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PILOT ON-FARM IRRIGATION TRIAL USING AUTOMATED STEM WATER POTENTIAL SENSING

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Project status in 2024: Year 1 of 1

PROJECT OBJECTIVES:

1. Establish a control and a delay block in a commercial walnut orchard in the Yolo/Solano area, and move the current instrumentation (water meters and FloraPulse sensors) from the Patterson site to the new blocks.
2. Closely monitor SWP with the pressure chamber as well as the sensors, including making multiple pressure chamber measurements over the day (morning to evening) in order to determine if there is a meaningful lag in sensor readings behind pressure chamber readings (as found in the Patterson trial in 2023).
3. During the 2024 season, determine the degree of drift and/or lag in sensor readings compared to the pressure chamber, and if periodic spot pressure chamber measurements are sufficient to account for these effects or a more comprehensive approach is needed.
4. Test whether periodic re-installation is a more reliable and/or efficient way to address calibration issues.
5. Obtain and analyze block-level yields and nut quality at harvest.
6. (Additional Objective): Test a new technology (optical dendrometer) for automated measurement of water stress in walnuts.

BACKGROUND

Starting irrigation at leaf out to match orchard ET in walnuts has been associated with the expression of a number of leaf nutritional disorders later in the season, suggesting that wet soil conditions early in the season may have a detrimental effect on walnut root health. Waiting for trees to transition from baseline (non-stressed) SWP to mild levels of stress avoids these problems and has proved to be safe in terms of yield and quality, as well as allowing savings in water and energy. Depending on year and soil conditions, irrigation can be delayed until substantially (more than 1 month) after leaf out, and in some cases has resulted in trees that appear to be more resilient to water stress at harvest. Developing reliable automated methods to continuously measure SWP and serve as an

early warning system, compared to 'snapshot' midday manual pressure chamber measurements, is an important focus of this research. The only currently reliable automated method for directly measuring SWP is microtensiometry (i.e., the FloraPulse sensor). To use this method in walnuts a non-wood-damaging installation technique was developed in 2023 and further improved in 2024, when it was deployed in a commercial walnut orchard. A key objective of this deployment was to document how reliable this method would be. The chosen orchard also exhibited areas of high and low tree vigor, presumably due to local soil variability, and so was a good opportunity to see if these areas were associated with differences in water stress, and if the same delay could be used in both areas. In addition, a single recently developed optical device for monitoring water stress in plants was included to determine if it exhibited a stable relation to SWP over time. Walnut is particularly well suited to this device (an optical dendrometer) due to its leaf size and anatomy.

KEY FINDINGS

In almond, FloraPulse sensors installed into active sapwood typically operate without the need for attention or maintenance for an entire season, and hence the sensors themselves are reliable. The overall installation success rate using the new method developed for walnut in 2023 was 83%, although only 63% provided a month or more of reliable data. The successful installations were able to reliably detect stress induced by early- and mid-season deficit irrigation regimes. Re-installation of sensors that were reporting erroneous SWP values showed similar success rates, again, supporting the conclusion that the sensors themselves are operating reliably. Hence, a single installation with two sensors on the same tree (which is the standard approach), should provide sufficient overlap for obtaining continuous and accurate SWP data in walnut, provided that erroneous reading sensors can be removed and reinstalled. A key issue however, is identifying when a sensor is measuring an erroneous SWP. Typical failures which are relatively easy to identify include a rapid apparent decrease in SWP to values indicative of extreme stress in walnut (e.g., below about -20 bars), or a gradual increase towards wet values (SWP near 0) and/or a loss in the normal daily SWP pattern. Occasionally a sensor will lose correlation with the pressure chamber but remain in a reasonable SWP range and maintain a normal daily pattern. In these cases, without making pressure chamber measurements it may be difficult to identify the sensor that requires re-installation. Another question that was investigated was whether a single sentinel tree can be a consistent indicator of the SWP of an orchard or area in an orchard. In both control and delay treatments as well as for low and high tree vigor areas within each treatment, a single sentinel tree remained within 1 bar of three neighboring trees, indicating that a single tree per block may be sufficient for monitoring purposes. Tests of a recently developed optical dendrometer developed in Australia (the Cavicam) were very encouraging. The advantage of this approach is in its technical simplicity and reliability, but the corresponding disadvantage is that it does not measure SWP directly, and hence requires calibration against the pressure chamber. It is possible that a 'universal' calibration could be developed specifically for walnut, but this will require verification. Based on the data collected in this study, the Cavicam readings could be expressed as an equivalent SWP value, and the details resolved by this device were impressive, particularly the details for the daily patterns of SWP after the harvest cutoff. In addition to the expected increase in stress over time after the last full irrigation, both Cavicam and

FloraPulse sensors indicated a substantial change in the daily pattern of water stress, with the overnight recovery phase changing more abruptly than the midday minimum phase. As far as we know, this is the first finding of a rapid and fundamentally different response to stress at different periods of the day. Even though the Cavicam measurement must be calibrated to read in SWP units, the technical simplicity of this non-invasive method should result in a much higher degree of reliability, as there are fewer sources of measurement error.