How to mitigate sugar content while maintaining wine quality ?

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How to mitigate sugar content while maintaining wine quality ?

Outline

> **What is wine quality and why the regulation of alcool contents is critical** ?

@ Modifications of cultivation practices
+ Early harvest or block mapping
+ Source/sink or PS efficiency
+ Vigor, phenology & microclimate

@ Cultivar selection and improvement
+ Rootstock adaptation
+ Cultivar selection

> Conclusions

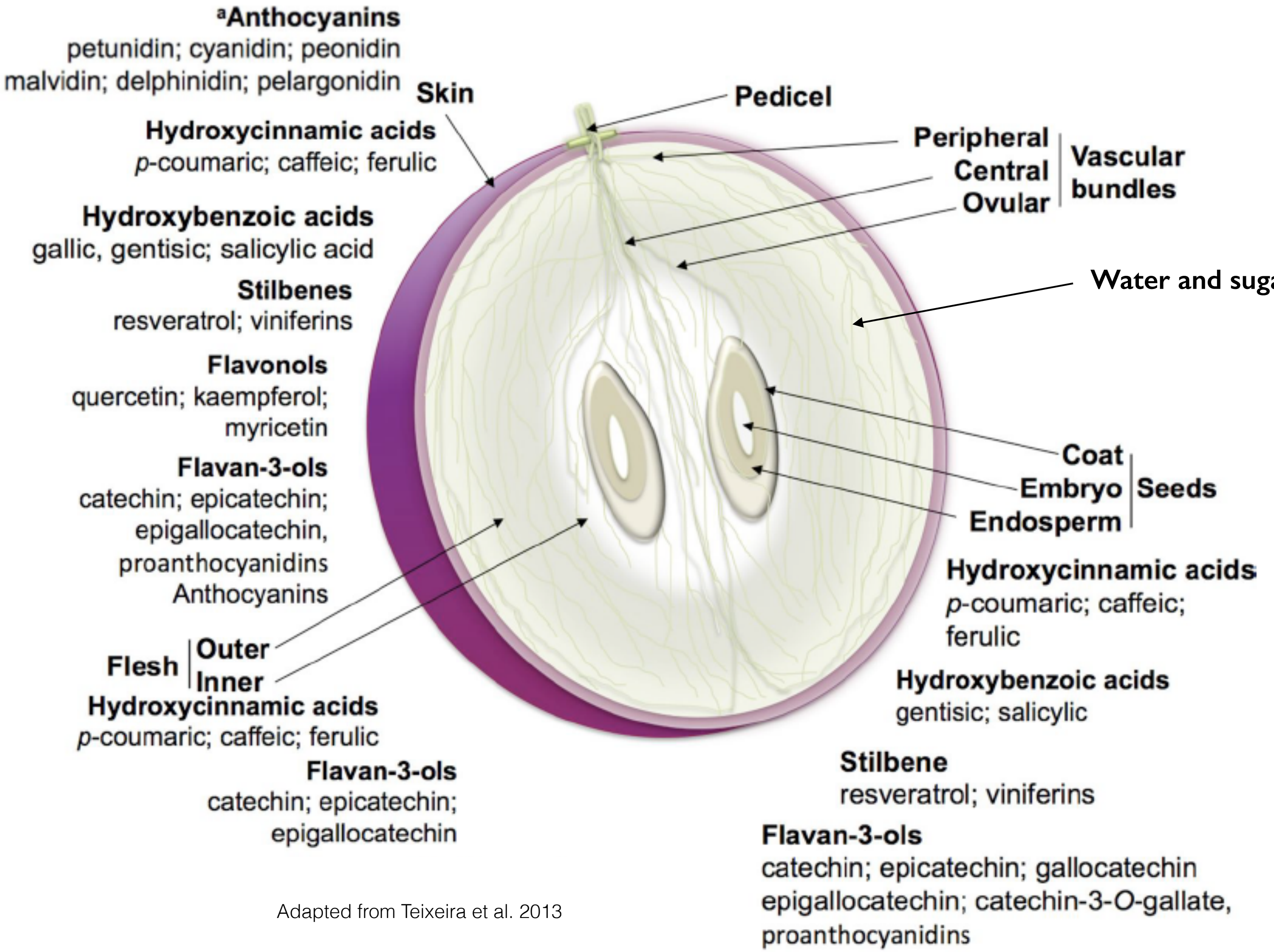
What are the main component of wine quality ?

Nutrition	Water: wine is a liquid	… up to 85%
	Salts (cations): Ca, K	…. up to 1g/l
Metab1	**Alcool**(s): **ethanol**, glycerol	… **up to 15%**
	Sugars: F & G	… up to 100g/l
	Acids: tartaric/malic, citric	…. up to 5gr/l
Metab2	Tannins (qty and forms)	… up to 1g.l
	Anthocyanidins	… up to 1g.l
	Aromas and flavors	… less than µg*

**IBMP (isobutyl-methoxy-pyrazine) 20-50 ng/kg*
**Terpenols (linalol, geraniol) 0.5-1µg/kg*

What are the main component of wine quality ?

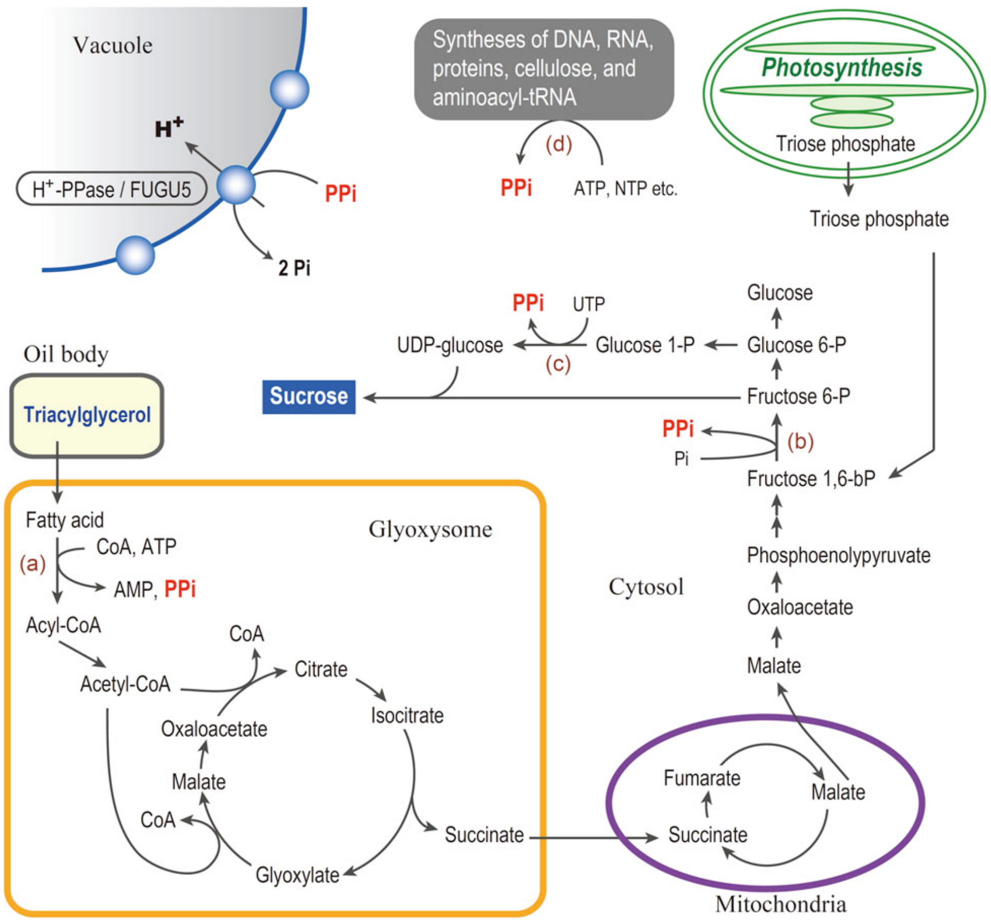
These compounds are not co-localized…

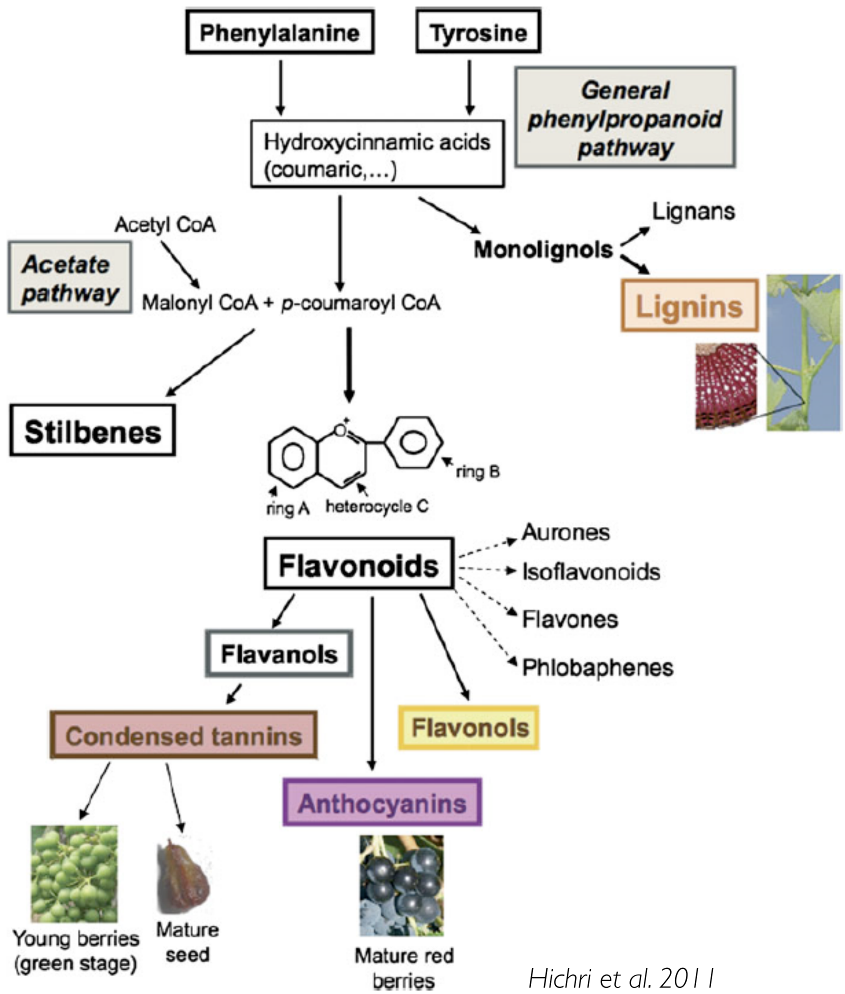


Adapted from Teixeira et al. 2013

What are the main component of wine quality ?

These pathway are not strictly linked….





Hichri et al. 2011

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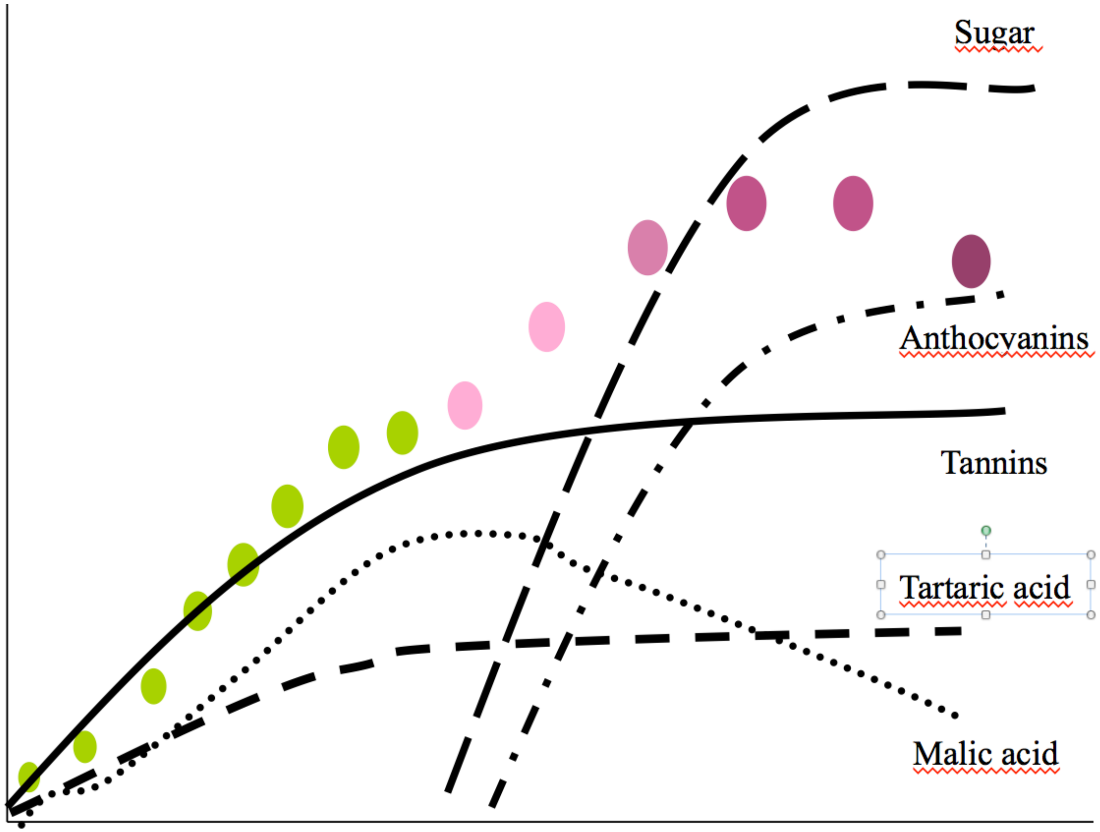
What are the main component of wine quality ?

But quality compounds fit sugar accumulation !



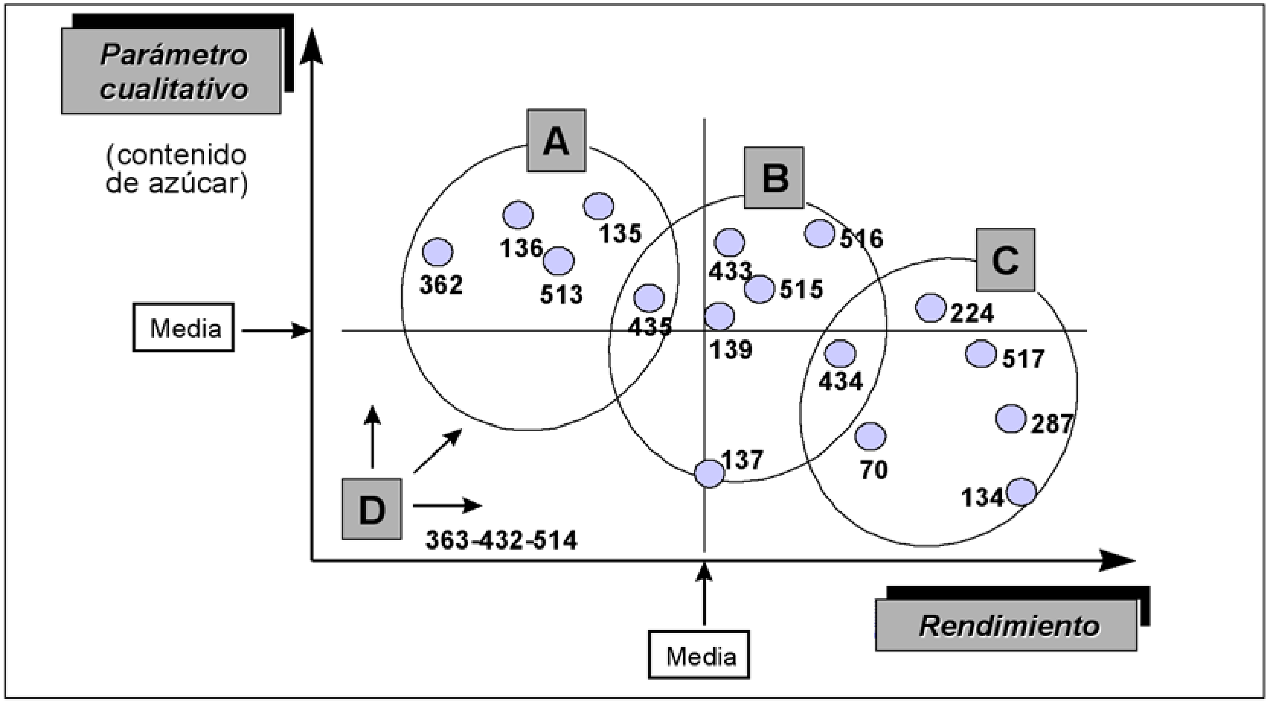
> Natural dispersers for grape seeds are birds

Anthocyanins are signals

Sugar and flavors are rewards

What are the main component of wine quality ?

But quality compounds fit sugar accumulation !



Scarzi (2002) d'après Oustric (1994)

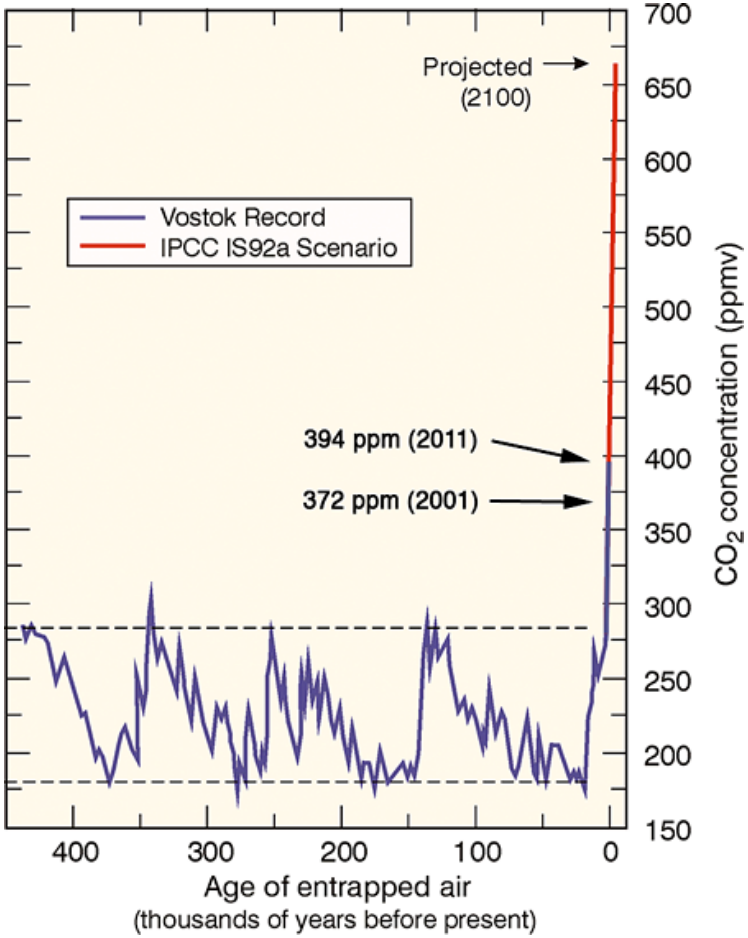
> Human domestication selected cvs with high sugar contents
> Modern clonal selection reinforced this tendency ☹

Ethanol-rich wines are more stables
Ethanol was expected in wines and linked to attractive sensations

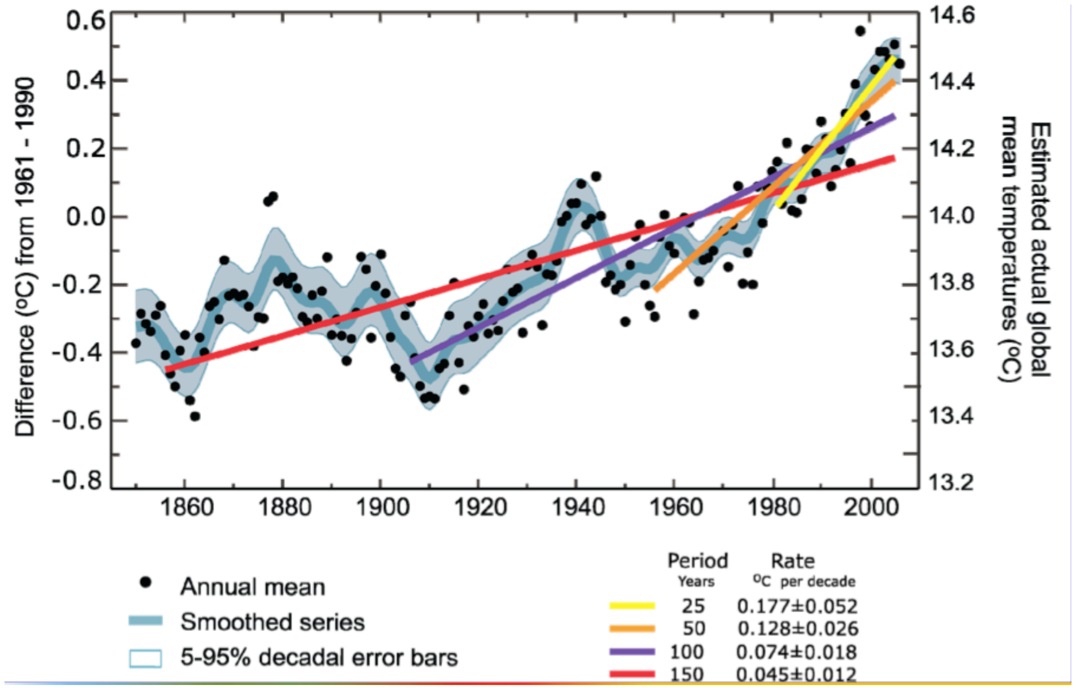
Why sugar content becomes a problem ?

> 1. Climate changes

CO2



T°



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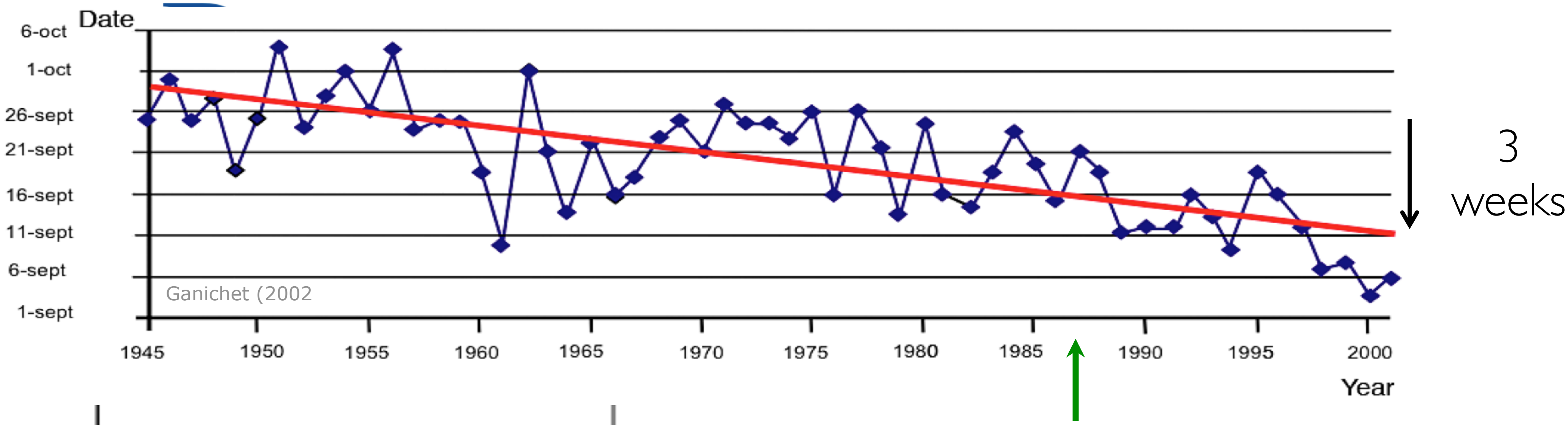
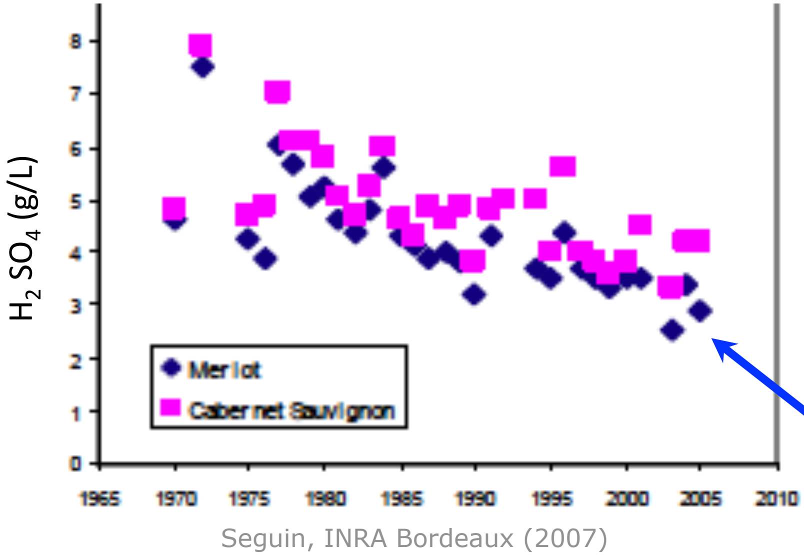
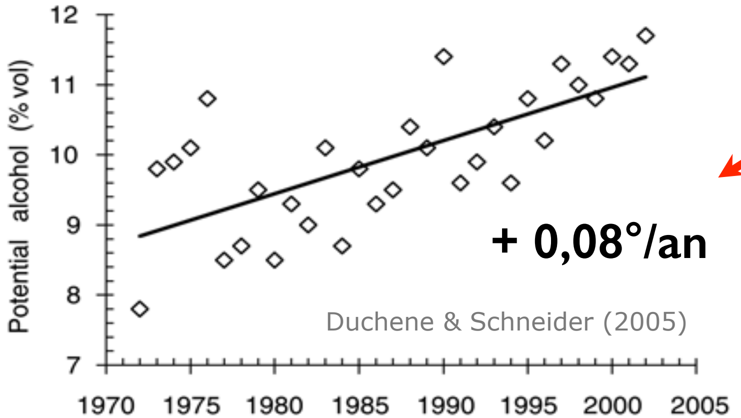


Grapevine development

Phenology
Fruit set, berry growth... yield

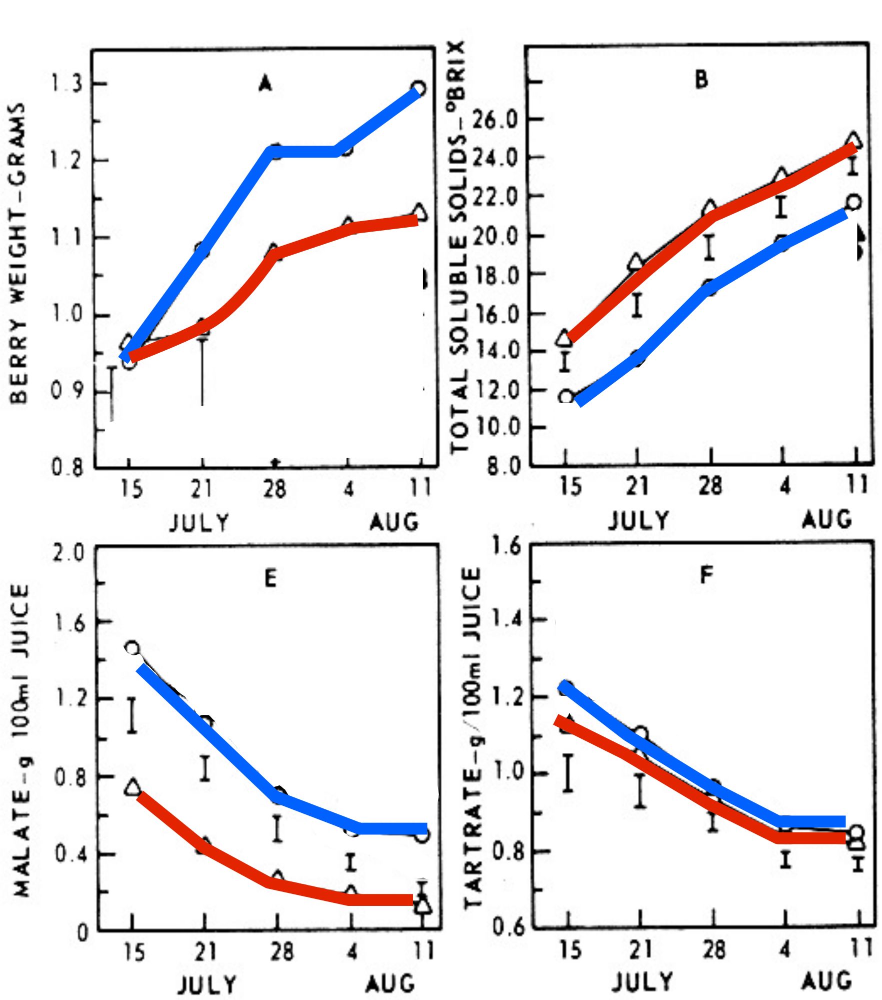
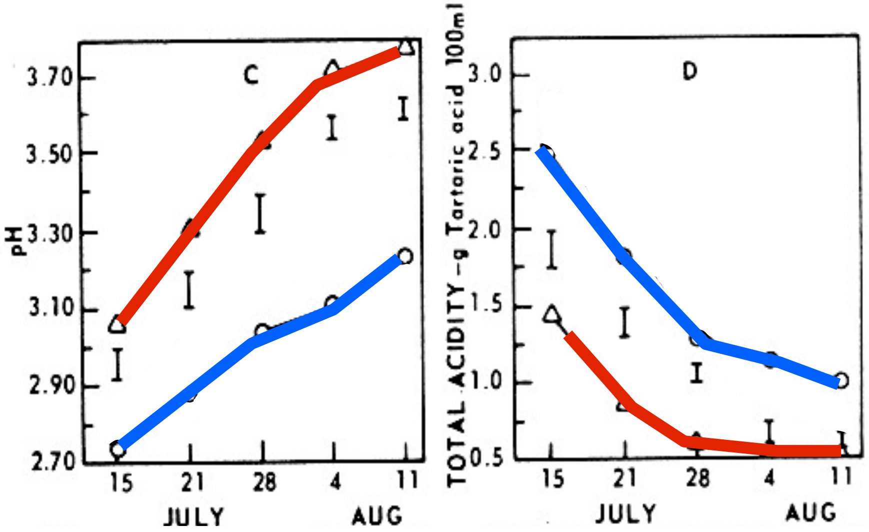




Wine composition

Acidity
Ethanol contents
Anthocyanidin pigments
Synchron. tannins vs sugar metabolisms
Aromatic profiles

Why sugar content becomes a problem ?

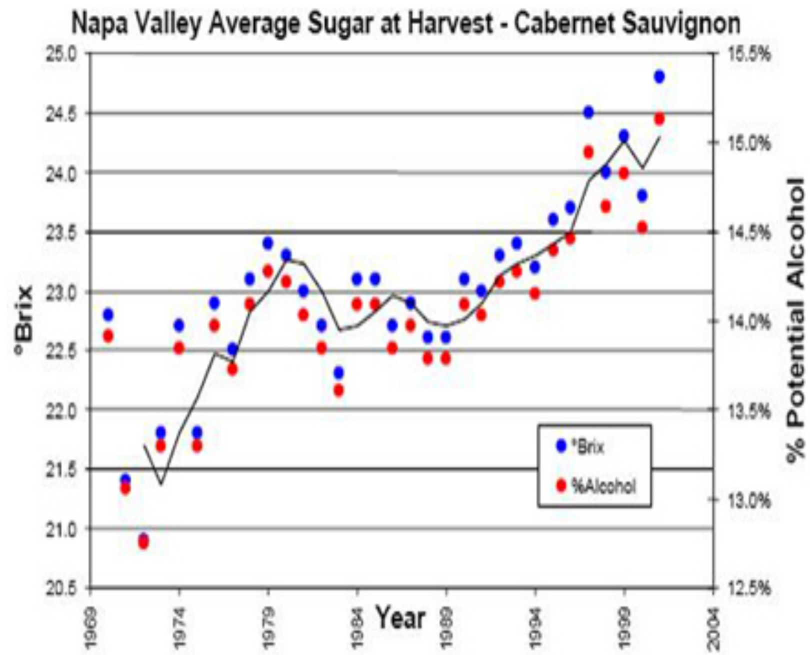



Kliewer and Lider(1970)

Pinot noir

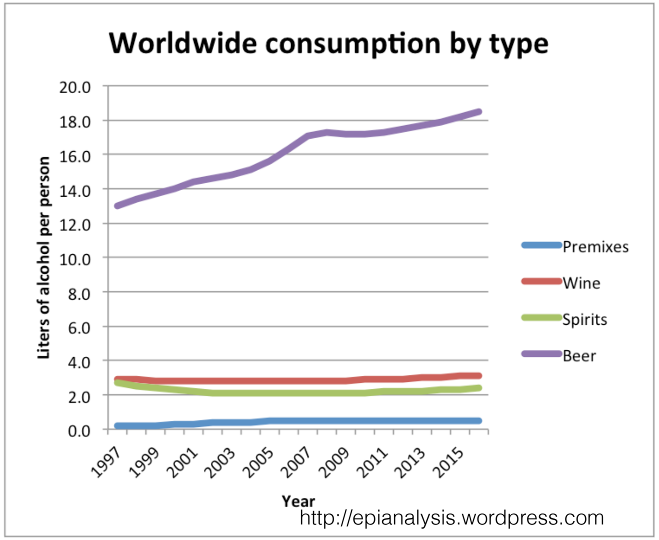
20°C day/15°C night

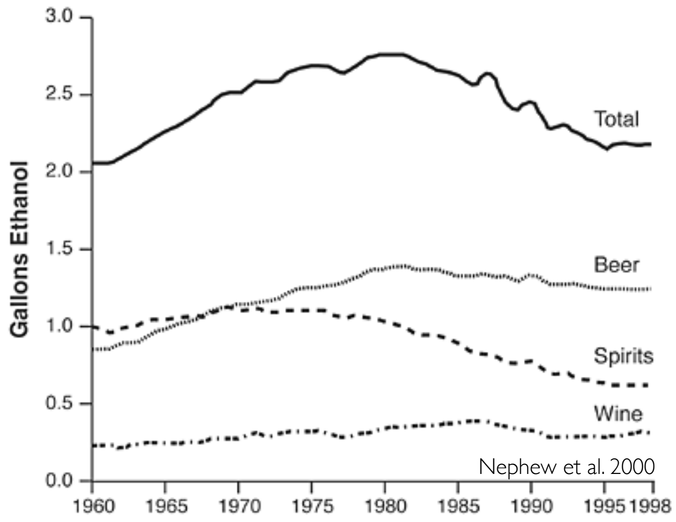
30°C day/15°C night



Why sugar content becomes a problem ?

> 2. Consumers habits





Per capita consumption of beer, wine, and spirits,
and total alcohol consumption in the United States, 1960–1998

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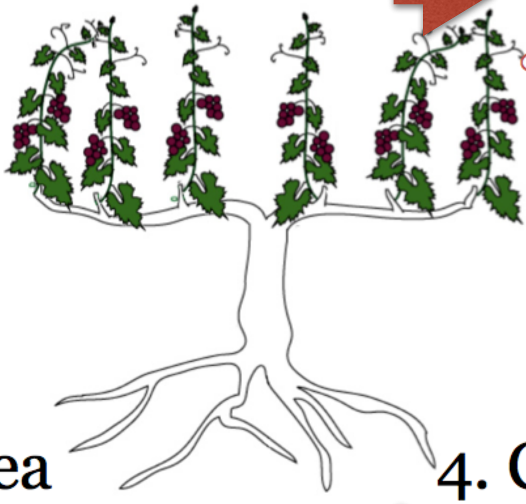
How to mitigate sugar content while maintaining wine quality ?

1. Viticultural practices
- Irrigation
- Shading
- Mist cooling
- Canopy management

2. Wine processing
- De-alcoolization
- New yeast strains
- Water dilution



3. Change growing area
- Move to a higher altitude
- Move to a cooler latitude

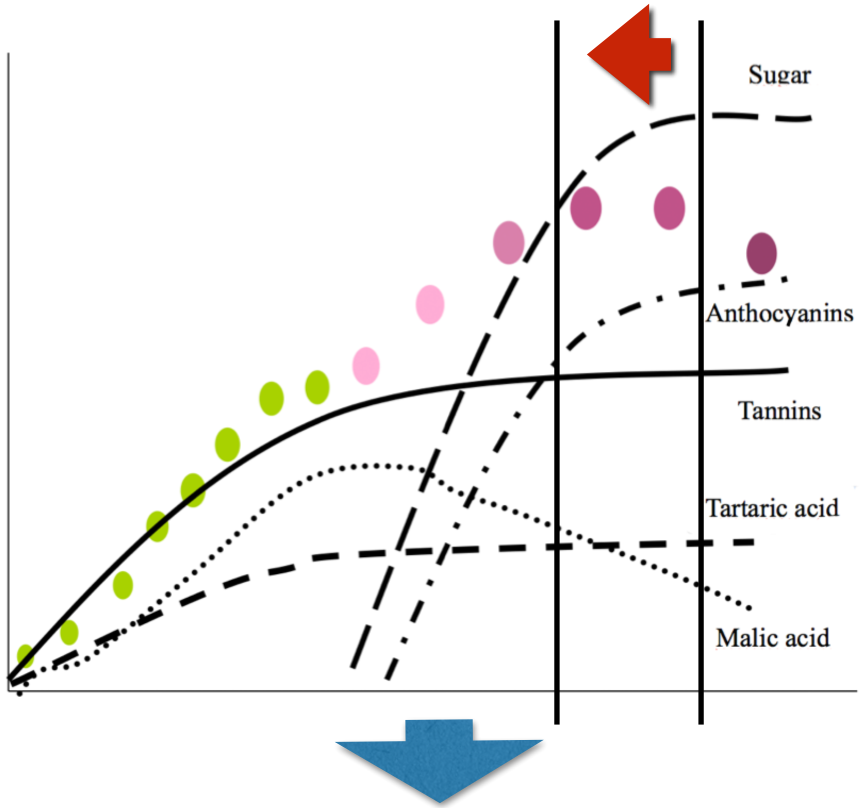
4. Change cultivars
- Selection from germplasm
- Breeding new cultivars

Seasonal terms	Medium terms (1-5 y.)	Long terms (10-15 y)

How to mitigate sugar content while maintaining wine quality ?

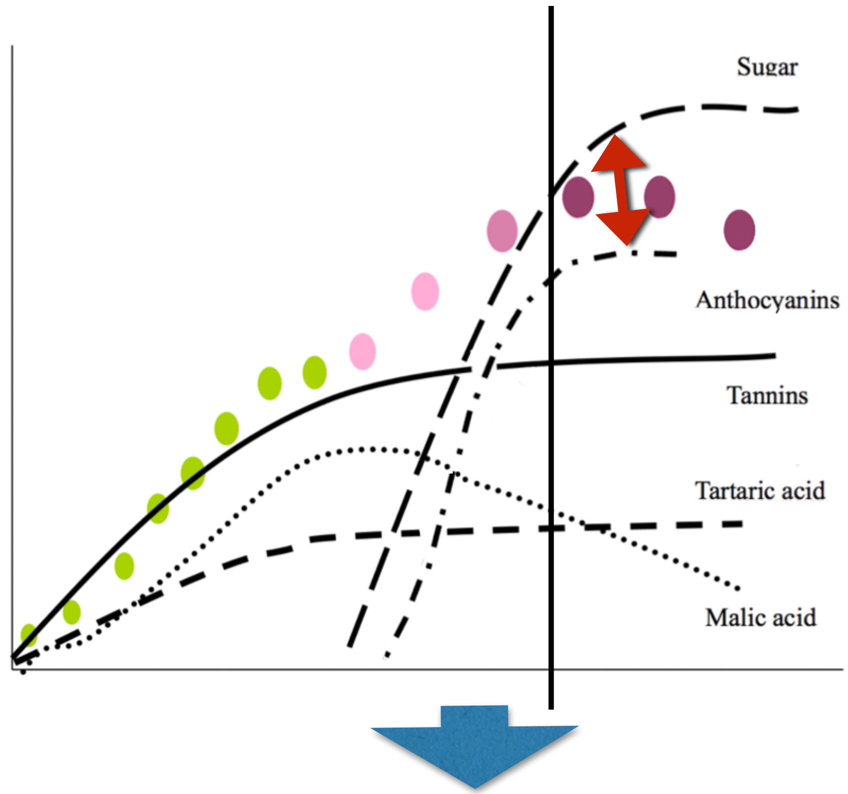
To decrease sugar content in the vineyard: 2 options

1. Harvest earlier ?



Only possible for some cultivars ?
and
mostly for rosé/white wines ?

1. Desynchronize metabolisms ?



Slowing down sugar flux towards the berry (metab1)
or
Stimulating secondary metabolisms (metab2)

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> Conclusions

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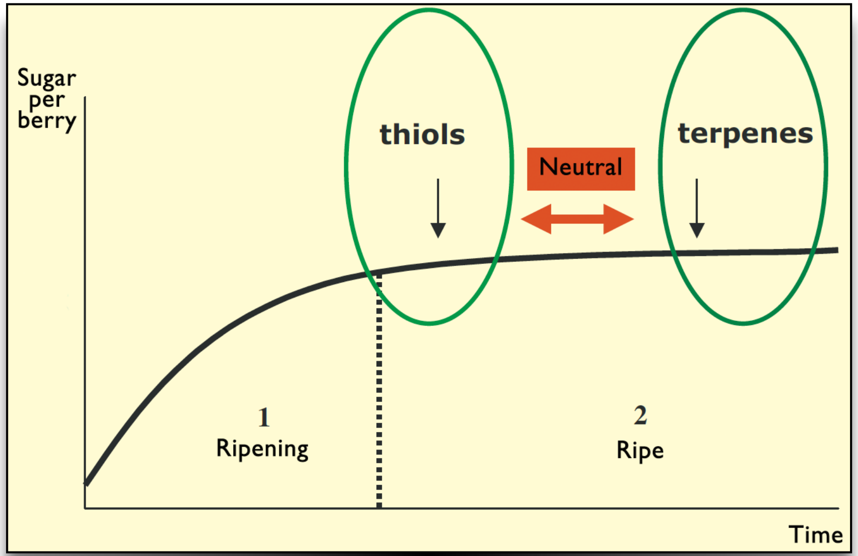
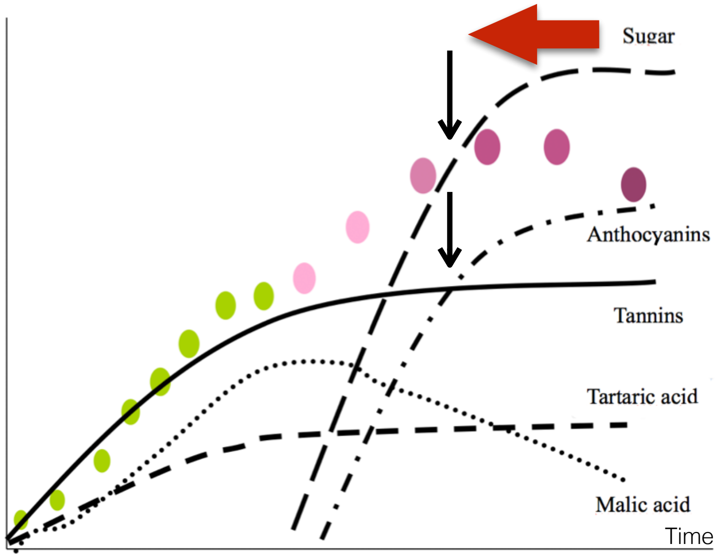
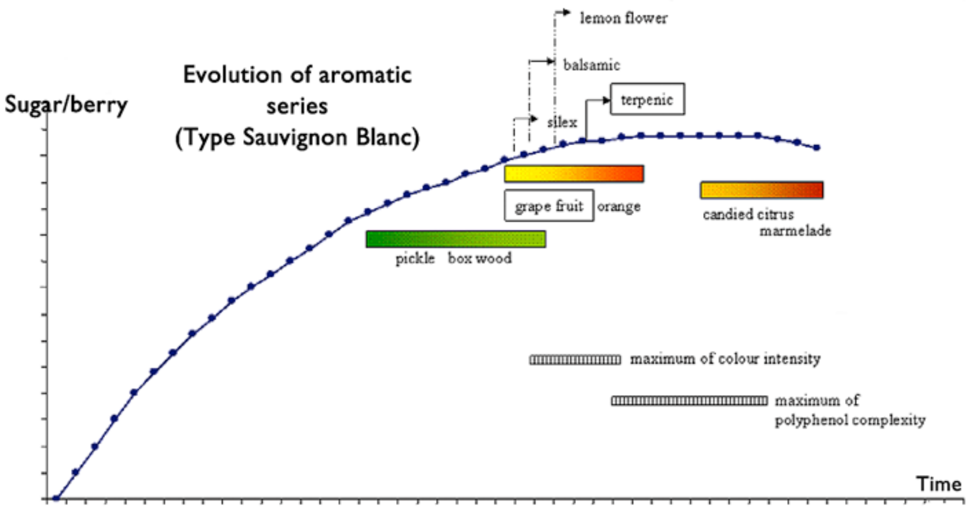
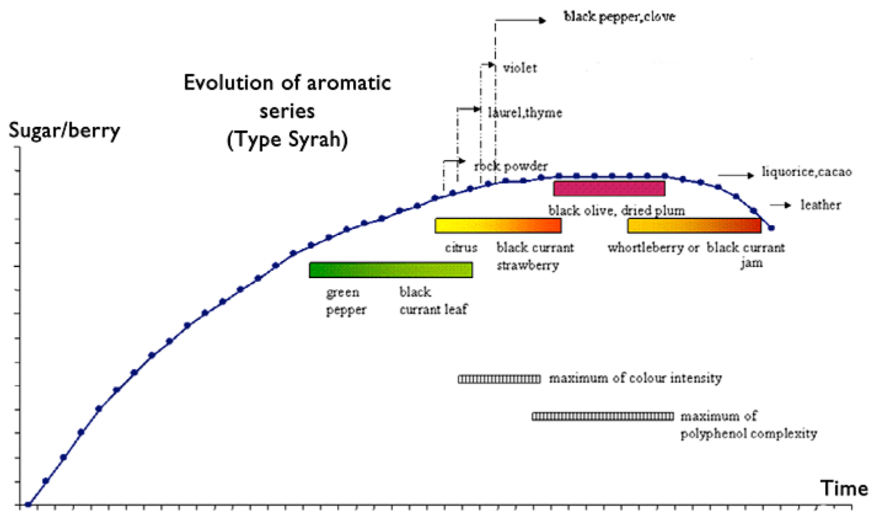


After Deloire (2006)



- Early harvest
- Double harvest
- Selective harvest





After Carbonneau (2007)

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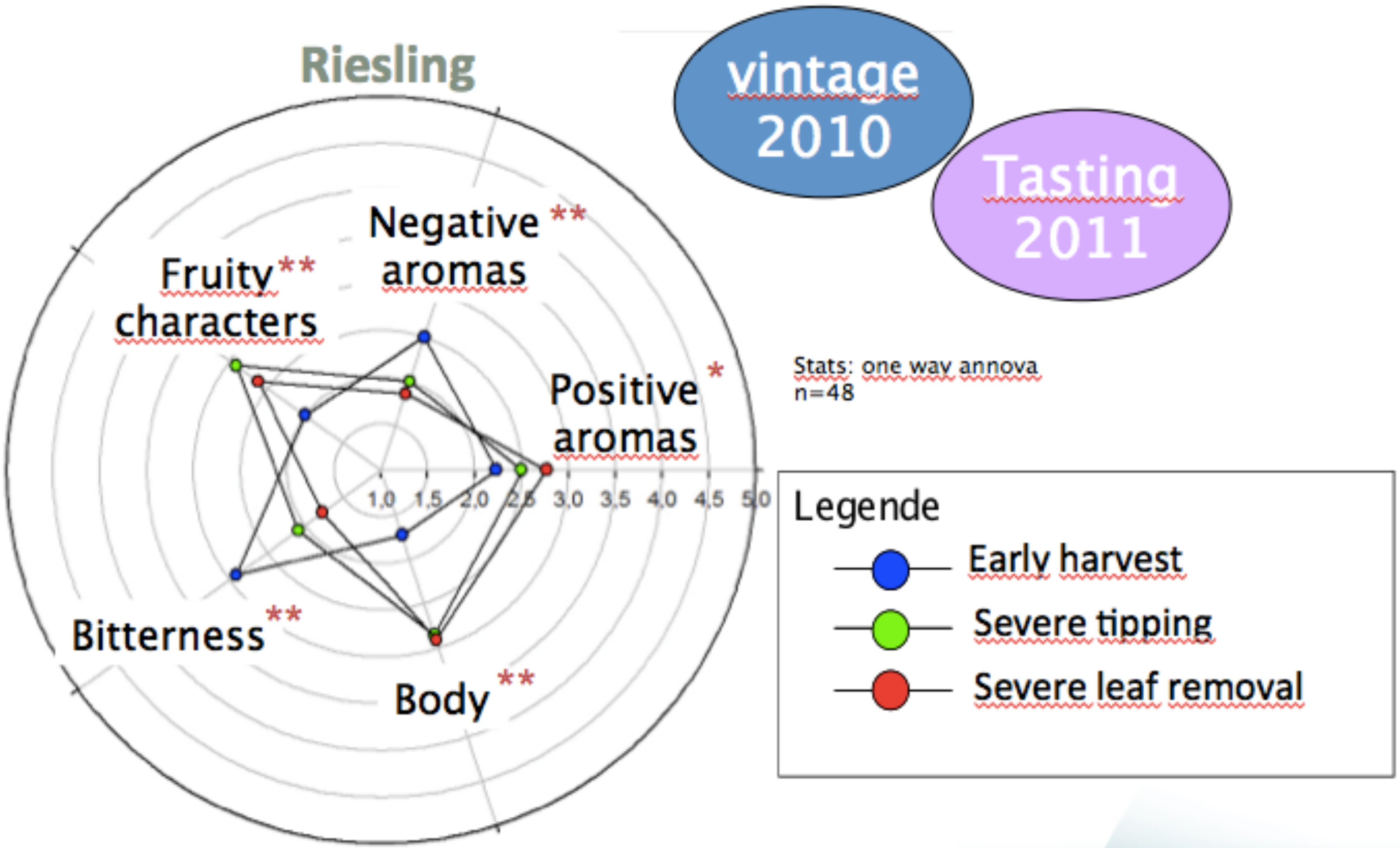


How to mitigate sugar content while maintaining wine quality ?

@ Modifications of cultivation practices

+ Early harvest or block mapping
+ Source/sink or PS efficiency
+ Vigor, phenology & microclimate

1. Hampers biomass accumulation:
Reduce Leaf Area (decrease sugar unloading) improving microclimate (i.e. light exp.)
***> Same date of harvest regarding polyphenols (red) and flavors** (whites)*

Or

2. Stimulate biomass acquisition changing C partitioning:
High Exposed Leaf Area (metab 2 better promoted than 1)
***> Harvest earlier regarding polyphenols** (Reds)*

How to mitigate sugar content while maintaining wine quality ?

> Reduce PS area

Shoot tipping, leaf and lateral removal

From fruit-set to "véraison"

Reduce the velocity of berry maturation

Reduce final sugar content

How to mitigate sugar content while maintaining wine quality ?

> Classical leaf removal around the bunches is not effective

Table 1. Yield and berry quality of Maréchal Foch after plant canopy management techniques of leaf and lateral removal around the fruiting clusters.[y]

Treatment[z]	Yield per plant (total lb)	Cluster number	Avg. berry weight (g)	Soluble solids concentration (%)	Initial pH	Titratable acid (%)
Control (trt 1)	13.0	78	1.12	Control 20.0 a	3.55 a	0.80 b
Treatment 2	15.3	85	1.11	18.9 b	3.39 b	0.92 a
Treatment 3	15.8	96	1.15	18.8 b	3.41 b	0.92 a
Treatment 4	16.4	94	1.14	19.2 b	3.49 ab	0.81 b
LSD P ≤ 0.05[x]	NS	NS	NS	0.5	0.13	0.08

[z]Treatment: 1) Control, no leaves or laterals removed, 2) leaf and lateral removed from across each cluster, 3) leaves and laterals removed from across each cluster and one node above each cluster, and 4) leaves and laterals removed from across each cluster, one node above, and one node below each cluster.

Table 2. Yield and berry quality of Vignoles after plant canopy management techniques of leaf and lateral removal around the fruiting clusters.[y]

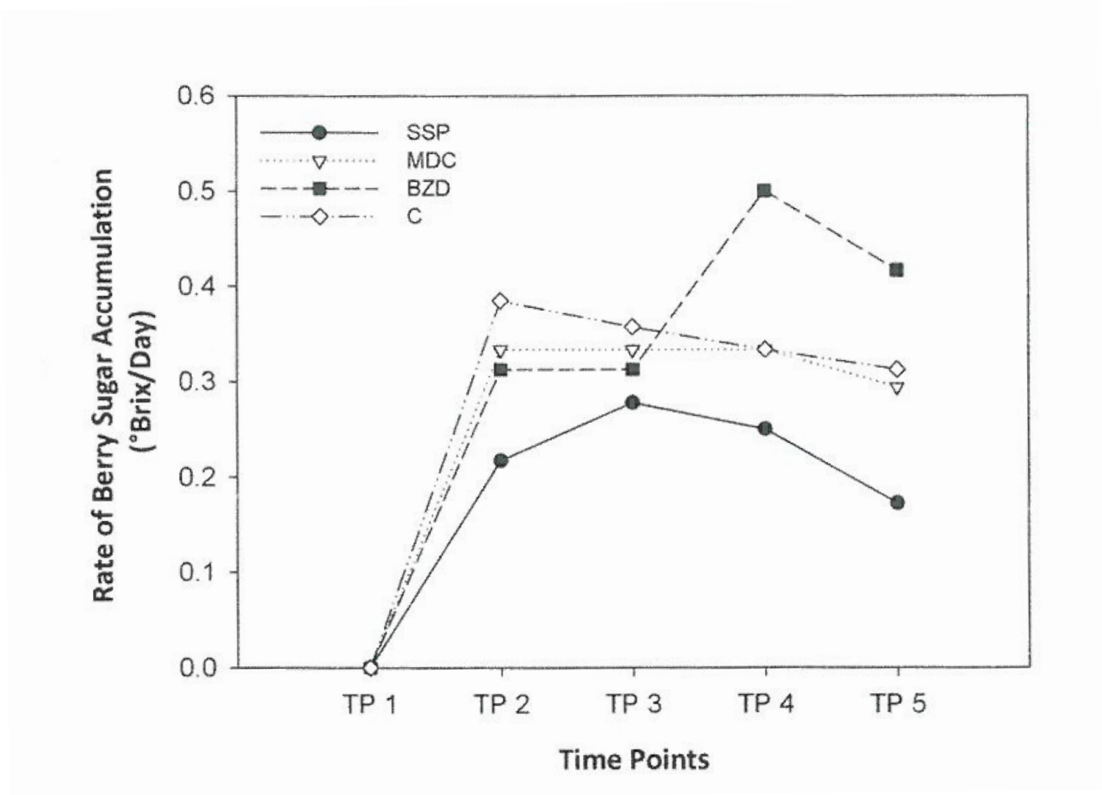
Treatment[z]	Yield per plant (total lb)	Cluster number	Avg. berry weight (g)	Soluble solids concentration (%)	Initial pH	Titratable acid (%)
Control (trt 1)	1.52	17	1.72	Control 22.8 a	3.07 b	1.29
Treatment 2	1.37	13	1.77	20.9 b	3.07 b	1.26
Treatment 3	1.36	14	1.67	22.3 ab	3.04 b	1.30
Treatment 4	2.28	18	1.66	22.8 a	3.15 a	1.27
LSD P ≤ 0.05[x]	NS	NS	NS	1.45	0.07	NS

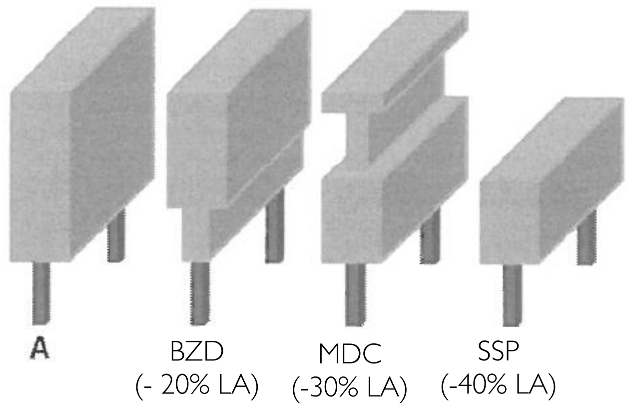
[z]Treatment: 1) Control, no leaves or laterals removed, 2) leaf and lateral removed from across each cluster, 3) leaves and laterals removed from across each cluster and one node above each cluster, and 4) leaves and laterals removed from across each cluster, one node above, and one node below each cluster.

Seeley et al., 2009

How to mitigate sugar content while maintaining wine quality ?

> A strong limitation of PS is necessary





Stoll et al. 2013 - Effect of leaf removal on Riesling sugar unloading

Table III. Effect of canopy manipulations on canopy architecture of Pinot Noir grapevines during the second season of application of the treatments.

	Main leaves size (cm²)	Lateral leaves size (cm²)	Main leaf area/vine (m²)	Lateral leaf area/vine (m²)	Total leaf area/vine (m²)	Lateral leaf area percent of total	Leaf:fruit ratio cm²/g fruit
Tipping							
No	99	31	5.69	2.13	7.82	24	15
Yes	113	38	2.47	1.73	4.18	32	11
Significance (*p*)	0.0067	0.0103	<0.0001	ns*	<0.0001	0.0049	0.0031
Laterals							
Absent	98	—	4.17	—	3.89 b*	—	9 b
Short	109	33	4.24	2.57	6.81 a	39 b	14 a
Long	112	35	3.80	3.22	7.02 a	46 a	15 a
Significance (P)	ns	ns	ns	<0.0001	0.0019	<0.001	0.0005
Leaf Removal							
No	109	37	4.50	2.19	6.68	29	15
Yes	103	32	3.64	1.68	5.32	28	10
Significance (*p*)	ns	ns	ns	ns	ns	ns	0.0012

*Values followed by the same letters within main factors and columns do not differ significantly; ns: not significant at the 5% level. Interactions between main factors were not significant.

Table IV. Effect of canopy manipulations on vine vigor and Ravaz Index of Pinot Noir grapevines during two consecutive seasons.

	Cane wt (g)	Pruning wt (kg/vine)	Trunk volume (cm³)	Ravaz Index (kg fruit/kg (prunings)
Tipping				
No	61	1.209	2394	4.0
Yes	43	0.678	2254	6.0
Significance (p)	<0.0001	<0.0001	ns*	<0.0001
Laterals				
Absent	46 b*	0.839	2282	5.6 a
Short	53 ab	0.953	2260	5.1 ab
Long	56 ab	1.038	2430	4.3 b
Significance (p)	0.0251	ns	ns	0.0158
Season				
Year 1	58	1.081	2458	3.2
Year 2	46	0.805	2190	6.8
Significance (p)	0.0001	0.0001	0.0004	<0.0001

*Values followed by the same letters within main factors and columns do not differ significantly; ns: not significant at the 5% level.

Table II. Effect of canopy manipulations on fruit composition of Pinot Noir grapevines during two consecutive seasons.

	Soluble solids °Brix	Juice pH	Titratable acidity (g/L)	Skin antho-cyanins (mg/berry)	Skin antho-cyanins (mg/g fruit)
Tipping					
No	22.5	3.23	7.24	0.933	0.791
Yes	21.9	3.19	7.52	0.885	0.757
Significance (*p*)	<0.0001	0.0192	ns*	ns	ns
Laterals					
Absent	21.7 c*	3.17 b	7.62	0.849 b	0.722 b
Short	22.2 b	3.22 ab	7.30	0.912 ab	0.772 ab
Long	22.7 a	3.24 a	7.21	0.966 a	0.828 a
Significance (*p*)	<0.0001	0.0045	ns	0.0076	0.0149
Leaf Removal					
No	22.5	3.22	7.50	0.924	0.789
Yes	21.9	3.20	7.26	0.894	0.760
Significance (*p*)	0.0001	ns	ns	ns	ns
Season					
Year 1	22.8	3.27	7.07	0.938	0.741
Year 2	21.6	3.15	7.69	0.880	0.807
Significance (*p*)	<0.0001	<0.0001	0.0006	ns	0.0270

* Values followed by the same letters within main factors and columns do not differ significantly; ns: not significant at the 5% level. Interactions between main factors were not significant.

Table V. Effect of canopy manipulations on trunk carbohydrate reserves of Pinot Noir grapevines during dormancy.

	Starch concentration	Sugar concentration	TNSC concentration	Starch g/trunk	Sugar g/trunk	TNSC g/trunk
Tipping						
No	9.3	3.9 a*	13.2	172.0	71.9 a	244.0
Yes	9.7	3.5 b	13.1	170.4	59.4 b	226.9
Significance (*p*)	ns*	0.0034	ns	ns	0.0011	ns
Laterals						
Absent	9.0	3.5	12.5	156.0	59.0 b	210.7 b
Short	9.4	3.6	13.1	170.1	64.9 ab	235.0 ab
Long	10.0	4.0	13.9	187.0	73.1 a	260.7 a
Significance (*p*)	ns	ns	ns	ns	0.0105	0.0186
Season						
Year 1	11.9 a	3.7	15.7 a	225.5 a	69.6 a	292.2 a
Year 2	7.0 b	3.7	10.7 b	117.0 b	61.7 b	178.7 b
Significance (*p*)	<0.0001	ns	<0.0001	<0.0001	0.0362	<0.0001

*Values followed by the same letters within main factors and columns do not differ significantly; ns: not significant at the 5% level. Interactions between main factors were not significant.

> Possible effects on fruitfulness in long term !

Vasconcelos and Cagnoti (2009) Effect of leaf and lateral removal, and tipping on Pinot Noir

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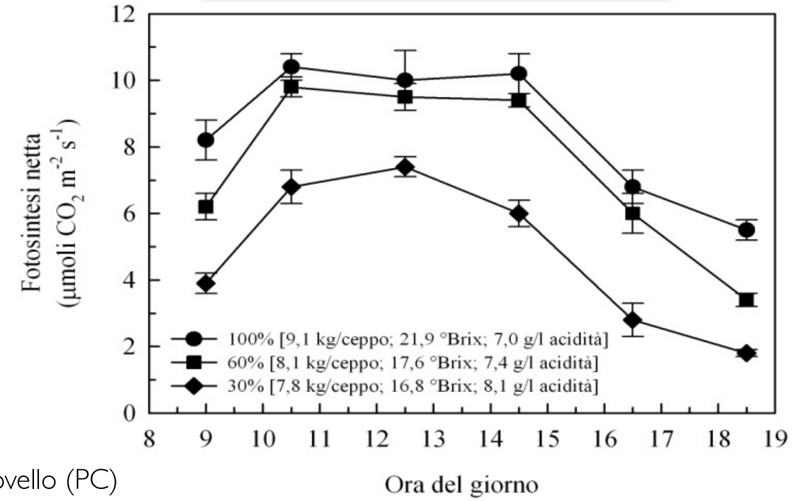
> PS efficiency: Shading nets*/powders or Anti-transpirant sprays

* *extra action on T°*



V. Novello (PC)

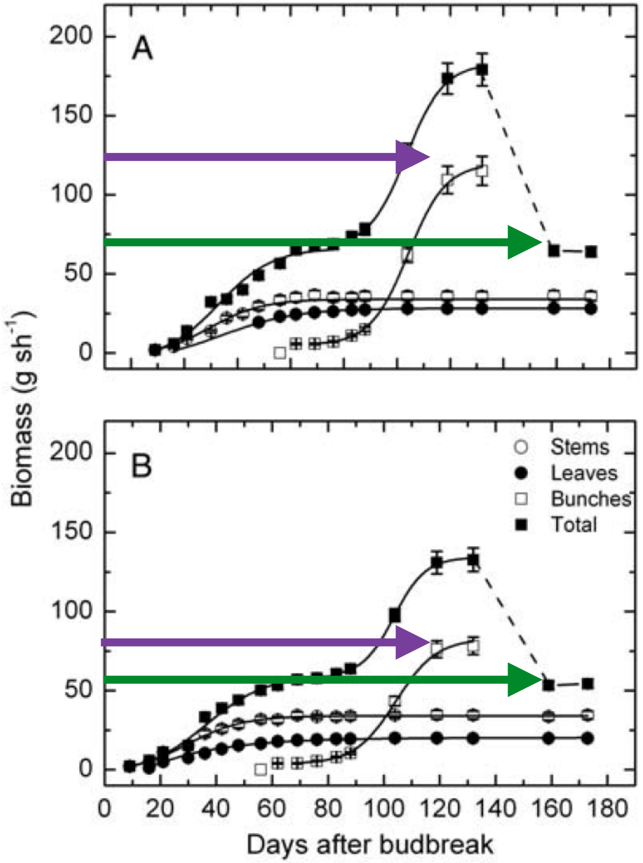


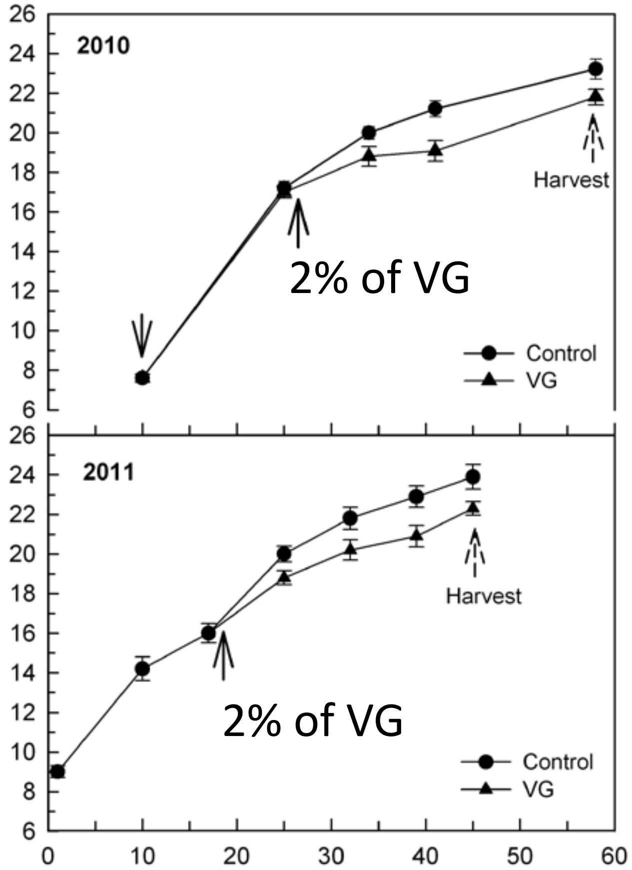
Fig. 1 Changes in dry weight accumulation of leaves, stems and bunches and the total biomass as indicated of shoots across the growing season on Semillon vines grown in an irrigated vineyard without (A) and with shade covering (B) and averaged over two growing seasons (means ± SE, n = 18–36).

Greer et al., 2011

How to mitigate sugar content while maintaining wine quality ?

Anti-transpirants = compounds from distillation of conifer resins 'pinolene'

V. Novello (PC)



Palliotti et al. (2013)

	Grechetto		Sangiovese	
	Control	Vapor Gard	Control	Vapor Gard
Alcohol (% vol.)	14.4 b	13.9 a	14.3 b	13.4 a
Titrat. Acidity (g/l)	4.3 a	4.7 a	4.1 a	4.2 a
pH	3.22 a	3.25 a	3.41 a	3.49 a
Anthocyans (mg/l)	---	---	149 b	101 a
Total Phenols(mg/l)	525 b	360 a	1536 a	1555 a

How to mitigate sugar content while maintaining wine quality ?

> Increase fruitfulness = increase sinks

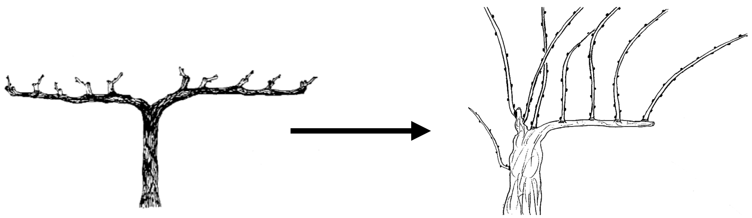
Increase bud load or fertility

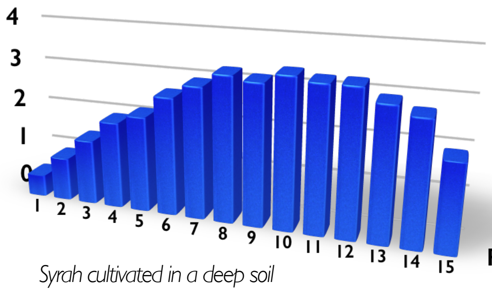
Increase fertilisation (N, H2O)

Use vigorous rootstocks

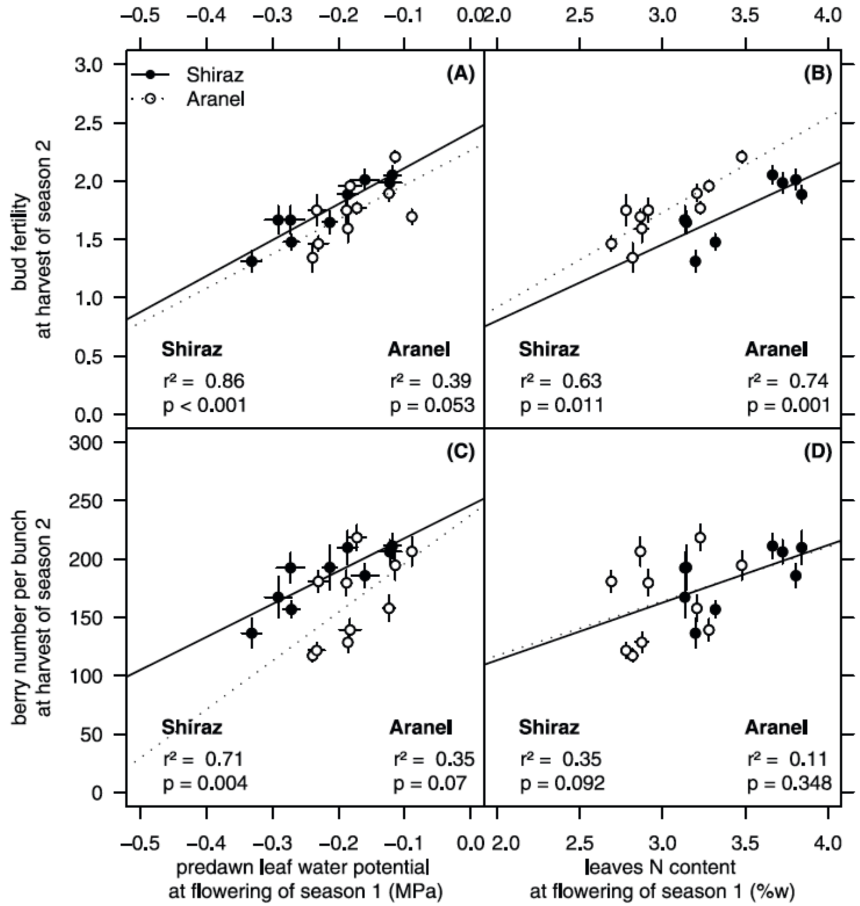
Use productive cvs & cl.

e.g. Pruning system (spur>cane pruning)





e.g. Effect of water and N status at Y-1 on bud fruitfulness at Y



Guilpart et al., 2014

But possible detrimental effect on quality ?

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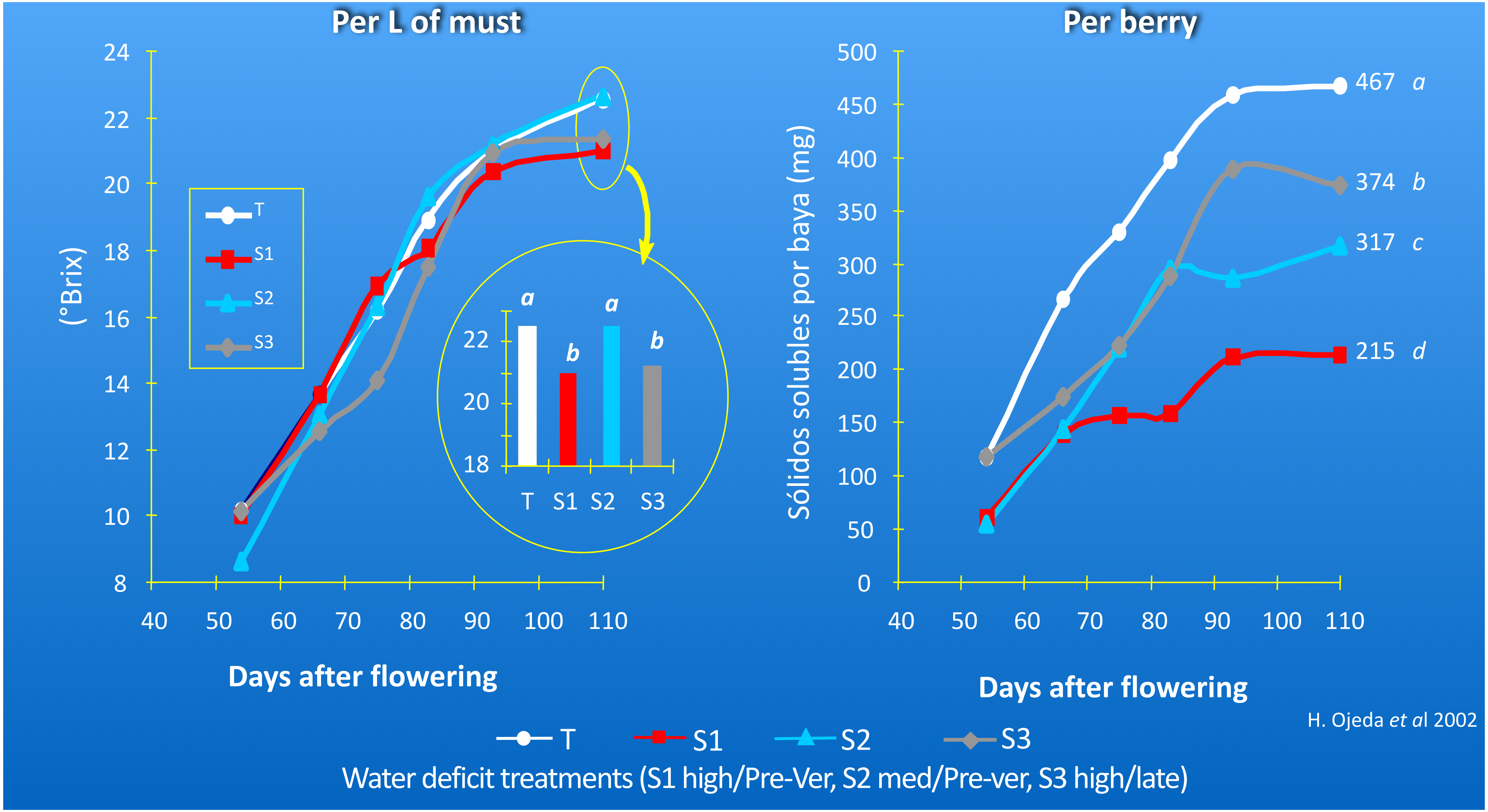

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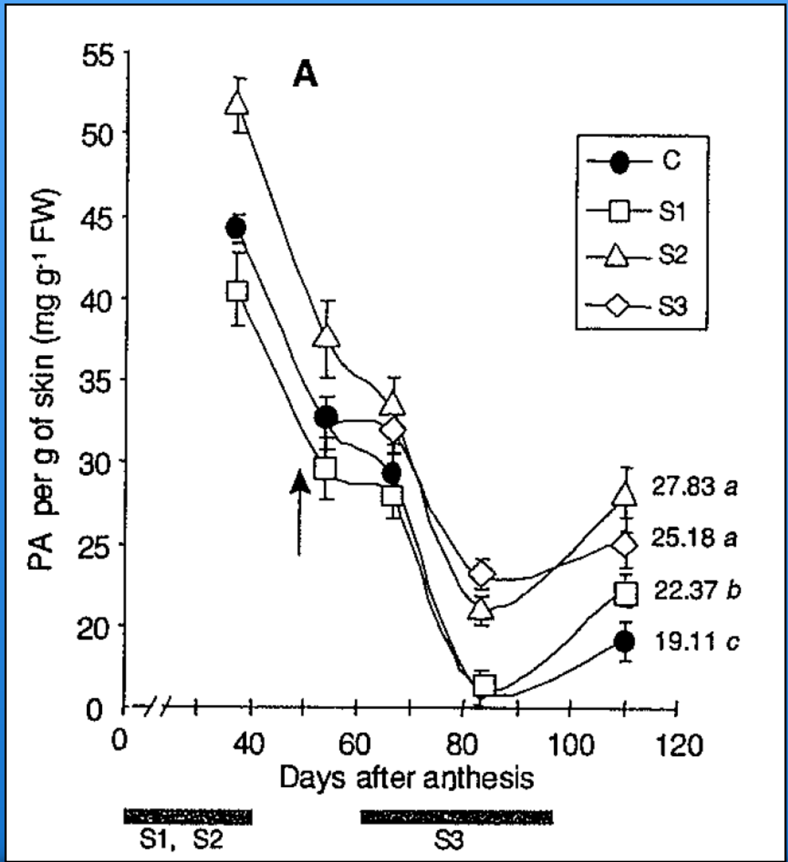

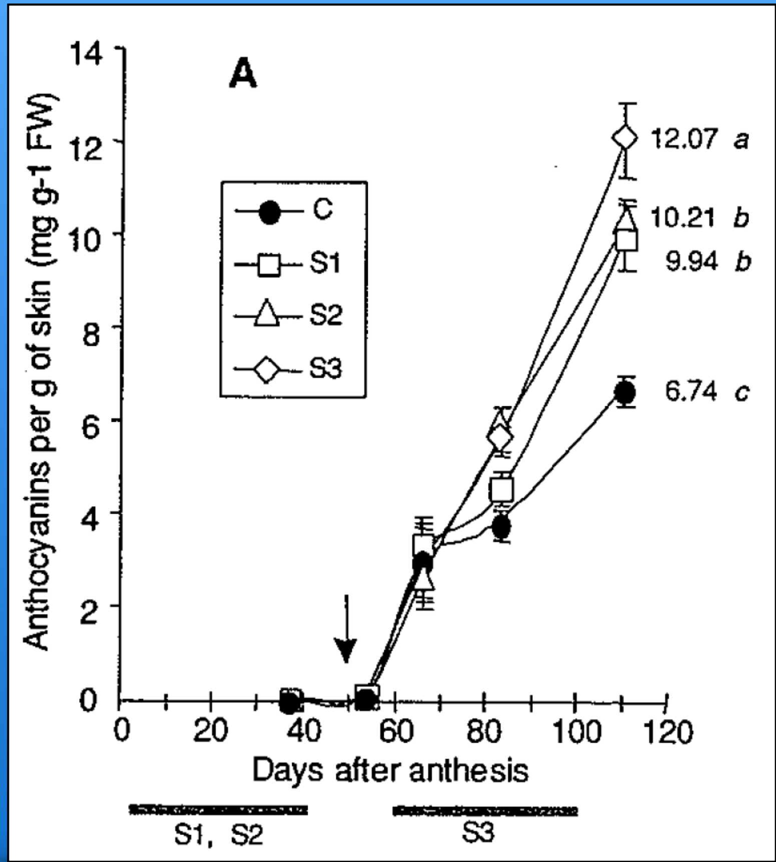

T S1 S2 S3

Water deficit treatments (S1 high/Pre-Ver, S2 med/Pre-ver, S3 high/late)

H. Ojeda *et al* 2002

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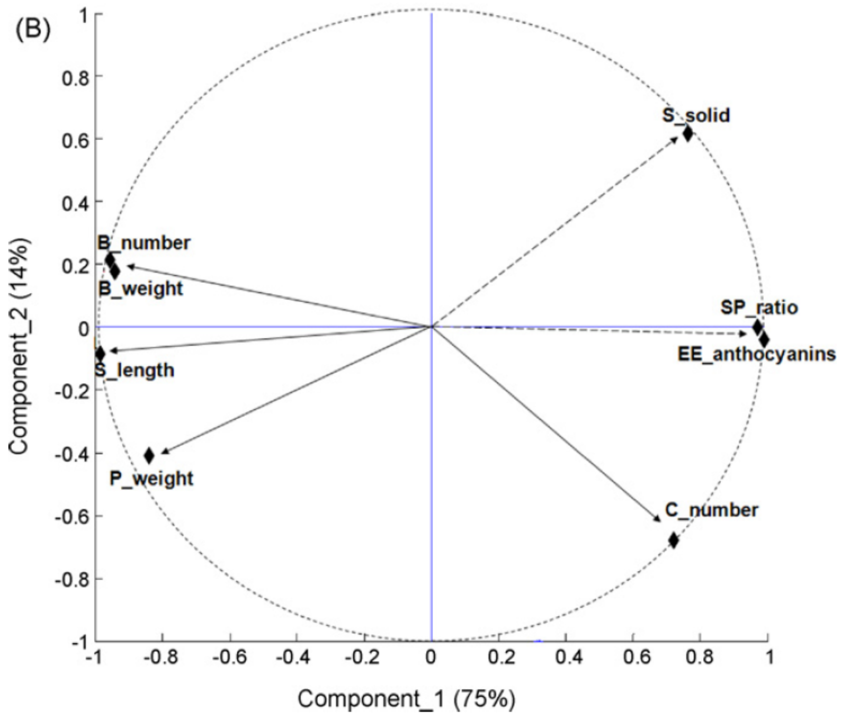
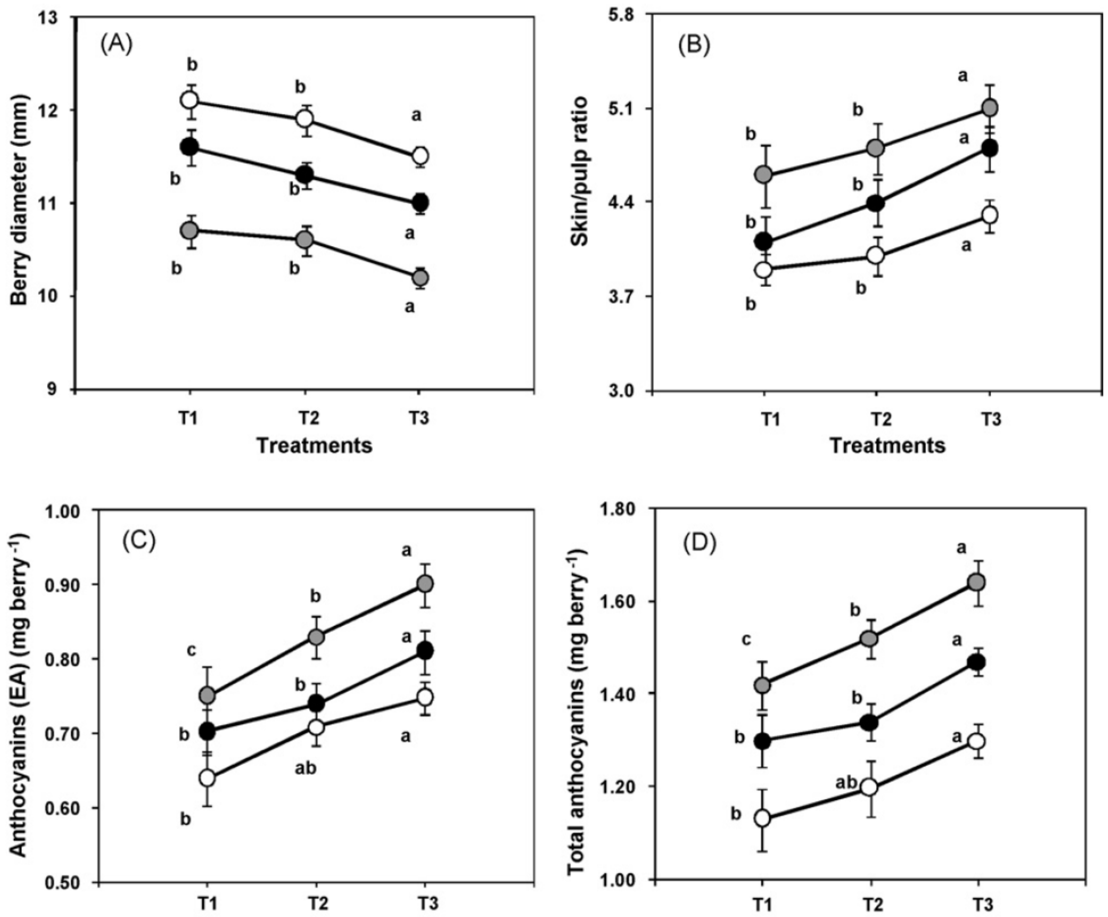
How to mitigate sugar content while maintaining wine quality ?





Regulation of watering (CS) : 3 vintages x 3 water supply charts
(T1 = low deficit, T2 = moderate deficit and T3 = severe deficit)

Acevedo-Opazo et al. (2010)

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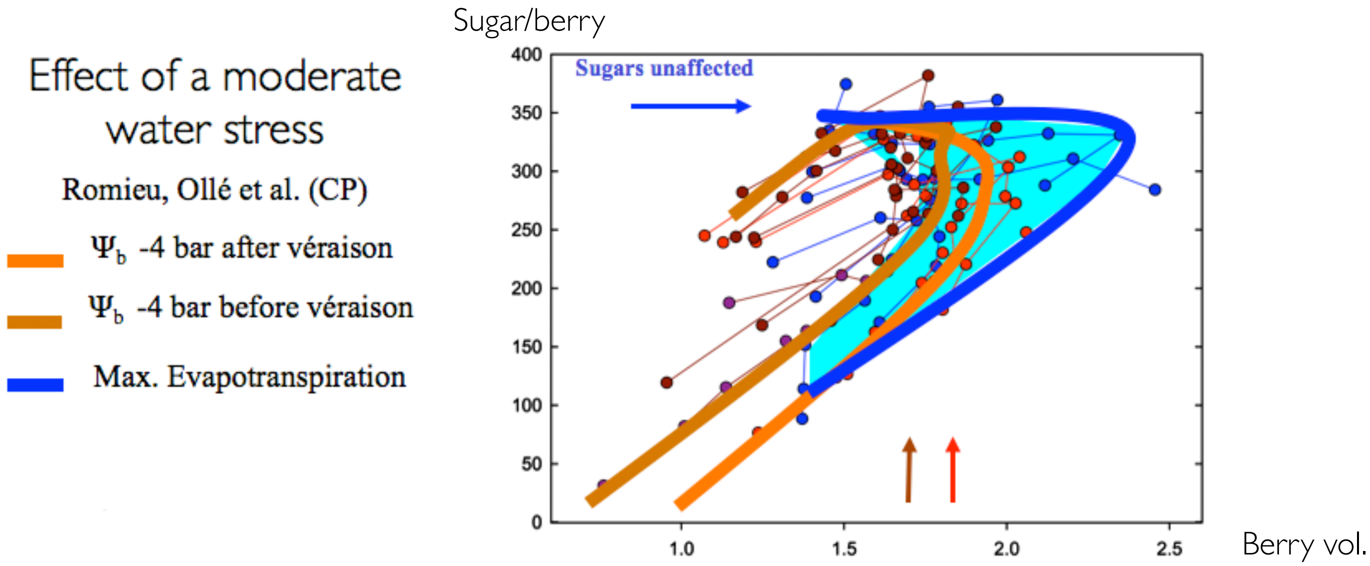
How to mitigate sugar content while maintaining wine quality ?

Effect of a moderate water stress

Romieu, Ollé et al. (CP)



> Severe preVer or postVer water deficits can decrease sugar maintaining polyphenol contents but with a yield loss (berry growth)….

> Abundant and late irrigations (after véraison) decrease sugar & polyphenols by dilution (& resuming vegetative sinks = trophic competition) but with loss of quality….

How to mitigate sugar content while maintaining wine quality ?

Changing the canopy system (microclimate & yield)

e.g. Minimal Pruning or Lyre vs VSP

Increasing yield (sink) with high exposed leaf area (source)
Small berries located outside the canopy
>>> Lower sugar & pH with good balance and phenolics
(GiESCO 2003, 2005, 2007, 2009, 2011, 2013)

How to mitigate sugar content while maintaining wine quality ?

Changing the canopy system (microclimate & yield)

e.g. Minimal Pruning

Table 2. Yield data for spur pruned and minimal pruned Riesling vines
Mean ± s.e. for three vines

	Spur pruned		Minimal pruned	
	1988–89	1989–90	1988–89	1989–90
Harvest date:	28 Feb. 1989	6 Mar. 1990	15 Mar. 1989	21 Mar. 1990
Yield (kg per vine)	8·4 ± 1·5	8·3 ± 0·1	19·1 ± 1·1	19·3 ± 2·2
Yield (t ha^{-1})	16·7 ± 3·0	16·5 ± 0·2	38·0 ± 2·2	38·4 ± 4·4
Sugar (°Brix)	21·4 ± 0·6	20·5 ± 0·1	18·1 ± 0·5	17·6 ± 0·6
Bunches per vine	73·0 ± 10·5	81·0 ± 1·0	421·0 ± 28·0	552·0 ± 2·2
Bunch wt (g)	113·0 ± 6·0	102·6 ± 1·7	45·5 ± 1·3	34·8 ± 3·0
Berries per bunch	121·3 ± 9·9	—	56·7 ± 2·6	—
Berry wt (g)	1·30 ± 0·04	—	0·80 ± 0·01	—
Berry diameter (mm)	13·3 ± 0·5	—	11·1 ± 0·1	—
Leaf area per fruit wt (cm^2/g)	28·3 ± 5·1	—	9·0 ± 0·5	—
Cane (g dry wt)	2076 ± 247	—	497 ± 43	—

Dowton and Grant (1992)

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How to mitigate sugar content while maintaining wine quality ?

Changing the canopy system (microclimate & yield)

e.g. Minimal Pruning

parameters varieties	Bacchus (1)		Müller-Thurgau (1)		Silvaner (2)	
training system	*MP*	*CPT*	*MP*	*CPT*	*MP*	*CPT*
yield kg/100 m²	154,3 a	141,7 a	150,5 a	133,7 a	297,6 a	96,6 b
must weight in °Oechsle	74,7 a	77,7 a	73,8 a	77,5 a	70,5 b	84,7 a
must acid g/l	6,2 a	6,4 a	5,8 a	7,00 a	9,0 a	7,2 b
leaf area m²/vine	13,9 a	4,3 b	14,4 a	4,0 b	36,0 a	4,5 b
leaf area index (LAI) m²/m²	5,79 a	1,79 b	6,00 a	1,67 b	9,60 a	1,20 b
leaf to fruit relation	2,54 a	0,91 b	3,40 a	0,91 b	2,19 a	0,95 a
total nitrogen in must mg/l	284 a	229 b	296 a	258 a	593 a	579 a
total amino acids in must in mg/l	1434 a	1043 a	1338 a	992 a	2203 a	2224 a
arginin in must in mg/l	402 a	238 b	370 a	259 a	969 a	1036 a
glutamin in must in mg/l	206 a	113 a	120 a	90 a	300 a	197 a
prolin in must in mg/l	106 a	134 a	187 a	137 a	49,6 a	114 a
methionin in must in mg/l	8,8 a	4,9 b	7,3 a	3,9 b	14,4 a	12,2 a
yeast assimilable amino nitrogen (YAN) mg/l must	276 a	181 b	231 a	167 a	514 a	514 a
residual extract in wine in g/l	8,35 a	6,90 b	5,30 a	3,92 a	7,94 a	8,13 a
sensoric valuation of wines (0-5 points)	1,86	1,8	2,01	1,9	1,63	1,47

Means with same letters are not significantly different at p < 0,05; MP = minimal pruning; CPT = cane pruned trellis,
(1) site Leinach, SW-site, sandy loam soil, 25 % inclination, permanent green cover, rootstock 5 C
(2) site Erlabrunn, S-exposed, profound and humous sandy loam, 35 % inclination, autum-winter green cover, rootstock 5 C

Schwab (1995)

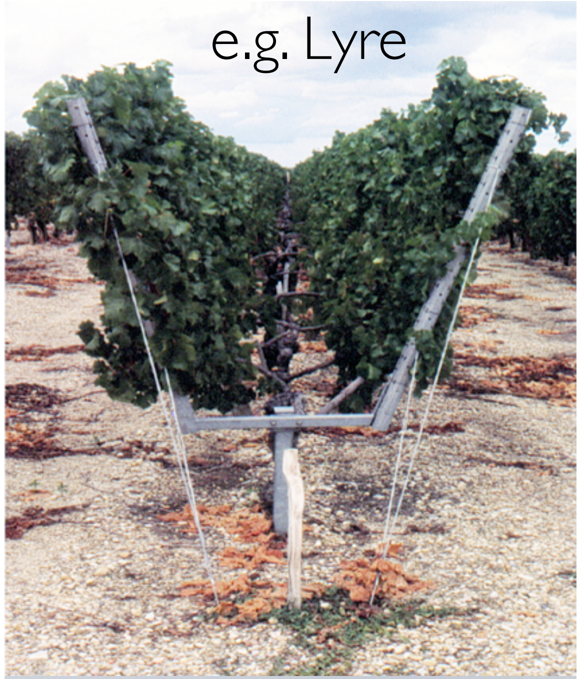
How to mitigate sugar content while maintaining wine quality ?

Changing the canopy system (microclimate & yield)

CARACTERISTIQUES PHENOLIQUES DES VINS DE MERLOT EN SOL DE GRAVES ET AOC « PREMIERES CÔTES DE BORDEAUX » - INRA Bordeaux

	ESPALIER TRADITIONNEL	LYRE OUVERTE
1983		
D 280	27	33
Anthocyanes (mg/l)	**308**	**325**
Tanins (g/l)	**1,27**	**1,74**
Indice de p v p (%)	42	38
Indice HCl (%)	19	19
Indice de gélatine (%)	**62**	**49**
1984		
D 280	30	34
Anthocyanes (mg/l)	**310**	**345**
Tanins (g/l)	**1,53**	**1,59**
Indice de p v p (%)	56	58
Indice HCl (%)	15	13
Indice de gélatine (%)	**45**	**30**
1985		
D 280	30	42
Anthocyanes (mg/l)	**398**	**560**
Tanins (g/l)	**1,50**	**1,97**
Indice de p v p (%)	46	51
Indice HCl (%)	16	23
Indice de gélatine (%)	**54**	**49**

Tableau x+8



Teneurs en 2-phényléthanol et en 2-phényléthyl acétate exprimées en µg de linalol/100 ml de vin, pour le Gewurztraminer, la récolte 1987 et les systèmes de conduite vigne traditionnelle alsacienne ® et Vigne en lyreouverte (L0). Résultats de l'INRA – Colmar (Domaine de Rorschwhir).

	R	LO
2-phényléthanol	1372	6603
2-phényléthyl acétate	21	90

Teneur en phényl-2-éthanol (mg/l) des vins produits dans une parcelle argilocalcaire du Domaine INRA de Couhins (Appellation « Graves »).
Résultats concernant le porte - greffe Fercal et un niveau normal de fumure.
Analyses de JP. ROSIER et A.BERTRAND.

	1988		1989		1990		1991		
Système de conduite	Sémillon	Sauvignon	Sémillon	Sauvignon	Sémillon	Sauvignon	Sémillon	Sauvignon	Moyenne des SC
Lyre ouverte	25,0	30,0	22,2	15,5	42,0	40,2	21,0	11,4	25,9
Vigne étroite classique	17,4	15,7	20,9	10,8	31,1	30,5	17,8	10,4	19,3
Moyenne du millésime	22,0		17,3		36		15,1		

Tableau x+10

How to mitigate sugar content while maintaining wine quality ?

Outline

> What is wine quality and why the regulation of alcool contents is critical ?

@ Modifications of cultivation practices
+ Early harvest or block mapping
+ Source/sink or PS efficiency
+ Phenology, vigor & microclimate

@ **Cultivar selection and improvement**
+ Rootstock adaptation
+ Cultivar selection

> Conclusions

How to mitigate sugar content while maintaining wine quality ?

> Effect of rootstock on Chenin blanc harvest characteristics (Loire valley)

1995	Harvest date	Yied Kg.vine	Ethanol % vol	Must sugars g/l	Total acidity g/l	pH	Tartaric g/l	Malic g/l
+++ *Fercal*	18/10/1995	1,236	12,8 +++	217,7	4,7	3,32	2,97	3,20
- - - *Gravesac*	18/10/1995	1,245	10,9 - - -	186,2	5,0	3,18	3,50	3,47
SO4	18/10/1995	1,012	11,1	188,4	5,0	3,15	4,15	3,10
1103P	18/10/1995	0,902	10,7	181,8	4,5	3,15	3,54	2,88
- - - *Rupestris*	18/10/1995	0,899	11,4 - - -	194,0	4,5	3,36	2,19	3,55
3309C	18/10/1995	1,149	11,1	188,4	4,5	3,17	3,15	2,93
+++ *110R*	18/10/1995	0,985	12,2 +++	207,5	4,3	3,29	2,75	3,21
+++ *Riparia*	18/10/1995	1,024	11,6 +++	196,3	5,1	3,10	3,43	2,79

1996	Harvest date	Yied Kg.vine	Ethanol % vol	Must sugars g/l	Total acidity g/l	pH	Tartaric g/l	Malic g/l
+++ *Fercal*	28/10/1996	0,506	13,9 +++	237,0	4,14	3,60	4,43	2,39
- - - *Gravesac*	28/10/1996	0,724	11,6 - - -	197,7	4,44	3,54	5,26	2,82
SO4	28/10/1996	0,551	13,1	222,9	4,87	3,53	5,35	3,00
1103P	28/10/1996	0,391	12,5	212,5	4,02	3,70	4,15	2,39
- - - *Rupestris*	28/10/1996	0,453	11,6 - - -	197,7	4,09	3,64	4,14	2,66
41B	28/10/1996	0,599	12,0	204,5	4,26	3,55	5,26	2,37
3309C	28/10/1996	0,519	12,5	221,5	4,76	3,49	4,98	3,11
+++ *110R*	28/10/1996	0,641	13,8 +++	234,6	4,48	3,61	3,76	3,40
101-14	28/10/1996	0,337	13,2	224,1	4,31	3,66	4,13	3,29
+++ *Riparia*	28/10/1996	0,582	13,1 +++	222,9	4,74	3,48	5,62	2,75

Millet (2000)

But:
1. Interactions (practices x year x cultivar) x rootstock ?
2. Difficult to control primary (sugar & acids) vs secondary metabolites

How to mitigate sugar content while maintaining wine quality ?

> New rootstocks with low-to-moderate vigor inducing capacities ?

Merbein series >>> color & phenolics (+ 20% in Shiraz with -1.5° Brix)

Shiraz/ Rootstock	Vigour	Harvest			Wine				
	Prun. Wt. (kg)	Juice °Brix	Juice pH	Yield (kg)	Acid Added (g/L)	Wine pH	Colour Density (au)	Colour Hue	Total Phenolics (au)
1103 Paulsen	4.2c	25.6d	4.18d	11.8b	4.72d	3.57b	6.26ab	0.61b	53.8b
Ramsey	4.3c	25.2c	4.25e	16.7c	5.95e	3.58b	5.84a	0.59b	49.5a
Merbein 5489	2.0b	24.3b	3.83a	13.3b	1.90a	3.49a	7.56c	0.54a	60.9c
Merbein 5512	1.5ab	24.5b	3.91b	8.8a	2.72b	3.48a	6.55b	0.55a	56.8b
Merbein 6262	1.2a	23.7a	3.94b	9.9a	2.60ab	3.51a	8.17d	0.53a	62.4c

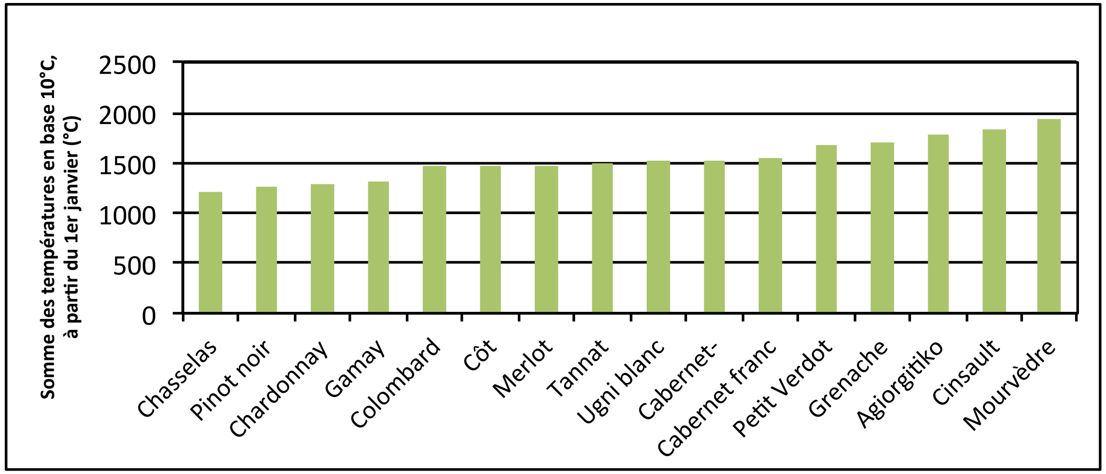


Canopy growth of Ramsey (left), Merbein 5512 (middle) and Merbein 6262 (right), managed with deficit irrigation (season 2010).

Clingeleffer et al. 2011

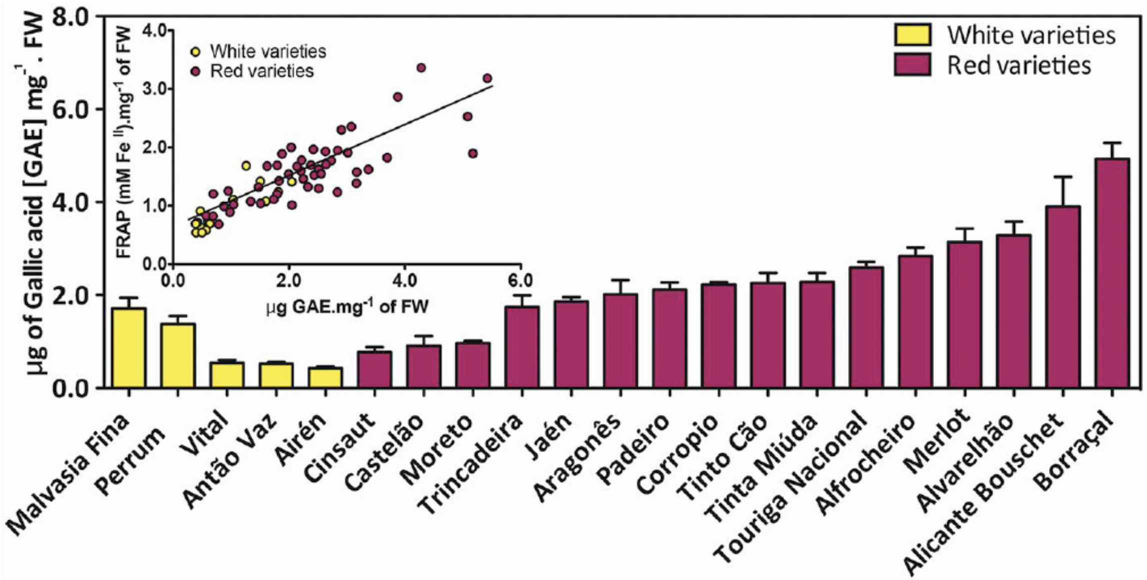
How to mitigate sugar content while maintaining wine quality ?

> Use cultivars with late harvest period (needs higher ∑ t° to ripe)



Van Leeuwen et al. (2008)

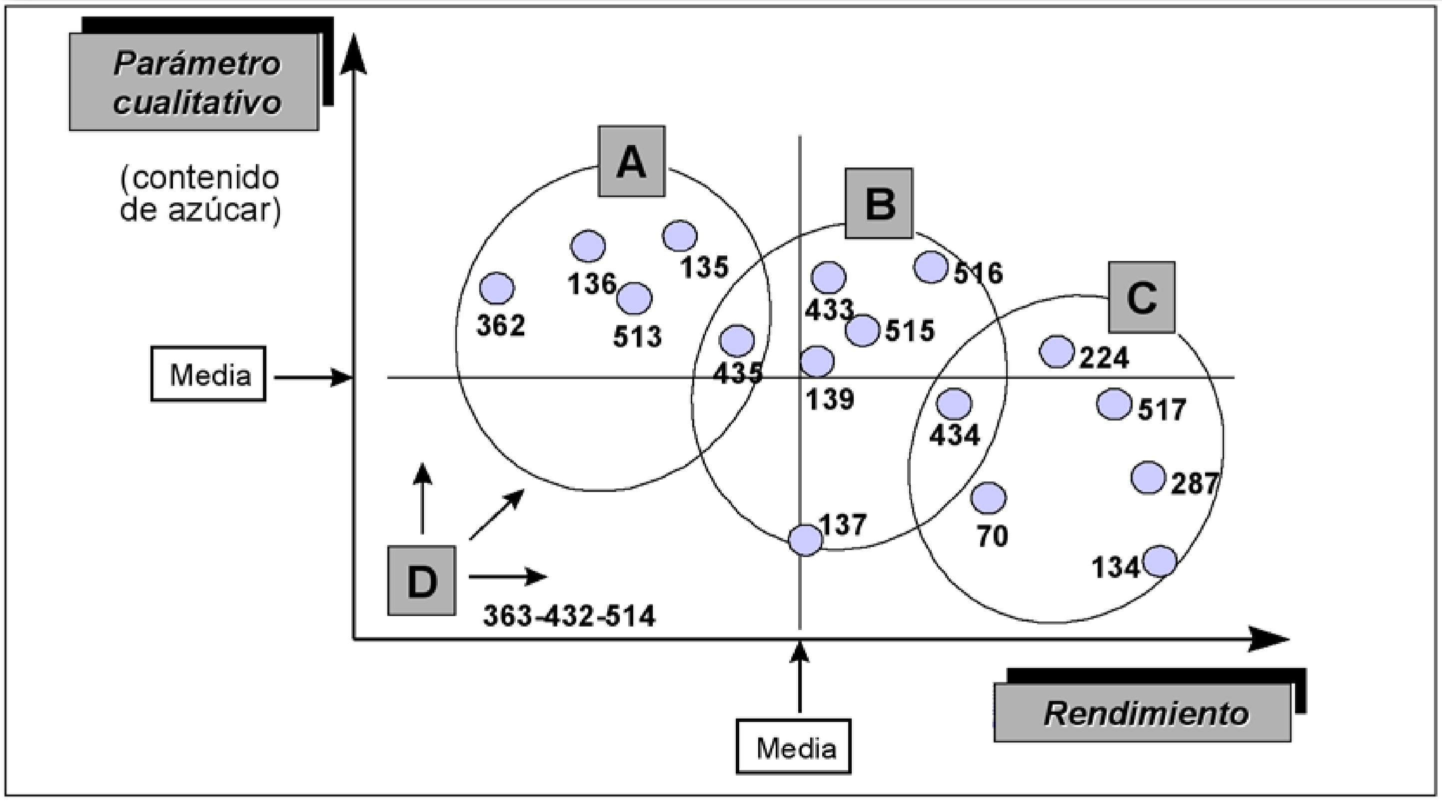
> Use cultivars with specific berry properties (e.g phenolics)



Teixeira et al. (2013)

How to mitigate sugar content while maintaining wine quality ?

> Select new clones that higher fruitfulness



Scarzi (2002) d'après Oustric (1994)

But, this supposes

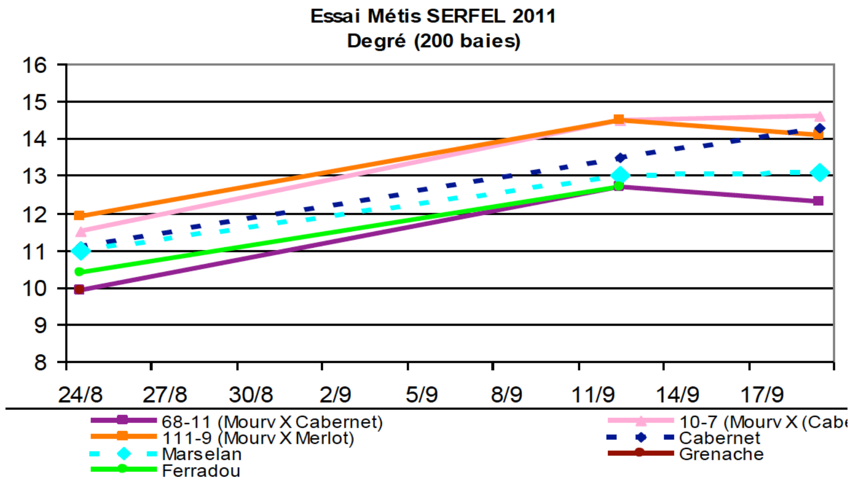
1. **Some clonal diversity was secured in germplasm and still available ?**
2. **Metab2 is not hampered regarding Metab1 (ex. Grenache cl. 70 ?)**

How to mitigate sugar content while maintaining wine quality ?

> Select new cultivars on specific physiological new criteria

Cienna (2000)
(Sumoll x CS)

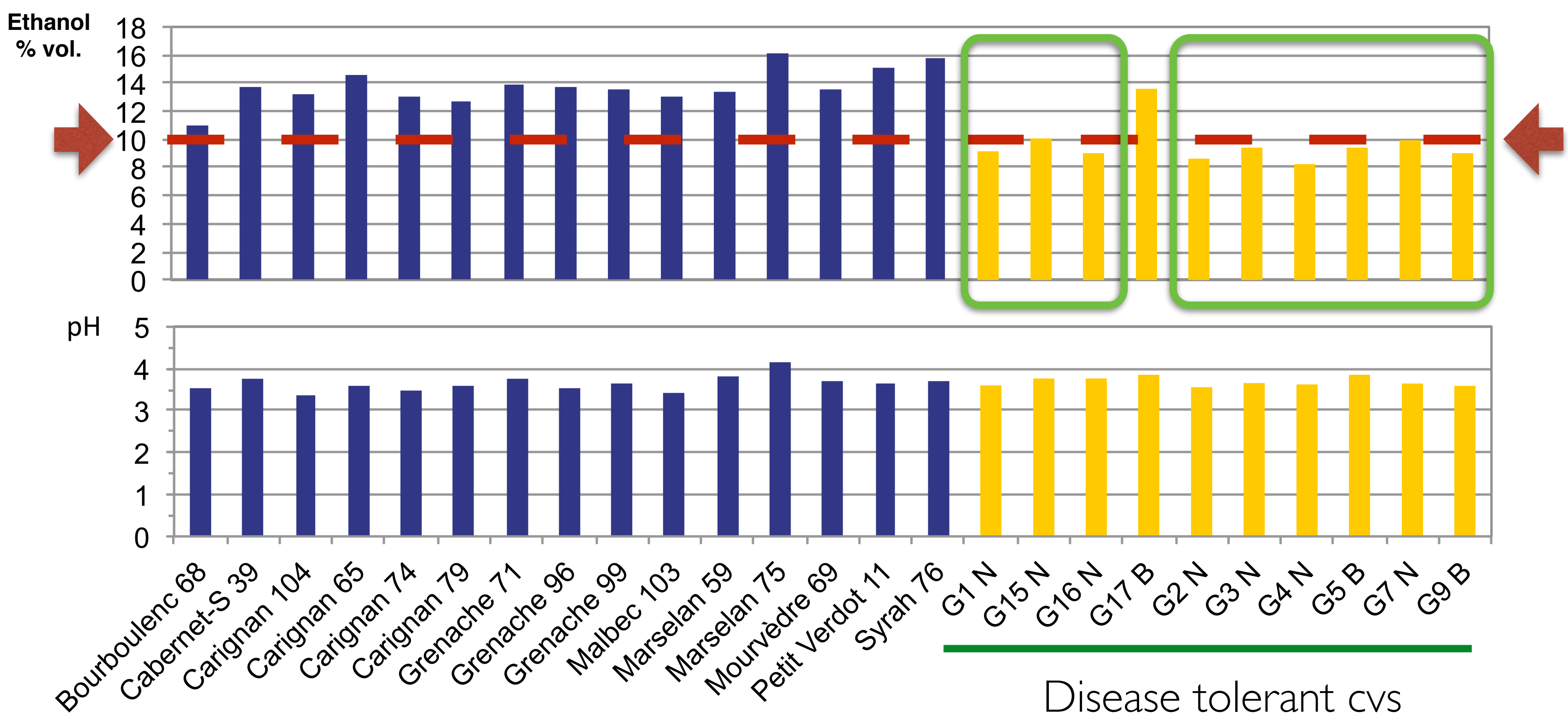
Cabestrel (2011)
(CS x Mourvèdre)



	2011		
	MARSELAN	**Cabestrel**	**Ferradou**
Date de récolte	19/09/11	19/09/11	14/09/11
Degré	11,8	11,5	12,2
AT	3,18	4,2	4,86
pH	3,86	4,05	3,19
AV	0,47	0,64	0,38
DO520/IPT	36	51	47
IC	7,53	12,8	19

How to mitigate sugar content while maintaining wine quality ?

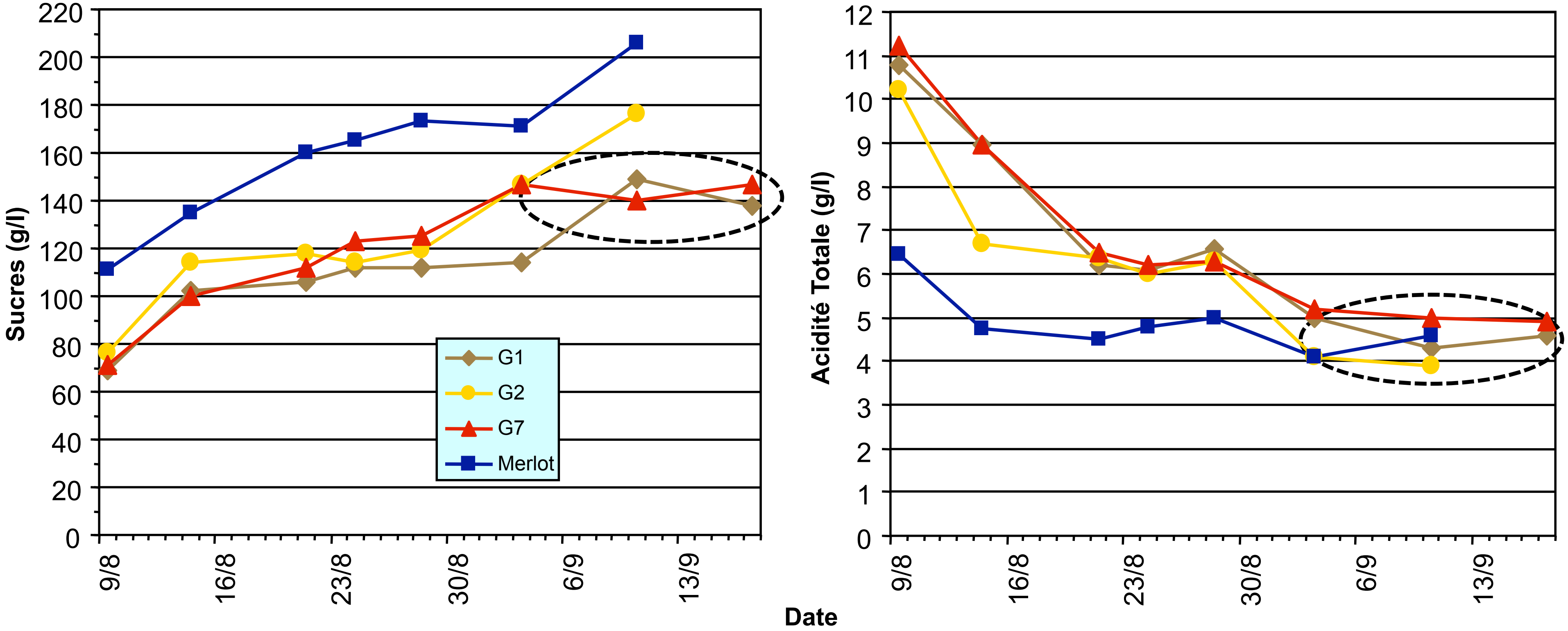
> Select new varieties (new metabolism dynamics)



VDQA project - A selection of classical cultivars and new accessions selected at INRA center of Pech-Rouge (Gruissan)

How to mitigate sugar content while maintaining wine quality ?

> Select new varieties (new metabolism dynamics)



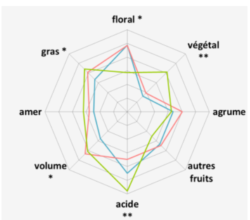
VDQA project - A selection of classical cultivars and new accessions selected at INRA center of Pech-Rouge (Gruissan)

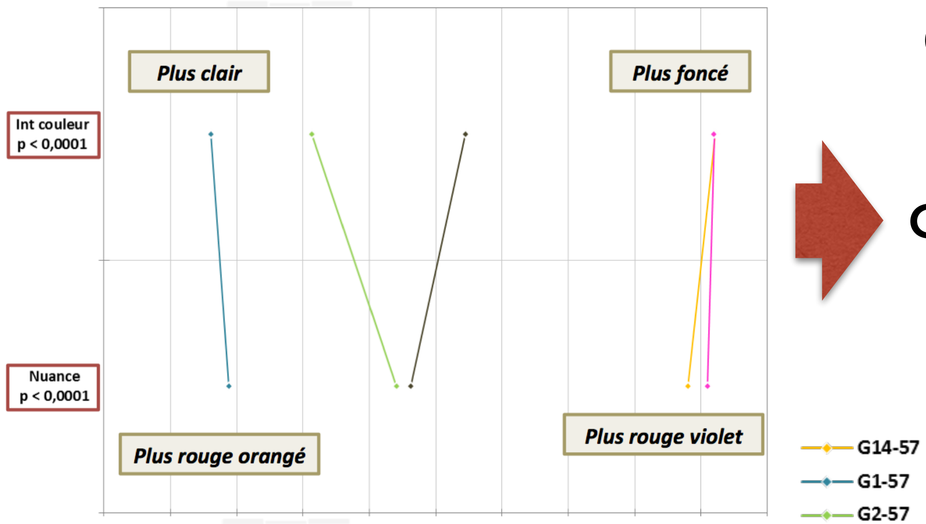
> G1, G2 and G7 are totally resistant to downy and powdery mildew

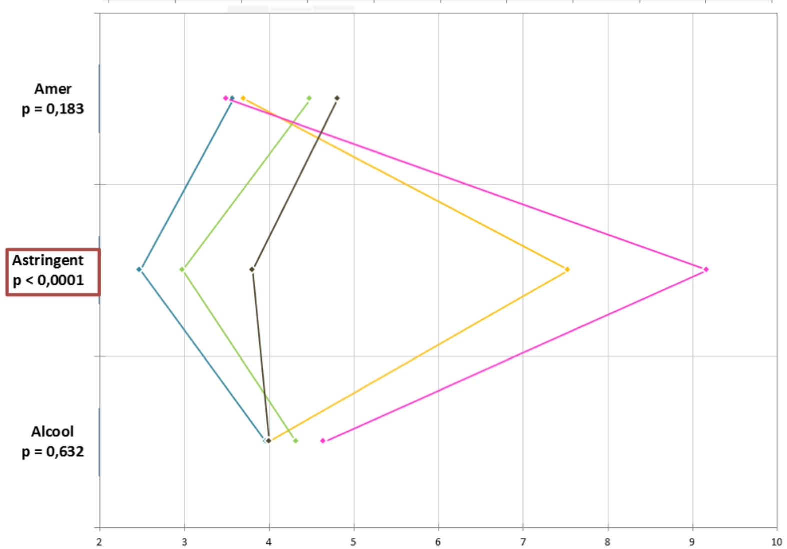
How to mitigate sugar content while maintaining wine quality ?

> Select new varieties (new metabolism dynamics)

Echantillon	Génotype	Variété
2013_VDQA_G1_57	G1	3197-144
2013_VDQA_G2_57	G2	3197-235
2013_VDQA_G7_57	G7	3197-373
2013_VDQA_G14_57	G14	3184-1-9
2013_VDQA_Morr		Morrastel







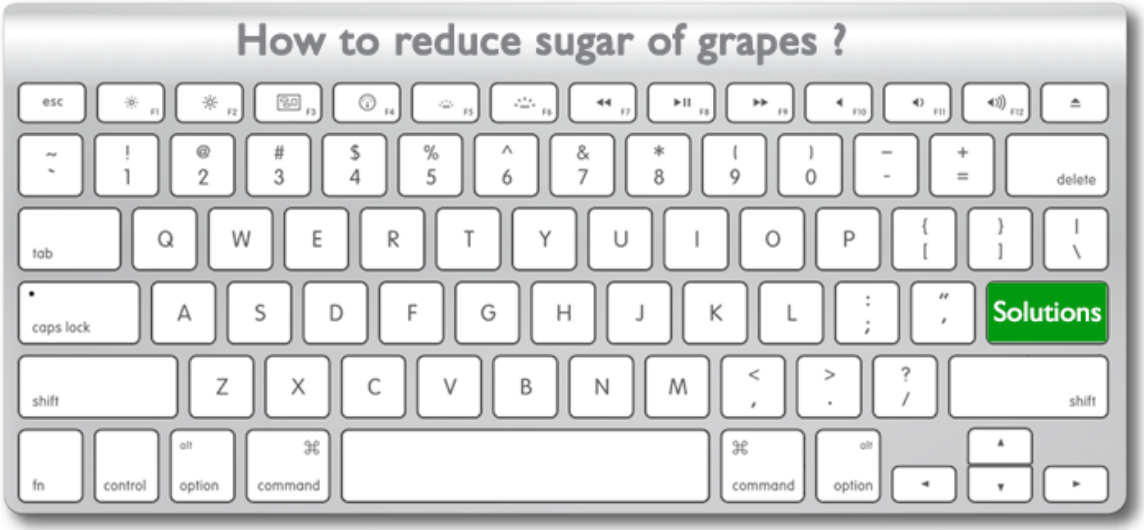
G7 & G14

Color intensity

Tannins conc.

> G1, G2, G7 and G14 are totally resistant to downy and powdery mildew

How to mitigate sugar content while maintaining wine quality ?



There are no recipes!

> Reducing alcohol levels in wine is a challenge for now and the future

> Several **viticultural strategies** could be useful to face the problem

> But grapevine has physiological plasticity (compensation responses)

> Grapes with low TSS may not have a suitable phenolic/aromatic potential

> Experimental results do not show univocal and universal indications

> Best results could be obtained from combining several approaches*

> **Most long term & promising approach: new cultivars !**

* *including wine processing technologies*