GrapeLinks
Viticultural Knowledge Management

Australian Government
Grape and Wine Research and Development Corporation

Benchmarking NE Victorian Shiraz
Season 04/05



REPORT

To GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

AUTHORS

Erika Winter, GrapeLinks Viticultural Knowledge Management, Consultant
Stephen Lowe, Stony Creek Vineyard, King Valley, Field Coordinator

Project Number: **RT 04/08-3a**

Principal Investigator: **Erika Winter**

Research Organisation: **GrapeLinks**
Date: 9.9.05

Contents

Abstract 2

Executive Summary 4

Background 9
Previous benchmarking work in the area

Material and Methods 12

Results
The sites 15
Climate, rainfall, vineyards

Wine assessments 21
Pointers to good wine quality

Young wine analysis 34
Correlations between grapes and young wine

Grape and vineyard analysis 41
Phenolics and other grape constituents
Phenolics and Berry Sensory Assessments
Phenolics and vineyard parameters

Anthocyanins and other grape constituents
Anthocyanins and BSA
Anthocyanins and vineyard parameters

Discussion 79

Conclusions and recommendations 85

Acknowledgements 87

References 88

Appendix 89
Data tables
Tab. 1 Vineyard information
Tab. 2 Wine assessment information
Tab. 3 Winemaking information to post ferment
Tab. 4 Young wine chemical analysis results
Tab. 5 Berry analysis results
Tab. 6 Evolution of berry traits results
Graphs Phenology of ripening and evolution of berry weights
Tab. 7 Berry Sensory Assessments results
Graphs evolution of BSA ripeness
Tab. 8 Bunch zone climate data
Tab. 9 Vineyard scoresheet

Abstract

A benchmarking study was carried out in 25 Shiraz vineyards in 5 regions of NE Victoria.
The aim of the project was to explore new ways of vineyard scoring and fruit quality assessments, to find common pointers for good grape and wine quality outcomes for a full bodied Shiraz wine style, to enable viticulturists and winemakers to change practice which may lead to better vineyards, better grapes and better wines and to raise issues for further surveys and research trials in NE Victoria.

New vineyard scoresheets designed by GrapeLinks placed greater emphasis on veraison measurements of vine balance, vigour, bunch leaf cover and leaf health as well as early cane lignification in order to give growers a chance for timely adjustments if needed. Berry Sensory Assessment (BSA) was carried out in all vineyards at approx.12.5 Bé and pre harvest by the field coordinator. BSA training was held for all growers involved. Electronic data loggers were bought by the growers and installed by the field coordinator in a representative spot of the vineyard in the canopy at the bunch zone for the observation of veraison to harvest daily bunch zone temperatures. Observations of phenological dates as well as information on location, slope, aspect, row orientation, trellis type, rootstock, clone, row and vine spacing as well as water management were collected. Berries from randomly taken bunch samples (separated into seeds and skins) were analysed for weights, anthocyanins, flavonols, total phenolics Bé, TA and pH by Myrrhee Consulting. Grape processing and fermentation data for the fruit was supplied by the relevant winemakers. Young wines were chemically analysed after fermentation. Five month old wines were judged by Nick Bulleid and a local winemaker. Extensive data analysis was performed by GrapeLinks.

Wine judgement showed that only the absence of bitterness, herbaceousness, harsh tannins and overripe aromas led to good overall wine scores, which could be reached by 9 out of 19 vineyards which had a large variation of vine balance, yields, as well as Bé, TA, berry size, colour and phenolics in the fruit at harvest. A low degree of cane lignification at veraison was a pointer to unripe fruit and unbalanced wine.
Good scores were observed in wines with grapes of moderately high temperature summation units from veraison to harvest (provided there were no bitter phenolics through petioles in the bin or over-extraction of unripe seeds). These vineyards had site adapted canopy management to result in warm bunches in the morning and no afternoon heat loads. Cooler sites were able to additionally use hangtime to increase temperature summations. The optimum temperature summation window for fruity aromas was relatively small – below which there were herbaceous aromas in the wine and above which jammy aromas were noted. There was a high positive correlation between bunch zone temperature summations and tannin softness rating up to 30,000 degrees from veraison to harvest, above which tannin softness dropped again.
The inexpensive temperature monitoring could be developed into a positive predictor system for grape quality. Research data are need to confirm the above findings and determine the optimum ripening temperature summations under various water regimes.

Several known negative pointers (lower wine scores when absent or low) could be drawn from young wine analysis and berry analysis, except BSA ratings of ripe skins which were a good positive predictor of tannin softness and BSA ratings for pulp aroma which when high correlated with high red and black fruit scores in the wines.
Total phenolics or colour in grapes were higher when bunch zone temperature summations were moderate but were less a predictor for wine scores than assumed in the literature. The relationship between colour and total phenolics in grapes was found over 2 years to be not linear and the ratio depended on the heat loads of the year and in the bunch zones, with anthocyanins being more sensitive to heat.
The very detailed survey showed that vineyards can reach higher grape phenolic, colour, mouthfeel and aroma potential in all regions and at all row orientations by innovative vineyard scoring including BSA and bunch zone temperature monitoring resulting in site adapted canopy management practices. If also harvesting and winemaking processes are adapted to avoid MOG and unripe seeds, wines of all regions can win at least bronze medal status.

Executive Summary

The project was carried out by

- A consultant (E. Winter)
- A field coordinator (S.Lowe)
- A field assistant (P.Blackshaw)
- A regional trainer (L. Campbell)
- Myrrhee Consulting (A. Buchanan)
- Bulleid Consulting (N. Bulleid)
- The King Valley Vignerons Inc.
- The participating growers and winemakers

Support was received from

- Grape and Wine Research and Development Corporation funding the project though the RITA program, and additional sponsorship through the KM fund.
- The Vineyards paying for the data loggers and BSA training.
- King Valley Vignerons Inc. with meetings and administrative work.
- The Centre, Wangaratta with the organisation of grower meetings.
- DPI Rutherglen with kind assistance with the veraison vineyard scoring.

The methods used were

- New vineyard scoresheets placing greater emphasis on veraison measurements of vine balance (*Winter and Whiting, 2004*), vigour, bunch leaf cover and leaf health as well as early cane lignification in 25 vineyards in 5 regions in order to give growers a chance for adjustments.
- New Berry Sensory Assessments of all vineyards at approx.12.5 Bé and pre harvest by the field coordinator.
- BSA training for all growers involved, by GrapeLinks (according to *Winter et al. 2004*).
- New data loggers in the bunch zone for the observation of veraison to harvest bunch zone temperatures (*Tinytag*, *Hastings, Port Macquarie*).
- Berry (separated into seeds and skins) chemical analysis for anthocyanins, flavonols and total phenolics at those two timings (*Myrrhee Consulting*).

- Bé, TA and pH as well as skin, seed and pulp weight of grapes.
- Observation of phenological dates and events and weather information for the regions.
- Information on location, slope, aspect, row orientation, trellis type, rootstock, clone, row and vine spacing, pruning and water management for each vineyard.
- Assembly of grape processing and fermentation data for the fruit from 23 vineyards.
- Young wine chemical analysis from samples after fermentation (*Myrrhee Consulting*).
- Assessments of 19 five month old wines by a Master of Wine *(Bulleid Consulting*) and a local winemaker.
- Extensive data analysis by a plant physiologist *(GrapeLinks).*
- Grower information assemblies before and after the duration of the project *(The Centre).*

The Background

The benchmarking surveys of Shiraz vineyards in Victoria started in Central Victoria in 20001/02 with follow-up surveys in 2002/03 and 03/04. The studies used a score sheet system developed and kindly made available by Southcorp. In 2003, three North East Victorian (Alpine Valleys, King Valley) Southcorp growers participated in that project. In 2004 a RITA project was undertaken by North East Victorian regions which allowed a greater number of growers and winemakers to participate, and encompassed all five G.I. regions. A summary of the outcomes of all RITA Shiraz benchmarking projects so far was undertaken by GrapeLinks and published in Australian Viticulture January/Feb 05. It was concluded that old myths of quality relevant vineyard practices did not hold true. Furthermore, to find relevant groups of quality pointers, new scoresheets were needed adapted to the findings of past years. Also quality pointers cannot be determined by general statistical analysis only. Cause-effect relationships must be established on single vineyard basis. Only this method leads to adoption of best practice for all and a chance for the realisation of the full potential for the resulting wines. Moreover, determining dependent variables requires physiological knowledge and time which has been spent to assist for the redesign of vineyard benchmarking in Australia.

The Challenge

The challenge of a benchmarking survey is the varieties of terroirs, climates, rootstocks, clones and plant arrangements. Management practice in the region is well advanced but shows differences and winemaking is very heterogenous.

Previous scoresheets mainly tracked down negative pointers to grape quality to lift management practices, in particular of new growers. With experienced growers and well established vineyards the challenge is to find pointers for good grape and wine quality independent of site and plant variability. As no identical winemaking was possible much information on winemaking was needed which again helped for the adoption of best practice from the vine to the wine.

The Reasoning underlying the new benchmarking system

Besides the necessary absence of negative specifications a prerequisite of grapes for good wines is that they are not only sugar ripe but also have a minimum of acidity left and ripe tannins and aromas as well as good colour.

In most Australian climatic conditions sugar ripening is not an issue – in the contrary, often sugar ripeness is reached well before aroma and tannin ripeness. Sugar concentration in grapes is largely dependent on the optimum conditions of the sugar factories (leaves) their active surface with respect to the weight of the fruit per shoot, competing sugar sinks and the availability of water to transport the sugar as well as the loss of water from the berries late in the season to the air or back into the plant.

Vine balance, young to old leaf ratio and leaf exposure check a big part of these prerequisites. This was included in the scoresheets, with particular emphasis on leaf health later in the season.

Tannin quantity cannot be easily measured thus grapes are normally assessed for total phenolics and anthocyanins as an indicator for tannin and colour potential in wines. It remained to be seen whether these values have the same importance for wine quality as in warm regions.

Tannin intensity and softness and aroma potential can be assessed in grapes by Berry Sensory Assessment which has been proven in France and lately in Australia to give a good correlation with wine potential. It was included in the scoresheets. Some sort of beery tasting is done by every winemaker, but the structured approach during BSA enhances the communication between growers and winemakers.

Aromas and aroma precursors in berries have been shown to depend on optimum temperatures to be produced (and also not to be lost). Temperatures may likewise be important in tannin development and ripening. Bunch zone temperature measurement is now cheap and accessible. It was to be established what the optimum bunch exposure is for each site to generate beneficial temperatures, and whether the aromas and tannins need different temperature optima for best expression in the wine.

The Results

We measured very many variables in vineyards, grapes and young wines. It generated many interesting correlations or trends. As every data point was pair correlated with other points which may be somehow physiologically related, the resulting flood of graphs was a one off attempt to distinguish the key factors and to avoid such work in the future. Combining vineyard data, photos, field coordinator observations, berry chemistry and the wine assessments some interesting things were noted.

Wine assessment (5 month old)

Wine was judged for overall score and different aroma and mouthfeel traits. As observed in the 2003 study using small batch winemaking, the correlation between high wine score and tannin softness and plum aromas was re- confirmed. In this assessment, the presence of nice fruit aromas and the absence of bitter, herbaceous and cooked fruit aromas was required for good scores. Colour and tannin intensity played a lesser role in the scoring, also due to the unfinished state of the wine.

Sugar concentration at harvest was insufficient as a predictor of wine score, slow speed of sugar accumulation however occurred in grapes used for wines with better wine scores.

TA at harvest was not a good predictor of wine scores, but slow speed of acid loss was seen as helpful for good wine rating.

BSA pulp aroma scores above 3 were a good indicator for good wine aroma potential if no mistakes were made in the grape processing.

If BSA ratings for skins show ripeness, tannins tended to be soft in the wine (if no petioles were is in the bin after harvest).

Most vines were in balance. Traditional vineyard measurements did not directly correlate with wine scores, including berry weights, except all wines with good scores had at least 40-60% of canes lignified at veraison and were not excessively leafy.

An indirect effect of vineyard management (fruit exposure and hangtime) is bunch microclimate. Good general wine scores were observed in wines with grapes of moderately warm temperature summation units (base $0^{o}C$) measured with data loggers in the bunch zone. Wines from grapes in these conditions without good wine scores all had bitterness for other reasons (MOG, heavy extraction of unripe seeds etc).

Good fruit aroma scores came from moderate bunch zone temperature summations. Wines from grapes above the narrow sector for optimum temperature summations had low pleasant fruit scores and jammy characters.

Herbaceous aromas in the wines were partially explained by the low heat summation units experienced by the grapes and partially by harvesting and winemaking processes.

Wines from grapes with up to 30,000 temperature summation units had softer tannins the warmer they were (excluding the harsh tainted samples from MOG etc), above that bunch zone warmth, tannin softness ratings dropped again.

Colour in wines was independent of the anthocyanin concentration of berries (winemaking!).

Tannin intensity in wines was only slightly related to the concentration of total phenolics in grapes. However as the literature places some emphasis on the importance of total phenolics for full bodied red wines this was followed with assessments in young wine and grapes.

Young wine analysis (after ferment)
All regions produced a wide spectrum of phenolics in young wine. More days on skins during the fermentation process resulted in a tendency to yield more phenolics but not more anthocyanins.

High concentrations of total phenolics in young wine were accompanied by high concentrations of flavonols. High flavonol concentrations were generally achieved with fewer leaf layers over the bunch zone. This trend is less expressed for anthocyanins.
Generally with high total phenolics in young wine young wine colour is good, but this is not the case in every sample.

All young wines with more than 80 units of phenolics came from berries with mature skins in BSA assessments; immature skins produced young wines with phenolics below 60 units. However, some skin-ripe berries produced young wines with low phenolics.

Low yield/ha, high Baumé and fast ripening which are commonly regarded as predictors for good wine quality did not correlate with high phenolics in young wine.

Very low total phenolics in berries (expressed per g fresh weight) led to low phenolics in young wine and very high berry phenolic concentrations to high phenolics in young wine. However, there is a middle field of values where other determinants must have played a role.
The relationship of phenolics in berries vs in those in young wine is closer when phenolics in berries are expressed per g fresh weight compared to calculations on a “per g skin basis”. This can be explained by the differences of skin to berry ratios, irrespective of berry weights.

Berry analysis
In this season many berries were not very small due to late season rainfall. Generally it is assumed that smaller berries have a higher proportion of skin to berry weight than larger berries. This is not the case in many vineyards in NE Victoria. There are moderately large berries with high skin weights. Very large berries had low skin weight proportions but they were unrepresentative of the large middle field.

Heavy berries generally had less phenolics per g fresh weight. Not all light berries had high total phenolics. There was a big middle field where berry weight was not indicative of phenolic potential.

There was no relationship between yield or vine balance and phenolics/g FW. Slow lignification of canes at veraison may be a pointer to low phenolic potential at harvest. Lignified canes at veraison are not a secure predictor of phenolic quality of the berries.
As expected a high leaf cover over bunches led to low phenolics in berries. Exposure after veraison seemed to be more important than before. Row orientation alone was not a predictor of good phenolics. The leaf cover of the bunches that was producing good phenolics in a warm site was counterproductive in a cool site. Leaf plucking had a great effect on phenolics, particularly on the morning sun side.
Hangtime (time from 50% flowering to harvest) was not a good predictor for phenolic quality. It was found that many vineyards were harvested due to fast acid loss or other reasons.

There was a very poor relationship between Baumé at harvest and phenolics in berries at harvest. During BSA, immature skins produced low phenolics in berry extracts. Some mature skins yielded less phenolics than expected.
Berries with low phenolics had also low flavonols and vice versa but there was a middle field of various phenolic readings with moderate flavonols. Flavonols are sun indicators but not temperature indicators.

Seasonal temperatures as can be seen from the regional minima and maxima curves were generally beneficial for producing good phenolics in grapes. Regional temperatures did not vary tremendously.

Daily temperature curves measured by data loggers in the bunch zone proved the importance of the interplay of row orientation and canopy management. The row orientation (E/W and NW/SE) that provided ample morning sun and fast rising temperatures in the bunch zone produced high phenolics in 6 out of 9 vineyards. However, if with those row orientations the canopy shaded the morning side of the bunches resulting in slow rising morning temperatures, less phenolics were measured at harvest (one vineyard was harvested too early to reach its full phenolic potential).
In N/S and NE/SW rows which provide distinct midday shading of the bunches by the canopy and plenty of afternoon sun only 7 out of 16 vineyards produced high phenolics at harvest. All of the high achievers had good morning sun either through plucking of the leaves over the bunches on the east or north side, or open canopies. They had no afternoon heat loads either through topography (sunset early behind hill, cool breeze on plateau) or foliar protection. Vineyards with berries of low phenolic values were those with bunch temperatures that were either too cold overall, too hot all day or too hot in the afternoon.
The relationship between colour and phenolics was good in this milder season but not linear. Berries with lower colour had higher than expected phenolics from lack of heat loads, two vineyards produced berries with high colour but lower than expected phenolics from being cooler than last year. Last season, most berries had higher phenolics than colour due to heatwaves, and the relationship was also not exactly linear. Good anthocyanins were only observed in conjunction with moderate flavonol levels. Sun exposure is not a predictor of colour. Good colour was produced at various leaf layer numbers. Cool sites, or cool canopy structures, irrespective of leaf layer numbers, had more colour per g FW at harvest.
There is no correlation between average heat load/day from veraison to harvest in the bunch zone with colour readings. Instead, frequent and prolonged high max temperatures in the bunch zone caused lower anthocyanins at harvest. Colour concentrations in berries compared to diurnal bunch temperature curves express the known heat sensibility of anthocyanins.
Bad cane lignification at veraison led to low anthocyanins in berries at harvest; however a high degree of cane lignification is not a pointer to high colour.
Vine balance was in the normal range for most vineyards, but some had a higher than usual cm^2 of leaf/g fruit – they produced colour (and sugar) in the bunches at a faster rate, under conditions favourable for colour preservation.
BSA scores for skin maturity were good predictors for colour extractability.

Potential for adoption

In comparison with the phenolic and colour data from last year it became clear that some vineyard owners have already drawn conclusions from the suggestions made after last season (*Winter, 2005*). The more intensified study of this year showed that vineyards can reach higher phenolic, colour and aroma potential in grapes at all row orientations and in all regions by inexpensive bunch temperature monitoring and simple site adapted canopy management practices. Seed ripeness is seldom reached but if winemaking processes are adapted the resulting wines can win at least bronze medal status.

Further activities

Recommendations are made for a third year with revised and simplified assessments encompassing vineyard scoresheets, bunch zone temperature monitoring, BSA, simplified grape analysis and wine judgement. Research recommendations are given for replicated trials with fewer variables and identical small batch winemaking.

Background

Previous benchmarking work in the area

The benchmarking survey of Shiraz vineyards in Victoria started in Central Victoria in 20001/02 encompassing 24 vineyards, with follow-up surveys in 2002/03 and 03/04. (GWRDC RITA Project No's RT 01/27-3, RT02/12-3 – RT02/15-3, *Rolley 2003, Lowe, 2004*).

The studies used a score sheet system developed and kindly made available by Southcorp to assess the vines visually and taste the berries pre harvest. Each region had a field coordinator to ensure that data gathering was relatively uniform. Bunch samples were sent to Myrrhee Laboratories for analysis of berries concerning their weight, skin weight, seed weight, Baumé, colour and phenolics in skins and seeds.

In 2003, three North East Victorian (Alpine Valleys, King Valley) Southcorp growers participated in that project (RT02/37-4).

In 2004 a RITA project was undertaken by North East Victorian regions which allowed a greater number of growers and winemakers to participate, and encompassed all five Geographical Indicator (G.I.) regions of the NE Victoria Wine Zone as well as vineyards within the confines of North East Victoria but not in a registered G.I., referred to as "other" (GWRDC RITA Project No. 03/22-4).

The aim of the studies was to investigate, in a large survey, vine plants and the resulting fruit and wine (if possible) in order to find correlations between growing practices and fruit quality and ultimately wine potential. It was also aimed at possibly finding quality factors in vines and grapes that could reliably predict wine quality.

A summary of the outcomes of all RITA Shiraz benchmarking projects was undertaken by GrapeLinks and published in Australian Viticulture January/Feb 05.

Important outcomes and conclusions:

Variability:

Central Victoria studied the variability of the measured parameters (standard deviation of the mean with 3 sampling locations of 20 samples) and higher than usual variability was recorded for shoot lignification pre harvest, leaf condition pre harvest, grower estimated berry size, field estimated colour and measured phenolics in seeds. *This shows that pre harvest assessments of shoot lignification and leaf condition may need larger sample sizes and berry parameters might be better analysed than field tested.* Extreme variability was found in the judgment of shrivel, grower rated bunch exposure and mouthfeel of sugar/acid balance. *A standardized method to assess berry aromas and flavours is needed and has been done in the present study through BSA done by the field coordinator. Sampling has a crucial importance in these studies and Precision Viticulture methods would be beneficial to select representative sampling locations.*

Seasonal variation:

In central VIC, in a cold year, the degree of cane lignification at harvest correlated with wine or berry quality, in a warm year all canes had caught up with lignification by that time. *It is better to assess cane lignification at veraison which was done in the present study, and good climatic records are needed to verify trends over several vintages.*

Regional variation:

In the 03 Central Victorian study regions of which wines reached scores above 15 also produced wines with below average scores. *This means that a cooler region (Bendigo) does not automatically mean a better wine and a warm region (Swan Hill) can make good wine with adapted management. Locations within the regions (French "climats") and management practices are more crucial than the region (traditional French "terroir").*

Wine quality:
In Central VIC in 2002 wines were commercially made by Southcorp and assessed by their grading system. In 2003 identical small batch wine making from the Central VIC benchmarking study was possible via CSU (to pilot their facility) and wines could thus be scientifically compared. In this study, the best scores were obtained when wines had **soft tannins and high flavour complexity with spicy and plummy notes.**
Only in small batch winemaking wines can really be compared to grapes and vineyards, but as this is very expensive other ways must be found to somehow establish a continuum between vineyard, fruit and wine in commercial vineyards. In the present study young wine and commercial samples were analysed and compared to fruit results and vineyard climate and management.

Berry quality and wine score:
Correlation of wine scores and grape parameters in Central VIC was highest for **anthocyanins** (r=0.68) and **skin phenolics** expressed /g berry fresh weight (r=0.54). **Baumé** shows a trend to be associated with higher wine scores albeit with much scatter, wine scores of below 15 were achieved when Baumé was low. *Here wine style will matter for final product quality, so target style will be included in this study.*
Yield was not significantly related to wine quality, scores above 15 were achieved with 3-18t/ha*. Vine balance (fruit/active leaf area) may be more decisive and has been included in the vineyard scoresheets of this study.*
In Central Vic all wines which had scores above 15 had **berry weights** below 1.1g. *In this study it will be investigated whether berry weight or proportion of skin matters, as heavy berries may have many seeds and little skin which may not deliver may skin related compounds.*

Vineyard parameters and wine score:
Leaf layer number over bunches had a good correlation (r^2=0.47) with wine quality in 2003, but not in 2002.
It must be seen in the context of climate: Bendigo produced two top wines with rather exposed bunches in the warmer year, many vineyards reported only one leaf layer and wine quality was from 14 to 16. Therefore we decided to assess leaves on the different sides of the canopy separately and do proper temperature monitoring in the bunch zone.
Leaf condition correlated somewhat with the wine score in the warm year but not at all in the cool year. *It shows something about the wine water status and together with other vineyard assessments will be indicative of plant stress.*
In the **"light on fruit"** rating those vineyards with either not enough or too much had wine grades below 15.5. *In the present study this aspect received high attention due to the involvement of cool sites and warmer sites.*
The extent of **cane lignification** (shoot periderm) before harvest only highly correlated with wine scores (r^2=0.7) in a cold year, less so in a warmer year (r^2=0.37).
We therefore decided to assess cane lignification earlier, at veraison to have a better discrimination.
Berry colour bleeding from skins correlated highly with wine score (r^2=0.63 in 2002 and r^2 =0.43 in 2003) or berry anthocyanin levels (NE-VIC). *This is a good field indicator if assessed by the same person. Better indicators are BSA scores which are included in this study.*
Ripening speed can tell about site and management factors of the vineyard. *It was considered important to include phenological dates in the present study.*
Harvest date plays a big role for quality factors in berries. *As in all studies harvest was at the discretion of the winemakers, and often depended on acid loss or other developments in berries. It means that physiological cause and effect cannot be drawn from phenology (time to harvest).*

Berry parameters of relevance for wine:

Berry size correlated higher with wine judgements in 2002 (r^2=0.66) than in 2003 (r^2=0.34) and more in warmer regions than in colder regions. Very big berries did not result in good wine scores. *This could be due to seasonal and regional variations but also to a learning curve of the growers involved. In NE VIC 2004 berry size was also a determining factor, but in the present study berry* ***weight*** *will be used for correlations as field determined size was too similar.*

Skin Phenolics

In the Central Victorian study there was a good correlation between **berry phenolics** (per g berry FW) and **wine score.** In the NE VIC study of 2003/04 when some outliers were not included there was a linear relationship between total **phenolics** in berries and total **phenolics in young wine** - expressed as g fresh weight. *Various sources in the literature (see in Somers, 1998) have established a relationship between phenolic content of red wines with their quality and storage potential. Somers states that in many cases phenolic contents of berries is related to that in wine. This was considered for the analysis of young wine in the present study.*

Many parameters in last year's study were correlated to phenolics **per g fresh weight** in berries as this was considered one of the close links between grape quality factors and wine rating. *Fresh weight is delivered at cellar door. In the present study calculations were also based on a per g skin basis. Relations of skin thickness or amount to berry fresh weights were examined.*

Anthocyanins

In all four studies anthocyanin concentrations of berries were in all sites and years generally **highly related to the concentration of total phenolics**. *However there are outliers of very unripe or shrivelled berry samples which make colour assessment not always the ideal quality parameter. Also the curve in the 04 NE VIC study showed that highest anthocyanins were found at phenolics levels below the expected values which may point to a benefit of dappled light for colour preservation (high flavonols which are produced as sunscreens lead to high total phenolics) and to the fact that in the high colour bracket some berries with lower than expected anthocyanins can still produce wines of high quality. This relationship is examined in detail.*

Flavonols

Analysing the raw data from Central and N VIC of the last 3 vintages it became clear that **low phenolics in berries co-occurred with low flavonols**. Highest phenolics were associated with above average flavonols especially in cool locations. *It seemed that high insulation favoured the flavonol production. Therefore exposure of bunches was more intensely investigated.*

In Central and NE VIC moderate amounts of leaf layers over bunches at harvest seemed to result in highest flavonols – too exposed bunches and too shaded bunches had less flavonols per g berry FW. Row orientation and location also seemed to determine flavonol and total phenolic content. *In the present study bunch temperatures were measured as a further indicator of exposure, and to examine whether light or warmth determined berry quality.*

Berry aroma

No studies on berry aroma were done in the past investigations. *Berry Sensory Assessment was included for the first time to deliver data on aroma ripeness and skin and seed ripeness which have a large influence on the taste and aroma of wine.*

All previous studies showed that:

No single quality factor can be universally declared for vineyards or berries pointing to a potential for quality wine in Shiraz. *However scoresheets for vines and grapes can be very helpful to detect mismanagement or point to cause and effect for good quality.*

Quality depends on wine style. *Target style must be included in scoresheets.*

To find groups of quality pointers new scoresheets are required so that no time is wasted looking for unimportant features. *The present study has adapted scoresheets to the findings of past years. However it includes veraison assessments to allow timely management changes and a formalised Berry Sensory Assessment to allow a better communication between grape growers and winemakers.*

Verification of those groups is needed between seasons and locations. *These is a work in progress and as the growers and winemakers are better trained to manage and judge vines and grapes we will need more sophisticated methods of vineyard and fruit scoring.*

Quality pointers cannot be determined by general statistical analysis only. As in the commercial situation there are outliers due to extremes in locations, climatic events and management practice. *There will rarely be a high correlation coefficient between dependent variables and single vineyards must be able to see their position within the scoring system for many parameters.*

Determining dependent variables requires physiological knowledge. *Consulting is required as false cause –effect conclusions can be very costly to the vineyard operators.*

Cause-effect relationships must be established on single vineyard basis in particular for those lying off the trendline of statistical correlations. *Only this method leads to adoption of best practice for all and a chance for the realisation of the full potential for the resulting wine.*

Winemaker – grapegrower cooperation is crucial, in particular for flavour descriptors of berries*. BSA will help to establish this link.*

Myths about some perceived quality pointers have been demystified:
Low Yield did not necessarily lead to best wine scores. Lowering yields will only lead to better fruit and wine quality in overcropped vineyards.
High Baumé also does not necessarily lead to good wine quality. There is a range of Bé in the good wine score sector, of course unripe fruit gave bad wine results for full bodied wine styles.
Fast ripening did not always yield good fruit. Harvest decisions were often made either to avoid acid loss in warmer locations or to avoid disease in cooler locations, or due to vineyard and winery logistics.
High colour did not automatically lead to high wine quality. Due to shrivel, overexposure, and other factors anthocyanins/g berry fresh weight was not linearly related to wine scores.
Seed phenolics analysed in berries have no relationship with wine quality as phenolic quality (bitter) is more important than quantity (high amounts of releasable seed phenolics point to unripe seeds). *This is a measurement that may be saved next time.*
Vine health and vigour parameters at harvest (basal leaf health, shoot length, laterals etc) may not be decisive of berry quality if no extreme conditions prevail.

The Project in 04/05

Material and Methods:

Vineyard selection and coding

Twenty-five vineyards - approximately five from each region - were selected by the project steering committee. The vineyards cover a broad range of small and large sites, and are a mixture of both winery owned and independent grapegrower operations. The selection process also ensured that there was a wide geographical spread of vineyards in each region.
Vineyards were coded by number and regions and all further data generation and processing was strictly anonymous by code only.
Some of the vineyards of last year did not participate again and they were replaced by new members of the region for which the vineyard code received an additional N.

Vineyard locations

The vineyards are located in valleys and plains on the northern slopes of the southern end of the Great Dividing Range in South East Australia.
Soils span a diversity of origin from volcanic to granitic and alluvial.
Vineyards have been managed in these valleys for more than 15 years. Site potentials are well known, and management practices are well established.

Beechworth, with an average elevation of 400m and its great variability of sites with respect to their position on the plateau had 2 sites on steep slopes facing n and w and 2 on only 3% slope.

Alpine Valley with altitudes ranging from 200 - 500 m with 3 vineyards on some rather steep slopes (see Table 1), and on eon flat terrain, mainly nw/se or ne/sw aspects and one rain fed vineyard.

King Valley vineyards were located at altitudes between 250 m to 550 m with a diverse range of aspects and with slopes of 10-15% or lower.

Glenrowan vineyards are located at the foothills of the Warby Ranges at approximately 200 m of altitude and faced mainly s/w or n/w.

Rutherglen vineyards (and “others”) were located on open plains at 150-200 m, had mainly north-westerly aspects and had 10% slope or less.

Climatic information

Climatic data both, long term average and 2004/05 consisting of temperature and rainfall was obtained from the Bureau of Meteorology for the King Valley, Beechworth and Rutherglen regions. Temperature and rainfall data was also obtained from a winery in the Glenrowan region and DPI Research Station in the Alpine Valleys region (see graphs in “Results”).

Site information
Site information including data on slope, aspect and rainfall before and after veraison was collected from the growers and can be best seen from **Tab. 1**.

Vineyard characteristics
Information such as planting date, trellis type; row orientation, row spacing and vine spacing, rootstock, clone, pruning method, harvesting mode and irrigation method were recorded in questionnaires (**Tab. 1**), yield was included after harvest.

Sampling site selection
Each block was divided into 3 sections, each encompassing a third of the total number of rows. The sampling technique involved "zig–zagging" along each side along the length of pre determined and marked rows in the section. Fruit samples were taken on each side along the complete row covering top and bottom parts of hills.

Vineyard scoring
Scoresheets were developed by GrapeLinks in conjunction with the region, discussed at a grower meeting and accepted for use. They were modified from scoresheets used be the past RITA studies incorporating more veraison measurements and less pre harvest assessments (**Tab. 9**).
During the vineyard assessment 20 shoots were selected along the marked rows by the field assessor and the grower at **veraison** and measured for average shoot length, active leaf area (according to *Winter and Whiting, 2004*), number of active leaves, proportion of young to active leaves, number of actively growing tips, average bunch number of shoots, leaf cover on front and back of bunches (noting which side front was facing), the condition of mature leaves and percentage of lignification on the canes.
At harvest the condition of the four oldest and younger leaves was assessed, the leaf cover over bunches was noted and the average bunch weight was recorded (**Tab. 9**). From the active leaf area per shoot and the bunch number and weight vine balance could be calculated *(Winter and Whiting, 2004)*.

Bunch climates
Data loggers (*Tinytag*, Hastings, Port Macquarie) were purchased by the growers and attached to the vine row-facing side of the posts within the canopy at the bunch zone and measurements were taken half hourly from veraison to harvest **Tab. 8.** Data were downloaded onto a computer by the field assessor and processed for analysis.
Total "heat loads" were calculated from the half hourly readings of data loggers for the period from veraison to harvest. They should be called temperature summations as they started from a base of 0^{o}C.

Berry sensory assessment
Field Berry Sensory Assessment was carried out twice, at approximately 12.5 Bé and at harvest (**Tab. 6 and 7**) all of them by the field coordinator (to ensure comparability) choosing 6 bunches and assessing them according to *Winter et al. 2004*.

Phenology
Dates of 50% flowering, veraison and harvest were recorded in the vineyard scoresheets and phenology was calculated (**Tab. 6a**).

Grape sampling
At 12.5 Bé and pre harvest 25 bunchlets (8 - 10 berries) were selected from the top, middle, bottom, inner and outer parts of the bunch and the top, middle and bottom of the fruiting zone of the canopy for berry analysis (**Tab. 5**).

Grape analysis

Three grape samples per vineyard in labelled plastic bags were hand delivered by the field assessor to Myrrhee Consulting Services. The samples consisted of 25 small bunchlets (of 10 or 12 berries each) collected across the chosen transect. Fifty berries from each sample were then selected for berry weight assessment. The berries were then dissected completely separating skins and seeds from residual juice and pulp.

The skins and seeds were then weighed to assess their percentage weight relative to that of the whole berry. The whole of the remaining berries from the 25 bunchlets was then crushed to mimic winery conditions to assess juice Baumé, pH and TA.

The skins and seeds were placed separately in a weighed amount of extracting solvent (1:1 methanol : water with 2% HCl) and left in contact for 12 h at room temperature. Then the skins were thoroughly pressed in the solvent and the seeds well mixed with the solvent. Aliquots of each sample were diluted appropriately for spectrometric analysis. Anthocyanins in skin extracts were measured at 250 nm and results were presented as absorption units per unit skin weight or berry weight using the percentage of the skin to the rest of the berries for calculation. Skin and seed total phenolics were measured at 280 nm and the flavonol component of the skins was measured at 360 nm. Data are presented in **Tab. 5** as averages over the three samples per vineyard. Due to the expense of standards the values were not converted to mg/g berry weight as often cited in the literature. Reproducibility of the data was good between the 3 parallel samples of the same vineyard.

Young wine analysis

A sample of young wine after fermentation was collected by the field assessor from the wineries and delivered on the same day to Myrrhee Consulting Services. A small aliquot of wine was diluted 50-fold with 1M hydrochloric acid to convert all anthocyanins to the coloured form. Spectrophotometric measurements were made 520 nm and 420 nm for anthocyanin and modified anthocyanin concentrations; at 280nm for a measure of total phenolics as well as 360 nm for an indication of flavonols. The results are presented in **Tab. 4** in absorption units, A.U. calculated back to the undiluted wine.

Wine making procedures

Procedures during commercial wine making including crushing, additions, soaking, fermenting and pressing were given in questionnaires by the collaborating winemakers for each vineyard code and are listed in **Tab. 3**.

Finished wine assessments

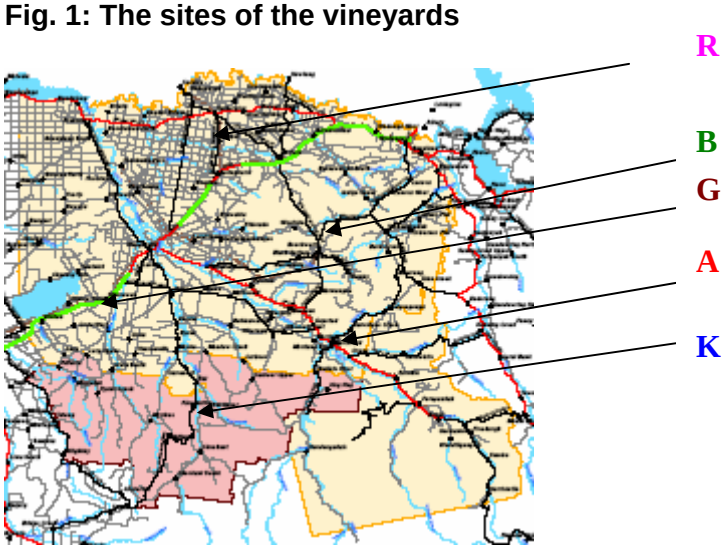
Wines were made as separate batches from the vineyards, not blended with wines from other locations or varieties and judged on 1. September (after only 5 month) by a Master of Wine (N. Bulleid, Bulleid consulting) and a local winemaker (Chris Killeen and he is the chief winemaker at Stanton & Killeen winery in Rutherglen) for the intensity of mouthfeel and aroma sensations, colour, hue and general wine score. Results were presented to the grapegrowers.

Results

The sites

Vineyards were spread over a wide range of altitudes and in valleys and on hills. The map shows the locations of the regions:

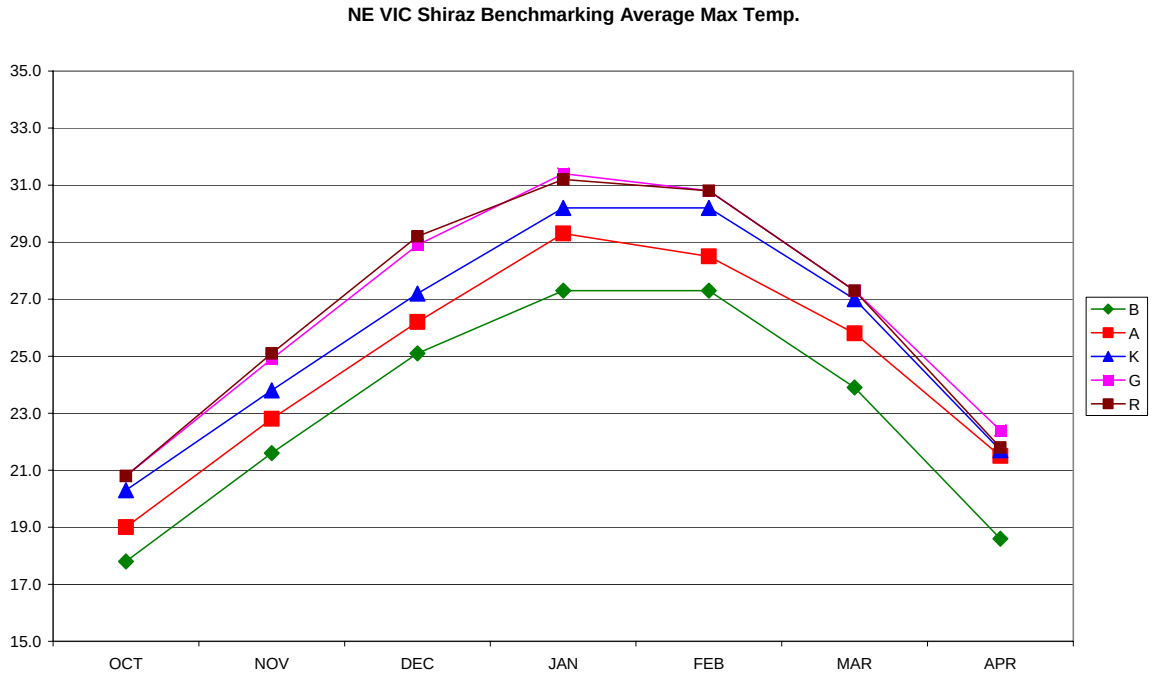
Fig. 1: The sites of the vineyards



The climate

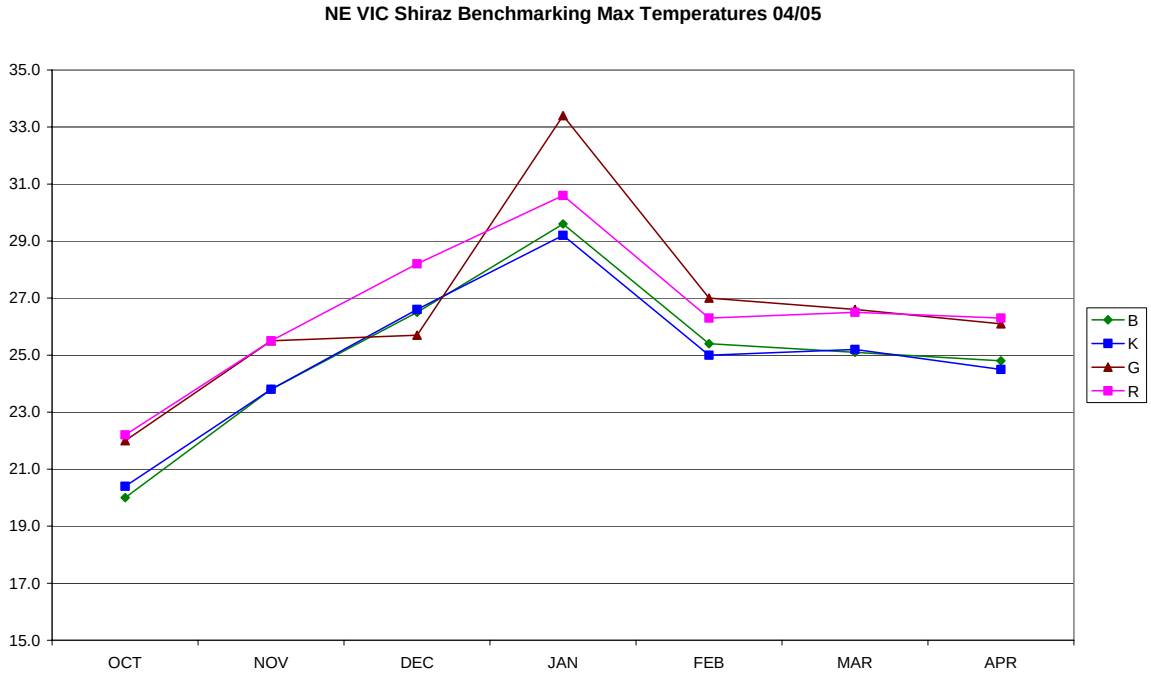
The region's long term average maximum and minimum temperatures follow similar annual curves of an inland Australian pattern. Beechworth is generally cooler than the other regions due to its altitude, followed by the higher Alpine Valleys.

Fig. 2: Average Max Temperatures in the regions, long term survey.



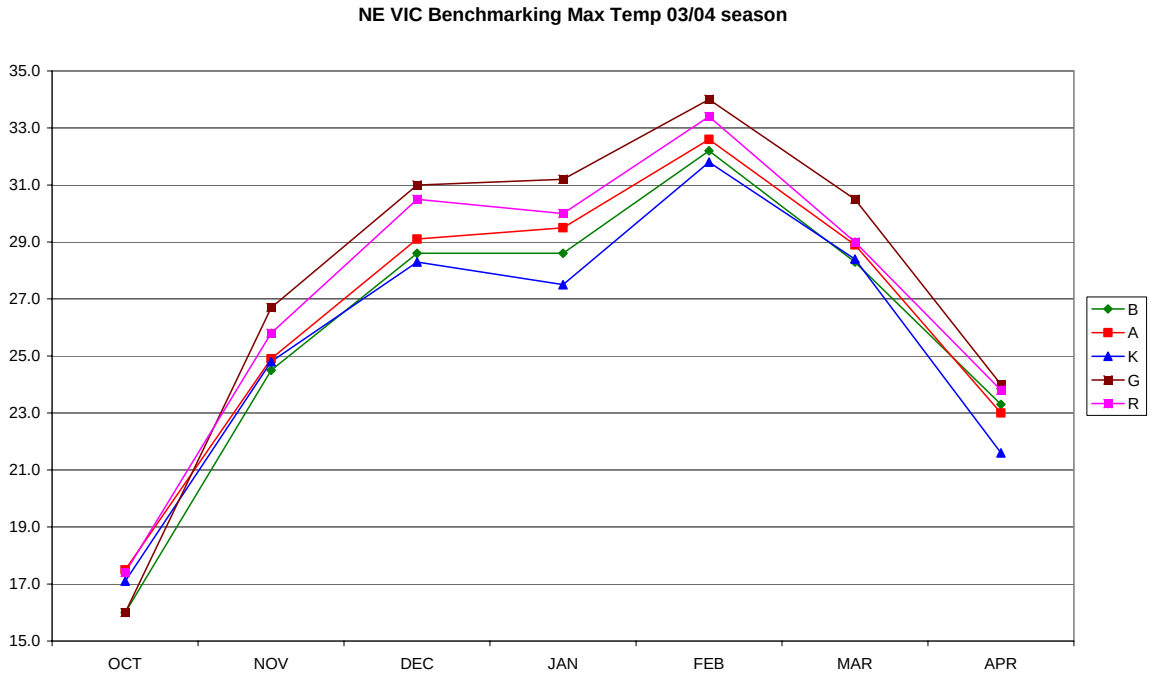
In this season, **maximum temperatures** of the hilly areas are similar; the areas closer to or on the plains have hotter summers. All regions had this year a milder February and a warmer than usual finish. Still the year presented less heat (in particular in Nov/Dec) than the previous season.

Fig. 3: Maximum temperatures in this season



Excessive heat was experienced in the 03/04 season in particular in February which is at the beginning of the main ripening period.

Fig. 4: The maximum temperatures last year



The long term average night temperatures in summer are (except for the Alpine Valley experiencing cold mountain air inflow) 14 degrees which has implications for ripening patterns.

Fig. 5: Average minimum temperatures

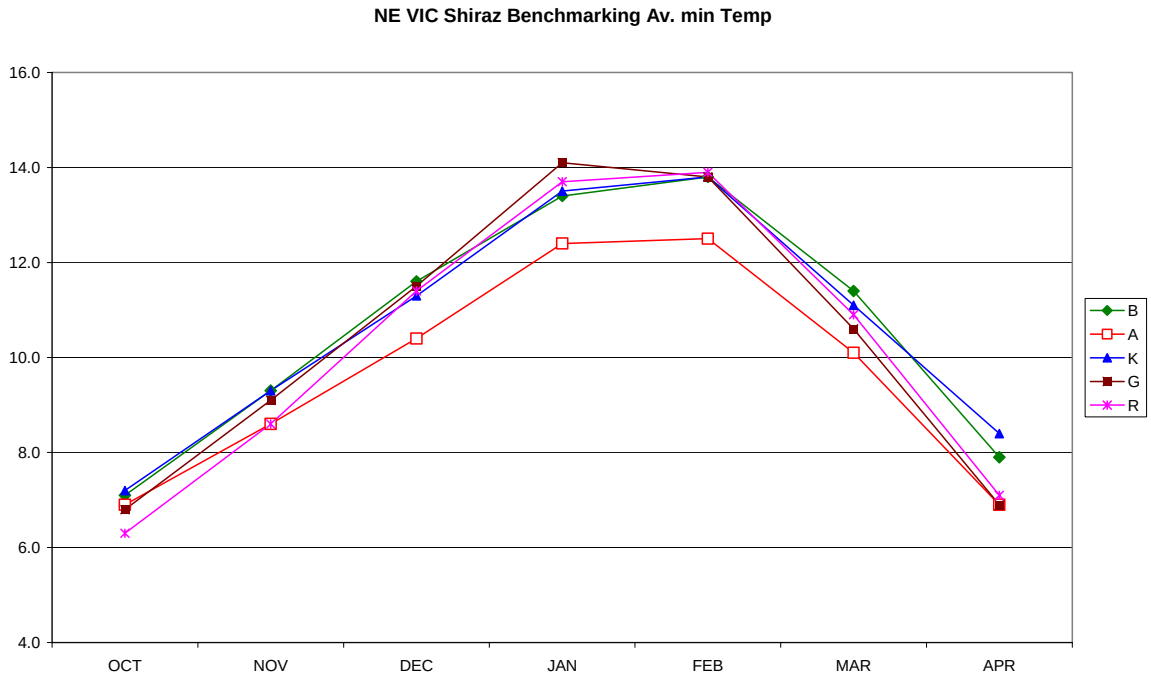
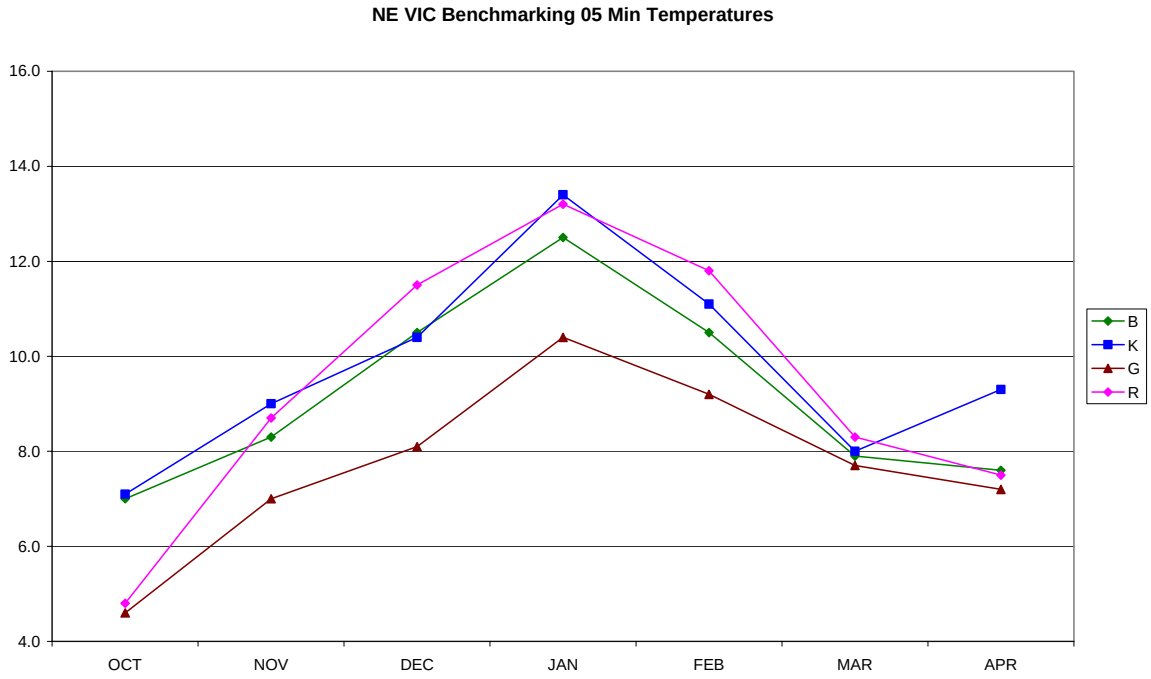


Fig. 6: This year's minimum, temperatures



The **minimum temperatures** this year were less than average (very cool summer night temperatures for Glenrowan) with a cooler February and March than usual experienced in all regions.

Rainfall

Is normally much lower further inland (Glenrowan and Rutherglen) than in the mountainous regions. Rain can occur at all times throughout growing season.

This year all regions experienced well above average rainfall in December (pre veraison) and particularly in early February (for some vineyards at veraison, for some post veraison) and the growing season finished with a very dry end.

Fig.7: Average rainfall

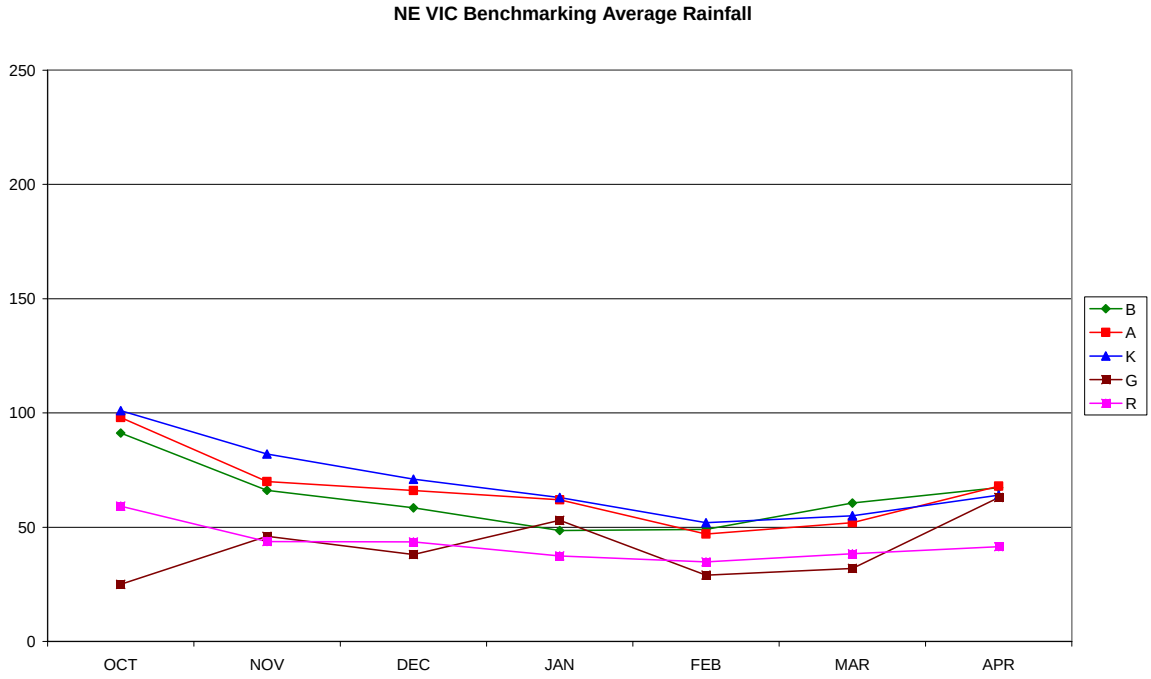
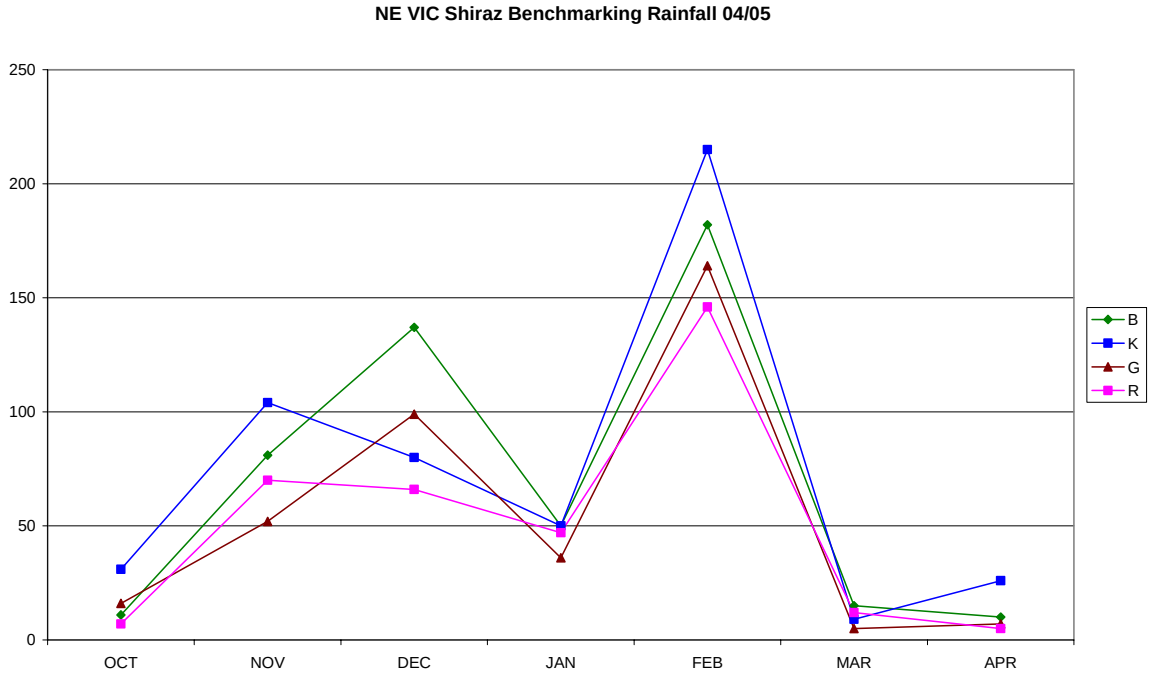
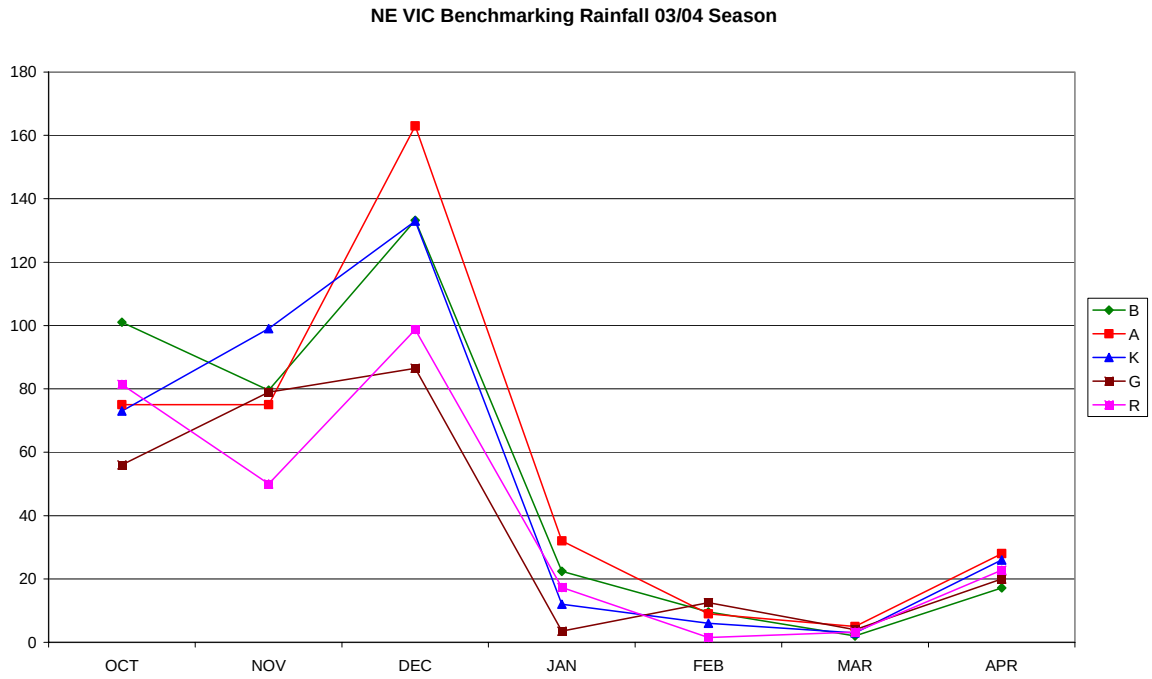


Fig. 8: This year's rainfall



Seasonal variations in rain patterns are common for all areas in the region. The previous year had high rainfall in December (after flowering).

Fig. 9: Last year's rainfall



The vineyards

As can be seen from **Tab. 1** there is quite a variety of locations, plat material (rootstocks, clones) and vineyards management practice (irrigation). Two solely rain fed vineyards stood out from the rest in many attributes that have a bearing on root density and water supply. One vineyard had very scarce water resources and relied on rain as of veraison.
One vineyard used intensive foliar fertilising; many vineyards tipped the shoots as required (noted in the scoresheets) some vineyards removed the leaves over the bunch zone which was noticed in the scoresheets under leaf cover.

All vineyards deliver fruit to winemakers who decided harvest date and fruit destination.

Despite those very varying circumstances it became clear that there were some common denominators for high quality – denominators for low quality (as some scoresheets had contained in the past, like desiccated vineyards, lack of shoot periderm formation at harvest, etc.) had been largely excluded from the scoresheets as the regions is very advanced in growing practices. Berry traits like split berries, mould etc. can be picked up by Berry Sensory Assessment.

The grape growers and winemakers

Good cooperation was achieved from all 25 vineyards and winemakers.

Wine assessments

Nineteen wines were delivered to the venue and could be assessed in proper glasses approximately 5 months after harvest.

Wine scoring

All wines were – for a full bodied Shiraz – very young and some had not finished malolactic fermentation.
No attempt was made to allow for the effect of different concentrations of SO_2 on colour depth and hue. Wines were at different stages with respect to malolactic fermentation (MLF), so there would have been a range of SO_2 concentrations.

Some wines were undergoing MLF and others were yet to do so, and several of these were showing aldehydic characters. One wine also showed distinct acetic volatility. These characteristics made accurate scoring and determination in the rank of wine descriptors less reliable.

Nevertheless Nick Bulleid and Chris Killeen were able to assess the aroma and mouthfeel potential and scoring was mutually agreed between them.

Twenty grapegrowers as well as those involved in the project (and Luke Rolley for having done the first 3 years of such studies) were present and were guided through the wines pre-tasted by Nick Bulleid.

Fig. 10: Nick Bulleid (left) and Chris Killeen (front) and the group tasting the wine



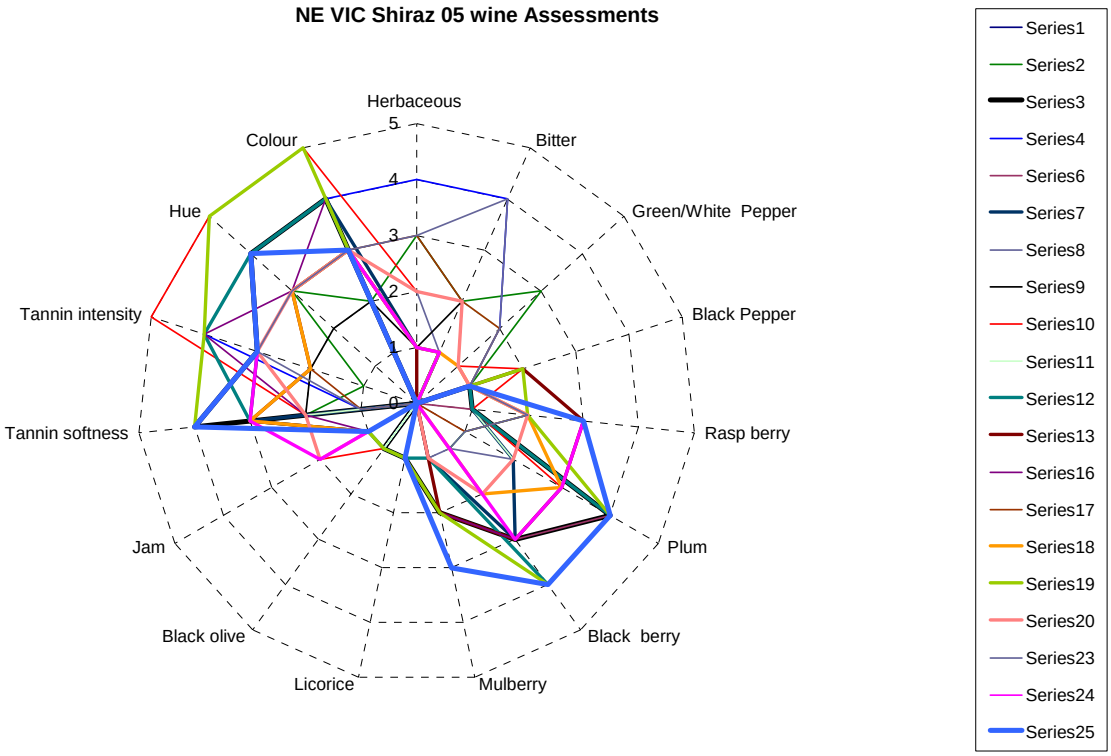
Results of the multifactorial scoring are depicted in **Tab. 2.** Good and bad aromas, mouthfeel and colour were later arranged so that the 2 undesirable groups and the 2 desirable groups were not close to each other when a spider diagram was constructed.

The spider-diagram depicts traits on axes with rankings from 0 to 5 – five being very intense.
It shows that in general a few wines had herbaceous or bitter aromas, very few had pepper notes this year and wines had various degrees of pleasant berry aromas (raspberry to mulberry) and not too many wines had cooked fruit or overripe aromas (jam, black olive or liquorice). Tannin softness and intensity varied immensely and nominated by the scoring team as a crucial trait for good overall wine scores.

The silver medal winners are traced in bold, bronze in semi bold. The ideal profile for the intended wine style is – in this assembly of traits – an 8 shape with "waistline" and one round curve over the berry aromas and one over tannins and colour, as for example in the bold blue line.

Single wines are described (together with the growing conditions of the grapes and winemaking information) in the Discussion on p. 79.

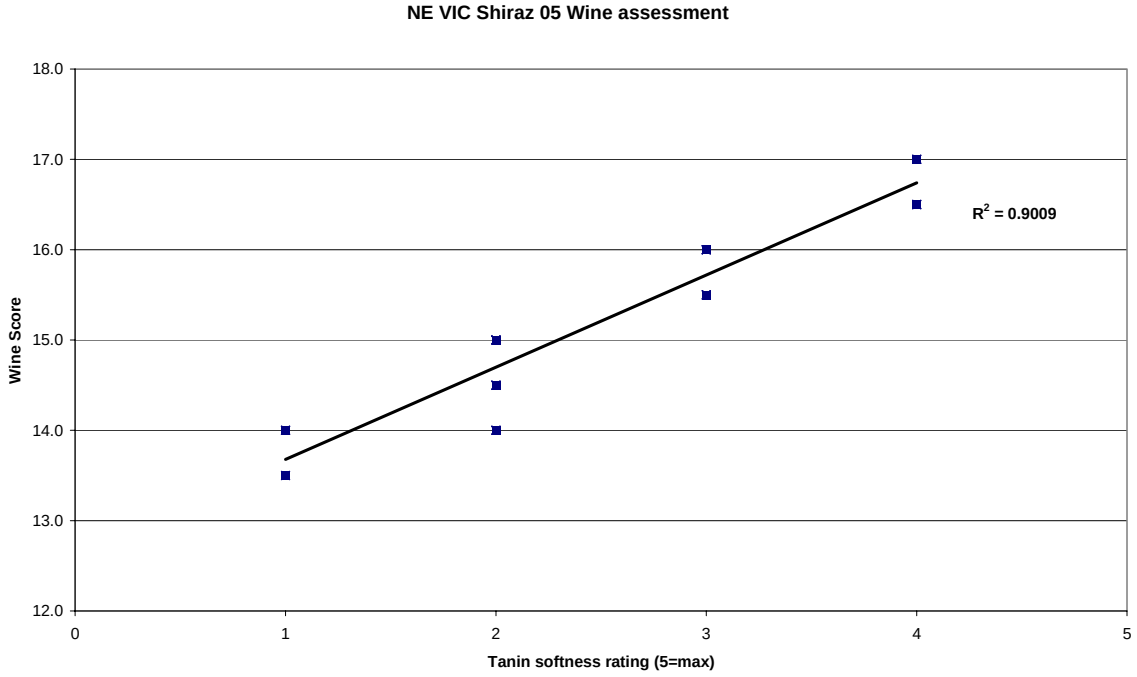
Fig. 11: Spider diagram of the traits rated in the 20 wines



Wine score and wine traits

The correlation between wine score and tannin softness and plum was again re-confirmed. The 9 and 13 dots respectively on the graphs represent 19 wines – some wines had similar scores so the dots overlay each other.

Fig. 12: Tannin softness had a strong influence on wines score



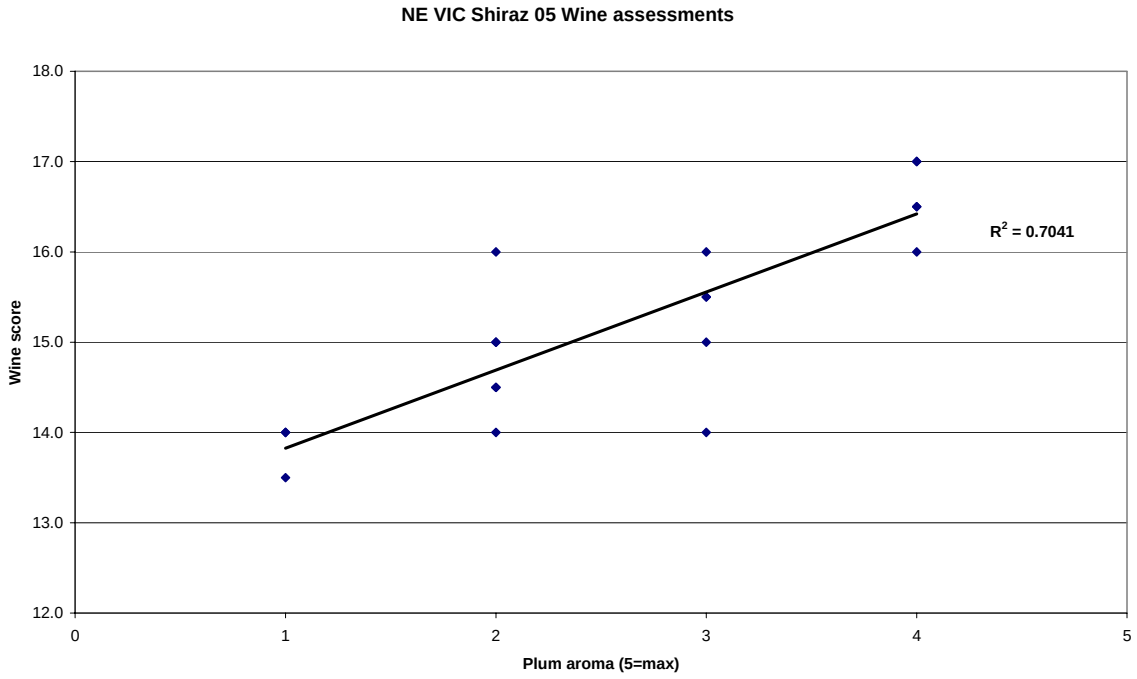


Fig. 13: Plum aroma had a strong influence on wine score

The sum of red fruit in the wine aroma was a good positive indicator for wine score whereas the sum of bitter and herbaceous aromas was negatively correlated. The two wines with very herbaceous and bitter ratings may have had high amounts of petioles in the bins. They used the same type of machine harvest equipment.

Fig. 14: Wine scores were high when the sum of all pleasant fruit aromas was high

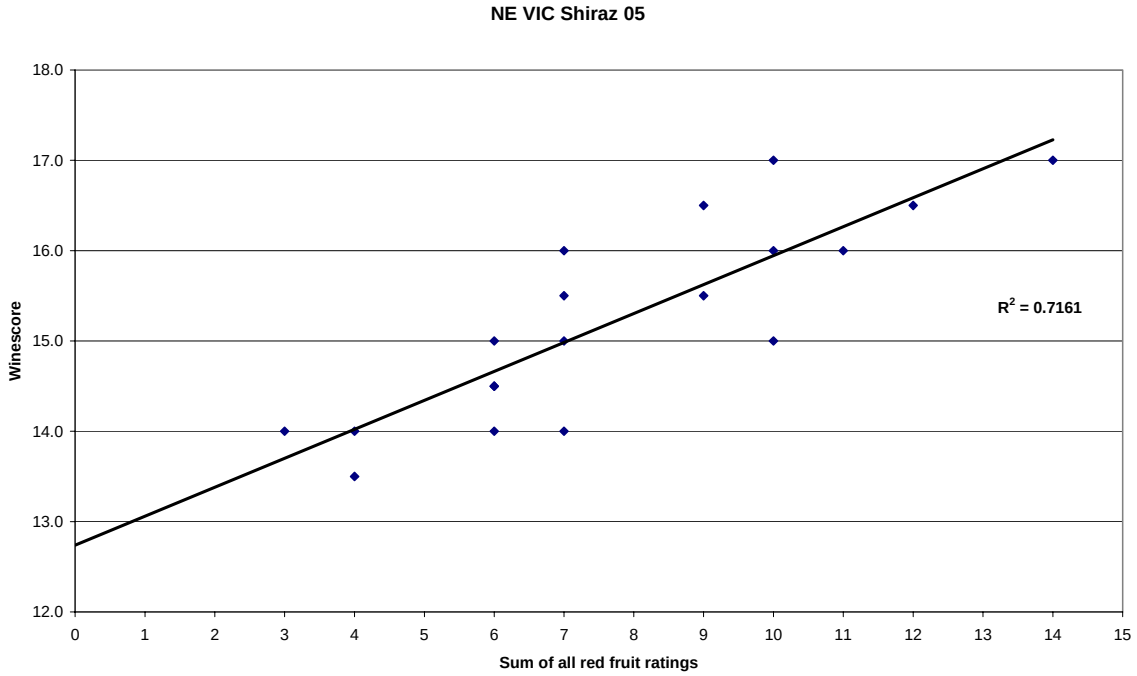
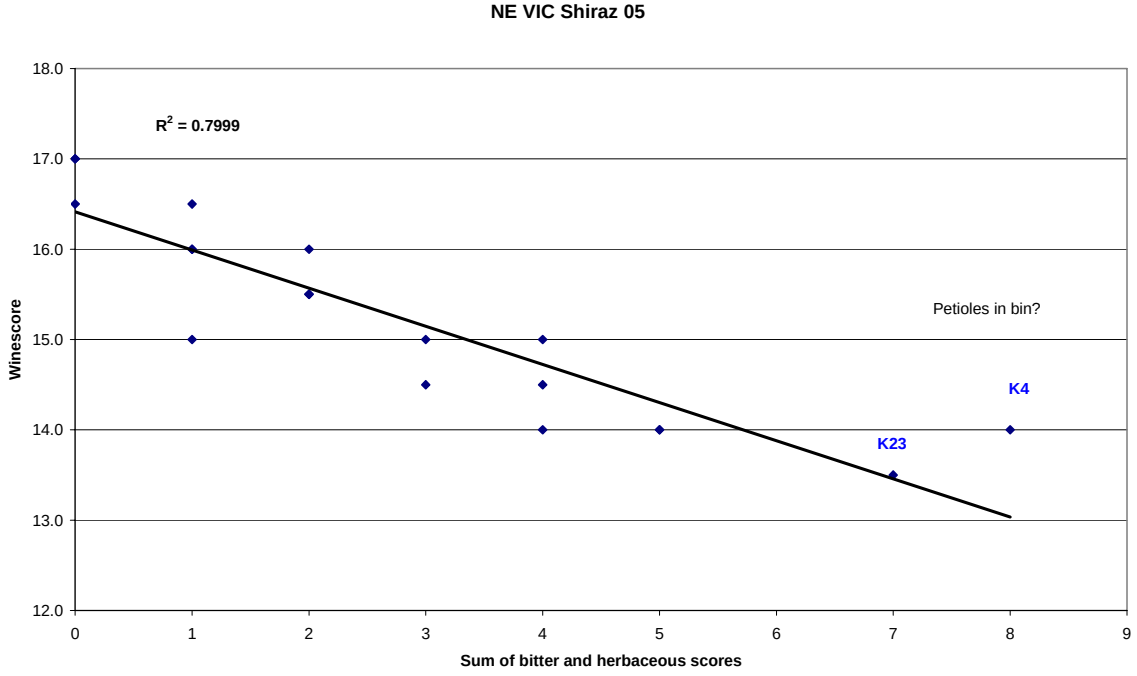
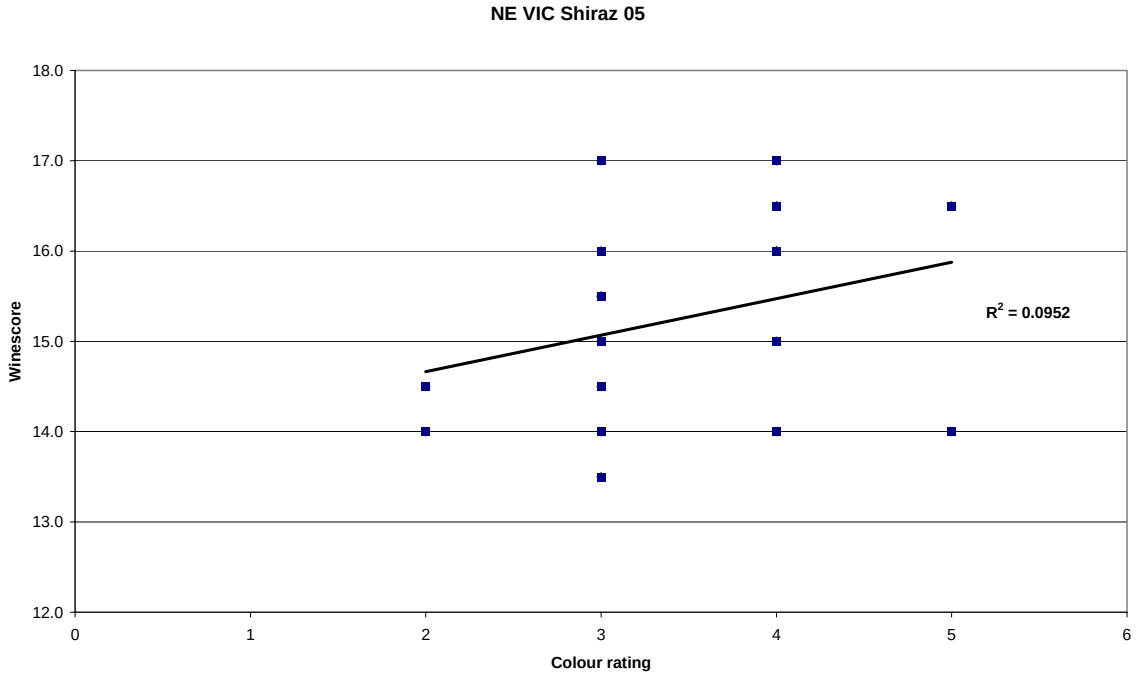


Fig. 15: Wine scores were low when the sum of herbaceous and bitter aromas was high



Colour rating in wines is important but at the ratings 3 and 4 a wide range of wine scores were given. Thus colour should not be the sole focus for wine assessment.

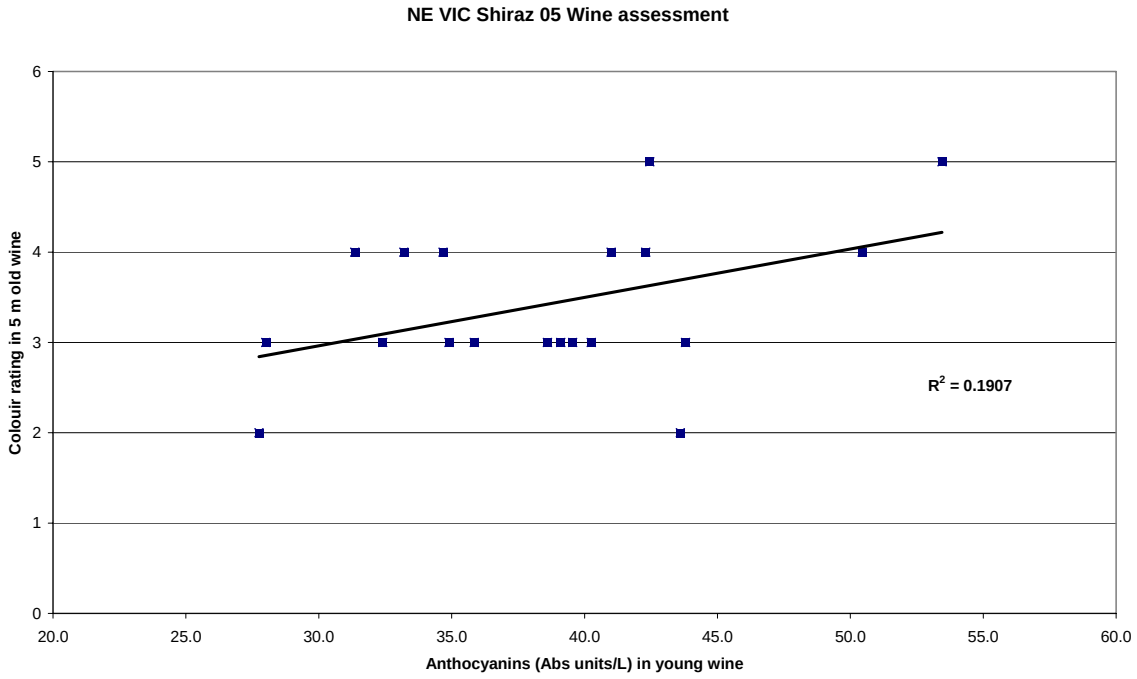
Fig. 16: Colour rating of wines had a lesser influence on total wine score



Young wine and 5 month old wine

The anthocyanins in young wine (post pressing) were a bad predictor of the colour in 5 month old wines in this commercial situation. Other correlations between young wine chemistry and wine judgements were not drawn – these can only be made with identical small batch winemaking.

Fig. 17: Anthocyanins in young wine were not a correct predictor of colour rating in 5 month old wine



Berry chemistry and wine traits

Colour in berries as measured in anthocyanin concentration per g fresh weight did not always correlate with colour in wine most likely due to factors in winemaking like extraction time, co pigmentation factors etc.

Fig. 18: Colour in wines was independent of anthocyanins in berries

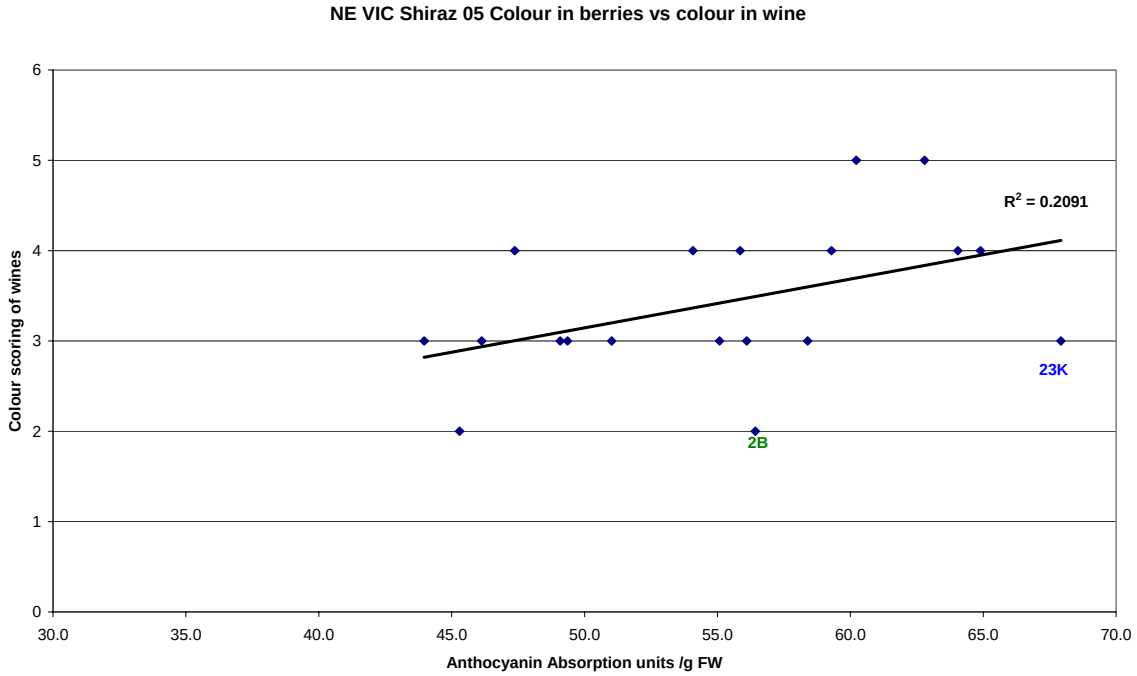
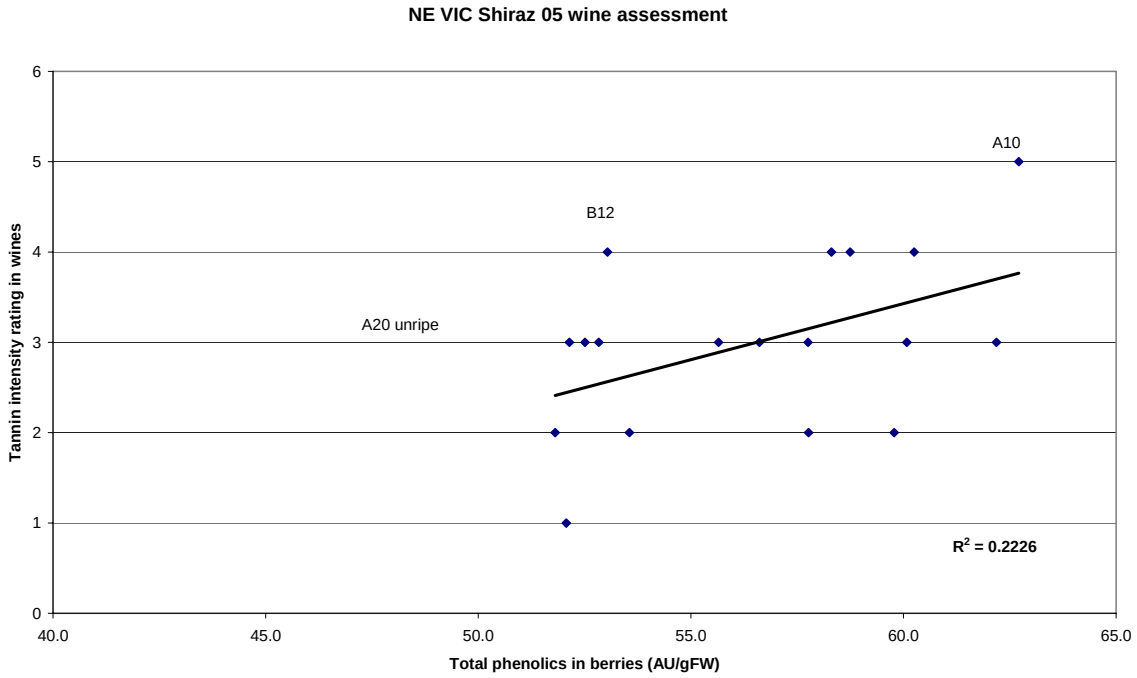


Fig. 19 Tannin intensity in wines had only little to do with total phenolics in grapes



Baumé at harvest correlated badly with wine score. The silver medal wines (Score 17) had no excessive sugar. Bronze medal wines (Score 15.5-16.5) had a wide range of Bé at harvest.

Fig. 20a: Sugar concentration at harvest was insufficient as a predictor of wine score.

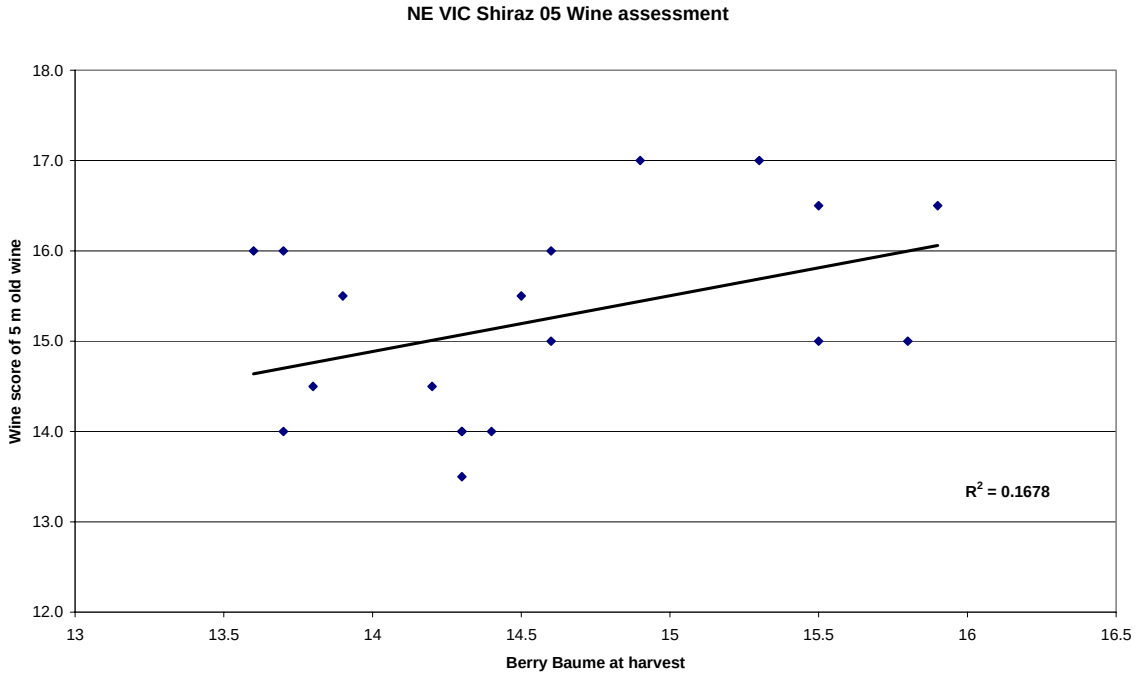
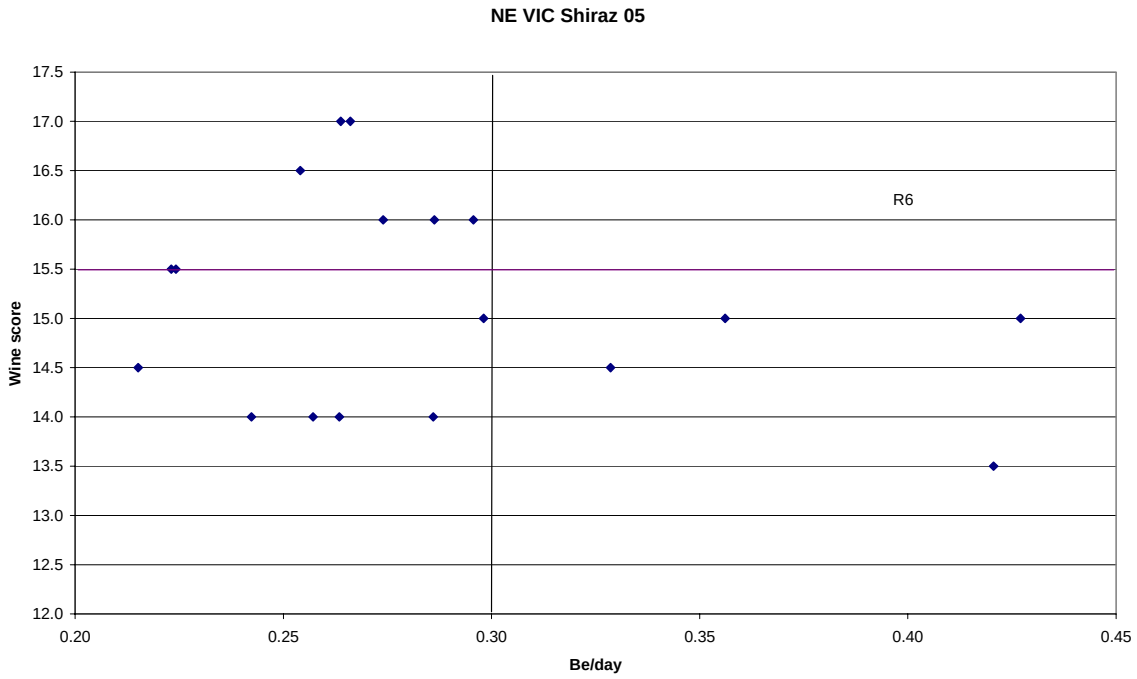


Fig. 20b: High speed sugar accumulation was (except in R6 where the jammy flavours were tolerated) correlated with lower wine scores.



TA at harvest did not correlate at all with wine scores. Very acidic berries did not score well.

Fig. 21a: TA at harvest is not a good predictor of wine scores.

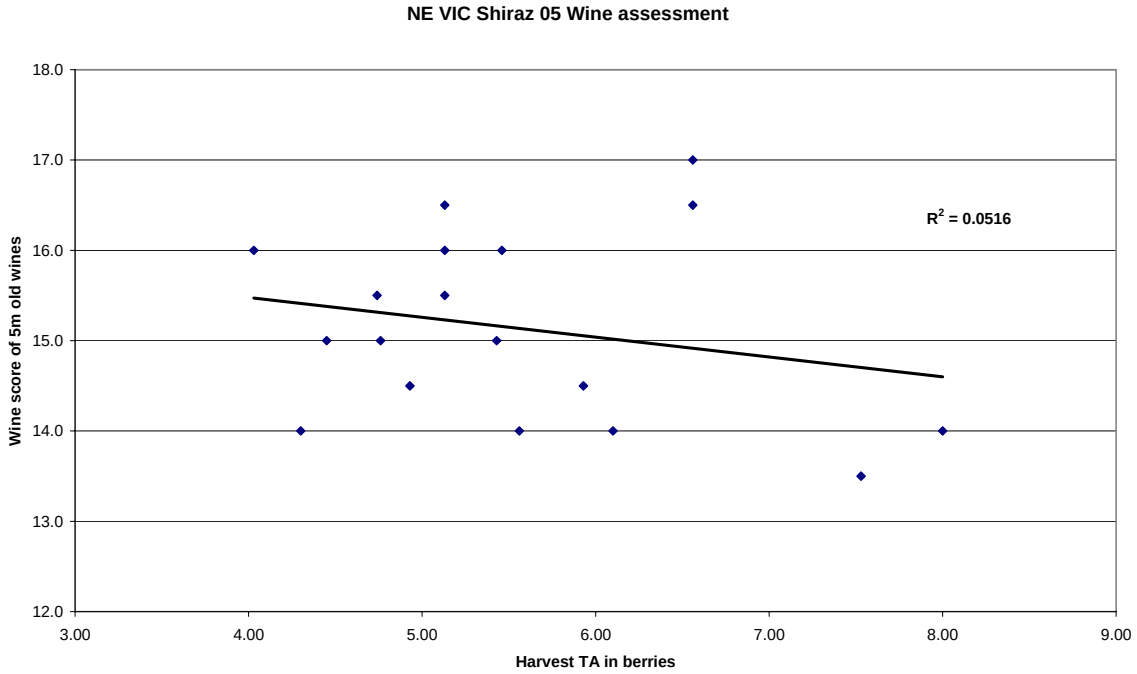
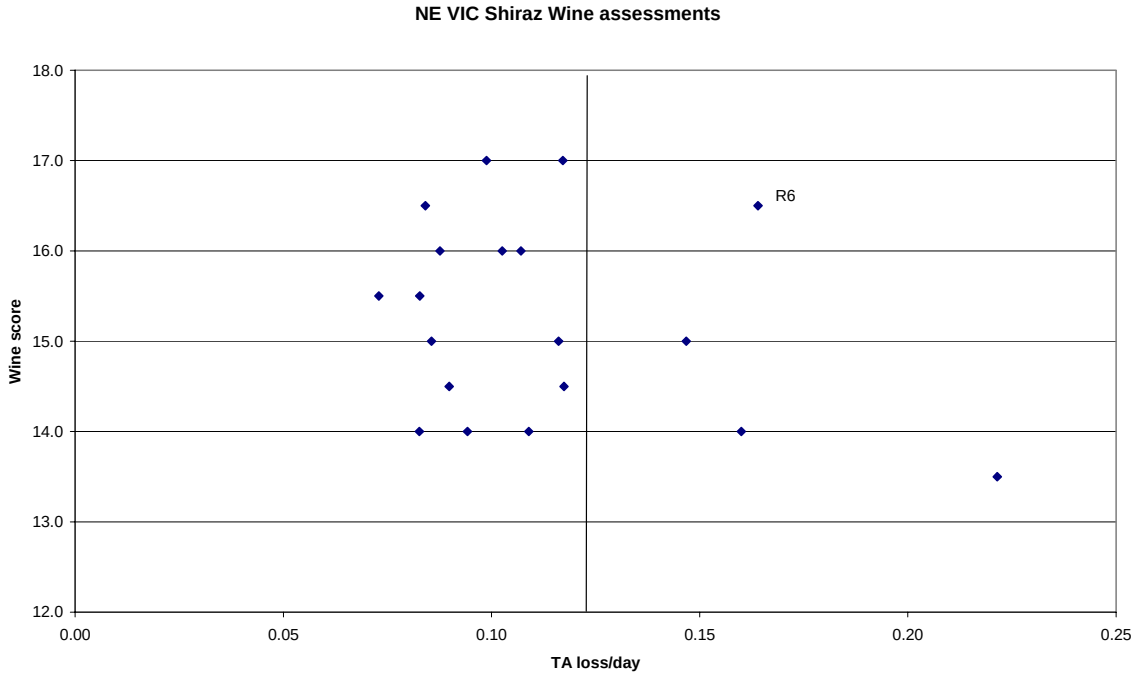
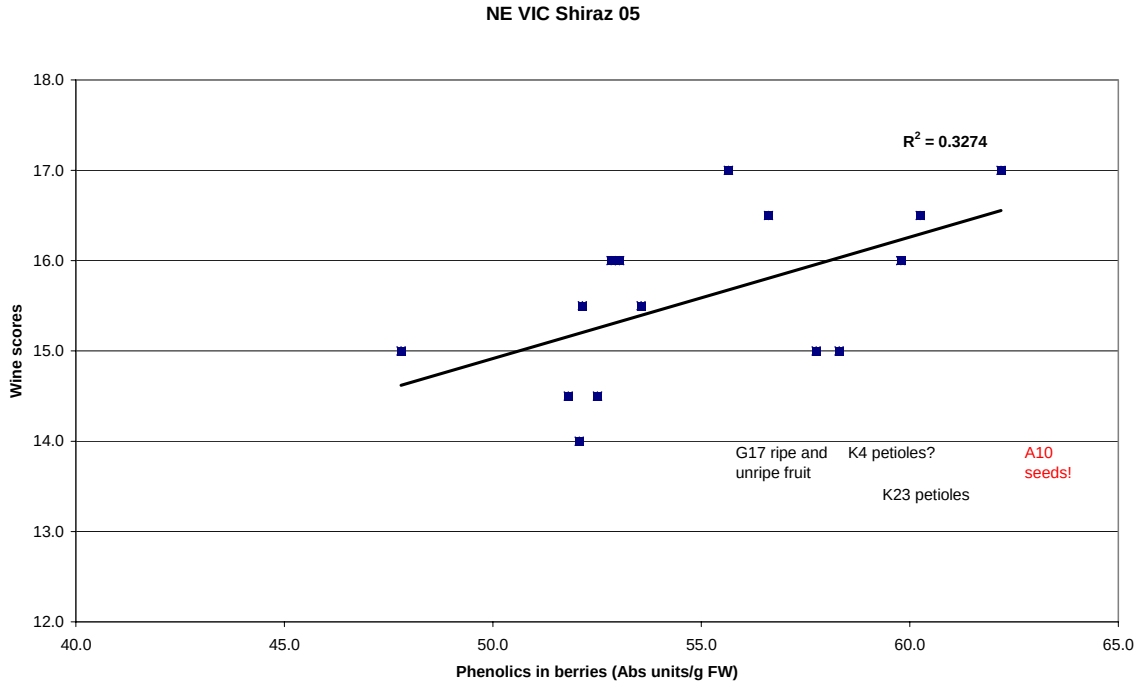


Fig. 21b: High speed acid loss was counterproductive to wine rating (again exception R 6).



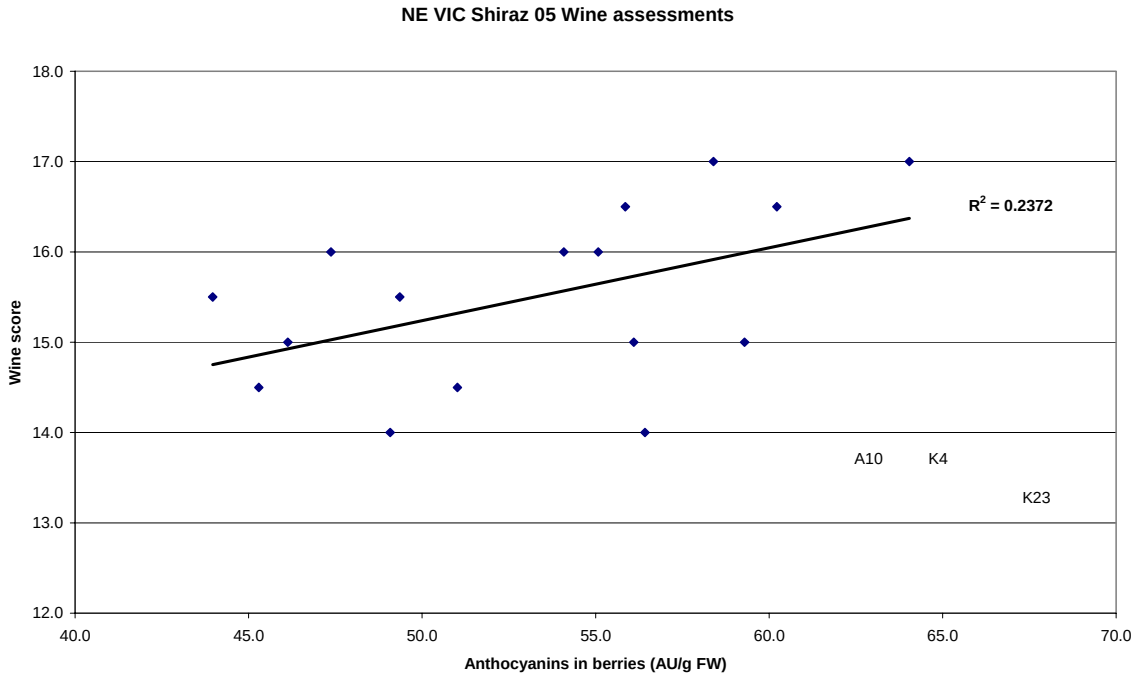
Total Phenolics in berries at harvest showed a trend with wine scores when the wines which had high phenolics but bitterness from MOG, unripe parcels of fruit and high seed extraction (see in Discussion) were excluded.

Fig. 22: If there are not many phenolics in grapes to start with it is hard to get a good wine score



Anthocyanins in berries had a weak relation to wine scores when the high colour bitter wines were excluded.

Fig. 23: Colour in berries was not intensely related to wine score.



Grapegrowing and wine scores

Yield was again totally unrelated to wine score. Also, vine balance, active leaf area, leaf cover over bunches front and back (too imprecise) hangtime and other assessments on the vineyard sheet did not correlate to wine score.

It is worth noting that all silver medallists had good **cane lignification** at veraison. Except for a lighter wine style wine and one with ripe fruit despite bad cane lignification, Bronze medallists all had well lignified canes at veraison. The group of wines with good cane lignification but bad wine scores had MOG, unripe fruit or overripe fruit.

Fig. 24: All wines with good scores had at least 40-60% of canes lignified at veraison.

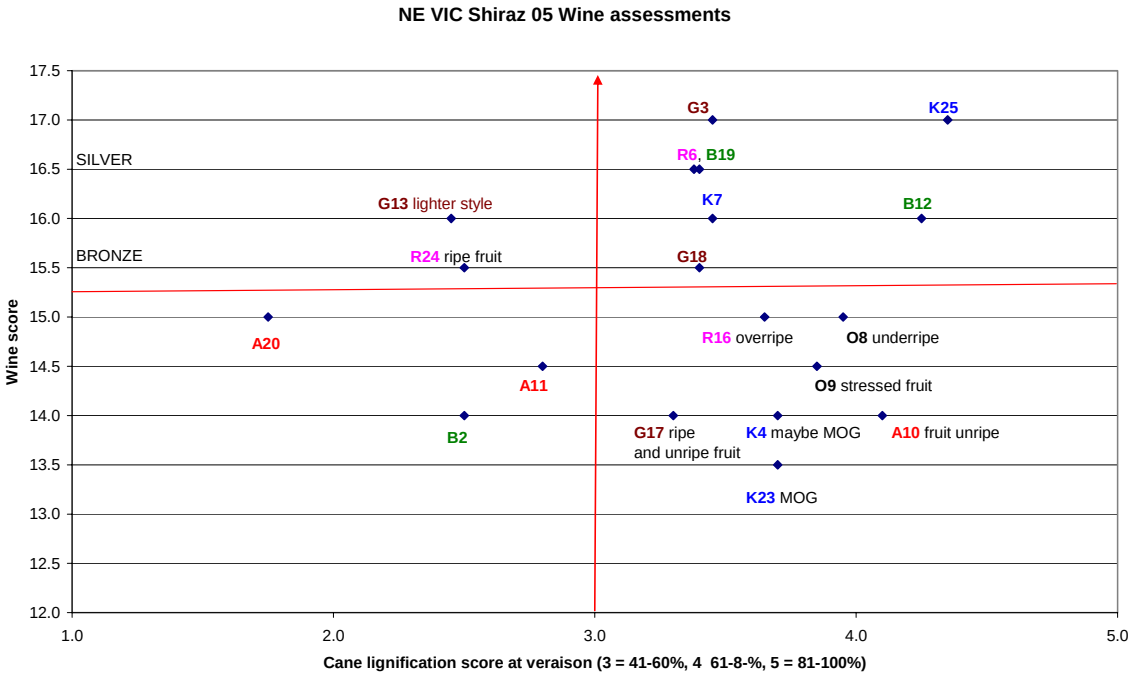
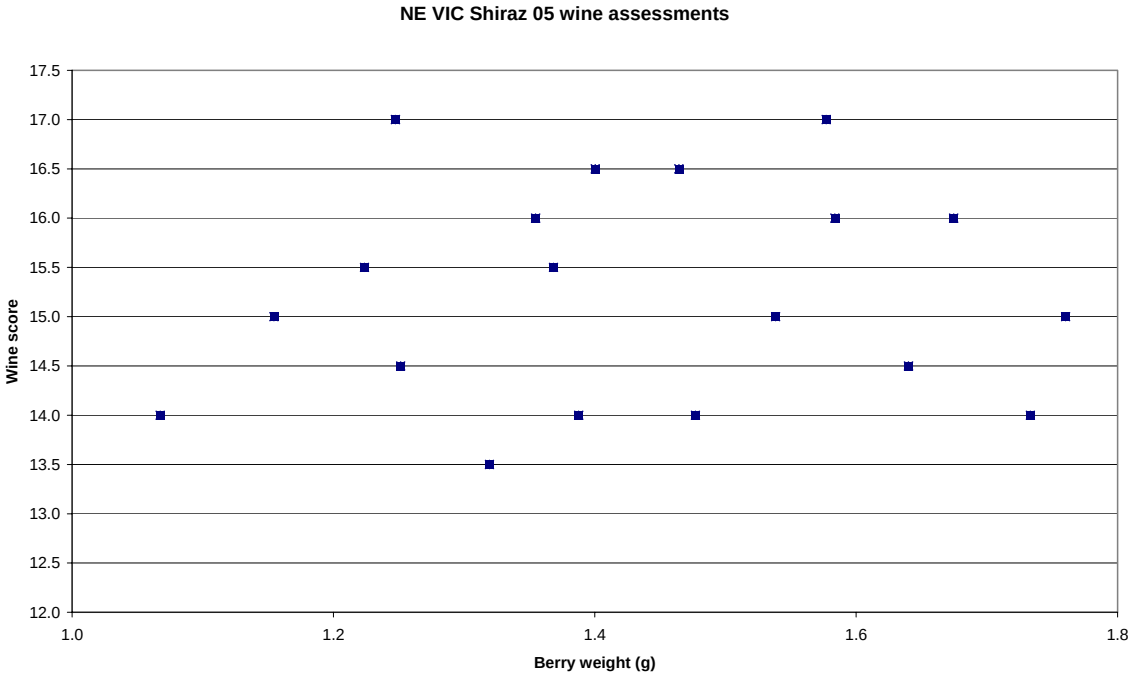


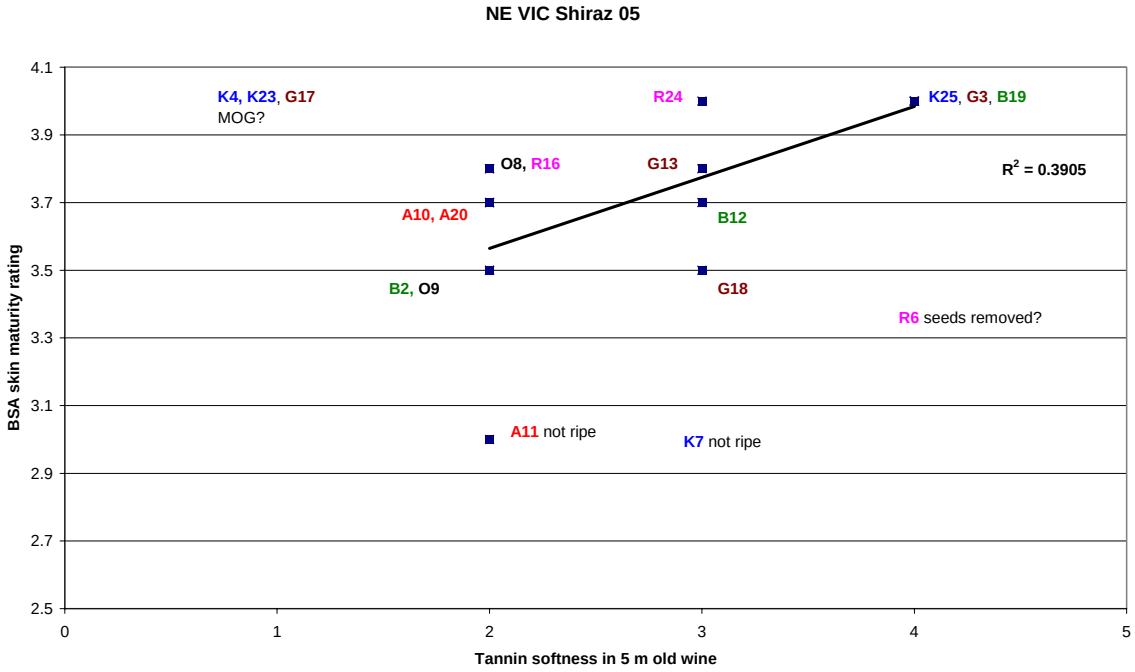
Fig. 25: Berry weight was not decisive for wine score.



BSA Score and wine traits

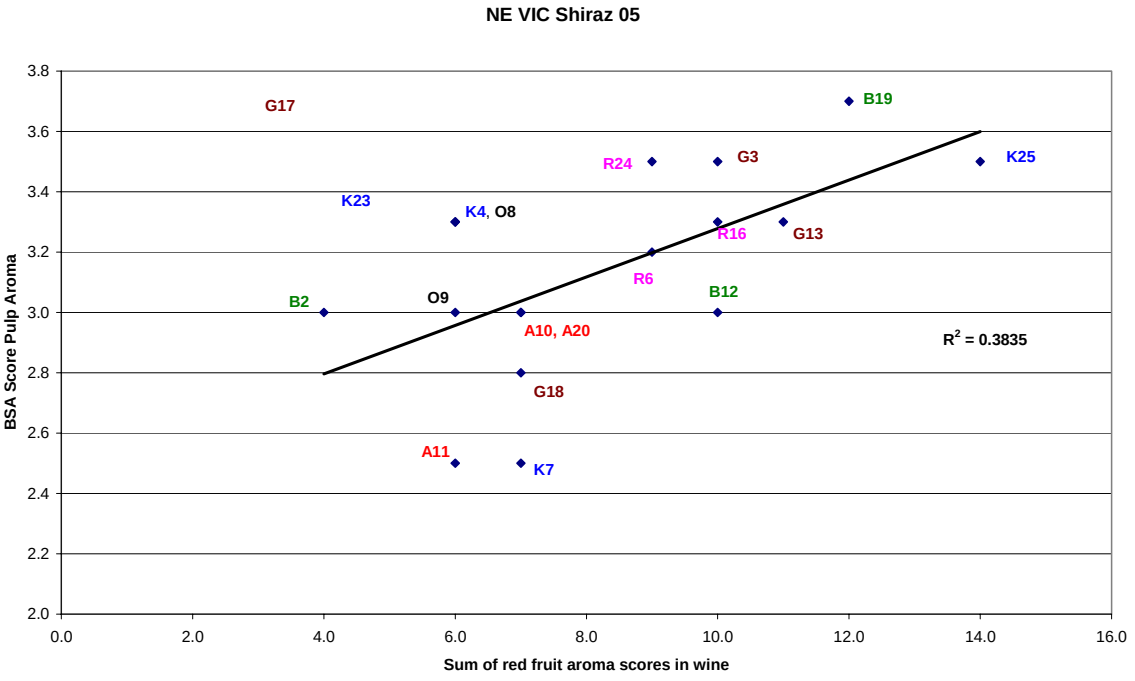
Wines with **soft tannins** generally came from good **BSA skin ripeness** scores. The two best wines had high skin maturity and soft tannins in the wine. Very ripe skins can be overpowered by harsh tannins from petioles (MOG) or seeds in the ferment.

Fig. 26a: If the skins are very ripe in BSA ratings for skins tannins tend to be soft in the wine (if no MOG was is in the bin)



Red fruit potential (pleasant fruit) in wine may be deduced from the **BSA score of pulp aroma** (exceptions taken out of the trendline are inhomogeneous batches-G17, harvester problems – K4 and K 23). This trend cannot be seen from the BSA of the skins (not depicted).

Fig. 26b: If the pulp aroma is above 3 in BSA pulp aroma scores and no mistakes are made in the processing, the chance for good fruit is there, the riper the better



Bunch climate and wine scores

Total score

Warmth on bunches added up over the season seemed to increase wine scores Highly scoring (bold) wines were made from grapes with moderate (but not cold) temperatures in the bunch zone. Wines which had good bunch temperatures but no high score had bitterness for various reasons overlying good fruit aromas.

Fig. 27: Good wine scores were observed in wines with grapes of moderate heat summation units in the bunch zone (exception R6 which could not be properly scored).

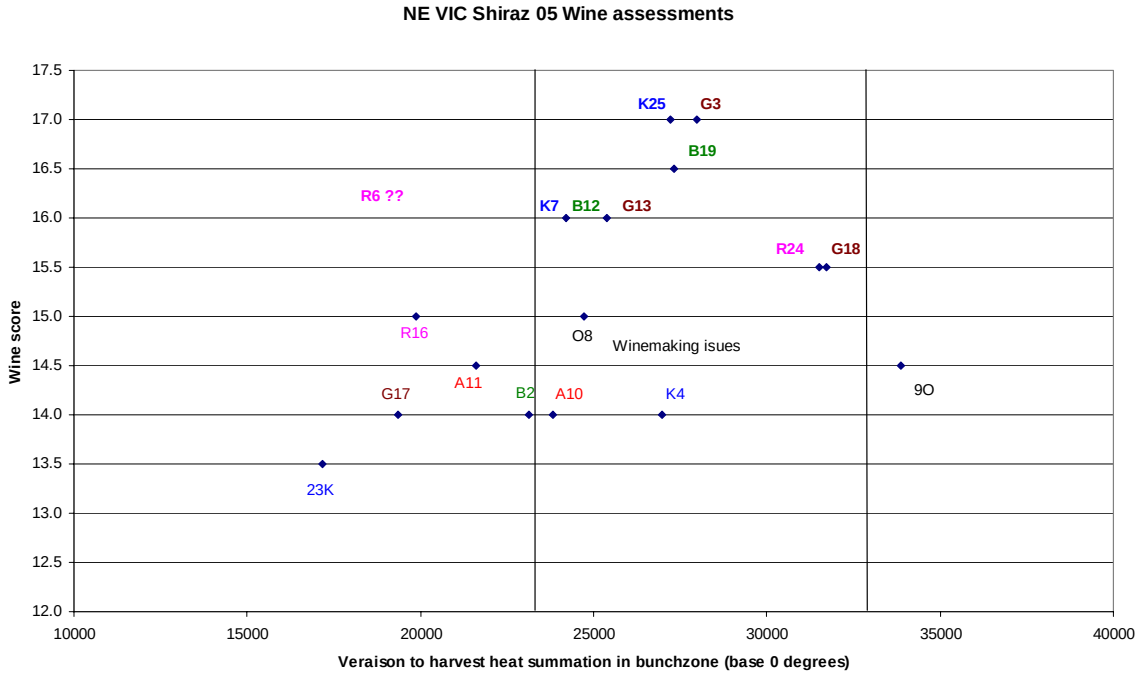


Fig. 28: Wines from grapes out of high temperature summation bunch zones had low fruitiness. Moderate heat summation only led to nice fruity wines if unripe and overripe flavours were avoided and fruit scores were high.

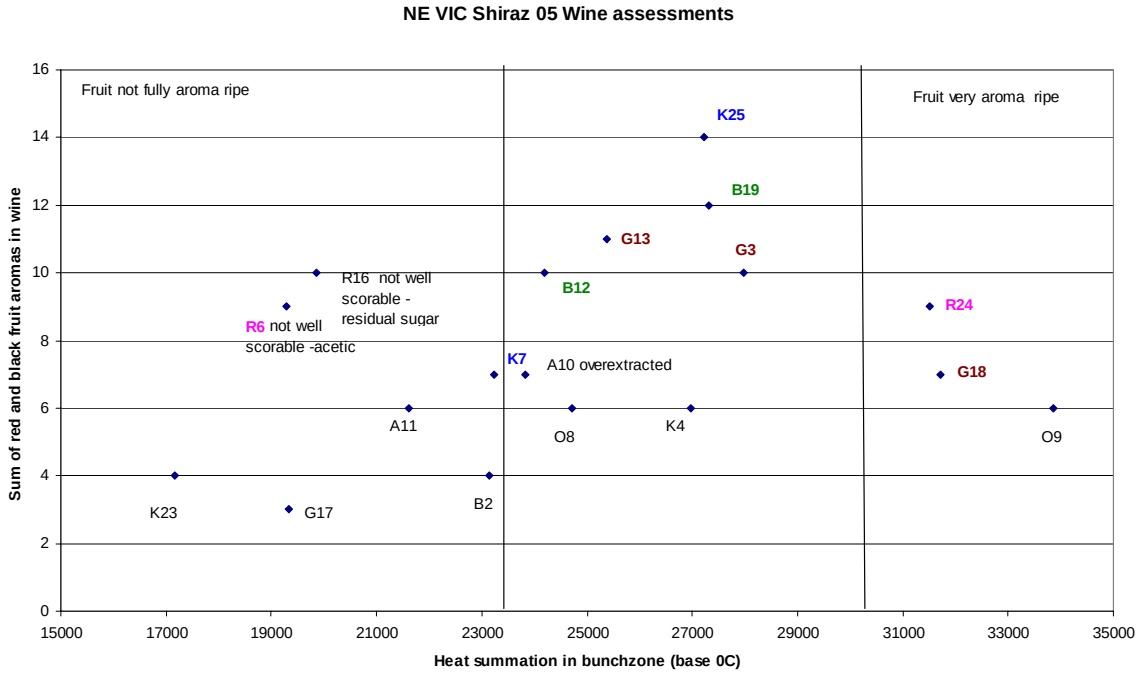
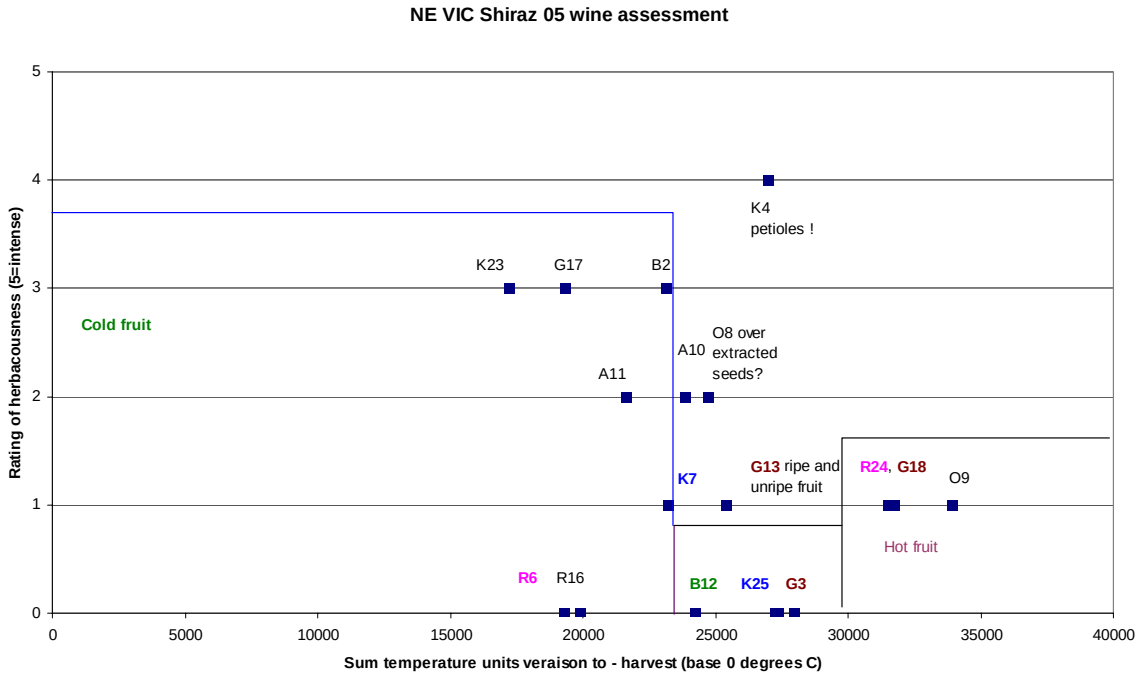
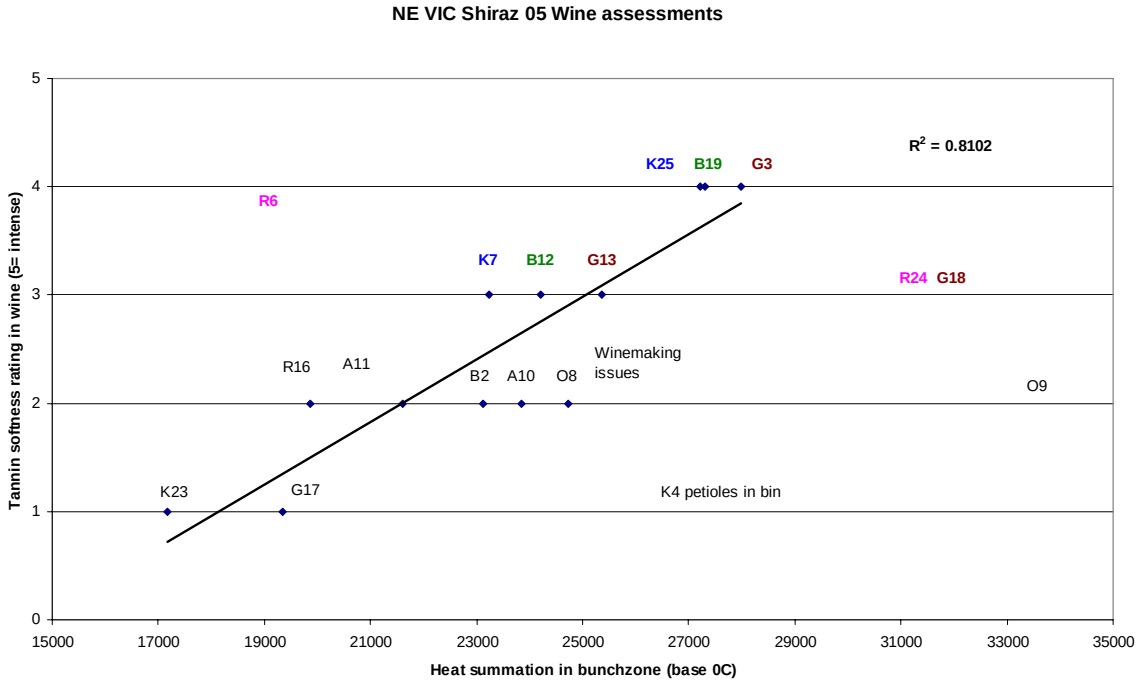


Fig. 29: Herbaceous aromas in fruit can be partially explained by the heat summation units experienced by the grapes and partially by harvesting and winemaking issues. The good corridor is rather narrow between 23,000 and 30,000. Award winning wines in bold.



Tanin softness seemed to need warm bunches.

Fig. 30: Wines from grapes with up to 30,000 heat units had softer tannins the warmer they were. Above that bunch zone warmth, tannin softness ratings seemed to drop again (values not in r calculation). Winemaking fault and MOG caused the ratings for outliers R6 and K4 respectively (not in trendline calculation). B2, A10 and O8 had great potential but seemed to have high extraction of seed tannins.



Young wines

Although no comparable small batch winemaking was possible due to excessive costs, the young wine (post ferment after pressing) from each vineyard was analysed in the chemical lab.

The focus of analysis was primarily on total phenolics as they are considered important pointers to quality of full bodied wine styles (*Somers, 1998*) and contribute to mouthfeel, balance and storage potential of the wines, and on colour and hue.

Wines and their regions

As can be seen in Fig. 1, all geographical indicator regions which participated in the study and the two vineyards just outside the region (others) produced young wines with a wide range of total phenolics.

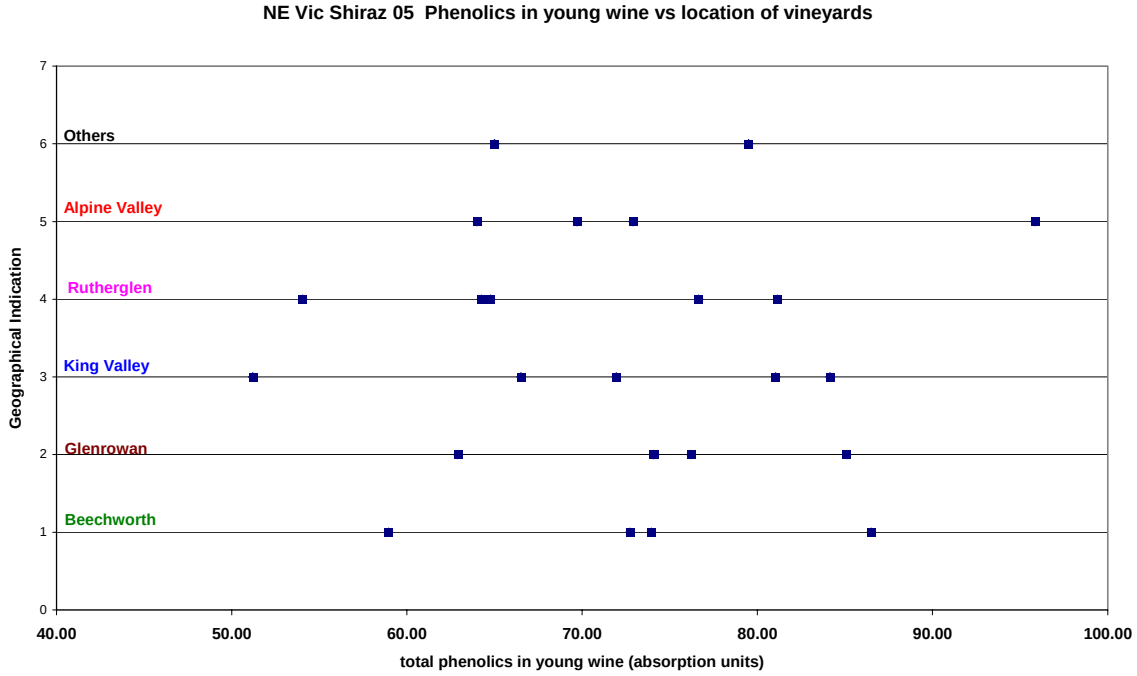


Fig. 31: All regions produced a wide spectrum of phenolics in young wine.

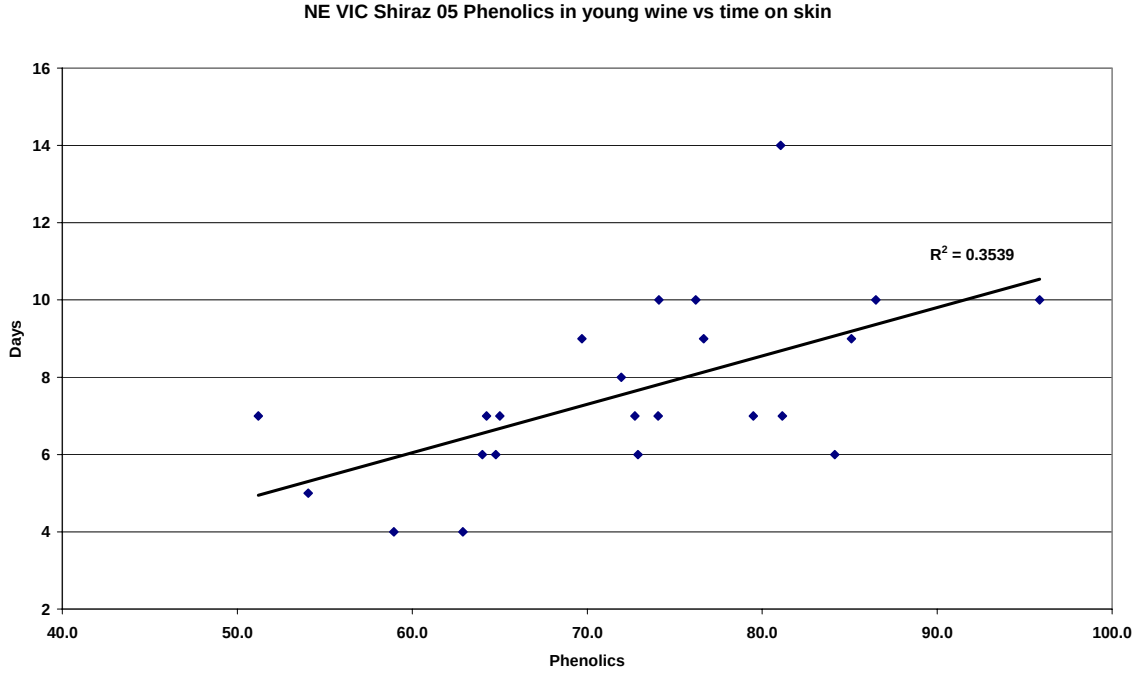
Wine constituents depend on **winemaking practice**, **harvest timing** and **grape quality**. As will be depicted later when BSA results are discussed, harvesting time focussed in many vineyards more on intended wine style and acid loss in berries than on phenolic ripeness.

The three wines with phenolics fewer than 60 units were made from fruit in the King Valley and Beechworth vineyards which were harvested at high acidity, with physiologically unripe BSA properties, in the Rutherglen area fruit was harvested at a lower Bé with low BSA scores.
These fruit characteristics were not counterbalanced by time on skin during winemaking, maybe due to the high amount of green seeds.

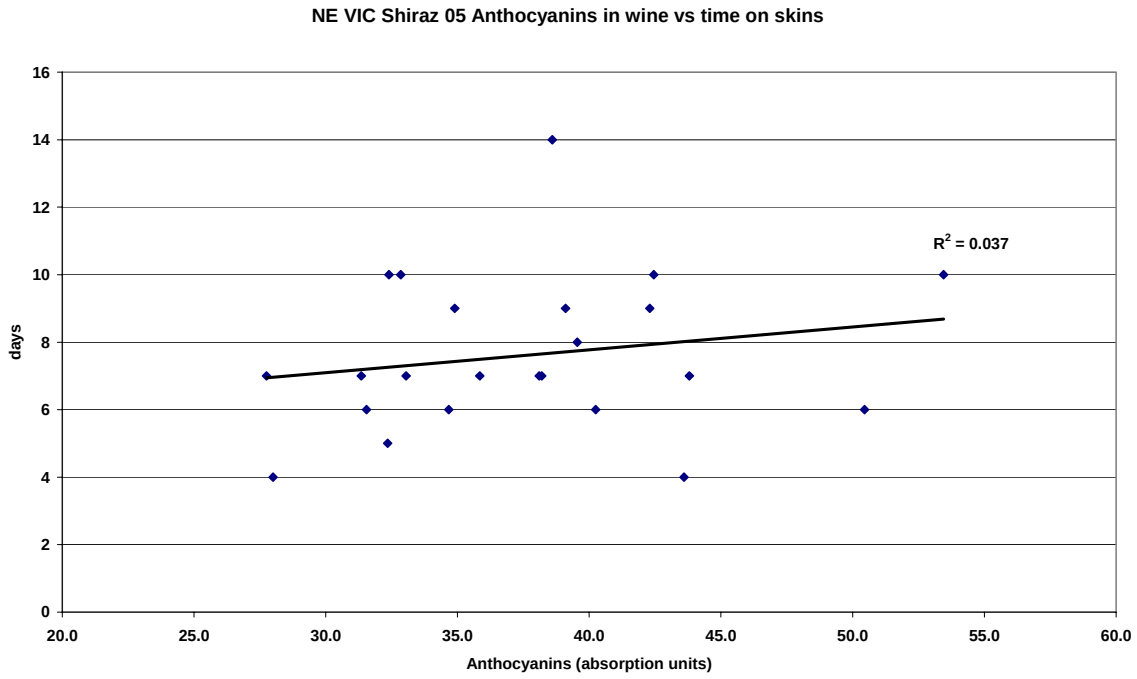
Concerning the winemaking process, **Tab. 3** showed what had happened to the grapes in the commercial wineries. Extreme values are highlighted.

Young wines and the fermentation process

The tannin or oak additions to the vat had less influence on the phenolics in young wine however time on skin mattered for phenolic extraction (Fig. 32), but less so for the extraction of anthocyanins (Fig. 33).



Figs. 32 and 33: More days on skins resulted in a tendency to yield more phenolics but not more anthocyanins in young wines (data points are young wine samples).



Young wines and their constituents

Tab. 4 shows pH, anthocyanins, colour density, hue, flavonols and total phenolics of the young wine samples, together with some winemaking, berry and vineyard parameters.

Highest values are highlighted in red, lowest in green. For the leaf area of the vineyard, highest values are in green, lowest in red.

The relationships of the wine constituents with each other deserve attention: There is a good correlation (r^2=0.47) between phenolics and anthocyanins in the wines. It would be better even without the outliers which have a higher proportion of skin anthocyanins than phenolics compared to the average. Berries of vineyards 2, 10 and 14 were very juicy, (2 and 10 being only rain fed vineyards) whereas those of vineyards 9 and 17 had high amounts of seeds and skins and came from areas with low soil water pre veraison. Berries from vineyards 2 and 14 still had high acidity (**Tab. 6**). Vineyard 4K has grapes of very high colour from open canopies in a cooler location.

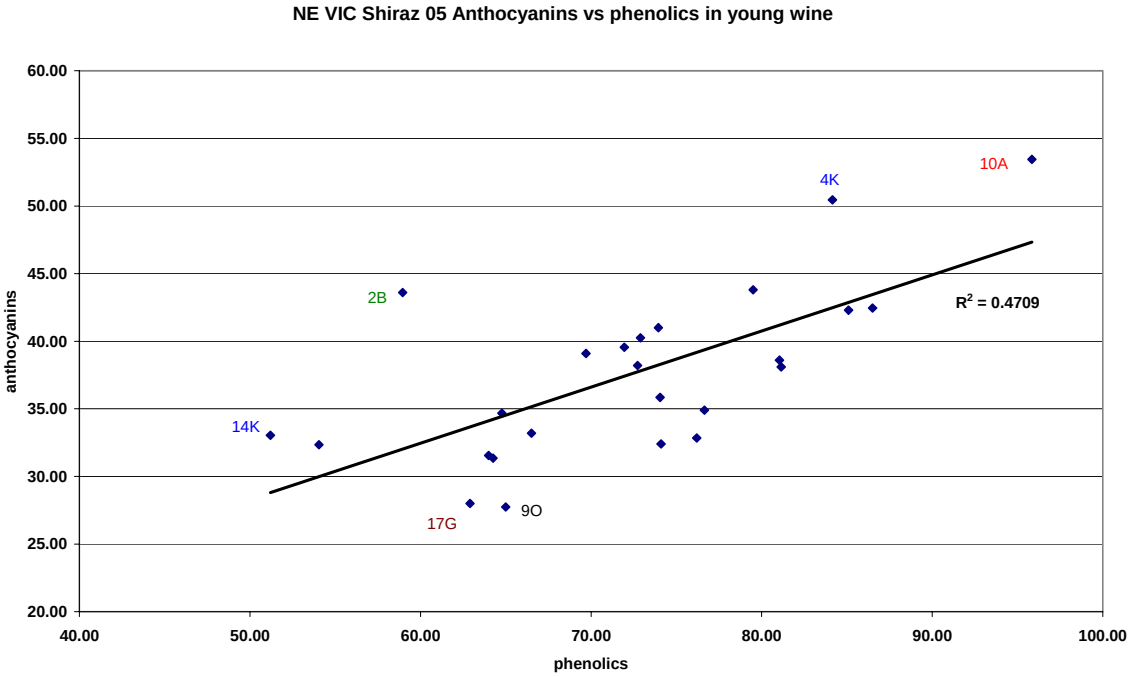
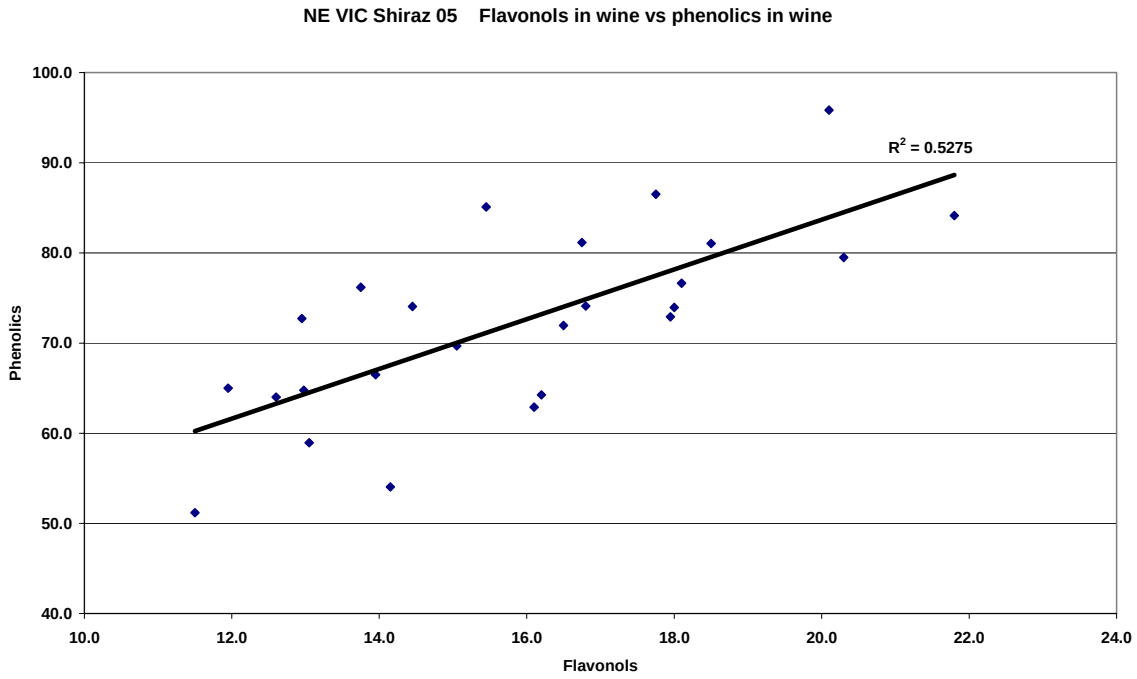


Fig. 34: Generally if we are discussing high total phenolics in young wine we may assume wine colour is good, but this is not the case in every sample.

Flavonols were highly correlated to phenolics in wine. As flavonols are produced as sunscreens (*Price et al. 1995*), bunch exposure warrants investigation.

Fig. 35: The more flavonol was measured in young wine the more phenolics were in generally present. Single values for vineyards can be seen in **Tab. 4**.



Viticultural practice and young wine constituents

As flavonols are produced as sunscreens and as in previous studies leaf cover over bunches played a role in wine quality, leaf cover rating in the vineyards was well correlated to wine flavonols (Fig. 36). Fruit from 9O had higher amounts of leaf cover earlier in the season resulting in lower flavonols but due to leaf loss and canopy rolling late in the season the data point is outside the trend.

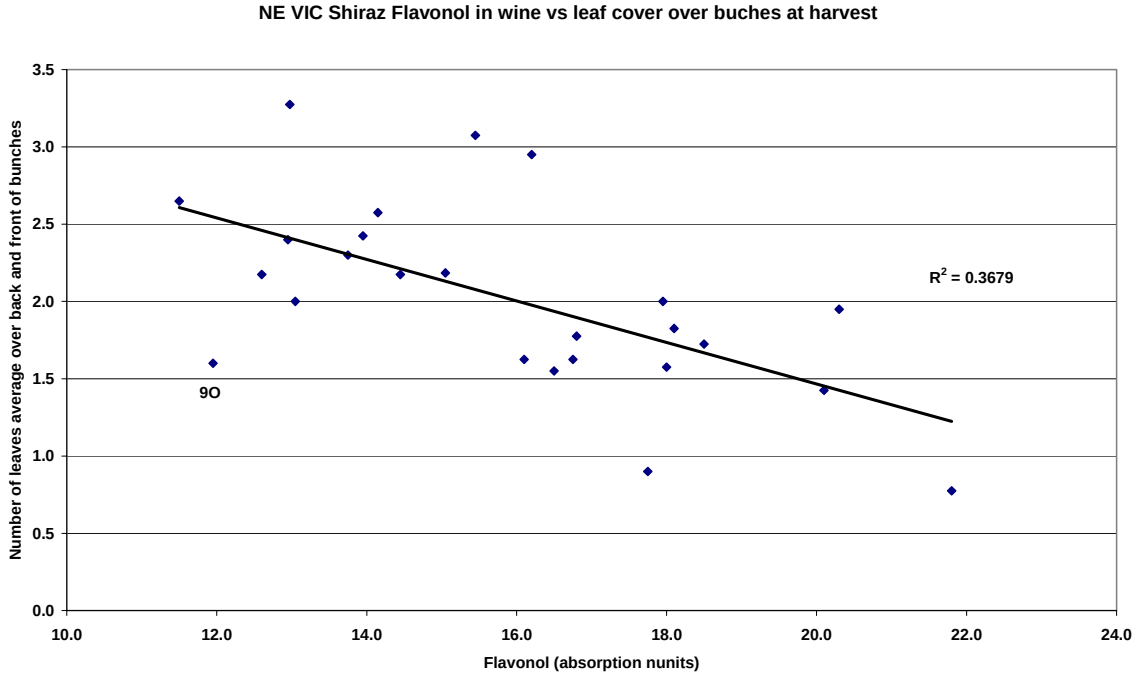


Fig. 36: Open canopies over bunches after veraison tend to result in more flavonols in young wine.

The correlation between leaf cover and **phenolics** is not as high (Fig. 37) due to extraction differences but there is a trend which will be examined in greater detail when discussing berries.

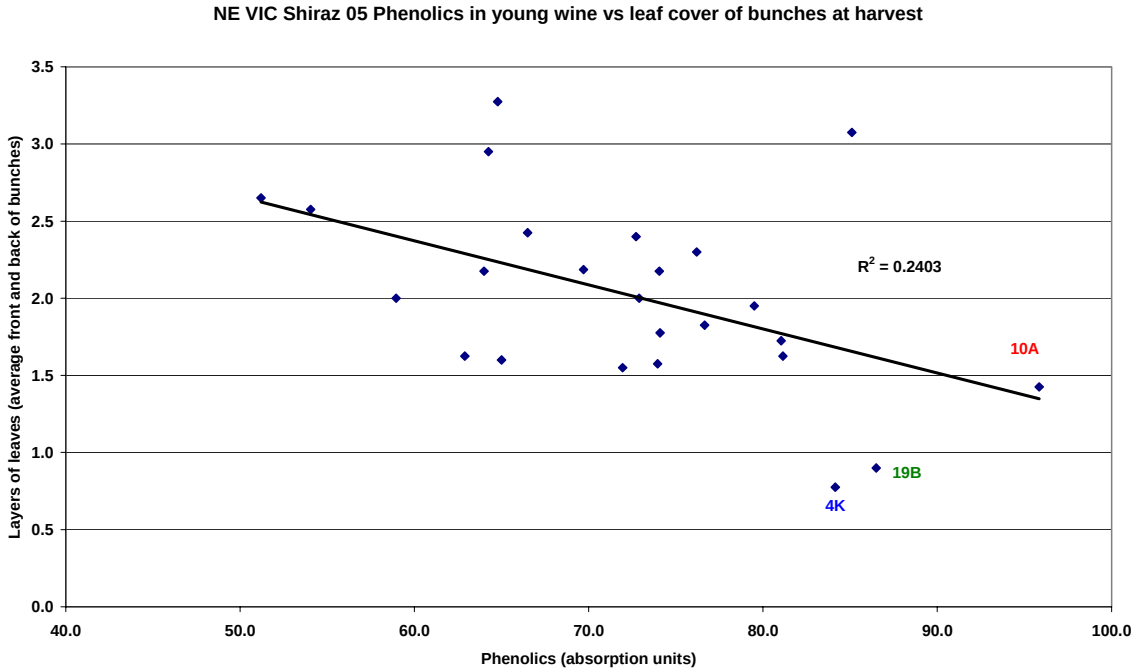


Fig. 37: There is a trend that fewer leaf layers over bunches produce more phenolics in wine. This trend is much less expressed for anthocyanins (see Fig 45).

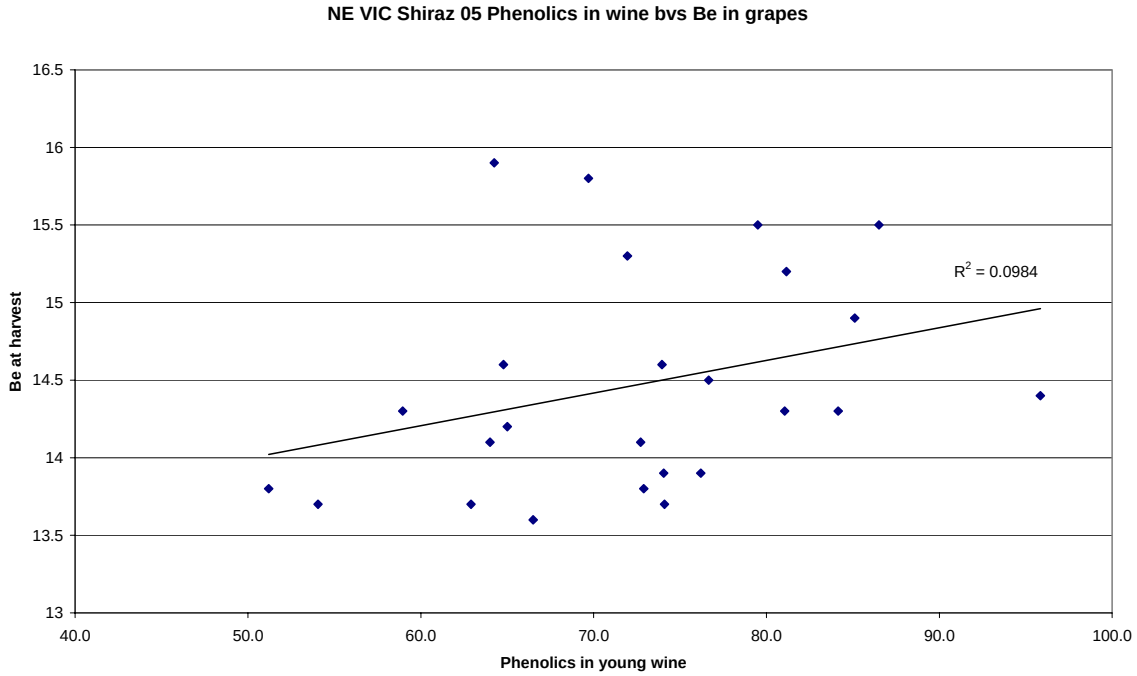
Photo of the east facing side in the sampling row of vineyard 19B



Pointers to potential quality in young wine

Low yield/ha, high Baumé and fast ripening which is commonly regarded as predictors for good wine quality did not correlate with high phenolics in young wine in this study (Fig. 38).

Fig. 38: Baumé at harvest was generally in the higher range and not an indicator for wine quality



There was a correlation between the skin maturity ratings of the berries in the BSA field assessment with final wine phenolics (Fig. 39). This is not the case with BSA ratings for seeds.

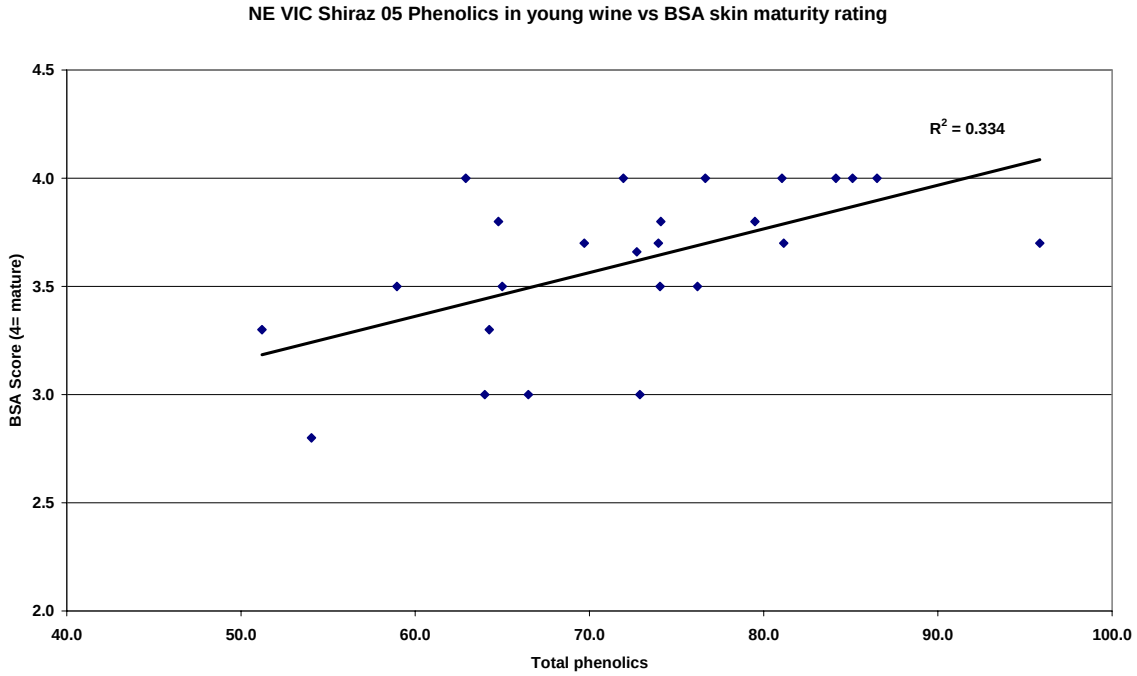


Fig. 39: All wines with more than 80 units of phenolics came from berries with mature skins; immature skins produced wines with phenolics below 60 units. Some skin-ripe berries produced young wines with low phenolics.

The next step was to see whether the phenolics in wine are also present in the same amount in the skins of the berries. Included in **Tab. 4** are phenolics measured in berries expressed /g skin and /g berry fresh weight. There is a good correlation between phenolics in young wine and phenolics per berry fresh weight (Fig.40).

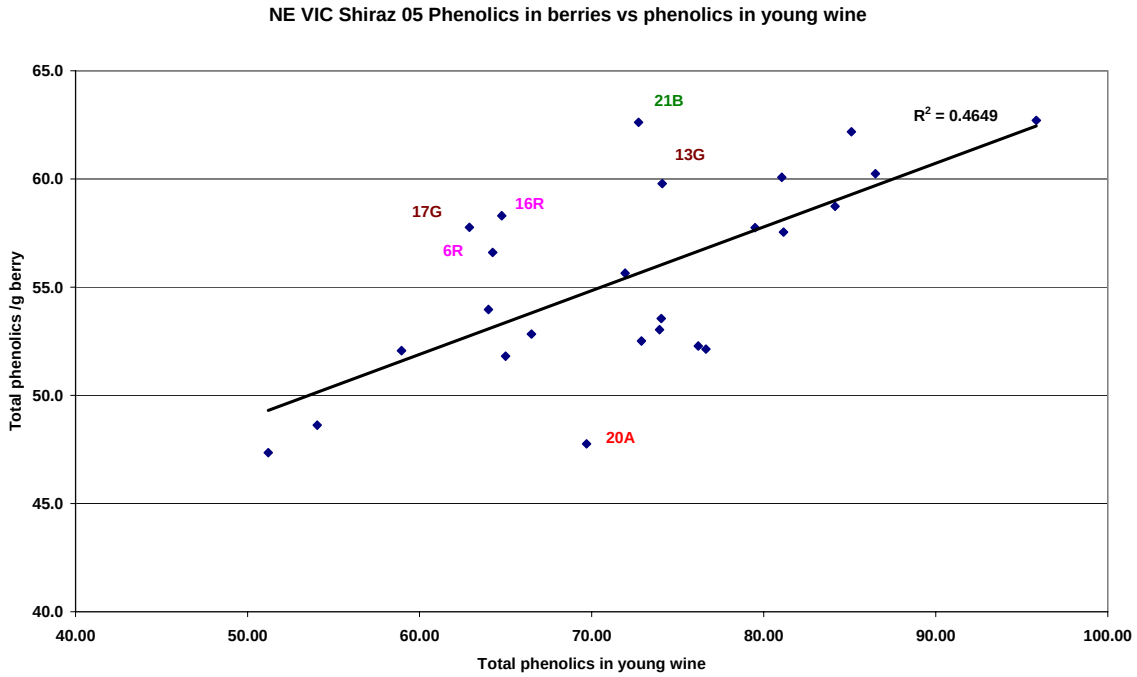


Fig. 40: Very low total phenolics in berries led to low phenolics in young wine and vice versa. There is a middle field with various outliers.

Fruit from vineyard 20A was not high in phenolics but cold soaking and 9 days on skins seemed to have extracted more phenolics than expected. In contrast, G 17 was only 4 days on skins and therefore underperformed in the wine. Other berry constituents like co pigmentation factors may contribute to the phenolic extraction and preservation in young wine which are not obvious from the data collected in this study. This correlation is less expressed when phenolics in berries are expressed per g skin (Fig.41).

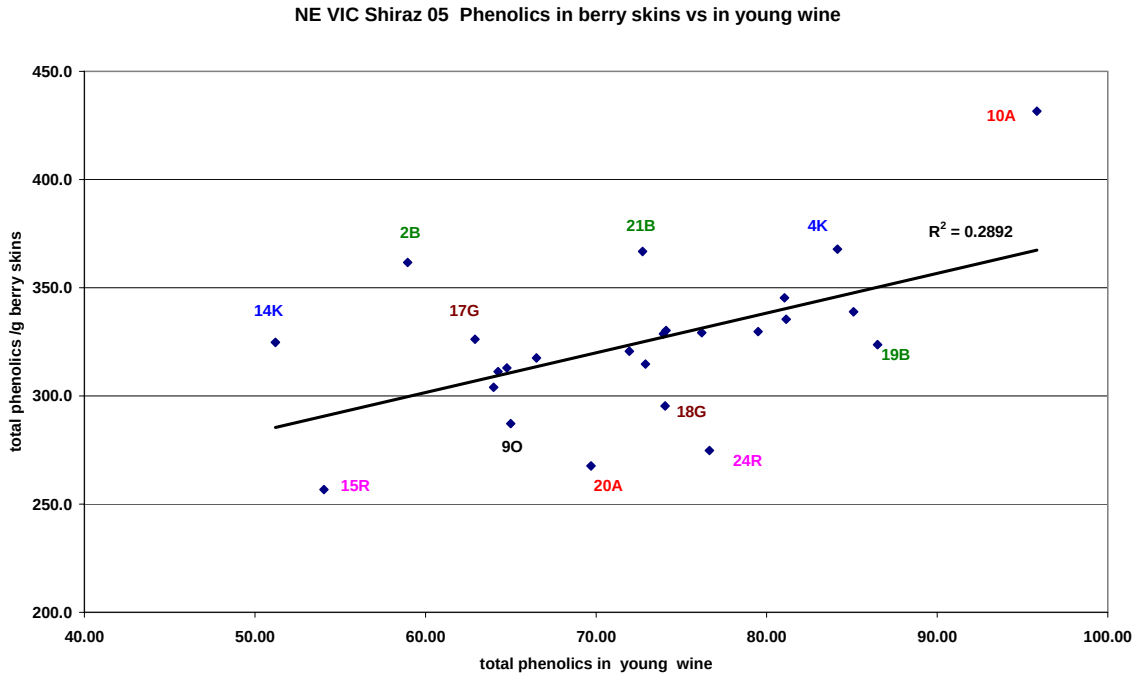


Fig 41: The relationship of phenolics in berries vs in young wine is less clear when phenolics in berries are expressed on a per g skin basis.

Grape and vineyard analysis

When the phenolics /g skin were depicted against the proportion of skin of the total berry weight it became clear that the highest amounts of phenolics occurred with berries which had a lower proportion of skin weight vs. berry weight; and low phenolics of skins were calculated when the skins were thick and comprised more than 18% of the berry (Fig.42). This was independent of berry weights.

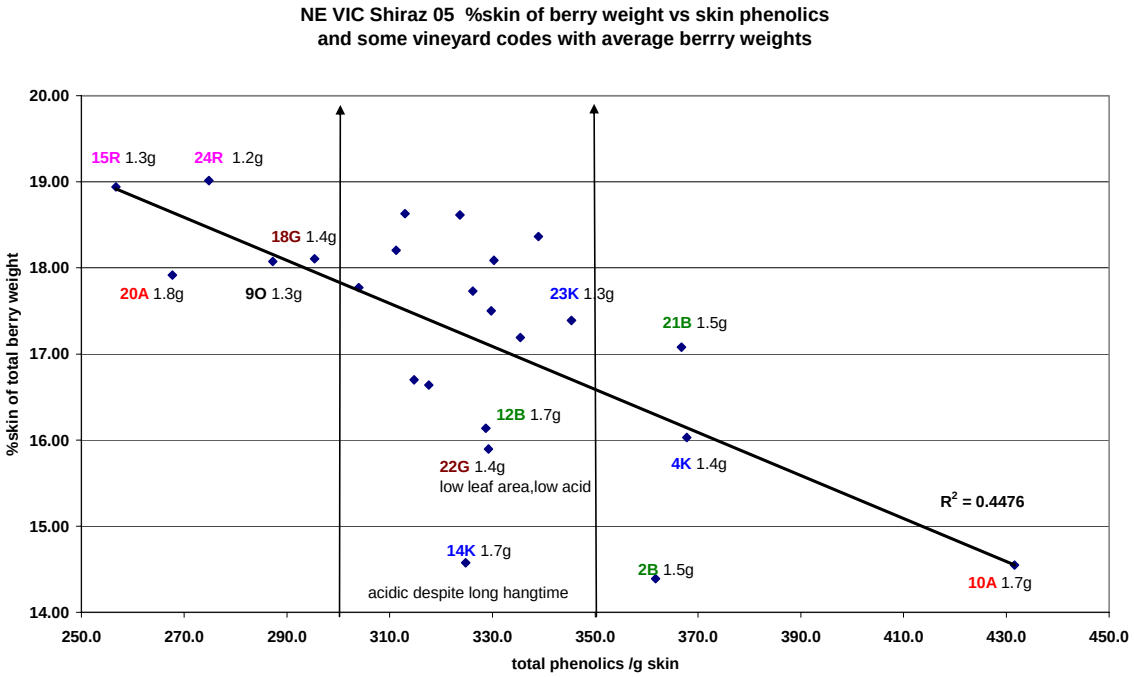


Fig. 42: Berries with thick skins (irrespective of their weight) contain phenolics only in the outer layers and therefore display lower concentrations of phenolics per g skin.

Berries from vineyard 20A had a very high berry weight but also a high percentage of skin. A lighter berry (24R) with a high skin to pulp ratio is more normal and the low concentration of phenolics per g skin in the upper left hand corner of the graph is possibly due to the thick skin all of which is not carrying phenolics.
Vineyard 10A has thin skinned big fruit from only rain fed vineyards after receiving 628 ml before veraison.
It can therefore be recommended that all berry constituent measurements should be expressed per g fresh weight of the berry. Fresh berries are made into wine and not skins! Berry weight was related to seed weight (r^2=0.55) but skin weight was independent of seed weight.

Previous studies found a correlation between berry weight and berry phenolics and also wine score. Therefore the old saying that small berries are good and big berries are bad was examined and not found to be so straightforward.
The dynamics of grape berry growth and the physiology of ripening (*Coombe and McCarthy 2000*) is still not fully elucidated. It has been shown that berry mass per se is unlikely to be a major influence on the solute concentration of wine when differently sized fruit was analysed (*Walker et al 2005*) and improvements seen on wine quality when berries were smaller were linked to the treatments that led to smaller berries, not to berry size.

Total phenolics in berries

The values discussed below are phenolics in skins only. If berries are ground up and seed and skin phenolics are measured together, berry quality cannot be assessed as the origin of the phenolics is unclear. Unripe seeds emit a large amount of phenolics (unwanted) and emit less when ripe, unripe skins emit less phenolics and more when ripe.

Phenolics in berries were found to often correlate with phenolics in wine (*Somers 1998*) but not always. This warranted investigation.
Also sunlight is said to have a positive effect for berries destined for full bodied wines (*Smart and Robinson, 1992*) – but this did not always work for warmer regions.

Phenolics and berry weights

If some extremes are excluded (codes without dots) a good correlation of phenolics and berry weight was observed: Smaller berries had higher phenolics per g fresh weight Berries with lower than expected phenolics are from early harvested (15R), shaded through canopy rolling (9O) and thick skinned (24R) fruit. Berries with higher than expected phenolics are from vineyard 10A with high exposure due to extreme defoliation due to leaf plucking on the east side only (see photo further below). Berry weight was not related to rainfall (not depicted).

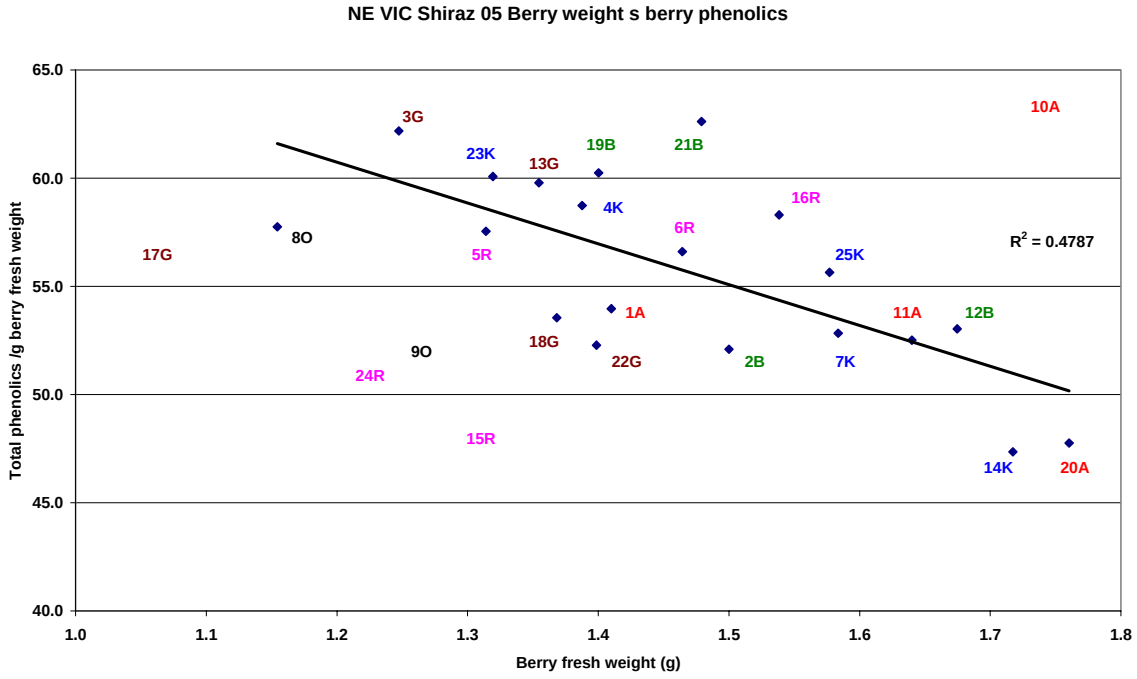


Fig. 43: Heavy berries generally have less phenolics per g fresh weight. Not all light berries have high total phenolics. There is a big middle field where berry weight is not indicative of phenolic potential per g FW.

When the proportion of the weight of skins to the total berry was related to the proportion of the weight of seeds, the berry juiciness could be detected (Fig.44). Very juicy berries with low proportions of seeds and skins are in the bottom left corner of the graph, thick skinned normal sized berries with moderate seed weights are in the mid upper part of graph berries with larger seeds and lower skin weights are at the right bottom part of graph. Cause and effect will be examined further below.

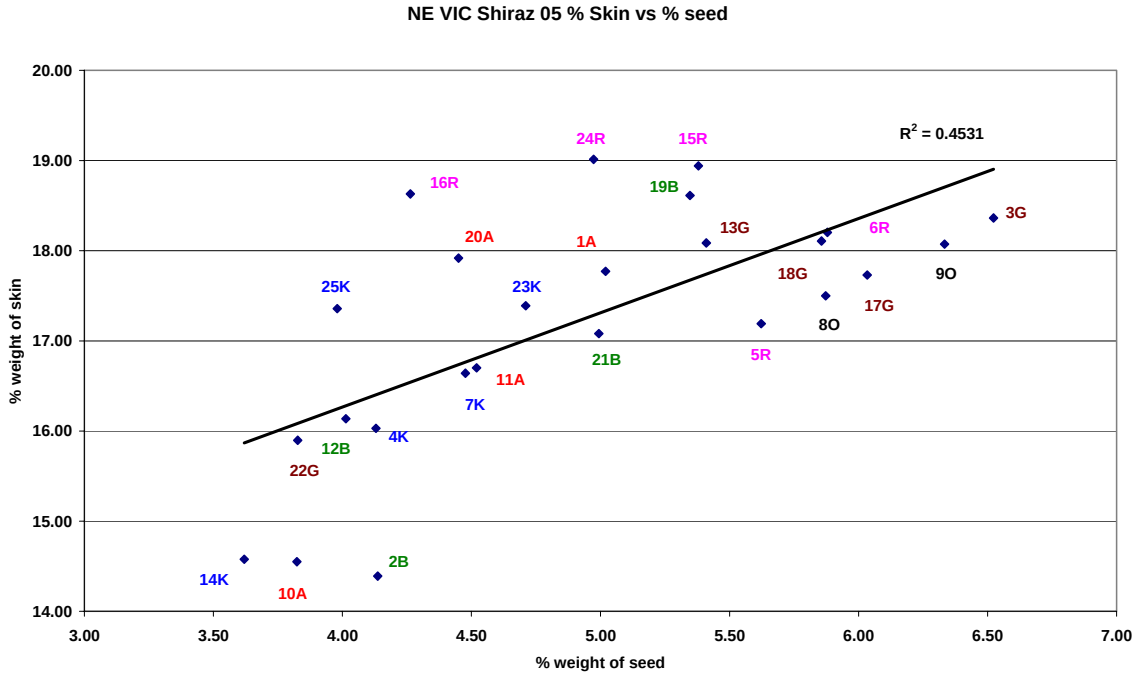
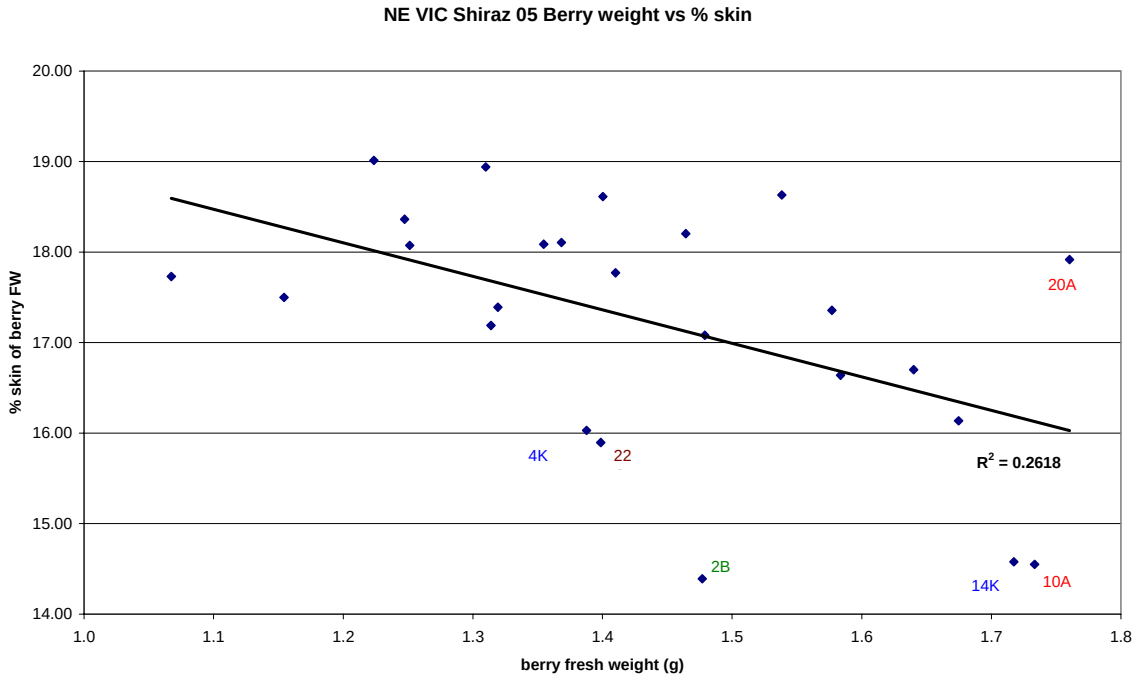


Fig. 44: Proportion of skins and seeds of the berry weight shows their hydration status.

Fig. 45: Not only lighter berries had a high skin to pulp ratio.



Phenolics and flavonols

In the berries, when expressed per g FW (**Tab. 5**), the phenolics were quite related to the flavonols (Fig. 46). Exceptions are berries which were harvested early due to a different wine style target (15R), and three rather leafy vineyards (21B, 10A, 3G).

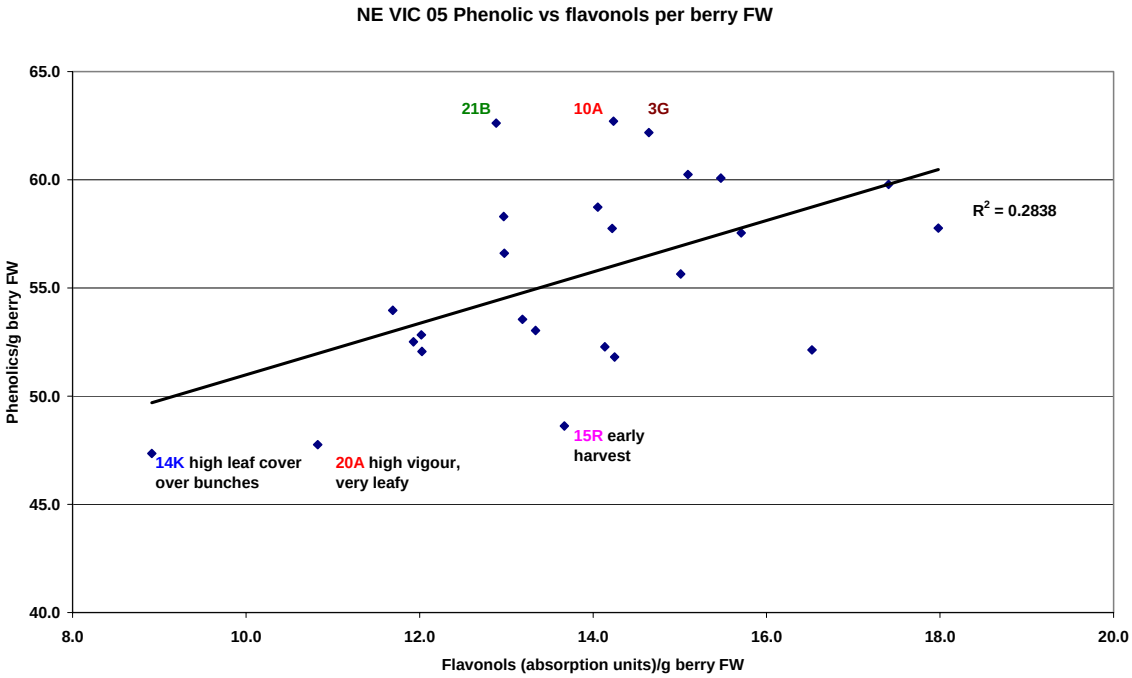


Fig. 46: Berries with low flavonols had also low phenolics and vice versa but there was a middle field of various phenolic readings with moderate flavonols.

Photo of vines from vineyard 14K showing dense leaf cover over bunches and shade from adjacent row.



Phenolics and Baumé

Sugar concentrations at harvest poorly correlated with harvest phenolics/g berry fresh weight (Fig. 47).

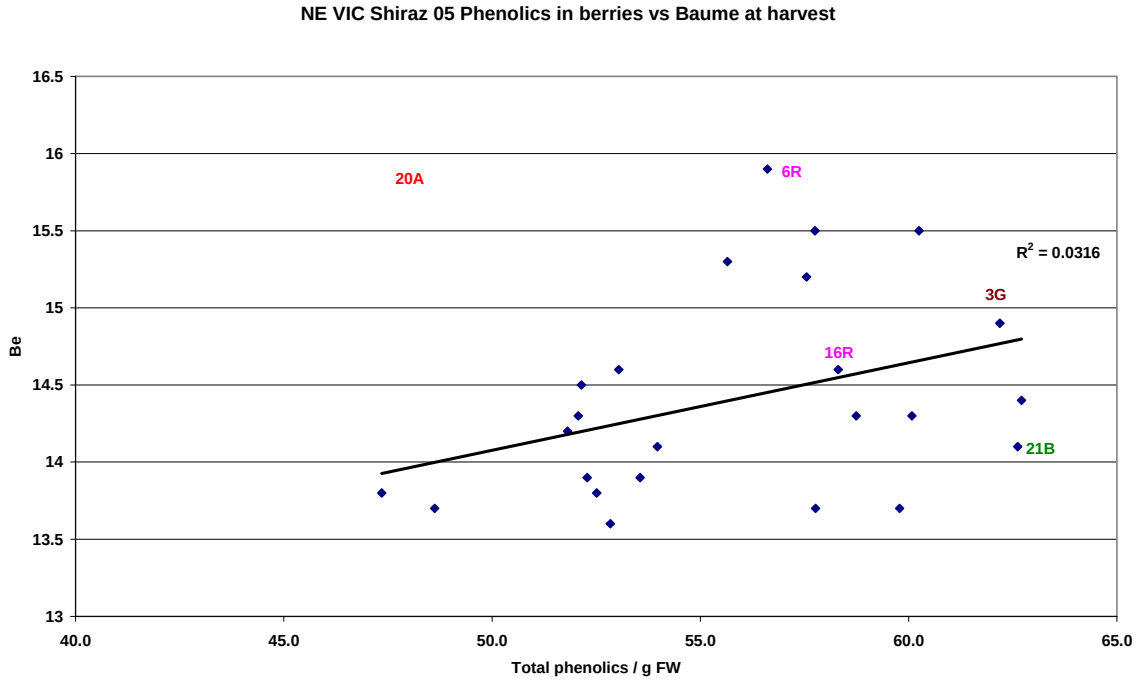


Fig.47: Moderate and good phenolic concentrations occur at a wide range of Bé.

This is because the grapes were harvested at different degrees of sugar ripeness. It can however be seen that the berries that accumulated sugar fast (when the Bé was divided by the days between veraison and winemaker determined harvest) also generated high concentrations of extractable phenolics when calculated on a per day basis.

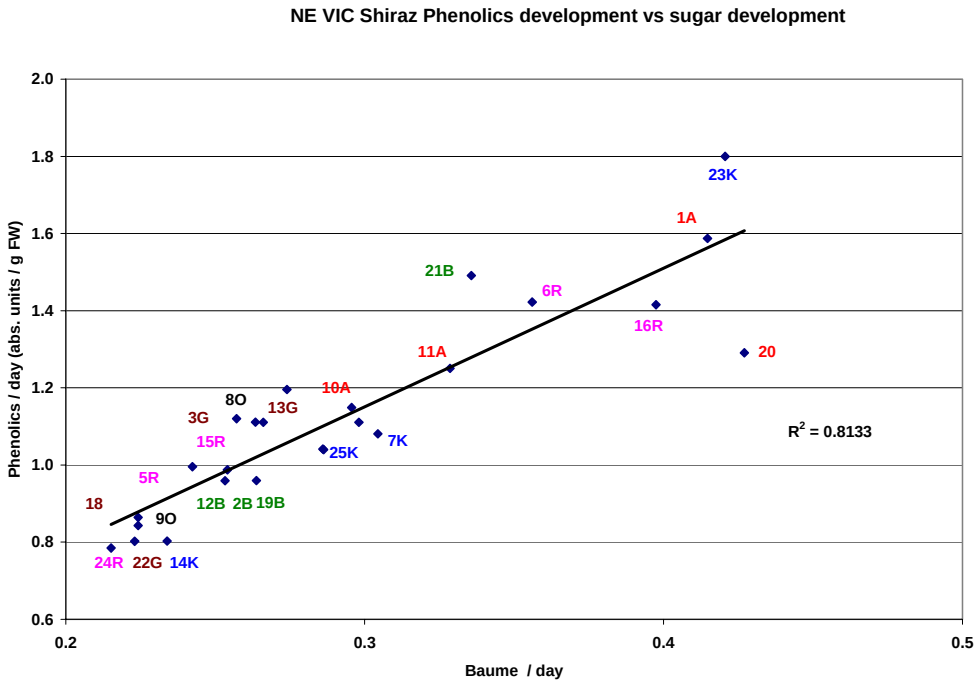


Fig 48: Speed of sugar accumulation, not endpoint of Bé seem to be an indicator of phenolic potential.

Phenolics and TA at harvest

There is no relationship, even if the very acidic berries are not included in the trendline formation, as grapes were taken off at different maturity stages.

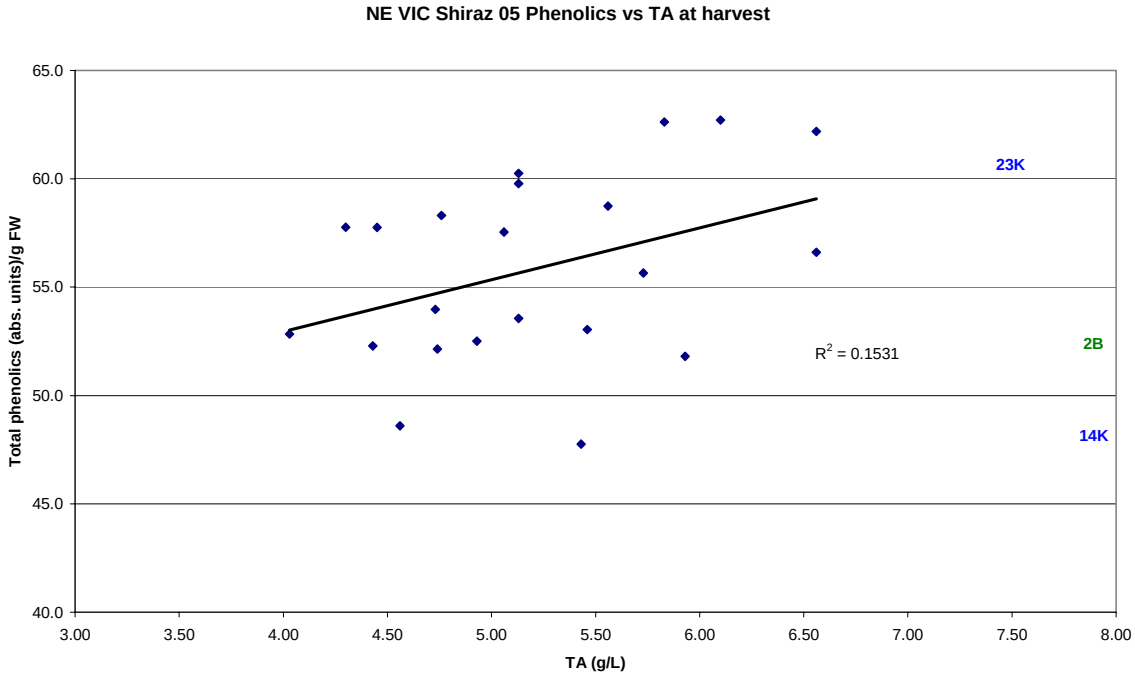


Fig. 49 Higher and lower phenolics were measured at a wide range of TA.

The acid at harvest divided by number of ripening days is a better measure of ripening speed. It was significantly accompanied by a high increase of phenolics per unit of hangtime when 14K (high leaf cover) and 2B (high leaf cover) were excluded. Retention of acidity is a sign of absence of heat loads. Fruit from vineyard 23K retained its acidity for long together with excellent physiological (BSA, sugar and phenolic) ripening.

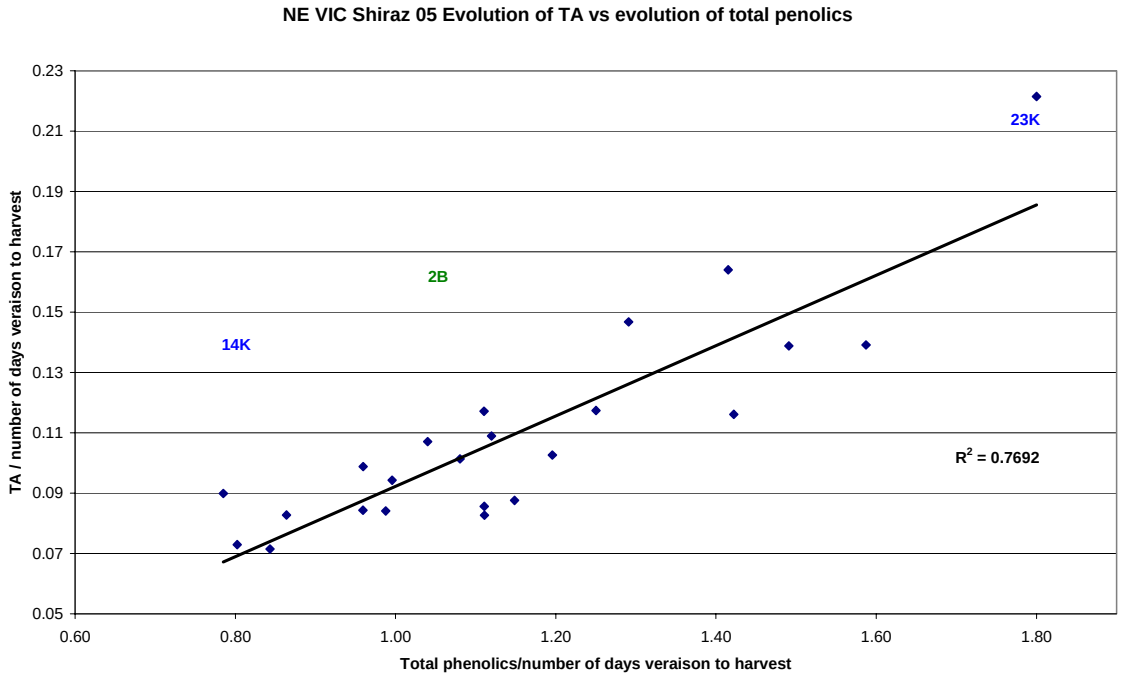


Fig. 50: Acid retention is highly related to phenolics per unit of hangtime.

Phenolics and anthocyanins
Are discussed further below under Anthocyanins.

Phenolics and BSA scores for skin maturity
Correlation between BSA score of skins (**Tab. 6**) and phenolics was good when outliers (tiny thick skinned berries of 24R and big berries from vigorous 20A) were removed.

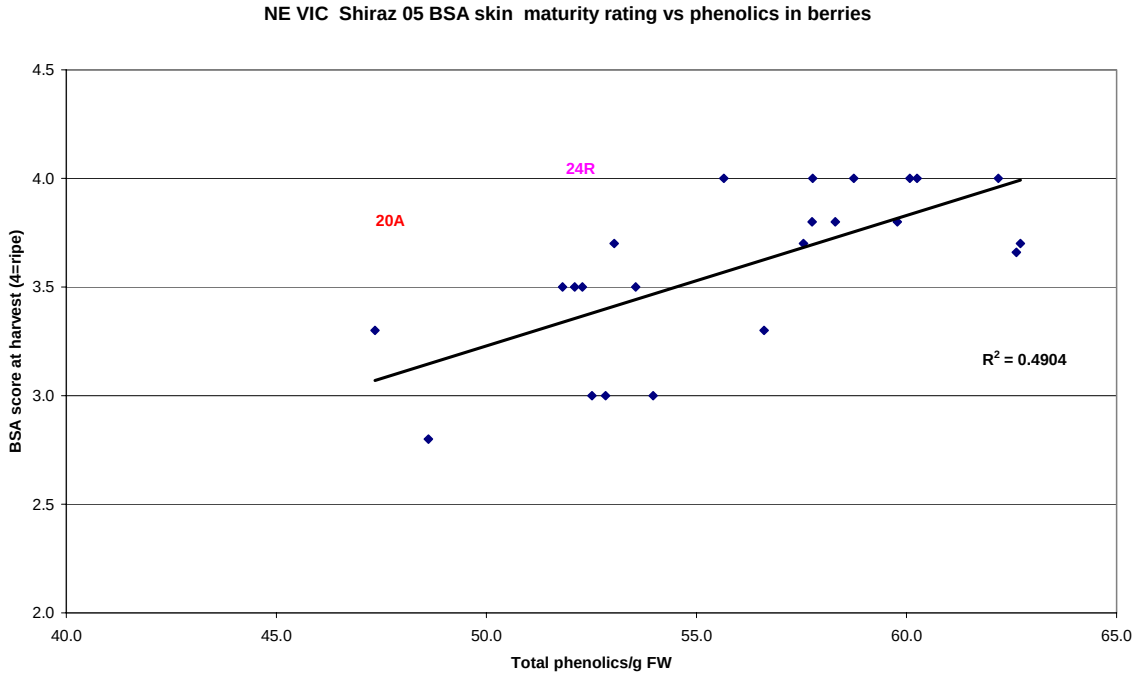


Fig 51: BSA scores for skin maturity and skin total phenolics/g berries correlate.

Phenolic content and extractability at two time points
The concentration of total phenolics /g berry FW at two different measurement times (**Tab. 6a**) shows that in vineyard 20A there was a loss of berry constituents late in the season /g FW of berry. It cannot mean they were diluted by excessive water uptake as all berries except from vineyard 4 lost weights before harvest (**Tab. 7c**). The sample may not have been representative as it was taken after harvest.
Fruit from vineyards 5R and 3G were left on the vine until high sugar ripeness and therefore increased in phenolics drastically between 11.5 and 12 Be respectively and 15.2 and 14.9 Be respectively at harvest. For most fruit there is no linear increase in total phenolics/ g berry weight in the last phase of ripening (Fig. 52).

The increase depends on the change in berry weight, skin maturity and therefore ease of extraction, and the ripeness stage at which the first reading was taken, which was not in all vineyards at 12.5 Be (Fig. 23)! Generally, phenolics are made before veraison and “ripened” thereafter (*Habertson et al. 2002*). It is of some doubt whether a 12.5 Be reading is needed as this is too late for management practice which could alter phenolics in grapes.

Fig. 52: Phenolic concentrations did not change drastically between approx. 12.5 Bé and harvest except 3 outliers.

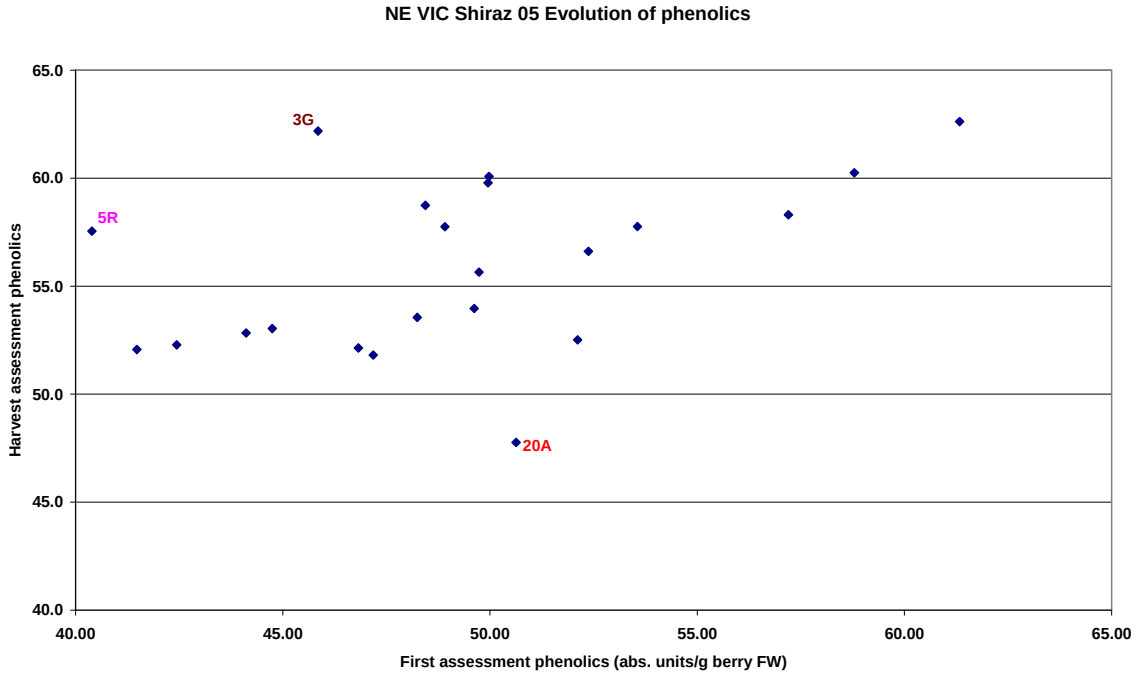
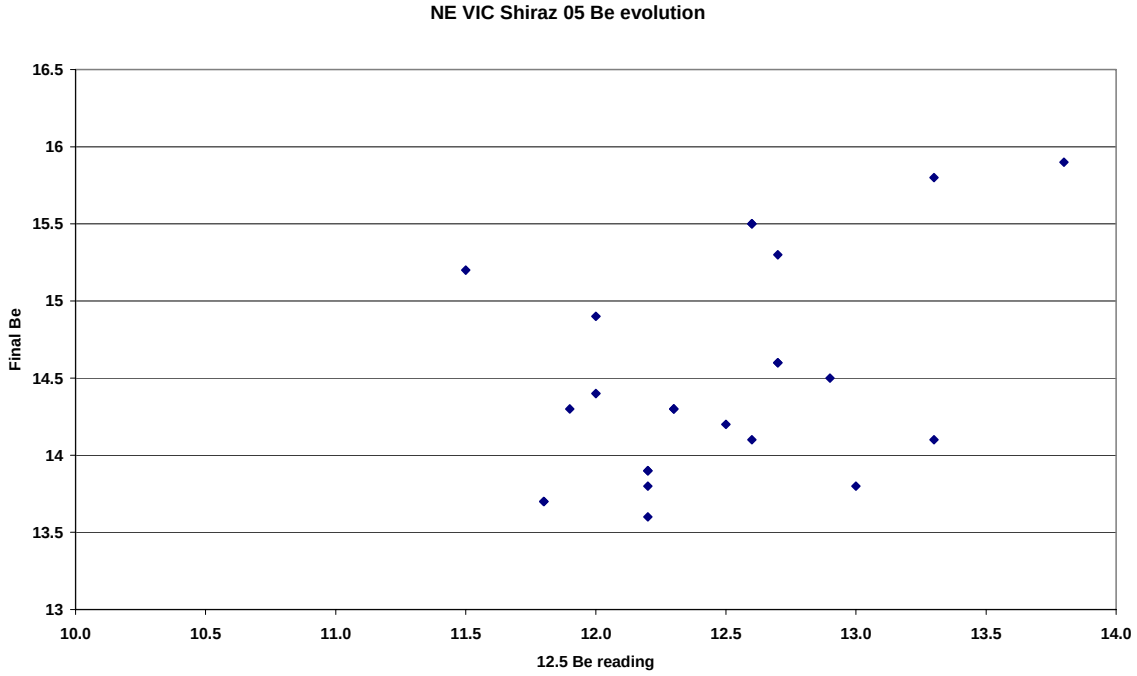


Fig. 53: First chemical analysis was done with berries harvested at between 11.5 and 13.8 Bé, a rather incomparable mix of samples.



Phenolics and vineyard parameters

As flavonols are sun-induced, and are related to phenolics, an investigation of the relationship between berry phenolics and **leaf cover** of bunches (average over front and back (**Tab. 9**) was undertaken (Fig. 54). When 4 outliers are excluded (3 of them from very warm vineyards) there is a high correlation between leaf layers over bunches pre harvest and the concentration of phenolics in berries at harvest.

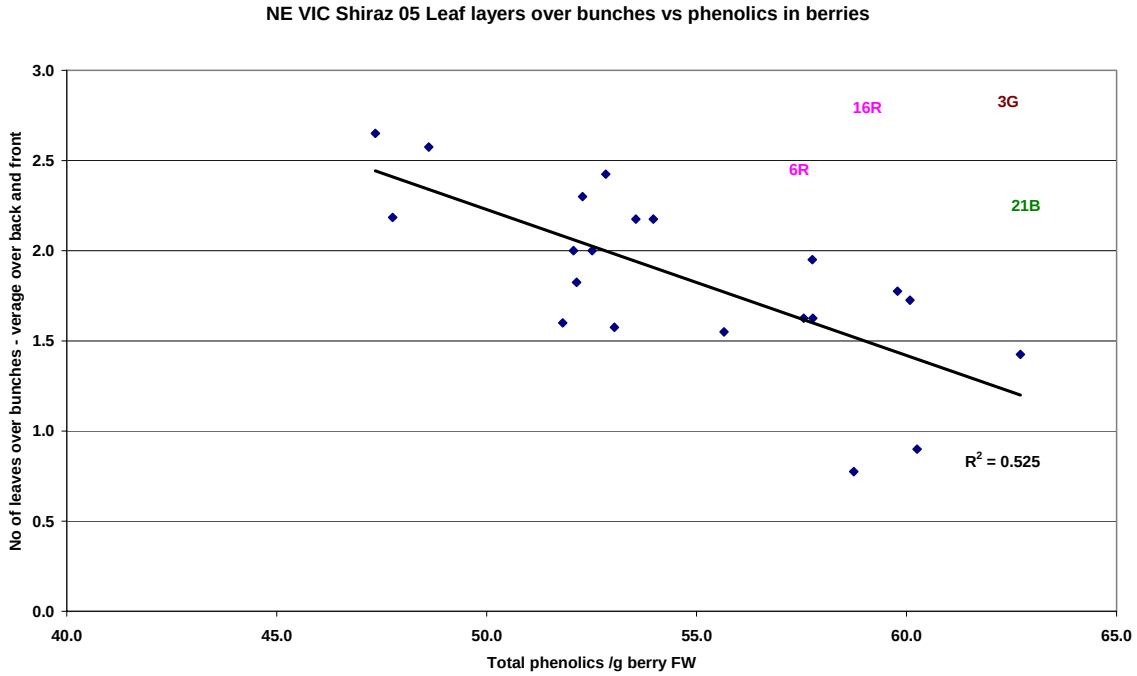


Fig. 54: Open canopies produce berries with higher skin phenolics at harvest.

The question may arise at what time good exposure needs to set in. It looks as if exposure after veraison was more linked to good phenolic extraction from berries than that before veraison (Fig. 55).

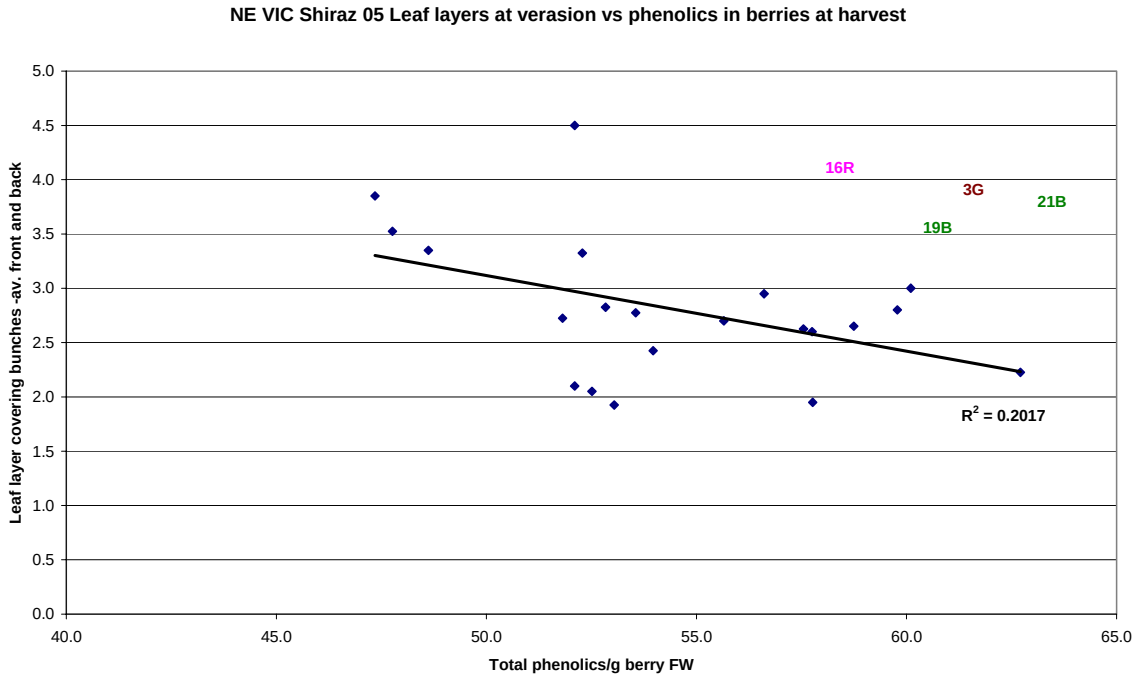


Fig. 55: Exposure of bunches seems to be less crucial at veraison for the production of high concentrations of skin phenolics.

Maybe "**hangtime**" (time form 50% flowering to harvest) is important for high phenolic readings at harvest? Even if the notoriously leafy vineyards are excluded for having below average phenolics, hangtime is not well correlated (Fig. 56).

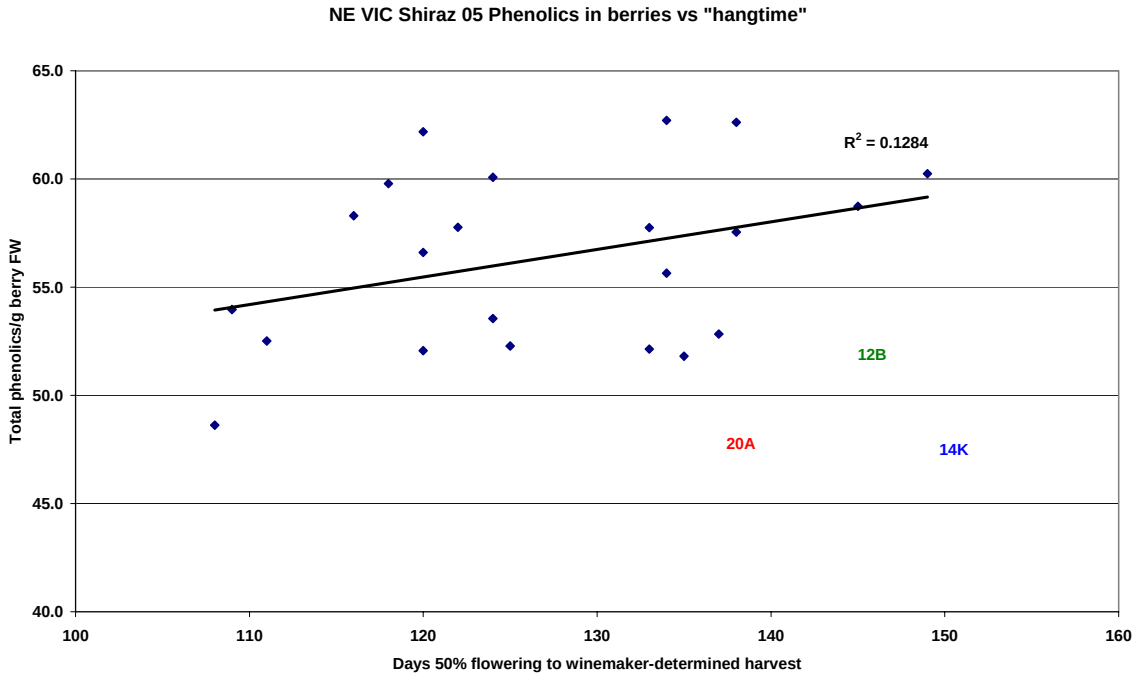
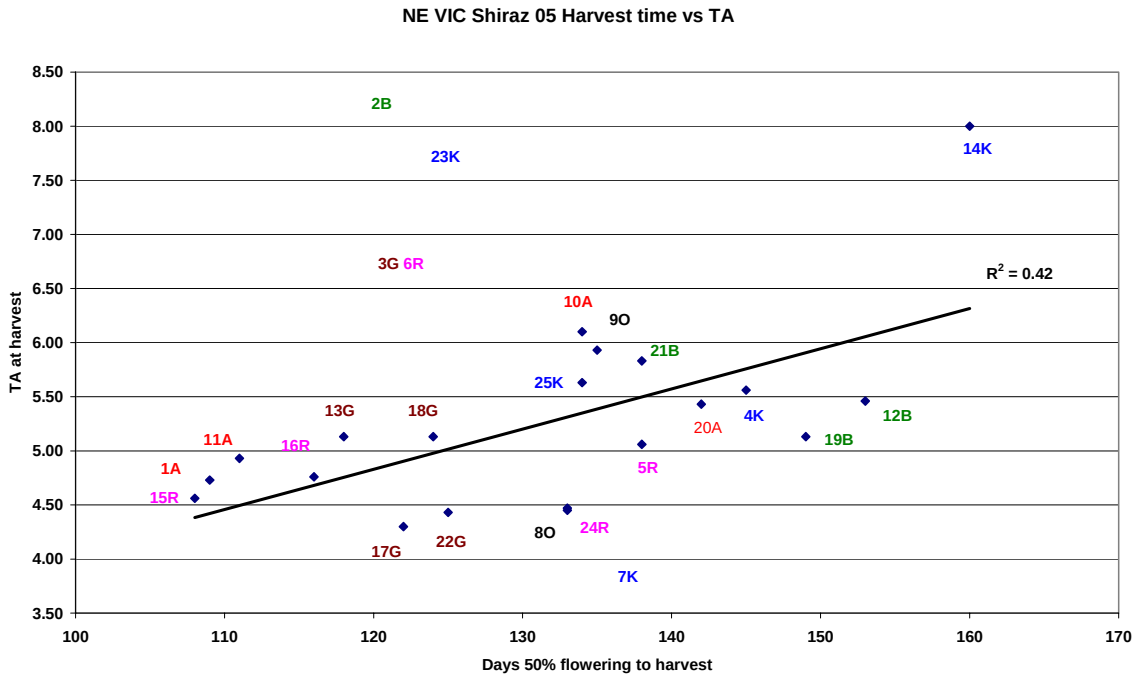


Fig. 56: Good phenolics were achieved at a wide spectrum of bunch life.

Hangtime was not determined by skin ripeness, harvest decisions were in most cases determined by observed acid loss (**Tab. 6**). As can be seen in Fig 57, except for 4 crops which may have been destined for a different winesytyle and were harvested early with higher acid, hangtime of under 125 days were found for crops approaching low TA.

Fig. 57: Hangtime was determined by acid loss, in particular in warmer regions.



Does hangtime have an influence on berry sensory characteristics (**Tab. 6**) of the skins? In the unripe sector there is a trend (Fig. 58) but many berries ripened fast and 7K and 14 K never ripened despite long hangtime. There was no correlation between seed maturity and hangtime.

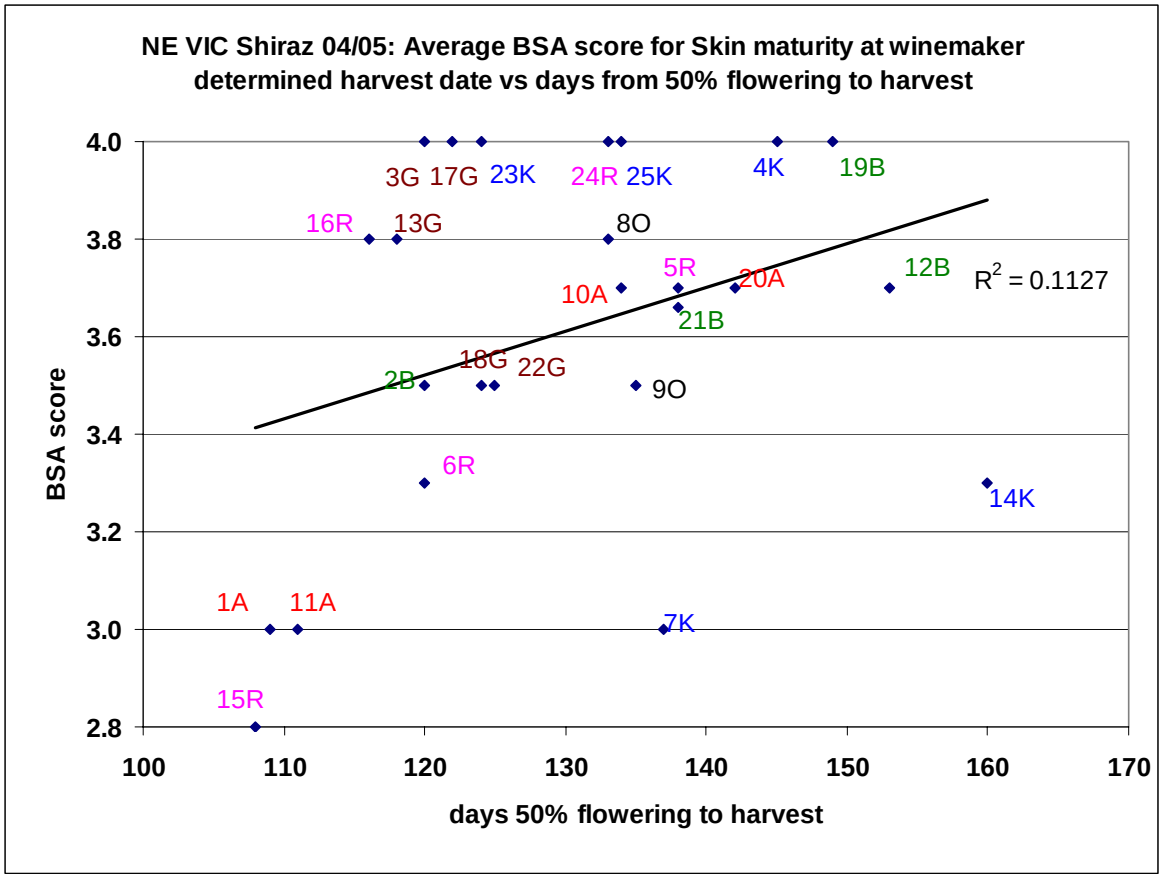


Fig. 58: Long hang time is not needed to produce BSA scores for ripe skins.

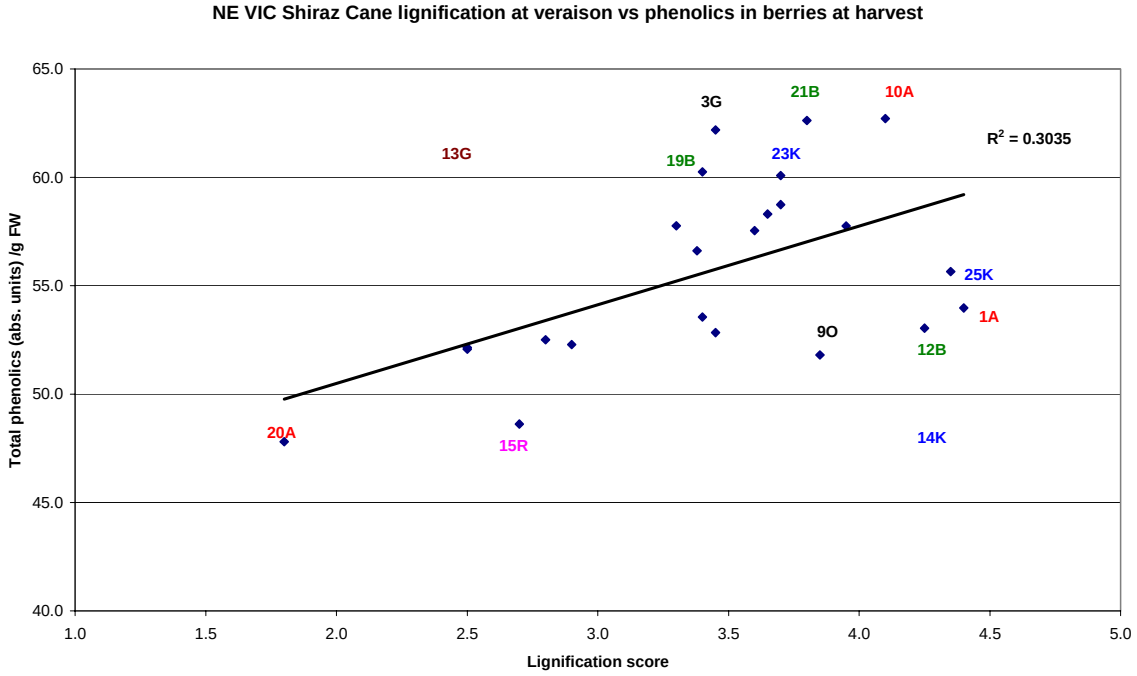
Phenolics and cane lignification at veraison

One of the hypothesis of the study was that degree of cane lignification at veraison (**Tab. 9**) is a pointer to the ripening earliness of a vineyard. If a transition from growing to ripening is indicated by fast can lignification, is this a pointer to good phenolic concentrations at harvest?

We excluded the fruit from vineyard 14K for its lower sugar ripeness and 13G for its exceptional phenolic status. Five vineyards with shoots lignified at veraison below score 3 (= 41-60%) correlated with low phenolics at harvest.

In this season most vineyards had good management practice and no excessive pre veraison rain periods resulting in good shoot lignification.
There were 4 vineyards with highly lignified shoots which still did not produce high phenolics for other reasons.

Fig. 59: Slow lignification of canes at veraison may be a pointer to low phenolic potential at harvest. Good cane lignification may not in all cases predict good phenolics at harvest.



Phenolics and vine balance

It was expected to see bad phenolic production and ripening in unbalanced vines. In this study almost all vines had leaf to fruit ratios in the balanced bracket.

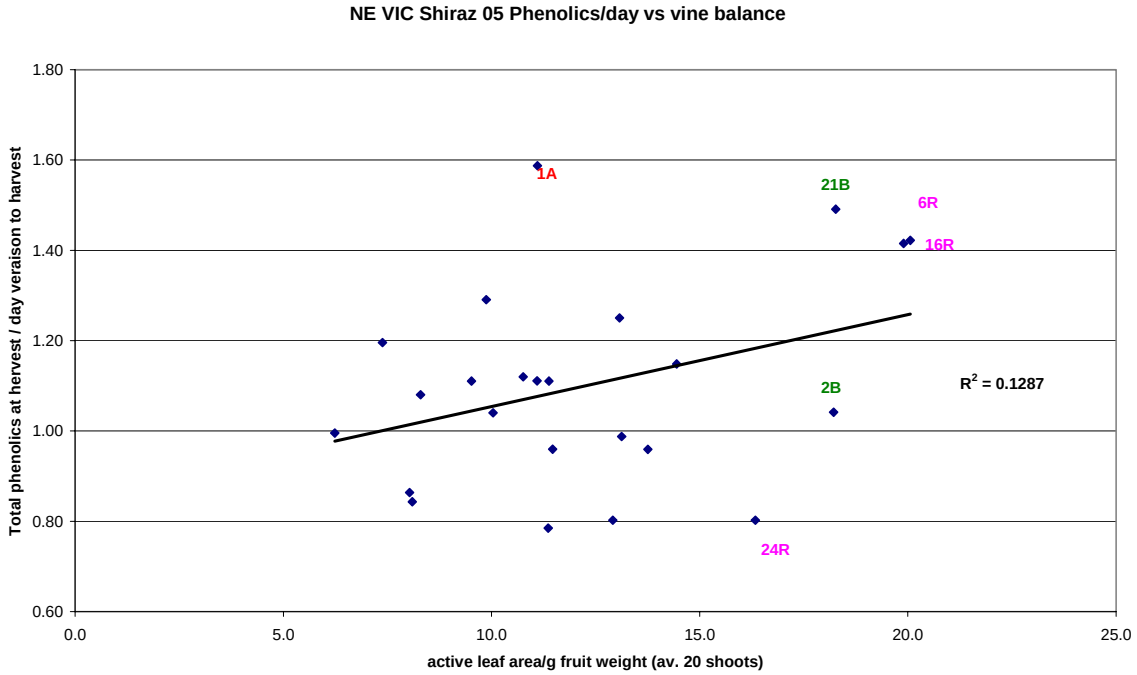


Fig. 60: In balanced vines, at a range of 8-15 cm^2 of leaves per g fruit no relationship existed between total skin phenolics (if divided by hangtime from veraison to harvest) and vine balance (this is in contrast to the sugar ripening – vine balance relationship).

Some very leafy low fruit weight vineyards made more phenolics in the time available but 2 of them did not have the highest endpoints. Other parameters must be looked at.

No other vineyard parameter listed in **Tab. 9** correlated with phenolics/g berry FW at harvest.

Phenolics and row orientation

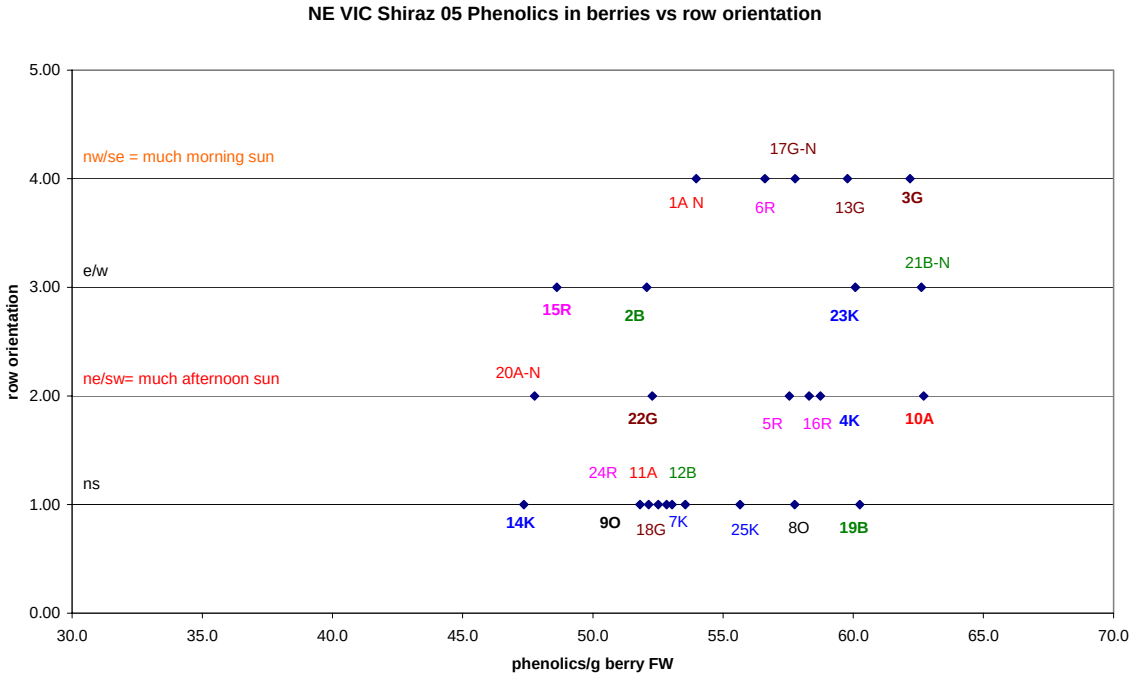
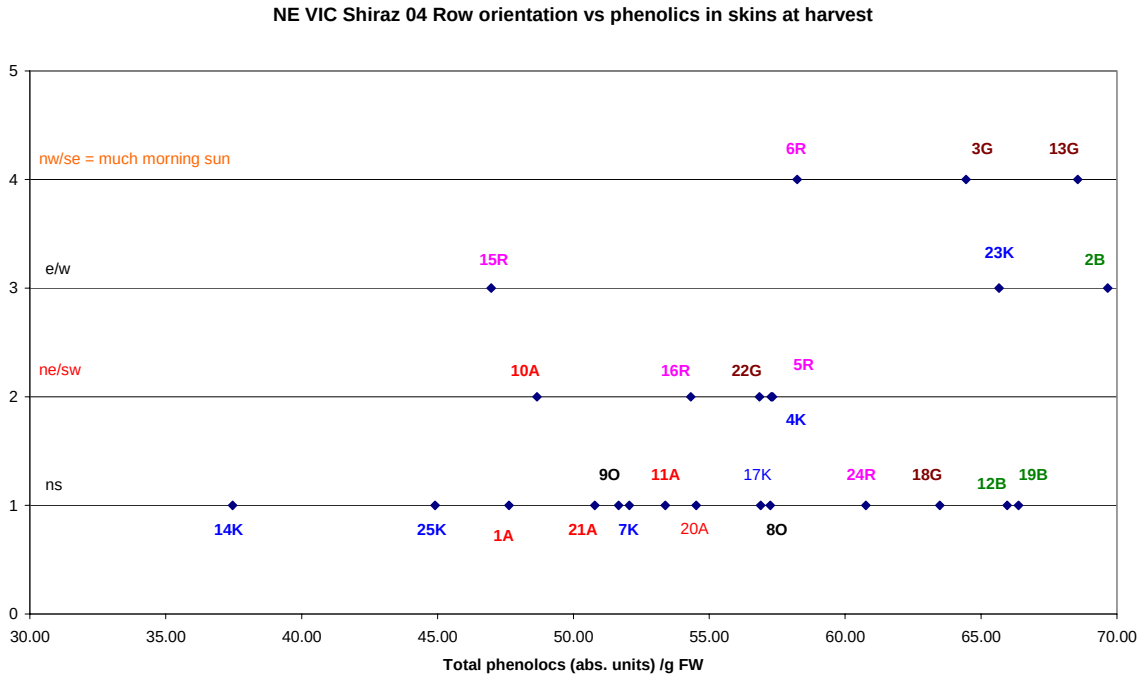


Fig. 61: A wide range of phenolics /g FW was seen at every row orientation. Bunch temperatures were more crucial than row orientation (N = new vineyard).

Fig. 62: Last year's situation – many vineyards had higher phenolics due to warmer season (?), some had lower phenolics and have since improved practice by plucking (25K and 10A) or lost quality by shading bunches (2B) see Fig. 83.



Phenolics and site differences

Temperature data loggers were put into the bunch zone to provide an objective measurement of bunch warmth. As examples we depicted temperatures at the bunch zone after veraison in a warm site (9O) and a cold site (19B). Both have a N/S row orientation and had similar leaf cover for most of the season and similar hangtime.

In particular during early ripening bunches of the warm site get heat loads (above 30°C) early, the cold site not at all.

Fig. 63: Comparison of the early ripening stage of a warmer (9O, upper graph) and cooler (19B, lower graph) site.

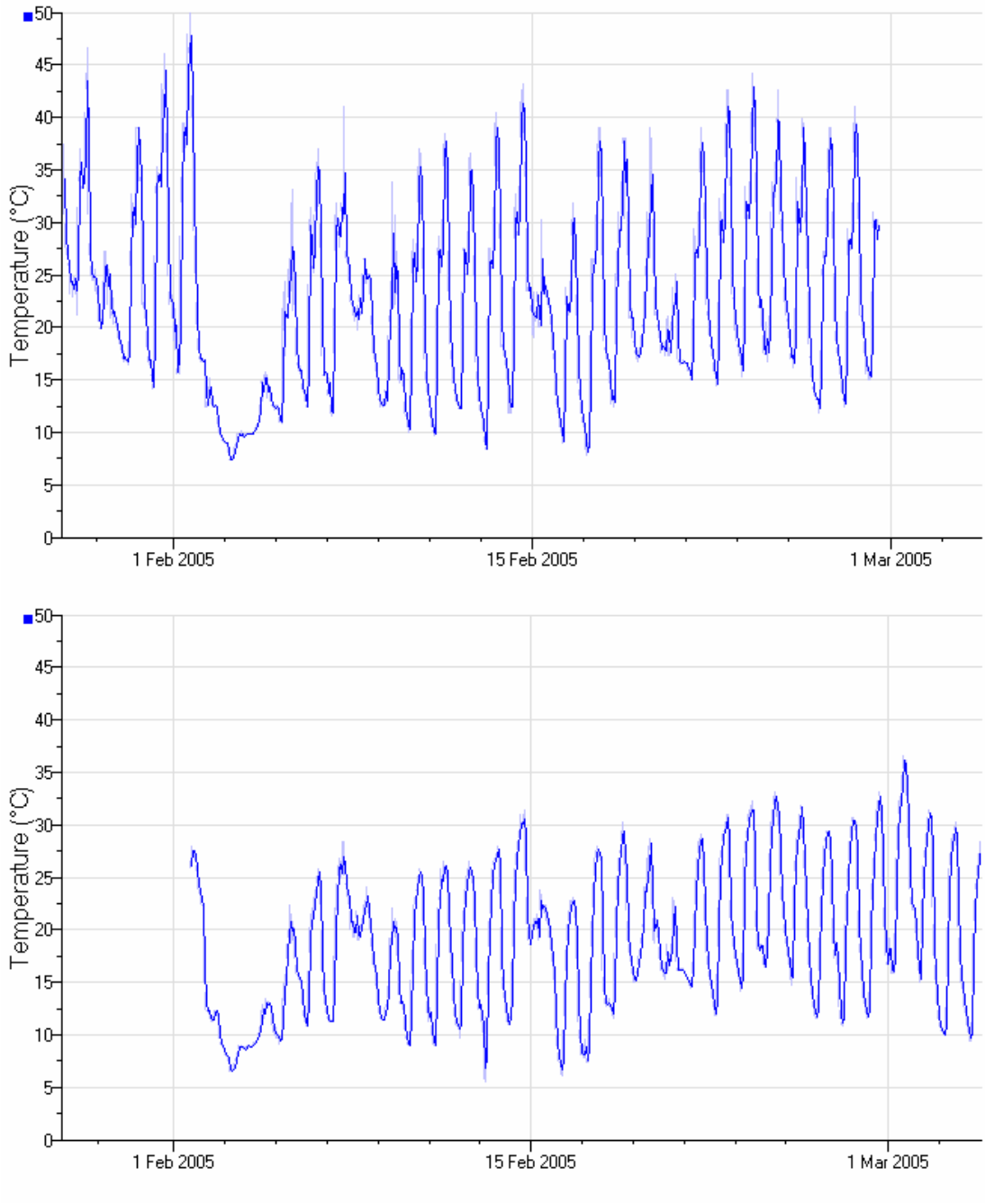
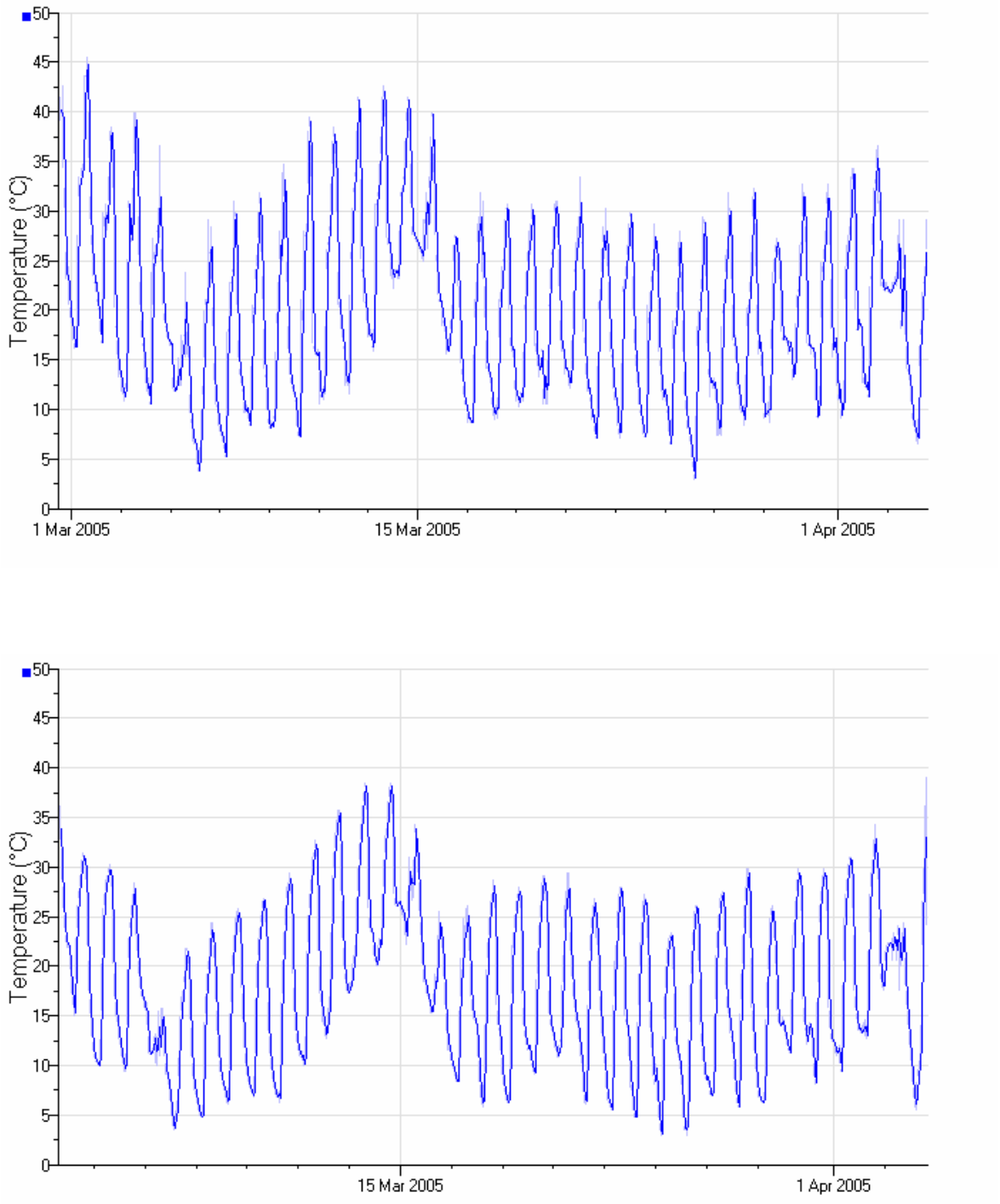


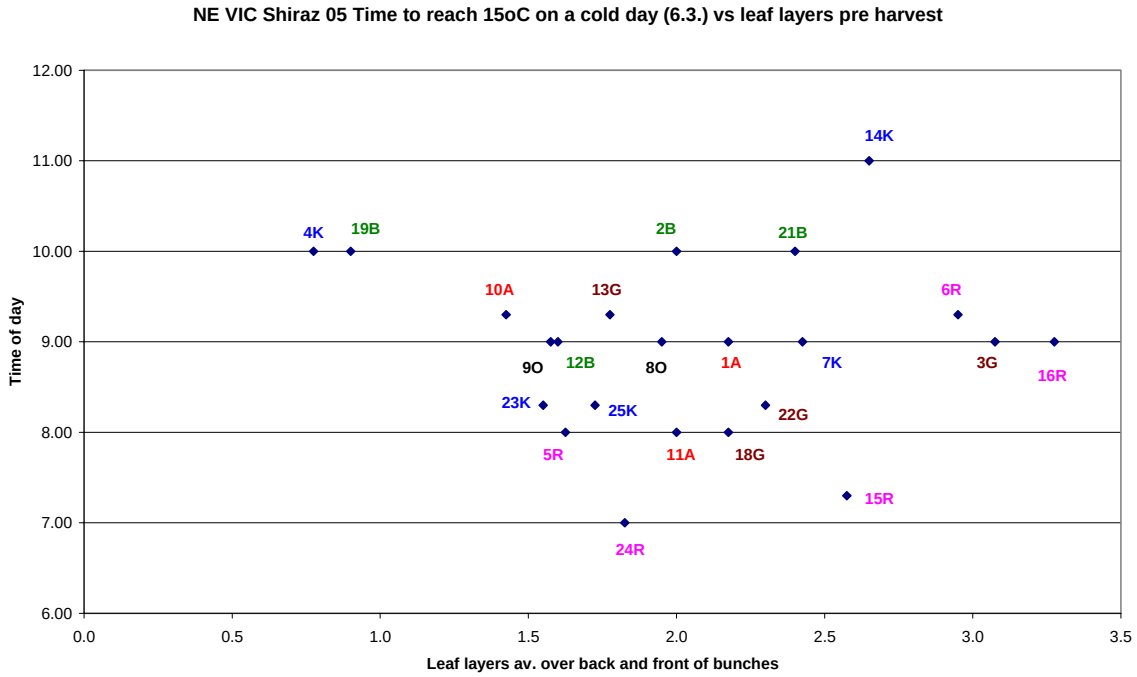
Fig. 64: Comparison of late ripening stage of a warmer (9O) and cooler (19B) site.



Closer to harvest the difference is less spectacular but the cooler site has less heat loads (over 35 degrees) more cold nights (below 10 degrees).

Site differences:

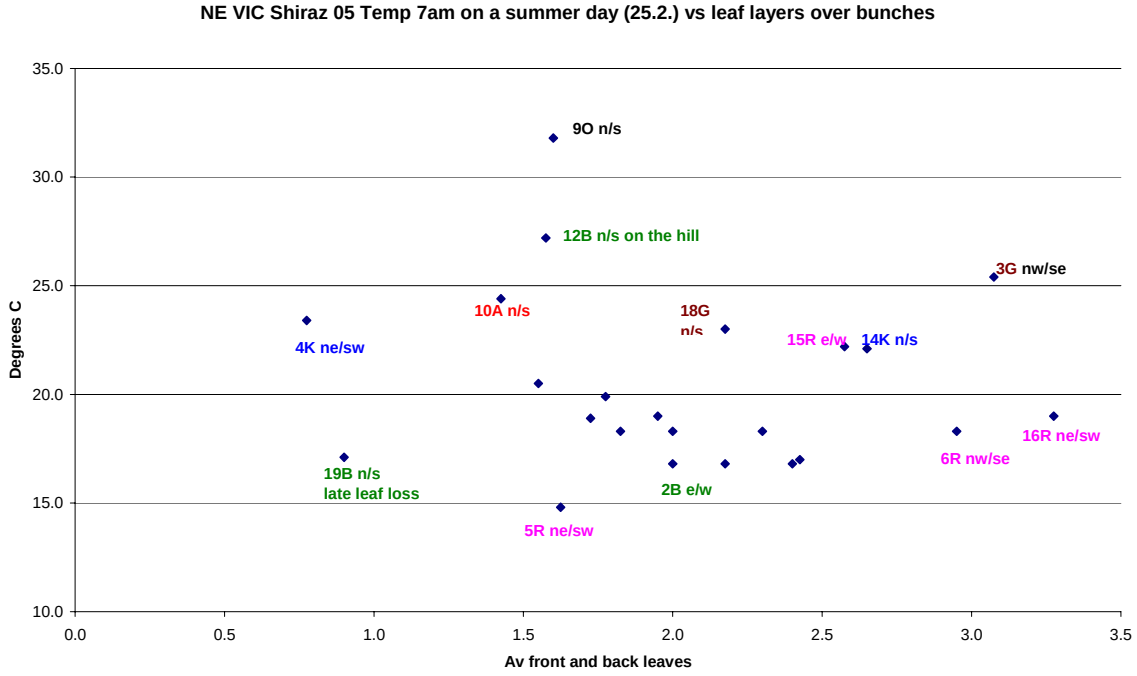
Fig. 65: On a cool day it takes until 10 am to reach 15°C in cold sites irrespective of leaf cover.



Phenolics and leaf layers

Temperature at 7am on a warm day clearly are hotter in hot sites which were warm despite many leaf layers (9O and 3G), and the warm sites in Rutherglen and the King Valley have warmer bunches than their leaf cover would suggest but in the middle field there is a trend towards cooler bunches with more leaf cover.

Fig. 66: Site temperatures can overrule the effect of opening up the canopy or providing leaf cover on a warm summer morning at 7am.



Phenolics and bunch micro climate
Several indicators so far point to a temperature dependency of phenolic production or extractability.

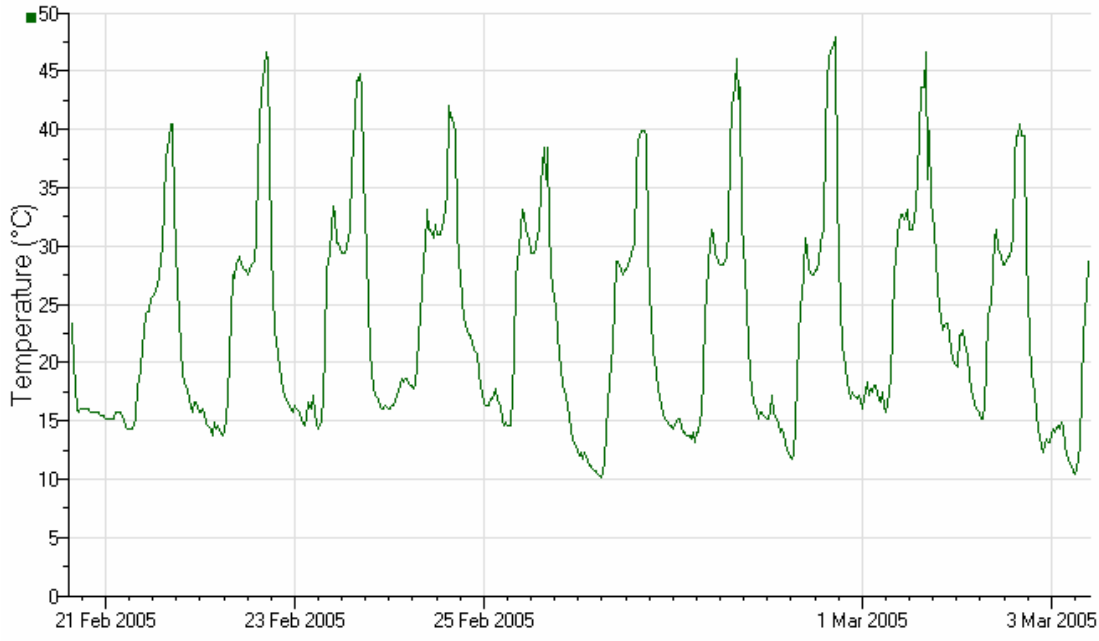
Below a few examples are listed for N/S and NE/SW rows (afternoon sun) as well as E/W and NW/SE rows and vineyards with very good and low (=below 55, marked in green) phenolic values in both.
It was considered important to depict all diurnal curves for each vineyard in a stable summer period.

It is appreciated that fruit is not at the same ripening stage on 25.2. in different climatic zones. Also early ripening must be considered. An electronic copy of the complete ripening temperature curves for each vineyard is available from Stephen Lowe.

N/S rows and NE/SW rows (afternoon sun)

In vineyard **12B** (*phenolic value 53*) temperature curves in the bunch zone are typical of a N/S row on a N slope high up on a plateau with long day length and overhead foliage but *too much bunch exposure*. Leaf layers pre harvest are 1.5 layers east and 1.7 layers west of the bunches. Temperatures rise as of 6am sharply to above 30 degrees, have a midday drop and rise again to *very high afternoon heat* until 4pm with 29 degrees still at 6pm from where they drop sharply to 20 degrees at sundown. These bunches are at 27.2 degrees at 7am on the 25.2 (**Tab. 8**)

12 B: Typical diurnal bunch temperature fluctuations of an exposed N/S row on a plateau



19B *(phenolic value **60.3**)* **N/S rows with 10% slope, on a plateau in a cool climate**. Unplucked with dead lower leaves and *very exposed fruit late season*. Takes long to warm up (17.5 degrees at 7am on a summer day) but *good increase of temperatures in the morning sun* with midday plateau at 33 degrees between 1.30 pm and 5pm. *No heat loads in the afternoon*. Long hangtime.

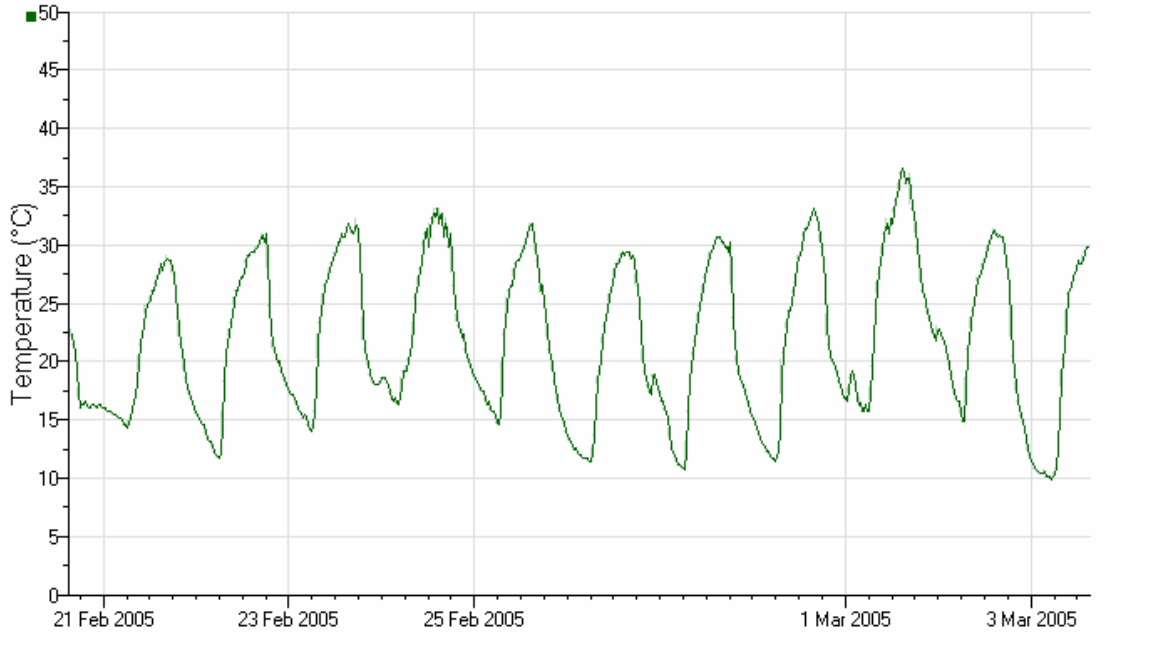


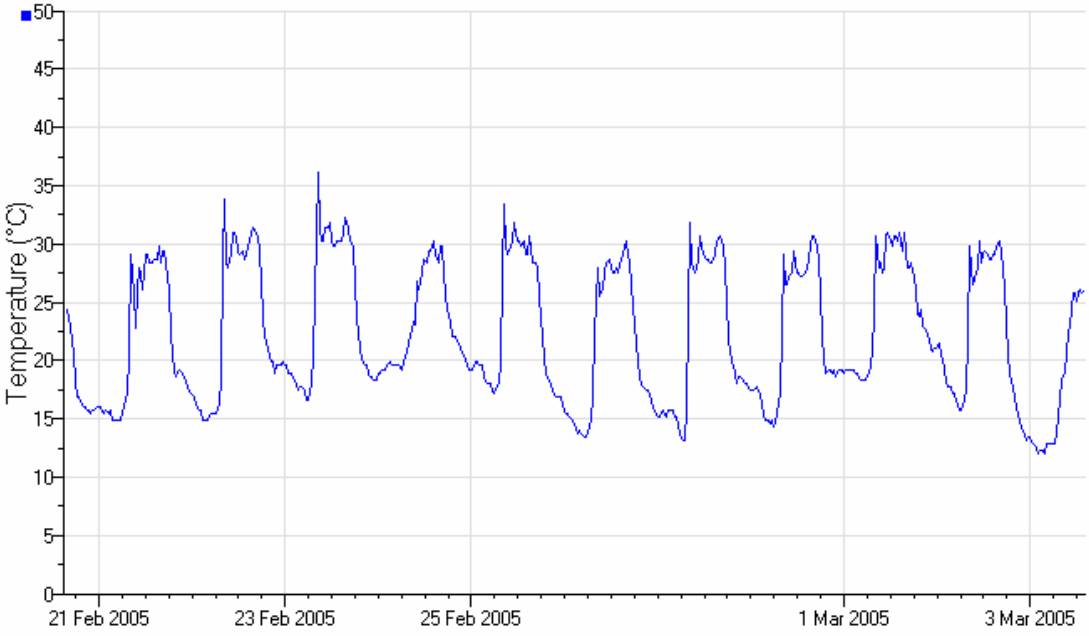


Fig. 67: Vineyard 19B before harvest, high on a ridge, not plucked, many dead leaves, long hangtime, east side facing viewer.

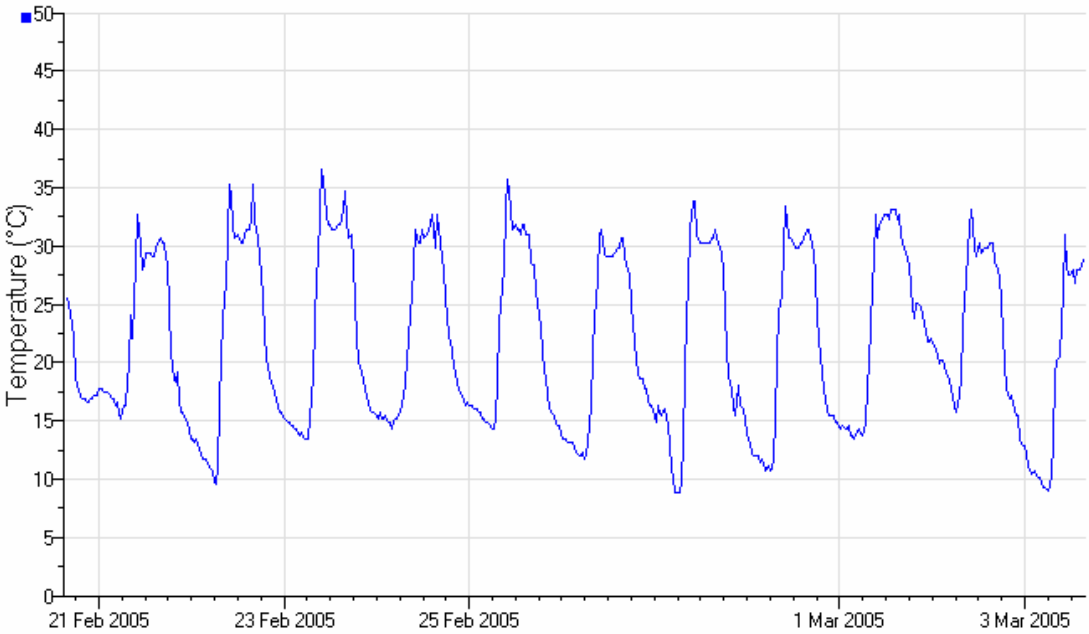


Fig. 68: Vineyard 19B before harvest, not plucked, west side facing viewer.

14K *(phenolic value 47.4)* **in a cool climate on N/S rows on a plateau.**
Typical n/s row overhead canopy warming up to 22.1 degree at 7am on a summer day (25.2.) but experienced low temperatures *due to shading from 8.30 to 4.30 from very dense canopy*, which may have kept the heat of the day inside on summer days. Hangtime did not increase phenolic concentrations at harvest due to low bunch temperatures at the end of the season.



4K *(phenolic value **58.7**)* **on NE/SW rows with 5% slope, unplucked, high bunch exposure.**
Bunch *temperature rises fast* to 35 degrees at 9.30 am. Bunches are at 23.4 degrees at 7am on the 25.2. Temperatures drop between 10 am and 3pm with overhead shading and rising again slightly at 3pm with an afternoon drop. *No afternoon heat loads, good morning sun.*



10A (*phenolic value* ***62.7***) ***plucked on east side*, NE/SW rows at 300m on a 10% nw slope in a cool climate.**

There is a *sudden increase of temperature* between 6am and 8am (with the temperature of the bunches at 24.4 degrees at 7am on the 25.2.) and a second rise between 10am midday where temperatures are at 30 degrees. From there they again rise for 4h in the afternoon of most days to 45 degrees *with cool bunches after 4pm* with the sun on the unplucked side.

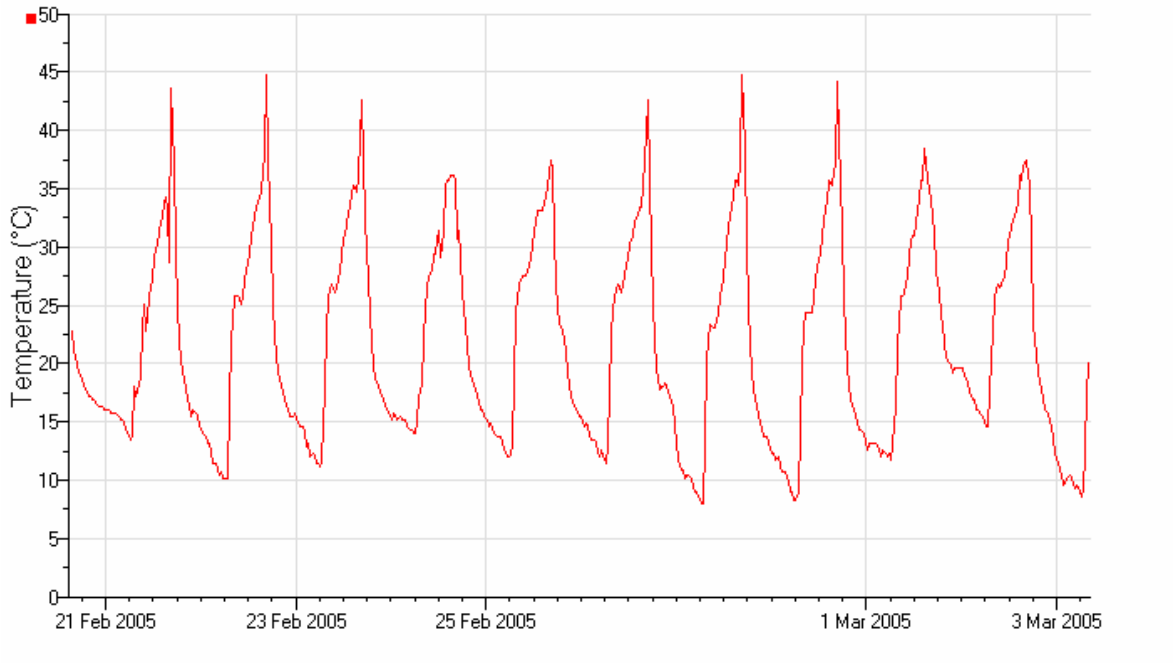




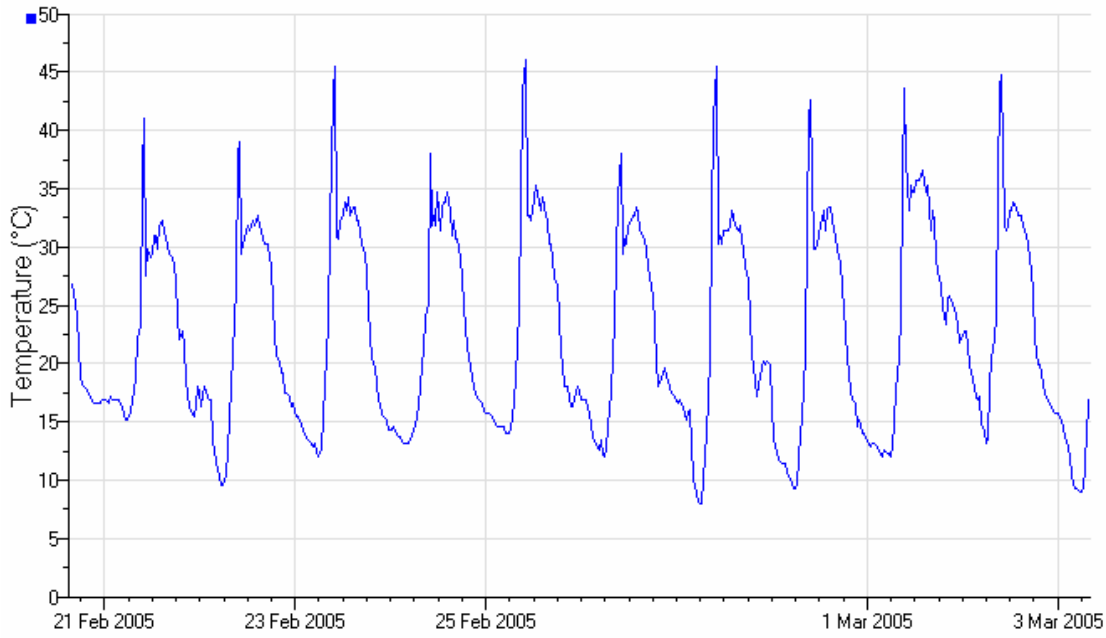
Fig. 69: Vineyard 10A before harvest, leaf removal occurred at veraison on east side (facing viewer).



Fig. 70: Vineyard 10A, before harvest, west side facing viewer.

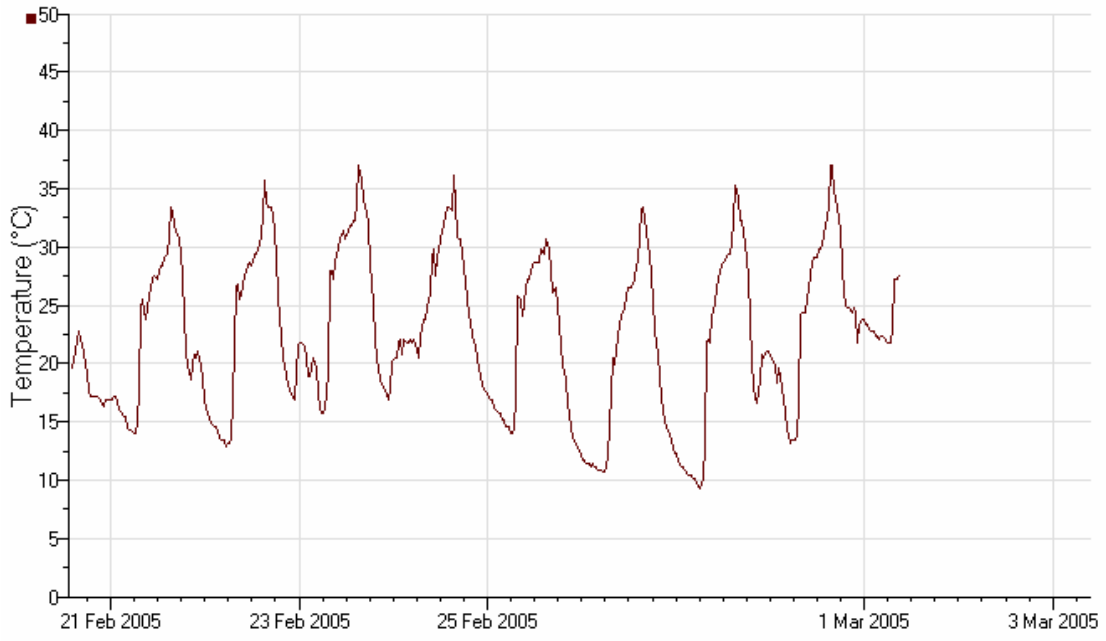
E/W rows and NW/SE rows with morning sun

23K (*phenolic value **60.1***)**. E/W row at 320 m on a N slope, plucked on north side.** These bunches are at 18.9 degrees at 7 am on 25.2.(**Tab. 8**). The temperature peaks briefly at 10 am as the foliage has been plucked on the north side so *the morning sun* shines into the canopy onto the bunches. There is a *30-35 degrees plateau from 11 am to 4pm* due to overhead foliage with 23 degrees at 6pm when the sun goes down behind the hill. *Bunches have no heat loads in the afternoon*. Very healthy leaves.

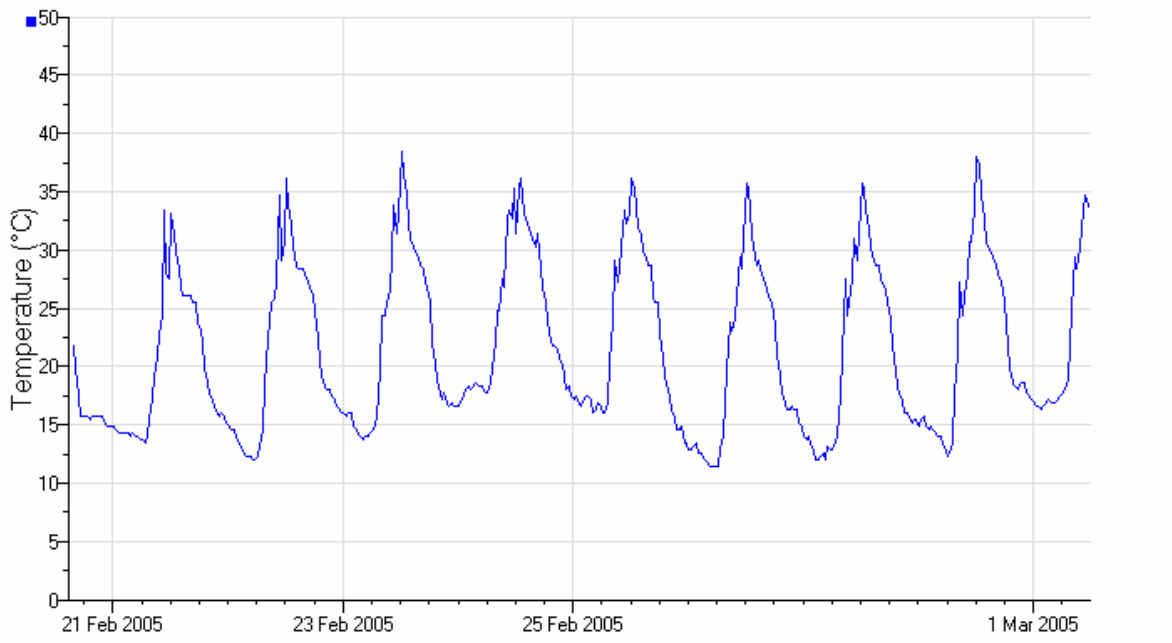


3G *(phenolic value **62.2**)* **not plucked on NW/SE rows on a 10% slope in a warm region.**

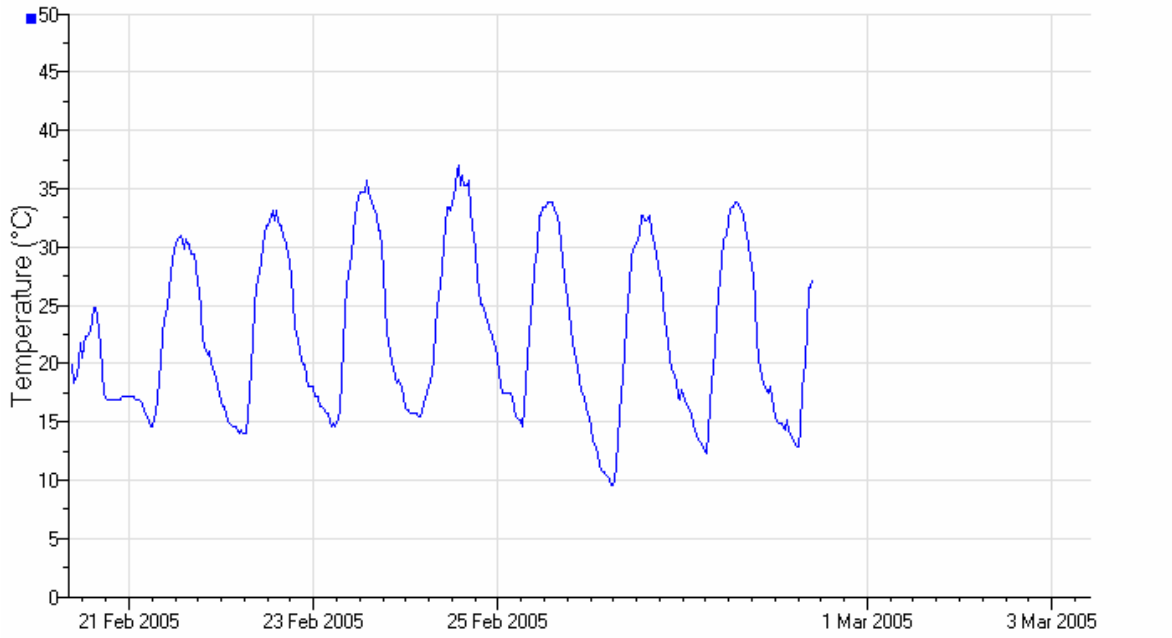
Bunches *warm fast in the morning* sun up to 25.4 degrees at 7am on a summer's day (25.2.) rise to 32 degrees at 11 am with an increase up to 35 degrees at 3pm, then sharp decline to sundown with *no afternoon heat loads*.



2B E/W row on a W / NW slope, *(phenolic value 52.1)* 1.7 leaf layers in the north and 2.4 in the south. Bunches on an e/w row on similar elevation at the plateau but with *poor exposure* showed a slow temperature increase from 6am in the mornings to a sharp warm peak at noon, then a drop and a shoulder around **27 degrees between 2 and 6pm in the afternoon**. These bunches are only at 16.8 degrees at 7am on 25.2. (see **Tab. 8**).

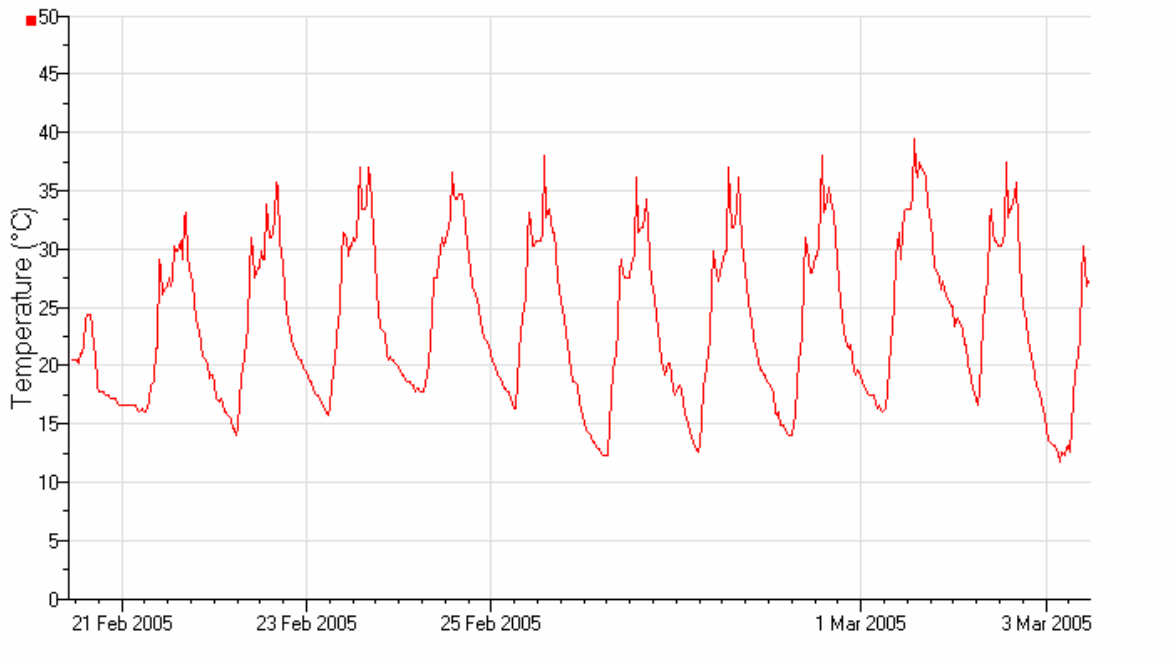


15R *(phenolic value 48.6)* **on E/W rows no slope, unplucked.** No heat loads and good exposure. Good potential, temperature in the bunch zone at 7am on the 25.2. is 22.2 degrees. *Early harvest* resulted in lower phenolics but suited the fruiter wine style.

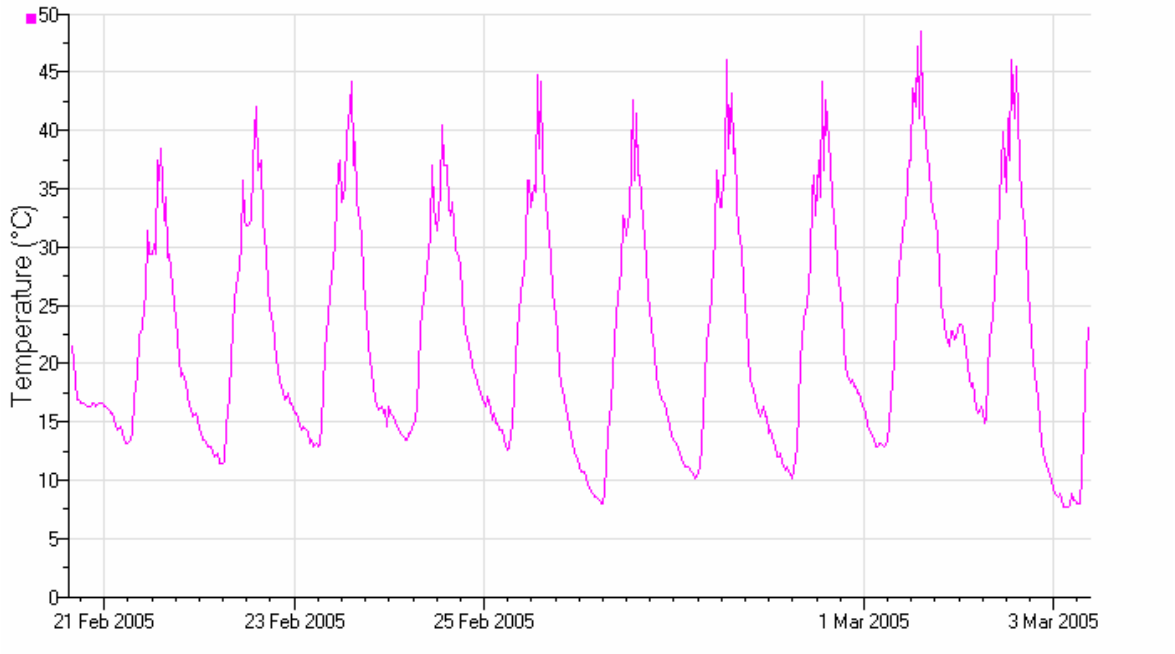


Below are the other diurnal curves with descriptions for the same period.

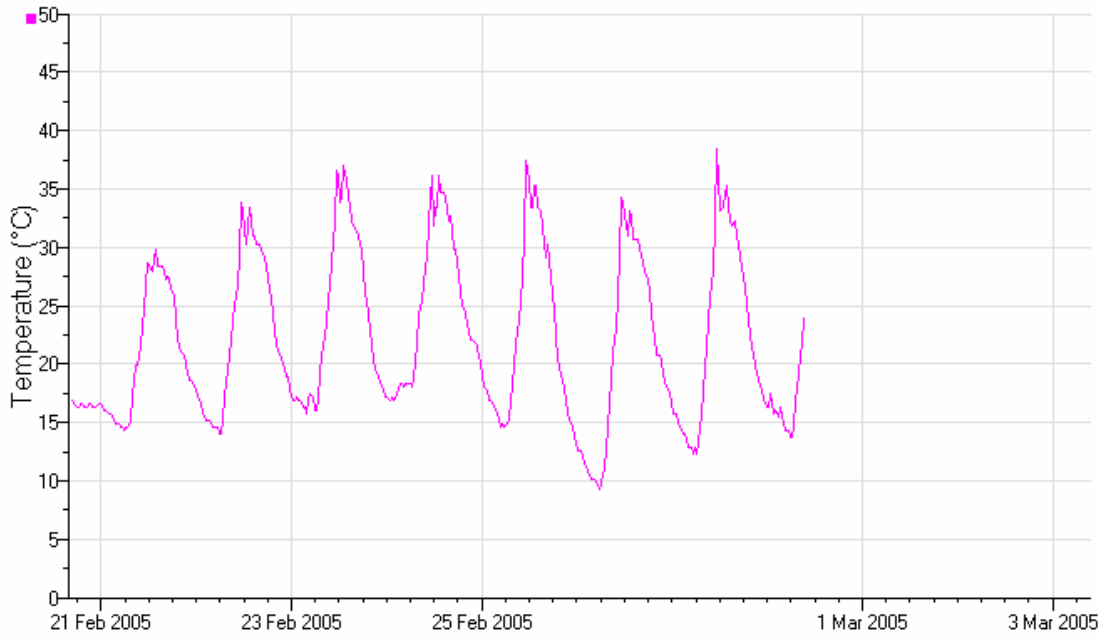
1A *(phenolic value 54.0)* **NW/SE** **rows on 20% slope unplucked** leaves dying on west side – *exposed fruit west, dense canopy east*. Temperature depression due to E-side foliar shading between 9.20 and midday, then steep rise to 38 degrees at 2pm with some foliar shade briefly.



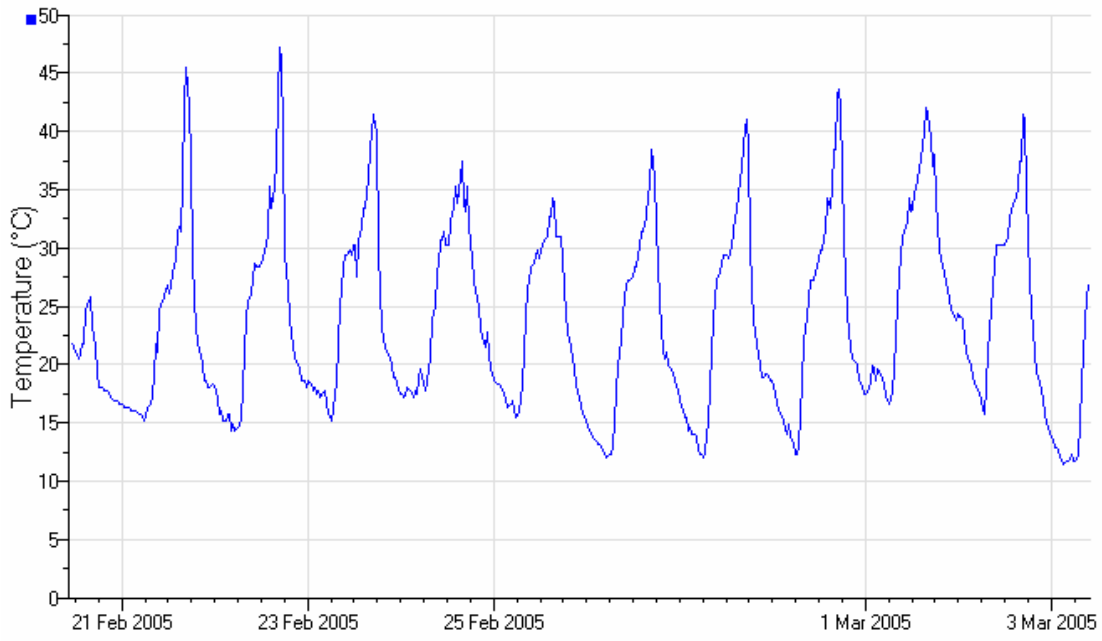
5R *(phenolics value **57.5**)* Sprawling canopy on **NE/SW** rows in warm region. Temperatures show a sharp rise to 36°C at 11 am, fruit sticking out of canopy in east. Little dip in temperature 11-12.30 and peak at 2pm, then sharp drop to 30°C at 4pm, foliage in west. 20°C at 7pm. Early morning warmth, no afternoon heat.



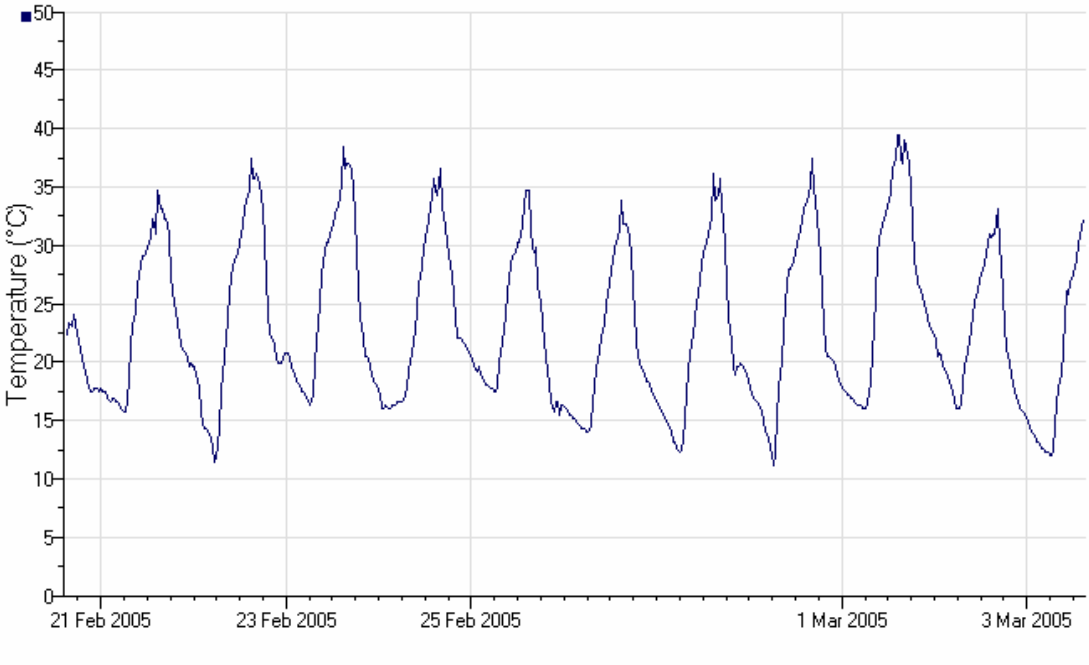
6R (*phenolic value* ***56.6*****)** **NW/SE** row dappled light from 2-3 leaf layers. Temperature peaks at 11 am with a small dip at midday and another rise at 2pm never much above 35°C and a slower drop than in 5R still 30° C at 5pm, 24°C at 7pm.



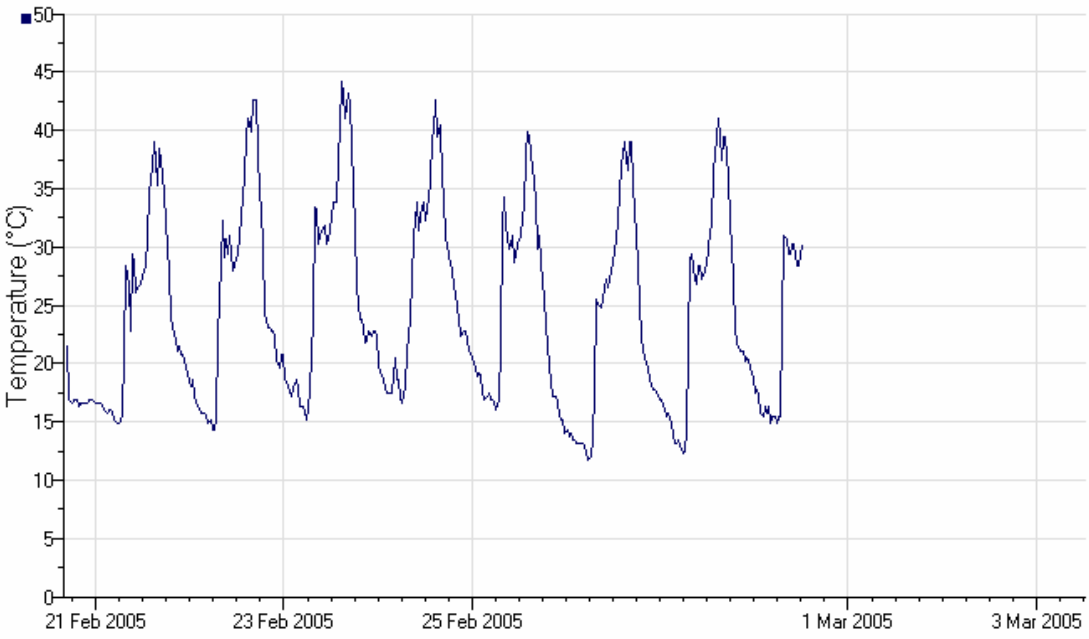
7K (*phenolic value 52.8*) **N/S row** 3 leaf layers over bunches east and high rows shading each other. Temp rises slowly to 30°C at 11 am and then shoulders around midday to rise again after 1pm to high heat at 4.30 from where it drops off. Slow morning warm-up and high afternoon heat loads.



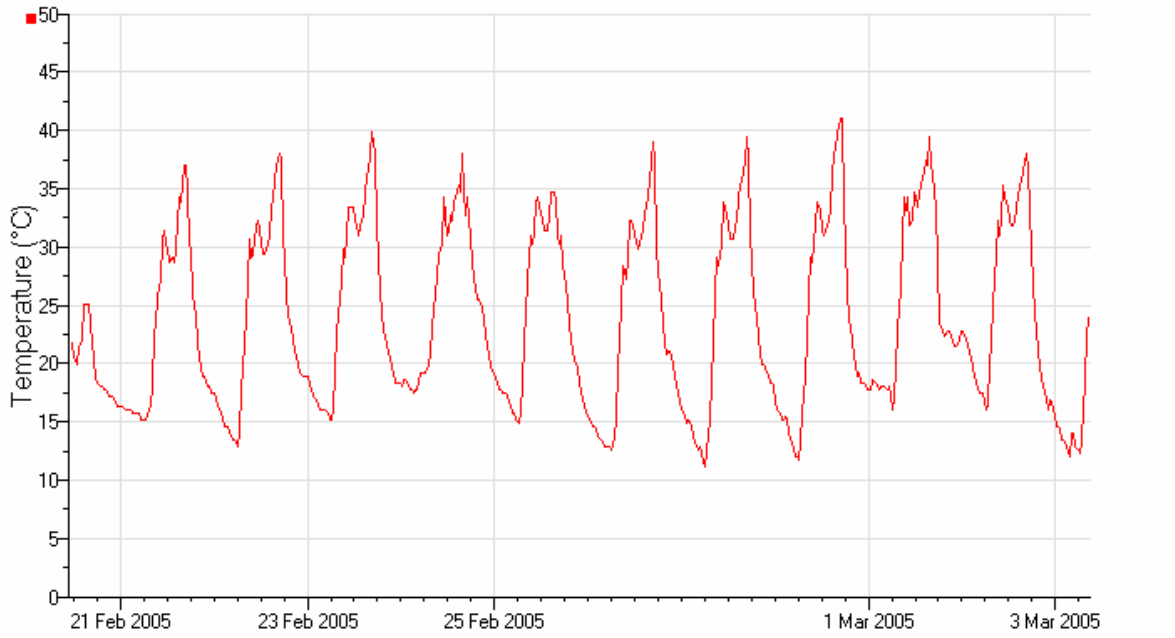
8O N/S row (*phenolic value 57.8*) N/S row. Fast warm-up to 30°C at 10am, peaking between 2pm and 4pm with small dip from overhead shade, generally not too hot (above 35°) in the afternoon.

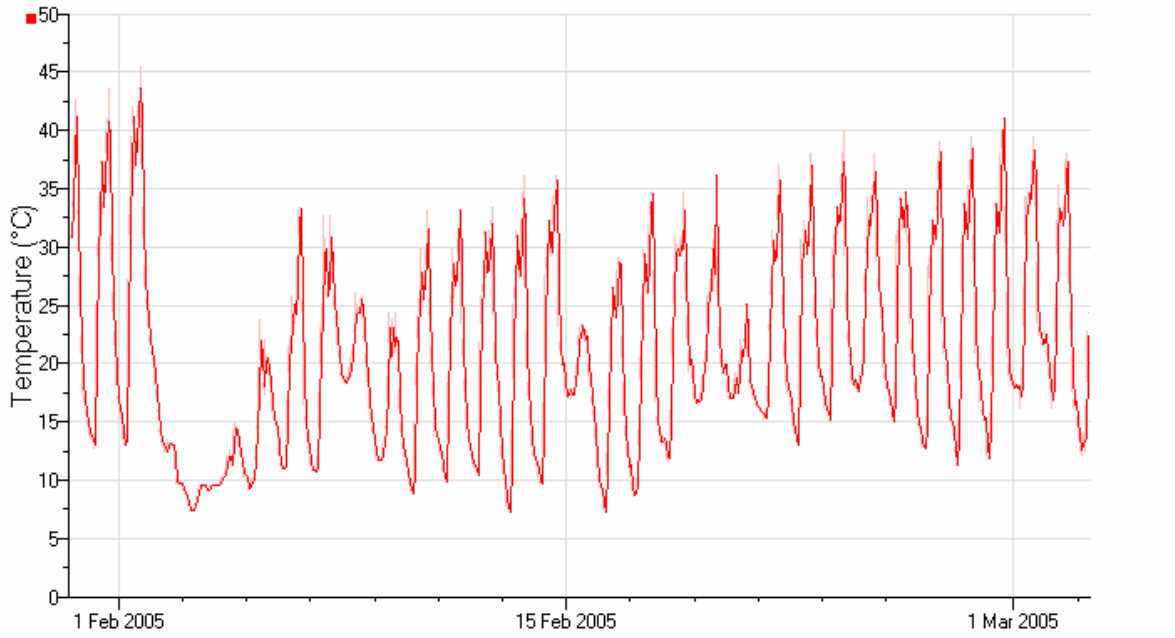


9O (*phenolic value 51.8*) **N/S row,** many dead leaves at harvest, very exposed fruit in the west as **canopy rolled over to the east**. Temperature rises to 34°C at 8am, then leaf shade gives a drop to 30°C until midday then sharp rise and heat loads with double peaks often above 40°C between 2 and 4pm, temperatures below 30° only at 6pm. Good example of the wrong shape of curve!

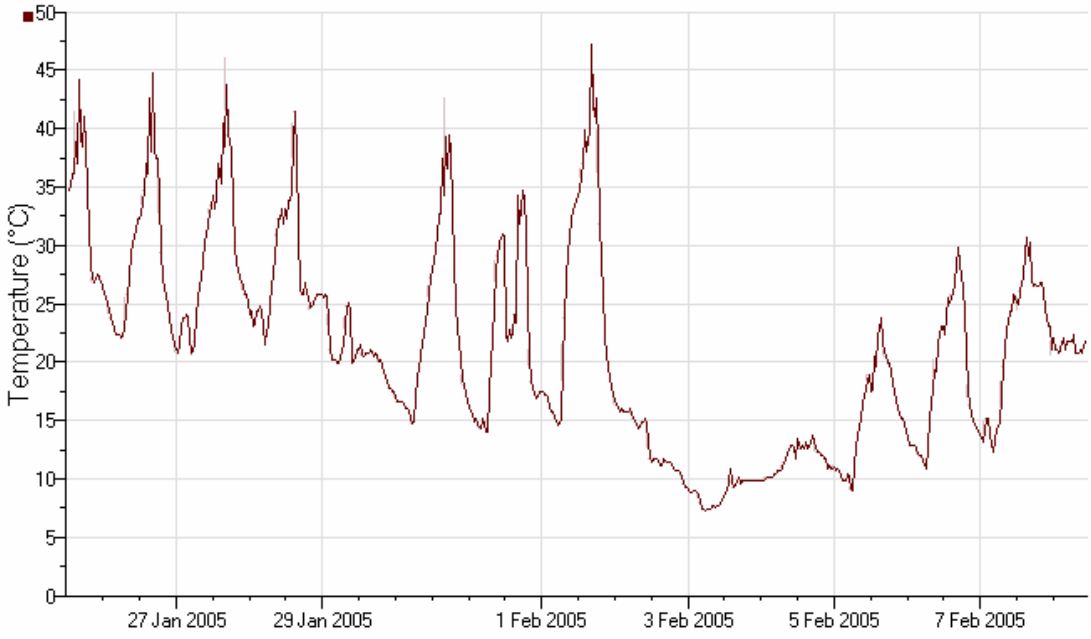


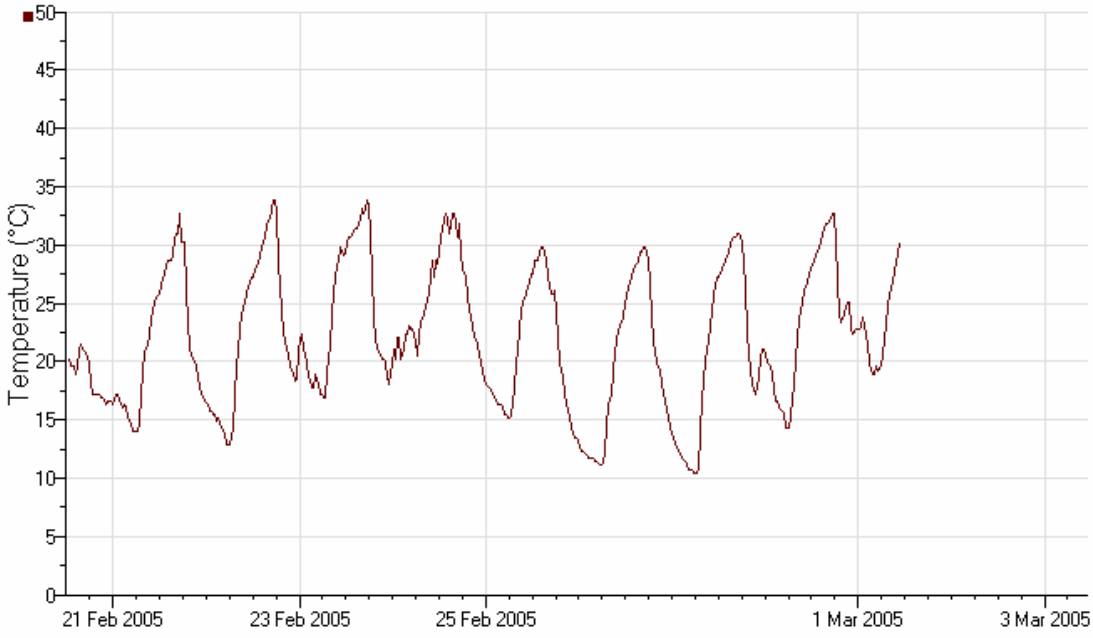
11A N/S row *(phenolic value 52.5)* Temperatures in fruit zone rise slowly to 30°C at 10 am then rise to 34°C at 11 am, dip as typical for N/S rows at 1pm and go up to 40°C on most days at 4.30 (fruit sticking out of canopy) dropping to 30°C at 6pm. Slow warm-up in a "cooler" region with hot start of the ripening period and high afternoon heat loads every day.



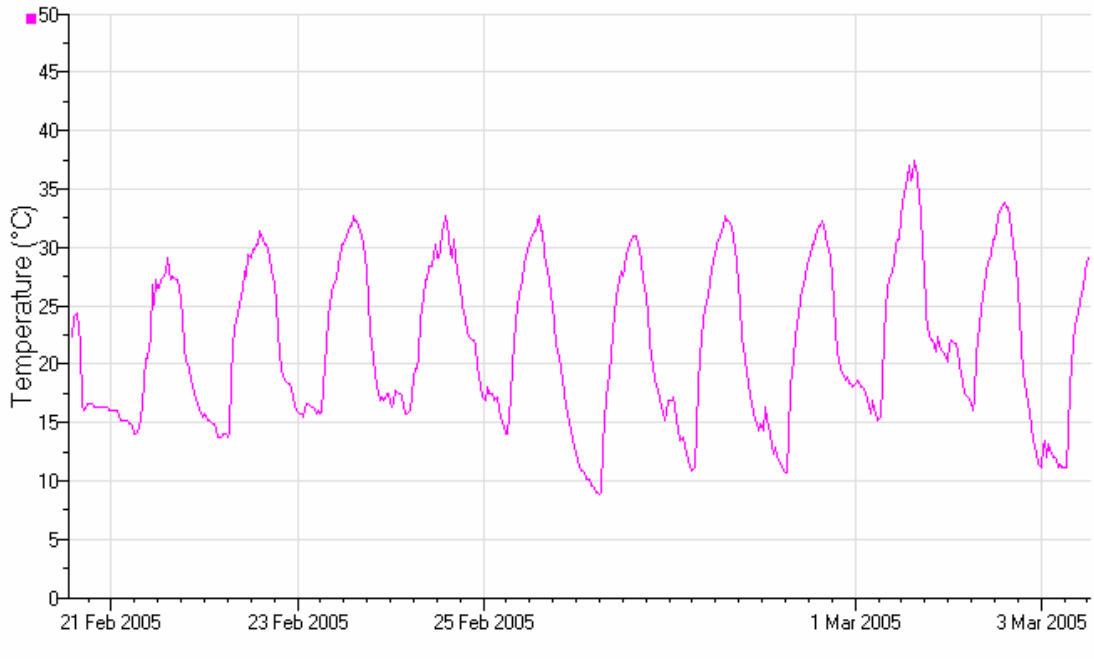


13G (phenolic value **59.8**) NW/SE row. In late season (lower graph) temperature rises to beneficial values up to 4.30 pm then sharp drop. No afternoon heat loads. This vineyard can be hot earlier in the season but still no afternoon heat loads with foliage in west and NW/SE rows.

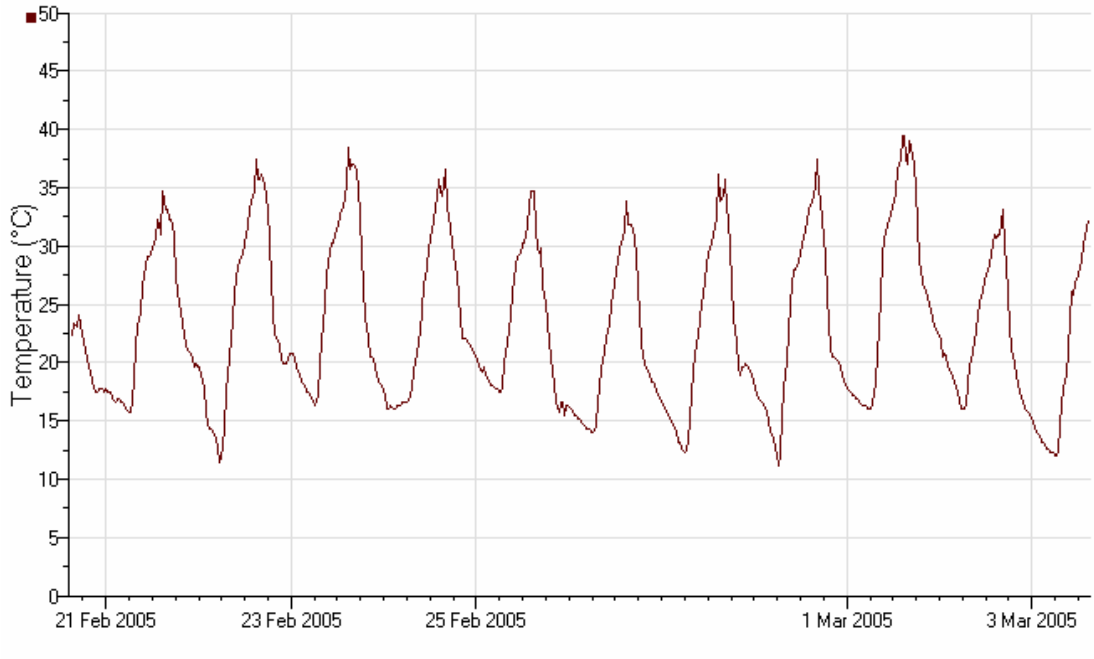




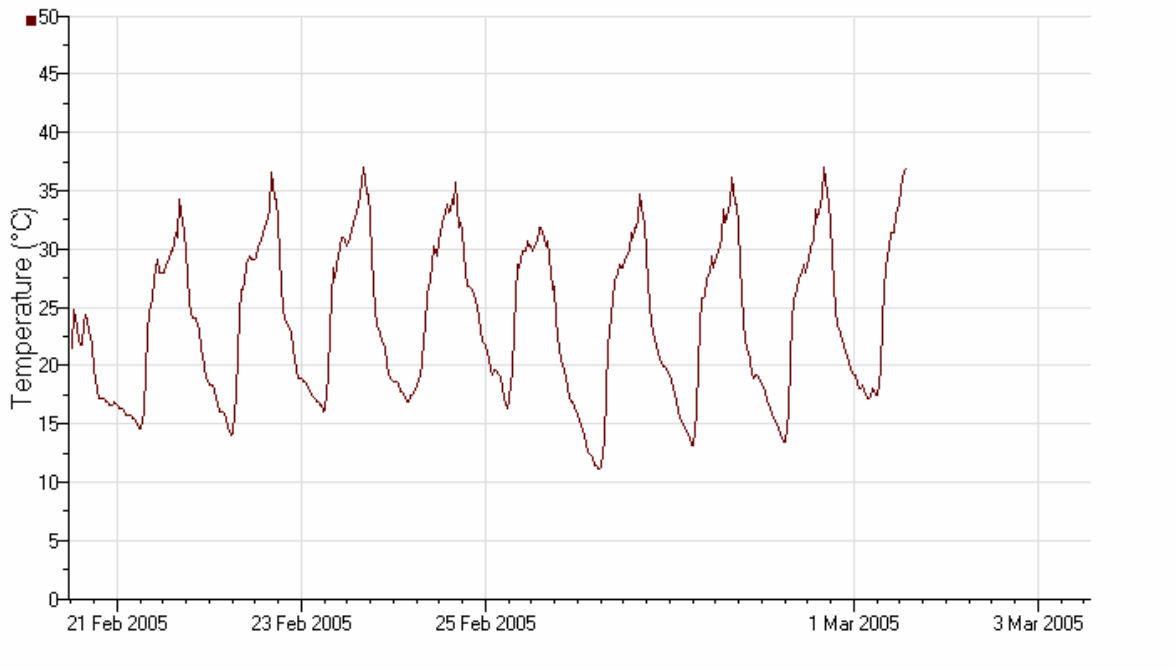
16R *(phenolic value **58.3**)* NE/SW rows 3-4 leaves back and front, slow rise of temperature to 30C at midday, no dip due to row orientation, 33°C at 4pm and no heat loads due to foliage. Even early season no heat loads on bunches.



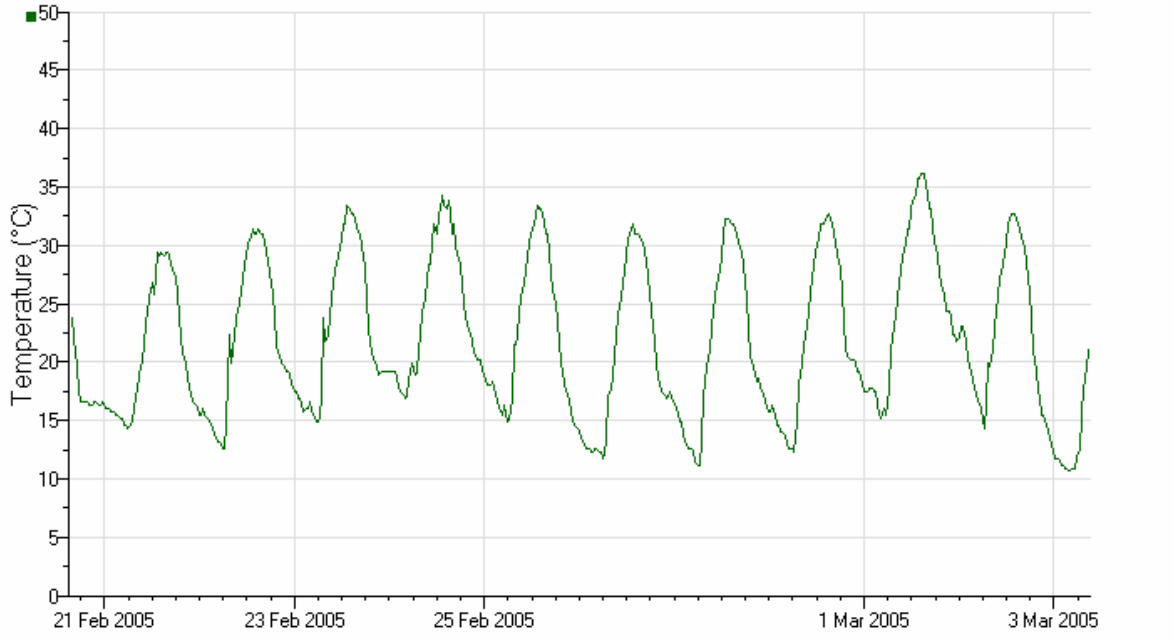
17G-N NW/SE rows *(phenolic value **57.8**)* Slow rise to 28°C at 9.30 dip at 35°C between 3 pm and 4.20 pm and drop to 30°C at 5.50pm.



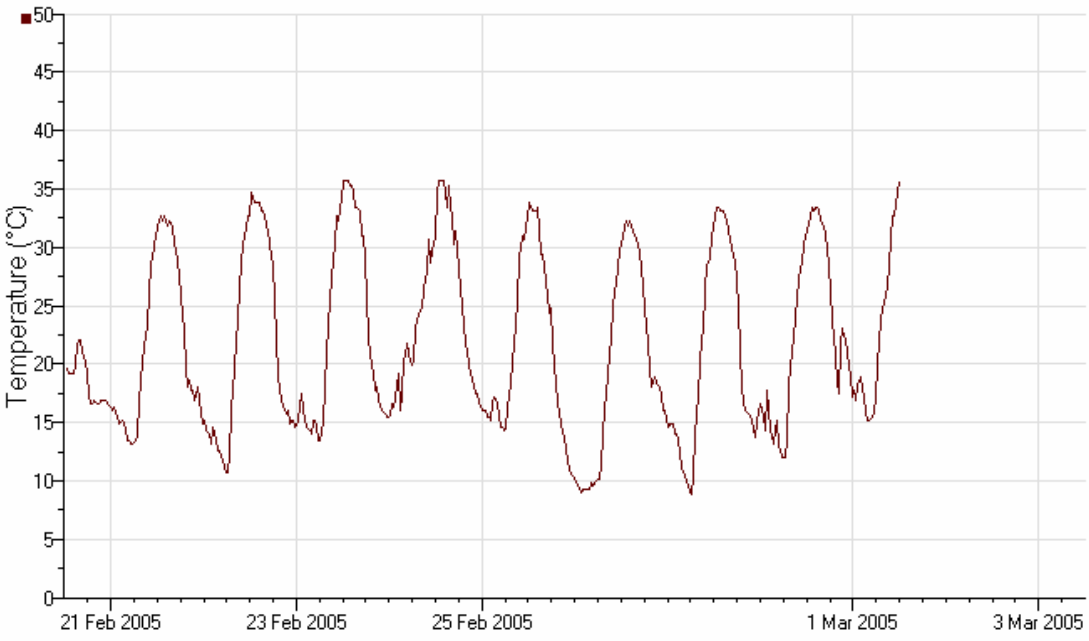
18G N/S row (*phenolic value 53.6*) Temperatures rise fast in the morning, shoulder at 10am, then increase to peak at 4pm and slow decline - still 30 °C at 6pm. Warm vineyards with few leaves. This pattern happens in February at 10 degrees hotter.



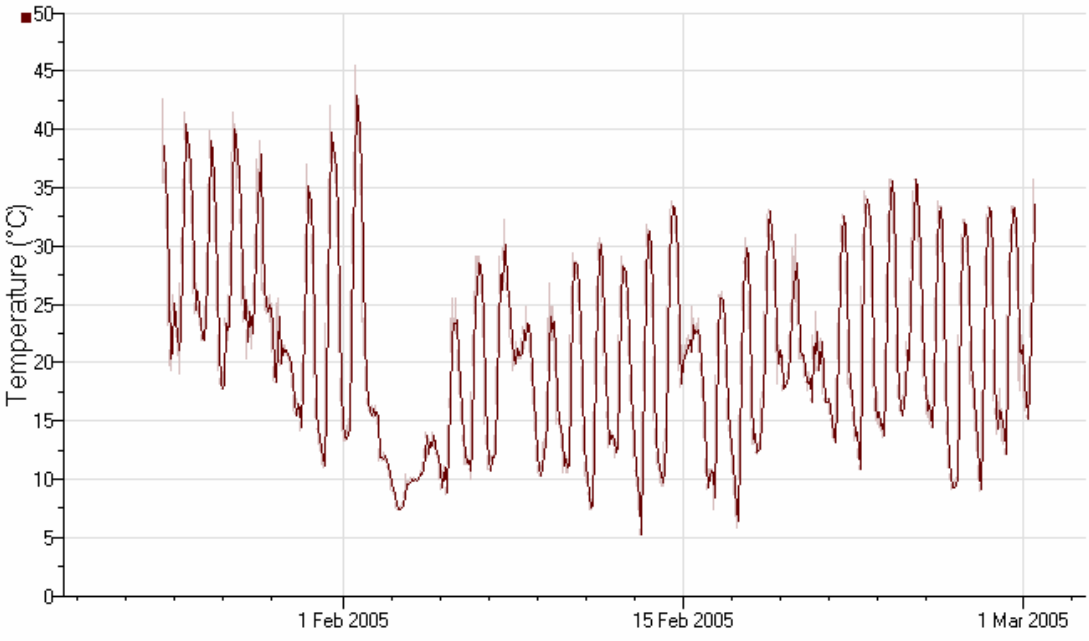
21B E/W row (*phenolic value **62.6***) Temperature rise to 30°C at midday, hottest is 35°C at 2pm, from there no more heat due to leaf cover of all bunches in canopy. Temperatures all summer never over 35°C.



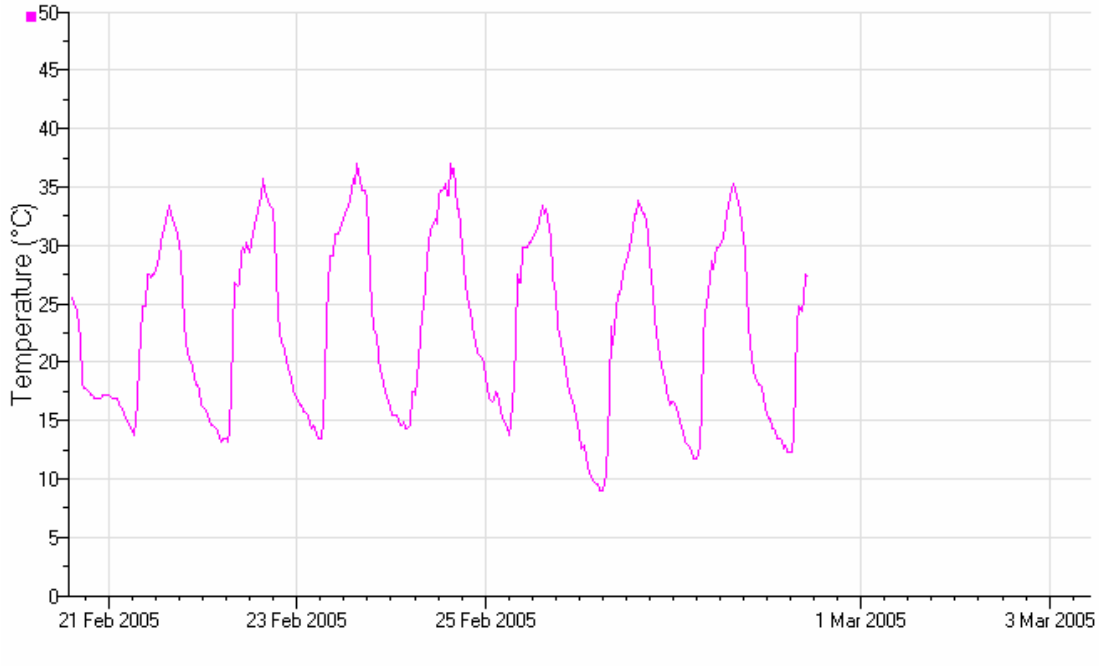
22G *(phenolic value 52.3)* NE/SW row. Between 30^{o} and 35^{o} C 10 am to 5pm. Very warm row orientation, warm site, sprawling with few leaves in canopy and some very exposed bunches.



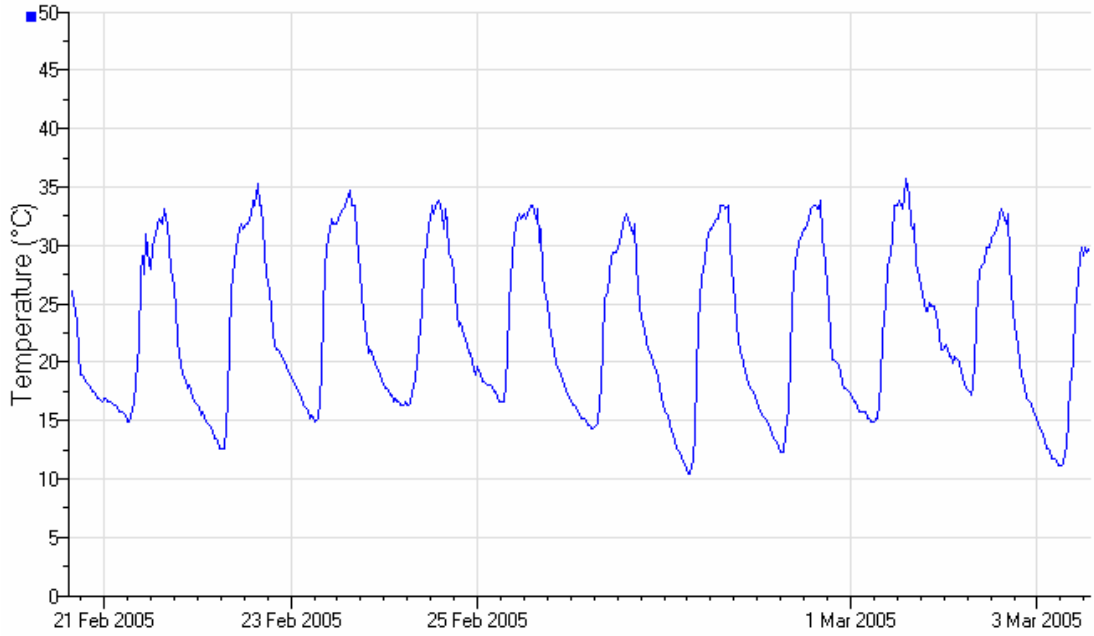
Very hot bunches early February.



24R N/S row (*phenolic value 52.1*) warm region, exposed fruit at 30°C at 9am steadily rising to 3pm, little overhead shade, still 30°C at 6pm and 20°C at 9pm. Early Feb looks like in 22G.



25K N/S row (phenolic value **55.7**), plucked on east side only. Quick warm-up to 32°C at 10am. Temperature plateaus at 33°C between 11pm and 12 noon , rises not higher than 35°C at 3pm then drops sharply to 25°C at 6.30. No afternoon heat loads.



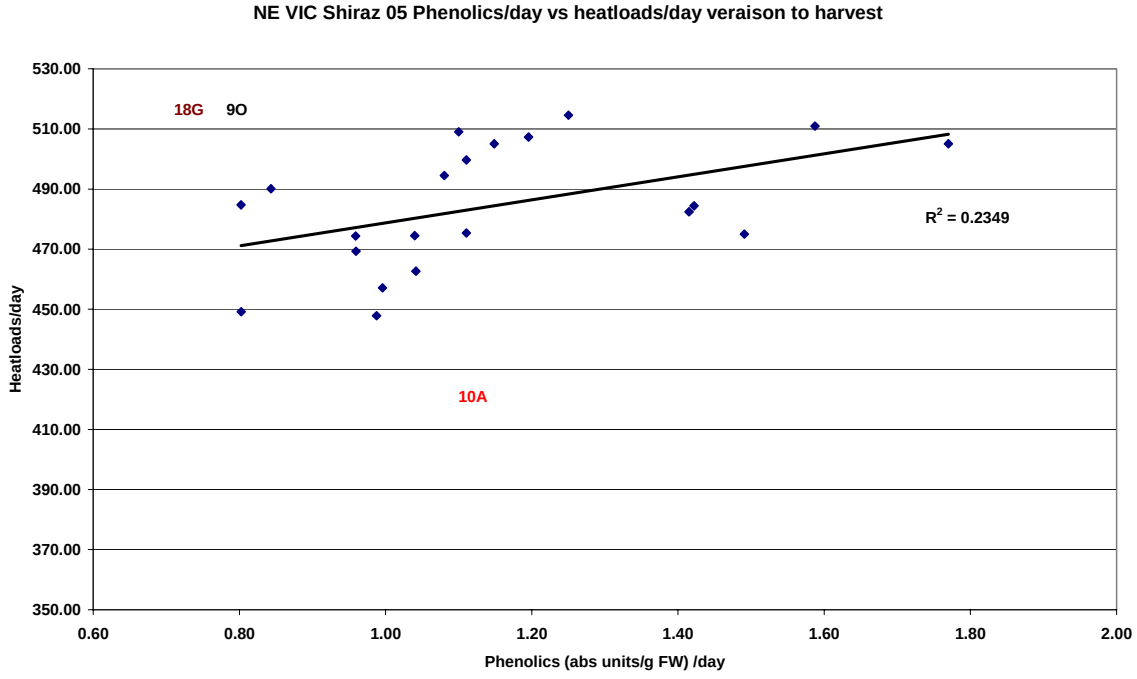
Temperature summations/day and phenolics

Temperature summation above 0°C for the bunch zones for the whole season are not a good measure as grapes were taken off at different times.

Dividing the sum of temperatures by the days of hangtime between veraison and harvest an average daily "heat load" can be calculated (**Tab. 8**).

In Fig. 71 there is a trend to a higher production rate of total phenolics with warmer bunches. Vineyard 10 A had low heat loads per day due to long hangtime but quite warm bunches. Vineyards 18G and 9O had such high heat loads that production of cellular components may have been affected.

Fig. 71: There may be a trend that warmer bunches have more phenolics when values are divided by hangtime.



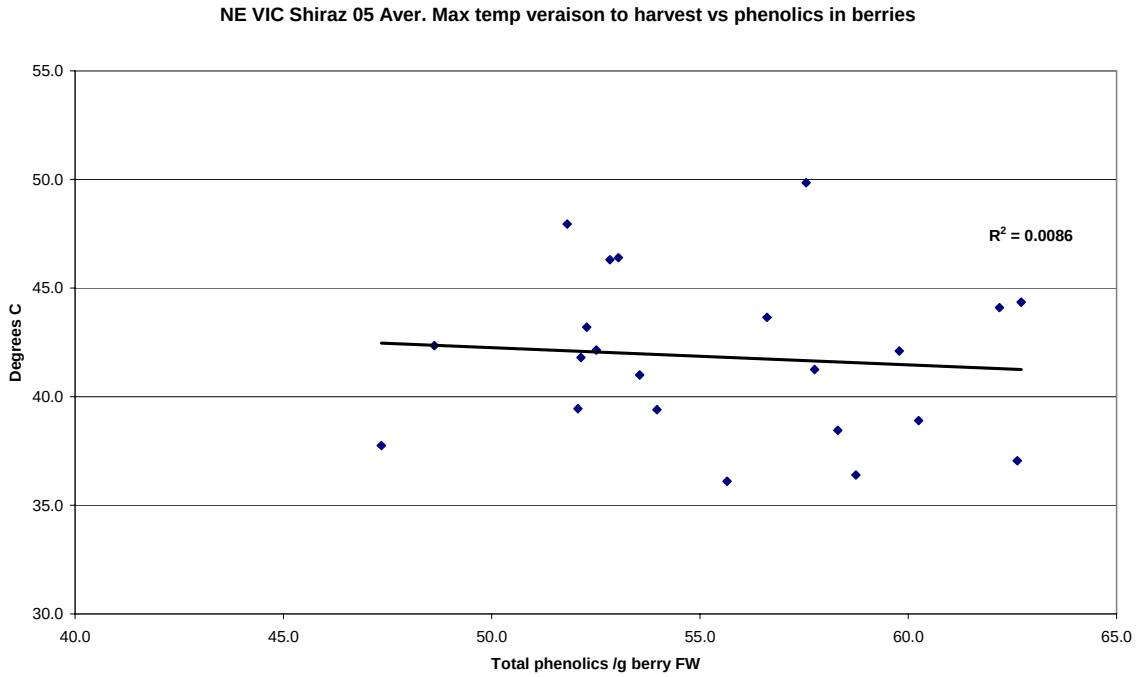


Fig. 72: Generally no correlation existed with maximum temperatures in the vineyards and phenolics (this is in contrast to anthocyanins – below)

Anthocyanins

Anthocyanins and phenolics

If the relationship had been 1:1 all dots would lie along the red diagonal line in the graph. At lower anthocyanin levels (bottom left corner of Fig. 73) phenolics were higher than anthocyanins. These were vineyards from warmer regions or with hot grapes. Some of the good colour producers had good but lower than expected phenolics as would be seen if the relationship had been linear (23K, 4K) they were from vineyards with cool bunches in the afternoon. The rest of the vineyards had a good relationship between phenolics and colour in this relatively mild season.

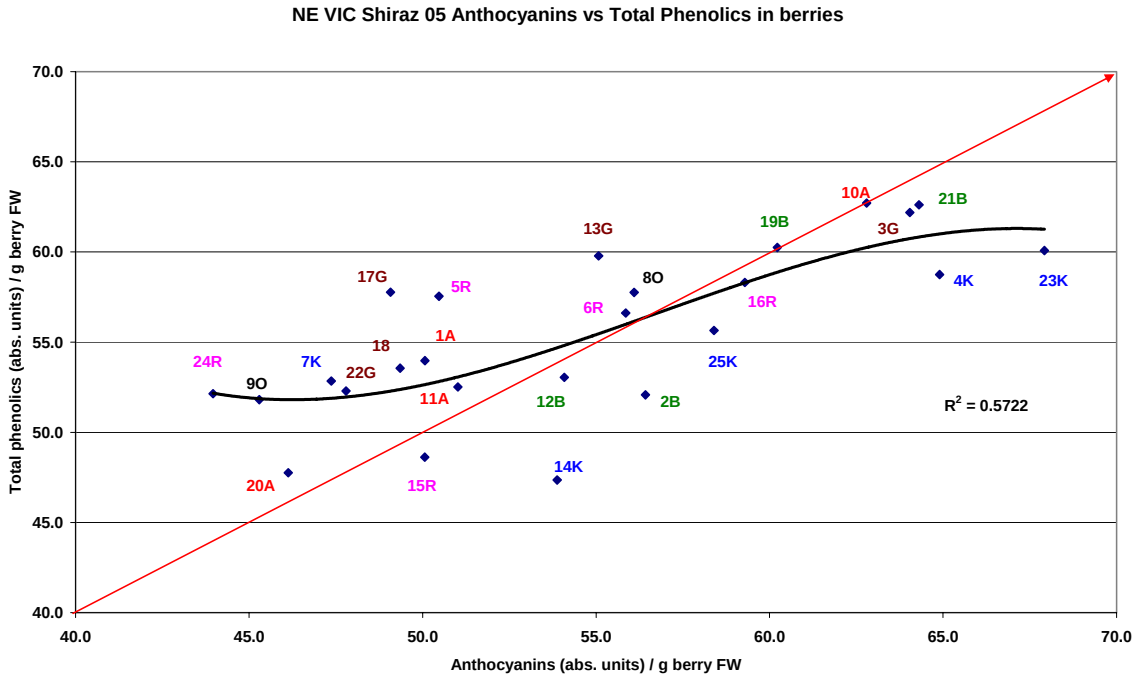


Fig. 73: The relationship between colour and phenolics is good but not linear. Berries with lower colour can have good phenolics, two with high colour had lower than expected phenolics in this milder year.

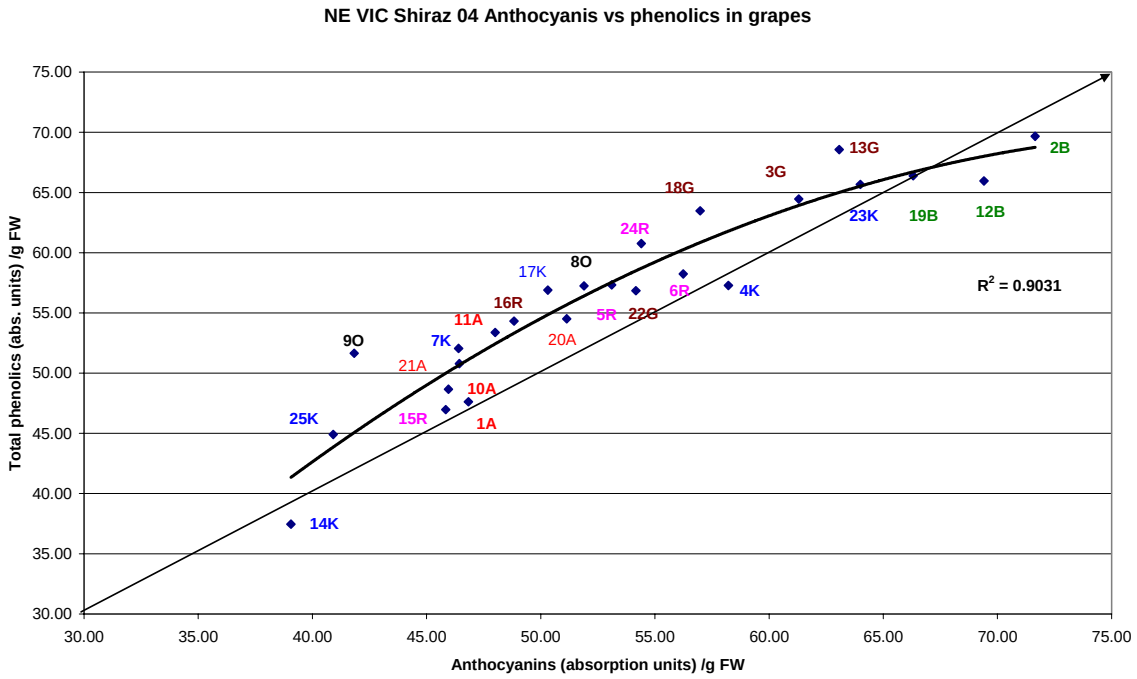
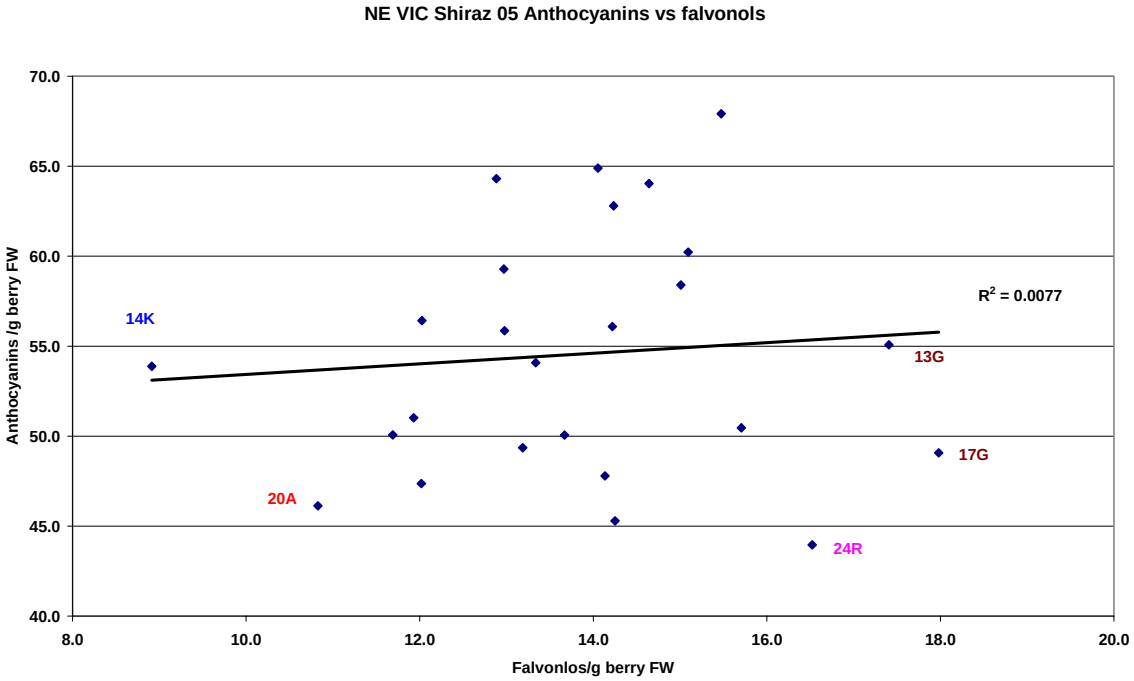


Fig. 74: In the hotter season 03/04 many berries had higher phenolics than anthocyanins except those on cool ridges producing high colour.

Anthocyanins and flavonols

Fig. 75: Good anthocyanins were only obtained in conjunction with moderate flavonol levels. Sun exposure is not a predictor of colour.

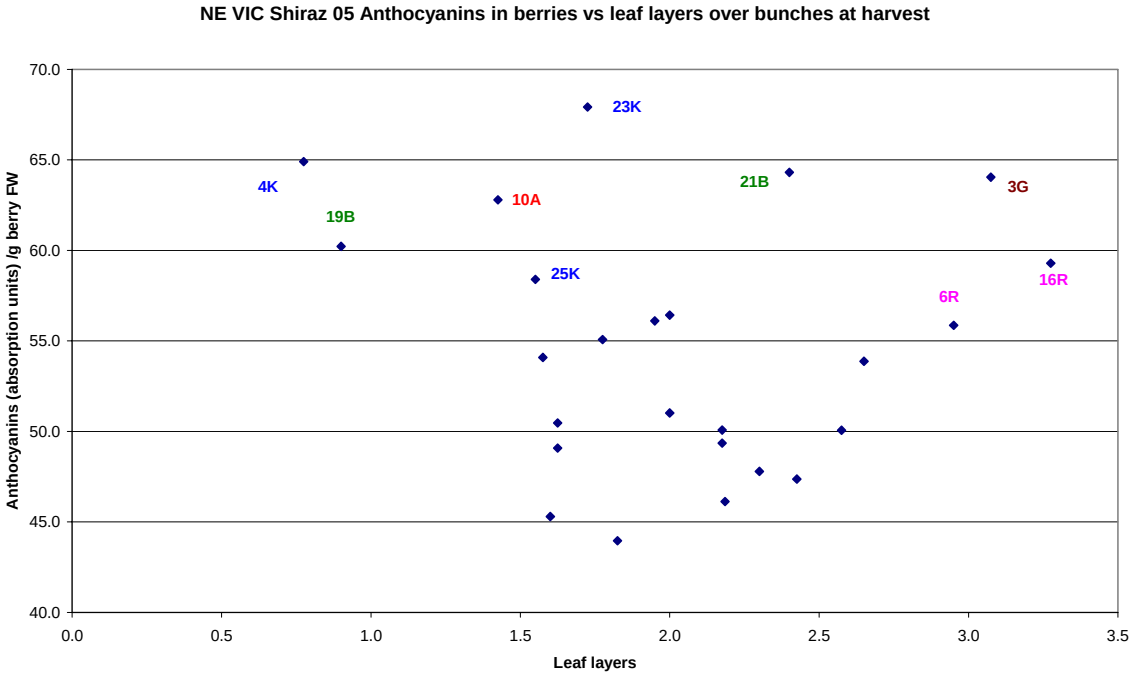


Anthocyanins and bunch leaf cover

As can be seen in Fig. 45, bunches with high leaf cover can have good anthocyanins in the warm vineyards of Glenrowan and Rutherglen. The observed good colour in apparently almost leafless 4K and 19 B can be attributed to late leaf loss (see Tab. 8).

Average leaf numbers may not reflect the full picture. We tested the correlation between leaf numbers on the east side of N/S rows and anthocyanins (or phenolics) – there is a trend of lower phenolics with higher leaf numbers (r^2=0.3) - less so for anthocyanins (r^2=0.2) – not depicted.

Fig. 76: Good colour was produced various leaf layer numbers, cool sites had more colour /g FW at harvest.

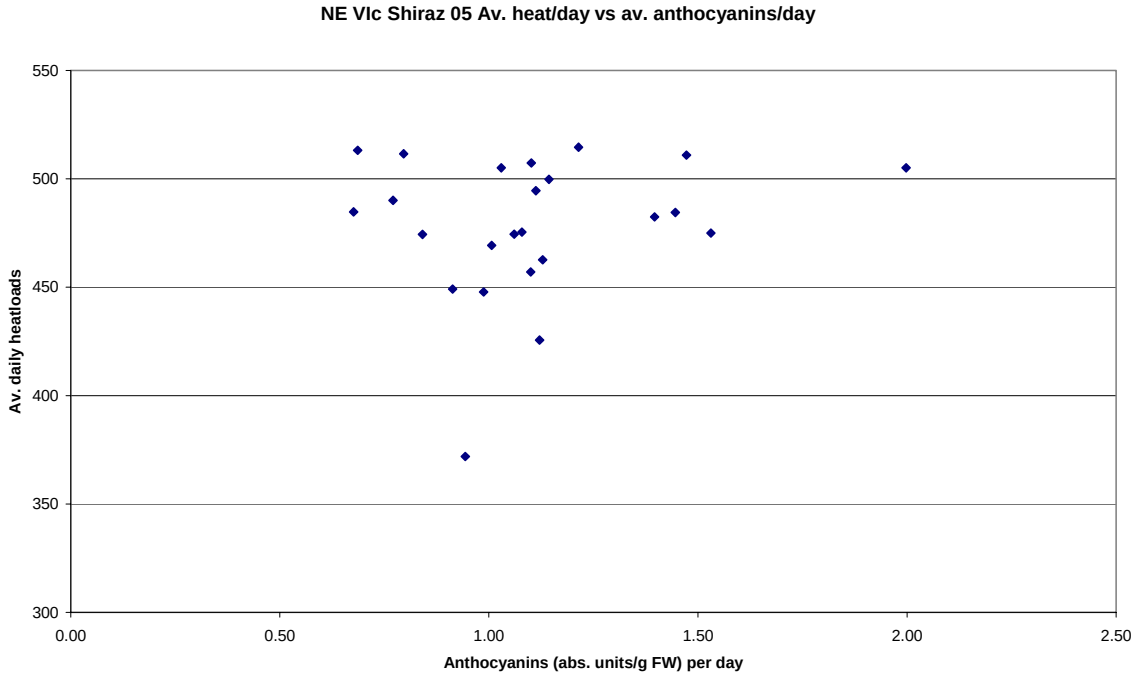


In the previous year N/S rows had lower phenolics in particular when berries were big. In this year some growers (10A, 25K, 21B) plucked the leaves off on the east or south side of bunches to increase warmth in the morning. They have above average anthocyanins for the average leaf layers of their vineyards.

Anthocyanins and bunch temperatures

As is known from the scientific literature (*Spayd et al. 2003*) colour loss or lack of production is not related to light levels but to heat. This makes comparison of bunch temperatures a necessity.

Fig. 77: There is no correlation between average temperature summation/day veraison to harvest in the bunch zone and average colour readings per day.



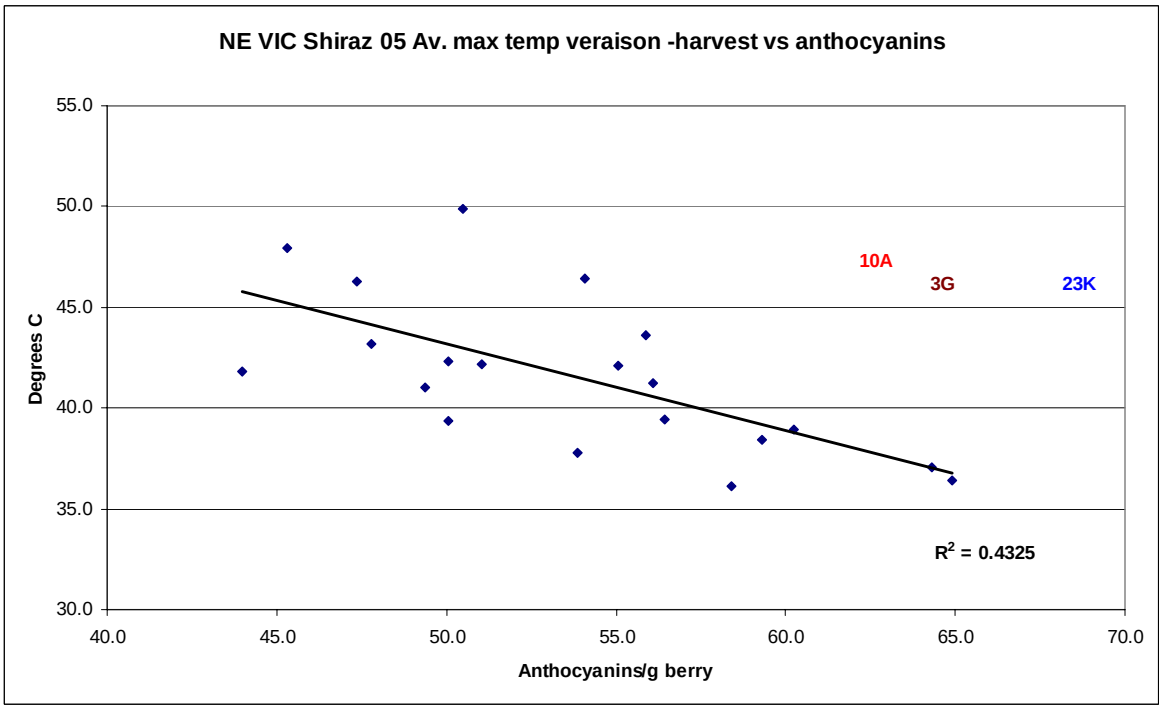


Fig. 78: However high max temperatures cause lower anthocyanins (exceptions 3, 10, 23 because they did not suffer high temperatures for long periods).

Anthocyanins and cane lignification

Berries with unlignified canes had low anthocyanins but at moderate to good lignification a wide range of colour was possible.

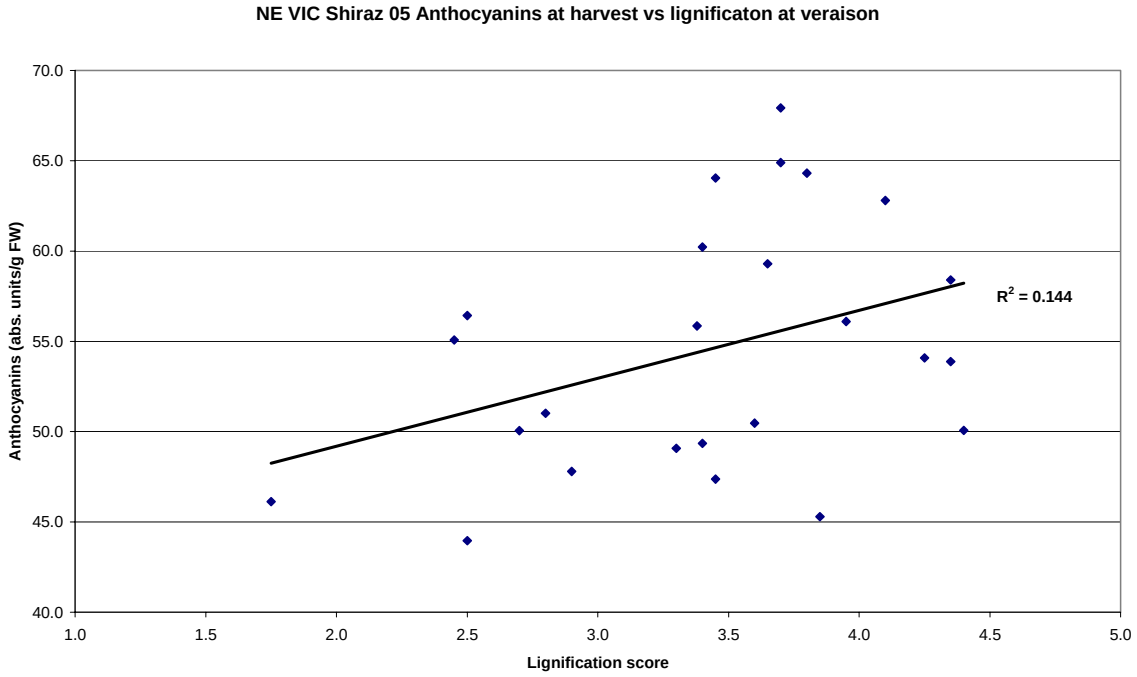


Fig. 79: Good cane lignification at veraison is not a pointer to good colour potential.

Anthocyanins and BSA scores for skin maturity

BSA scores for skin maturity were related to anthocyanins in berries when 3 extremes (*24R high bunch exposure thick skins, 17G water stressed 15R due to early harvest)* was omitted form the calculations.

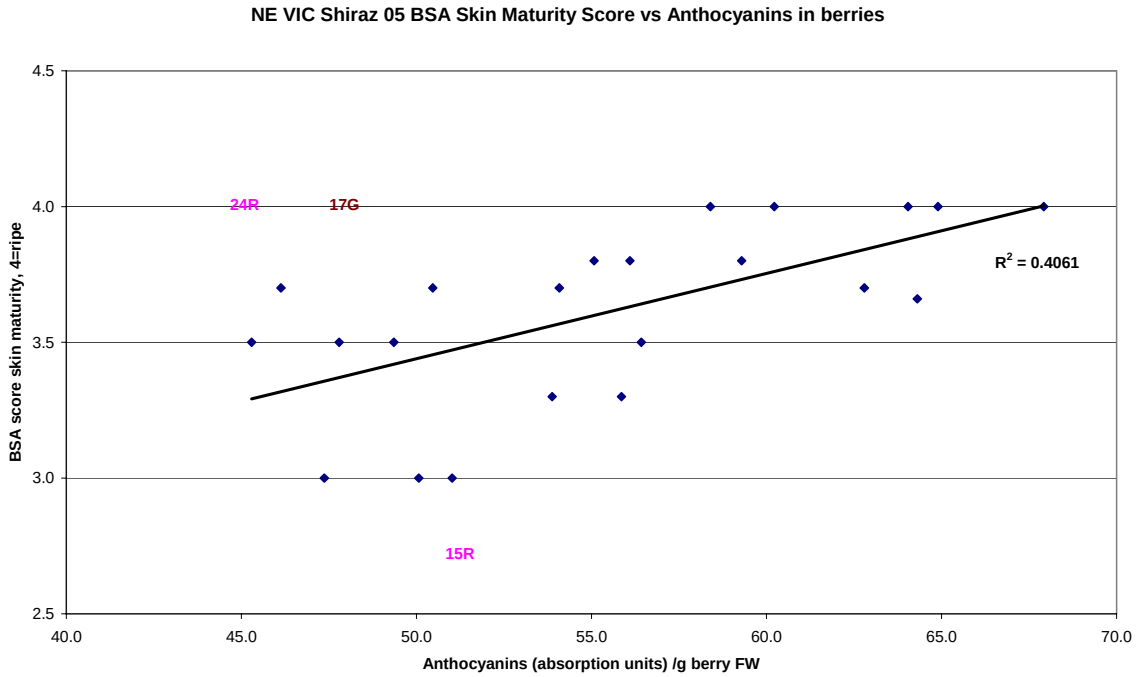


Fig. 80: BSA scores for skin maturity are predictors for colour extractability in particular when the skins are not 100% ripe.

Anthocyanins and vine balance

In the usual bracket considered as relatively balanced vines (6-15 cm^2 leaf area/g fruit) Higher vine balance did not increase anthocyanins. However there were very leafy and low fruit vineyards which made more colour per day (23K, 21B, 2B).

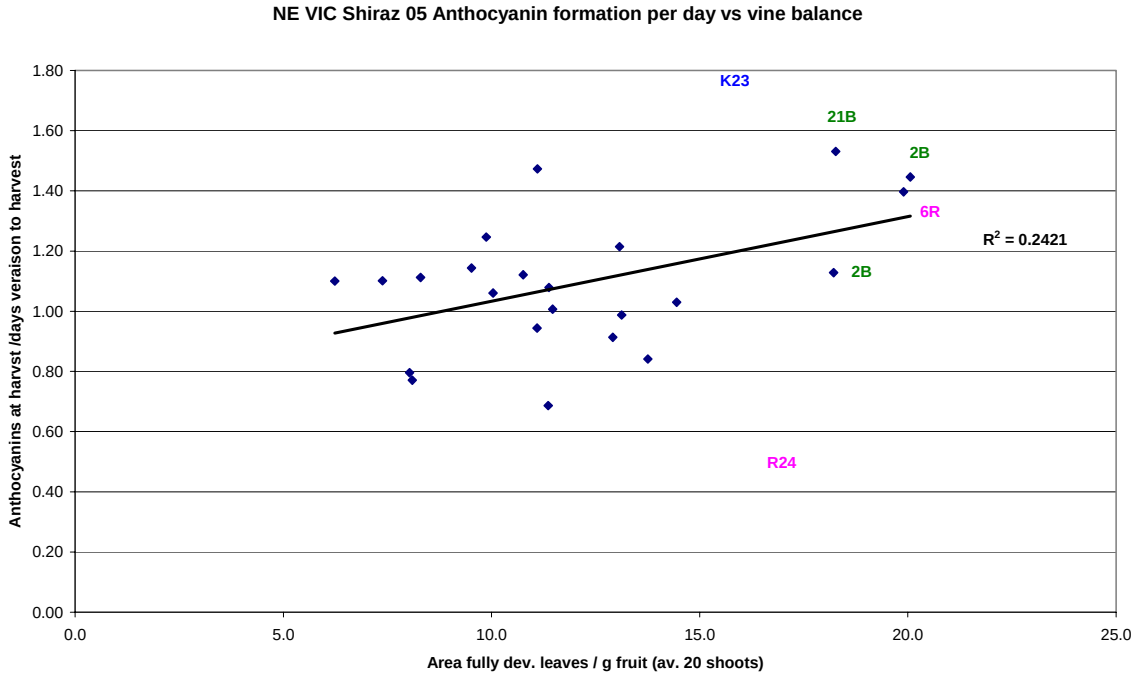
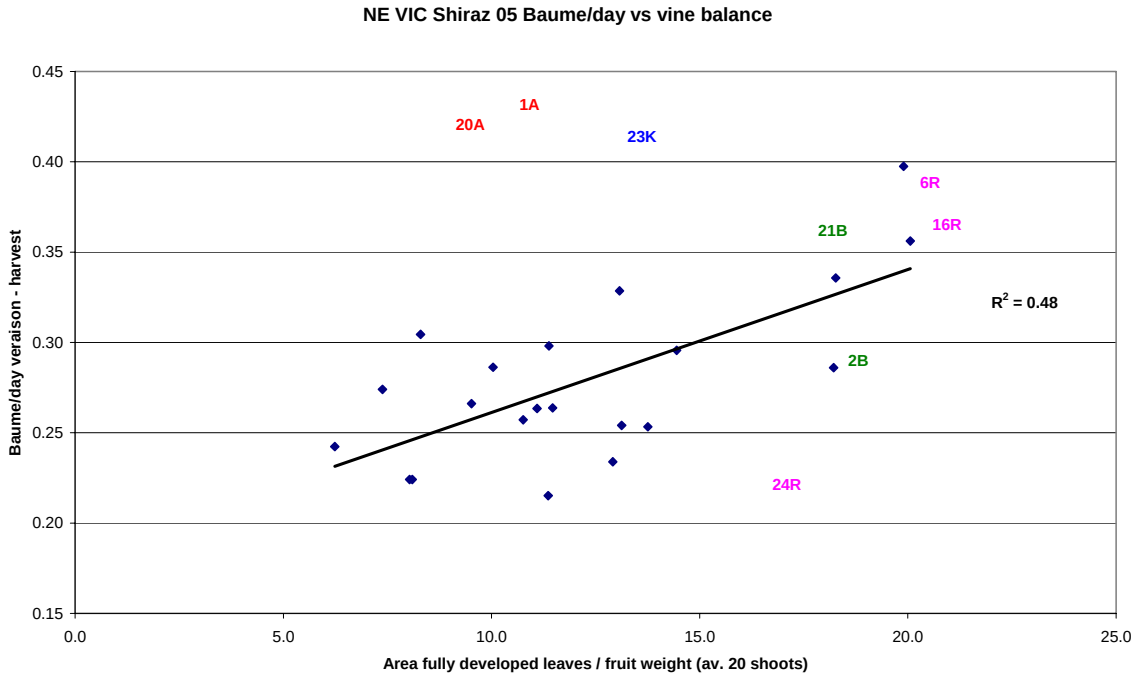


Fig. 81: Vine balance affects ripening speed. More leaves generate more energy in conditions favourable for colour preservation.

Vine balance did not play a big role for sugar accumulation in berries when in the range of 6-15 cm^2/g fruit. However there were – leafier vineyards with less fruit weight accumulated faster (in warm sites in the plain and on the warmer ridge).

Fig. 82: Vine balance is related to speed of sugar production.

Fast sugaring berries at normal vine balance were found in 20A, 1A (hot bunches) and in 23K.



Discussion

Tentative correlation of wine traits with winemaking, harvesting and grapegrowing

The wines are discussed in sequence of their overall wine score (**Tab. 2, Fig. 11**) from low to high in conjunction with some of the traits from climate, vineyard, and berry and young wine data described in detail above:

K23 (Score 13.5) Harsh tannins and high bitterness were tasted by the judges, although phenolic concentrations in young wines and berry skins were very high (Tab. 4 and 5) and skins were ripe in BSA analysis but berries had unripe seeds and a not fully ripe pulp with high TA (Tab. 6). Vines had a very green leafy canopy. Bitterness maybe from high amounts of petioles in the bin (confirmed by grower).

B2 (Score 14) Had herbaceous and pepper characters with low fruitiness and tannin softness and intensity. A lighter style wine from too shaded fruit in a cool area.

K4 (Score 14) Had highest herbaceousness, low fruit and low tannin softness with high tannin intensity from stressed canopies with high amounts of dead leaves pre harvest. Used same type of harvest equipment as K23. Petioles were seen in the bins (confirmed by grower).

A10 (Score 14) Extreme phenolic extraction (Tab. 3) lacking softness maybe due to 5 days cold soaking and 10 days on skins (in the presence of unripe seeds see Tab. 10) Good red fruit but some jammy character from highly exposed bunches due to plucking on the east side of canopy, good colour due to lack of heat loads in the afternoon with leaf cover in the west. A vineyard with well lignified canes at veraison, good vine balance and big bunches with big berries but high anthocyanin and phenolic concentrations/g berry weight. Good potential if softness can be improved by winemaking techniques.

G17 (Score 14) Had a little bit of everything but not intense. Wine tasters called it a mystery wine as it was described as inhomogeneous and sweet/sour. With the original BSA analysis sheets it could be traced back that the 6 BSA samples had 4 riper and 2 unripe readings in the vineyard. The unripe fruit was in the bottom half of the block closer to a row of gumtrees at the end of the rows. This block had run out of irrigation water at veraison and vines in the bottom half of the block had few leaves, very small bunches and high exposure (see flavonol values in grape samples) with stressed fruit. The block would best have been harvested in two different bins for two wines, one more intense and one a lighter style.

O9 (Score 14.5) Notation of high oak flavour, light colour, no brilliance with bitter (some from oak?) flavour and savoury characters, small values for fruit and tannin softness. Fruit had been in high heat due to canopy accidentally rolling in the wind over to the east side and exposing bunches to the hot western sun producing stressed fruit with low colour and phenolics, unripe pulp and seeds and a skin which is almost ripe but exhibits 15% shrivel.

A11 (Score 14.5) Tannins were felt to be a bit green and dominating. Sweet fruit missing. BSA scores one of the lowest. Canes not well lignified at veraison. Fruit not fully ripe, harvested a little early possibly due to fast acid loss at the end of the season from high afternoon heat loads - in a “cool region”!

O8 (Score 15) Good colour, hue and tannin intensity (rotary fermenter – high extraction) but lack of tannin ripeness or softness, some raspberry and plum aroma but also tasting more herbaceous than ripe. High sugar at harvest may have come from shrivel, berries not aroma ripe (BSA). Acid loss and high Bé may have led to the harvest decision.

R16 (Score 15) Almost the ideal 8 shape (Fig. 11) of scores but some jammy aromas from overripe fruit. Stuck fermentation with residual sugar – this wine is hard to judge. Berries showed BSA ripe skins and pulp but the high Be and acid loss late in the season and 5% shrivel may have added to jammy aroma. Good potential maybe if fruit was more exposed earlier (very leafy vineyard)?

A20 (Score 15) Wine judged as having jam and dead fruit (fruit was very sugar ripe at harvest -15.8 Be) and also herbaceous and bitter. Pulp and skin were BSA-mature but pulp aroma not, berries were at harvest still somewhat acidic (TA 5.4 for such high sugar?). Big berries on heavy bunches (overcropped?) with not many leaves (low leaf area to fruit weight) turning yellow before harvest. Management practice could aim at adjusting vine balance, bunch climate data not available but could be too cold early season and too warm and drought stressed at the end due to dead leaves (photo) and high sugar.

R24 (Score 15.5 –Bronze) Better on fruit than others but no mulberry and some marmalade/jam. Slight bitterness and moderate amounts and medium softness of tannins. Good hue but moderate colour (low anthocyanins in berries – hot place see Tab. 8 and high insulation –flavonols Tab. 5). BSA ripe pulp and skin but not seeds. High heat loads early season (– slow lignifier, slow seed ripener?). Adjusting yield downwards may help, important to avoid bitterness from unripe seeds.

G18 (Score 15.5 Bronze) Elliptical shape without waistline (Fig. 11) with tastings of bitterness and pepper as well as black olive and jam. Moderate amounts but soft tannins and moderate colour (low anthocyanins in berries) and hue. Moderate fruit flavours with more plum than others. A warm area vineyard with a low leaf area to fruit weight ratio. In the BSA scoring berries had high pulp acidity and low aroma (from slow ripening and maybe insufficient hangtime?), although with leaves turning red from stress and fruit having ripe skins and starting to shrivel maybe no point. Vine balance and early season bunch temperatures may need to be watched?

K7 (Score 16 Bronze) Soft tannins and very good colour and fruit but green flavours which will not disappear with age and may later overpower the fruit. Vineyard has a curtain of leaves (3 layers) and N/S rows shading each other. No full red fruit aroma, more towards black fruit (from shrivel and long hangtime?), but also herbaceous and bitter tastes from unripe pulp and seeds.

B 12 (Score 16 Bronze) Wine tasters scored colour and tannins quite high, felt some chalkiness, and acknowledged good palate structure. Savoury notes, black pepper, some bitter tinge. Jam, black olive, liquorice and chocolate flavours. The vineyard is in a place that can get 49^{o}C as peak bunch zone heat and has in summer high afternoon heat loads. Accordingly, colour in berries is not high and pulp maturity and acidity is not in step with sugar and skin ripening which is racing ahead with 5% shrivel. Still good potential if heat loads could be avoided.

G13 (Score 16 Bronze) Wide spectrum of sufficiently intense red fruit and some little jam (10% shrivel). Excessive hangtime wisely avoided. Not bitter despite 10 days on skins and not fully ripe seeds (wine has been fined already), only a little herbaceous (not quite ripe pulp – low leaf area to fruit weight?), low tannin intensity (fining) despite phenolics in skins having been high. Good tannin softness, moderate colour (high heat peaks during ripening) and less than expected hue. Very pleasant early drinking wine. Should not be over-oaked.

R6 (Score 16.5 Bronze) A balanced wine, when the technical mistake acetic volatility is overlooked. No bitter or herbaceous aromas noted but difficult to assess fruity aromas. The grapes however are not BSA ripe at a point of 15.9 Be and 10% shrivel so although the ripening process for sugar and phenolics is swift the acid loss is fast and fresh aromas are lost with jammy flavours appearing. Here aroma and colour loss must be prevented in a place with the potential of bunch zones experiencing 47^{o}C max despite having a cooler total heat summation due to cooler nights.

19B (Score 16.5 Bronze). Temporarily tasting like brown apple but not yet finished malo – S will mop it up. Wine with great intensity and high scores for plum, blackberry, colour, hue, tannin softness and intensity (high extraction during winemaking – seeds almost ripe but only almost – a hint of bitterness in the wine). Long hangtime with no heat loads in the afternoon and exposed fruit. Not a totally cool place but not hot, no max temp over 36 from veraison on! Great potential if bitterness is avoided. Will still change.

G3 (Score 17 Silver) This wine is almost similar to that of K25 which has also a silver medal score. The characteristic is **smooth** with very soft tannin intensity sufficient but not too much and good colour and hue. It has **no greenness or bitterness** and **nice fruit** (as 25 in Fig. 11, the line is not visible in diagram) except not much raspberry and **no jam**. Fruit was harvested very ripe but with still some acidity, however pulp and skin was well ripe when BSA tested. Berries had high colour and phenolics with not many heat loads due to 3 leaf layers above bunches in a warm area (5 layers at veraison). Good management practice with not too many dead leaves, good heat protection – no plucking in this climate!). **Good winemaking. Viticulture adapted to the site.**

K25 (Score 17 Silver) **Smooth big balanced wine**. Moderate tannic intensity but very soft, good hue, less colour than G3**. No bitter or herbaceous aromas** and an **array of all fruit with "early aromas" black pepper and raspberry preserved**, plum and blackberry dominating, mulberry there and **only a hint of liquorice and jam**. Berries had very ripe skins and pulp at high sugar ripeness with still some acidity. Fruit was cautiously exposed to the east (hand plucked) in a warm area however no peak heat events and no afternoon heat loads ever occurred in the bunch zone. The 15% shrivel is seen in the jam character, leaf desiccation at harvest pointed to some late season stress which may have been counterproductive for seed maturation? **Excellent winemaking. Viticulture adapted to the site, adoption of best practice since last year.**

Comments

As mentioned in results it is difficult to judge 5 month old wine. Ideally, future surveys should aim for wine assessment in one of the following two ways:

- Replicated small-batch winemaking.
- Assessment of wines immediately after primary fermentation (using cold or frozen sample storage) with a follow-up tasting when all wines have finished MLF, have similar SO_2 regimes and before fruit characteristics are partially disguised by new oak.

Synoptic view of phenolics and anthocyanins in grapes and their bunch exposure

Diurnal temperature patterns which produce higher values of colour and phenolics seem to be

- the absence of either too hot or too cold veraison to harvest temperature summations in the bunch zone (**Tab. 8**)
- the speedy warm up of bunches to optimum ripening temperatures (Fig. 83, ++).
- the absence of heat loads on bunches in the afternoon (Fig. 83, -)

Fig. 83: Summary of diurnal bunch temperature patterns and grape quality factors colour and total phenolics with reference to management practice.

Location	Phenolic value	Antho-cyanin value	Bunch tem-perature morning	Bunch tem-perature afternoon	Change in Phenolics to last year	Some canopy manage-ment in 04/05
1A	54.0	50.1	-	++		
2B	52.1	56.4	-	-	down	leaf cover
3G	62.2	64.0	++	-		
4K	58.7	64.9	+	-		
5R	57.5	50.5	++	-		
6R	56.6	55.9	+	+		
7K	52.8	47.4	-	++		
8O	57.8	56.1	++	-		
9O	51.8	45.3	++	++		rolled canopy
10A	62.7	62.8	+	-	up	plucked east
11A	52.5	51.0	-	++	down	
12B	53.0	54.1	+	+	up	
13G	59.8	55.1	+	-	up	
14K	47.4	53.9	-	--	up	leaf cover
15R	48.6	50.1	+	-		early harvest
16R	58.3	59.3	+	-	up	
17G	57.8	49.1	+	-		
18G	53.6	49.4	+	+	up	
19B	60.3	60.2	+	-	Down a bit	
20A	47.8	46.1	na	na		
21B	62.2	64.3	+	-		plucked S
22G	52.3	47.8	++	++	down	lacking leaf
23K	60.1	67.9	++	-	up	plucked N
24R	52.1	44.0	++	++	up	
25K	55.7	58.4	+	-	up	plucked east

The classification of phenolic and anthocyanin values in low (green) and high (black) were only relative to each other.

Berry anthocyanins seemed to do better in cooler (shaded) bunches and did worse in hotter and/or exposed bunch zones. It is not shade or “Sunlight” (*Smart 1992*) that influences the wine. No difference in phenolics was found when grapes were shaded but held at the same temperature than exposed grapes, (*Downey et al. 2004*). Shiraz berry phenolics were described to be higher in canopies with higher radiation and lower number of leaf layers over bunches irrespective of trellis systems (*Wolf et al. 2003*) – bunch temperatures were not measured (*except in Spayd et al. 2002*).

Scores for wine traits seemed to also reflect this dependency on bunch zone temperatures when harvesting and wine making avoided bitter phenolics from plant parts and seeds (Fig. 84). Never before were wine tastings related to bunch temperature measurements. This warrants further investigation in replicated standardised research.

Fig. 84: Synoptic view of total phenolics, anthocyanins, aroma and mouthfeel scores in wines and bunch exposure with some explanatory notes for possible reasons of the grape and wine results.

	Total pheno-lics	Antho-cyanin	Over all Wine score	Sum red + black fruit	Sum herbac. + bitter	Tannin soft ness	Bunch temp. am	Bunch temp. pm	Some comments
1A	54.0	50.1					-	++	
2B	52.1	56.4	14	4	5	2	-	-	Leaf cover
3G	62.2	64	17	10	0	4	++	-	Very good site adaptation
4K	58.7	64.9	14	6	8	1	+	-	Petioles in bin
5R	57.5	50.5	na				++	-	
6R	56.6	55.9	16.5	9	0	4	+	+	Good site adaptation
7K	52.8	47.7	16	7	2	3	-	++	Leafy
8O	57.8	56.1	15	6	3	2	++	-	Strong seed extraction by rotary fermenter
9O	51.8	45.3	14.5	6	3	2	++	++	rolled canopy
10A	62.7	62.8	14	7	4	2	+	-	Extreme seed extraction
11A	52.5	51	14.5	6	4	2	-	++	Unripe fruit
12B	53.0	54.1	16	10	1	3	+	+	Good site adaptation
13G	59.8	55.1	16	11	1	3	+	-	Lighter style
14K	47.4	53.9	na				-	--	
15R	48.6	50.1	na				+	-	
16R	58.3	59.3	15	10	1	2	+	-	
17G	57.8	49.1	14	3	5	1	+	-	Ripe and unripe fruit
18G	53.6	49.3	15.5	7	2	3	+	+	Good site adaptation
19B	60.3	60.2	16.5	12	1	4	+	-	Good site adaptation
20A	47.8	46.1	15	7	4	2	na	na	
21B	62.2	64.3	na				+	-	
22G	52.3	47.8	na				++	++	
23K	60.1	67.9	13.5	4	7	1	++	-	Petioles in bin
24R	52.1	44	15.5	9	2	3	++	++	Good site adaptation?
25K	55.7	58.4	17	14	0	4	+	-	Very good site adaptation

Colour code (except for locations): green is low positive score or high negative score, purple is moderate to good, bronze medal in wine scores, red is silver medal in wine scores.

Quality factors for NE Victorian full bodied Shiraz

Negative pointers:

Results of the survey pointed to a trend that low **total phenolics in grapes** were associated with low wine scores and better wines had often but not always higher phenolics. The synopsis above however revealed that in half of the cases wine scores were good when not maximum amounts of total phenolics in grapes were measured.
Lack of phenolic production or extractability seemed to be a pointer to lower wine potential but not vice versa.
The same held true for **colour in grapes**, high colour did not necessarily mean good wine, proven by 6 out of 20 wines.

BSA assessment of seeds can discriminate unripe seeds which have implications for the winemaking process if bitterness if extracted.

Vineyard observations showed that **extreme leafiness**, bunch shade, **lack of cane lignification at veraison** and extreme overcropping could be negative pointers to wine quality. Many of those are already known and had been confirmed in the present study.

With vineyards under very good management practice positive pointers for grape quality are needed.
The present survey indicated that maximum wine scores can only be obtained when tannins are soft, fruit flavours are intense and herbaceous aromas and bitterness is absent or very low.

Positive pointers:

BSA assessments of skins were good indicators of tannin softness in wine.
A BSA assessment of the pulp was a good pointer to red and black fruit potential in wine.

Bunch exposure to result in the absence of afternoon heat loads seems to be (with one exception) correlated with good wine scores.

Veraison to harvest temperature summation in the bunch zone (base zero) was highly positively correlated with tannin softness (up to a cut-off temperature summation) and a good pointer to fruit aroma potential.

These findings will hopefully be further investigated in other benchmarking surveys.

Site adapted management practice:

The best 3 wine scores came from vines that had similar heat summation units but got there with different, site adapted management: K25 from a “warm site”, leaves plucked cautiously on east side of N/S rows, normal hangtime, G3 from a “warmer site”, not plucked, shorter hangtime, and B19 from a “cooler site”, having well exposed bunches and long hangtime.

Research issues:

The following questions remain:

- Where is the optimum temperature summation window for a pleasant aroma profile in other years?
- Where exactly is the upper cut-off point for tannin softness?
- How are these optimum windows influenced by water management?

Trials in the same vineyard (same soil, clone, rootstock, water etc) and with identical winemaking procedures for sub samples to investigate the herein discovered trend of a relationship of temperatures in the bunch zone with wine outcomes would be highly recommended.

Conclusions and recommendations

The RITA Benchmarking study was extremely successful for the following reasons:

- ✓ Enough vineyards participated to produce valid statements and statistical correlations.
- ✓ Grower and winemaker involvement was excellent with detailed information on all aspects of grapegrowing and winemaking.
- ✓ Coordination by below acknowledged agencies was helping with cohesion of the group and good planning of the activities.
- ✓ A local field coordinator provided impetus, consistency and accuracy to the study.
- ✓ The painstaking dissective method of chemical analysis of berry parts instead of whole berries (where seed phenolic blur the picture) made it possible to produce the necessary data for phenolic studies.
- ✓ Wine tasting was performed by an experienced pair of tasters producing not only scores but wine characteristics and information was given freely for winemakers to learn.
- ✓ Willingness of the participants to try out new scoring systems developed by GrapeLinks - which took into account latest literature (GrapeLinks), embraced modern technology (data logger) and encompassed new training (BSA) led to greater insight to improve practices. Vineyards each contributed approximately $200 to the study.
- ✓ The survey gave BSA a good test run in many vineyards. BSA results correlated well with quality parameters thus proved to be a powerful tool to be applied in other regions.
- ✓ New insights were largely based on inexpensive, grower suitable temperature measurements in the bunch zone which will possibly become standard practice in many other viticultural regions growing for full bodied red wines.
- ✓ A high rate of grower and winemaker adoption of new best practice will be possible due to the detailed data analysis and reporting where every vineyard was considered – instead of statistical analysis of the group only.
- ✓ The piloting of the new vineyard assessment system and thorough evaluation was only possible through the extra financial contribution from GWRDC's Knowledge Management fund.
- ✓ The findings have been discussed with the growers and winemakers and resulted in a high degree of involvement and enthusiasm which will lead to
  - a higher motivation of the participants to aim high in difficult times
  - some financial benefits after changed practice
  - sustainable growing practices
  - an even better cohesion of the regional grapegrowers and winemakers
  - attraction of researchers to perform replicated trials in well known sites
  - an enhanced image of the grapegrowing and winemaking skills of NE Victoria.

Recommendations for further studies:

- ☞ The large amount of samples for berry analysis created more work than can be done in the future. It is recommended that only one representative sample is taken per vineyard and no seed analysis is performed as these data did not correlate with quality parameters.

- ☞ Vine balance measurements at veraison were useful to characterise the vineyards but must be recorded on a palm pilot so that no cumbersome data entry has to be done by hand.

- ☞ Bunch zone temperature veraison to harvest has proven to be a critical quality indicator. This can be tested in other RITA studies and in research trials at relatively low cost.

- ☞ Tiny-tag data loggers proved effective and can be recommended. However they should be set to 1 h intervals next year – 30 min is not needed and creates more data than can be stored in the device from veraison to harvest. They need to be initiated 2 weeks before veraison when phenolics are produced (*Downy et al. 2003*), not only during their "ripening" process.

- ☞ Photos taken at harvest were of enormous value to judge vineyards retrospectively during data analysis. A digital camera would be of use for photo demonstrations of canopy structures in particular to grower groups.

- ☞ As the production and extractability of phenolics has been shown in the literature to also depend on soil moisture levels (*Petrie et al. 2004*), in the future soil characterisation and soil moisture monitoring would enhance the understanding of cause and effect relationships.

- ☞ BSA proved be a key indicator for wine quality. More growers and winemakers should use the standardised method.

- ☞ As BSA had shown in one vineyard that there were differences between the bunches from the top to those from the bottom, and this carried through to the inhomogeneous aromas in the wine it would be good to have a means to assess zones. NDVI images to depict plant cell density would be a good means to do this, and possibly affordable if shared in a region.

- ☞ It has to be clear at the beginning into which wine style the fruit is to be grown and only such vineyards must be chosen that aim for similar styles to avoid outlying data points from grapes which were harvested very early.

- ☞ There is no single quality parameter for every wine style. In this study major emphasis was placed on phenolics for full bodied Shiraz styles. Not all of the conclusions above be immediately transferred to other wine styles or varieties, separate studies with other varieties are needed.

- ☞ Wines were neither fresh after ferment nor properly finished when they were tasted after 5 month (so as to finish the report on due date). It was suggested by the winemakers to taste the wine after ferment and possibly again a year later.

- ☞ This was a comparative study of Shiraz vineyards in various situations with various rootstocks and clones and varying management practice. Also harvest date and winemaking followed commercial decisions. Some observed phenomena seemed to correlate to site conditions and growing practice. Proper testing of those relationships in replicated trials must follow to undermine these observations.

Acknowledgements

This work would have been impossible without the support and cooperation of:

Grape and Wine Research and Development Corporation for funding the project though the RITA program, and John Harvey, RITA Program Manager for his support and for the additional sponsorship through the KM fund.

Myrrhee Consulting and Alan Buchanan and his team for chemical analysis of grapes and young wine.

Nick Bulleid, MW, Bulleid Consulting **and Chris Killeen** chief winemaker at Stanton & Killeen winery in Rutherglen**,** for judging the finished wines.

King Valley Vignerons Inc. and David Maples, President, for his support, as well as Wendy Batey, Executive Officer, for her kind administrative work.

The Centre, Wangaratta and Lachlan Campbell, for his enthusiasm and the organisation of grower meetings.

DPI Rutherglen and Paul Blackshaw, for his kind assistance with the veraison vineyard scoring.

The Project Steering Committee consisting of Professor Alan Buchanan & Alison Earp, Myrrhee Consulting Services; Bruce Holm, Sam Miranda Wines; Paul Dahlenberg, Baileys of Glenrowan; Lachlan Campell, The Centre; Paul Blackshaw, DPI Rutherglen and Stephen Lowe, Stony Creek Vineyard for their guidance, support and encouragement throughout the project.

The Participating Shiraz Vignerons for their enthusiasm, generosity and time during the hectic harvest period, and for volunteering their vineyards to be open for this study.

The Participating Wineries/Processors for their co-operation and assistance in collecting wine samples and filling in questionnaires at their busiest time of year.

Disclaimer

The advice provided in this publication is intended as a source of information only. The author and other persons/organisations named in this report do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims any liability for any error, loss or consequence, which may arise from you relying on any information in this publication.

References

Coombe, B.G. and McCarthy, M.G. Dynamics of grape berry growth and physiology of ripening. Aust. J. Grape and Wine Res., 6, 131-135, 2000.

Dry, P.R., Iland, P.G. and Ristic, R. What is vine balance? Proc. of the 12 Australian Wine Industry Technical Conference. pp 68-74, 2004.

Downey, M.O., Harvey, J. S. and Robinson, S.P. Analysis of tannins in seeds and skins of Shiraz grapes throughout berry development. Aust. J. Grape and Wine Res., 9, 15-27, 2003.

Downey, M.O., Harvey, J. S. and Robinson, S.P. The effect of bunch shading on berry development and flavonoid accumulation in Shiraz grapes. Aust. J. Grape and Wine Res., 10, 55-73, 2004.

Habertson, J.F, Kennedy, J.A. and Adams, D.O. Tannin in skins and seeds of Cabernet Sauvignon, Syrah and Pinot noir berries during ripening. Am. J. Enol. Vitic. 53 (1) 2002.

Haselgrove, L., Botting, D., vanHeeswijk, R., Hoj, P.B., Dry, P.R., Ford, C. and Iland, P.G., Canopy microclimate and berry composition: the effect of bunch exposure on the phenolic composition of *Vitis vinifera* L. cv. Shiraz grape berries, Aust. J. Grape and Wine Res., 6, 141-149, 2000.

Howell, S. Sustainable grape productivity and the growth-yield relationship. Am. J. Enol. Vitic. 52(3) pp 165-174, 2001.

Kliewer, W.M and Dokoozlian, N.K. Leaf area/crop weight ratios of grapevines: Influence on fruit composition and quality. Proc. ASEV Ann. Meeting, Seattle, pp 285-295, 2000.

Lowe, S. North East Victoria Wine Grape Quality Measurement and Benchmarking. Vintage 2004 Report to GWRDC.

Petrie, P.R., Cooley, N.M. and Clingeleffer, P.R. The effect of post-veraison water deficit on yield components and maturation of irrigated Shiraz in the current and following season. Aust. J. Grape and Wine Res., 610, 203-215, 2004.

Price, S.F., Breen, P.J., Vallaladao, M. and Watson, B.T. Cluster sun exposure and quercetin in grapes and wine, Am. J. Enol. Vitic., 46, 187-194, 1995.

Rolley, L. Wine Grape Quality Measurement and Benchmarking. Central Victoria, Vintage 2002 and 2003 Reports to GWRDC.

Smart, R. and Robinson, M. Sunlight into Wine. A handbook for wine grape canopy management. Winetitles, 1992.

Somers, C. The Wine Spectrum. Winetitles1998.

Spayd, S.E., Tarara, J.M., Mee, D.L. and Ferguson, J.C. Separation of sunlight and temperature effects on the composition of *Vitis vinifera* cv. Merlot berries. Am. J. Enol. Vitic. 53 (3), 2002.

Walker, R.R., Blackmore, D.H,., Clingeleffer, P.R., Kerridge, G.H. and Ruehl, E. Shiraz berry size in relation to seed numbers and implications for juice and wine composition. **.** Aust. J. Grape and Wine Res., 11, 2-8, 2005

.**Winter, E. Whiting, J. and Rousseau, J.** Winegrape Berry Sensory Assessment in Australia. Winetitles, 2004.

Winter, E. and Whiting, J. Using leaf area to crop weight to determine vine balance. Australian Viticulture Jan/Feb pp 70-73, 2004.

Winter, E. Growing good Shiraz. Three years of Shiraz benchmarking studies in Victorian Vineyards. Australian Viticulture Jan/Feb. pp 61-64, 2005.

Wolf, T.K., Dry, P.R., Iland, P.G., Botting, D., Dick, J., Kennedy, U. and Ristic, R. Response of Shiraz grapevines to five different training systems in the Barossa Valley, Australia. Aust. J. Grape and Wine Res., 9, 82-95, 2003.

APPENDIX

Table 1: Vineyard characteristics sorted by vineyard code. N= vineyard new participant (not the same vineyard as under this code last year)

Shiraz vineyards: NE Victoria. Scoresheets: GrapeLinks Assessor : Stephen Lowe Season: 04/05

Site	Location *	Area (Ha)	Slope %	Aspect	vine age	Trellis Type	No. of wires	Row orientation	Row spacing m	Vine spacing m	Pruning Method	Clone	Rootst.	Irrigation type	Output L/h	Water Source	Rain before verais.	Rain after verais.	Rain total mil.	Yield (t/ha)
1N	A	3.2	20	ne	6	vsp	1	nw/se	3.0	2.0	spur	pt 23	r99	drip	4	dam	182	145	327	10.0
2	B	0.1	3	wnw	11	s/d	1	e/w	2.5	1.5	cane	na	schw	non	0	sky	474	0	474	12.0
3	G	13.2	10	sw	9	s/d	1	nw/se	3.0	2.0	spur	na	na	drip	1.8	dam	206	164	370	10.6
4	K	3.6	5	ne	12	s/h	2	ne/sw	2.7	1.8	spur	pt23	own	drip	na	creek	472	43	515	11.8
5	R	6.0	10	sw	8	sprawl	1	ne/sw	3.0	2.1	spur	1654	r99	drip	na	dam	160	143	303	10.0
6	R	12.0	10	wnw	7	s/d	1	nw/se	3.0	2.0	spur	1654	schw	drip	2.3	dam	169	142	311	9.7
7	K	2.1	5	wsw	11	s/h	2	n/s	3.0	1.8	spur	na	schw	drip	4	dam				14.8
8	O	4.0	0	0	13	s/d	1	n/s	3.0	3.0	spur	pt23	schw	furr	na	river	346	222	568	13.9
9	O	6.0	15	wnw	7	s/d	1	n/s	3.0	2.0	spur	tahbilk	rug/paul	drip	2.6	dam	215	178	393	6.4
10	A	3.0	10	nw	10	s/d	1	ne/sw	3.0	2.0	spur	pt23	schw	non	0	sky	628	38	666	10.0
11	A	2.4	25	e	7	s/d	1	n/s	3.0	2.0	spur	1654	teleki	drip	2.4	dam	253	198	451	7.5
12	B	1.0	3	n	7	s/d	1	n/s	3.0	2.4	spur	pt23	schw	drip	na	dam				5.4
13	G	2.0	3	wsw	11	vsp	1	nw/se	3.3	2.7	spur	pt23	schw	ohead	65	dam	188	164	352	6.5
14	K	4.4	0	0	11	s/d	1	n/s	3.0	3.0	spur	pt23	schw	drip	4	dam	526	47	573	11.5
15	R	4.5	3	w	9	s/h	2	e/w	3.0	2.0	spur	pt23	kober	drip	na	river	173	115	288	10.5
16	R	2.2	3	n	8	s/h	2	ne/sw	3.0	2.0	spur	pt23	kober	drip	4	dam	241	154	395	13.0
17N	G	2.0	5	sw	7	vsp	1	nw/se	3.0	1.8	cane	pt23	rugg	drip	8	dam	159	156	315	2.7
18	G	2.3	3	e	7	s/d	1	n/s	3.0	2.0	spur	pt23	schw	drip	na	dam	189	254	443	7.0
19	B	3.4	10	n	6	s/d	1	n/s	3.0	2.0	spur	pt23	schw	drip	4.6	dam	504	20	524	7.3
20N	A	4.0	0	0	10	s/d	1	ne/sw	3.0	3.0	spur	pt23	schw	drip	2.1	river	284	149	433	18.0
21N	B	5.0	25	w	7	s/d	1	e/w	2.7	1.8	spur	bvrc12	r99	drip	2.3	dam	278	195	473	5.0
22	G	2.0	0.5	nnw	35	sprawl	1	ne/sw	3.3	1.8	spur	na	arg1	drip	4	dam	176	187	363	5.0
23	K	5.0	10	n	7	s/d	1	e/w	3.0	3.0	spur	pt23	schw	drip	2.3	dam	480	35	515	10.0
24	R	2	0	0	5	s/h	1	n/s	3	2	spur	bvrc12	schw	drip	2.3	river	269	138	407	14.5
25	K	1.5	15	w	9	s/d	1	n/s	2.7	2.5	spur	1654	schw	drip	na	na	323	36	359	5.8

Tab. 2 Wine assessment results

NE VIC RITA Benchmarking Project. Wine assessments by Nick Bulleid and Chris Killeen, 1.9.05

Aroma (0=absent, 5= intense, overlaying faults due to unfinished MALO ignored) **Mouthfeel (0=absent, 5 = intnese)**

Loc.	Site	Herbaceous	Bitter	Green/ White Pepper	Black Pepper	Raspberry	Plum	Blackberry	Mulberry	Licorice	Black olive	Jam	Tannin softness	Tannin intensity	Hue	Colour	"Wine Show" Score
A	1																
B	2	3	2	3	1	2	1	1	0	0	1	0	2	1	3	2	14.0
G	3	0	0	0	1	1	4	3	2	1	1	0	4	3	4	4	17.0
K	4	4	4	2	1	2	2	2	0	0	1	0	1	4	4	4	14.0
R	5																
R	6	0	0	0	0	1	4	3	1	1	1	1	4	3	4	4	16.5
K	7	1	1	0	1	1	2	3	1	0	0	0	3	3	4	4	16.0
O	8	2	1	0	1	2	2	1	1	1	0	0	2	3	4	3	15.0
O	9	1	2	1	1	2	2	2	0	0	0	0	2	2	2	2	14.5
A	10	2	2	1	2	1	3	3	0	1	1	2	2	5	5	5	14.0
A	11	2	2	2	1	1	2	2	1	0	1	0	2	3	4	3	14.5
B	12	0	1	0	1	1	4	4	1	1	1	1	3	4	4	4	16.0
G	13	1	0	0	2	3	3	3	2	0	0	1	3	2	3	3	16.0
K	14																
R	15																
R	16	0	1	0	1	2	3	3	2	1	1	1	2	4	3	4	15.0
G	17	3	2	2	1	2	1	0	0	0	0	0	1	2	3	3	14.0
G	18	1	1	1	1	2	3	2	0	1	0	1	3	2	3	3	15.5
B	19	0	1	0	2	2	4	4	2	1	1	1	4	4	5	5	16.5
A	20	2	2	1	1	2	2	2	1	0	0	2	2	3	3	3	15.0
B	21																
G	22																
K	23	3	4	2	1	2	1	1	0	0	0	0	1	3	3	3	13.5
R	24	1	1	0	1	3	3	3	0	0	0	2	3	3	4	3	15.5
K	25	0	0	0	1	3	4	4	3	1	0	1	4	3	4	3	17.0

Tab 3: Berry conditions at cellar door, harvest method and **winemaking steps** provided by the commercial wineries participating in the study.

NE VIC Shiraz 05 Winemaking Parameters

Loc.	Site	Grape Be	Harvest method	Grape temp C	% runoff pre crush	% runoff post crush	Additions Tannins g/t *	Additions Red tannin or Grape extract	Additions Oak kg/t *	Cold soak days	Cold soak Temp C	Type Fermenter	Stir cap times /day	Juice Temp max	Cap Temp max	Time on skins	Press. Be	Yield L/t
A	1	14.1	mach	25	0	0	100.0	0.0	2.0	1.0	10	static	3	27	na	6	0.0	728
B	2	14.3	hand	25	0	0	0.0	0.0	0.0	0.0	0	open	4	28	32	4	0.0	658
G	3	14.9	mach	22	0	0	75.0	0.0	0.0	0.0	0	static	3	25	26	9	0.7	750
K	4	14.3	mach	18	0	0	3.0	0.0	200ppm	0.0	0	static	3	30	na	6	1.2	780
R	5	15.2	mach	21	0	0	200.0	0.0	0.0	0.0	na	static	4	28	31	7	1.5	730
R	6	15.9	mach	21	0	0	100.0	0.0	0.0	0.0	na	static	3	25	25	7	1.0	770
K	7	13.6	mach	19	0	0	200 ppm	0.0	0.0	1.0	19	static	3	25	32	8	0.5	710
O	8	15.5	mach	15	0	0	35.0	0.0	2.0	1.0	14	rotary	4	26	na	7	<1	770
O	9	14.2	hand	25	na	15	0.2	0.0	0.0	0.0	na	static	4	28	28	7	0.2	600
A	10	14.4	hand	20	0	10	48.0	0.0	0.0	5.0	20	static	7	28	29	10	0.0	650
A	11	13.8	mach	na		0	35.0	0.0	0.0	0.0	20	static	3	25	na	6	0.7	767
B	12	14.6																
G	13	13.7	mach	16	0	0	0.0	0.0	0.0	1.0	16	static ++	2	25	na	10	0.0	750
K	14	13.8	mach	12	0	0	150.0	0.0	3.0	7.0	23	static	3	24	na	7	<1	770
R	15	13.7	mach	23	0	0	50ppm	0.0	0.0	0.0	na	static	2	25	na	5	2.0	824
R	16	14.6	mach	17	0	0	0.0	0.0	0.0	0.0	na	static	3	28	na	6	1.5	730
G	17	13.7	hand	28	0	0	0.0	0.0	0.0	0.0	0	static	3	30	30	4	1.0	650
G	18	13.9	mach	24	10	0	0.0	0.0	3.0	0.0	na	static	3	30	34	7	0.0	675
B	19	15.5	mach	18	0	0	3.5	50ppm	200ppm	2.0	10	static	2	30	na	10	0.9	735
A	20	15.8	mach	20	0	0	0.0	0.0	2.8	0.4	18	static	3	34	na	9	0.0	700
B	21	14.1	hand	14	0	0	0.0	0.0	0.0	0.0	na	static	3	25	30	7	0.0	735
G	22	13.9	mach	23	0	0	75.0	0.0	0.0	0.0	na	static	3	26	26	10	0.7	791
K	23	14.3	mach	17	0	0	0.0	0.0	0.0	2.0	10	static	2	30	na	14	0.3	788
R	24	14.5	mach	23	0	0	100.0	1.5	0.0	0.0	na	sweeper	8	24	32	9	0.0	738
K	25	15.3	mach	20	0	0	150.0	0.0	1.8	0.0	na	open	3	30	28	8	0.6	614

* The units were given like this in the questionnairs

Tab.4: Analysis of young wine (purple) compared to berry data (blue), BSA of skins at harvest (pink) and selected vineyard data.
Sites are colour coded by regions; data are colour coded into four groups to highlight very low, moderate, high and exceptional values.

NE VIC Shiraz 05 Young Wine Analysis Myrrhee Laboratories

Site		Pre-harv. leaf layers front + back	Ver. *active leaf area cm2*	BSA skin maturity	Time on skins	Yield (t/ha)	Berry Be	BERRY Antho cyanins	Flavo nols	Phe nolics	WINE pH	Anthocyanins E520	Modif. Antho. E420	Col. Density E520 + E420	Hue Index E420 / E520	Flavonols E360	Phenolics E280
A	1	2.2	3598	3.0	6	10.0	14.1	50.1	11.7	54.0	3.39	31.5	9.3	40.8	0.3	12.6	64.0
B	2	2.0	5150	3.5	4	12.0	14.3	56.4	12.0	52.1	3.60	43.6	13.4	57.1	0.3	13.1	59.0
G	3	3.1	2878	4.0	9	10.6	14.9	64.0	14.6	62.2	3.26	42.3	13.9	56.2	0.3	15.4	85.1
K	4	0.8	2370	4.0	6	11.8	14.3	64.9	14.1	58.7	3.67	50.4	17.7	68.1	0.4	21.8	84.1
R	5	1.6	4050	3.7	7	10.0	15.2	50.5	15.7	57.5	3.45	38.1	13.7	51.8	0.4	16.8	81.2
R	6	3.0	5255	3.3	7	9.7	15.9	55.9	13.0	56.6	3.57	31.3	10.2	41.6	0.3	16.2	64.2
K	7	2.4	3135	3.0		14.8	13.6	47.4	12.0	52.8	3.12	33.2	11.4	44.6	0.3	14.0	66.5
O	8	2.0	2638	3.8	7	13.9	15.5	56.1	14.2	57.8	3.61	43.8	15.0	58.9	0.3	20.3	79.5
O	9	1.6	2273	3.5	7	6.4	14.2	45.3	14.3	51.8	3.67	27.8	9.0	36.8	0.3	11.9	65.0
A	10	1.4	4650	3.7	10	10.0	14.4	62.8	14.2	62.7	3.57	53.5	18.4	71.8	0.3	20.1	95.9
A	11	2.0	3433	3.0	6	7.5	13.8	51.0	11.9	52.5	3.83	40.3	13.7	53.9	0.3	17.9	72.9
B	12	1.6	4315	3.7		5.4	14.6	54.1	13.3	53.0	3.54	41.0	13.9	54.9	0.3	18.0	73.9
G	13	1.8	1860	3.8	10	6.5	13.7	55.1	17.4	59.8	4.20	32.4	10.4	42.8	0.3	16.8	74.1
K	14	2.7	4083	3.3	7	11.5	13.8	53.9	8.9	47.4	3.36	33.1	11.1	44.1	0.3	11.5	51.2
R	15	2.6	1693	2.8	5	10.5	13.7	50.1	13.7	48.6	3.87	32.4	10.6	43.0	0.3	14.1	54.0
R	16	3.3	3990	3.8	6	13.0	14.6	59.3	13.0	58.3	3.56	34.7	11.8	46.5	0.3	13.0	64.8
G	17	1.6	2385	4.0	4	2.7	13.7	49.1	18.0	57.8	3.55	28.0	9.7	37.7	0.3	16.1	62.9
G	18	2.2	1930	3.5	7	7.0	13.9	49.4	13.2	53.6	3.16	35.9	12.3	48.1	0.3	14.5	74.0
B	19	0.9	5170	4.0	10	7.3	15.5	60.2	15.1	60.3	3.56	42.4	14.4	56.8	0.3	17.7	86.5
A	20	2.2	6370	3.7	9	18.0	15.8	46.1	10.8	47.8	3.55	39.1	13.2	52.3	0.3	15.0	69.7
B	21	2.4	4412	3.7	7	5.0	14.1	64.3	12.9	62.6	3.71	38.2	13.0	51.2	0.3	12.9	72.7
G	22	2.3	1895	3.5	10	5.0	13.9	47.8	14.1	52.3	3.19	32.9	10.1	43.0	0.3	13.8	76.2
K	23	1.7	3680	4.0	14	10.0	14.3	67.9	15.5	60.1	3.61	38.6	14.2	52.9	0.4	18.5	81.1
R	24	1.8	2830	4.0	9	14.5	14.5	44.0	16.5	52.1	3.50	34.9	11.7	46.6	0.3	18.1	76.6
K	25	1.6	3813	4.0	8	5.8	15.3	58.4	15.0	55.7	3.22	39.6	13.3	52.9	0.3	16.5	72.0

Tab. 5 Chemical analysis of berries taken prior to harvest. Values are averages over 3 samples per vineyard

NE VIC Shiraz Project 04/05 Lab analysis: Myrrhee Consulting

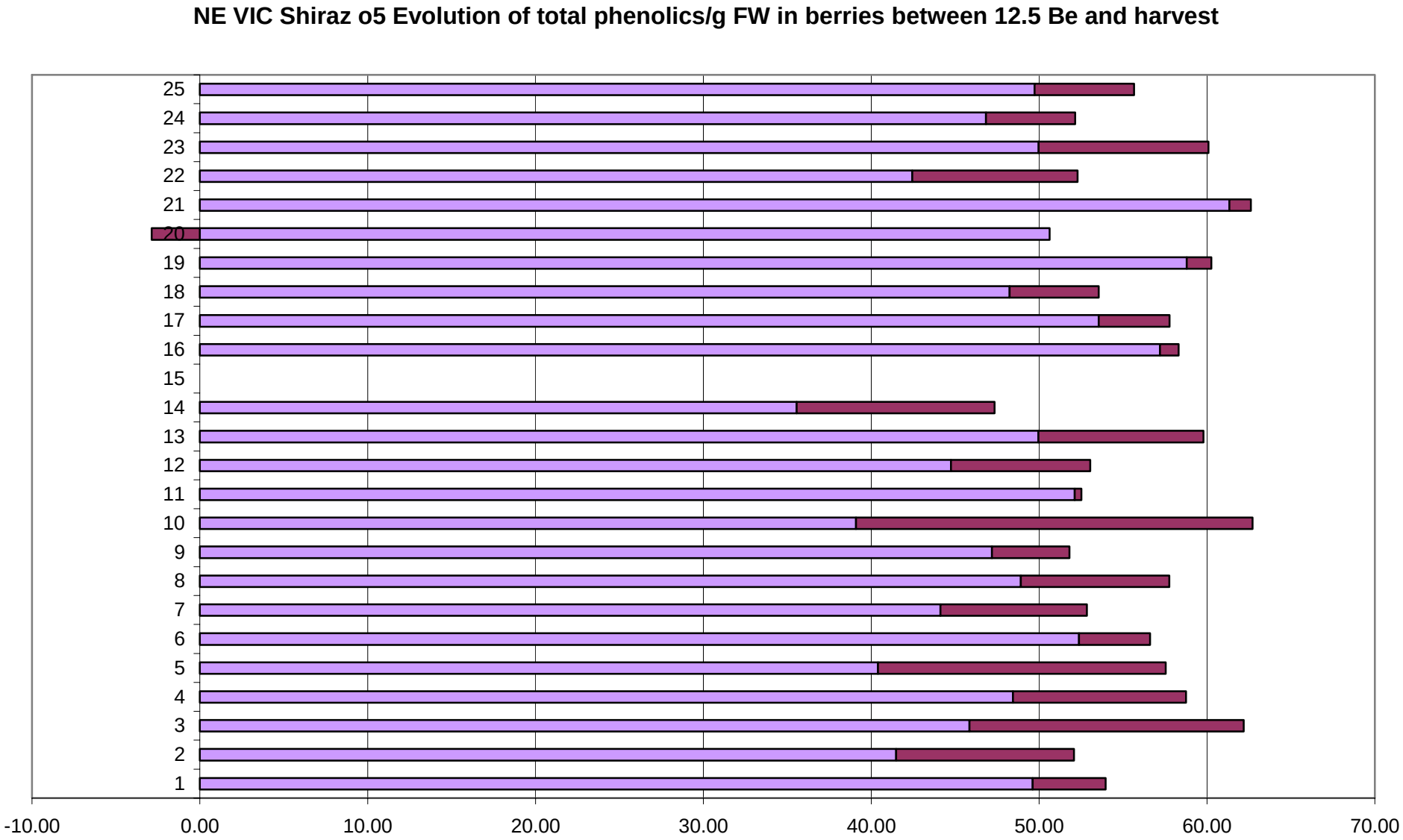
		Baume at harvest	Average Berry Wt (gms)	Average Skin Wt (gms)	% Skin / Berry	Skin extr./g Berry FW Anthocyar	Flavonols	Phenolics	Av Seed Wt (gms)	% Seed / Berry	Seed Phenolics	Skin extr. /g skin Anthoc.	Flav.	Phen.	Av leaf layers harvest
1N	A	14.1	1.4	0.25	17.77	50.1	11.7	54.0	0.07	5.02	33.17	282.1	65.8	304.0	2.2
2	B	14.3	1.5	0.21	14.39	56.4	12.0	52.1	0.06	4.14	32.26	391.9	83.6	361.7	2.0
3	G	14.9	1.2	0.23	18.36	64.0	14.6	62.2	0.08	6.52	27.78	349.2	79.8	338.9	3.1
4	K	14.3	1.4	0.22	16.03	64.9	14.1	58.7	0.06	4.13	18.89	406.5	87.8	367.8	0.8
5	R	15.2	1.3	0.23	17.19	50.5	15.7	57.5	0.07	5.62	35.70	294.5	91.5	335.4	1.6
6	R	15.9	1.5	0.27	18.20	55.9	13.0	56.6	0.09	5.88	46.56	307.2	71.2	311.3	3.0
7	K	13.6	1.6	0.26	16.64	47.4	12.0	52.8	0.07	4.48	44.80	284.8	72.2	317.6	2.4
8	O	15.5	1.2	0.20	17.50	56.1	14.2	57.8	0.07	5.87	19.69	320.3	81.2	329.8	2.0
9	O	14.2	1.3	0.23	18.07	45.3	14.3	51.8	0.08	6.33	22.19	251.2	79.3	287.2	1.6
10	A	14.4	1.7	0.25	14.55	62.8	14.2	62.7	0.07	3.82	22.91	432.1	97.9	431.6	1.4
11	A	13.8	1.6	0.27	16.70	51.0	11.9	52.5	0.07	4.52	52.25	305.8	71.5	314.8	2.0
12	B	14.6	1.7	0.27	16.14	54.1	13.3	53.0	0.07	4.01	32.92	335.4	82.7	328.7	1.6
13	G	13.7	1.4	0.24	18.09	55.1	17.4	59.8	0.07	5.41	32.75	304.0	96.1	330.3	1.8
14	K	13.8	1.7	0.25	14.58	53.9	8.9	47.4	0.06	3.62	29.49	369.7	61.2	324.8	2.7
15	R	13.7	1.3	0.25	18.94	50.1	13.7	48.6	0.07	5.38	18.54	264.7	72.2	256.7	2.6
16	R	14.6	1.5	0.29	18.63	59.3	13.0	58.3	0.07	4.26	29.52	318.5	69.4	313.0	3.3
17N	G	13.7	1.1	0.19	17.73	49.1	18.0	57.8	0.06	6.03	25.30	277.0	101.5	326.2	1.6
18	G	13.9	1.4	0.25	18.11	49.4	13.2	53.6	0.08	5.86	51.05	272.1	72.7	295.4	2.2
19	B	15.5	1.4	0.26	18.61	60.2	15.1	60.3	0.07	5.35	34.67	323.5	81.0	323.7	0.9
20N	A	15.8	1.8	0.32	17.92	46.1	10.8	47.8	0.08	4.45	28.16	258.9	60.7	267.7	2.2
21N	B	14.1	1.5	0.25	17.08	64.3	12.9	62.6	0.07	4.99	31.31	376.2	75.4	366.8	2.4
22	G	13.9	1.4	0.22	15.90	47.8	14.1	52.3	0.05	3.83	54.59	300.9	88.9	329.2	2.3
23	K	14.3	1.3	0.23	17.39	67.9	15.5	60.1	0.06	4.71	24.74	390.4	89.0	345.4	1.7
24	R	14.5	1.2	0.23	19.01	44.0	16.5	52.1	0.06	4.97	23.43	231.9	87.1	274.8	1.8
25	K	15.3	1.6	0.27	17.36	58.4	15.0	55.7	0.06	3.98	24.89	336.6	86.8	320.7	1.6

Tab. 5a Berry trait evolution

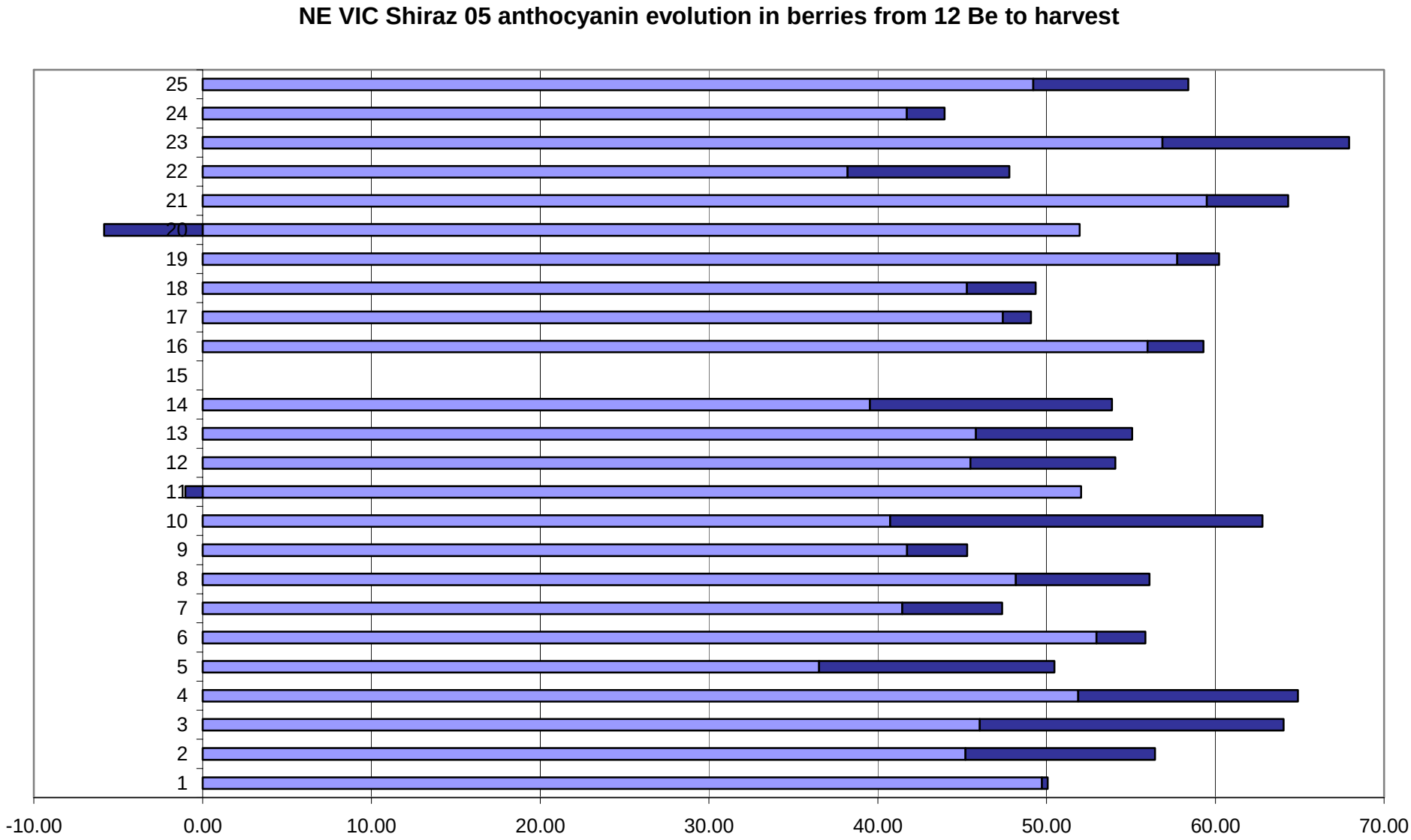
Lab analysis: Myrrhee Consulting

No	Location	12Be berry wt.(gms)	Harvest berry wt.(gms)	Pre-H Baume	Harvest Baume	Pre- H TA	Harvest TA	HA shrivel (%)	12 Be Anthocyanins	Harvest Anthocyanins	12 Be Flavonols	Harvest Flavonols	12 Be Phenolics	Harvest Phenolics
1	A	1.57	1.41	13.3	14.1	4.80	4.73	5	49.73	50.1	13.13	11.7	49.62	54.0
2	B	1.51	1.48	11.9	14.3	9.40	8.00	5	45.20	56.4	8.69	12.0	41.48	52.1
3	G	1.65	1.25	12.0	14.9	6.00	6.56	10	46.05	64.0	9.32	14.6	45.85	62.2
4	K	1.32	1.39	12.3	14.3	8.23	5.56	5	51.88	64.9	13.46	14.1	48.44	58.7
5	R	1.56	1.31	11.5	15.2	6.47	5.06	10	36.52	50.5	12.30	15.7	40.39	57.5
6	R	1.57	1.46	13.8	15.9	5.50	6.56	5	52.95	55.9	13.93	13.0	52.37	56.6
7	K	1.77	1.58	12.2	13.6	5.70	4.03	5	41.46	47.4	11.99	12.0	44.11	52.8
8	O	1.31	1.15	12.6	15.5	5.60	4.45	10	48.18	56.1	11.97	14.2	48.91	57.8
9	O	1.37	1.25	12.5	14.2	6.23	5.93	5	41.74	45.3	13.37	14.3	47.18	51.8
10	A	1.82	1.73	12.0	14.4	9.20	6.10	5	40.73	62.8	10.09	14.2	39.09	62.7
11	A	1.74	1.64	13.0	13.8	6.86	4.93	0	52.04	51.0	11.81	11.9	52.11	52.5
12	B	1.67	1.67	12.7	14.6	6.13	5.46	0	45.50	54.1	10.91	13.3	44.75	53.0
13	G	1.50	1.35	11.8	13.7	5.86	5.13	0	45.83	55.1	13.38	17.4	49.95	59.8
14	K	1.91	1.72	12.2	13.8	10.64	8.00	15	39.54	53.9	7.88	8.9	35.55	47.4
15	R		1.31		13.7		4.56	0						
16	R	1.59	1.54	12.7	14.6	7.40	4.76	5	55.99	59.3	11.69	13.0	57.20	58.3
17	G	1.22	1.07	11.8	13.7	6.23	4.30	10	47.42	49.1	16.10	18.0	53.56	57.8
18	G	1.58	1.37	12.2	13.9	6.13	5.13	5	45.28	49.4	12.60	13.2	48.24	53.6
19	B	1.60	1.40	12.6	15.5	7.23	5.13	10	57.75	60.2	12.75	15.1	58.79	60.3
20	A	1.88	1.76	13.3	15.8	4.93	5.43	0	51.96	46.1	12.00	10.8	50.63	47.8
21	B	1.67	1.48	12.6	14.1	8.20	5.83	0	59.49	64.3	12.02	12.9	61.33	62.6
22	G	1.60	1.40	12.2	13.9	7.03	4.43	0	38.22	47.8	10.30	14.1	42.44	52.3
23	K	1.46	1.32	12.3	14.3	7.70	7.53	5	56.87	67.9	12.60	15.5	49.98	60.1
24	R	1.38	1.22	12.9	14.5	5.26	4.74	10	41.72	44.0	16.54	16.5	46.83	52.1
25	K	1.67	1.58	12.7	15.3	7.20	5.73	15	49.22	58.4	10.00	15.0	49.73	55.7

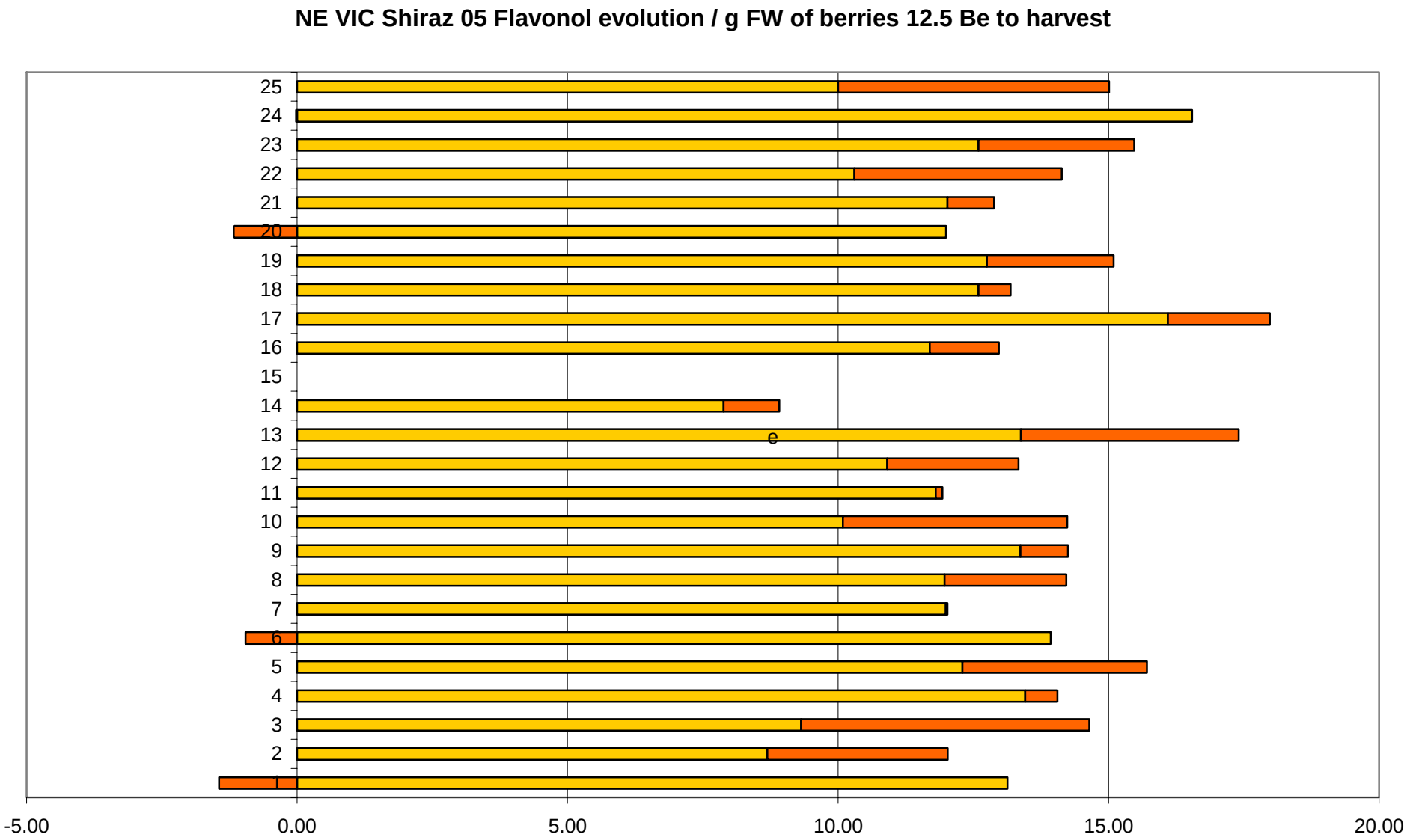
Tab. 5b: Evolution of total phenolics in the berries from approx. 12.5 Bé to harvest



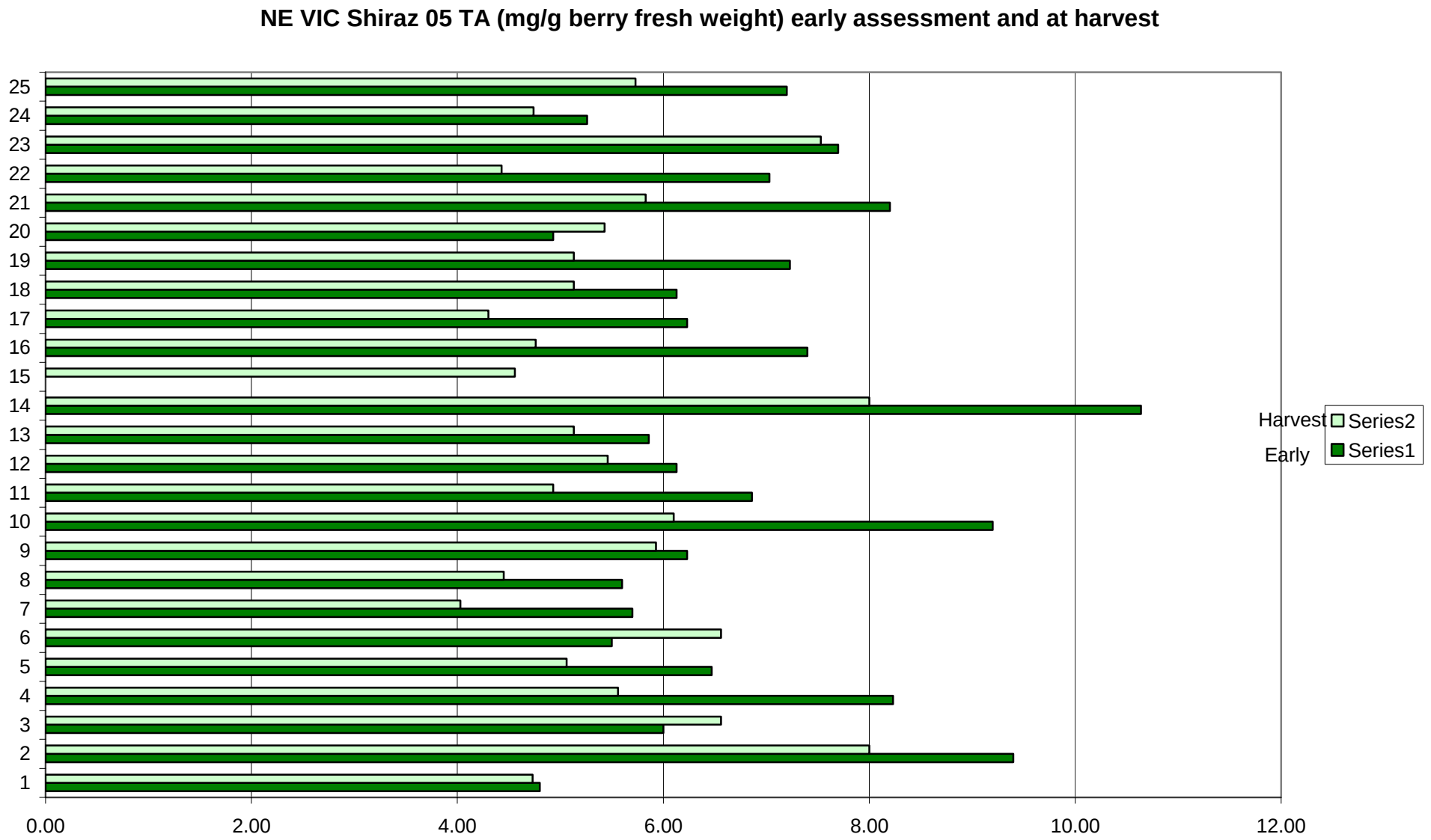
Tab. 5c: Evolution of anthocyanins in the berries from approx. 12.5 Bé to harvest



Tab. 5d: Evolution of flavonols in the berries from approx. 12.5 Bé to harvest



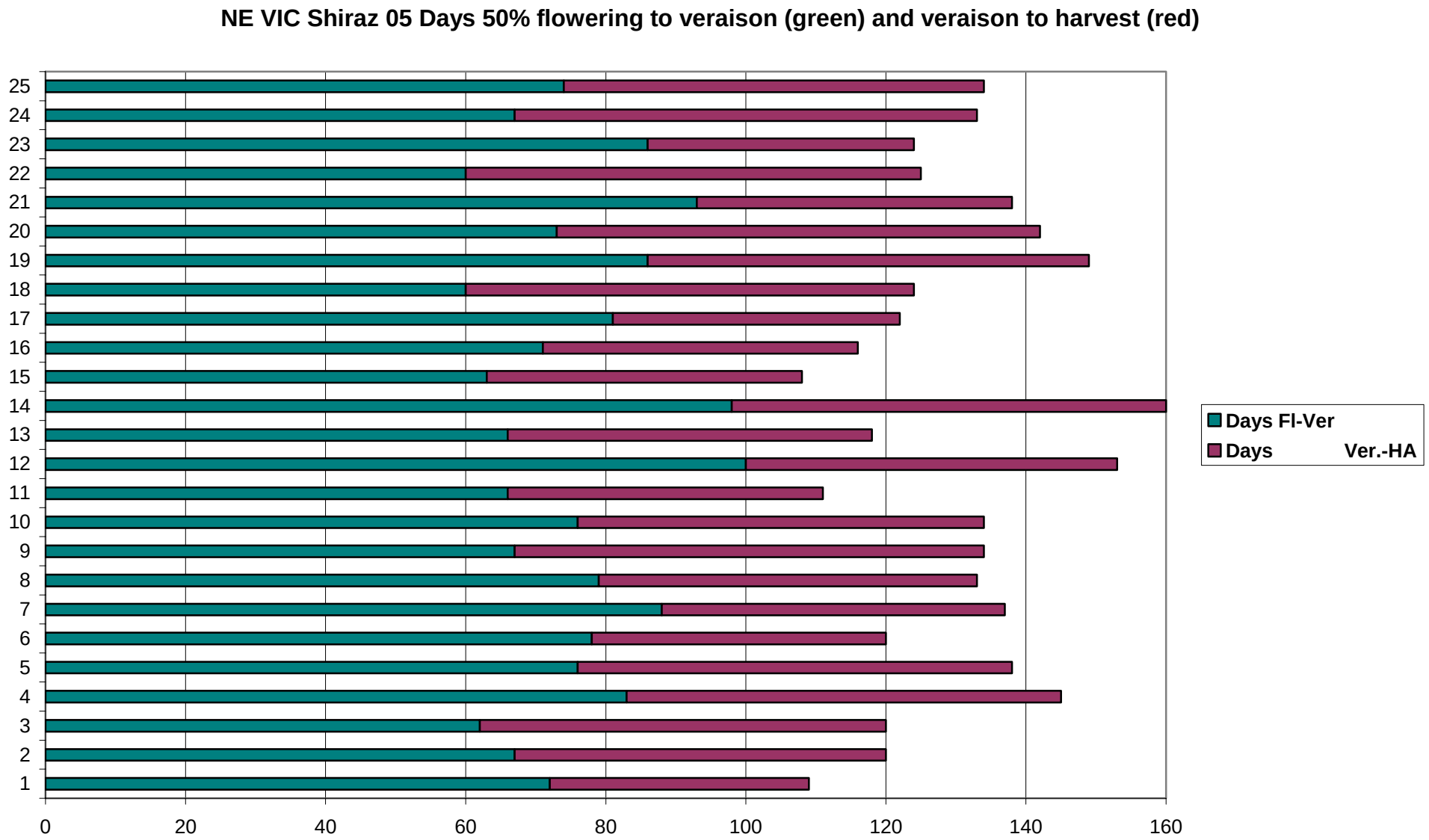
Tab. 5e: Evolution of acidity in berries from approx. 12.5 Bé to harvest



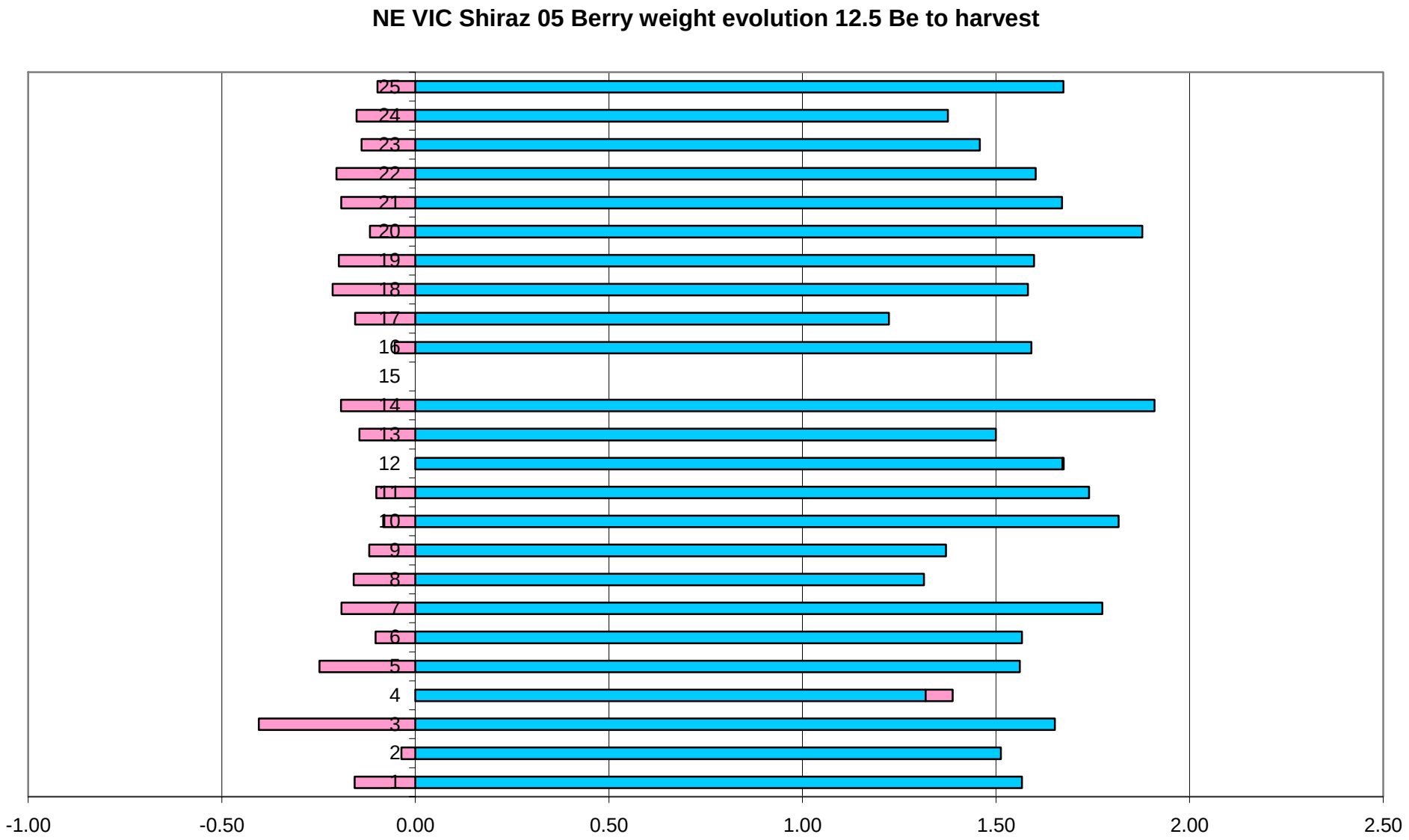
Tab. 6: Phenology of ripening, berry chemical assessments and **Berry Sensory Assessment** results at harvest**.**

			Assessor: Stephen Lowe , Analysis: Myrrhe Consulting											**BSA harv. 6 bunches** 1=unripe, 4=ripe			
	Location	**Av. yield**	**50% Flowering**	**Veraison date**	**Harvest date**	**Days Flow.-HA**	**Berry shrivel (%)**	**Leaf layers harv.**	**Berry wt (g)**	**Harvest Baume**	**TA**	**pH**	**Phenolics / g berry FW**	***Pulp maturity***	***Pulp aroma***	***Skin maturity***	***Seed maturity***
1N	**A**	**10.0**	**25.11.**	**7.2.**	**14.3.**	**109**	0	**2.2**	**1.4**	**14.1**	**4.73**	**4.00**	**54.0**	**3.0**	**3.0**	**3.0**	**2.7**
2	**B**	**12.0**	**10.11.**	**17.2.**	**10.4.**	**120**	**5**	**2.0**	**1.5**	**14.3**	**8.00**	**3.45**	**52.1**	**3.7**	**3.0**	**3.5**	**3.0**
3	**G**	**10.6**	**23.11.**	**25.1.**	**23.3.**	**120**	**5**	**3.1**	**1.2**	**14.9**	**6.56**	**3.55**	**62.2**	**3.8**	**3.5**	**4.0**	**3.3**
4	**K**	**11.8**	**19.11.**	**18.2.**	**13.4.**	**145**	0	**0.8**	**1.4**	**14.3**	**5.56**	**3.34**	**58.7**	**3.5**	**3.3**	**4.0**	**3.0**
5	**R**	**10.0**	**23.11.**	**30.1.**	**10.4.**	**138**	**10**	**1.6**	**1.3**	**15.2**	**5.06**	**3.79**	**57.5**	**3.2**	**3.0**	**3.7**	**3.0**
6	**R**	**9.7**	**23.11.**	**28.1.**	**23.3.**	**120**	**10**	**3.0**	**1.5**	**15.9**	**6.56**	**4.05**	**56.6**	**3.0**	**3.2**	**3.3**	**3.0**
7	**K**	**14.8**	**10.11.**	**7.2.**	**27.3.**	**137**	**5**	**2.4**	**1.6**	**13.6**	**4.03**	**3.86**	**52.8**	**3.0**	**2.5**	**3.0**	**2.7**
8	**O**	**13.9**	**20.11.**	**7.2.**	**2.4.**	**133**	**10**	**2.0**	**1.2**	**15.5**	**4.45**	**3.67**	**57.8**	**3.3**	**3.3**	**3.8**	**3.3**
9	**O**	**6.4**	**20.11.**	**27.1.**	**4.4.**	**135**	**15**	**1.6**	**1.3**	**14.2**	**5.93**	**3.53**	**51.8**	**3.3**	**3.0**	**3.5**	**3.3**
10	**A**	**10.0**	**6.12.**	**17.2.**	**19.4.**	**134**	0	**1.4**	**1.7**	**14.4**	**6.10**	**3.72**	**62.7**	**3.5**	**3.0**	**3.7**	**3.0**
11	**A**	**7.5**	**24.11.**	**27.1.**	**15.3.**	**111**	0	**2.0**	**1.6**	**13.8**	**4.93**	**3.66**	**52.5**	**3.0**	**2.5**	**3.0**	**2.3**
12	**B**	**5.4**	**8.11.**	**17.2.**	**10.4.**	**153**	**5**	**1.6**	**1.7**	**14.6**	**5.46**	**3.68**	**53.0**	**3.0**	**3.0**	**3.7**	**3.0**
13	**G**	**6.5**	**20.11.**	**24.1.**	**18.3.**	**118**	**10**	**1.8**	**1.4**	**13.7**	**5.13**	**3.83**	**59.8**	**3.3**	**3.3**	**3.8**	**3.0**
14	**K**	**11.5**	**4.11.**	**18.2.**	**13.4.**	**160**	0	**2.7**	**1.7**	**13.8**	**8.00**	**3.49**	**47.4**	**3.0**	**3.0**	**3.3**	**2.3**
15	**R**	**10.5**	**23.11.**	**25.1.**	**11.3.**	**108**	0	**2.6**	**1.3**	**13.7**	**4.56**	**3.82**	**48.6**	**3.0**	**2.7**	**2.8**	**2.7**
16	**R**	**13.0**	**30.11.**	**8.2.**	**25.3.**	**116**	**5**	**3.3**	**1.5**	**14.6**	**4.76**	**3.64**	**58.3**	**3.7**	**3.3**	**3.8**	**3.2**
17N	**G**	**2.7**	**17.11.**	**7.2.**	**19.3.**	**122**	**5**	**1.6**	**1.1**	**13.7**	**4.30**	**3.62**	**57.8**	**3.8**	**3.8**	**4.0**	**3.7**
18	**G**	**7.0**	**26.11.**	**25.1.**	**30.3.**	**124**	**10**	**2.2**	**1.4**	**13.9**	**5.13**	**3.42**	**53.6**	**3.0**	**2.8**	**3.5**	**3.0**
19	**B**	**7.3**	**7.11.**	**8.2.**	**5.4.**	**149**	**5**	**0.9**	**1.4**	**15.5**	**5.13**	**3.45**	**60.3**	**4.0**	**3.7**	**4.0**	**3.5**
20N	**A**	**18.0**	**15.11.**	**27.1.**	**6.4.**	**142**	**5**	**2.2**	**1.8**	**15.8**	**5.43**	**3.76**	**47.8**	**3.5**	**3.0**	**3.7**	**3.0**
21N	**B**	**5.0**	**7.11.**	**8.2.**	**25.3.**	**138**	**10**	**2.4**	**1.5**	**14.1**	**5.83**	**3.87**	**62.6**	**3.5**	**3.2**	**3.7**	**3.2**
22	**G**	**5.0**	**25.11.**	**24.1.**	**30.3.**	**125**	**5**	**2.3**	**1.4**	**13.9**	**4.43**	**3.79**	**52.3**	**3.0**	**3.0**	**3.5**	**3.3**
23	**K**	**10.0**	**15.11.**	**11.2.**	**19.3.**	**124**	0	**1.7**	**1.3**	**14.3**	**7.53**	**3.73**	**60.1**	**3.8**	**3.5**	**4.0**	**3.0**
24	**R**	**14.5**	**23.11.**	**28.1.**	**5.4.**	**133**	**5**	**1.8**	**1.2**	**14.5**	**4.74**	**3.63**	**52.1**	**3.5**	**3.5**	**4.0**	**3.2**
25	**K**	**5.8**	**28.11.**	**11.2.**	**11.4.**	**134**	**15**	**1.6**	**1.6**	**15.3**	**5.63**	**3.52**	**55.7**	**3.5**	**3.5**	**4.0**	**3.1**

Tab. 6a: Phenology of ripening in 25 vineyards of NE Victoria.



Tab. 6b: Evolution of berry weights

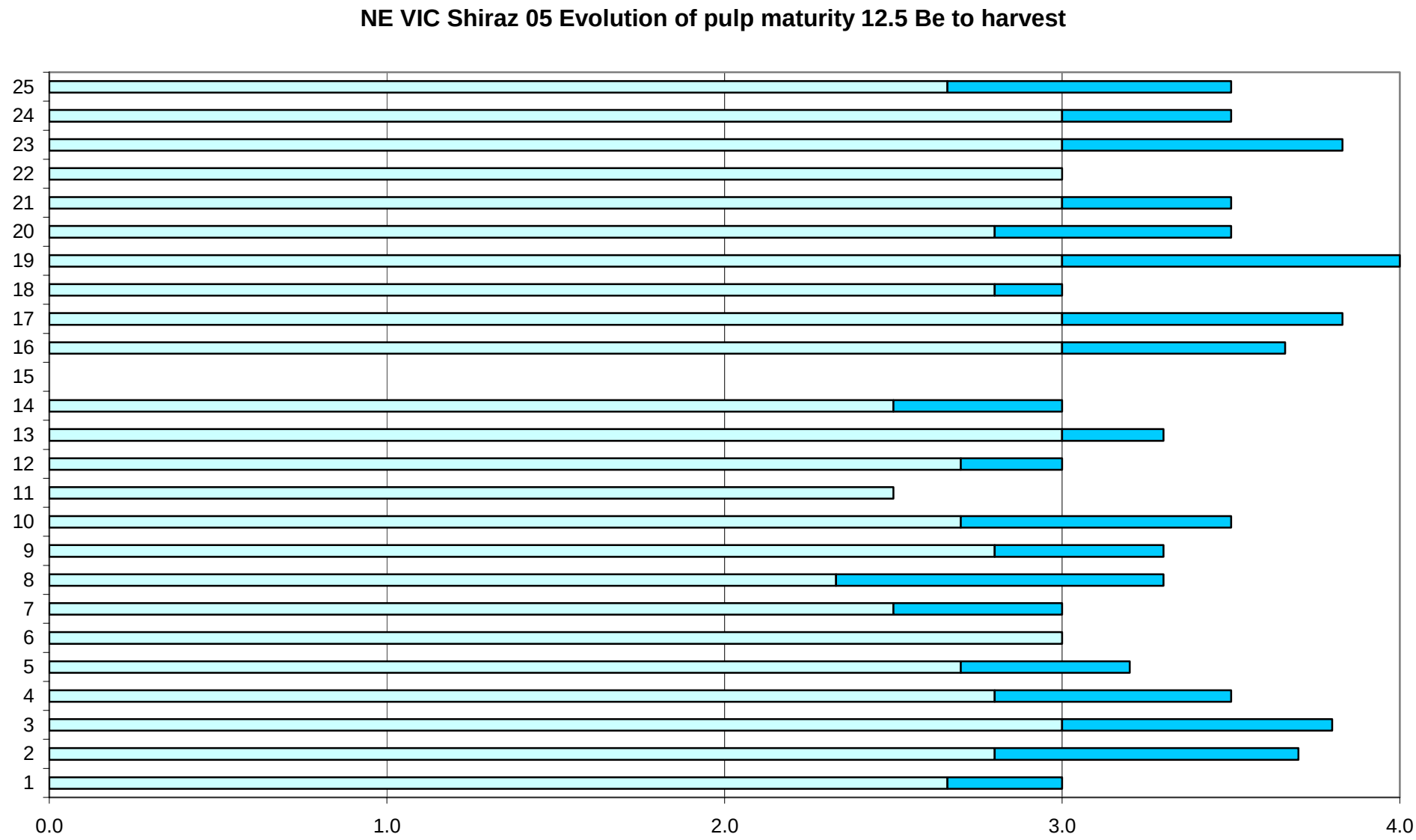


Tab. 7: Evolution of Baumé and BSA scores

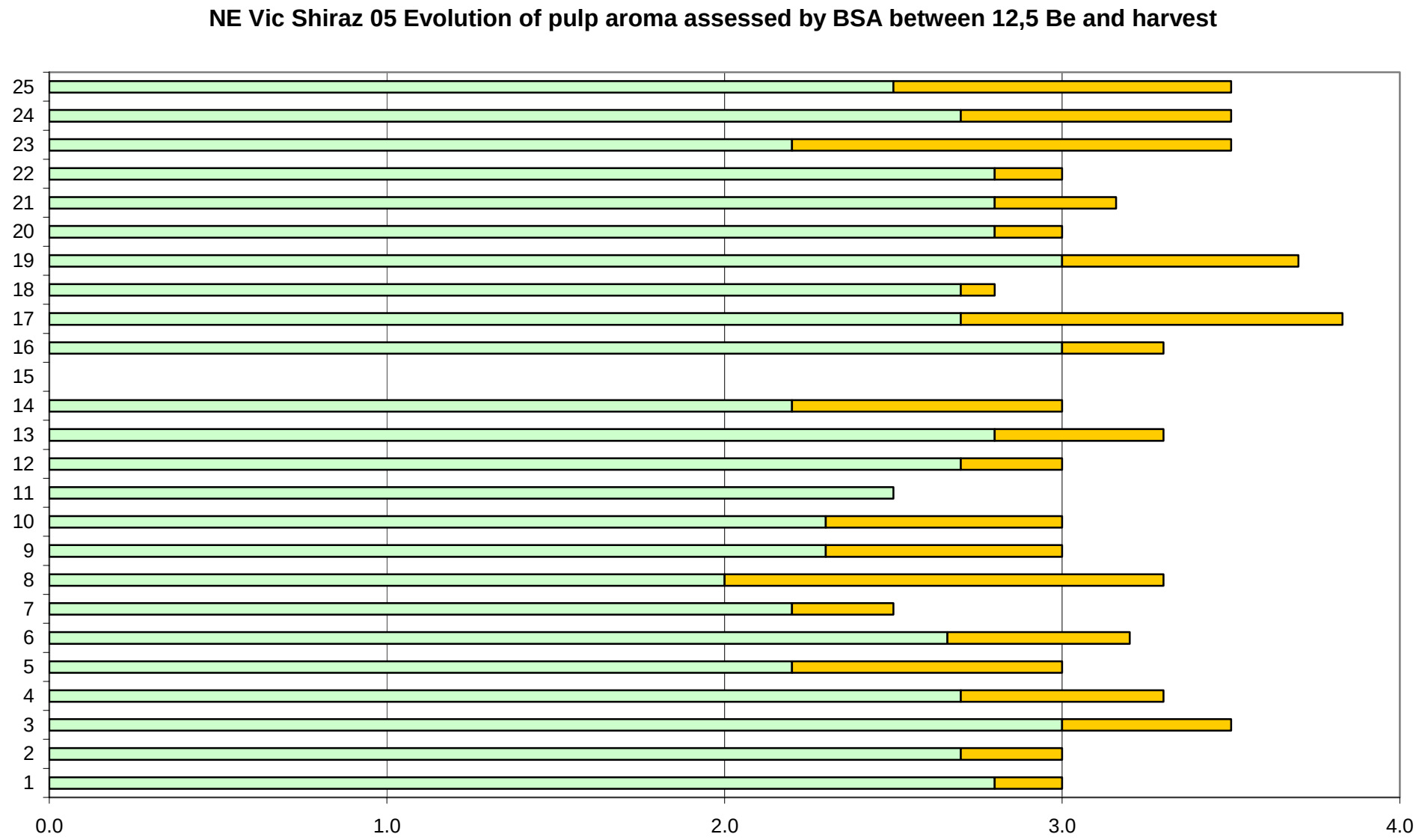
Lab analysis: Myrrhee Consulting **Assessor: Stephen Lowe** 1=unripe, 4=ripe

No	Location	Days Flow.-HA	Pre-H Baume	Harvest Baume	Pre- H TA	Harvest TA	HA shrivel (%)	*Pre-H Pulp maturity*	*HA Pulp maturity*	*Pre-H Pulp aroma*	*HA Pulp aroma*	*Pre-H Skin maturity*	*HA Skin maturity*	*Pre-H Seed maturity*	*HA Seed maturity*
1	A	135	13.3	14.1	4.80	4.73	5	2.7	3.0	2.8	3.0	3.0	3.0	2.7	2.7
2	B	120	11.9	14.3	9.40	8.00	5	2.8	3.7	2.7	3.0	2.7	3.5	2.7	3.0
3	G	120	12.0	14.9	6.00	6.56	10	3.0	3.8	3.0	3.5	3.0	4.0	3.0	3.3
4	K	145	12.3	14.3	8.23	5.56	5	2.8	3.5	2.7	3.3	3.0	4.0	2.0	3.0
5	R	138	11.5	15.2	6.47	5.06	10	2.7	3.2	2.2	3.0	2.2	3.7	2.2	3.0
6	R	120	13.8	15.9	5.50	6.56	5	3.0	3.0	2.7	3.2	3.0	3.3	3.0	3.0
7	K	137	12.2	13.6	5.70	4.03	5	2.5	3.0	2.2	2.5	2.0	3.0	2.0	2.7
8	O	133	12.6	15.5	5.60	4.45	10	2.3	3.3	2.0	3.3	2.0	3.8	2.0	3.3
9	O	135	12.5	14.2	6.23	5.93	5	2.8	3.3	2.3	3.0	3.0	3.5	3.0	3.3
10	A	134	12.0	14.4	9.20	6.10	5	2.7	3.5	2.3	3.0	2.0	3.7	2.0	3.0
11	A	111	13.0	13.8	6.86	4.93	0	2.5	2.3	2.5	2.5	3.0	3.0	2.0	2.3
12	B	153	12.7	14.6	6.13	5.46	0	2.7	3.0	2.7	3.0	2.5	3.7	2.0	3.0
13	G	118	11.8	13.7	5.86	5.13	0	3.0	3.3	2.8	3.3	3.0	3.8	3.0	3.0
14	K	160	12.2	13.8	10.64	8.00	15	2.5	3.0	2.2	3.0	2.0	3.3	2.0	2.3
15	R	108		13.7		4.56	0		3.0		2.7		2.8		2.7
16	R	116	12.7	14.6	7.40	4.76	5	3.0	3.7	3.0	3.3	3.0	3.8	2.3	3.2
17	G	122	11.8	13.7	6.23	4.30	10	3.0	3.8	2.7	3.8	3.0	4.0	2.8	3.7
18	G	124	12.2	13.9	6.13	5.13	5	2.8	3.0	2.7	2.8	2.7	3.5	2.3	3.0
19	B	149	12.6	15.5	7.23	5.13	10	3.0	4.0	3.0	3.7	2.8	4.0	2.5	3.5
20	A	142	13.3	15.8	4.93	5.43	0	2.8	3.5	2.8	3.0	3.0	3.7	2.2	3.0
21	B	138	12.6	14.1	8.20	5.83	0	3.0	3.5	2.8	3.2	3.0	3.7	2.5	3.2
22	G	125	12.2	13.9	7.03	4.43	0	3.0	3.0	2.8	3.0	3.0	3.5	3.2	3.3
23	K	124	12.3	14.3	7.70	7.53	5	3.0	3.8	2.2	3.5	3.0	4.0	2.2	3.0
24	R	133	12.9	14.5	5.26	4.74	10	3.0	3.5	2.7	3.5	2.8	4.0	2.8	3.2
25	K	134	12.7	15.3	7.20	5.73	15	2.7	3.5	2.5	3.5	3.0	4.0	2.0	3.1

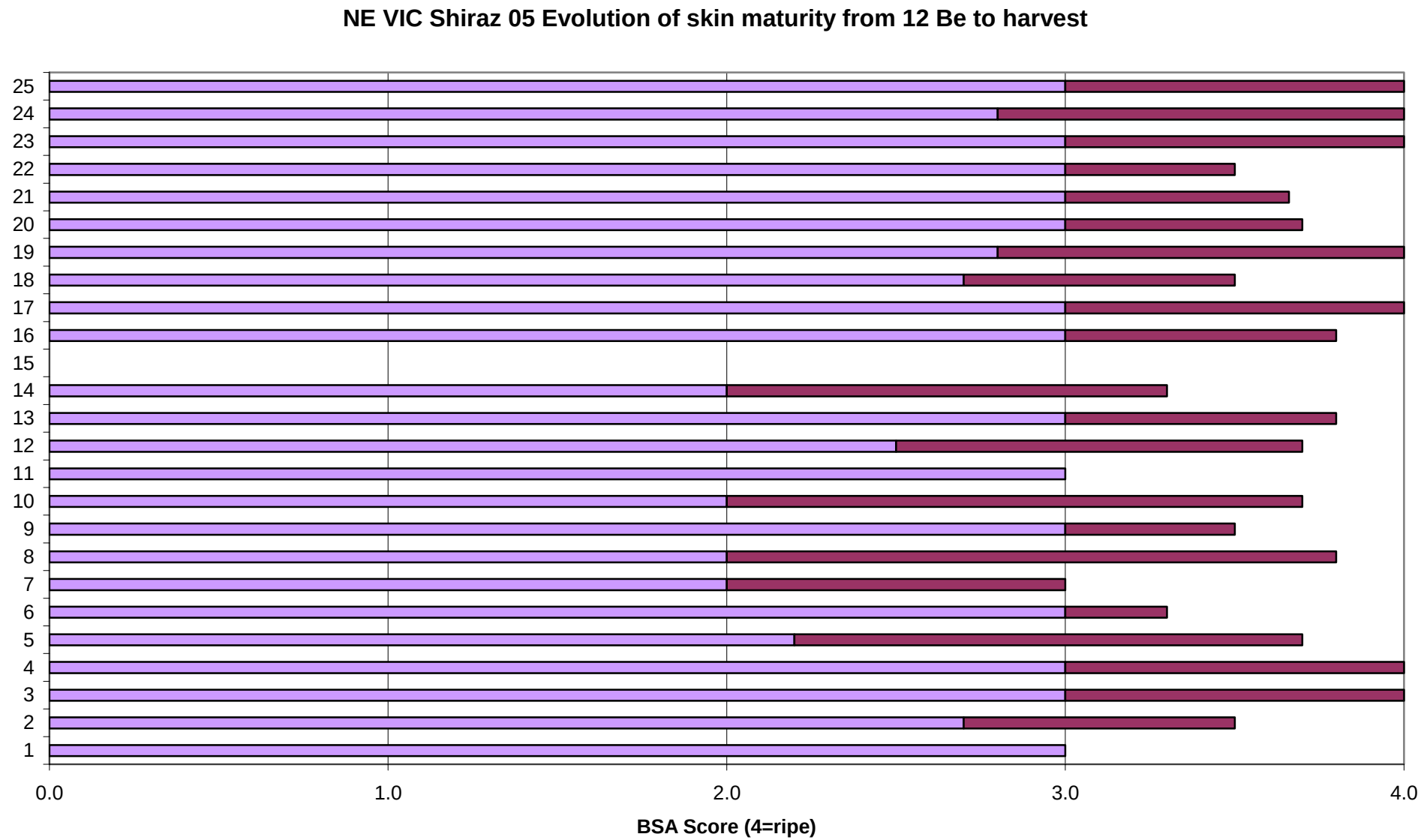
Tab. 7a: Evolution of pulp maturity assessed by BSA



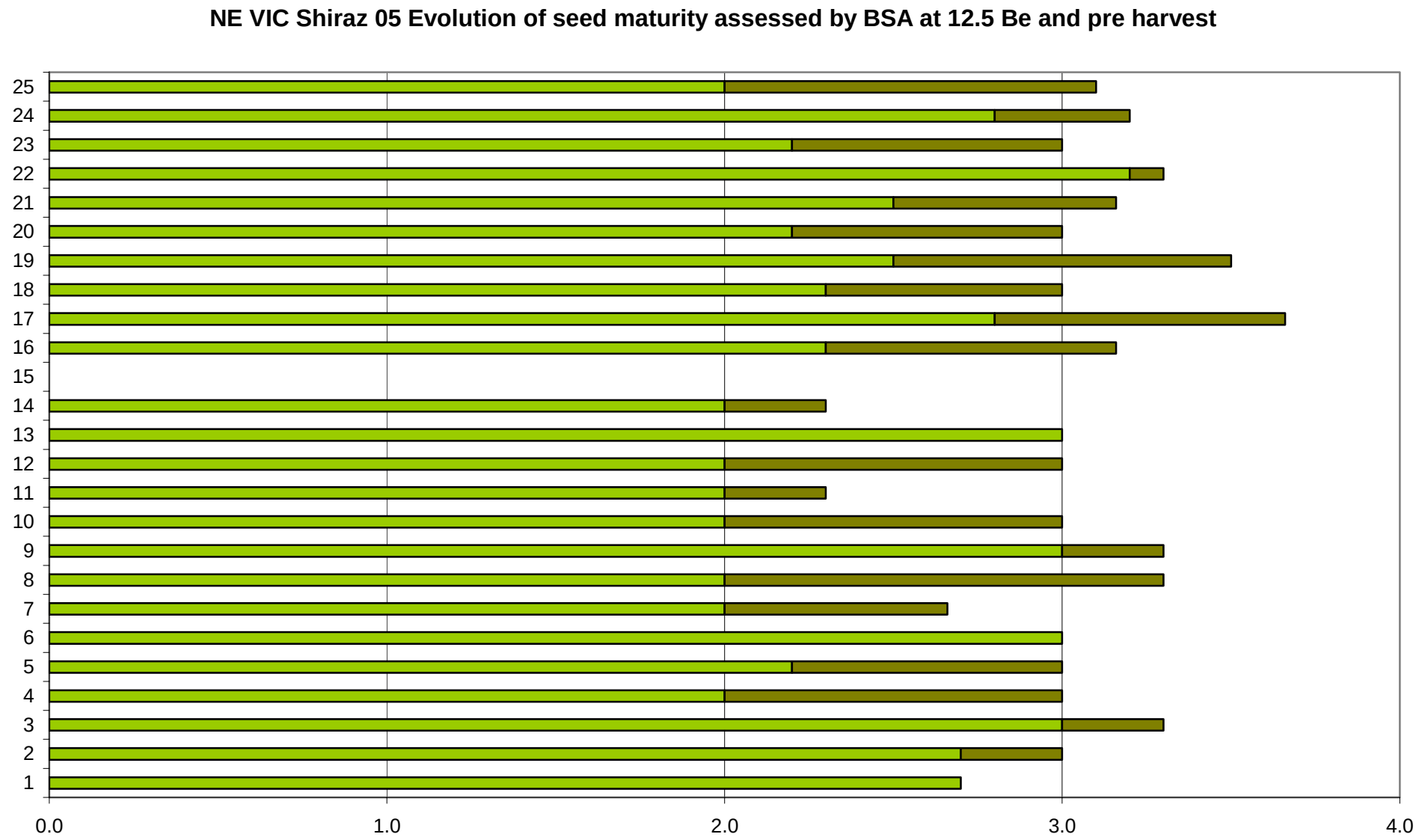
Tab. 7b: Evolution of pulp aroma



Tab. 7c: Evolution of skin maturity



Tab. 7d: Evolution of seed maturity



Tab. 8: Bunch climate and related assessments.

Shiraz vineyards: NE Victoria. Bunch temperatures via Tinytag Dataloggers, Data capture: The Centre, Wangaratta

Site	Loc.	Be	Days Ver.-HA	Be per day	Days of first temp. curve	Lowest T Ver-Pre H.	Highest T Ver-Pre H.	Av. Temp. Ver.-Pre Harv.	Temp at 7am on 25.2.	Temp at 7am on 6.3.	Time of 15°C on 6.3.	Row orientation	leaf layers over bu. front	front =	leaf layers over bu. back	Days of last temp. curve	Min °C before harv.	Max °C before harv.	Av max temp ver-ha	Av. Temp before harv.	Ver-Ha bunch heat load	Heat load /day
1N	A	14.1	34	0.4	29	6.2	39.4	20.6	16.8	8.8	9.00	nw/se	2.4	w	2.0	5	8.0	39.4	39.4	20.2	17373	511
2	B	14.3	50	0.3	33	2.1	41.0	19.3	16.8	8.3	10.00	e/w	1.7	n	2.4	17	3.8	37.9	39.5	17.3	23133	463
3	G	14.9	56	0.3	34	4.9	47.2	20.9	25.4	6.2	9.00	nw/se	3.5	w	2.7	22	3.4	41.0	44.1	19.8	27984	500
4	K	14.3	59	0.2	35	3.9	38.5	19.5	23.4	6.4	10.00	ne/sw	0.7	e	0.9	24	3.9	34.3	36.4	17.1	26968	457
5	R	15.2	60	0.3	29	1.8	48.5	19.6	14.8	10.1	8.00	ne/sw	1.6	e	1.7	31	0.9	51.2	49.9	19.3	28462	474
6	R	15.9	40	0.4	30	7.0	43.1	19.9	18.3	5.9	9.30	nw/se	2.6	s	3.3	10	4.1	44.2	43.7	19.1	19298	482
7	K	13.6	46	0.3	28	5.4	47.2	20.7	17.0	9.1	9.00	n/s	2.3	e	2.6	18	5.1	45.4	46.3	20.2	23234	505
8	O	15.5	52	0.3	29	3.4	39.4	20.2	19.0	7.5	9.00	n/s	1.5	w	2.4	23	3.6	43.1	41.3	19.0	24720	475
9	O	14.2	66	0.2	31	7.2	50.5	22.3	31.8	11.5	9.00	n/s	1.1	w	2.2	35	2.8	45.4	48.0	20.0	33871	513
10	A	14.4	56	0.3	28	1.0	47.2	19.1	24.4	4.6	9.30	ne/sw	0.4	e	2.5	28	0.8	41.5	44.4	15.9	23835	426
11	A	13.8	42	0.3	34	7.2	45.4	21.1	18.3	7.5	8.00	n/s	1.4	e	2.6	8	4.1	38.9	42.2	18.9	21614	515
12	B	14.6	51	0.3	33	1.6	49.1	22.2	27.2	8.5	9.00	n/s	1.5	e	1.7	18	2.8	43.7	46.4	18.0	24199	474
13	G	13.7	50	0.3	35	6.2	47.2	21.0	19.9	8.3	9.30	nw/se	2.0	e	1.6	15	4.6	37.0	42.1	20.2	25365	507
14	K	13.8	59	0.2	34	3.4	36.1	19.4	22.1	6.4	11.00	n/s	2.3	e	3.1	25	5.7	39.4	37.8	16.6	26502	449
15	R	13.7	45	0.3	34	7.5	43.7	21.5	22.2	14.3	7.30	e/w	2.4	s	2.8	11	5.0	41.0	42.4	16.0	22254	495
16	R	14.6	41	0.4	30	3.4	37.5	21.8	19.0	14.0	9.00	ne/sw	3.0	e	3.6	11	4.6	39.4	38.5	20.2	19862	484
17N	G	13.7	38	0.4	29	3.4	39.4	20.2	19.0	7.5	9.00	nw/se	1.5	e	1.8	9	8.5	41.5	25.0	22.3	19338	509
18	G	13.9	62	0.2	35	7.5	42.6	21.8	23.0	10.1	8.00	n/s	1.9	e	2.5	27	6.4	39.4	41.0	20.1	31714	512
19	B	15.5	61	0.3	61	2.8	38.9	18.4	17.1	9.3	10.00	n/s	0.7	e	1.1				38.9		27316	448
20N	A	15.8	37	0.4	na							ne/sw	2.3	w	2.1							
21N	B	14.1	42	0.3	30	3.4	36.1	19.1	16.8	10.4	10.00	e/w	2.9	n	2.0	12	6.2	38.0	37.1	20.2	19951	475
22	G	13.9	62	0.2	35	5.1	45.4	22.8	18.3	5.9	8.30	ne/sw	2.1	n	2.5	27	1.8	41.0	43.2	18.5	30387	490
23	K	14.3	34	0.4	24	3.9	46.0	19.9	18.9	8.8	8.30	e/w	1.7	n	1.8	10	5.4	45.4	45.7	20.3	17172	505
24	R	14.5	65	0.2	30	7.7	43.7	20.8	18.3	14.5	7.00	n/s	1.8	e	1.9	35	1.6	39.9	41.8	19.2	31506	485
25	K	15.3	58	0.3	28	4.6	35.6	19.9	20.5	7.2	8.30	n/s	1.7	w	1.5	30	4.4	36.6	36.1	18.5	27220	469
													pre harves		pre harve							

Table 9: Vineyard scoresheet and Vine balance calculations. Values are averages from 20 shoots.

Shiraz Vineyards NE Vic 04/05 Scoresheets: GrapeLinks, Assessor: Stephen Lowe.														VERAISON			HARVEST				
No.	av. shoot length	Trimmed	no. of leaves/ shoot sized 100 cm^2	no. of leaves/ shoot sized 150 cm^2	no. of leaves/ shoot sized 200 cm^2	**Active leaf area cm2**	No act. Leaves	leaf no. per shoot	**young/ active leaves**	av. bunch number per shoot	No. of actively growing tips per shoot	% of canes lignified	leaf layers over bunches front	no of leaf layers over bunches back	leaf condition mature leaves	condit. four oldest leaves	condit. younger leaves	leaf layers over bu. front	front =	leaf layers over bu. back	Av Bunch weight (gm)	**Vine balance**
1A	3.8	1	20.0	5.3	4.1	3598	29.3	42.5	0.69	1.8	0.7	4.4	2.3	2.6	4.0	3.4	4.0	2.4	w	2.0	180	11.10
2B	3.8	0	33.6	4.4	5.7	5150	43.7	59.5	0.73	2.0	1.1	2.5	5.1	4.0	4.0	2.1	3.3	1.7	n	2.4	145	18.21
3G	3.1	1	12.7	5.1	4.3	2878	22.0	35.7	0.62	2.0	0.5	3.5	2.0	5.5	4.0	3.3	4.0	3.5	w	2.7	155	9.52
4K	3.8	1	11.4	3.7	3.4	2370	18.5	29.5	0.63	1.9	0.0	3.7	2.4	3.0	2.2	1.6	1.6	0.7	e	0.9	200	6.24
5R	4.1	1	19.5	5.3	6.6	4050	31.3	45.9	0.68	1.9	0.2	3.6	2.9	2.4	3.6	1.8	3.3	1.6	e	1.7	155	13.75
6R	3.9	1	26.7	9.9	5.5	5255	42.1	53.6	0.79	1.9	0.7	3.4	1.7	4.2	4.0	2.9	3.1	2.6	s	3.3	139	19.90
K7	4.0	1	14.0	5.8	4.4	3135	24.1	33.1	0.73	1.6	0.0	3.5	3.4	2.3	3.1	2.5	3.6	2.3	e	2.6	140	14.45
O8	3.6	1	11.0	4.7	4.2	2638	19.9	30.3	0.66	1.9	0.1	4.0	2.8	2.4	3.1	2.6	4.0	1.5	w	2.4	122	11.38
O9	3.4	0	12.5	4.0	2.2	2273	18.6	36.7	0.51	2.0	0.0	3.9	1.5	4.0	4.0	2.0	3.6	1.1	w	2.2	100	11.36
A10	3.9	1	25.1	4.5	7.4	4650	36.9	47.2	0.78	1.8	0.7	4.1	1.4	3.1	3.7	2.3	3.5	0.4	e	2.5	240	10.76
A11	4.3	1	10.8	4.7	8.3	3433	23.7	37.6	0.63	1.8	0.4	2.8	1.0	3.1	3.9	3.0	3.8	1.4	e	2.6	150	13.08
B12	4.0	1	22.6	4.1	7.2	4315	33.9	47.0	0.72	2.2	0.0	4.3	1.7	2.2	3.7	2.1	3.4	1.5	e	1.7	200	10.03
G13	3.9	1	7.2	3.9	2.8	1860	13.9	36.0	0.38	1.8	0.2	2.5	1.9	3.8	3.6	2.8	3.9	2.0	e	1.6	140	7.38
K14	3.8	1	19.1	4.6	7.5	4083	31.1	40.8	0.76	1.7	0.7	4.4	4.0	3.8	4.0	3.0	3.3	2.3	e	3.1	186	12.91
R15	3.5	1	5.6	3.4	3.2	1693	12.1	28.1	0.43	1.7	0.4	2.7	2.0	4.7	3.4	2.4	3.5	2.4	s	2.8	120	8.30
R16	3.8	1	18.6	5.9	6.3	3990	30.7	43.5	0.71	1.7	0.1	3.7	3.7	4.2	4.0	2.9	3.8	3.0	e	3.6	117	20.06
G17	3.5	0	11.6	3.9	3.2	2385	18.7	27.8	0.67	2.2	0.0	3.3	1.9	2.1	3.6	2.1	3.5	1.5	e	1.8	100	11.09
G18	3.7	0	7.1	3.7	3.4	1930	14.1	35.8	0.39	1.6	0.5	3.4	1.1	4.5	4.0	3.2	3.9	1.9	e	2.5	155	8.03
B19	3.3	1	30.5	7.1	5.3	5170	42.9	55.5	0.77	2.0	0.7	3.4	3.2	3.4	4.0	1.6	3.1	0.7	e	1.1	202	13.13
A20	4.5	1	27.9	10.2	10.3	6370	48.4	61.2	0.79	2.2	2.2	1.8	2.1	5.0	3.9	2.7	3.9	2.3	w	2.1	300	9.88
B21	4.0	1	22.3	6.3	6.2	4412	34.8	45.1	0.77	1.8	0.0	3.8	4.0	3.4	3.3	2.9	4.0	2.9	n	2.0	138	18.27
G22	3.2	1	10.8	3.9	1.2	1895	15.9	39.4	0.40	1.8	0.2	2.9	1.9	4.8	4.0	2.8	3.9	2.1	n	2.5	130	8.10
K23	3.8	1	18.1	5.1	5.6	3680	28.7	37.4	0.77	1.7	0.1	3.7	3.4	2.7	4.0	3.4	4.0	1.7	n	1.8	140	15.93
R24	3.4	0	15.6	6.3	1.7	2830	23.5	31.7	0.74	1.7	0.5	2.5	1.0	3.1	3.8	2.7	3.9	1.8	e	1.9	105	16.33
K25	3.7	1	18.7	4.1	6.7	3813	29.4	40.0	0.74	1.8	0.1	4.4	3.6	1.8	3.5	2.0	3.3	1.7	w	1.5	190	11.47
Explanations	1=<40 cm 2=40-80 3=-120 4=>120 5=>160	1=y 0=no	use template diam. 11.3cm	use template diam. 13.8cm	use template diam. 16cm	calculation			ratio	after bunch removal if done	average for the vine	1=<20% 2=21-40% 3=41-60% 4=61-80% 5=81-100	.	Back faces what direction?	5=green 4=pale green 3 =yellowing 2=yell/brown 1 = absent						from fruit assessment	leaf area/g fruit wt