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EDITORIAL

Special issue on water management in grapevines

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Population growth, economic development, environmental demands, and climate change converge into a scenario of water scarcity worldwide (Fereres and Gonzalez-Dugo 2009). Water supply may therefore constraint grape production for quality wine. In this context, deficit irrigation (DI) strategies to stabilize yield and maintain or improve wine quality are critical. Recently, the use of regulated deficit irrigation (RDI) has expanded in vineyards to improve (sometimes to reduce) water application, yield per unit water supply, berry composition, and wine quality. The objective of RDI is to apply water deficits of predetermined levels during certain phenological stages when their effects on fruit growth and quality are neutral or positive, while keeping vineyard vigor in balance with potential production (Girona et al. 2006, 2009; Pellegrino et al. 2006; Greven et al. 2005). The short and long-term impact of deficit irrigation on production and quality vary with vineyard conditions, namely soil texture and depth, variety, atmospheric environment, and viticultural practices. These factors make it difficult to predict the best timing for imposing water deficits. Also, the desired intensity of deficit is not easy to impose uniformly over the whole vineyard, and the risks of excessive water deficits must be avoided through careful monitoring. Furthermore, there is a trade-off between regulated water deficit to improve yield per unit water supply and the need to maintain well-watered vines to reduce heat damage in warm and hot regions (Sadras and Soar 2009; Soar et al. 2009). Understanding the effects of timing and amount of irrigation on yield and berry composition is key to achieve the desired yield and berry quality. Thus, the correct determination of vineyard water requirements (or evapotranspiration, ET) and the monitoring of soil and vine water status are critical to apply the appropriate deficit irrigation strategies.

The conventional crop coefficient (K_c) approach provides a simple and convenient way to estimate vineyard water requirements for a variety of soil and climatic conditions, but a major uncertainty in this approach is that the empirical nature of K_c which requires local calibration and monitoring of plant water status. Vine water status can be monitored with predawn, noon leaf, and stem water potentials, which integrate the effects of soil water status on both the environment (soil and atmosphere) and the vine (root and canopy size, stomatal conductance). However, there is no general agreement on which method is the most reliable to evaluate vine water status. This discrepancy may be explained by the combined effect of variety and rootstock, soil type and depth, range of soil water deficit, variability of weather conditions throughout the growing cycle, atmospheric evaporative demand, and source/sink ratio as affected by growing conditions and management practices shifting the balance between leaf area and fruit load. Midday stem water potential of horticultural trees, for example, is lower with high source/sink ratio (Sadras and Trentacoste 2011).

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This special issue of *Irrigation Science* includes nine papers describing the effects of different deficit irrigation strategies on water use efficiency, yield, and quality (Intrigiolo et al.; Junquera et al.; Williams; Romero and Martinez-Cutillas; Basile et al.); the effects of soil and climatic conditions on noon and basal (predawn) leaf water potential (Alves et al.); the estimation of K_c as a function of canopy features, thermal time, or vine water status (Picón-Toro et al.; Ferreira et al.); and a model to evaluate irrigation needs of rainfed Mediterranean vineyards (Gaudin and Gary).

In this issue, Intrigliolo et al. describe the yield components and grape composition responses to seasonal water deficits in Tempranillo grapevines in Spain. These authors compared pre- and post-veraison water restrictions to identify the best period for imposing water restrictions according to the grape composition style desired and the available irrigation water.

Junquera et al., *this issue,* describe the long-term effects of different irrigation strategies on vegetative growth, yield components, and berry composition of Cabernet-Sauvignon vines in Spain. Results of this study indicated that the maintenance of water deficit over 5 years led to a gradual reduction in yield and vegetative growth, without major changes in grape composition.

Williams*, this issue*, investigates during five growing seasons the interaction of different applied water amounts and leaf removal in the fruiting on vine and cluster water status, canopy size, and productivity of Merlot grown in the San Joaquin Valley of California. This report provided a reliable estimate of ET and applied water amounts to maximize yield. Also, Williams indicates that deficit irrigation may not be economically sustainable in the San Joaquin Valley because the grower's profitability is still based upon the quantity of fruit produced.

Partial root-zone drying (PRD) alternates irrigation in space and time to generate wet-dry cycles in different sections of the root system; this seeks to promote chemical signals from roots in dry soil, thus reducing stomatal conductance, transpiration, and shoot growth, while maintaining crop water supply from roots in the wet soil fraction, thus avoiding severe water deficit (Davies et al. 2002). This irrigation method improves yield per unit applied irrigation water with respect to controls receiving substantially more water, but similar gains are generally achieved with conventional deficit irrigation (Sadras 2009). Romero and Martinez-Cutillas, *this issue*, described the effects of partial root-zone irrigation (PRI) and regulated deficit irrigation (RDI) on the vegetative and reproductive growth of field-grown Monastrell under semiarid conditions. They found that the responses to water deficits via both strategies differed depending on the level of water applied under the experimental conditions. Low water application in PRI induced severe water stress and showed no advantage for the fruit growth and development compared to RDI. However, higher irrigation amount under PRI seems to be more effective to produce a favorable effect in berry growth and development compared to RDI.

There are few reports regarding the responses of white grapevine cultivars to DI, in terms of berry composition and wine sensory attributes. Studies in Chardonnay indicated that timing of irrigation cut-off significantly affected wine sensory attributes (Reynolds et al. 2007). Wines produced from DI vines had lower intensity of apple, citrus, floral, and earthy aromas than well-irrigated vines. The paper by Basile et al., *this issue*, report on the effects of four irrigation levels on vine growth, yield, and quality of must and wine for Chardonnay grafted onto rootstock SO4 and planted in 50-l plastic containers in the field.

In this issue, Alves et al. report the influence of soil water status and vapor pressure deficit (VPD) on noon and basal (or predawn) leaf water potential of vines "Touriga Nacional" under different irrigation treatments in Portugal. Their report challenges the use of leaf water potential at noon as an indicator under high VPD.

In vineyards, the K_c reported in the literature is often not adapted to local conditions due to the nonlinear interactions between soil, cultivar and atmospheric conditions, and canopy management practices. This consideration is especially important for vineyards with sparse canopies and high spatial variability of soil and vegetation coverage. In addition, canopy cover of vineyards is generally non-uniform as a result of the canopy geometry generated by planting patterns and training systems (Prieto et al. 2012; Ortega-Farias et al. 2010). Under these conditions, K_c should be adjusted by using different canopy features to improve the estimation of ET. It has been demonstrated that the K_c is highly correlated with several canopy features such as leaf area, leaf area index (LAI), and canopy cover (CC) (Netzer et al. 2009; Williams et al. 2003). Also, correlations between K_c and thermal time have been used to reduce the effect of seasonal variation on crop development and water consumption. *In this issue*, Picón-Toro et al. report on the effects of canopy size and water stress on the K_c of a "Tempranillo" vineyard in Western Spain during 5 years. Their results were analyzed to develop a model that allows extrapolation of the K_c values to a wide range of vineyard production systems. When applying DI strategies, a stress coefficient (ratio of actual to maximum transpiration) is necessary for estimating ET. Therefore, basal crop (Kcb) and stress (Ks) coefficients are much needed for a proper application of DI. The study by Ferreira et al., *this issue*, deals with the discrimination between basal crop (Kcb) and stress coefficients (Ks) and compares these coefficients for five vineyards under different edaphoclimatic conditions. This paper established linear correlation between Kcb versus LAI and Ks versus predawn leaf water potential.

Gaudin and Gary, *this issue*, used a soil water balance model to assess the variability of irrigation needs in relation to the soil properties, and in the context of irregular rainfall during 39 years in south France. They concluded that soil and canopy management should be considered together with irrigation for an integrated approach of water management under high inter-annual variability of rainfall.

The wide diversity of approaches presented in the different papers suggests that vineyards for wine production are complex systems where optimal irrigation strategies are difficult to generalize. It may be that the interactions between varieties, production systems, and quality goals in relation to water management are not yet fully understood and that leads to the very different approaches presented in this issue. It is hoped that information distilled from the experiments described in this issue will contribute to the development of more precise, general guidelines for wine grape irrigation.

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