# Water use efficiency in Almonds (*Prunus dulcis* (Mill.) D. A. Webb)


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# Abstract

Almond (*Prunus dulcis* (Mill) D. A. Webb) is a nut tree in the family Rosaceae, which compared to other nut crops, grown in Mediterranean climates, is relatively drought resistant. Due to the lack of, or high cost of water, almond growers are more inclined to improve gross production water use efficiency (WUE) by adopting water saving irrigation strategies. To this aim, the sensitivity and accuracy of different water status indicators need to be compared to design a suitable irrigation schedule. Meanwhile, instantaneous water use efficiency ($WUE_i$) that is a measure made at the leaf scale can also be used as a criterion for estimating WUE in breeding programs.

To study the effects of different deficit irrigation strategies, sustained and regulated deficit irrigations (SDI and RDI) were applied on almond trees for two consecutive seasons (2009-2010 and 2010-2011). Five levels of water amount were applied; namely, 55, 70, 85, 100 and 120% $ET_c$. Kernel yield, midday stem water potential (MSWP), stomatal conductance ($g_s$), increment in trunk circumference (ΔTC) and carbon isotope discrimination ($\Delta^{13}C$) were measured for both seasons. Results obtained in the 2009-2010 season showed that regardless of irrigation strategy, kernel yield was reduced in 70% $ET_c$ of irrigation or less. Meanwhile kernel yield, WUE and water status indicators in this season were more sensitive to the quantity of water applied rather than to the deficit strategy (SDI or RDI). However, kernel yield was slightly lower in RDI 70% $ET_c$ compared to SDI 70% $ET_c$ treatments.

Although, there were high correlations between all water status indicators and the amount of water applied, $g_s$ and $\Delta^{13}C$ showed lower sensitivity towards water deficit compared to MSWP and ΔTC, implying an anisohydric behaviour of almond trees. Meanwhile, in the first season, the observed correlation coefficients between kernel yield and ΔTC were lower than those of other water status indicators: MSWP ≈ $g_s$ ≈ $\Delta^{13}C$ > ΔTC. In addition, there was only a moderate correlation ($R^2$= 0.61) between $\Delta^{13}C$ and WUE in the first season indicating that $\Delta^{13}C$ may not be a reliable indicator of changes in WUE in almond trees. In the 2010-2011 season, there were no significant differences in kernel yields and water status indicators

between different treatments. It was probably due to the humid weather and frequent rain in the second season that negated the effects of deficit irrigation on almond trees.

To study the $WUE_i$ in different genotypes, $g_s$ and assimilation rate (*A*) in 5 mixed crosses of almond were examined. The significant correlations between $g_s$, *A* and internal concentration of $CO_2$ ($C_i$) indicated that *A* was probably limited by both stomatal and non-stomatal parameters that might be affected by genotype variations. Mesophyll anatomy and $g_s$ between three almond varieties (Nonpareil, Carmel and Masbovera) were also compared. The results demonstrated that the post-venous hydraulic distance $D_m$ and the density of mesophyll cells might indirectly affect $g_s$.

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# List of Abbreviations

| | |
|---|---|
| A | assimilation rate per unit of leaf area (µmol $m^{-2}$ $s^{-1}$) |
| $C_a$ | external $CO_2$ |
| $C_i$ | Internal $CO_2$ |
| $D_m$ | post-venous hydraulic distance |
| E | transpiration rate per unit of leaf area (mmol $m^{-2}$ $s^{-1}$) |
| $E_{pan}$ | class A evaporation pan |
| $ET_c$ | potential crop evapotranspiration |
| $ET_o$ | reference crop evapotranspiration |
| $g_c$ | stomatal conductance to $CO_2$ (mmol $m^{-2}$ $s^{-1}$) |
| $g_m$ | mesophyll conductance (mmol $m^{-2}$ $s^{-1}$) |
| $g_s$ | stomatal conductance (mmol $m^{-2}$ $s^{-1}$) |
| $g_w$ | stomatal conductance to water vapour (mmol $m^{-2}$ $s^{-1}$) |
| HCFM | hydraulic conductance flow meter |
| $k_{leaf}$ | leaf hydraulic conductance |
| $K_c$ | crop coefficient |
| KF | kernel fraction |
| KY | kernel yield (t $ha^{-1}$) |
| $L_1$ | leaf hydraulic conductance normalized to leaf area (kg $s^{-1}$ $mpa^{-1}s^{-2}$) |
| MDB | Murray-Darling River Basin |
| MSWP | midday stem water potential (Mpa) |
| PPFD | photosynthetic photon flux density µmol $m^{-2}$ $s^{-1}$ |
| RDI | regulated deficit irrigation |
| SDI | sustained deficit irrigation |
| VPD | vapour pressure deficit |
| $W_a$ | external water vapour |

| | |
|---|---|
| $W_i$ | internal water vapour |
| WUE | water use efficiency or gross production water use efficiency (kg $mm^{-1}$) |
| $WUE_i$ | instantaneous water use efficiency ($\mu molCO_2\ mmol^{-1}\ H_2O$) |
| $\Delta^{13}C$ | carbon isotope discrimination |
| $\delta_a$ | carbon isotope composition in atmosphere |
| $\delta_p$ | carbon isotope composition in plant tissue |
| $\delta^{13}C$ | isotope discrimination for carbon 13 |
| $\Delta TC$ | increment in trunk circumference (mm) |

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