Effects of soil water content and environmental conditions on vine water status and gas exchange of *Vitis vinifera L. cv. chardonnay*

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INTRODUCTION

Vine water status has a significant influence on vineyard yield and berry composition (Williams and Matthews, 1990 ; Williams *et al.*, 1994). It has been hypothesized that the response of plants to soil water deficits may be due to some sort of "root signal" (Davies and Zhang, 1991). This signal probably arises due to the roots sensing a reduction in soil water content or an increase in the mechanical impedance as the soil dries out.

An irrigation study currently is being conducted in the Napa Valley of California. This offers an opportunity to determine the relationship between various measures of vine water status and soil water content and ambient weather conditions. Future goals of this study are to correlate vine water status with wine quality.

MATERIALS AND METHODS

Vitis vinifera L. (cv. Chardonnay) was planted in June, 1990, at the Mondavi Carneros vineyards. The trellis was a vertical wire system with the cordon wire at 0.9 m and the top wire at 2.3 m. Vine and row spacings were 1.52 and 2.13 m, respectively. Irrigation of the vine was based upon evaporative demand and crop coefficients developed for this particular vineyard. Evaporative demand was determined from data collected at a California Irrigation Management Information System (CIMIS) weather station located in the Carneros district. In order to determine if the amount of applied water was appropriate, soil water content was monitored with a Campbell Pacific Nuclear soil moisture gauge (neutron probe) once every two weeks. The access tube arrangement used to measure soil water content was such that one quarter of an individual vine's soil volume was measured each time (six access tubes per site, down to a depth of 3.05 m). Measurements were made at 30 cm intervals. Each site was replicated four times for each irrigation treatment. Values of soil water content were the mean of all six access tubes per site measured to a depth of 3 m.

Vineyard irrigation treatments consisted of water applications at various fractions of that determined to be full ET. The study was set up as a line-source irrigation experiment in which each adjacent row received more or less water depending upon the direction the block was designed. The five irrigation treatments began with the application of water at 0.25 ET_c and increased by 0.25 intervals up to 1.25 ET_c. Each irrigation plot was 17 vines in length.

Measures of plant water status for all irrigation treatments were taken at midday once every two weeks beginning approximately one month after budbreak. Leaf water potential was measured with a PMS pressure chamber. Leaves were placed in a plastic bag just prior to excision and left covered during pressurization. Net CO_2 assimilation rate and stomatal conductance were measured with an Analytical Development Company gas exchange apparatus. All measurements were made on the most recent, fully expanded leaf. Photon flux density was greater than 1500 $\mu mol\ m^{-2}\ s^{-1}$ on all measurement dates.

RESULTS

Vine water use ranged from 272 mm for the 0.25 treatment up to 462 mm for the 1.25 irrigation treatment. Soil water content decreased gradually throughout the growing season in 1994 for all irrigation treatments receiving water application amounts less than full ET. Leaf water potential was never lower than -1.0 MPa for vines receiving full ET water amounts throughout the growing season while those of the 0.25 treatment was -1.45 MPa just before harvest. There were significant differences among irrigation treatments with regards to net CO_2 assimilation rate and stomatal conductance. Both of the aforementioned measurements decreased gradually for all treatments receiving less than full ET irrigation amounts. There was a significant, linear reduction in leaf water potential as the soil dried out (Figure 1). The reduction in soil water content accounted for 82 % of the decline in leaf water potential as the season progressed. There were also significant, linear reductions in net CO_2 assimilation rate and stomatal conductance (r^2 values were 0.88 and 0.65, respectively) as the soil dried out. Leaf water potential was only poorly correlated with ambient temperature ($r^2 = 0.13$).

DISCUSSION

Vine water status has been shown to have a major influence on vine yield and fruit composition (Williams and Matthews, 1990 ; Williams *et al.*, 1994). Both over and under irrigation of vines can reduce yields (Williams, 1996). Vine water status will affect berry growth and the accumulation of soluble solids, titratable acidity, anthocyanins, and phenolics (Williams and Matthews, 1990). The above mentioned berry characteristics may be due to a direct effect of water status or an indirect one mediated via the water status' effect on vegetative growth (Williams *et al.*, 1994).

The results from this study indicate that the availability of soil moisture was the predominate factor affecting vine water status (particularly leaf water potential and photosynthesis). The Carneros district is generally characterized by mild temperatures, high solar radiation and none to little rainfall from anthesis to fruit maturation. However, maximum temperatures can approach 40 °C for short periods of time during the growing season. The lower r^2 value for the relationship between stomatal conductance and soil water content is probably due to the fact that stomatal functioning can also be affected by ambient temperature and the vapor pressure deficit.

Premium wine grapes are produced in this region of Napa Valley. To date, sensory analysis of wines made from grapes in each irrigation treatment indicates a preference for vines irrigated from 75 to 100 % of full ET. Thus, wine composition can be manipulated by differential irrigation regimes subsequent to anthesis in this grape growing region.

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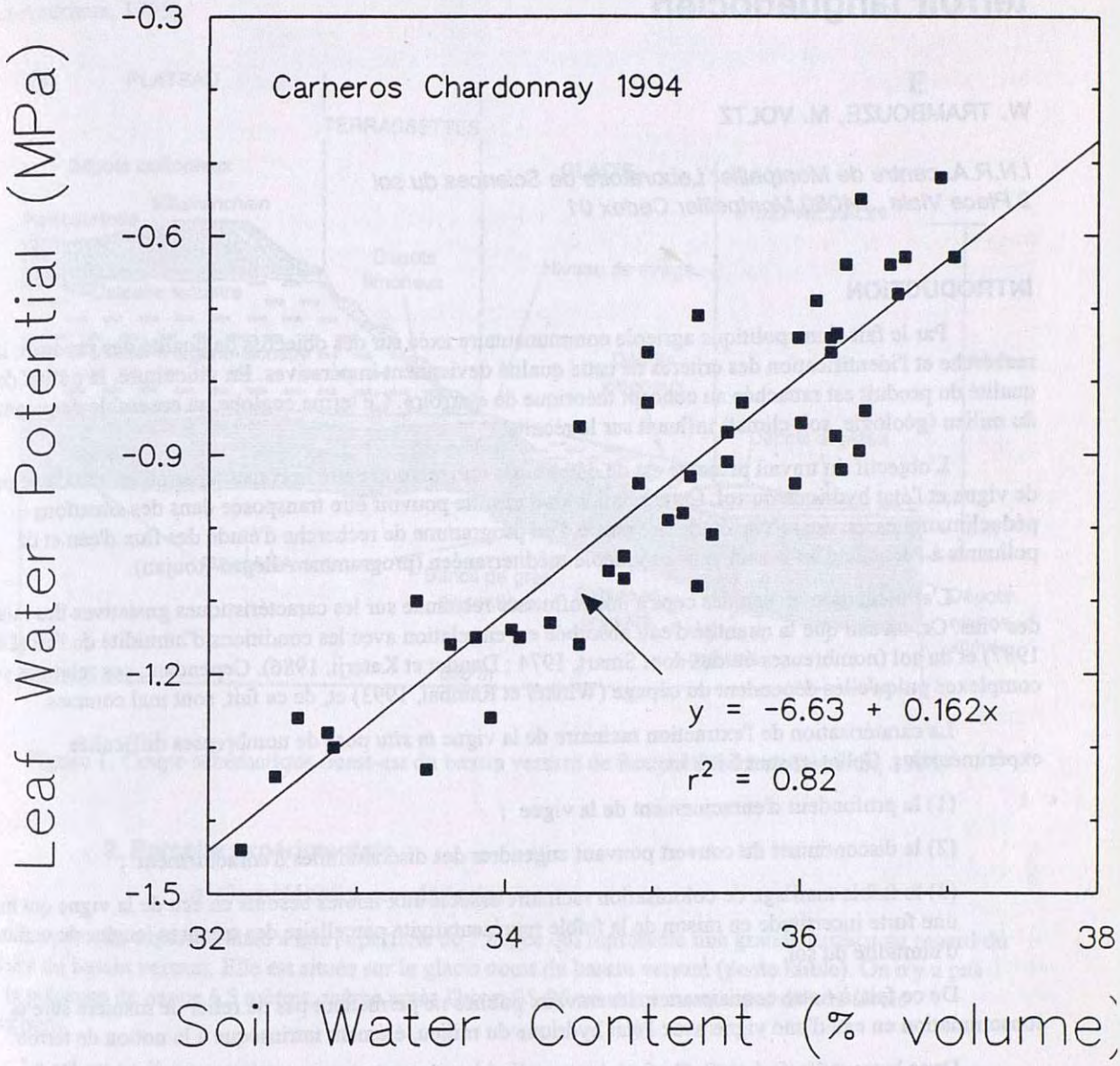

Figure 1 - The relationship between midday measures of leaf water potential and soil water content in a Chardonnay vineyard. Both measurements were made on the same day. Data points are the mean of at least 6 leaf water potential measurements and four measures of soil water content. The data were generated by using five different irrigation treatments (various fractions of calculated vineyard ET).