

Geophysical Research Abstracts
Vol. 19, EGU2017-1340, 2017
EGU General Assembly 2017
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Monitoring plant water status and rooting depth for precision irrigation in the vineyards of Classic Karst

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The extreme summer drought and heat waves that occurred in South-Europe in 2003 and 2012 have led to the loss of more than 50% of winery production in the Classic Karst (NE Italy). The irrigation of vineyards in this area is not appropriately developed and, when used, it does not consider the actual water status and needs of plants, posing risks of inappropriate or useless usage of large water volumes. The predicted future increase in frequency and severity of extreme climate events poses at serious risk the local agriculture based on wine business. We monitored seasonal trends of pre-dawn (Ψ_{pd}) and minimum (Ψ_{min}) leaf water potential, and stomatal conductance (gL) of 'Malvasia' grapevine in one mature (MV, both in 2015 and 2016) and one young vineyard (YV, in 2016). Moreover, we extracted xylem sap from plant stems and soil water from samples collected in nearby caves, by cryo-vacuum distillation. We also collected precipitation and irrigation water in different months. Oxygen isotope composition ($\delta^{18}O$) of atmospheric, plant, soil and irrigation water was analyzed to get information about rooting depth. In 2015, at the peak of summer aridity, two irrigation treatments were applied according to traditional management practices. The treatments were performed in a sub-area of the MV, followed by physiological analysis and yield measurements at grape harvest. In 2016, the soil water potential (Ψ_{soil}) at 50 cm depth was also monitored throughout the season.

Under harsh environmental conditions the apparently deep root system ensured relatively favorable plant water status in both MV and YV and during both growing seasons. The Ψ_{soil} at 50 cm depth gradually decreased as drought progressed, reaching a minimum value of about -1.7 MPa, far more negative than Ψ_{pd} recorded in plants (about -0.5 MPa). In July, significant stomatal closure was observed, but Ψ_{min} never surpassed the critical threshold of -1.3 MPa, indicating that irrigation was not needed. The xylem sap $\delta^{18}O$ was about -6‰ and a significantly lower value was recorded after the irrigation treatments (-7.2‰), highlighting absorption of irrigation water (-8‰) by plants. However, Ψ_{min} and yield of irrigated and non-irrigated grapevines were not significantly different. Interestingly, Ψ_{min} and in particular Ψ_{pd} , were found to be slightly more negative in the MV compared to YV. On the other hand, gL measured in July, if compared to that of the spring period, decreased by about 92% in MV, but only about 70% in YV, suggesting a relatively more anisohydric and isohydric behavior in the two groups of plants, respectively.

Our data demonstrate the feasibility of the development of precision irrigation methods in karstic areas, as based on physiological parameters reflecting actual water needs of plants (Ψ_{min}), which would assure a more sustainable management and significative savings of the, already limited, water resource.