Understanding the climatic, site, canopy and cultural factors affecting Pinot Noir expression in the vineyard

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VITI FACTORS INFLUENCING PINOT NOIR QUALITY

- REGIONAL CLIMATE INFLUENCE
- YIELD
- RIPENESS OF FRUIT- TIMING OF HARVEST
- SOIL
- SEASONAL CLIMATE INCL STRESS
- CLONE
- VINEYARD NUTRITION & BALANCE

COLOUR, CROP LOAD ,SUGAR

The anthocyanin and tannin graphs below show that wine grapes may contain a five-fold difference in colour and tannin in a given amount of skin despite comparable sugar levels at harvest; in this survey the low tannin/colour site cropped at 15-20

t/ha compared with less than 7.5 t/ha at the other sites

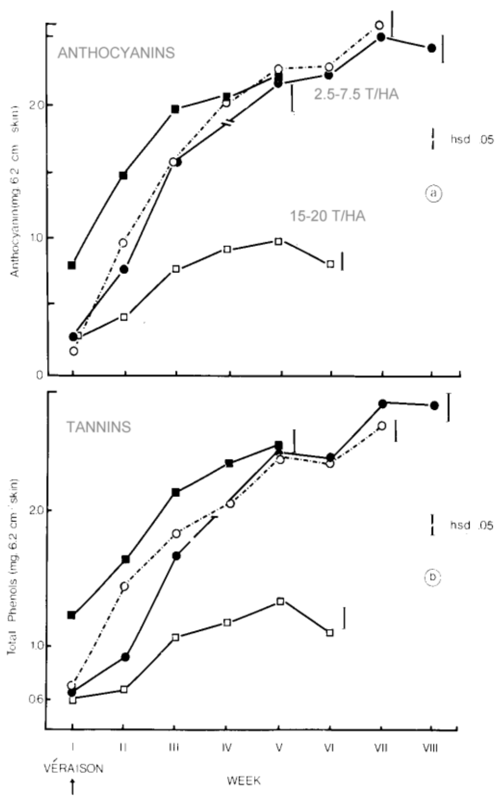


Fig. 1. Rates of accumulation of anthocyanins[a], and total phenols[b] per unit area of skin between 'véraison' and 'maturity'. (– ■ –) Mudgee 'A' Shiraz; (– ● –) Botobolar 'W' Cabernet S; (– o –) Botobolar 'W' Shiraz; (– □ –) Griffith 'DA' Shiraz. Vertical bars show hsd ($P < 0.05$) values for all harvests at each vineyard.

Table 3. Accumulation of total soluble solids (°Brix) in grape berries during the ripening period.

Harvest no.	Botobolar 'W' Shiraz	Botobolar 'W' Cabernet	Mudgee 'A' Shiraz	Griffith 'DA' Shiraz
I	10	12.5	15.0	14.5
II	—	16.0	15.9	16.9
III	—	—	15.5	18.0
IV	17.0	17.5	17.7	19.0
V	19.0	15.0	20.1	21.7
VI	19.7	20.5	23.0[a]	23.7[a]
VII	20.6	22.2[a]		
VIII	21.0[a]			

Pirie A.J.G. (1977) Phenolics Accumulation in red wine grapes (Vitis vinifera L.), Department of Agronomy and Horticultural Science, University of Sydney, Sydney. pp. 141.

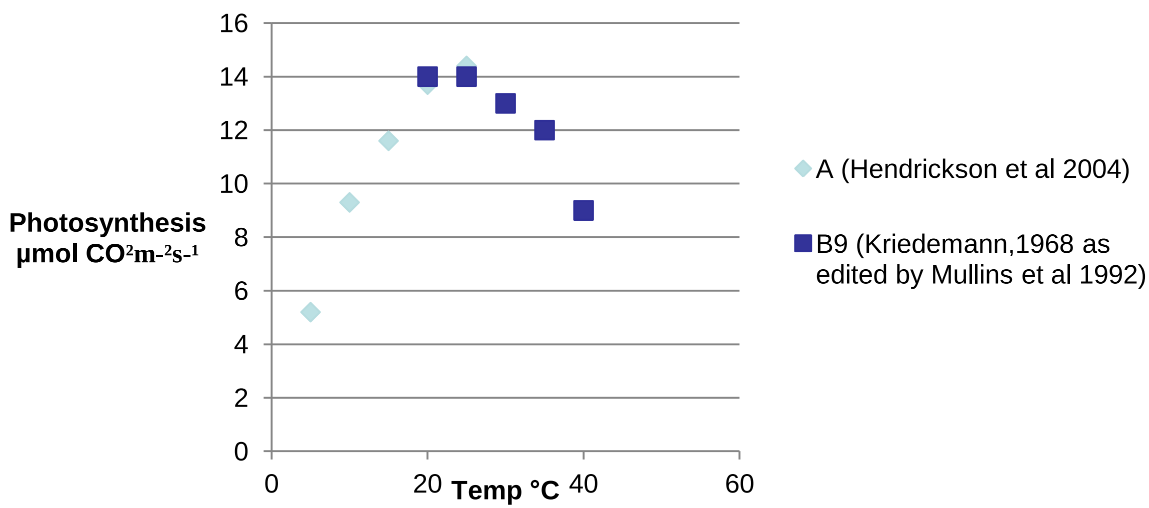
PHYSIOLOGY OF THE VINE

Fundamentals driving quality (Acy, Tannins, Flavour)

- PHOTOSYNTHESIS
- TEMPERATURE
- SOIL MOISTURE STRESS AND VINE WATER POTENTIAL

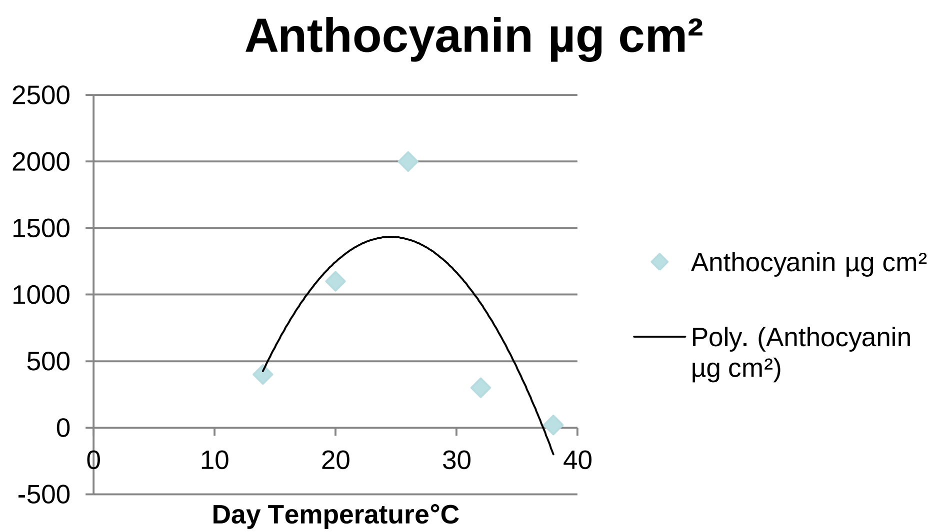
PHYSIOLOGY OF THE VINE

PHOTOSYNTHESIS-Temperature



PHYSIOLOGY OF THE VINE

TEMPERATURE- impact on anthocyanin accumulation



Hale C.R., Buttrose M.S. (1973) Effect of temperature on the anthocyanin content of Cabernet Sauvignon berries. CSIRO Division of Horticultural Research Report 1971-3:98-99.

PHYSIOLOGY OF THE VINE

TEMPERATURE- impact on phenolics

TABLE IV
COMPOSITION OF RED WINES FROM FIVE VARIETIES OF GRAPES GROWN IN COOL (I) THROUGH HOT (V) REGIONS

	I	II	III	IV	V
Number of samples	125	126	97	219	67
Alcohol content (%)	12.2	12.4	12.2	11.9	11.6
Anthocyanin (intensity, arbitrary units)	239	297	297	188	158
Total phenols (mg/liter)	1260	1310	1450	1100	1140

Singleton V.L., Esau P. (1969) Phenolic substances in grapes and wine, and their significance. Adv Food Res Suppl 1:1-261.

REVISED TEMPERATURE CLASSES Pirie (2012)

Source	Cool Definition	Comments	Suitable cultivars
TOO COOL	GST <13°C GSS<12 MJ/m2 >20 Rain days last 2 months > -3°C MTCM	Based on current world distribution of commercial vineyards	
VERY COOL	GST 13-14 °C	Separates very early (precocious) grape cultivars from regions with 1st Epoque grapes	1erEpoque Precoce , Müller Thurgau, Seyval, Schönberger, Reichensteiner, Bacchus, Pinot Noir Precoce
COOL	GST 14-16 °C	Based on historical distribution 1erEpoque Cultivars, especially Pinot Noir (=<GST 16 °C)	1erEpoque (Chasselas+ 0 days) and some 2nd Epoch (

GST best Pinot Noir table wine

GST Group	Regions	GST °C
14-16	Bourgogne Cote de Nuits	15.3
Cool	Crookwell NSW (887m)	15.3
	Martinborough	15.3
	Macedon/Kyneton (524 m)	15.3
	Campania S Tas.	15.4
	Mornington Main Ridge (230 m)	15.4
	Cromwell C Otago	15.4
	Bicheno Tas (11 m)	15.4
	Okanagan Oliver BC	15.5

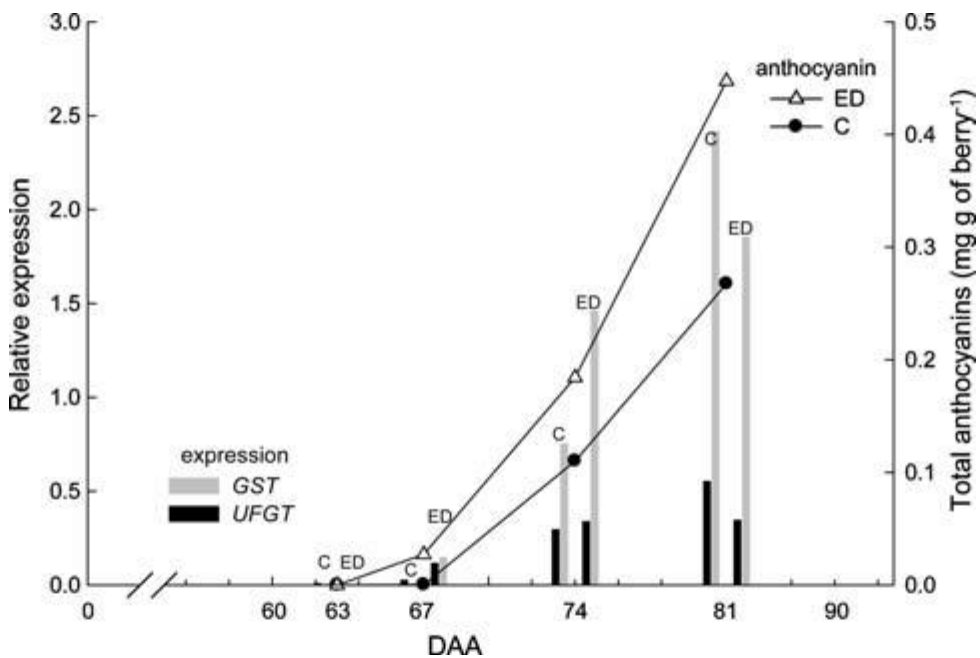
GST AND OTHER CLIMATIC INFLUENCE

Location	Latitude	Altitude m	GST ° C A-O NH O-A SH	Aridity Index mm Deficit- /Surplus + (P -0.5E) mm
Bicheno Tas	41.87 °S	11	15.4	-63
Kyneton- Macedon Vic	37.25 °S	509	15.3	-265
Crookwell NSW	34.46 °S	887	15.3	-223
Cromwell Central Otago	45.0°S	213	15.4	-324
Dijon	47.18 °N	219	15.3	+116
Ranelagh	42.98 °S	50	13.8	+12.1

Moisture Stress on anthocyanin

Fig. 5 Summary of anthocyanin accumulation, and *UFGT and GST* expression at veraison in berry skins of *C and ED vines*

nine structural genes of the flavonoid pathway (*F3H, F3H, F35'H, FLS1, LDOX, DFR, LAR2,*
BAN, UFGT) and GST)



Castellarin S.D., Gambetta G.A., Matthews M.A., Di Gaspero G. (2007) Water deficits accelerate ripening and induce changes in gene expression regulating flavonoid biosynthesis in grape berries. Planta 227:101-112.

Moisture Stress on anthocyanin

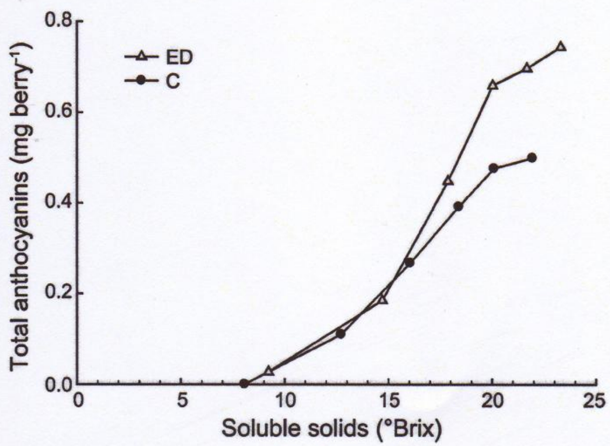


Fig. 8 Relationship of anthocyanin content to sugar concentration during berry development. Data taken from Figs. 2c and 3b

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PHYSIOLOGY OF THE VINE

Mediation of impact on Anthocyanin and Phenolics of leaf/crop ratio, girdling, stress

- Sugar Flux to fruit ?
- ABA levels in fruit?
- High carbohydrate status of vine

- Pirie A., Mullins M.G. (1976) CHANGES IN ANTHOCYANIN AND PHENOLICS CONTENT OF GRAPEVINE LEAF AND FRUIT TISSUES TREATED WITH SUCROSE, NITRATE, AND ABSCISIC-ACID. Plant Physiology 58:468-472.

Ripening physiology

Castellarin et al 2010

- that sugar and ABA play a predominant role in regulating

the expression of a suite of genes at the onset of ripening,

including those responsible for moisture stress – induced increase in anthocyanin biosynthesis

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Moisture Stress on anthocyanin

Fig. 5 Summary of anthocyanin accumulation, and *UFGT and GST* expression at veraison in berry skins of *C and ED vines*

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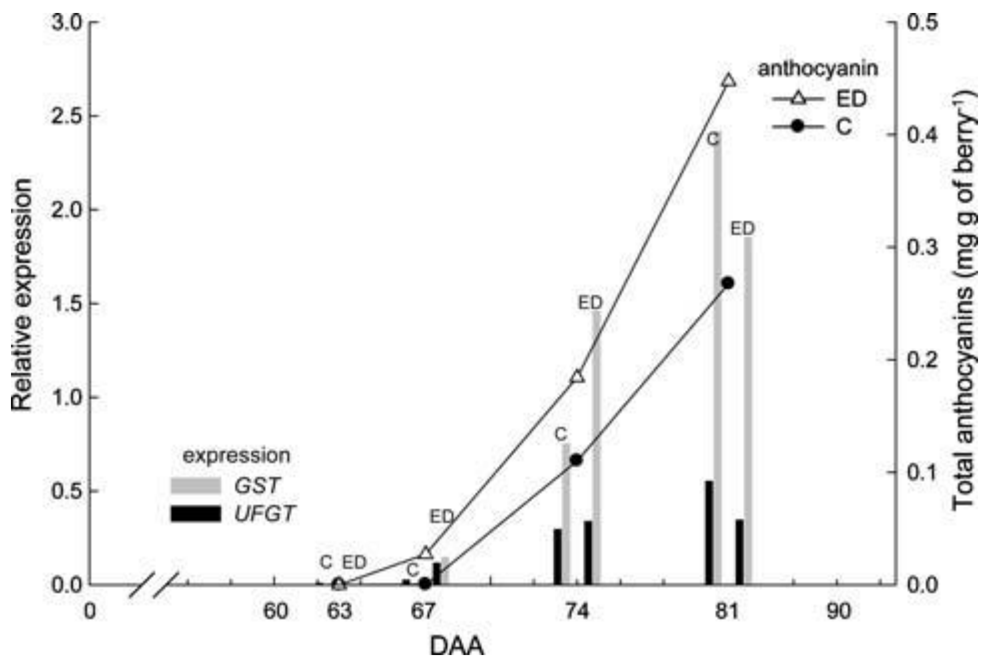

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PHYSIOLOGY OF THE VINE

Mediation of impact on Anthocyanin and Phenolics

- grape orthologs of key sugar and ABA-signaling components are regulated by sugar and ABA in non-climacteric fleshy fruit.

- Gambetta G.A., Matthews M.A., Shaghasi T.H., McElrone A.J., Castellarin S.D. (2010) Sugar and abscisic acid signaling orthologs are activated at the onset of ripening in grape. Planta (Berlin) 232:219-234

HOW MUCH STRESS
SOIL kPa

Table 1. Suggested soil water tensions in three soil types for RDI management.

	Suggested soil water tension (kPa)		
	Sand (or shallow roots or hot climate)	Loam (or medium roots or temperate climate)	Clay (or deep roots or cool climate)
Full irrigation (no stress)	40	50	60
RDI	100	200	400

LOW STRESS> 200 kPa med texture

HOW MUCH STRESS

- Vine water potential -1.4 mPa
- Mid-day reading

PS & STRESS

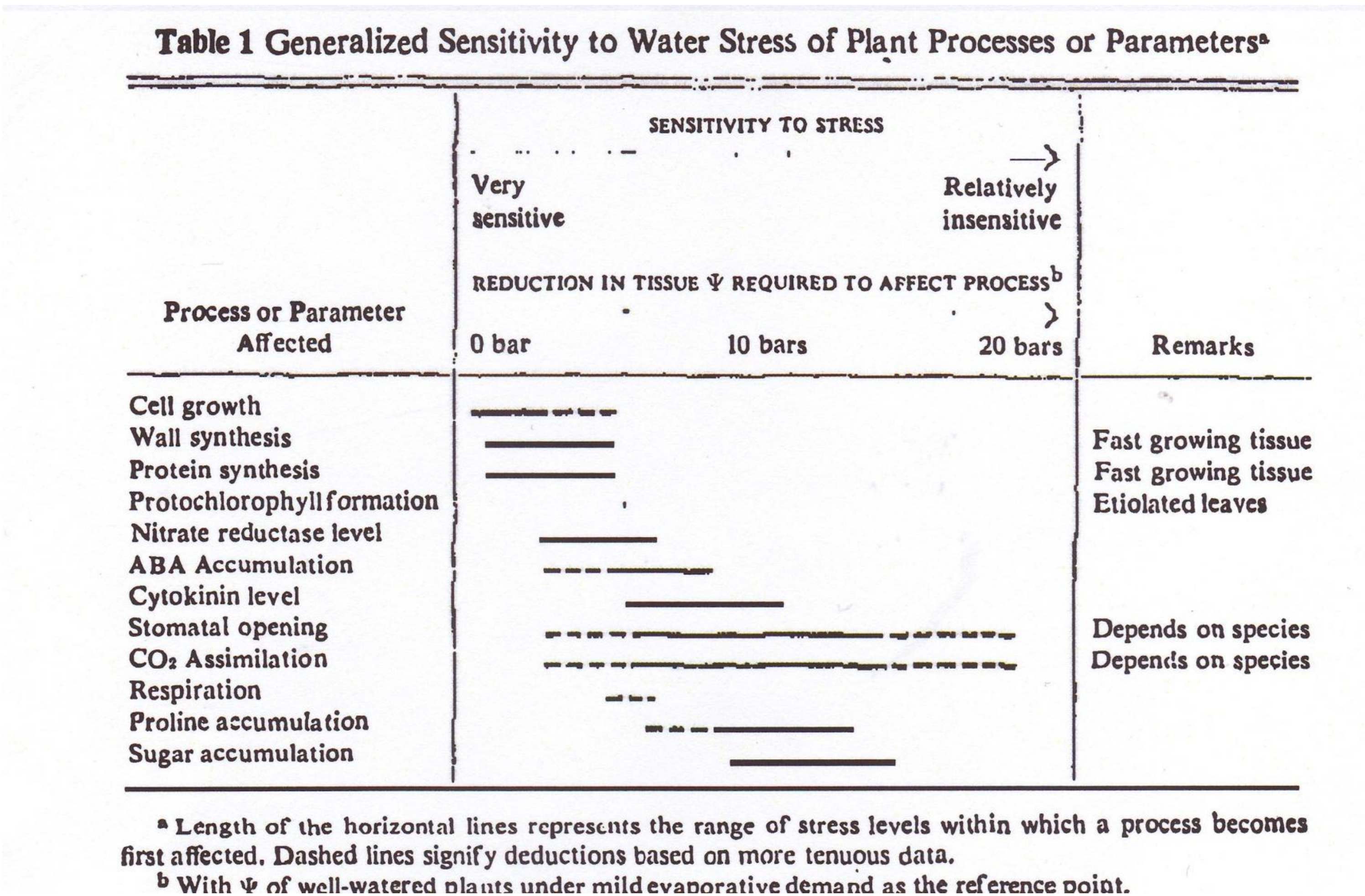


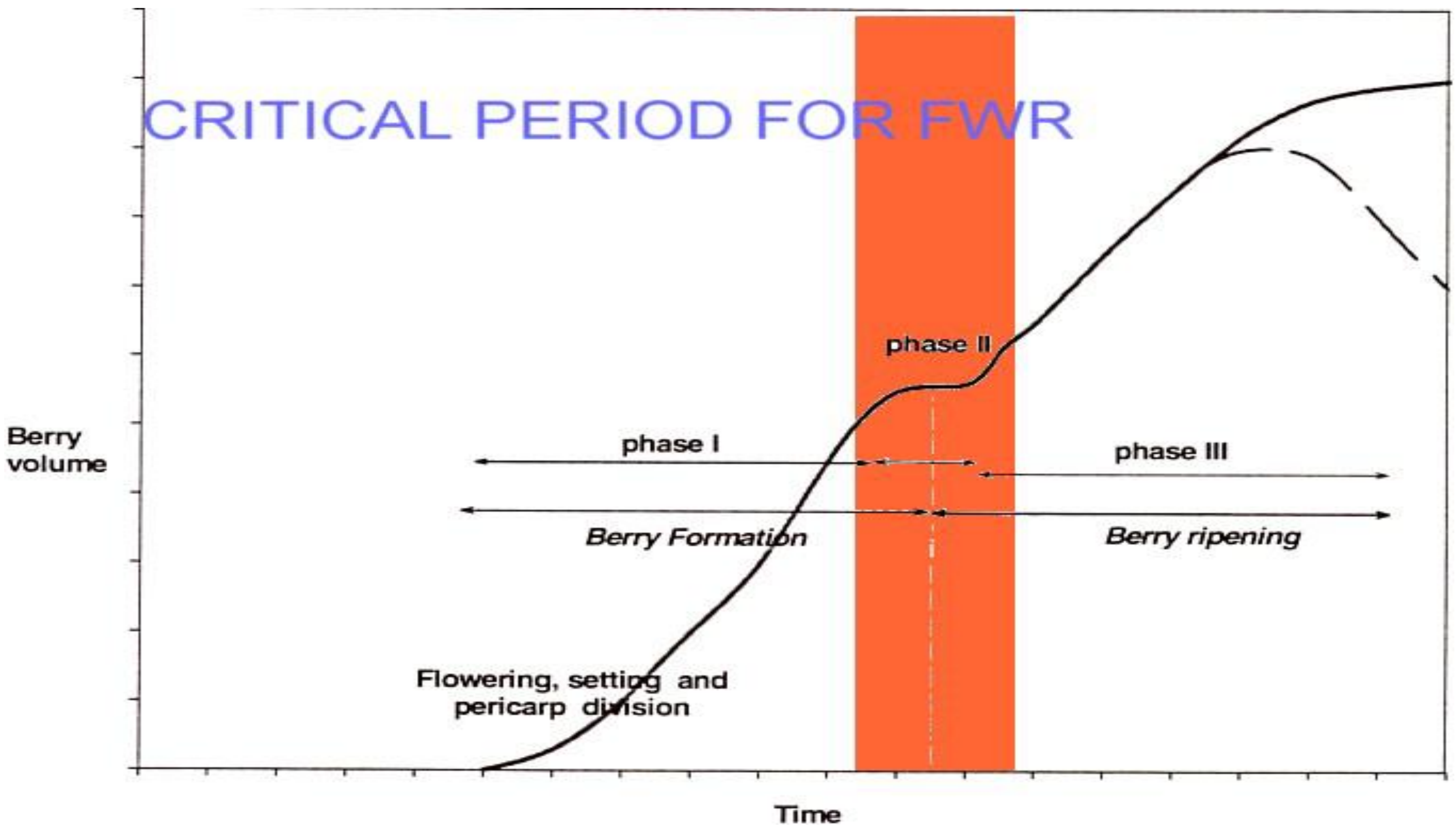
Table 1 Generalized Sensitivity to Water Stress of Plant Processes or Parameters[a]

Process or Parameter Affected	SENSITIVITY TO STRESS: Very sensitive → Relatively insensitive; REDUCTION IN TISSUE Ψ REQUIRED TO AFFECT PROCESS[b]: 0 bar, 10 bars, 20 bars	Remarks
Cell growth		
Wall synthesis		Fast growing tissue
Protein synthesis		Fast growing tissue
Protochlorophyll formation		Etiolated leaves
Nitrate reductase level		
ABA Accumulation		
Cytokinin level		
Stomatal opening		Depends on species
CO_2 Assimilation		Depends on species
Respiration		
Proline accumulation		
Sugar accumulation		

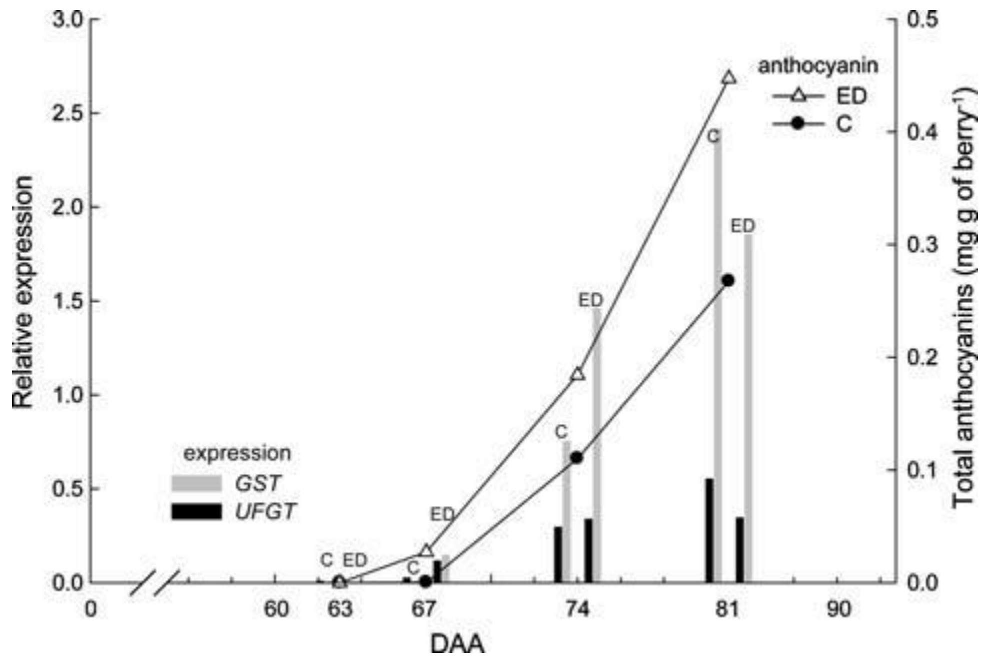
[a] Length of the horizontal lines represents the range of stress levels within which a process becomes first affected. Dashed lines signify deductions based on more tenuous data.
[b] With Ψ of well-watered plants under mild evaporative demand as the reference point.

Hsaio , TC Ann Rev Plant Physiol . 24-519-570 (1973)

Ripening physiology



Anthocyanin pathway gene expression



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CLASSIFYING RIPENESS

1. Industrial Wine Ripeness- to make legal wine measured by Brix, TA, pH
2. Commercial Wine Ripeness – Good beverage to Premium wines Brix , TA, pH, fruit taste
3. Fine Wine Ripeness – Ultra premium wines ,complex and ideally with distinctive regional character Brix , TA,pH & high in secondary metabolites

Ripening physiology

- **Stage 1**
- Cell division
- Tartaric acid synthesis
- Malic acid synthesis
- Methoxypyrazine flavours defend unripe berries
- Seed tannins develop

Ripening physiology

- **Stage II**
- Lag phase
- Maturation of embryo
- Lignification of the seed coat
- Colour changes in skin signals the end of the phase

Ripening physiology

- **Stage III**
- Cell expansion
- Sugar accumulates in the skin and pulp layers
- Anthocyanins rise and the predominant tannins of the berry change in the skin and seed mainly
- Potassium, amino acids increase via Phloem
- Malic acid is degraded
- Most “ripe’ flavours develop
- ABA (Abscisic Acid) levels spike 10-14 days from onset of colour change

PHYSIOLOGICAL RIPENESS?

Critical issues

- Concentration of pigments, flavour precursors and quality of tannins appear to be determined early in ripening by the flux of sucrose to individual berries and by a particular hormonal balance in the sap resulting from an interplay between the activity of leaves, shoot tips and roots (ABA and stress important)
- Sugar and acid concentrations are determined by broader variety/season dynamics with sugar accumulation and acid degradation possible over a long period as long as dry autumns permit hang-time. This means that grapes can attain "normal" ripeness as measured by sugar content, with widely varying content of secondary metabolites such as flavours and tannins (physiological ripeness)

The critical period for FWR- The Time

- **The critical period for “Fine Wine Ripeness (FWR)”**
- Likely to be set in Stage II and the first two weeks of Stage III when the enzyme machinery is at its most active for production of anthocyanins and flavour precursors (elsewhere studies on disruption of photosynthesis due to extreme stress show that disruption in Stage II just preceding colour change has the most long lasting and permanent effect on disturbing pigment synthesis; similarly vine shading experiments at this stage show shading to cause a small reduction in sugars at maturity but cause a large (4-5 fold decline) in berry pigment content.

The critical period for FWR- The Time

- **The critical period for “Fine Wine Ripeness (FWR)”**
- I believe it to be in Stage II and the first two weeks of Stage III

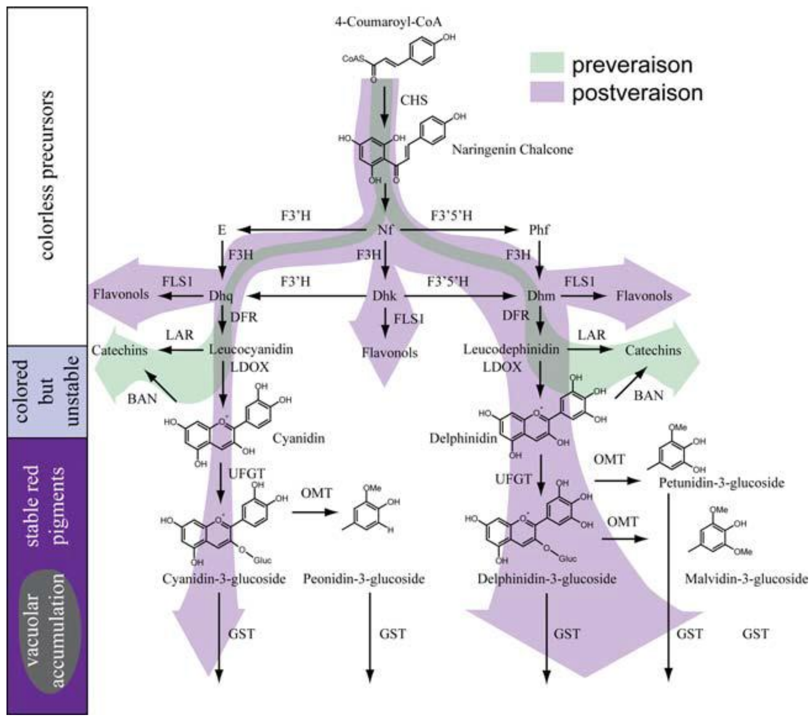
- L’AOUT FAIT LE GOUT
- August makes the taste
- *Old saying in Champagne*

THE “QUALITY” PRODUCTION LINE

- **The machinery** : eg flavonoid bisosynthetic pathway
- **The fuel:** sucrose phosphate from the leaves – best flux in a situation of semi-stress
- **The catalysts;** enhanced levels of stress hormones (abscisic acid and possibly ethylene) in the sap resulting from semi- stress where shoot tip and new leaf growth is restricted, mature leaves are healthy and fully expanded- the most productive stage for photosynthesis

THE "QUALITY" PRODUCTION LINE

- **The machinery** :



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THE “QUALITY” PRODUCTION LINE

- Related influences
- Fruit exposure – warm (19-27 deg C) but not hot berries increase machinery activity
- Flavonols produced in direct response to solar radiation stabilise pigments
- Healthy canopies- higher photosynthetic capacity
- Water- the right mid-stress to allow PS but restrict shoot growth
- “Adequate leaf area /fruit weight ratio set up early before veraison (fruit or fruit+shoot thin?)

High leaf area /fruit weight ratio

- 1 m2 leaf area/kg fruit the old bench mark for Table grapes as the minimum adequate leaf area for ripening
- A low leaf area to fruit weight ratio has been shown to cause a four-fold decrease in pigment content of berries without substantial changes in berry Brix levels.
- A possible quality response up to 2.4 m2/kg of bunch weight in quality of wine grapes in Grand Cru Burgundy (eg 12 leaves per 50 g bunch) has been observed… this observation fits well with prevalence of yield control and positive impact of low yield in particular on pinot noir wines (also this fits with the flux theory)

Conclusions for Pinot Noir winemakers

- Optimize broad varietal- regional crop dynamics for best quality
- GST 15.2-15.4

i.e. Don't ripen too early or too late on average Ideally 25 March -15 April (SH)

25 Sept-15 Oct (NH)

Conclusions for Pinot Noir winemakers

- In high latitudes (> 38 deg) aim for maximum fruit exposure to sun after achieving adequate leaf area display for FWR

Conclusions for Pinot Noir winemakers

- the leaf area/crop weight ratio required for

maximum level of total soluble solids, berry weight, and berry coloration at harvest ranged from 0.8 to 1.2 m2/kg*, could be as high as 2.4 m2/kg, should be achieved as early as possible in the season-

*Kliewer W.M., Dokoozlian N.K. (2005) Leaf Area/Crop Weight Ratios of Grapevines: Influence on Fruit Composition and Wine Quality. Am. J. Enol. Vitic. 56:170-181.

Conclusions for Pinot Noir winemakers

- Traditional measures of industrial ripeness have little relevance to the measurement of grape’s FWR (fine wine ripeness)

Conclusions for Pinot Noir winemakers

- Hang time may be less important in FWR than achieving EARLY optimal leaf area/fruit ratios on well displayed canopies