consequently not necessary for dosage and wine flavourants cannot become volatile due to oxygen bubbles.

The next article looks at the influence of micro-oxygenation on wine composition and the influence of sulphur dioxide on micro-oxygenation.

REFERENCE

Dykes, Stuart & Kilmartin, Paul. 2007. Micro-oxygenation – optimising the maturation process. Wine Industry Journal 22(5): 31 - 44.

Micro-oxygenation (Part 2)

In the previous article in the series on micro-oxygenation the process was discussed in general. This article addresses the role of sulphur dioxide on tannin changes during micro-oxygenation.

The phenolic reactions in wine are able to modify tannins, break down existing tannins or form new tannins. The polymerisation or depolimerisation of tannins and anthocyanins (red colourants) may therefore exert considerable influence on the sensorial qualities of the wine. Traditionally winemakers have believed that the percentage composition of the different size condensed tannins which derive from grape seeds and skins depends exclusively on the degree of ripeness of the grapes. Condensed tannins are, however, unstable. Exposure to oxygen may cause various structural changes in tannins and anthocyanins, resulting in more stable products and ensuring improved colour intensity. The sensorial perception of astringency is caused by the reaction of polyphenols with saliva proteins in the mouth. The perception of astringency in a wine is mostly a negative sensation, which is blamed on the observation of insoluble substances that cause an unpleasant coarseness and dryness on taste (Zoecklein, 2007).

A distinction is made between micro-oxygenation before and after malolactic fermentation (MLF), but the relationship between the two is coincidental, since the change in the wine has more to do with the addition of sulphur dioxide than with the microbiological effect. Sulphur dioxide is presumed to have a significant effect on condensed tannins. An experiment was conducted to follow the tannin development in wine with or without the addition of oxygen or sulphur dioxide. The addition of sulphur dioxide is assumed to delay the formation of polymeric pigments and other condensed tannins, which may in turn influence the sensorial change during micro-oxygenation. Four treatments were given, namely no oxygen and no sulphur dioxide, no oxygen and 100mg/l sulphur dioxide, oxygen and no sulphur dioxide, oxygen and 100mg/l sulphur dioxide. Analyses were done to determine the reduction in colour intensity of the wine. The most evident results may be summarised as follows:

- The narrow correlation of the treatments where no sulphur dioxide was given. In both instances the colour intensity increased in due course of time.
- In instances where sulphur dioxide was given, the colour intensity of the wines was initially the same, but in due course the colour intensity improved in those wines that also received oxygen.

The results obtained using colour intensity readings were similar to those obtained with colour polymerisation analyses.

It seems, therefore, that the use of sulphur dioxide during the ageing of wine could have a bigger influence on the tannin development of wines than oxygen.

In conclusion, the results of the study showed that oxygen accelerated the chemical and sensorial development of wine. Increasingly large dosages will also accelerate the development process (Dykes and Kilmartin, 2007).

REFERENCES

Dykes, Stuart & Kilmartin, Paul. 2007. Micro-oxygenation - optimising the maturation process. Wine Industry Journal 22(5): 31 - 44.

Zoecklein, Bruce W. 2007. Current Theory and Applications Micro-oxygenation. Practical Winery & Vineyard 29(4): 24 - 33.

Cleaning and disinfection of oak barrels and oak adjuncts with high-power ultrasonics

The November 2007 edition published an introductory article about the use of ultrasonics to clean and disinfect barrels. This article develops the theme.

Storage of wine in barrels goes hand in hand with the deposit of tartrates on the inside of the barrels. Depending on the wine and barrel cleaning programme, the deposit might accumulate as much as 1 cm thick. As a result the wine will not be able to receive any exposure to wood, oxygen will not move through the pores of the wood to the wine and the deposit also serves as a breeding ground for undesirable micro-organisms. While a new barrel may enable the dissolved oxygen level in the wine to increase by 0.3 to 0.5 mg/l, the possibility is reduced to 0.1 mg/l if barrels are used 3 to 5 times. The barrels then simply become containers of wine. Current practice to clean barrels with warm water and/or chemicals is ineffective.

Barrels deriving from different size cellars, that were used for 3 to 5 years and cleaned with various temperature and water pressure treatments during that period, were inspected and the findings may be summarised as follows:

- The tartrate deposits in the barrels may be flat (up to 1 mm thick) or occur in blisters (up to 1 cm high).
- The deposits may range from soft to very hard, or crystalline to powdery.
- The flat deposits are firmly attached to the wood surface and do not flake when dried.
- Tartrate deposits occur not only on the dowel surfaces, but also in the croze of the barrels where the barrel heads fit into the dowels.
- The extent of the tartrate deposits in the cleaned barrels increases with repeated usage of the barrels.
- The effectiveness of the washing processes differed depending on the various interior surfaces of the barrels.
- None of the water treatments of barrels removed all the tartrate deposits from the croze.
- The cold and warm water treatment of barrels only removes the deposit on the wood surfaces, while that which occurs in the pores remains intact.
- Municipal water pressure was too weak to remove tartrate deposits from the barrels.
- Some staves that appeared clean visually, nevertheless had impregnated deposits in the wood tissue.

It appears that existing barrel cleaning methods do not efficiently remove tartrate deposits from barrels.

Various micro-organisms are adapted to surviving in wine barrels. Bacteria and yeasts are protected by the tartrate deposits occurring on the interior surface of wooden barrels and are therefore able to survive in the wood pores, so that wine pumped over into the barrels may be infected. Barrels infected with acetic acid bacteria or moulds are usually discarded, because these are difficult to remove from the wood pores. Biofilms constitute another form of barrel contamination. They are created when a liquid is in contact with an inactive surface and any microbial cells in the liquid attach themselves to the surface. Biofilms may occur on the surface of stainless steel tanks, for example, and therefore one expects them also to occur on barrel surfaces. Californian research showed that 50% of the Brettanomyces/Dekkera yeast cultures may form biofilms. Biofilms are far more resistant to biocides, chemical cleaning and sanitation agents. The influence of the formation of biofilm on the structure of barrels and the consequences thereof are unknown and the effectiveness of cleaning aids should be measured against their ability to break down biofilms. Ultrasound offers an effective method of creating stress factors for biofilm organisms and neutralising their attachment to the fixed surface. Brettanomyces/Dekkera spoilage of wines is a widespread occurrence throughout the world and has increased dramatically over the past 30 years. The insufficient sanitation of wine barrels and increase in the second-hand trade in wine barrels are some of the reasons that gave rise to this phenomenon.

High energy ultrasonics is a powerful new aid to address the cleaning problems of wine barrels. Laboratory analysis has confirmed that this technology is able to kill Brettanomyces/Dekkera cells effectively. The application of high energy ultrasound to clean and sanitise oak barrels and oak adjuncts such as staves has the following cost savings potential for cellars:

- The elimination or prevention of microbiological spoilage problems.
- The constant, uniform cleaning of barrels.
- Reduction in the use of sulphur dioxide or other preservatives to restrict microbiological spoilage.
- The elimination of the use of dangerous chemicals.
- The simultaneous cleaning and sanitation of barrels.
- The possible extension of the barrel's lifetime.
- The use of environmentally friendly technology that does not result in runoff residue.

(Andrew Yap, Vladimir Jiranek, Terry Lee, Paul Grbin, Mark Barnes & Darren Bates, 2007).

REFERENCE

Yap, Andrew; Jiranek, Vladimir; Lee, Terry; Grbin, Paul; Barnes, Mark & Bates, Darren. 2007. Cleaning/disinfection of oak barrels/oak adjuncts with high-power ultrasonics. Practical Winery & Vineyard 29(4): 6 - 23.

Effective oak maturation of wine

The technology of wood maturation has changed considerably over the years. Cellars have become more particular about the specifications of barrels, the use of oak sources from Eastern Europe has become more transparent, the use and product variety of alternative oak products have increased considerably and the application of micro-oxygenation combined with alternative wood products has become the rule rather than the exception. In order to obtain clarity about the current status and future of oak in vinification, the Wine Industry Journal conducted a question and answer session with Australian and New Zealand cellars and cooperages, the gist of which is summarised in this article.

Cellars in Victoria, the Hunter Valley and Hawkes Bay, with individual barrel inventories ranging from 140 to 1 500 barrels, provided the following information:

- The barrels are mostly medium toasted French *barriques*. American barrels and *puncheons* are used for experimental purposes only. American barrels are used for Shiraz and Tempranillo especially. Wines from Italian cultivars such as Nebbiolo and Sangiovese are matured in old barrels to obtain the barrel's oxidative influence and not its wooden character. Sometimes the preference is for softer tannins deriving from barrels of which the dowels are bent through immersion in water. In general barrels are preferably made from wood with a fine grain.
- 80 - 100% of all red wines are matured in barrels, while a small percentage of white wines are matured in barrels.
- A wide variety of wine styles from different white and red cultivars are fermented and/or matured in barrels.
- If barrels are properly maintained they may be used for 4 to 15 years. If barrels are used for the fermentation of white wines only with subsequent lees contact and wood character is not important, they may be used for a very long time, unlike barrels for red wines, where the wood character is important, which can be used for shorter periods only. When cleaning barrels for recycling care should be taken to prevent excessive temperatures, which may result in undesirable coconut flavours in the wine.
- Barrels from Francois Frères, Sirugue, Mercurey, Demptos, Séguin-Moreau, Dargaud & Jaegle and Saury cooperages are most commonly used, although experimentation occurs with barrels from a larger variety of cooperages. Most important considerations when selecting a cooperage are oak quality, sustainability of oak quality, integrity and good craftsmanship.
- There has been a downswing in the use of new barrels for various reasons, namely a decrease in the emphasis on intense oak character, as well as for financial reasons due to the cost of new barrels.
- Alternative wood products are used only when cheaper wines are produced, but from a quality point of view barrels are still preferable. In the long term alternative oak products are unlikely to replace barrels.

Oak suppliers Oak Wine Barrels Cooperages 1912, Kauri NZ Ltd and Radoux Australia, representing various cooperages, gave the following replies, in a nutshell:

- Most cellars prefer French oak barrels. American oak does not constitute more than 30% and European oak, apart from French, not more than 5 %.
- Although the toasting level of barrels is a relative concept, the greater emphasis on fruity wines has resulted in an awareness that the toasting of barrels should contribute to rather than suppress fruitiness. The US market still prefers wines with an aggressive oak character.
- Cellar preferences for specific oak characters are addressed by aspects such as extended natural wood drying, barrel size, grain density, toasting level, improved toasting techniques and the bending of the staves through water immersion instead of an open fire.
- The use of wood alternatives instead of barrels is considered for cheaper wines only. Cellars would use barrels only if the price of barrels did not come into play.
- Australian and New Zealand winemakers also make wines for the international market and their focus when using oak in vinification does not differ significantly from other wine countries.
- More and more cellars are considering the use of larger barrels, which impart less oak character, but allow the same exposure to oxygen. Cellars are increasingly interested in using larger vats for fermentation.

REFERENCE

Anonymous. 2007. Oak users have their say on effectively ageing wine. Wine Industry Journal 22(6): 63 - 70.

This article is also available on the website www.winebiz.com.au.

What's up in the vineyard and cellar

Series by Charl Theron, Consulting Oenologist

Different methods of cold maceration in red wine making

Charl Theron

As with so many other products or practices in the wine industry, the development of cold maceration before alcoholic fermentation of red wines apparently also came about by chance. In Bordeaux, France, the temperature during the crush is obviously much lower than in South Africa, for example. As a result Bordeaux cellars often had difficulties with the onset of alcoholic fermentation. The subsequent extended skin contact at a low temperature before the start of the alcoholic fermentation resulted in softer, more flavourful wines, thereby converting the problem into an opportunity.

The cold maceration process before the alcoholic fermentation of red wines improves the acqeous extraction of flavour and taste components obtained from the skins, as opposed to the alcoholic extraction that occurs during alcoholic fermentation. As a result of the low maceration temperature the alcoholic fermentation is delayed and extraction from the skins limited. Wines made in this way generally have more fruit flavours, flavour and colour intensity as well as improved mouthfeel with less tartness.

Cold maceration usually occurs between 4 and 15°C for a period of two to seven days. Cooling of the mashed grapes may by achieved by a naturally low temperature, mechanical refrigeration or by using cryogens (hypothermic refrigeration). The latter method calls for the application of carbon dioxide (dry ice) or liquid nitrogen. If the cryogens are used at a very low temperature such as minus 5°C, the intracellular water of the grapes is frozen, which in turn causes the grape components to migrate from the fixed parts of the grapes as a result of the bigger volume. Fruity, dark coloured wines with increased resistance to oxidation are thus obtained.

Initial research into this topic in Italy in 2003 resulted in the development of the Boreal liquid carbon dioxide cooling system for must chilling. As an outflow of that research it was claimed that the quality of the wine is determined by various factors such as the ripeness of the grapes, the use of oxygen, temperature, maceration techniques and fining methods. By varying these different factors, the quality profile of the wine can be adjusted to comply with specific market requirements.

The Boreal system of refrigeration involves an inline juice cooling system which uses liquid carbon dioxide and is able to chill 40 tons of grapes per hour to 5°C. This system was patented by Air Liquide. The system has several advantages:

- The heat exchange of the system takes place through direct contact, thus ensuring minimal release of residual gases. Mechanical cooling contributes 60 to 70% of a cellar's energy consumption, which obviously impacts on the emission of carbon dioxide into the atmosphere. By using the Boreal system, the routine mechanical cooling management of cellars can be reduced significantly.
- Seeing that the heat exchange and carbon dioxide emission takes place in the same container, the chilled juice may be released without carbon dioxide.
- Pressure is variable and the installation of pumps for liquid transfer is therefore eliminated.
- It is computer controlled and may be installed inside or outside the cellar depending of the placement of the crusher.

The Boreal system was initially evaluated in Italy, but subsequent evaluation took place in France, the USA and Spain from 2002 to 2006. The observations of winemakers in the respective countries over this period may be summarised as follows:

- The system is consumer friendly and does not require additional or specialist labour.
- It is more expensive than mechanical cooling, but requires less tank space.
- More wine aroma and increased oxidation resistance are obtained and the system is recommended for a quality improvement programme (Allen, 2007).

REFERENCE

Allen, D. 2007. Pre fermentative cryo maceration. Australian & New Zealand Grapegrower & Winemaker, August 2007: 59 - 64.

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Automation of the red wine fermentation process

Skin contact before and during the alcoholic fermentation of red wine is a given except when using thermovinification, in which case the heat benefits extraction from the skins. Traditionally the mixing of the juice and skins in red wine vinification has always required a considerable amount of manual labour and late working hours, whether this took place by means of racking or punching down. Cellars therefore had no option but to consider automatic methods.

Various types of new equipment have been developed to facilitate the red wine fermentation process. This includes inter alia the stacking of tanks, the programming of racking or juice/skin mixing, the use of tanks with sloping bottoms that facilitate cleaning or the removal of grapeseeds, or tanks designed for the installation of wooden staves. The most revolutionary development is probably the use of compressed air to favour the mixing of the juice/skins. Although this principle was first used in the USA in 1985, its popularity dates from 2001.

To impart a French connotation to the technique, it is referred to as pneumatage and it can obviously be seen as a replacement for two other well-known French techniques, namely pigeage (punching down of the skins) or remontage (racking and aeration). The following method was used to develop the technique: a standard steel pipe that reaches below the skins layer, is attached to an air compressor and the pipe is attached to the lid of the tank using a three-piece. The air supply through the pipe may be programmed, and when the air moves through the pipe a huge air bubble is created that rises up towards the surface of the skin crust, which it then breaks up, thereby ensuring that the juice and skins are mixed. The programme can obviously be adjusted to ensure different durations and frequencies of mixing.

The air to be used has to be purified. A standard compressor will have to be equipped with a filter and a piston compressor will have to be fitted with an oil filter. Air is preferable to nitrogen, since air will stabilise the colour and also promote yeast growth due to its high oxygen content.

There are various methods to break the skin crust. More and more fermentation tanks have slanted or cone shaped bottoms. This offers numerous advantages with regard to the cleaning of the tanks, vinification techniques and safety. Lees and grapeseeds settle in a compact substance in such tanks and are easily removed. The removal of the grapeseeds also reduces the so-called green character of red wines. It is easy to clean the bottoms of the tanks without the cellar workers having to enter the tank. Tank suppliers are able to offer different combinations of tank bottoms, pneumatage and stirrers, thereby giving winemakers various options. Labour may be significantly reduced and the resulting grapeseeds are so clean that they are preferred by the suppliers of grapeseed oil. The shape of the tank also plays a very important role in the vinification process. Conical tanks, the base of which is broader than the top, have a thicker skin crust and more contact with the juice. It is also easier to break the skin crust to improve juice/skin mixing. As a result of the smaller height/width ratio of the tank there is less pressure on the bottom of the tank, seeing that high pressure may hamper the activities of the yeasts. Although tanks have traditionally been round because fewer corners facilitate cleaning, they require a lot of space. At present it is possible to produce square tanks, which facilitates stacking, with rounded corners to eliminate the cleaning problems of the past (Falchek, 2007).

REFERENCE

Falchek, D. 2007. Automating the Fermentation Process. Vineyard & Winery Management, July/August 2007: 64 - 70.

This information is also available on www.vwm.online.com.

The influence of malolactic fermentation on the volatile composition of red wines

The most basic definition of malolactic fermentation (MLF) is the bacteriological conversion of malic acid to lactic acid, accompanied by a decrease in the total acid content and an increase in the pH of the wine. It is also known that MLF changes the mouthfeel and flavour profile of wines. However, very little detail is known about the latter.

The volatile composition of wine is influenced, inter alia, by the alcoholic fermentation, MLF and wood maturation. The former two processes are particularly influenced by the Saccharomyces and Oenococcus organisms respectively. It is common knowledge that Saccharomyces cerevisiae, which is mostly responsible for alcoholic fermentation, may form significant quantities of flavourants such as higher alcohols, fatty acid ethyl esters and acetate esters in the course of the process. Although it is generally accepted that MLF goes hand in hand with changes in the flavour composition of wines, knowledge about the factors that influence this process is limited. Considerable quantities of diacethyl, which is responsible for the buttery character in wines, are formed during MLF, but different esters may be formed during this process. MLF bacteria are also able to form flavour compounds from flavourless precursors and break down flavourants that are formed during the alcoholic fermentation. However, the bulk of the research on this topic has been done using model solutions and not wine.

Recently research was conducted in Italy on the indigenous red cultivar, Aglianico. Wines were fermented using Lallemand D47 yeast strain and four different MLF cultures were then used for MLF. The wines were matured in bottles for two months following completion of the MLF before they were compared. The four different MLF strains caused an increase in the quality of ethyl butanoate, ethyl hexanoate, ethyl octanoate, ethyl decanoate, acetate esters and ethyl-3-hydroxy butanoate during MLF. The latter compound is especially associated with the strawberry character of Pinot noir. MLF did not influence the quality of ethyl-2-methyl butanoate and ethyl-3-methyl butanoate, which play an important role in the flavour of red wines. Other volatile compounds that are formed during alcoholic fermentation, such as the qualities of higher alcohols and fatty acids, were generally not influenced by MLF. The quality of 3-(methylthio)-1-propanol, which is associated with the boiled cabbage character of wines and considered an off-odour in high concentrations, was increased during MLF by two of the MLF strains. In all instances the concentrations thus formed exceeded the detectable threshold value of the compound.

It has long been known that glycocidic flavour precursors are able to play an important role in the flavour of grapes or wine. The hydrolysis of such precursors may result in the release of terpenes and norisoprenoids, which may contribute to the cultivar character of wines. MLF bacteria are also able to effect this hydrolysis process. For example linalol, an important colourant, especially in white wines, and farnesol, an important flavour component of Tempranillo and Grenache grapes, both increased during the MLF.

The concentrations of two volatile phenols, 4-vinyl phenol and 4-vinyl guaiacol (which is also associated with Brettanomyces), increased in two of the MLF yeast strains during MLF.

In conclusion, research has shown that Oenococcus oeni has the potential to change the flavour profile of red wines during MLF through the flavourant formation of the bacteriological metabolism, or through the hydrolysis of glycocidic flavour precursors that derive from the grapes (Ugliano & Molo, 2007).

REFERENCE

Ugliano, M. & Molo, L. 2007. Malolactic fermentation and wine flavour: Changes in the volatile composition of red wine following malolactic fermentation with four commercial strains of Oenococcus oeni. The Australian & New Zealand Grapegrower & Winemaker, Annual Technical Issue: 53 - 60.

See website www.winebiz.com.au

Cross flow filtration

The clarification of juice or wine is one of the standard production practices at all wine cellars. Different fining agents, filtration aids and mechanical clarification equipment such as filters and centrifuges are available and depending on the size of the cellar and the composition of the product portfolios, winemakers must be sensible when selecting the most effective practice for their circumstances.

Cross flow filtration has been used in the food industry since 1960, but only really took off in 1980. At the time the technology was developed for a different industry and it was not even adapted to the wine industry. The wine industry experienced various problems with cross flow filtration. Different quality problems ensued because of oxygen uptake and increases in temperature that occurred during the winemaking process and wines were practically stripped of their character. Moreover, the equipment was difficult to operate and very expensive to purchase. As a result, the technique was used for low quality white wines only and not highly regarded by the wine industry. By 2000 it had practically disappeared from the wine industry.

The manufacturers of the equipment then started paying attention to the development of technology for the wine industry and membrane technology in particular saw vast improvements. Since 2005 it has featured increasingly in wine industries. Operating the equipment is now much simpler and the capacities of the units have been adjusted for use in different size cellars. Actual aspects such as labour, wine losses, difficulties with diatomaceous earth and filtration quality were addressed. The "new" cross flow filtration techniques are now able to execute any type of filtration from solids and tartrate stabilisation to volatile acid removal and yeast or bacteria removal. It is practically possible for plate and frame filtration to filter more fluids per unit surface, but the ability decreases considerably when the filtration progresses and the filtration medium becomes blocked. On the other hand there is no possibility of blockage in cross flow filtration. Most of the cross flow filtration systems have a nominal pore size of 0.2 micron which implies that 95 to 98% of the particles will be removed from the liquid using this or a bigger diameter. A so-called absolute specification of 0.2 micron implies that 99% of the particles will be removed.

The NTU reading of wine refers to the degree of opacity. With cross flow filtration an opaque wine with an NTU reading of 1 000 may be clarified to 1. It is a continuous process and the effective throughput exceeds sheet filtration by far, especially when filtering large amounts of wine. There are considerable labour savings since only one person has to initiate and arrest the process. Neither sheet replacements nor rinsing of sheets takes place, consequently losses are restricted to a minimum. The potential health hazards associated with the use of diatomaceous earth as a filtration aid, obviously contribute to the popularity of cross flow filtration among wine cellars (Pregler, 2007).

A cost comparison between cross flow filtration and diatomaceous filtration, done in Europe, is indicated in Table 1 (Human, 2007).

REFERENCE

Human, G. 2007. Personal communication.

Pregler, P. 2006. Crossflow Filtration Systems. Wine Business Monthly, July 2006: 36 - 41.

TABLE 1: Cost comparison between cross flow filtration and diatomaceous earth filtration (R) (E1 = R10)

Assumptions: 26.5 million litres of still wine, 140 000 litres of wine per day, 16 hours of filtration per day		
COST ITEM	CROSS FLOW FILTRATION	CIATOMACEOUS EARTH FILTRATION
Labour	83 600	334 400
Electricity	60 800	133 760
Water	3 990	7 980
Production material	43 680	707 160
Wine losses	39 750	140 000
TOTAL PRODUCTION COST	**231 820**	**1 323 300**
Filtration cost per litre	0.0087	0.0499
Capital amortisation cost per litre	0.0110	0.0070
TOTAL COST PER LITRE	**0.0197**	**0.0569**

Oxygen ingress in bottled wines

A wine that is bottled with different closures and filling heights develops into different wines that also age differently. An important cause of this phenomenon is that different bottle closures have varying oxygen permeability. The consequences for wine quality may surpass the influence of different viticultural and oenological practices.

Wine is exposed to oxygen at various stages in the course of the vinification process. The stages with the greatest possibility of oxygen exposure are during pumping over procedures, filtration and bottling of the wine. During the bottling process oxygen ingress may occur in the wine bin of the filling machine, or from the air in the fill space, or it may derive from the bottle closure. This article focuses in particular on the role of the bottle closure during the closing process of the bottle and afterwards. If a vacuum can be created in the fill space before the bottle is closed, the air may be expected to move into the fill space after the closing process; if the closure does not expand rapidly enough, or with compression of the closure, oxygen will move from it in various directions and especially to the lower pressure in the fill space.

After bottling and during storage of wine the most important source of exposure to oxygen occurs as a result of air moving through the bottle closure to the fill space. The Oxygen Transmission Rate (OTR) depends on the inherent oxygen permeability of the matter that the closure is made of, on the contact surface and length of the closure, as well as on the difference in oxygen concentration inside and outside the bottle. The OTR of long corks will obviously be lower than that of short corks as a result of the distance through which the oxygen has to diffuse, provided the cork is in close contact with the inner surface of the bottle over its entire length. The OTR values of bottle closures are usually expressed as ml/annum or mg/annum, but should actually be expressed as ml/bottles/annum and the closure and bottle neck details should also be specified. If OTR values are expressed per litre, for example, the value must be adjusted for different bottle sizes. For example, a value of 2ml/closure/annum is 2.7ml/l/annum for a 750ml bottle and 5.3ml/l/annum for a 375ml bottle.

The question arises how the OTR value of a bottle closure, if known, may be used. According to previous research oxidative characters will develop in a white wine if the free sulphur dioxide quality of the wine drops below 10mg/l. Theoretically, 1mg oxygen is able to react with 4mg sulphur dioxide. If one presupposes that the main reaction of the dissolved oxygen in the wine is with sulphur dioxide and that the free and total sulphur dioxide in a wine are not in equilibrium with each other, the following calculation may be made and conclusion reached:

Suppose a white wine with a low phenol content contains 30mg/l free sulphur dioxide after bottling with a bottle closure with an OTR value of 2mg/annum/closure, then:

- The annual sulphur dioxide loss = 2 x 4 = 8mg.
- If a 750ml bottle is used, the loss is = 8/0.75 = 10.7mg/l/annum.
- After 2 years the expected free sulphur dioxide quality of the wine = 30 - (2 x 10.7) = 8.6mg/l.

One can therefore expect the wine to start showing signs of oxidation after 2 years.

Up to now it has been very complicated to determine the OTR value of bottle closures. A chemical dye has been developed, however, that will indicate the extent to which oxygen penetrates the bottle by means of colour changes inside the bottle. This method has considerable potential for application in the wine industry (Skouroumounis & Waters, 2007).

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The use of computer software in the wine cellar

The use of computer software in the wine cellar has been widespread for some time. The vinification of wines from grapes, the treatment of the wine and the eventual packaging thereof constitute a production process that lends itself par excellence to monitoring with computer programmes. Yields, stock management, keeping of official records, reporting and traceability from the market are some of the aspects that may be successfully addressed by applied computer programmes. Many cellars do not have the necessary expertise to evaluate equipment before purchase and are consequently dependent on the integrity of suppliers.

Before reaching a decision about the purchase of specific computer software, the following questions should be answered:

1. The size, extent and activities of the cellar are important. Apart from the tonnage processed, it is also important whether the cellar processes its own grapes only or also grapes that are bought in. Is there a single cellar or different crush facilities that have to be served by the same network? Is the packaging of products handled by the cellar or contracted out? Cellars that also have spirits in their product portfolio will have significantly different requirements as regards the handling of the spirit.
2. The compatibility of new equipment with existing systems in the cellar or other divisions of the business is also important. Liaise with the financial and sales divisions to ensure that mutual benefits may be obtained from the network instead of developing an isolated system for the cellar.
3. Clearly define that which has to be measured. The quality of processed data depends entirely on the data that is fed into the system. Software is able to process, not create, data. A profit analysis of all the different actions in the logistics chain will most probably be essential for a wholesaler, but not for a boutique cellar.
4. The budget that is available for purchases is a key factor, but in this regard cellars shoud avoid a few pitfalls. It may be shortsighted, for example, to buy on the cheap, without taking into account future needs or other requirements in the network. The quotations from software suppliers also differ in format and are not easy to compare. A comprehensive analysis i.r.o. cost, services and benefits is therefore required. Licencing fees, technical support, service fees and hardware replacement should also be included in the analysis and the cost and benefits of the various suppliers be projected over a period of at least 5 years.
5. The functionality of the equipment also requires detailed investigation. Once again the various actions of the cellar in question will play a decisive role in the required functionalities. The viticulturist, winemaker or packaging manager will obviously each have a different focus on data required and once again care should be taken that the general needs are addressed. It is also important when the origin or treatments of specific products must be traced. Authorities throughout the world require more and more information about the use of spraying substances in the vineyard or vinification products in the cellar. Data that have been processed should not only have historical value, but should also be used for planning such as purchases and expansions. Care should be taken that the reports of processed data are in a consumer friendly format.
6. Make sure about client service and support offered by various suppliers. Fellow cellars are a source of information and even if their experience is different, it may shed light on certain issues.

Once all the questions have been followed up and a specific choice(s) made, the system in question must be operated using experimental data. The price of computer software is such that purchases cannot be finalised based only on presentations and product data, without any personal operating evaluation.

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Cellar sanitation

Sanitation is a non-negotiable practice in a wine cellar. The nature of wine creates a microflora that, given favourable conditions, may not only be detrimental to the quality of the wine, but also have far-reaching financial consequences for the cellar. Consumers no longer simply accept the final product without further ado, instead they demand that cellars adhere to the required quality standards and that they use acceptable effective sanitation products.

World consumption of wine is expected to increase by 6.2% from 2004 to 2009, while the market value will increase by 10.9% over the same period. Market growth will therefore occur in the premium sector which requires that cellars implement the best process quality control and sanitation practices.

In the past cellars mostly used chlorine products for sanitation. This was followed by a citric acid solution, which neutralised the former. Barrels were usually cleaned by first rinsing them with low pressure water, whereafter a rotating spray ball was used to remove lees and tartaric acid crystals. As a result of the relationship between chlorine and TCA (2,4,6-trichloro anisole), which is associated with a mouldy character in wines, many cellars have switched to cleaning aids that do not contain any chlorine. Ozone water is one of the alternatives to consider. Ozone offers high sanitation quality, time and energy savings, as well as reducing the use of chemicals. Ozone, the most effective disinfectant available, is broken down to elementary oxygen, without leaving any harmful by-products. Ozone may be used to clean barrels, surfaces, equipment, tanks and CIP (Cleaning in Place) systems.

Standard practice when cleaning healthy barrels with ozone usually entails a high pressure rinse with warm water, followed by a 2.5 dpm ozone water solution for 2 minutes. The ozone treatment of barrels does not impact on the composition of flavourants extracted from the barrels. As a result of the positive effect of ozone treatment on barrels, the second-hand price of such barrels is also higher.

Although ozone is the most popular non-chlorine based cleaning aid for the initial sanitation of wine tanks, many cellars use it for the follow-up rinsing of tanks.

The highest risk for contamination of wine is during the transfer of wine between containers, therefore large cellars are compelled to install CIP pipelines. This entails cleaning and sanitation of pump systems, tanks, rubber hoses, filters and bottling lines. If soap, solutions and chemicals such as chlorine or iodaphore solutions are used, several rinsing actions with warm water and steam are required to remove all residue. This requires large volumes of water and moreover exposes employees to dangerous chemicals. The use of ozone in CIP systems reduces both these disadvantages.

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This article is also available on the website www.winebiz.com.au.

Microbes in wine

Wine cannot be produced without microbes. Yeasts are required to convert grape juice into wine and malolactic bacteria may have a considerable influence on the taste and flavour of wine. It is unfortunately also true that undesirable microbes may occur, with detrimental consequences for the quality of the wine and potentially even spoilage. Although wine microbiology is one of the oldest disciplines in the wine industry, there is often confusion regarding the different microbes. This article presents an overview of the various microbes that may occur in wine.

As a result of the low pH of grape juice, most microbes are unable to grow in it. The formation of alcohol during the alcoholic fermentation process renders the growth environment for microbes even more unfavourable. Pathogens that are able to cause human disease are unable to survive in wine, only a few isolated yeasts and bacteria are able to do so.

Moulds may flourish in vineyards under favourable conditions, causing various vine diseases. In addition to extracting nutrients from the grapes, they are able to release the enzyme laccase, which, together with other compounds, may cause browning in juice and wines, eventually resulting in high sulphur dioxide levels. As a result of the physical damage to the grapes, it also becomes accessible to yeasts and bacteria that may have other negative consequences. Although it is unable to survive at alcohol levels above 0.5%, it is able to grow on wood or cork products, when trichloro anisole (TCA) may be formed which may end up in the wine through migration and impart a mouldy character. A mould such as Botrytis cinerea may have a beneficial impact on grapes under certain conditions, resulting in noble rot, which may be used to great advantage to make noble late harvest wines.

Yeasts may occur in the vineyard in various guises. Some may induce alcoholic fermentations partially or completely, or grow on the surface as a crust. The term "wild yeasts" that are often used for these natural yeast flora, may be deceptive as it may refer to any yeast that is not added to the juice or to all species apart from Saccharomyces. Kloeckera apiculata is the yeast species that most frequently occurs on grapes. It is resistant to low temperatures (10°C) and although normal levels of sulphur dioxide inhibit its growth, it is not eliminated. It is considered undesirable because it may form defective aromas such as ethyl acetate, amyl acetate and acetic acid as well as exhaust the nutrients required by desirable yeasts during fermentation.

Saccharomyces cerevisiae does not commonly occur on grapes, but is frequently found in wine cellars. The species is especially known for its ability to complete alcoholic fermentations. Stuck fermentations, however, may occur if there are stressful conditions such as high alcohol, nutrient deficiencies and temperature shocks etc.. The formation of undesirable sulphur compounds by this species is usually ascribed to nutrient deficiencies, spray residue and other causes. If these occur in wine with residual sugar after fermentation, secondary alcoholic fermentation may take place, which could have serious repercussions, especially in bottled products.

Zycosaccharomyces bailli is an osmotolerant yeast that may consequently occur in grape juice concentrate. It is also resistant to preservatives such as sulphur dioxide, sorbate and benzoate and may therefore cause secondary alcoholic fermentation in products that contain sugar.

Dekkera/Brettanomyces is commonly known as "Brett" and the various species differ considerably with regard to substrate and resistance to alcohol, temperature and sulphur dioxide. It was originally isolated from beer, but is widespread in all wine industries. Most strains form flavourants that have a significant influence on the flavour profile of wines. It is commonly described by flavour descriptives such as "sweaty horse" and "band aid". These yeasts are able to survive on the nutrient residue of other organisms and therefore they do not require significant amounts of res sugars. Widespread occurrence is possible in cellars or in bottled wines.

Aerobic yeasts or bacteria which require oxygen for survival, may also occur in cellars. *Candidia* and *Pichia* are the most common aerobic yeasts and may form acetaldehyde from ethanol. As both require oxygen for growth, they often occur as a crust on the surface of wine. Acetobacter or in other words acetic acid bacteria are the best known spoilage bacteria. Due to their aerobic demand, the exclusion of contact with oxygen is the easiest form of control. In the presence of oxygen they grow as a crust on the surface of wine, when the ethanol is converted to acetic acid and ethyl acetate, which is reminiscent of paint remover. Fortunately this reaction cannot occur in bottled wines, except when using a closure that is not airtight.

Lactic acid bacteria that occur in wine belong to three different genera, *Oenococcus, Lactobacillus and Pediococcus*. They are responsible for the conversion of malic acid to lactic acid during malolactic fermentation (MLF), but may also cause spoilage problems. High pH wines are usually preferred for growth; they may differ with regard to resistance to sulphur dioxide and they may also break down sorbate to products with a prominent geranium flavour. Oenococcus oeni is the species most favoured by cellars and used commercially to inoculate wines. This species grows at a lower pH and forms fewer off-flavours. Various Lactobacillus-species occur, differing in certain respects, but they can basically be divided into two groups, namely those which form acetic acid from the sugar in wine and those which do not. The latter species usually form compounds such as diacethyl (which has a buttery flavour), sauerkraut-flavours or biogene amines, but are generally not as harmful as the former group. The former group prefer pHs = 3.6, low sulphur dioxide and temperatures above 18°C. They usually occur in red wines. Under favourable conditions they may flourish during MLF, forming acetic acid from the fermentable sugars. The acetic acid thus formed may contribute to stuck fermentations. Pediococcus bacteria do not cause the formation of acetic acid, but may cause pentoses or malic acid turbidity in bottled wines as a result of the breakdown of residual sugars. A considerable increase in the viscosity of the wine, known as "ropiness", may also occur. Lactobacillus and Pediococcus species may also break down certain amino acids occurring in grapes or yeast, to biogene amines. Histamine is the best known and may cause headaches, hot flushes and other side-effects in sensitive persons. Several countries already have or are in the process of imposing regulatory limitations.

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This article is also available on the website www.vwm.online.com.

Different barrel washers

Barrels are washed for two particular reasons. The pore structure of barrels serves as a highly suitable habitat for micro-organisms and the effective washing of barrels is extremely important to ensure the desired barrel hygiene. To make certain that the wine remains in contact with the wood surface, deposits such as colour or tartaric acid crystals, must also be removed during the washing of the barrels.

The high capital cost of wood barrels induces cellars to follow best practices for barrel washing, so as to ensure the most effective use of the barrels. The use of chemicals has become unpopular with winemakers, who place a priority on wood integrity. Peroxide products that degrade spontaneously after application may be the exception to the rule. Barrel washers usually consist of a rotating spray head placed inside the barrel through the bung hole. Spray heads, detergents and washing conditions, for example temperature, differ and the various combinations thereof have to be taken into account when winemakers make certain decisions.

Depending on the size and requirements of the cellar, a decision should be taken regarding the amount to be spent on barrel washing equipment. The throughput tempo of the equipment is a determining cost factor. Some washing equipment also requires additional equipment, such as heating of water and ozone supply, which should be taken into account.

The basic goal of different barrel washers remains the cleaning of barrels, but the amount of mechanisation plays a significant role in the equipment on offer. The position of the spray head in the barrel also plays an important role and there are various options in this regard:

- The simplest and cheapest system is the so-called "peg leg" system in which a tripod or quadripod stand supports the spray head. It has been designed to wash a barrel with the bung hole pointing downwards, which means that manual labour is required to turn the barrel, place the spray head inside the barrel and switch on the washing process. As a result of the position of the bung hole, the wash water will drain from the barrel by itself.
- A vacuum condition may also be created inside the barrel to remove the wash water from the barrel without the bung hole being directed downwards, but the amount of water injected into the barrel must be the same as that which is removed from the barrel in order to prevent accumulation of water in the barrel.
- So-called "hand-truck" washers have the barrel positioned on a roller, which makes it possible to rotate the barrel so that the spray head may be positioned through the bung hole from the side. After the wash process the barrel may then be rotated to turn the bung hole downwards and the wash water will drain from the barrel.
- Semi-automatic and automatic equipment make it possible to remove barrels mechanically from stacks, place them on rollers for rotation and apply a wash cycle. Such equipment will obviously be expensive and can only be justified by large cellars.

The temperature of the water used by barrel washers plays a very important role. The removal of tartaric acid from barrels, for example, requires a temperature of 60 to 80°C, while it also plays an important role in the sanitation of barrels. As a result of the porosity of wood, barrels present a very suitable growth environment for undesirable microbes and moreover, wood is a good isolator and consequently a poor conductor of heat. From a practical point of view, it is therefore difficult to obtain effective sanitation in the wood. A distinction should be made between the sanitation and sterilisation of barrels. For example, if Brettanomyces is said to be killed at 80°C, one should also realise that this is only possible if that temperature is maintained for 30 minutes, an impractical option considering the above-mentioned characteristics of wood. Higher temperatures such as 100°C are undesirable as they may result in off-flavours in the wine. The use of steam is also an option. In addition to the high temperature of such treatment, a vacuum in the barrels, which is created by the cooling process, will be closed following the steam treatment, thereby extracting wine residue from the pores. The energy cost to achieve the specific temperature of the process is also a significant consideration.

The pressure and flow tempo is another important physical factor when washing barrels. The pressure during treatment ranges from 60 to 1 500 psi in different washing equipment, while the flow tempo ranges from 13.5 to 36 litres a minute. These two factors play an important role in the wash action of some spray heads and cellars will have to decide which specifications are preferable depending on their requirements. The effective removal of tartaric acid requires high pressure and temperature, for example. From a cost point of view the water consumption of the various systems will also have to be compared.

The possible use of ozone when washing barrels should also be considered. It is effective for sanitation but not for cleaning, which means that barrels must be cleaned sufficiently before using ozone. Ozone may be an irritant and should be handled as a hazardous agent. In order to penetrate the wood, it should preferably be used in gas format. Due to the cost involved, it is usually not an option for small cellars.

More information may be obtained on the websites www.sustainablewinegrowing.org or www.pge.com.

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Chemical risks in viticulture

The demands made by wine consumers and the distributors of wine such as retail chain groups have changed considerably over the years. In the past these demands were mostly product oriented, whereas nowadays the emphasis is increasingly on side-effects. Wine labels feature more and more warnings, there is a general awareness of conservation, wines are increasingly analysed for ingredients such as spraying residue and consumers also want to be reassured that the working conditions of farm and cellar workers are favourable.

Although there is a tendency to limit spraying programmes in the vineyard and organic and biodynamic approaches have become increasingly popular, chemicals are still used in vineyards to control certain diseases. The use of chemicals, however, goes hand-in-hand with certain risks. These include, inter alia, risks to human health, environmental and market risks. The potential risks have to be managed by vineyard managers.

Acute toxicity or chronic toxicity can be harmful to human health. The toxicity status of chemicals is usually indicated in degrees stated on the label of the container. Publications indicating the product data of various products are generally available. Chemicals currently used in vineyards cover a broad range of toxicities, from low in the case of sulphur to very high in the case of herbicides.

Although some labels and product data brochures provide information about the environmental impact of chemicals, information in this respect is limited and more research is required.

Australia has comprehensive information about the market risks of using chemicals. This may be obtained from the website www.awri.com.au or in the July/August 2007 edition of Australian Viticulture.

Simply being aware of chemical risks is not sufficient to address the problem. It is essential that risk assessments be conducted. By so doing the possible occurrence and extent of a threat is assessed and marks for both aspects are indicated on a 5-point scale. By multiplying the two numerical values, an evaluation value is attached to the threat. The higher the value, the more serious the nature of the threat.

After the evaluation process certain control measures may be initiated and implemented to prevent the extent and recurrence of the threat.

The following practical measures may be taken to limit the threat of risks:

- Sufficient training of operators
- Attendance of chemical risk management courses by management and technical personnel
- Develop and implement documented policies and procedures for the handling of chemicals and communicate these to all personnel
- Emphasise the importance of wearing safety equipment
- Conduct an official assessment of all existing and new chemicals
- Keep records of product data, training, policies and procedures
- Make provision for occupational health and safety operational and capital budgets
- Verify the usage prescribed and market requirements of chemicals before they are purchased and used
- Adhere to the prescribed safety periods of various chemicals
- Reduce unnecessary spraying of chemicals by taking into account weather conditions during spraying
- Calibrate spraying equipment regularly

REFERENCE

Wright, James. 2008. Managing chemical risk in viticulture. Australian Viticulture, January/February 2008: 81 - 82.

This article is also available on the website www.winebiz.com.au

Red wine fermentation in small barrels

Skin contact before, during and after the alcoholic fermentation of red wines is an essential vinification practice when making red wine. Various methods and techniques to ensure the effectiveness of this practice are constantly being investigated or developed. Besides adapting the construction of fermentation containers to implement a particular method, the role of the container has received very little attention.

Skin contact during the vinification of red wine traditionally takes place in stainless steel, cement or plastic tanks and various methods of punching down the skins or racking the juice are used to mix the juice and the skins. In recent years some wine cellars have begun filling small barrels with mashed grapes and using various methods of moving the barrels to facilitate mixing. The use of barrels for white wine fermentation is much older because obviously the absence of skins makes it much easier to do so.

The development of new equipment to handle the barrels has played a significant role in the use of barrels for red wine fermentation. As a result even 225 litre barrels are easily filled with mashed grapes and the barrels rotated up to 360 degrees to obtain mixing. It is a commonly held opinion that wines made in this way have a more integrated wood character, the grape tannins are softer, the fruit flavours richer and the colour intensity better than wines made in large containers. Apart from crushing of the skins, all the vinification processes from cold maceration until just prior to bottling are able to take place in the same barrel. The practice is used internationally, even at famous chateaux such as Lascombes and Beychevelle. The winemaker of the well-known Californian winery Beaulieu Vineyard ferments his flagship wine in small barrels and he is convinced that the resultant wine is more complex, the colour of the wine better stabilised and the tannins softer.

Obviously the practical feeding of the mashed grapes into the barrel and the subsequent removal of the skins and grape seeds are problematic; however, several solutions are possible. Tonnelerie Vernou, for example, foresees that their barrels, supplied in 900 or 1 200 litre capacity, will be fitted with a stainless steel entry port, equipped with a seal and pressure release valve (the 2008 prices of the two capacities are respectively US$7 000 and US$10 000). These barrels are mounted on rollers and the grapes can be fed and removed from the barrels either by gravity or by using a pump. The Vinification Integrale system, which supplies a wide range of barrels by Tonnelerie Baron, with capacities ranging from 225 to 500 litres, has a 150 mm entry port in one of the barrel heads with the bung hole serving as pressure valve. Some cellars find the filling and emptying processes too time-consuming and prefer to remove one of the barrel heads, then replacing it before or after juice/skin separation. Cold maceration may be applied for five to seven days, with the addition of dry ice and during the subsequent fermentation, juice/skin mixing may be achieved by turning it six times a day. To remove the skins one barrel head is removed and the juice separated from the skins with a sieve, where after the skins may be crushed.

The initial capital outlay and high labour costs associated with this practice must be weighed up against the following pros and cons before deciding in favour of its implementation:

- The juice/skin mixing of the system is much more effective than any punching down or racking system.
- The fermentation temperature is usually lower.
- The volatile acidity of the final wine is lower.
- The wines are softer and more aromatic, but their maturation potential remains unknown.
- The total vinification process is able to take place with minimal input from the winemaker.
- Excessive rotation may result in high lees percentages, thereby complicating crushing of the skins.

REFERENCE

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The retention of flavourants in white wines

The popularity and renown of wines from the so-called New World wine countries may be ascribed mainly to their fruitiness. Loss of flavour in young white wines particularly is disconcerting to South African winemakers and various practices are being adopted to address this problem.

The oxidation of young white wines usually occurs in two stages. Firstly a transformation process of the flavourants takes place, resulting in losses of the wines' unique flavour profiles. This is accompanied by the formation of other flavourants associated with maturation or spoilage. Secondly a browning process takes place. Wine contains numerous phenolic compounds; being anti-oxidants, these are able to offer natural protection against oxidation of the wine. It has been reported, for example, that caffeic and gallic acid are able to inhibit the flavour degradation of white and red wines during oxidative storage. Amino acids and peptides are also inhibitors of browning in a wide range of food products. Glutathione is one of the most active compounds in this regard.

Sulphur dioxide is commonly used as a preservative and anti-oxidant in the wine industry, but above certain amounts it may have a negative impact on flavour and some consumers with health problems such as asthma can suffer complications. The general trend is therefore to keep the sulphur dioxide levels of wine as low as possible.

A project was launched in Greece to determine how the use of caffeic acid and/or glutathione combined with sulphur dioxide impacts on the flavour concentrations of white wines during storage. A 2004 white wine made from Debina was used in the study. Debina is a late cultivar and the wines oxidise readily. The two different sulphur dioxide levels used in the study were 35 mg/l free and 143 mg/l total as opposed to 55 mg/l free and 166 mg/l total. Ascorbic acid at a concentration of 90 mg/l was a standard addition to all wines. The various caffeic acid and glutathione additions comprised 60 mg/l caffeic acid, 20 mg/l glutathione and a combination of 30 mg/l caffeic acid and 10 mg/l glutathione respectively. Wines were stored at 20°C in a dark room for varying periods of time.

Various flavourants were analysed over the different periods. The findings of the project can be summarised as follows:

- Wine samples with the two different sulphur dioxide levels have similar concentrations of flavourants.
- Sulphur dioxide apparently does not play a key role in the protection of flavourants during storage.
- he addition of caffeic acid and glutathione or combinations thereof prevents losses of several volatile esters and terpenes during the storage of wines with a lower sulphur dioxide content. This includes, inter alia, important esters such as isoamyl acetate, ethyl caproate, ethyl caprilate, ethyl caprate and linalol.
- The inhibiting effect of caffeic acid and glutathione on flavour losses can probably be ascribed to their anti-oxidant characteristics (Roussis *et al.*, 2007).

Caffeic acid and glutathione are natural ingredients of wine. Caffeic acid's ester, with tartaric acid and caphtaric acid, predominates in grapes. Glutathione increases to quantities of 2 - 5 mg/l with ripening of grapes and during fermentation. At present in South Africa none of these components may be added during vinification.

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A clean and green wine industry

Series by Charl Theron, Consulting Oenologist

Environmental concern

Charl Theron

Throughout the world environmental concern is no longer a topic for discussion by the so-called "greens" only. The impact of environmental changes has become so obvious that politicians, economists, several other professions and the general consumer also approach and "use" it as a focus point. The climate, a complex effect of the environment, is changing. Polar ice is melting, wind and rainfall patterns alter and sensitive eco-systems are under pressure. Wine industries too are unable to escape these realities.

If the activities of the wine industry, from viticulture to the supply of the finished product to the consumer, are taken into account, the impact on the environment may be enormous:

- Natural resources such as soil and water are indispensable for viticulture.
- Virgin soils are sometimes deforested and developed for expansion.
- Fertiliser is used for growth.
- Diesel driven equipment is used for cultivation or harvesting.
- Leaching of soil constituents in natural water resources may result from irrigation.
- Chemical weed control is applied at times.
- Chemical spraying programmes are used to control disease.
- Chemical preparatories are used during vinification.
- Large amounts of carbon dioxide are released during fermentation.
- Water is used for washing purposes in wine cellars.
- Detergents are used for sanitation in wine cellars.
- Liquid and solid waste are generated during vinification.
- Synthetic packaging material is used at times.
- Damaged packaging material has to be dumped.
- Fuel of fossil origin is used to transport products.

The list may be expanded even further, but the above will suffice to confirm how important responsible environmental management is from wine industries' point of view.

The debate surrounding this topic has coined terminology that was previously unheard of in the wine industry. The most important concepts are explained in this article.

Current use of fungicides, chemical herbicides and chemical preparatories in conventional agricultural and vinification practices disrupts the balance of all forms of life, which will threaten the sustainability of nature if it continues unabated.

The application of correct biodiversity principles aims to minimise the loss of threatened natural habitat in order to support sustainable production. In South Africa its application resorts under the Integrated Production of Wine (IPW) system. An industry initiative under the aegis of the Wine and Spirit Board, it is a system which uses Mother Nature to her full potential, with the least amount of human intervention. If implemented correctly, it may result in environmentally friendly production of wine (www.ipw.co.za).

Organic cultivation and winemaking maintain an ecological system approach which conserves natural resources and strives for biodiversity. It is applied by using mostly biological disease control, maximising the recycling of nutrients, regenerating the soil and eliminating GMO organisms, radiation, pesticides, chemical weed control and synthetic fertilisation (www.fetzer.com).

Biodynamic cultivation is another level of environmentally friendly cultivation that requires the addition of 1 to 100 grams of a catalyst per hectare, whereby an attempt is made to revive and maintain the cycle of the natural processes.

Global warming is the result of the increasing release of hothouse gases, especially carbon dioxide, methane and nitrogen oxide into the atmosphere, which may cause temperature increases of 2 to 3°C within the next half century. If prolonged, this trend may eventually result in the demise of the planet (Bonthuys, 2007). In 2000 the USA and South Africa respectively released 6 928 and 417 million tons of hothouse gases (in carbon dioxide equivalent) (Bonthuys, 2008).

The carbon footprint is the numeric valuation of the hothouse releases by countries, industries or individual instances, giving a comparative indication of their releases (Anonymous).

The water footprint is the second footprint left by humans. The carbon footprint initially received the bulk of the attention, but the latter features increasingly. Each individual can calculate his or her footprint by making certain assumptions. This obviously includes the total amount of water required to produce the finished product. One glass of wine, for example, requires 120 litres of water (Tempelhoff, 2008).

Subsequent articles in this series will discuss the various aspects in greater detail.

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Organic certification

The organic cultivation of wine grapes with a view to making organic wines is gaining increased prominence throughout the world. A wide variety of wines made from various cultivars, in different styles and by a number of countries, is commonly available. This, despite the fact that the primary producers of such products struggled to make ends meet. To foster the credibility of organic products, regulations have been implemented by several countries.

When purchasing organic wine, the consumer has to ensure that the product is certified as such and although differences exist among countries, organic certification should confirm that:

- No synthetic products such as pesticides, herbicides, fungicides or chemical fertilisation were evident in the vineyard, but rather only products with regulatory approval.
- No - or as few as possible - sulphites were added during vinification.
- No synthetic additives were used during vinification, only approved natural products.
- In the case of European products, these may not contain any genetically modified organisms (GMOs).
  (www.organicwineforyou.com)

When comparing the standards of the United States of America (USA) and the European Union (EU), there are slight differences, but the following requirements apply in both instances:

- Certification should take place by a third party.
- Annual terrain inspections and audits are required.
- Accreditation of the certification process is important.
- A sustainable farming plan must be submitted.
- Only approved production material may be used.
- The term "organic" implies that 95% of the product ingredients have to be organic.
- The term "produced from" implies that 70% of the product ingredients have to be organic.
- Transition periods for the changeover from normal to organic cultivation are defined.
  (www.ota.com)

Current EU wine legislation does not contain any definition for "organic wine" and consequently does not permit any such claim on wine labels. Prescriptions for the cultivation of organic grapes do exist, but all grapes thus cultivated are not necessarily certified as such. Labels claiming that the wine has been certified constitute a valuable guarantee for the consumer. Various deceptive labels and logos occur (www.morethanorganic.com). In Australia seven different instances certify organic practices. All of these are accredited with the Australian Quarantine and Inspection Service (AQIS) and International Federation of Organic Agriculture Movements (IFOAM). The basic requirements for accreditation may be summarised as follows:

- The soil should be managed in such a way that it contains sufficient minerals, constitutes a balanced source of nutrition for plants, retains moisture and is biologically active. Practices such as composting, crop rotation and green fertilisation are recommended.
- Pest control must be facilitated through biodiversity where some surfaces are not cultivated, to enable habitats for organic pest control.
- Weed control should be mechanical and not chemical, using methods such as beating, cutting, ploughing, heat treatment and sunlight.
- Diseases such as black spot, botrytis, oidium and downy mildew should be restricted through good hygiene practices, quarantine and cultivation practices. Copper, sulphur and trichoderma treatment are approved practices for the organic cultivation of vines.
- Practices should also be in place to restrict or prevent contamination of non-organic environments.
  (Austin, 2008)

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Organic viticulture

The production chain of organic wines starts with the cultivation of wine grapes. As several countries do not make provision for the use of the term "organic wine", but often only refer to wine from organic grapes, it is obvious that the organic cultivation of wine grapes plays a decisive and practical role.

In 2003 California had 7 940 acres on which certified organic wine grapes were produced, according to the Californian Department of Food and Agriculture. The National Organic Standards Board (NOSB) determines the standards of organic cultivation in the USA. Organic food and beverages can only be produced if most conventional pesticides, fertilisers that are produced from synthetic ingredients or sewerage sludge, bio-engineering or radiation, are not used. Organic meat, poultry, eggs and dairy products cannot be produced from animals that were fed antibiotics or growth hormones. The NOSB defines organic agriculture as "an ecological production management system that promotes and advances biodiversity, biological cycles and the biological activity of soil" (Robin, 2006).

The organic cultivation of grapes demands that viticulturists have sufficient knowledge of the interaction between the plant, the soil and the environment. Organically grown grapes are also said to contain more phyto nutrients, proteins and anti-oxidants. Sheep may also be allowed to graze in such vineyards so as to maintain the natural balance. The sheep eat the grass, multiply the microbes during the digestive process and transmit these to the soil. The production cost of organic grape cultivation is nevertheless higher and since the eventual wine consumer does not necessarily want to pay more for wines made from such grapes, this kind of viticulture is often not viable (Jones, 2008).

Producers of organic grapes must have an organic management plan to indicate how all practices on the farm are conducted in an organic manner. The practices indicated in the management plan have to be applied for a certain number of years before claims may be made on the label that the grapes are organic.

In Australia the permissible practices or products, together with their corresponding limitations, are tabulated thereby enabling a producer to draw up his production plan. For example, there are lists of permissible fertilisers, soil preparation methods and control products with prescribed limitations for pest and disease control. Hence straw may be used as a cover crop, but not for animal feed. Sewerage sludge may be used to irrigate trees, but not for food crops. Specifications for permissible products are prescribed and usually concern purity as regards the potential pesticide- or metal contamination thereof (Austin, 2008).

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The conflicting relationship between carbon footprint and poverty

The so-called carbon footprint grading of products according to the emission of hothouse gases during production or supply thereof to markets has become a topical qualification prerequisite for large supermarket chains. This clinical calculation gives rise to scientific and moral questions.

Environmental concern has infiltrated everyday life. People are increasingly involved in actions to conserve water, recycle and use fewer plastic bags, for example.

The wine industries of Australia, California, New Zealand and South Africa have collaborated to develop a method by which a winery may calculate its carbon footprint. The details may be obtained on the websites www.wfa.org.au or www.ipw.co.za.

The concept of food miles contributes to the carbon footprint of any product, as it implies the distance from the production locality to the eventual market. The further the required distance to transport the product, the bigger the carbon footprint. Depending on the particular production process, the importance of food miles may be overemphasised. Studies undertaken in the UK have indicated that the impact of food supply from industrialised countries on global warming cannot simply be compared to the food miles of countries that are far removed from the market. The carbon footprint of New Zealand dairy products, lamb and apples for example is four times smaller than similar products produced in the UK, even taking into account the transport, by ship, of those products to the UK. The same applies to the carbon footprint of flowers cultivated in Kenya and transported to the UK by air, which is only one fifth that of flowers cultivated in Holland in hothouses that require heating and lighting and are transported to the UK over a much shorter distance. Besides the fact that it may be unfair to boycott agricultural products from Africa based on scientific facts, the implications of such boycotts could have far-reaching effects for the workers who are directly or indirectly involved in the production of export products (Müller, 2007).

The same argument may apply to the South African wine industry. If South African wines are discriminated against based on food miles, the consequences for thousands of workers in the wine industry may be negative.

Obviously the question arises as to where one would find possible solutions. Besides feasible political solutions, the following aspects deserve attention:

- Labelling of products in such a way that the benefits of a reduced carbon footprint are emphasised in conjunction with the community benefits of the product in question.
- A move away from transport that uses more fuel and consequently impacts on the carbon footprint. Shipping transport should be adjusted to reduce the disadvantages thereof, compared to air transport. (Müller, 2007).
- The international wine sector should reduce the packaging waste that arises annually from wine. The use of environmentally friendly material and possible recycling of packaging material should enjoy preference (Merletti, 2008).

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The implementation by wine cellars of environmentally friendly procedures

Although wine cellars represent only one link in the production chain of wine, several input and output procedures that take place in the cellar impact enormously on the environment. By paying the required attention, a significant contribution can be made to attain a cleaner and greener wine industry.

When building a wine cellar, unconventional materials and concepts should be considered, for example more environmentally friendly and energy saving building material. One option is the use of rectangular straw bales that are sealed, or recycled material such as old bricks from buildings that have been demolished. By building subterranean cellars the cost of cooling can be reduced, so too the sensible placement and tinting of windows. Insulation of cellar buildings has a considerable impact on the cost of energy, but care should be taken to use the correct material that does not cause mould or damp.

Conventional energy supply in the form of electricity should be reconsidered. Sunlight energy is an alternative, the large roof surfaces of wine cellars being ideal. The use of ground water with a relatively constant temperature is another option, but it requires expert engineering and planning. Consumption and release of energy in cellars should be exchanged to prevent unnecessary waste.

The water consumption by cellars requires serious attention, without compromising the importance of cellar hygiene. Leaking valves, toilets, water pipes and hoses should be checked on an ongoing basis. Has provision been made for the water used to wash tanks, or is it used at random? What happens to rain-water from the gutters? Are cellars aware of their water consumption per litre wine produced, compared to other cellars? The use of cellar waste material, such as skins and grape seeds, for recycling should be continuously investigated.

In a large cellar the amount of carbon dioxide produced during fermentation is enormous and depending on the extent, processing it for recycling could be financially viable. About 20 years ago cellars paid dearly to recycle waste products such as cartons, paper and glass and consequently it was not even considered. The market benefits of such procedures should outweigh preconceived notions (Payette, 2008). Cork is a natural product with a very low carbon footprint that gives a marketing edge to those who sell and use it. With the necessary management it is also a sustainable industry (AMORIM Newsletter, August 2008). Oak barrels and oak alternatives can be recycled; they are biodegradable and popular with the gardening industry. Trees for cork production use carbon dioxide and release oxygen during photosynthesis. Glass bottles can be recycled and should definitely form part of a recycling, or renewable production programme.

Innovative practices such as those mentioned below have benefits that are often overlooked:

- It is much easier for cellars that implement green practices to obtain loans for such projects and it is quite possible that they pay less interest.
- By employing the electronic media for promotions and marketing, the use of paper is reduced.
- Environmentally friendly ink using a soya base helps the environment, but ensure that it can be reconciled with the paper of the labels.
- Deliveries can be reduced considerably if cellars collaborate and co-ordinate transport.

A balanced approach is necessary so that product quality is not sacrificed in the process. No consumer will be prepared to buy an inferior product simply for the sake of environmental conservation (Payette, 2008).

The information may also be obtained on the website www.vwm-online.com

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Wine Industry Network of Expertise and Technology
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