18th International Symposium GiESCO 2013
7th – 11th July 2013
PORTO - PORTUGAL

# FACTORS AFFECTING BERRY COMPOSITION OF TEMPRANILLO GRAPEVINES BEFORE THE ARREST OF PHLOEM TRANSPORT

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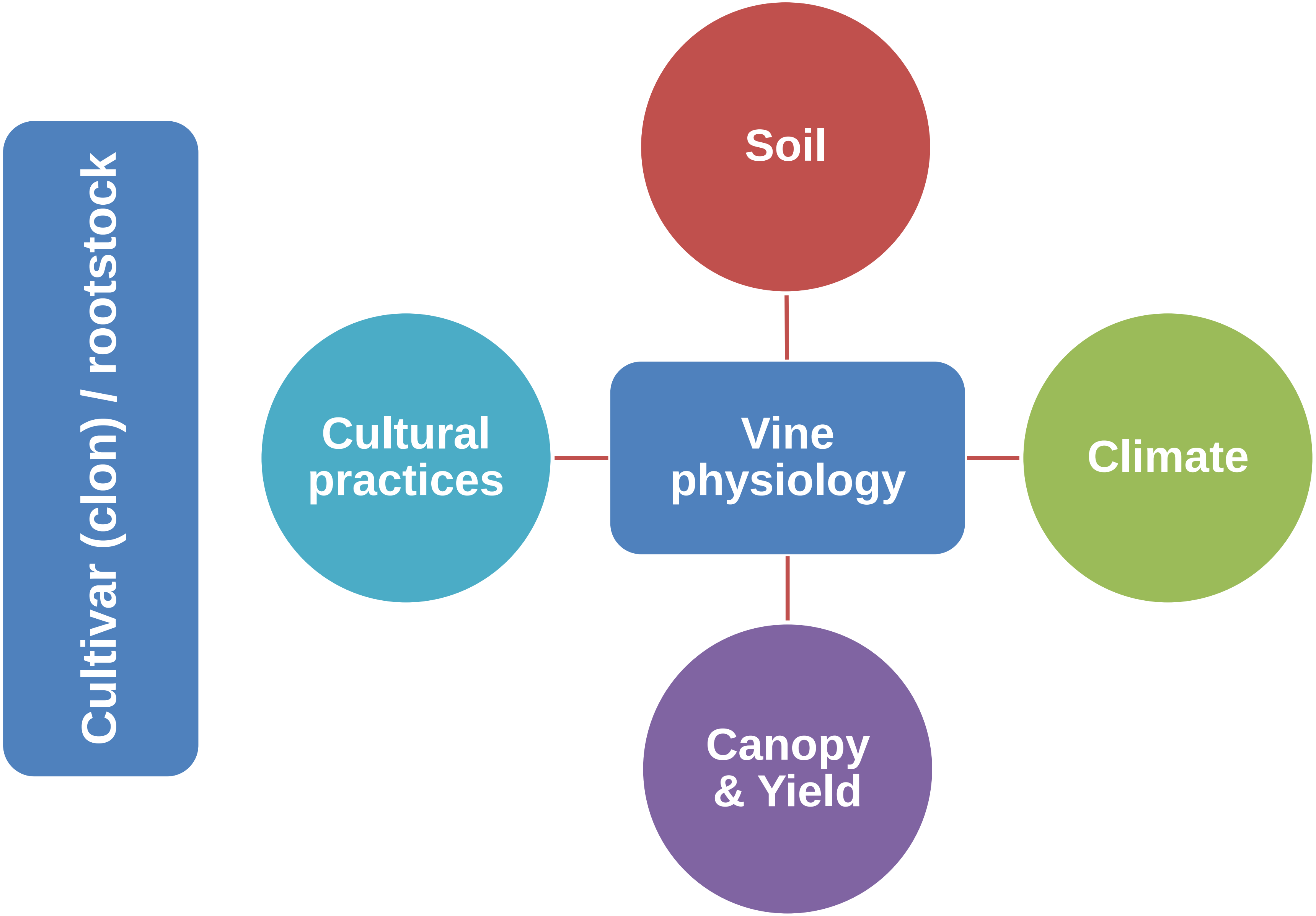
# Factors affecting ripening and berry composition



# Main goal

Determine the relative importance of

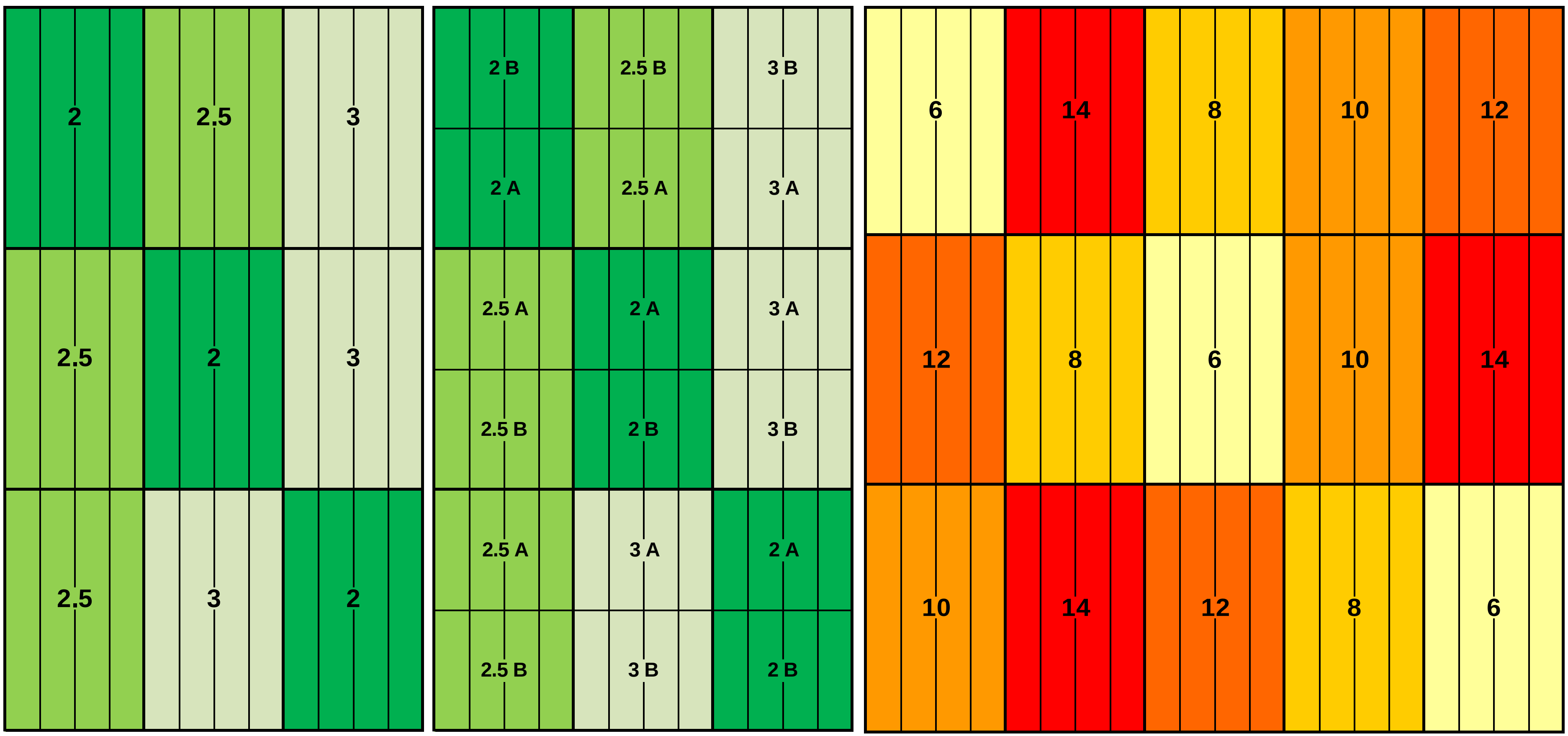
- ✓ leaf:fruit ratio
- ✓ environmental conditions
- ✓ physiological activity of the vines

on the maturity of **Tempranillo** grapes

in particular during the early-stage of berry ripening

| | VINEYARD N.1 | VINEYARD N.2 |
|---|---|---|
| **Cultivar (clon) rootstock** | Tempranillo (RJ51)/140 Ru | Tempranillo (771)/110 R |
| **Soil** | 0 - 20/30 cm: silty-loam<br>20/30 - 100 cm: clay-loam or clay<br>pH = 8.5 | |
| **Climate** | 40º 8’ N, 3º 23’ W, 730 m amsl<br>Mediterranean climate<br>Temperate, with hot, dry summers | |
| **Cultural practices** | Irrigation: 0.4 x Eto<br>Mowing between rows, and herbicides under the vines | |
| **Canopy & Yield** | Unilateral cordon, spur pruned, VSP, N-S orientated | |
| | **2 - 2.5 - 3 x 1.25 m**<br>12 shoots/m<br>**canopy height: 0.9-1.2 m** | 2 x 1.1 m<br>**6-8-10-12-14 shoots/m**<br>canopy height: 1.1-1.2 m |

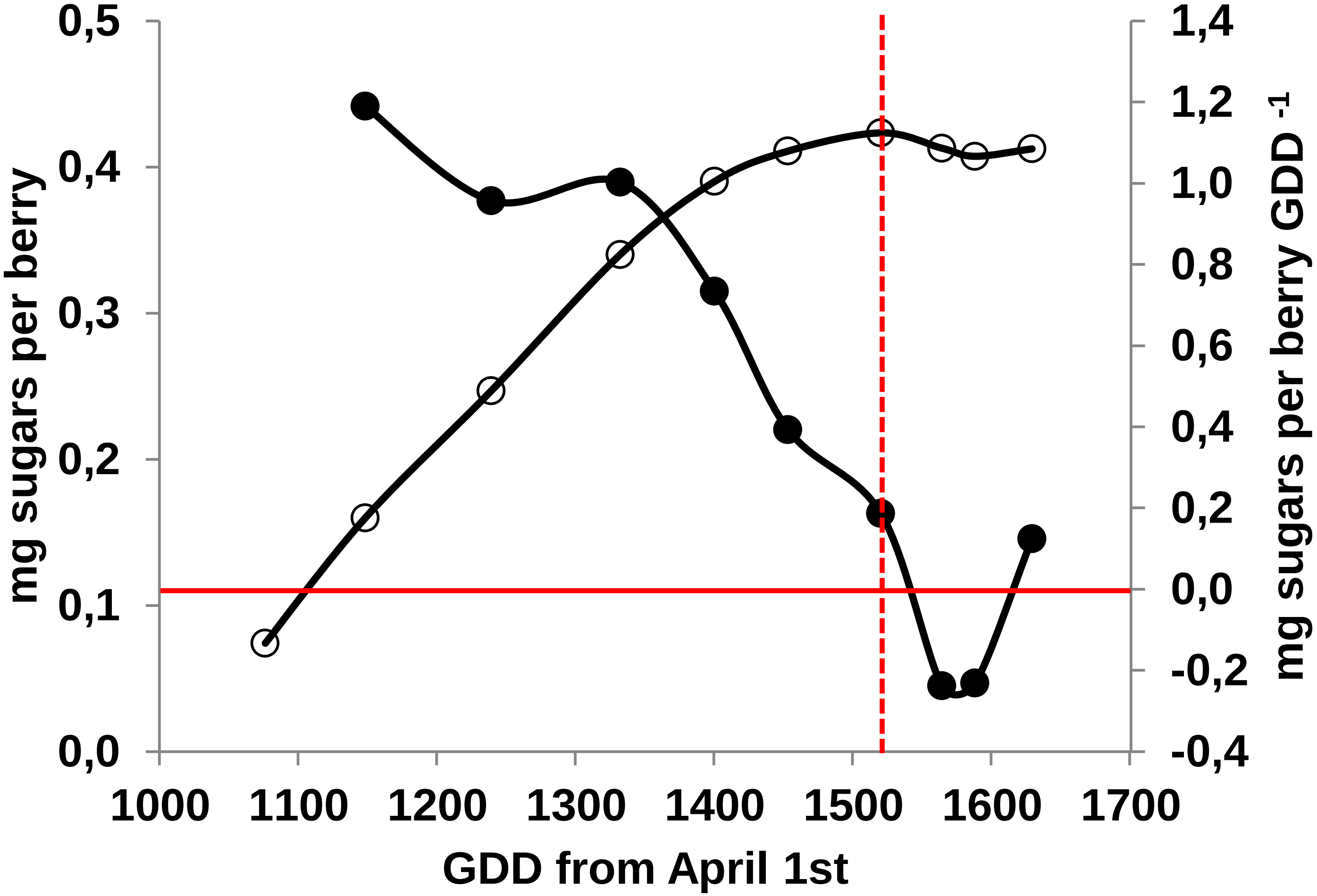
| VINEYARD N.1 | | VINEYARD N.2 |
|---|---|---|
| 2005 | 2006 | 2007-2008 |
| 3 inter-row distances | 3 inter-row distances<br>2 canopy heights | 5 shoot densities |



| | |
|---|---|
| **Climate** | GDD berry set – *veraison*<br>GDD veraison – “maturity” * |
| **Canopy & Yield** | Leaf area (LA)<br>Canopy surface area (SA)<br>Yield |
| **Vine physiology** | Leaf water potential ($\Psi_f$, MPa)<br>Stomatal conductance ($g_s$, mmol $H_2O/m^2/s$)<br>Mid-morning (9:00 utc) and solar noon (12:00 utc)<br>Average values during ripening (2 days) |
| **Grape composition at “maturity” *** | Total Soluble Solids (TSS, Brix),<br>pH<br>Titratable Acidity (TA, g/L $TH_2$)<br>Total Phenol Index (TPI, $OD_{280}$) |

# “Maturity” = stop of sugar accumulation

$$\text{estimated solutes per berry} = \frac{\text{juice Brix}}{100} \times \text{berry weight (g)}$$ (Coombe, 1980)



# Results

## Multiple regression analysis, stepwise method

| | min | max |
|---|---|---|
| $GDD_{s\text{-}v}$ (°C) | 684 | 785 |
| $GDD_{v\text{-}m}$ (°C) | 336 | 491 |
| LA/yield ($m^2$/kg) | 0.53 | 1.81 |
| SA/yield ($m^2$/kg) | 0.35 | 1.21 |
| $\Psi_{f9}$ (MPa) | -1.22 | -0.90 |
| $\Psi_{f12}$ (MPa) | -1.33 | -1.09 |
| $g_{s9}$ (mmol $H_2O/m^2/s$) | 78 | 211 |
| $g_{s12}$ (mmol $H_2O/m^2/s$) | 77 | 138 |

| | min | max |
|---|---|---|
| TSS (Brix) | 20.7 | 25.4 |
| pH | 3.17 | 3.82 |
| TA (g/L $TH_2$) | 4.5 | 7.0 |
| TPI ($OD_{280}$) | 39 | 74 |

N = 19

# TSS (Brix) → SA/yield, $g_{s9}$, ($GDD_{v-m}$)

| Model | $R^2$ | p | | B[a] | β[b] | p | VIC[c] |
|---|---|---|---|---|---|---|---|
| 1 | 0.488 | 0.001 | constant | 20.585 | | < 0.001 | |
| | | | SA/yield | 3.288 | 0.698 | 0.001 | 1.000 |
| 2 | **0.902** | < 0.001 | constant | 16.154 | | < 0.001 | |
| | | | **SA/yield** | 4.307 | **0.915** | < 0.001 | 1.113 |
| | | | **$g_{s9}$** | 0.028 | **0.679** | < 0.001 | 1.113 |
| 3 | 0.933 | < 0.001 | constant | 13.946 | | < 0.001 | |
| | | | SA/yield | 4.823 | 1.024 | < 0.001 | 1.500 |
| | | | $g_{s9}$ | 0.020 | 0.498 | < 0.001 | 2.162 |
| | | | **$GDD_{v-m}$** | 0.006 | **0.297** | 0.019 | 2.842 |

[a] Non-standardized regression coefficient; [b] Standardized regression coefficient; [c] Variance inflation coefficient.

# TPI ($OD_{280}$) → SA/yield, $g_{s12}$, $GDD_{v-m}$

| Model | $R^2$ | p | | B[a] | β[b] | P | VIC[c] |
|---|---|---|---|---|---|---|---|
| 1 | 0.601 | < 0.001 | constant | 4.490 | | 0.623 | |
| | | | $g_{s12}$ | 0.460 | 0.775 | < 0.001 | 1.000 |
| 2 | 0.799 | < 0.001 | constant | -5.215 | | 0.467 | |
| | | | $g_{s12}$ | 0.456 | 0.768 | < 0.001 | 1.000 |
| | | | SA/yield | 13.435 | 0.446 | 0.001 | 1.000 |
| 3 | **0.881** | < 0.001 | constant | -24.689 | | 0.009 | |
| | | | **$g_{s12}$** | 0.350 | **0.590** | < 0.001 | 1.388 |
| | | | **SA/yield** | 20.426 | **0.678** | < 0.001 | 1.658 |
| | | | **$GDD_{v-m}$** | 0.056 | **0.407** | 0.006 | 2.030 |
| 4 | 0.947 | < 0.001 | constant | -53.067 | | < 0.001 | |
| | | | $g_{s12}$ | 0.135 | 0.227 | 0.065 | 3.397 |
| | | | SA/yield | 26.929 | 0.893 | < 0.001 | 2.368 |
| | | | $GDD_{v-m}$ | 0.069 | 0.506 | < 0.001 | 2.178 |
| | | | $\Psi_{f9}$ | -36.808 | -0.443 | 0.001 | 2.998 |

[a] Non-standardized regression coefficient; [b] Standardized regression coefficient; [c] Variance inflation coefficient.

# TA (g/L $TH_2$) → $GDD_{v-m}$, $GDD_{s-v}$, ($\Psi_{f9}$, SA/yield)

| Model | n | $R^2$ | p | | B[a] | β[b] | p | VIC[c] |
|---|---|---|---|---|---|---|---|---|
| 1 | 19 | 0.794 | < 0.001 | constant | 10.607 | | < 0.001 | |
| | | | | $GDD_{v-m}$ | -0.012 | -0.891 | < 0.001 | 1.000 |
| 2 | 19 | **0.950** | < 0.001 | constant | 15.286 | | < 0.001 | |
| | | | | **$GDD_{v-m}$** | -0.010 | **-0.746** | < 0.001 | 1.135 |
| | | | | **$GDD_{s-v}$** | -0.007 | **-0.421** | < 0.001 | 1.135 |
| 3 | 19 | 0.964 | < 0.001 | constant | 18.032 | | < 0.001 | |
| | | | | $GDD_{v-m}$ | -0.008 | -0.619 | < 0.001 | 2.313 |
| | | | | $GDD_{s-v}$ | -0.010 | -0.563 | < 0.001 | 2.615 |
| | | | | $\Psi_{f9}$ | 1.553 | 0.193 | 0.032 | 2.747 |
| 4 | 19 | 0.980 | < 0.001 | constant | 23.801 | | < 0.001 | |
| | | | | $GDD_{v-m}$ | -0.008 | -0.575 | < 0.001 | 2.431 |
| | | | | $GDD_{s-v}$ | -0.015 | -0.825 | < 0.001 | 6.801 |
| | | | | **$\Psi_{f9}$** | 3.483 | **0.432** | < 0.001 | 6.232 |
| | | | | **SA/yield** | -0.742 | **-0.254** | 0.004 | 3.908 |

[a] Non-standardized regression coefficient; [b] Standardized regression coefficient; [c] Variance inflation coefficient.

# pH → $GDD_{s-v}$, $GDD_{v-m}$, (SA/yield, $\Psi_{f12}$)

| Model | n | $R^2$ | p | | B[a] | β[b] | p | VIC[c] |
|---|---|---|---|---|---|---|---|---|
| 1 | 19 | 0.847 | < 0.001 | constant | 0.259 | | 0.441 | |
| | | | | $GDD_{s-v}$ | 0.004 | 0.920 | < 0.001 | 1.000 |
| 2 | 19 | **0.933** | < 0.001 | constant | 0.151 | | 0.511 | |
| | | | | **$GDD_{s-v}$** | 0.004 | **0.813** | < 0.001 | 1.135 |
| | | | | **$GDD_{v-m}$** | 0.001 | **0.312** | < 0.001 | 1.135 |
| 3 | 19 | 0.985 | < 0.001 | constant | -0.579 | | 0.002 | |
| | | | | $GDD_{s-v}$ | 0.004 | 0.915 | < 0.001 | 1.336 |
| | | | | $GDD_{v-m}$ | 0.002 | 0.445 | < 0.001 | 1.476 |
| | | | | SA/yield | 0.230 | 0.299 | < 0.001 | 1.722 |
| 4 | 19 | 0.990 | < 0.001 | constant | -1.888 | | 0.002 | |
| | | | | $GDD_{s-v}$ | 0.005 | 1.075 | < 0.001 | 6.067 |
| | | | | $GDD_{v-m}$ | 0.002 | 0.434 | < 0.001 | 1.497 |
| | | | | **SA/yield** | 0.331 | **0.430** | < 0.001 | 4.856 |
| | | | | **$\Psi_{f12}$** | -0.579 | **-0.167** | 0.014 | 5.145 |

[a] Non-standardized regression coefficient; [b] Standardized regression coefficient; [c] Variance inflation coefficient.

# In short …

<table>
<tr><td>Sugars</td><td>SA/yield, $g_{s9}$, $GDD_{v-m}$</td><td rowspan="2">SA/yield, $g_s$, $GDD_{v-m}$</td></tr>
<tr><td>Phenolics</td><td>SA/yield, $g_{s12}$, $GDD_{v-m}$</td></tr>
<tr><td>Acidity</td><td>$GDD_{v-m}$, $GDD_{s-v}$, $\Psi_{f9}$, SA/yield</td><td rowspan="2">$GDD_{v-m}$, $GDD_{s-v}$<br>SA/yield, $\Psi_f$</td></tr>
<tr><td>pH</td><td>$GDD_{s-v}$, $GDD_{v-m}$, SA/yield, $\Psi_{f12}$</td></tr>
</table>

- SA/yield was a better indicator of vine balance than LA/yield
- $g_s$ was a better indicator of physiological activity than $\Psi_f$
- Tª was essential to explain berry ripening, mainly to explain must acidity and pH

# Is Tempranillo a grape variety sensitive to sugar accumulation disorder?

- ✓ Stop of berry growth and sugar accumulation were observed in 2006 and 2008
- ✓ No berry weight decrease was noted in any year
- ✓ No leaf senescence was observed
- ✓ Stomatal conductance as well as net $CO_2$ assimilation rates were not too low
- ✓ So… was there an arrest of phloem transport?

# and with regard to acidity and pH …

- Temperature accumulation was essential to explain the must acidity

- ✓ Tempranillo is a variety that has a low tartrate:malate ratio before *veraison*

  High temperatures from this point ($GDD_{v-m}$) may cause a strong reduction of total acidity due to malic acid degradation

- ✓ A separate analysis is needed in order to understand why a greater $GDD_{s-v}$ causes a decrease in acidity

  This may be related to a lower water status and a lower synthesis rate of organic acids during the stage I of berry growth

# THANKS FOR YOUR ATTENTION

*muito obrigado!!*

**Research project AGL2005-07787-C02-01, Spanish Ministerio de Educación y Ciencia**
**Agreement P040260543, Universidad Politécnica de Madrid - IMIDRA**