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VINEYARD MANAGEMENT FOR ENVIRONMENT VALORISATION

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ABSTRACT
The impact of selected cultivation practices on the valorisation of the environment in which the grapevine is grown, is discussed. To maximise the valorisation of the growth environment, a solid foundation, matching terroir, cultivar and rootstock, and prospective selection and judicious application of cultivation practices are required. Maximum valorisation would comprise an integration of climatology, viticulture and oenology and would require a total strategy to obtain the highest wine quality to compete in all market sectors.

KEYWORDS
Environment – terroir – rootstock/scion – spacing – trellising – row orientation – ripening

INTRODUCTION
The physiological functioning of the grapevine and capacity of the grapevine to buffer the environmental impact on growth are an integrated expression of the terroir conditions, cultivar-rootstock combination, and cultivation practices (Calò *et al.*, 1996; Hunter, Bonnardot, 2002; Vadour, 2004; Hunter *et al.*, 2010). Both the terroir factors and cultivation practices, including harvesting time, would impact on the final valorisation of the environment, expressed in the wine (Coombe, 1987; Hunter, 2000; Hunter *et al.*, 2004; Ojeda *et al.*, 2002; Hunter, Deloire, 2005; Nadal, Hunter, 2007). This paper briefly addresses the impact that selected cultivation practices (long and short-term) may have on the valorisation of the environment (climate, soil, topography) in which the grapevine is grown.

Integration of cultivation practices
Long- and short-term choices and practices which would impact on typicity, level of wine quality and different styles of wine that may be obtained are summarised in Fig. 1.

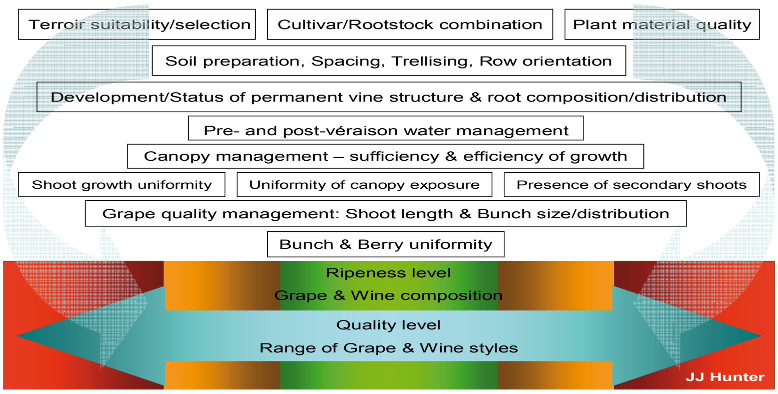

Fig. 1. Long and short term practices impacting on the grape and wine quality level and the range of grape and wine styles that can be expected.

Varying plant material, ill-considered choices and improper application of vineyard practices often result in poor grapevine functioning, complicating the prediction of vineyard behaviour within a specific terroir. The more informed and judicious each level of these practices is executed, the better grapevines would be able to buffer environmental and physiological stress conditions, the more uniform the growth that would be obtained and the less inputs would be required during the growth season. Terroir and cultivation practices would therefore impact on vegetative-reproductive growth balances in the vine, microclimate to which canopy and grapes are exposed, grape composition and level of grape ripeness that may be achieved, level of wine quality, and the harvesting window. The latter would provide grower and winemaker with a wider choice in grape ripeness level and timing of harvest for potentially different styles of wine. Different wine styles would add further dimension to wine typicity, i.e. wine style may differ, but typicity according to place of origin is retained.

A uniform vineyard is a prerequisite for improving control over grape ripening and wine style. However, heterogeneous growth is a global and prominent complicating factor of grape ripening. Causes are multiple, but soil variation, plant material quality, and basic practices (e.g. planting techniques, grapevine training/pruning) are certain contributing factors (Fig. 2). Variation can be negative or positive, depending on whether and when it is identified and how it is managed. Different forms of variation would occur, but it would always be present because of environmental (growth being an integrated result of capacity and adaptation), biological (sensitivity of plant material/reaction of vine physiological processes), and human influences (interpretation/management/cultivation differences). We merely strive to uniformity in cultivation efforts to improve control (under environmental, biological and economic pressure).

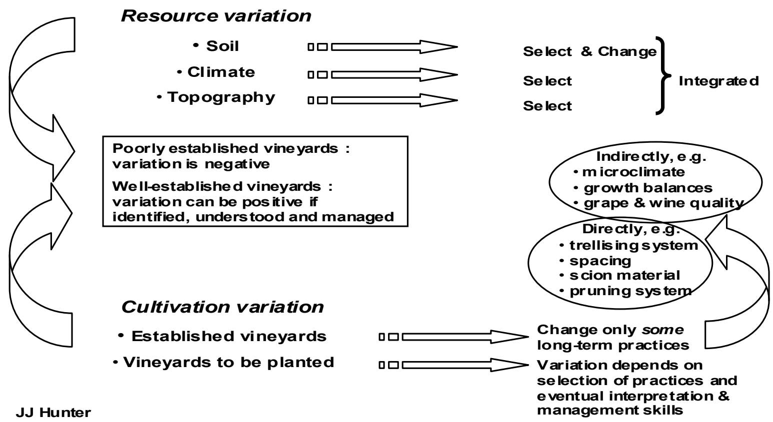

Fig. 2. Causes of heterogeneity (variation) in vineyards and options to manage.

Terroir conditions

Natural terroir factors, namely climate (e.g. sunlight hours, temperature range, prevailing wind, humidity, rainfall), topography (e.g. altitude, aspect, slope) and soil (e.g. soil fertility, soil water holding capacity, drainage), dictate suitability of sites for vineyard establishment. Growth (e.g. low, medium, high vigour) and grape composition (e.g. organic acid, flavour profile) characteristics of a selected cultivar and ultimate style of wine required should be matched with these factors. The decision on terroir suitability is based on retrospect and prospect.

Climate

It is commonly observed that climatic indices are only an indication of the reality in the vineyard and failure to marry (macro-, meso- and micro-) climatic conditions, cultivation practices and (grapevine/grape) physiological requirements would lead to under-exploitation/-valorisation of the cultivar and terroir potential and its expression in wine. Global warming (IPCC, 2007) and a further break down in the stratospheric ozone layer seem inevitable. The reaction of plants to increasing CO_2 concentrations, yet higher temperatures and drier conditions, presents an unavoidable research challenge. Effects of increased UV-B radiation on vine physiological processes and grape composition were shown, but consequences are yet to be fully quantified (Schultz *et al*., 1998). In South Africa, a Köppen classification of climates shows large variation in the Western Cape Province (from temperate humid to arid) and Winkler indices for representative grape growing areas show increases of growing degree days (GDD) of typically more than half a climatic group (Bonnardot, Carey, 2008). Implications of global warming on winegrape growing and wine quality may involve added pressure on already scarce water supplies, and a change in terroir and cultivar selection, timing of phenological events, harvest date, and wine style (Jones, 2007; Bonnardot, Carey, 2008; Van Leeuwen *et al*., 2008). High temperatures and drought conditions during grape ripening are major concerns. If the window for optimal photosynthesis [25–30°C adapted from Kriedemann (1977) – Hunter, Bonnardot (2002)], is superimposed onto the average ambient day/night temperature profile during ripening (January–March) in the Robertson region, it shows that the region is reasonably well suited for photosynthesis (Hunter *et al.,* 2010). However, projected temperature profiles for 2050 and 2100 show that at a rate of +0.02°C/year (predicted linear increase) photosynthesis may benefit until 2050, but after that the optimum temperature period for photosynthesis may shift to the morning and become shorter (Fig. 3). This is confirmed when a ambient temperature profile of a hot (max 37°C) day is compared to that of a warm (max 30°C) day (Fig. 3). The hot day allowed only a short time for optimum photosynthesis in the morning. High temperature would therefore effectively decrease the utilisation period of sunlight. High temperature stress would also have been experienced by the vine. The impact of a reduction in sunlight utilisation and the timing and duration of diurnal temperature increases on photosynthesis and physiological processes in the canopy, grapes, and roots require clarification. Differential effects may be expected.

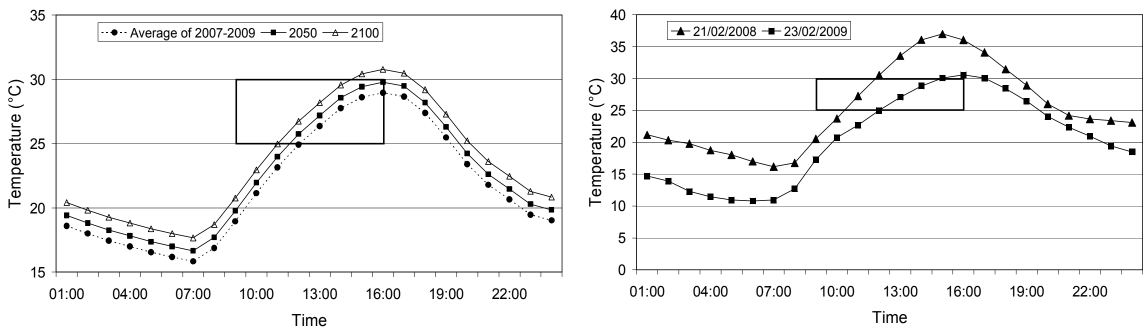

Fig. 3. Window for optimal PS superimposed onto (left) average ambient day/night temperature profile during ripening (January – March) (Robertson, South Africa) and projected change in PS suitability for 2050 and 2100 (@ +0.02°C/yr) and (right) hot and warm day temperature profiles (Hunter et al., 2010).

Climate conditions in South Africa, and globally, pose large cultivation challenges to growers to reduce environment induced stress on growth as well as grape and wine quality. Cultivars should be grown in an environment that would compliment their natural characteristics.

Soil

Soil type affects vine water relations and balances between subterranean and aboveground growth *via* water percolation and holding capacity, nutrient availability, temperature, depth, proneness to compaction and presence of soil born pests (Southey, Archer, 1988; Archer, Hunter, 2005). Buffer capacity of soils is defined as the ability of soil to supply enough water to the roots in order to at least maintain turgor under unfavourable conditions and to allow continued photosynthetic activity under favourable conditions. Buffer capacity of soil types can be improved by adjusting soil preparation procedures (Van Huyssteen, 1988). Grapevine roots mainly occupy 0–80/100 cm soil depth (Swanepoel, Southey, 1989; Hunter *et al*., 1995; Hunter, 1998a). Soil compaction impedes root distribution and should be alleviated (Van Huyssteen, 1988). Deeper soil preparation (from 400-1200 cm) increased the uptake of minerals (N, Ca, Mg, K) by young Pinot noir/99 Richter vines (Conradie *et al*., 1996). Rootstocks (140 Ru, 110 R, 99 R, Rupestris du Lot, SO4, 44-53 Malégue, 101-14 Mgt, Ramsey) responded positively to higher soil pH, generally increasing root mass (Conradie, 1988). Nitrogen absorbed during the post-harvest period is preferentially mobilised to support spring growth (Conradie, 1991). Fertilisation neglect and water stress during autumn would have a detrimental effect on canopy and bunch development during the following season. Yielding capacity of soils can be further increased by, e.g., ridging, liming, irrigation and nitrogen fertilisation (Conradie, 1991; Christensen *et al*., 1994). Irrigation and high soil water holding capacity may, within limits, compensate for soil depth (Myburgh *et al*., 1996). Sporadic, deep-penetrating roots seem to contribute to water supply during periods of prolonged water stress without necessarily stimulating vigour (Van Huyssteen, 1988). Alleviating natural root restricting soil layers before planting would contribute to obtaining homogeneous vineyards capable of buffering environmental stress for production of sustainable, high quality yields.

Rootstock and scion cultivar selection

Rootstock cultivar

Although all rootstocks have shortcomings, they should be selected according to their properties to buffer unfavourable environmental conditions. Some properties of selected rootstocks (under South African growth conditions), are listed in Tab. 1 (Southey, 1992).

Tab. 1. Rootstock properties under South African conditions (scion: Chenin blanc) (Southey, 1992).

Rootstock	Affinity	Vigour	Phyllo-xera	Nema-todes	Phytoph-thora	Lime	Salinity	Wetness	Drought
99 Richter	A	A	1	2	4	B	B	C	B
110 Richter	A	A	1	2	3	B	B	B	A
101-14 Mgt	C	B	2	2	2	D	A	A	C
420-A Mgt	B	B	3	3	2	D	D	C	B
143-B Mgt	B	A	2	2	1	C	B	A	B
Jacquez	A	B	4	4	1	B	C	B	C
775 Paulsen	C	A	1	2	1	B	B	B	A
1045 Paulsen	C	B	1	2	2	B	B	B	B
1103 Paulsen	A	A	1	2	4	B	C	B	A
3306 Couderc	C	B	2	3	4	B	D	B	C
3309 Couderc	B	B	1	2	3	B	D	C	D
140 Ruggeri	A	A	2	3	3	A	B	C	A
SO4	B	B	2	2	4	C	D	B	D
Rupestris du Lot	C	A	1	1	4	B	B	B	B

A=Excellent; B=Good; C=Fair; D=Poor; 1=Resistant; 2=Moderately resistant; 3=Moderately susceptible; 4=Susceptible

Since water for agricultural use is becoming increasingly scarce and this being a serious constraint for sustainability, drought tolerance is all the more important as a rootstock property. Establishment is often constricted by soil variation over short distances; this is a global feature of grape growing regions and restricts the use of a single rootstock. It was shown that rootstocks (mother material) differ in mineral requirement/absorption ability for growth (Hunter *et al*., 2003). Performance is also affected by the scion partner (Southey, 1992). This is a logical physiological effect, given the interaction between canopy and root system regarding, e.g., water, carbohydrate, minerals, amino acids and hormone exchange. A larger, deeply penetrating root system would increase the ability of the grapevine to withstand the impact of environmental stress, such as drought and high temperature, on growth and would allow slow, continuous and predictable grape ripening.

Scion cultivar

Expression of the full potential of the cultivar can only be realised in the wine if selection is based on its inherent characteristics and sensitivity profile to environmental impact. The terroir should compliment cultivar characteristics and induce prominent features in the wine, recognisable as being typical of the terroir and which would therefore transcend personal style or taste of the winemaker. It should therefore induce unique characteristics in the wine, irrespective of viticulture practices and oenological procedures. Although environmental and cultivating conditions would impact on cultivar phenology, it can be accepted that the latter is a genetically fixed characteristic that varies greatly between cultivars. Timing of grape ripening has a higher or lower importance in different countries. In Europe, this feature bears a high significance for terroir selection (Van Leeuwen *et al.*, 2008), e.g., at cool, high altitudes, earlier ripening cultivars and at warm, low altitudes, late ripening cultivars, are preferred. In South Africa, a similar strategy is followed and high consideration is given to management of organic acid and flavour profiles of grapes. All the characteristics of the cultivar and terroir need to be considered, without following recipes. Furthermore, oenological aspects, such as preferred production/quality level and wine style as well as the target of the wine would also play a dictating role. It is important to realise that the higher the risk factor when matching cultivar, rootstock and terroir, the greater the margin for error and the less the control over grape ripening and composition and eventual wine quality would be.

Cultivation practices

Soil management

Soil preparation should be done under optimum soil moisture conditions; too wet soils would result in trenches of which the compacted sides would be impenetrable to roots, whereas too dry soils would lead to large clods which would also be impenetrable to roots – both situations would effectively decrease available soil volume for root distribution (Van Huyssteen, 1988). Deep, vertical root distribution should be promoted. For this, judicious soil preparation, proper basic planting techniques, a favourable water regime and good soil drainage are required. Soils in South Africa (and in other countries) commonly vary over short distances. This requires that the planting site be thoroughly mapped to indicate existence of different soil types (Saayman, 2009; Archer, Hunter, 2010). This would dictate soil preparation method, soil amelioration, cultivar/clone and rootstock selection, vine spacing and trellis size; correct decisions are prerequisites for establishment of uniform vineyards and would also reduce production costs. Changes should be made even within vineyard blocks to reduce growth variation. Under conditions of limited water supply, drought resistant rootstocks (e.g. 140 Ruggeri, 110 Richter) may be used, whereas with expected high vigour, de-vigourising rootstocks (e.g. 101-14 Mgt, 3306 Couderc, 3309 C, 1045 Paulsen, 420 A Mgt) may be used (see Tab. 1), depending on availability of water for irrigation. Uniform growth and grape ripening are critical for controlling harvest date. Different rootstocks can be combined with a single scion cultivar (and even different clones) in the same vineyard to change wine style by means of grape composition and flavour spectrum changes. Soil variation can therefore be accommodated and the negative impact reduced by mapping soil type/potential, trellis, row orientation, and where practices such as ridging should be used (shallower areas or where high water tables or salinity occur). If uniform soil patches are large enough, separate blocks can be made. If not, the rootstock, scion clone and spacing can be changed in the same block.

Vine spacing
Vine spacing should be selected according to the vigour potential of the soil to accommodate growth in such a way that shoot crowding is prevented and optimal water consumption and soil utilisation are obtained by roots. The main objective is to maximise yield without forfeiting quality; in this way, it is ensured that land surface is fully utilised. Vine spacing affects rooting depth and distribution. Root systems of Pinot noir/99 Richter vines on medium potential soil under non-irrigated and low intensity irrigated conditions showed a more vertical angle and deeper penetration when vines were spaced closer together, thus maintaining a relatively large root volume (Archer, Strauss, 1985; Hunter, 1998a). Root density and root size composition changed with vine spacing (Tab. 2) (Hunter, 1998a). Narrower spacing under deeper soil conditions may lead to roots literally compensating vertically for the lack of horizontal space.

Tab. 2. Vine spacing effect on root density of P. noir/99 R (Hunter, 1998a).

Spacing (m)	**Number of roots/profile wall**	**Root density/m^2 profile wall/root size (mm)**					**Total root density/m^2 profile wall**
		<0.5	**0.5 - 2**	**2 – 5**	**5 - 10**	**>10**	
3 x 3	506.0 a	120.1 c	12.2 c	5.6 c	1.3 a	1.4 a	140.6 b
3 x 1.5	307.3 bc	133.0 bc	15.6 c	7.1 c	2.6 a	1.7 a	160.1 b
2 x 2	382.7 b	124.5 c	23.8 bc	8.5 c	1.7 a	1.1 a	159.4 b
2 x 1	337.3 bc	230.3 a	33.3 ab	14.2 ab	1.7 a	1.7 a	281.1 a
1 x 1	301.7 bc	208.9 ab	30.6 b	9.4 bc	1.1 a	1.4 a	251.4 a
1 x 0.5	236.3 c	265.7 a	44.9 a	15.7 a	1.4 a	0.5 a	328.2 a

Shading of inter-row soil led to lower soil temperatures with narrower spacing (Hunter, 1998a). Although this may have decreased evapotranspiration, high soil occupation by roots of narrower spaced vines resulted in high water depletion, reducing leaf and bunch water potential and increasing xylem sap abscisic acid concentration. This, together with unfavourable canopy microclimate conditions, led to lower photosynthetic activity and water use efficiency in these vines. Under such conditions, drought resistant rootstocks would be preferred. Faster ripening occurred under medium potential soil conditions with narrower spacing, reducing the harvesting window (Tab. 3) (Hunter, 1998b).

Tab. 3. Vine spacing effect on grape composition of P. noir/99 R (Hunter, 1998b).

Spacing (m)	**Soluble solids (°B)**	**Titratable acidity (g/l)**	**pH**	**Anthocyanin (A_{520})**	**Anthocyanin (mg/g dry skin mass)**	**Anthocyanin (mg/skin)**
3 x 3	21.72 d	7.38 bc	3.07 d	2.07 cd	4.14 cd	0.36 c
3 x 1.5	22.79 c	7.39 bc	3.15 c	1.97 d	3.94 d	0.33 c
2 x 2	23.66 ab	7.05 c	3.20 c	2.45 bc	4.91 bc	0.47 ab
2 x 1	23.33 bc	7.89 a	3.25 b	2.64 b	5.29 b	0.41 bc
1 x 1	23.48 abc	7.53 ab	3.28 ab	2.35 bcd	4.71 bcd	0.39 bc
1 x 0.5	24.16 a	7.71 ab	3.31 a	3.12 a	6.24 a	0.53 a

Narrowest possible row spacing is required to achieve maximum cordon length, shoot number and bunch number per ha. Row spacing of 2.0-2.2 m is viable, but frequently impossible to use on steep slopes when planting on a contour. In such cases, planting down-hill is an option to maintain narrow rows, but soil surface management is critical to prevent erosion. Presently, narrower in-row spacing is used on low-medium potential soil and wider in-row spacing on medium-high potential soil. Natural, non-restrictive soil depth, soil preparation, fertilisation, water availability, and vigour of the graft combination would change spacing in any scenario.

Trellising and canopy management

A stable and sufficient trellis system (incl. canopy support wires), allowing a physical and physiological bearing on crop size and quality is required. The volume of canopy growth is largely dictated by the extent of root growth, as supported by the scion (Archer, Hunter, 2005). Trellis size is a function of expected vigour. Maximum photosynthetic capacity is required within the dimensions of the trellis. A sufficient, yet efficient canopy is needed under any circumstances to support the permanent structure of the vine and crop. Sufficiency refers to leaf area size and composition. Development of young, contributing leaves on secondary shoots should be stimulated in the canopy by means of seasonal canopy management (leaf thinning, tipping, topping) before véraison, to secure continued photosynthetic capacity that would support the required grape ripeness level (Hunter *et al.,* 1994). They should be present in the whole canopy and well exposed by means of judicious removal of infertile shoots, shoot positioning, and leaf thinning (Hunter, 2000; Hunter *et al.,* 2004). The canopy also has a physical role to protect grapes against excessive sun exposure. Shoots should be uniformly distributed and managed in such a way that a uniform microclimate of the whole canopy is obtained. This is critical for uniform ripening and predictable ripeness level and harvest date.

Conversion of a trellis that was insufficient to effectively accommodate growth that occurred for Chenin blanc showed that a trellis that increase effective leaf area and accommodate and re-distribute vigour by improving the balance between vegetative and reproductive growth (Tab. 4), increase yield (Tab. 4) (Hunter, Volschenk, 2001) without negative effects on grape composition (Tab. 5) (Volschenk, Hunter, 2001). This was also found for Cabernet Sauvignon and Crouchen blanc (Zeeman, 1981). Leaf efficiency and extension of the aboveground permanent structure increased demand on the root system (Tab. 6) (Hunter, Volschenk, 2001). Although data showed that root development was stimulated, the impact on root system efficiency seemed higher, therefore challenging the general concept of ‘’mass x activity’’; the root system also seemed to react, similar to the canopy, upon demand.

Tab. 4. Trellis conversion effect on cane mass and yield of C. blanc/99 R (Hunter, Volschenk, 2001).

Trellising system	Cane mass		Yield		Yield:cane mass ratio
	Kg/vine	Kg/ha	Kg/vine	Ton/ha	
Vertical	0.74 c	2044.3 b	8.3 c	23.1 c	11.22
Vertical (extended)	1.23 a	1711.8 c	18.4 a	25.6 b	14.96
Lyre	0.86 b	2395.5 a	13.7 b	38.1 a	15.93

Tab .5. Trellis conversion effect on grape parameters of C. blanc/99 R (Volschenk, Hunter, 2001).

Parameter	5-strand VSP	Lyre trellis
Yield (t/ha)	23,1b	38,1a
Sugar concentration (ºB)	19,9a	19,4a
Titratable acidity (g/l)	7,74a	7,82a
pH	3,13a	3,08a

Tab. 6. Trellis conversion effect on root growth of C. blanc/99 R (Hunter, Volschenk, 2001).

Trellising system	Number of roots/profile wall	Root density (number of roots/ m^2 profile wall/root size)					Total root density (number of roots/m^2 profile wall)
		<0.5 mm	0.5 – 2 mm	2 – 5 mm	5 – 10 mm	<10 mm	
Vertical	508 b	279 a	46 a	21 a	5 b	2 a	353 a
Vertical (extended)	1129 a	323 a	42 a	20 a	5 b	1 a	392 a
Lyre	595 b	319 a	50 a	30 a	13 a	3 a	413 a

Conversion of existing vigorous vines by increasing aboveground:subterranean growth ratios may be implemented as a long-term solution to problems such as shoot crowding, high levels of canopy shade, yield and quality reduction and inefficient disease control. Preferably, the trellis should initially be sufficient to effectively accommodate growth and create a balanced vine that would allow higher valorisation of land surface.

Row Orientation

Row orientation may have a determining effect on terroir valorisation, mainly because of its effect on total amount of sunlight energy being intercepted (Intrieri *et al*., 1996; Zufferey *et al*., 1999; Intrieri *et al*., 1999; Hunter, Volschenk, 2008; Hunter *et al*., 2010). Impact of row orientation on functioning of leaves and grapes would also depend on other factors, such as growth dimensions, plant spacing, trellis and latitude (Smart, 1973; Intrieri *et al*., 1999). Row orientation is often dictated by steepness and aspect of slope and prevailing wind direction. In hilly and mountainous landscapes, contours dictate orientation; this would require more negotiated decision-making. Despite this, orientation of a vineyard row is critical for energy distribution and sunlight and heating effects on leaves and grapes at vineyard level. Radiation interception profiles for Shiraz/101-14 Mgt planted to four row orientations in the Robertson region of South Africa are shown in Fig. 4 (Hunter, Volschenk, 2008).

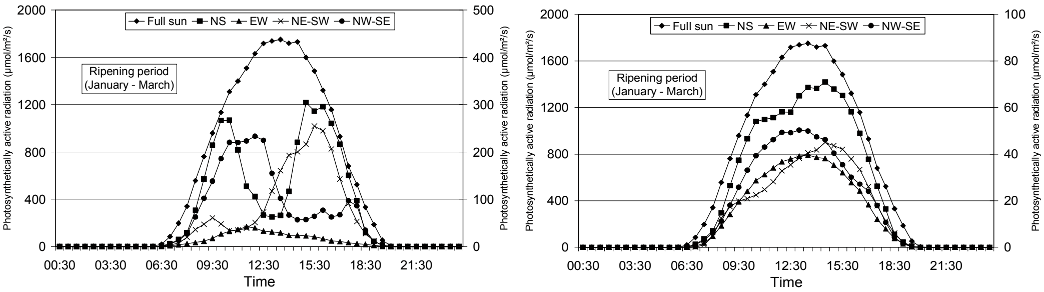

Fig. 4. Row orientation effect on radiation in the bunch zone, (left) canopy-filtered and (right) soil-reflected, measured during grape ripening, Robertson region, South Africa (Hunter, Volschenk, 2008).

Row orientation affected berry pulp temperature during ripening with diurnal differences between canopy sides (Fig. 5); morning sun exposed berries (from NS and NW-SE orientations) heated up fast in the morning and maintained a high temperature (Hunter, Volschenk, 2008).

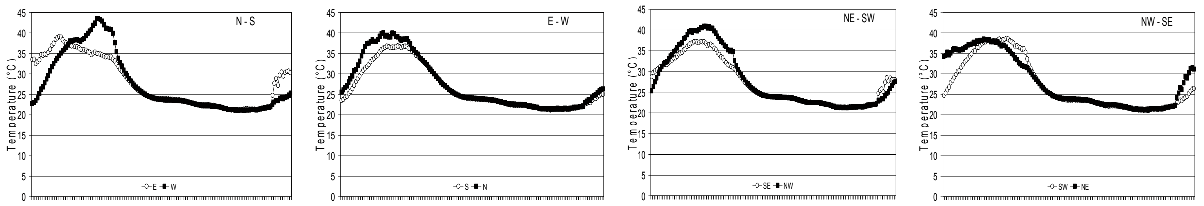

Fig. 5. Row orientation effect on day/night temperature profiles of the berry pulp, measured during the ripening period in Robertson, South Africa (Hunter, Volschenk, 2008).

Row orientation would have more pronounced effects on berry temperature under higher ambient temperatures. This was evident when berry pulp temperature measured on a hot (max 37°C) day was compared to that measured on a warm (max 30°C) day (Hunter *et al*., 2010). Physiologically, long-term exposure of berries to high ambient temperature would lead to high respiration rates, resulting in low titratable acidity, colour and flavour loss, and high pH. In addition, the harvest window would be reduced and high alcohol wines, lacking complexity and structure, would result. This has serious implications for terroir selection, especially in warm and hot climates and under conditions where row orientation is dictated by the terrain (aspect, slope); here, harvesting time would be critical to buffer the temperature impact. Row orientation may be a management tool to manipulate the impact of environmental stress in practice.

Timing of harvest (optimal ripeness)

On any land surface, continuous, uniform canopies and root systems are required to support healthy and viable yields and berry composition that would result in high wine quality and different wine styles (Hunter *et al*., 2004; Archer, Hunter, 2005; Nadal, Hunter, 2007). Ripening of grapes is directly related to size and activity of root system and canopy. Physical and physiological changes in berries would impact on the harvest window, level of grape ripeness achieved and potential for different wine styles on a specific terroir (Ojeda *et al*., 2002; Hunter *et al*., 2004; Hunter, Deloire, 2005). The primary question is whether root absorption, canopy water potential, canopy sugar production and demand for sugar and water by the berry would be sufficient during late ripening to sustain transport to the berry under mostly unfavourable environmental conditions (lower ambient and soil temperatures) and a senescing canopy (Hunter *et al*., 1994; Hunter, Ruffner, 2001; Hunter *et al*., 2004). The water potential gradient between canopy/conduits of the parent plant and berry pericarp may decrease so that water flow and concomitant transport of sucrose to the berry would diminish, even with visually normal, intact bunch stem, rachis and pedicel; this may lead to an ''independence'' of the berry. Canopy and berries undergo stress/senescence during this time and the better their functioning can be maintained, the larger the harvesting window may be. In a study in the Stellenbosch region, South Africa, changes in physical and chemical parameters in the canopy, berries and wine were followed at different grape ripening stages of Syrah/99 Richter and related to wine sensory data. Remarkable synchronisation between canopy and berries existed. Based on this, different wine styles were distinguished (Tab. 7) (Hunter *et al*., 2004; Nadal, Hunter, 2007). Sauvignon blanc/110 Richter (Tab. 8) was also monitored at different ripeness levels (Hunter, 1999; Hunter *et al.,* 2004).

Tab. 7. Different wine styles distinguished for Syrah/99 R (Hunter et al., 2004).

°B:TA <2.0e	°B:TA <3.0d	°B:TA <4.0c	°B:TA <5.5b	°B:TA >5.5a
Herbaceous, astringent, diluted, high acidity, lacking flavour & colour	Herbaceous & fruity, unbalanced, semi-concentrated	Fruity & tannic, balanced, concentrated	Fruity & tannic, well balanced, concentrated, good structure, typical colour & flavour	Tannic, harsh, unbalanced, jammy, overripe, high alcohol, poorly related colour & sensory quality

Tab. 8. Different grape styles distinguished for S. blanc/110 R in the vineyard (Hunter, 1999).

In general, fruity and vegetative flavours dominated the flavour profile, complimented by herbaceous, green pepper, spicy, asparagus and green bean flavours
19 °B: Low – moderate fruity and strong vegetative character
21 °B: Moderate – intense fruity and vegetative character
23 °B: Intense fruity character, low vegetative character

Overripe grapes would minimise the opportunity for making a unique or even terroir-specific wine and would also reduce effects of any special cultivation practices. Monitoring of ripening, and harvesting within a window that would allow effects of terroir and vineyard-specific practices to surface are critical. Variation in berry size inside bunches, even under visually uniform conditions (Tab. 9 - Barbagallo *et al.,* 2009; Guidoni *et al*., 2009), would complicate timing of harvest. Variation in berry size may originate prior to berry set, possibly during differentiation of flower primordia from asynchronous cell division; resynchronisation seemed to occur during late ripening (Gray, Coombe, 2009). Floral differentiation and timing of harvest are therefore important. Uniform vineyard growth conditions would nonetheless still favour control and management of harvesting time and a more informed decision.

Tab. 9. Berry heterogeneity inside a Syrah/99 R bunch (Barbagallo et al., 2009).

Berry size & Number of berries per 1 kg grape bunch			
< 1.50 g	1.51 – 2.00 g	2.01 – 2.50 g	> 2.50 g
769	555	435	370
Surface of skin per 1 kg grape bunch			
2968	2625	2375	2305

Integration of soil, cultivar sensitivity, growth and water management

Examples applicable to different terroirs are given in Fig. 6 for Sauvignon blanc and in Fig. 7 for Syrah.

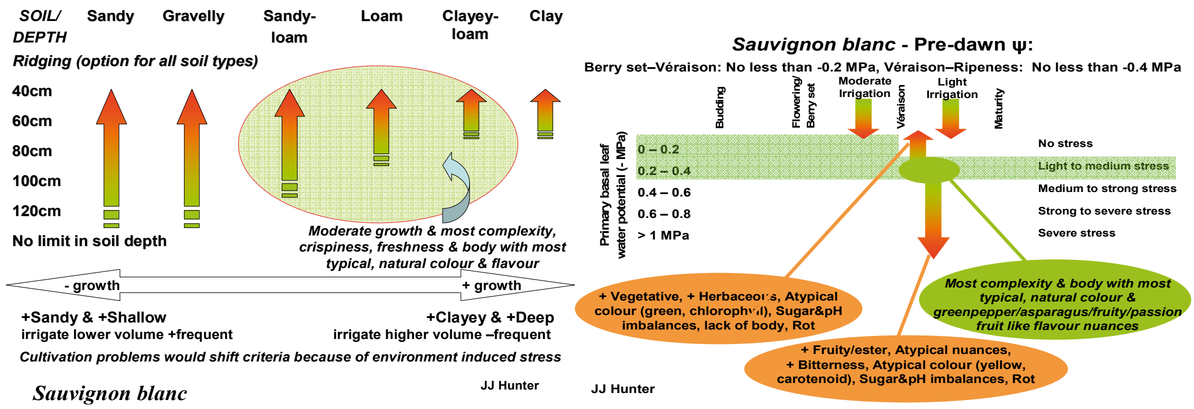

Fig. 6. Integration of soil, growth and water management for S. blanc.

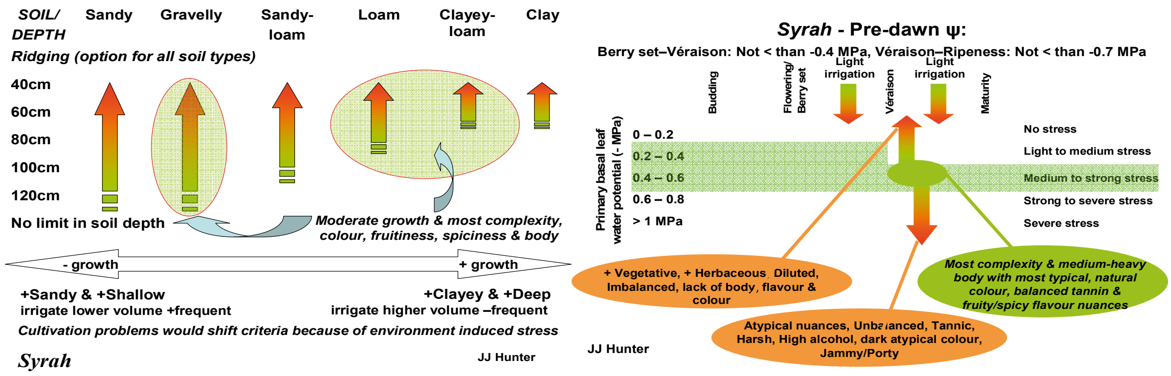

Fig. 7. Integration of soil, growth and water management for Syrah.

Labour input

Environment valorisation and sustainability of vineyard produce would be affected by labour needed for application of seasonal practices. Comparing vineyards in the Stellenbosch region, it was evident that terroir suitability and choice of long term practices would impact significantly on labour input for Sauvignon blanc and Cabernet Sauvignon (Tab. 10, 11).

Tab. 10. Labour input for two S. blanc vineyard blocks under drip irrigation.

Block description: Soil potential: High; Altitude: 80 m; Aspect: South; Row orientation: N-S; Spacing: 3.0 x 1.4 m; Trellis: 5-Wire hedge, fixed wires; Rootstock: 110 Richter; Pruning: Spur; Bud load/m cordon:16.5				
Pruning	Shoot thinning	Shoot positioning	Tipping (hand)	Leaf thinning
86	131	205	64	86
Total labour input (man hours/ha): 572				
Block description: Soil potential: High; Altitude: 140 m; Aspect: South; Row orientation: NE-SW; Spacing: 2.2 x 1.8 m; Trellis: 7-Wire hedge, movable wires; Rootstock: 110 Richter; Pruning: Spur; Bud load/m cordon:16.5				
Pruning	Shoot thinning	Shoot positioning	Tipping (hand)	Leaf thinning
78	21	18	15	16
Total labour input (man hours/ha): 148				

Tab. 11. Labour input for two C. Sauvignon vineyard blocks under drip irrigation.

Block description: Soil potential: Medium; Altitude: 85 m; Aspect: West; Row orientation: N-S; Spacing: 3.0 x 1.2 m; Trellis: 5-Wire hedge, fixed wires; Rootstock: 101-14 Mgt; Pruning: Spur; Bud load/m cordon:16.5				
Pruning	Shoot thinning	Shoot positioning	Tipping (hand)	Leaf thinning
75	86	129	1.8	54
Total labour input (man hours/ha): 345.8				
Block description: Soil potential: Medium; Altitude: 95 m; Aspect: West; Row orientation: N-S; Spacing: 3.0 x 1.2 m; Trellis: 5-Wire hedge, fixed wires; Rootstock: 99 Richter; Pruning: Spur; Bud load/m cordon:16.5				
Pruning	Shoot thinning	Shoot positioning	Tipping (hand)	Leaf thinning
94	105	197	4.2	89
Total labour input (man hours/ha): 489.2				

CONCLUSIONS

Knowledge of climate, soil, and eco-physiological behaviour of the grapevine is required to obtain the highest valorisation of the available environment in which grapevines are grown. The more informed the matching of terroir, cultivar and rootstock, the better the foundation for reaching full potential of the cultivar and highest wine quality to compete in all market sectors. In addition, prospective and judicious selection and application of both long and short term cultivation practices are required. Maximum valorisation would comprise an integration of climatology, viticulture and oenology and would certainly require a total strategy in which all decisions and practices should be judged as valuable and complementary to each other.

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