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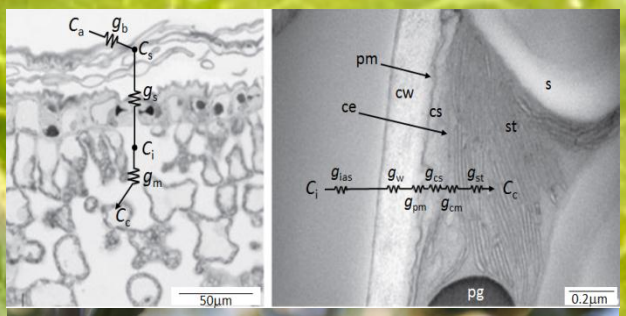

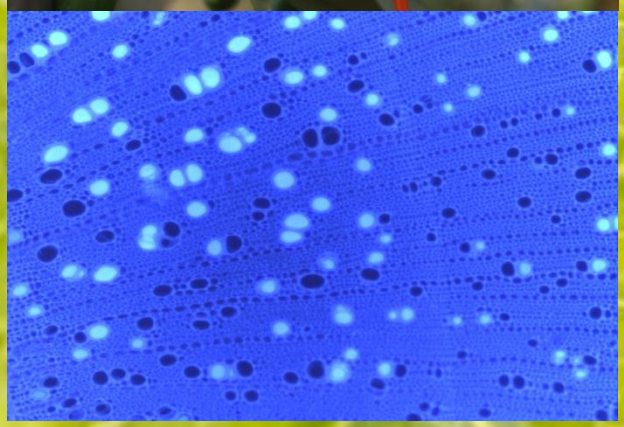

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Evolution of amino acids and amines during berry ripening in *Vitis vinifera* L. cv. Tempranillo subjected to water deficit irrigation

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ABSTRACT

Water deficit irrigation to grapevines reduces yield and berry growth altering its ripening process, all of which may influence fruit composition and wine quality. Therefore, the goal of this work was analyze variations in fruit composition and specifically, in N-compounds under water deprivation. The study was carried out using container-grown Tempranillo grapevines grown under controlled conditions in a greenhouse. Two irrigation treatments were imposed: a control (well watered), and a sustained deficit irrigation (SDI). Water deficit reduced yield, berry size and concentrations of main phenolic compounds. At harvest, the content of amino acids and free ammonium was low in both treatments but SDI-treated berries showed a significant accumulation of amines.

INTRODUCCIÓN

In grapevines, a regulated water deficit is the base of different agronomic practices and it has been largely used to achieve an appropriate balance between vegetative and reproductive development. A mild water stress, maintained through partial irrigation, may reduce vine vigour and promote a shift in the partition of photosassimilates towards reproductive tissues and secondary metabolites, which may increase fruit and wine quality (López *et al.,* 2007; Ruiz-Sánchez *et al.,* 2010). Nitrogen (N) compounds in wine are second only to sugars in importance in quantitative terms as a nutrient for yeast, because the N content is the metabolic factor that determines the rate of wine fermentation (Herbert *et al.,* 2005). Amino acids represent 30-40% of the total wine N and contribute to wine aroma, taste, and appearance (Hernández-Orte *et al.,* 2003). Amines are organic nitrogenous bases of low molecular weight that are formed during the metabolic processes of living organisms. In wine, amines have unpleasant effects at high concentrations and have cause health risks to sensitive individuals (Ancín-Azpilicueta *et al*., 2008). Therefore, the aim of the study was assess the evolution of amino acids and amines during berry growth and ripening in plants subjected to regulated water deficit.

MATERIAL AND METHODS

The study was carried out using container-grown Tempranillo grapevines grown under controlled conditions in a greenhouse. Two irrigation treatments were imposed: a control (well watered), and a sustained deficit irrigation (SDI). Samples were obtained from berries collected at distinct stages of berry ripening: pea size berries (7 mm diameter) corresponding to Eichhorn and Lorenz (E-L) growth stage 31 (pea size); berries beginning to colour and enlarge (approximately 9°Brix) (E-L 35 stage, onset of veraison) and commercially ripe berries (approximately 22°Brix) (E-L 38 stage, harvest).

Hydroalcoholic extracts were used for the determination of phenolic compounds, amino acids, amines and ammonium ions. Anthocyanins and flavonols were determined following protocols of Fernández *et al.* (2011). For analysis of amino acids and amines, aminoenone derivatives were obtained as described by Gómez-Alonso *et al.* (2007) and then, they were separated by HPLC. Total soluble sugars were measured using a temperature-compensating refractometer. Must pH was measured with a pH meter and titratable acidity was measured by titration with NaOH.

RESULTS AND DISCUSSION

Results show that application of a sustained water deficit (SDI) procedure to grapevine cv. Tempranillo during fruit development and ripening did not affect plant or berry water status, but growth and yield were reduced (Table 1). Plants subjected to SDI have smaller berries with higher proportion of skin mass and lower concentration of phenolics (Table 2).

Table 1. Plant water status and yield recorded at harvest from Tempranillo grapevines subjected to different irrigation treatments: full irrigation (Control) or sustained deficit irrigation (SDI).

Measurement	Control	SDI
Plant water status		
Pre-dawn leaf water potential (MPa)	-0.97 a	-0.80 a
Berry water content (g water g-1 FM, %)	87.01 a	89.60 a
Yield and plant growth		
Yield (g plant^{-1})	231.5 a	119.4 b
Bunch weight (g)	242.6 a	133.1 b
Leaf area (m^2 plant^{-1})	0.22 a	0.06 b

The amino acid content in berries was highest at the pea size stage, especially in SDI-treated plants and it was diminished at the onset of veraison and harvest in both irrigation treatments (Figure 1). The minimum concentration of amines was found at the beginning of fruit ripening (veraison) in both treatments, but afterwards, SDI treatment exhibited significant accumulation of amines at harvest. Finally, the ammonium concentration in berries was

highest at the onset of veraison in both water regimes assayed but in SDI treatment berries have low ammonium concentration at pea size stage.

Table 2. Berry characteristics and composition measured at harvest from Tempranillo grapevines subjected to different irrigation treatments: full irrigation (Control) or sustained deficit irrigation (SDI).

Measurement	Control	SDI
Berry characteristics		
Berry size (g berry^{-1})	0.84 a	0.66 b
Relative skin mass (% berry FM)	22.5 b	34.1 a
Fruit composition		
Total soluble solids (°Brix)	22.1 a	17.7 b
Juice pH	3.7 a	3.7 a
Titratable acidity (g L^{-1})	6.1 a	5.4 a
Anthocyanidins (mg g^{-1} FM)	1.2 a	0.7 b
Flavonols (mg g^{-1} FM)	0.03 a	0.02 b

FM: fresh matter

In grapes, amines mainly come from the decarboxylation of amino acids, which supported the contention that in berries of SDI, accumulation of amines at harvest was originated from amino acids present at the pea size stage. The influence of water deficit on amine metabolism is poorly understood. For instance, Bover-Cid *et al.* (2006) concluded that water stress in vineyards does not seem to be a factor influencing the amine content. By contrast, our data are in agreement with those of Coelho *et al.* (2005), which showed that the content of every amine increased in lettuce plants subjected to water stress.

CONCLUSION

This study shows that application of a sustained water deficit procedure to grapevine cv. Tempranillo during fruit development and ripening produced reductions in berry size and phenolic compounds, and an accumulation of amines at harvest. These alterations in N-compound composition could compromise fruit quality.

ACKNOWLEDGEMENTS

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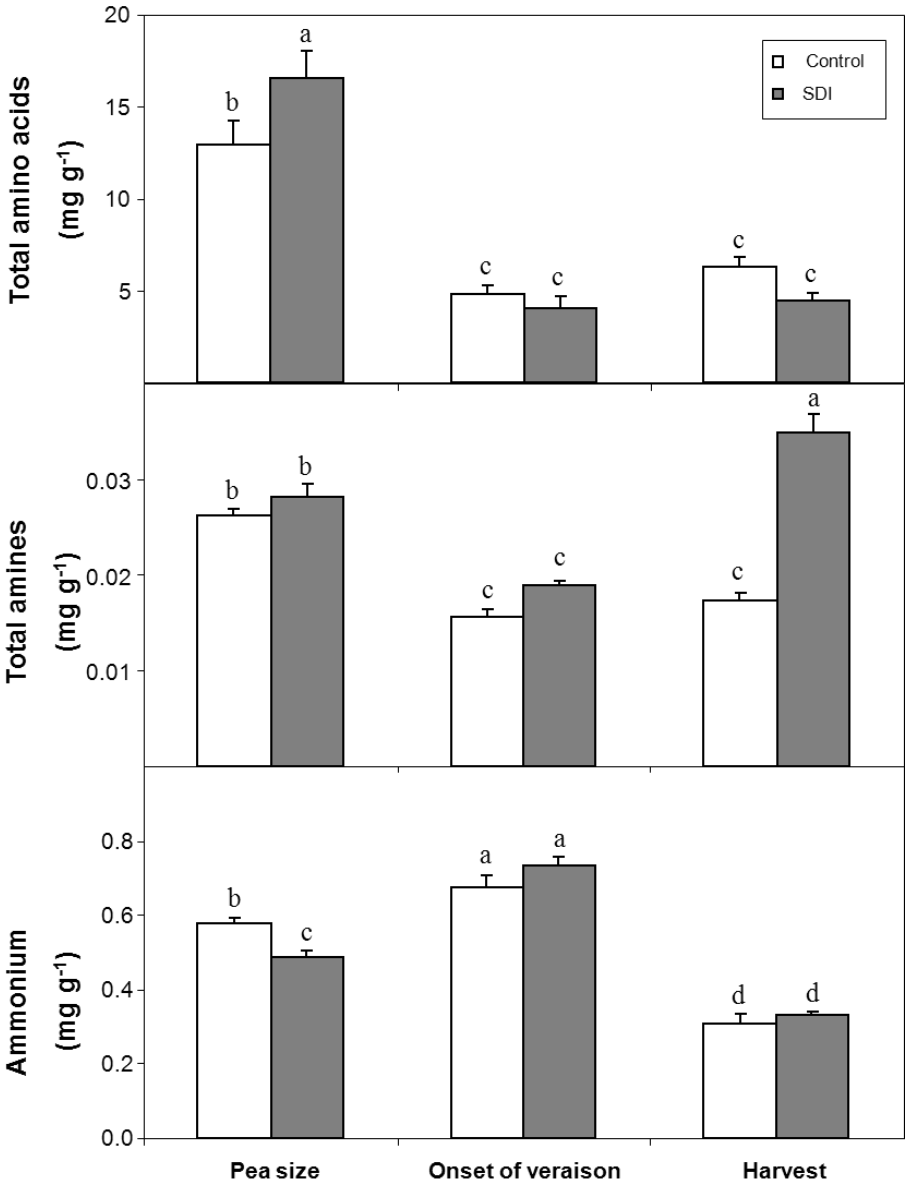

Figure 1. Nitrogen compounds in berries of fruiting cuttings of Tempranillo grapevines subjected to different irrigation treatments: full irrigation (Control), or sustained deficit irrigation (SDI).

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