Photosynthetic down regulation in red and white Tempranillo under different climate change scenarios

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Climate Change

• An effect of human activities
• Major ecological, social and economic problem of the planet.
  • Effects:
    • Increasing temperature (1.4 to 5.8°C)
    • Widespread melting of snows and ice
    • Rising global sea levels
    • Decreasing rainfall
    • Changing species distribution
    • Plant vulnerability and mortality
    • Affecting crops, etc.

• Associated directly and indirectly to:
  ➢ Elevated CO₂
  ➢ Temperature increase
  ➢ Drought
Climate Change

Evolution of the atmospheric CO$_2$ concentration in the last 50 years

Evolution of the atmospheric CO$_2$ concentration and temperature during the last 400,000 years (Ice cores, Antarctica)
Direct Effects of Elevated CO$_2$

**In the short time period:** Increasing photosynthesis and growth

**In the long time period:** Decline of photosynthesis → Acclimation

In the literature, acclimation may be due to three main causes:

1. **Stomatal limitations** resulting from stomatal closure and the corresponding decreased sub-stomatal CO$_2$ concentration ($C_i$)

2. Reduced **Rubisco carboxylation activity**

3. Reduced amount of **Rubisco** or **leaf TSP**
Effects of Climate Change in Mediterranean Area

➢ Grapevine is an economically important crop worldwide that occupies the largest area of cultivated hectares (OIV 2013).

➢ In the Mediterranean area, crop yield and quality changes are occurring due to climate change, associated to atmospheric CO₂ concentration increases, enhanced temperatures and scarce water availability (Tubiello et al., 2000).

➢ Previously, we reported, within the three above mentioned factors, a drastic reduction of vegetative growth under drought conditions in fruit-bearing cuttings of two grapevine (Vitis vinifera L.) cultivars (Red and White Tempranillo) (Kizildeniz et al., 2015).

➢ Therefore, climate change scenarios and the plant responses is a matter that deserves further investigation.
Aim

Assessing the photosynthetic acclimation phenomenon in red Tempranillo grapevine plants and its natural, spontaneous mutant white Tempranillo, growing under elevated CO$_2$, elevated temperature and water deficit.
Material and Methods

Temperature Gradient Greenhouses (TGG)

- Ambient T and Ambient T + 4°C
- CO₂ Control (400 and 700 mmol mol⁻¹)
- Control of water availability (cyclic drought and full irrigation)
- Illumination (natural intensity and photoperiod)

Ambient CO₂

700 ppm CO₂

Temperature

CO₂

Water availability

Substrate Water Content (m³ H₂O m⁻³ substrate) x 100

Days of treatments

Elevated CO₂ 700 mmol mol⁻¹

Ambient CO₂ 400 mmol mol⁻¹

Ambient Temperature + 4°C

Ambient Temperature

Temperature Gradient Greenhouses (TGG)
Results and discussion

Photosynthetic rate

Growing red and white Tempranillo under ECO$_2$ resulted in lower photosynthesis, and this reduction was observed under the two temperature regimes, the two WA, and the combination of T+4 and CD.

This is the first evidence that red and white Tempranillo acclimated to elevated CO$_2$. 
Results and discussion

Leaf C/N ratio

Leaf C/N ratio increased significantly in response to ECO₂ in both red and white Tempranillo (with the unique exception) due to decreases in the leaf N concentrations.

This is the second evidence for photosynthetic acclimation to ECO₂ in red and white Tempranillo plants.
Results and discussion

Leaf C/N ratio is considered a measure of the extent of the acclimation to E CO₂.

When red and white Tempranillo plants were included in the regression analyses, leaf C/N ratios were positively correlated to leaf starch concentrations.

Any given leaf starch white Tempranillo had higher values of C/N ratio than red Tempranillo, suggesting a more intense acclimation in white than in red Tempranillo for a given leaf starch accumulation.
Results and discussion

Causes of photosynthetic acclimation were not associated with stomatal closure, extractable Rubisco activity or Rubisco amount.

Probably, it appears to be induced by CO$_2$ mesophyll conductance limitations and/or inhibition of other anabolic enzyme/s mediated by starch (or starch-derived products).
Conclusions

• Photosynthetic capacity decreases leaf starch accumulation, and increases in leaf carbon/nitrogen ratio.

• Photosynthetic acclimation was well correlated to leaf starch, but not to soluble sugars, accumulation.

• The white Tempranillo has altered its response to prolonged exposure to elevated CO$_2$.

• The mutation in white Tempranillo has affected loci other than grape colour.
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Thank You

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