Terroir and vine water relation effects on grape ripening and wine quality of Syrah/R99

Influence du terroir et de l'état hydrique de la vigne sur la maturité des raisins et la qualité des vins de Syrah/R99

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Abstract: A Syrah/R99 vineyard in the Stellenbosch area was used. The vineyard is vertically trained and spaced 2.75 x 1.5 m in north-south orientated rows on terroir with Glenrosa soil and west-facing slope. Irrigation (to 100% field water capacity) treatments were applied at different development stages [all stages (including berry set stage); pea size; véraison; post-véraison]. Combined effects of water status and ripeness level were investigated. Preliminary results are presented. Irrigated and non-irrigated vines differed in terms of soil water status, particularly during ripening. Vine water status during late ripening stages varied according to timing of water supply. Secondary leaves seemed most sensitive to water stress, but essential to buffer extreme terroir conditions. Vines displayed independence of soil water during late ripening. Irrigation favoured berry mass stability. Sucrose flow to berries was restricted at the last ripeness level, indicated by increased concentrations in bunch rachis. This may serve as tool to determine a window for harvesting. The window from ripe to over-ripe grapes was reduced when vines were exposed to lower soil water levels. Similar anthocyanin patterns found with skin and whole berry extraction and reduced skin sucrose contents indicated disintegration, oxidation and respiration during the last ripeness level in skins. Treatments being deficit-managed for a longer period showed earlier maximum wine quality (ripeness level 1). Vines irrigated at all development stages and those irrigated at pea size stage, showed later maximum wine quality (ripeness level 2). Wine quality of all treatments was reduced at the third ripeness level. Pre- and post-véraison cultivating conditions seem to have a determining effect on grape ripening. Preliminary results showed that the ripening period may be extended and berry condition maintained for longer by improved vine water status on a specific terroir.

Key words: terroir, water relations, canopy, grape ripening, wine quality

Introduction

It is generally accepted that selection of terroir and technological intervention by means of long and short term practice for the cultivation of a particular cultivar is determining in the expression of terroir potential in wine (Carey and Bonnardot, 2004; Vadour and Shaw, 2005, and references therein; Novello, 2005). Initial choices and technological interventions during the lifespan of the vine are dictated and steered by requirements in terms of the market and wine style (Hunter *et al*., 2004). The extent to which requirements are met is dependent on available information and the level of skill applied during application of viticultural and oenological practices.

Together with temperature, water stress is recognized as one of the most critical environmental stresses affecting the performance of the grapevine and the quality of grapes and wine (Coombe, 1987; Hunter and Myburgh, 2001; Hunter and Bonnardot, 2002). The gradual depletion of soil water during the growth season is mainly dependent on the specific soil water holding capacity and climatic conditions of the terroir (Hunter and Myburgh, 2001; Hunter and Archer, 2001; Hunter and Bonnardot, 2002). The physiological functioning of the vine is an integrated expression of the terroir conditions and the cultivation practices applied. Since so many terroir-dependent and cultivation factors affect the water status of the grapevine (Hunter and Myburgh, 2001; Hunter and Archer, 2001) and berry development (Hunter *et al*., 2004; Hunter and Deloire, 2005), optimum vine water status, allowing timely stress in order to curb excessive vegetative growth, to maintain good canopy microclimate and to benefit grape composition and wine quality, as depicted by different wine styles, is still pursued.

In order to fully quantify the role of water relations in the final grape composition and wine quality, it is essential that the changes during the ripening process be quantified and the water status-grape ripening interrelationship be optimized to the benefit of yield, grape and wine quality and the classification of different wine styles (Hunter and Deloire, 2005; Deloire *et al*., 2005). Considering the vegetative and reproductive growth patterns of the grapevine during the season, it is evident that the availability of water in terms of volume, accessibility and time during the season, may have differential effects on grape and wine quality *per se*, but also on the length of the ripening period (harvesting window), thereby impacting on the level of ripeness achieved and the potential for different styles of wine on a particular terroir (Ojeda *et al*., 2002; Hunter *et al*., 2004; Hunter and Deloire, 2005).
The purpose of this investigation was to further elucidate the relationship between vine water status (imposed during different developmental stages of the vine), the ripening of the grapes, and wine quality. In this paper, we report on preliminary findings.

Materials and methods

Cultivation

A seven-year-old *Vitis vinifera* L. cv. Syrah (clone SH1A) vineyard, grafted onto Richter 99 (*Vitis Berlandieri* x *Vitis rupestris*) (clone RY2A), was used. The vineyard is located at ARC Infruitec-Nietvoorbij in Stellenbosch (Western Cape). The area is affected by Mediterranean climate, resulting in occasional rain during the growth season. Vines are spaced 2.75 m × 1.5 m on a Glenrosa soil (Soil Classification Working Group, 1991) with Western aspect (26^{o} slope) and trained onto a 7-wire (cordon wire and three sets of movable wires) VSP Trellising System. Vines were pruned to 2-bud spurs, being spaced approximately 15 cm apart. Shoot positioning (vertically in line with spurs and applied on a regular basis) and topping (30 cm above the top wire and applied up to pea berry size stage) were done on the 1.4 m canopies (Hunter, 2000). Micro-sprinkler irrigation was applied at 32 L/hour.

Treatments

A complete water management experiment was laid out with two block replications of 15 treatments each and 30 vines per treatment replicate. It comprises different water status levels, irrigation timing, and different ripeness levels. In this paper, we report only on results obtained with a non-irrigated treatment, a wet treatment irrigated at all development stages (berry set, pea size, véraison, post-véraison), and treatments irrigated at different stages, namely pea size, véraison, and 1 month post-véraison, respectively. All irrigated treatments were irrigated to 100% field water capacity at the relevant stages. Grapes were harvested at three ripeness levels (1 March, 15 March and 30 March).

Measurements and analyses

Soil water was determined gravimetrically and by means of a neutron moisture probe. Leaf and stem water potential of primary and secondary leaves was determined during early afternoon using a pressure chamber. Shoots and grapes were harvested at all development stages and at three different dates during ripening. Primary and secondary leaf area as well as bunch and berry mass were determined from random sampling of seven shoots per replicate. Further analyses, i.e. must Balling, titratable acidity and pH (standard analyses); sucrose contents of bunch rachis and berry skins (Hunter and Ruffner, 2001); and berry and skin anthocyanin, tannin and phenolics (Hunter *et al*., 1991; Ribéreau-Gayon *et al*., 2000), were done on these bunches/berries. Wines were made similarly (Hunter *et al*., 2004) and were organoleptically evaluated by a trained panel of judges. In this paper, we only report on results obtained during ripening.

Results and discussion

In spite of rainfall during the growth season, irrigated and non-irrigated treatments differed in soil water content, non-irrigated vines being subjected to markedly lower soil water from approximately véraison (fig. 1). As expected, the soil water content in the rooting profile followed a gradient from top to bottom, the top soil losing water faster than the deeper soil layers and reacting more to water deficits (data not shown). Continuously irrigated and non-irrigated vines had similar stem and leaf water potential from approximately six weeks after véraison (approx. 21 ^{0}B), in spite of differences in soil water potential (although water potential of non-irrigated vines may have been positively affected by approximately 50 mm of rainfall just after véraison) (fig. 2). Although irrigated vines had higher water potential before this point, the lack of large differences between these treatments may point to irrigated vines, with higher initial leaf area development,

losing more water *via* transpiration and non-irrigated vines having reduced stomatal conductance to compensate for the dry conditions (data not shown). However, after six weeks post-véraison, the similar water potentials occurring for irrigated and non-irrigated vines were probably imposed by a lack of continued high water absorption by the roots in irrigated vines (therefore losing more water through the larger leaf area than being gained by water potential gradient) and restricted transpiration in non-irrigated vines. This would have been promoted and highlighted by a senescing leaf area as well cooler day and night temperatures during this time, all impacting on water potential gradients and source:sink relationships. Although vines apparently effectively recuperated in terms of water relations during the second part of the ripening period, the level of recuperation and seasonal trend seemed affected by the length of water deficit in particular (timing of irrigation). Evidently, the later the irrigation was applied during the season (after the deficit period), the higher the water potential during the last ripening stages, decreasing in order of continuously irrigated, post(one month after)-véraison irrigated, véraison irrigated, and pea size irrigated. Water was apparently more efficiently absorbed after the « dry » period and vines seemed to stay at the same level of water potential after water supply. Considering the differences between continuously irrigated, non-irrigated and stage-irrigated treatments, physiological adaptations to high and low water conditions for both of the former two treatments may have largely contributed to the peculiar findings.
Primary and secondary leaf water potential patterns were almost similar to those of stem water potential. Secondary leaves seemed most sensitive to water stress. Secondary leaves had highest photosynthetic activity during the latter part of the ripening period and would have been more affected by environmental fluctuations, being more involved in metabolic processes to satisfy sucrose and osmotic balance demands during this time (Hunter *et al*., 1994; Hunter and Ruffner, 2001; Hunter *et al*., 2004). Ostensibly, vines displayed an independence of soil water during this late stage of ripening. This was also evident from the relationship between sucrose content and °B, the leaves reducing their sucrose supply and the berries losing more water than it could gain by water potential gradients, resulting in the linear relationship being decreased markedly (Hunter and Deloire, 2005). A natural loss in primary and secondary leaf area occurred during berry ripening (data not shown); the impact of water stress on leaf area occurring approximately two weeks earlier for primary compared to secondary leaves. This again illustrated the value of secondary leaves in canopies to extend the ripening period, to make a continued contribution to grapes, and to increase vine capacity to buffer the impact of extreme environmental conditions on grape ripening (Hunter, 2000; Hunter *et al*., 2004; Novello and Hunter, 2004).
As found previously (Hunter *et al*., 2004), berries reached highest mass about two to three weeks after véraison, after which the mass first slowly and then markedly decreased (Fig. 3). This occurred for all treatments, but very significantly for non-irrigated vines after the second ripeness level (March 15). Irrigation clearly favoured berry mass stability. Treatments nevertheless displayed similar soluble solid concentrations (data not shown). Sucrose concentrations in the bunch rachis and berry skins were decreasing up to March 1, the first ripeness stage, where after it kept stable until the second harvesting stage (March 15), and then further decreased in the skins and markedly increased in the bunch rachis at the last harvesting stage (March 30) (Fig. 4). This period corresponded with the reduction in berry mass (Fig. 3) and the loss in ^{0}B/sugar content relationship (Hunter and Deloire, 2005). There seemed to be a stable period of 14 days which may be described as a window for harvesting. Vines grown under higher soil water levels showed slower final ripening and a possibility to increase the window for harvesting. Similar anthocyanin patterns found with skin and whole berry extraction (Fig. 5) and reduced skin sucrose contents (data not shown) indicate that disintegration, oxidation and respiration probably occurred during the last ripeness level in skins. During the last harvesting stage, grapes were over-ripe and wine alcohol contents increased to more than 18 %, whereas wine residual sugar levels reached a high of 93 g/L. Treatments being deficit-managed for a longer period, showed earlier maximum wine quality (ripeness level 1). Vines irrigated at all development stages and those irrigated at pea size, showed later maximum wine quality (ripeness level 2). Wine quality of all treatments was reduced at the last ripeness level.

Conclusions

Both pre- and post-véraison cultivating conditions seem to have a determining effect on grape ripening. The ripening period may be extended and berry condition maintained for a longer period by improved vine water status created by water management on a specific terroir. This matter is further investigated.

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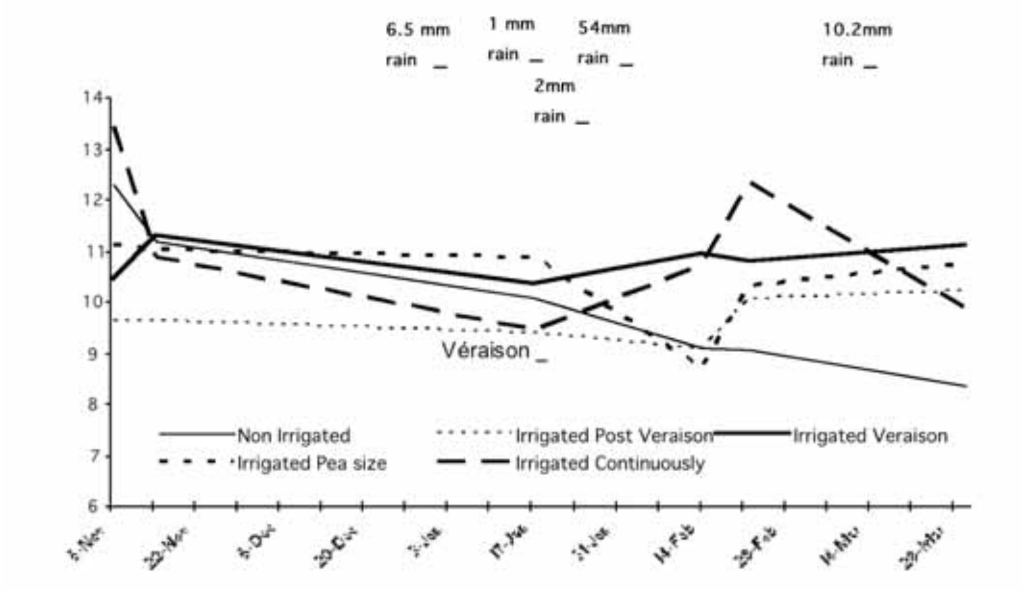

Figure 1 - Soil water content of treatments irrigated at different development stages.

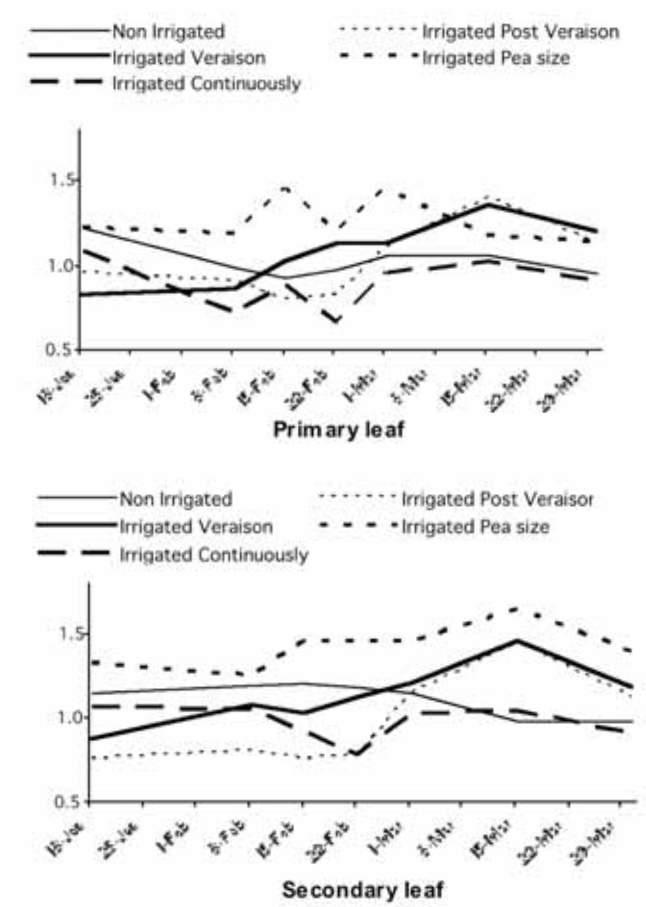

Figure 2 - Stem and leaf water potential of treatments irrigated at different development stages.

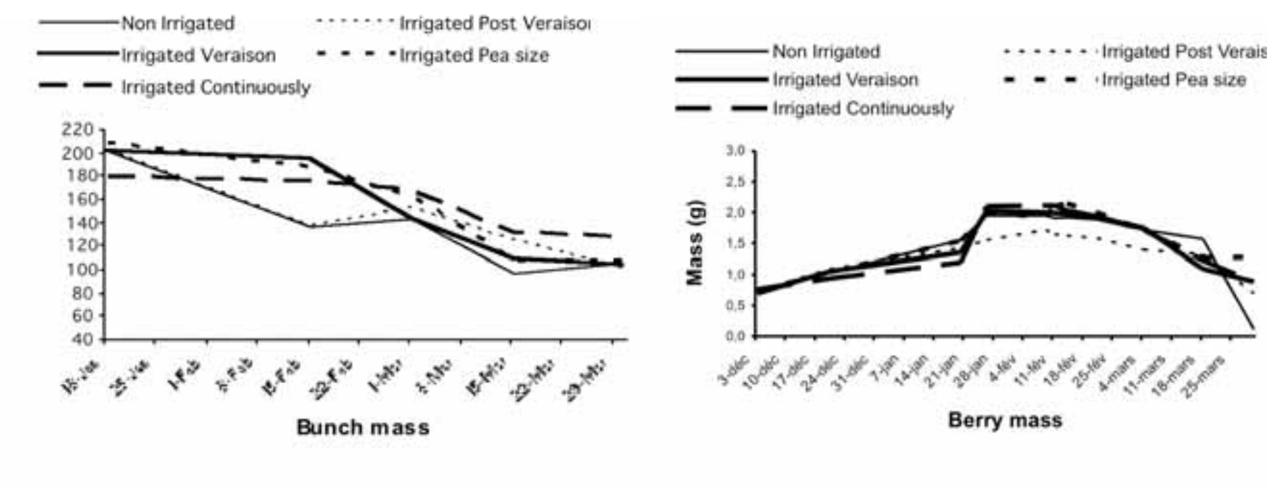

Figure 3 - Bunch and berry mass of treatments irrigated at different development stages.

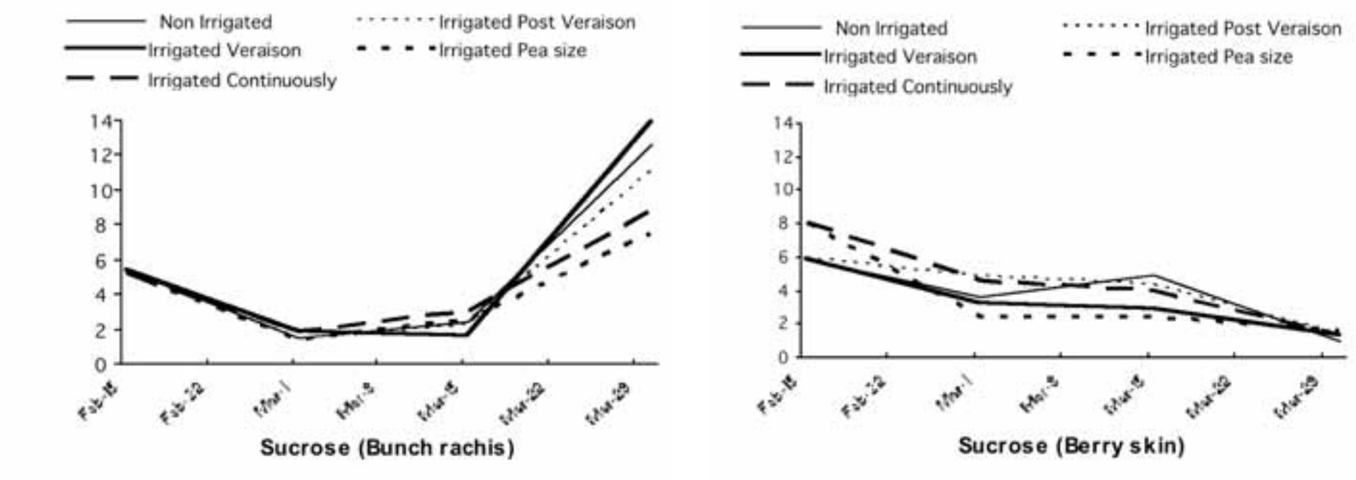

Figure 4 - Sucrose concentrations in rachis and skins of treatments irrigated at different development stages.

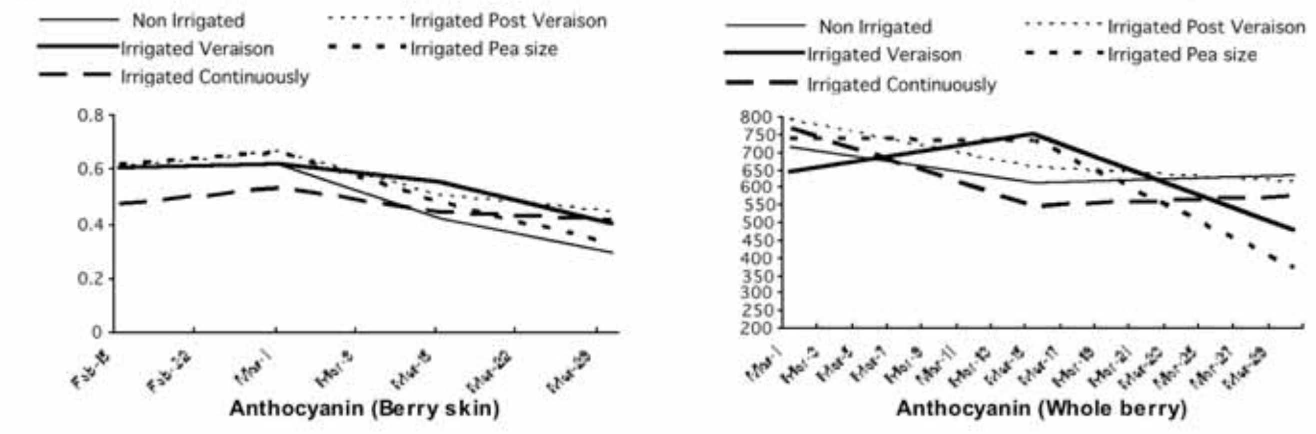

Figure 5 - Anthocyanin contents in skins and whole berries of treatments irrigated at different development stages.

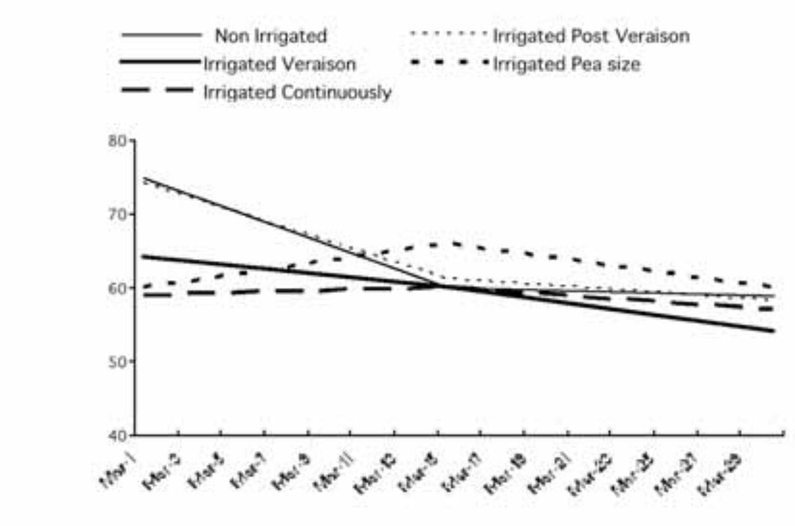

Figure 6 - Overall organoleptic wine quality of treatments irrigated at different development stages.