# Plant-Based Measures of Water Stress for Irrigation Management in Multiple Almond Varieties

**Project No.:** **11-HORT9-Shackel**


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**Objectives:**

- Determine whether different almond varieties exhibit differences in stem water potential (SWP) across a range of soil and orchard conditions.
- Determine whether there are differences in response to water stress among selected almond varieties and whether any observed differences are related to inherent physiological differences among the varieties.
- Determine whether there is a reliable and consistent relationship between SWP and other candidate plant-based and soil-based measures of water stress, particularly those that can be automated.

**Interpretive Summary:**


In 2012, the seasonal pattern in stem water potential (SWP) of Nonpareil and Monterey varieties were similar within an orchard, but reflected differences in soils and irrigation management when comparing commercial Tehama and Kern county sites. Periods of relatively severe stress (-25 bars in Kern, -30 bars in Tehama) occurred at both sites around harvest (August/September). Relatively minor but consistent variety differences in SWP occurred later in the season with Monterey showing somewhat more stress than Nonpareil, perhaps related to the earlier harvest of Nonpareil. Thus far there has been no evidence for any fundamental water relations differences in almond scions, but it is possible that rootstock or scion/rootstock interactions may determine root distribution/depth, and hence influence the level of plant water stress experienced under the same field conditions. Considerable effort has been devoted to testing/developing a reliable method for continuous and automated psychrometric measurement of SWP in almonds, and on some, but not all occasions, good agreement has been found between psychrometer and pressure-chamber measured SWP. In some cases two psychrometers will agree for a period and then diverge, indicating that disagreement is not a function of individual psychrometer calibration. In order to be of practical use, it will be necessary to identify the sources of error in the psychrometer measurements, and develop methods to reliably operate these devices. This research is ongoing.

## Materials and Methods:

Mature, commercial almond orchards in Kern and Tehama counties were selected and 6 trees of each of two varieties (Nonpareil and Monterey) were monitored for midday stem water potential (SWP) over the season. Baseline values of SWP were calculated from air vapor pressure deficit (VPD) data from the closest CIMIS station for the time of SWP measurement to the nearest hour. Commercial temperature compensated in-situ psychrometers (PSY1, ICT international, NSW, AU, **Figure 1**) were typically mounted to leaves, enclosed in a thermally buffered environment as shown in **Figure 2**, and SWP measured every 30 minutes. **Figure 2** shows a description of the process of sealing the psychrometer to the leaf surface, and the steps required to insulate the psychrometer against rapid fluctuations in temperature. The insulation used in 2012 was rather bulky, but we are currently working on a less bulky prototype.

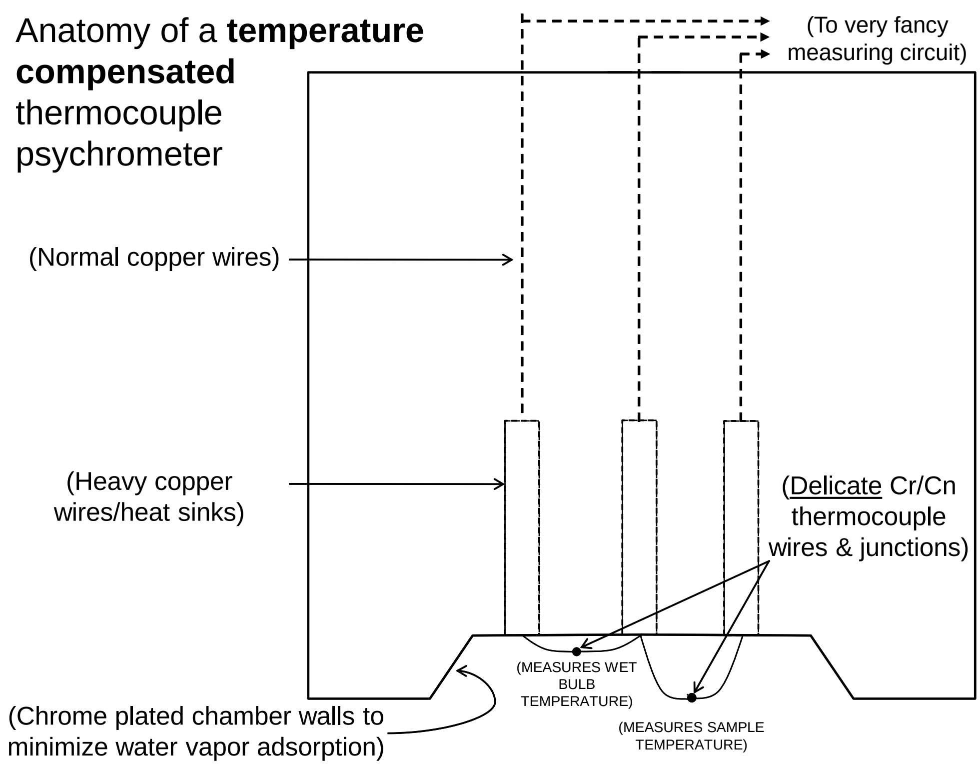


**Figure 1.** Schematic diagram of a thermocouple psychrometer used to measure SWP automatically. The lower chrome plated surface of the psychrometer is sealed against a leaf or stem, creating a small chamber above the tissue. A data logger measures the relative humidity of the chamber every 10 - 30 minutes using a thin wire thermocouple junction. Maintaining a clean junction and a uniform temperature throughout the psychrometer are critical to obtain accurate data.


**Figure 2.** Steps in the process of sealing an in-situ psychrometer to an almond leaf. The chrome face of the psychrometer must be lined with a thin strip of non-toxic silicone grease (1 and 2), then placed in an aluminum block which fixes the psychrometer against the leaf (3 and 4). The leaf surface in the area covered by the psychrometer must be gently abraded in order to have good vapor exchange between the leaf and the psychrometer (not shown). The psychrometer and attached leaf are enclosed in metal cans which dampen thermal fluctuations (5 and 6). This system is relatively bulky and must be supported by clamping to a nearby scaffold. During the insulation assembly, it is critical that the leaf is not disturbed with sufficient force to disturb the psychrometer/leaf seal or damage the leaf or leaf/stem connection.

## Results and Discussion:

Differences in soils and irrigation management between the Tehama and Kern county sites were evident in differences in the seasonal pattern of SWP at the two sites, but similar to previous findings. For the same site, SWP differences between Nonpareil and Monterey varieties do not appear to be substantial (**Figure 3**). At both sites, Monterey and Nonpareil exhibited essentially identical SWP values early in the season (to mid-July in Tehama, mid-August in Kern), but Monterey consistently exhibited somewhat more stress than Nonpareil after this. At the same site, the two varieties exhibited the same overall seasonal pattern of SWP showing periods of relatively severe stress (-25 bars in Kern, -30 bars in Tehama) around harvest (August/September). The somewhat lower SWP for Monterey under stress conditions may be indicating an interesting difference in drought resistance between Monterey and Nonpareil. This will be investigated further.

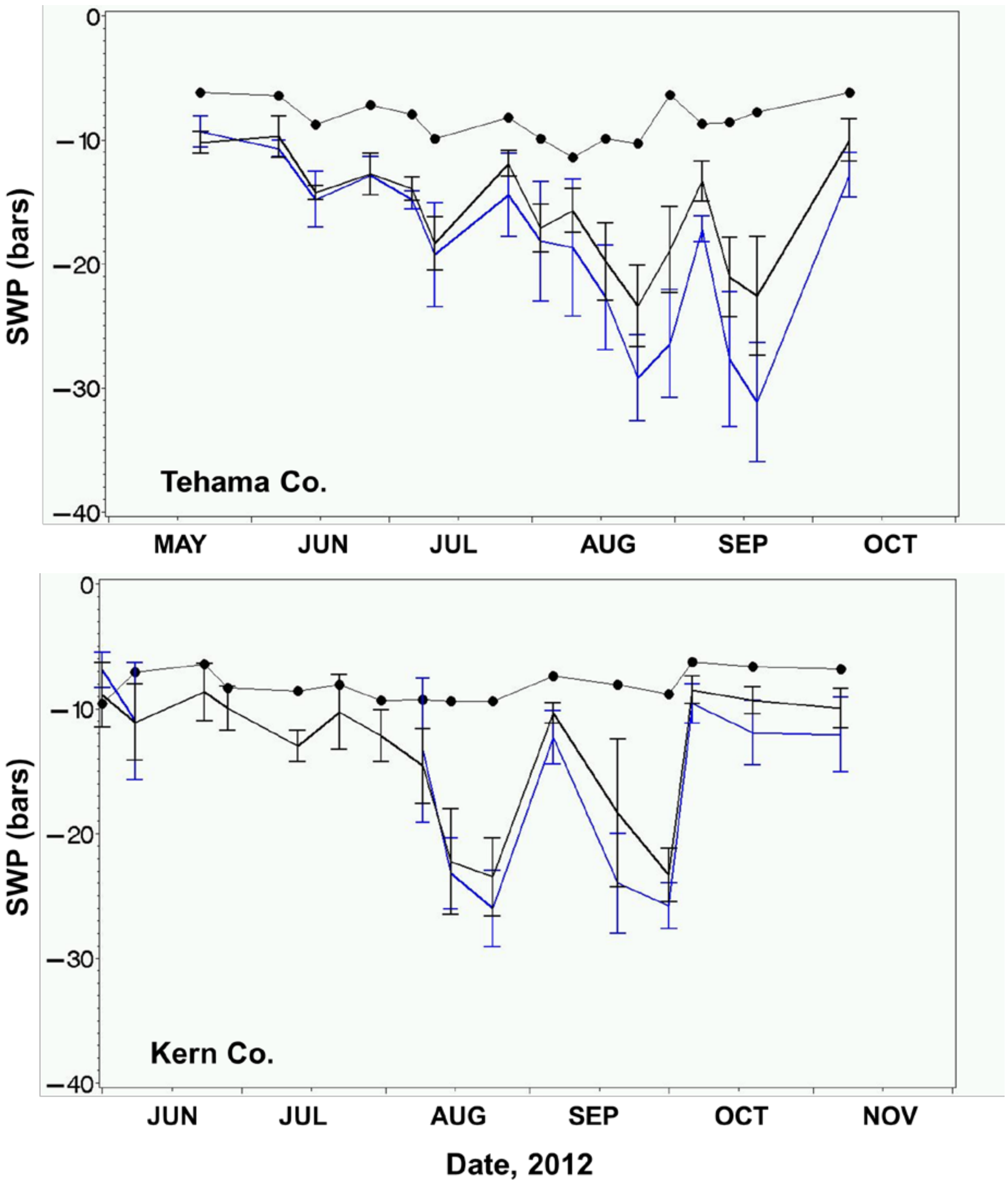


**Figure 3**. Comparison between Nonpareil (black line) and Monterey (blue line) SWP in commercial orchards at two locations. Also shown are the baseline values for the dates and times of sampling based on VPD data from the nearest CIMIS station.

A major effort was undertaken to evaluate the reliability of a commercially available psychrometer for the automated measurement of SWP in almonds.  Initial results obtained in 2011 (**Figure 4**) were promising in terms of the apparent reliability of the data (reasonable daily patterns and in some cases good agreement with the pressure chamber), although exact agreement with the pressure chamber was not always obtained. Since the SWP measured with the pressure chamber on different leaves of the same tree are generally within about 0.2 bar, it was expected that two psychrometers would also agree to this extent.  In some cases this was found true for almond (**Figure 5**, top).  However, there were occasions in which psychrometers agreed closely on a particular day (**Figure 5**, September 4-5), but diverged over time (**Figure 5**, September 6-10), with no obvious differences that might indicate an artifact such as differences in psychrometer temperature (**Figure 5**).  A change to the surface of the leaf (such as spreading of the silicone grease) could cause artifactually low apparent SWP  If artifacts of this magnitude (5 bar) do occur, then the psychrometer will not be reliable enough for irrigation scheduling in almonds.  No firm conclusions about the reliability of the psychrometer can be made at this time. Since the physical principle of measurement in the psychrometer and pressure chamber are entirely different, it is likely that the good agreement found on some occasions indicates that the psychrometer approach is sound and that such disagreement as shown in **Figure 5** indicates the presence of an artifact.  We are currently performing additional experiments to determine the possible source(s) of this artifact.

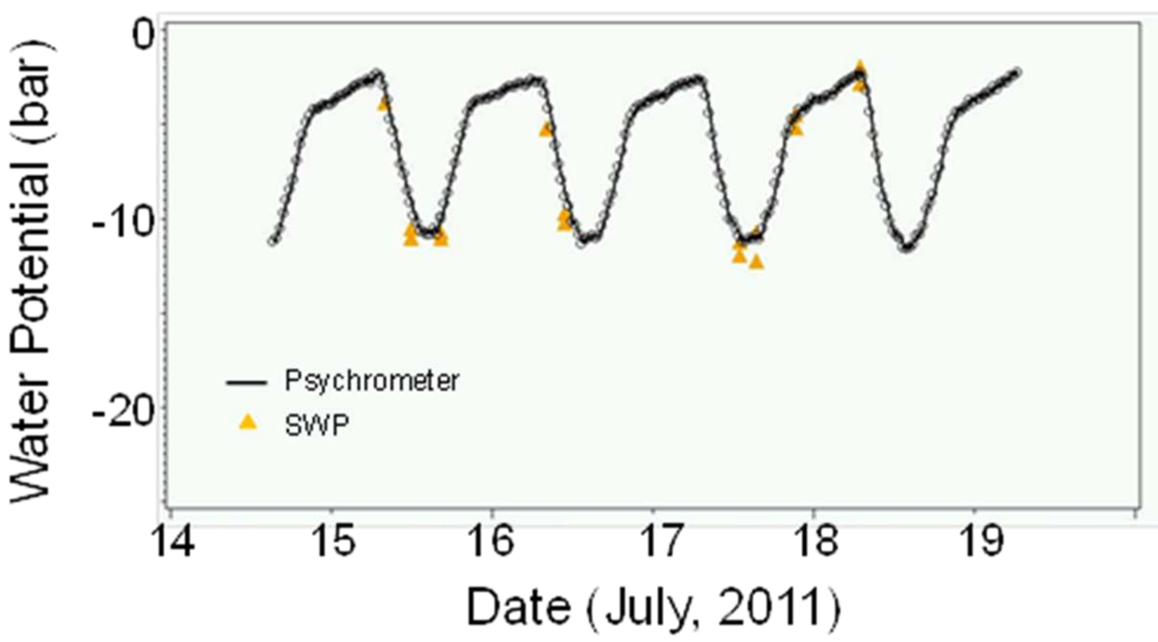


**Figure 4.**  Example of automated measurements of SWP on a cherry tree in the field using the psychrometer, and periodic measurements of SWP on the same tree with the pressure bomb.

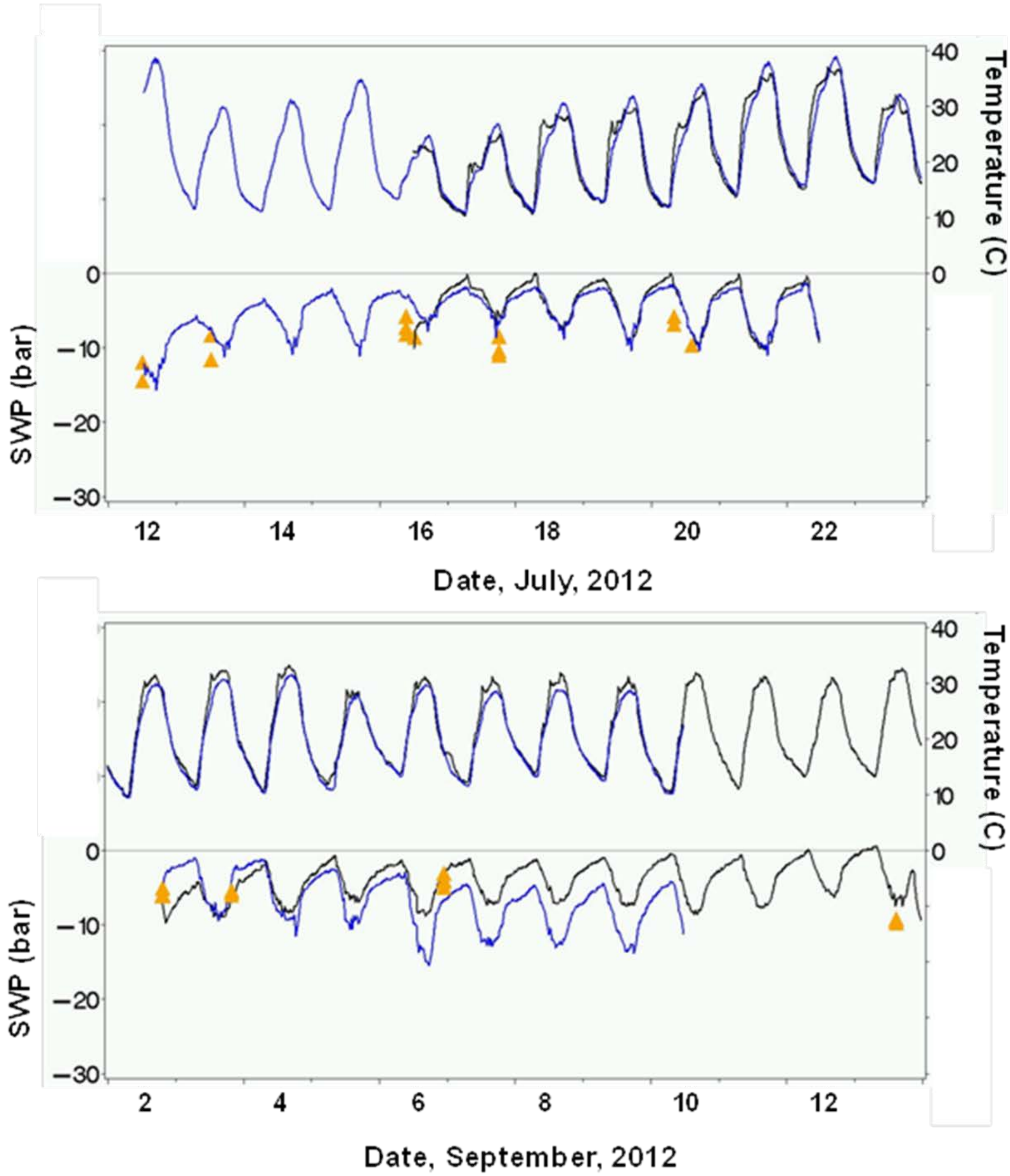


**Figure 5.** Examples of good agreement (top – July 2012) and poor agreement (bottom – September 2012) for two psychrometers (blue line and black line) measuring the same almond tree. Also shown are the respective temperatures of the two psychrometers and periodic SWP measurements (triangles) made with a pressure chamber on the same tree.

## Research Effort Recent Publications:

None at this time.