Variable Rate Irrigation Practices on Almond

Project No.: **17-HORT32-Bali/Culumber**

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Objectives:

1. Demonstrate variable rate irrigation capacity to improve water and nutrient use efficiency, tree growth, and yield in commercial almond orchards.
2. Determine variable irrigation requirements based on site climatic conditions, soil texture and salinity, and tree growth stage among other site-specific factors to improve water use efficiency.
3. Develop a system to assist growers in defining "zones" of similar characteristics, then develop variable irrigation scheduling programs for each zone to meet crop needs.
4. Retrofit existing irrigation systems to control water applications in small zones (1 acre)
5. Develop irrigation schedules that meet an orchard's crop water requirements, decrease water and nitrogen losses and reduce energy use.

Interpretive Summary:

Almond growers in California are under continuous pressure to grow orchards with limited water supplies. In recent decades, pressurized micro-irrigation systems have greatly improved distribution uniformity and water use efficiency of applied water. However, different portions of

a field may have varying water and fertilizer requirements due to soil spatial variability, water quality, climate and other factors influencing tree growth across the block.

Most irrigation systems have little capacity to differentially irrigate different sections of the field to account for various factors that affect crop water needs. Water applications to the entire field are based on the needs of the 'weakest' areas, which may lead to over applications and reduced system efficiency and yield potential. Variable rate irrigation (VRI) systems may improve water use efficiency by tailoring irrigation zones and sets to meet changing tree water requirements. We are testing here VRI system on a 70-acre block to document the impact of using such technology on crop yield, water use efficiency, economic feasibility, and potential improvements in energy and fertilizer use efficiency.

Materials and Methods:

<u>Site Selection:</u>
Efforts were made in early 2017 to select a field site for the variable rate irrigation project in Fresno County. One field was selected in Helm, CA and baseline soil and tree water status, canopy, and nutrition parameters were collected. Data observations were initiated in early April and continued through August 2017. A comprehensive salinity survey was conducted for the entire 118-acre block of nine-year old almonds in early April. The southern block was divided into a 60 (1.5 acre) grid to understand tree water status, nutrition, and canopy size (yield potential) patterns across the block. Stem water potential readings were collected for one tree within each 1.5-acre plot twice a month. Leaf tissue samples were collected from the three centermost trees in each plot in late July. Canopy light interception as midday canopy photosynthetically active radiation (PAR) was measured in mid-June and again in mid-August. A survey of tree health in the block indicates numerous trees are infected with wood rot fungi (Ganoderma sp.) and that high rate of tree mortality may ensue in coming years. The research group decided to abandon this location for establishing a variable rate irrigation trial and select another field.

In October 2017, a 70 acre, 4-year old commercial almond orchard was selected in near Hanford in Tulare County, CA to establish the trial in 2018 (**Figure 1**). Thirty-six 1-acre variable irrigation zones were implemented on approximately 50% of the field and the other 50% were used as control. Netafim installed the variable rate irrigation system in 2018, however, there have been delays in the implementation of the variable rate irrigation since the system was not fully functional as of summer of 2018. We are planning to implement irrigation scheduling using VRI technology and compare it to the grower standard irrigation practices on the other 50% during the 2019 growing season. Each zone is approximately one acre in size with approximately 105 trees per plot (total 3,781 trees on 34.378 acres). Two Tule evapotranspiration weather stations (**Figure 2**) were installed in each of the VRI and control sections of the field. Three locations for soil moisture measurements were established to estimate soil moisture in the root zone. Two stations were installed in zones representing low and high density vegetation soil moisture sensors and one station in the control (**Figure 2**).

<u>Irrigation scheduling:</u>
No irrigation treatments were implemented during the 2018 growing season due to the extended delays in the installation of the VRI system. The grower irrigated using their standard

irrigation practices. Average application rates and irrigation duration were determined to establish baseline figures for the farm. Soil moisture data and Tule actual evapotranspiration were recorded. In the 2019 growing season, irrigation scheduling for the different zones and the conventional control will be determined using a combination of evapotranspiration measurements from an on-site weather station, soil moisture monitoring and tree water status measurements. Additional soil moisture capacitance probes will be distributed across different soil zones of both the VRI and conventional irrigation system to guide irrigation decisions related to frequency and duration. Physiological measurements of tree water status were collected in a subset of trees, to determine how consistently the different zones relieve water stress across the block. A pressure chambers were used to determine midday stem water potential (SWP) before and after irrigation. Flow meters in each zone will be used to compare water use efficiency between VRI and conventional irrigation zones.

Plant Water Status

Baseline soil and tree water status, and canopy parameters were collected at Clark Ranch (36.240445, -119.4670198) in Tulare, CA. Data observations were initiated in early April and continued through July 2018. The 2013 planted orchard block of Nonpareil are arranged in a 18ft x 22ft, and the second variety Wood Colony, in a 15ft x 22 ft pattern. Both varieties are on Nemaguard rootstock. Baseline data was collected during the 2018 season to identify any spatial variation in tree canopy size and plant water status prior to implementing the variable rate irrigation trial. There are 36 zones from which data was collected. Stem water potential (SWP) readings were collected from the two centermost trees within each 1-acre plot at least once a month. Reference baseline values were determined according to the temperature and relative humidity (RH%) as outlined in Fulton and Buchner (2014). Canopy light interception as midday canopy photosynthetically active radiation (PAR) (Lampinen et al. 2012) was measured in early June, data analysis is still ongoing. Dendrometers will be installed in 2019 in subset of zones to compare continuous plant water status measurements with SWP.

Virtual Orchard

Drone flights were conducted in June 2018 to determine the area, canopy coverage, average height, maximum height, and volume index in each zone. The parameters were determined for each of the tree in the orchard and we are in the process of determining the average parameter in each zone as well as the control zones (**Figures 3-5**).

Yield

A weigh cart with load cells, GPS, and auto-sub sampler will be used to measure continuous almond yields within each irrigation zone in both the VRI and conventional systems. The almond sub-samples will be evaluated for kernel weight and quality. Canopy light bar measurements at harvest and almond yield will be correlated to records of total water, to identify changes in productivity in response to the VRI system.

Results and Discussion:

Tree water status was uniform across the orchard early in the season at an average SWP (-7.0 ± -0.11 bars), which fell at or slightly more negative the baseline for well-watered trees. However, stress increased as the 2018 season progressed, with SWP values running an average -7.0 to -10 bars below the baseline in June and July (**Figures 6-7**). Although the current orchard irrigation schedule is applied in pulses to match weekly ETc, SWP readings indicate severe tree stress throughout the block. Water infiltration issues (**Figure 8**) resulting from the coarse-loamy soil characteristics are likely contributing to high stress levels observed at the site. Different soil amendments and soil modifications will be tested within different zones to increase infiltration in the 2019 season.

Implementation of irrigation scheduling on VRI zones will be initiated in the 2019 season. Using the data collected from the virtual orchard work, we will determine the average distribution of % shaded area and volume index as the initial basis for determining the irrigation run time for each zone. We will then use SWP, PAR, and NDVI to further fine-tune the irrigation schedule of each zone. In addition, soil moisture status will be utilized to ensure that the zones are irrigated correctly. Irrigation scheduling will be determined by both Netafim and UCCE with input from all collaborators.

Research Effort Recent Publications:

The following educational activities were conducted during the 2017-2018 season:

- Poster at the 2017 Annual Almond Conference in Sacramento (Poster No. 39), December 2017, Sacramento California
- Presentation at the Annual Almond Conference in Sacramento, December 2017.
- Two presentations to almond growers at the Irrigation and Nutrient Management Workshop, Modesto, CA (May 9, 2018)- K. Bali- Irrigation Scheduling Considerations to help identity yield thresholds and management allowable depletions using calculations of daily crop use. D- Zaccaria- Distribution uniformity (DU) & Productivity. Review application efficiency, water use, energy use and the relation to crop productivity.
- University of California Cooperative Extension, Irrigation workshop. July 13, 2018. Fresno, CA. Culumber- Irrigation Scheduling with ET in Nuts and Vines

References Cited:

Fulton, A. and R. Buchner. (2014). Using the pressure chamber for irrigation management in walnut, almond, and prune. UCANR pub 8503.

Lampinen, B., V. Udompetaikul, G. Browne, S. Metcalf, W. Stewart, L. Contador, C. Negron, and S. Upadhyaya (2012). A Mobile Platform for Measuring Canopy Photosynthetically Active Radiation Interception in Orchard Systems. HortTechnology vol. 22:2, p. 237-244

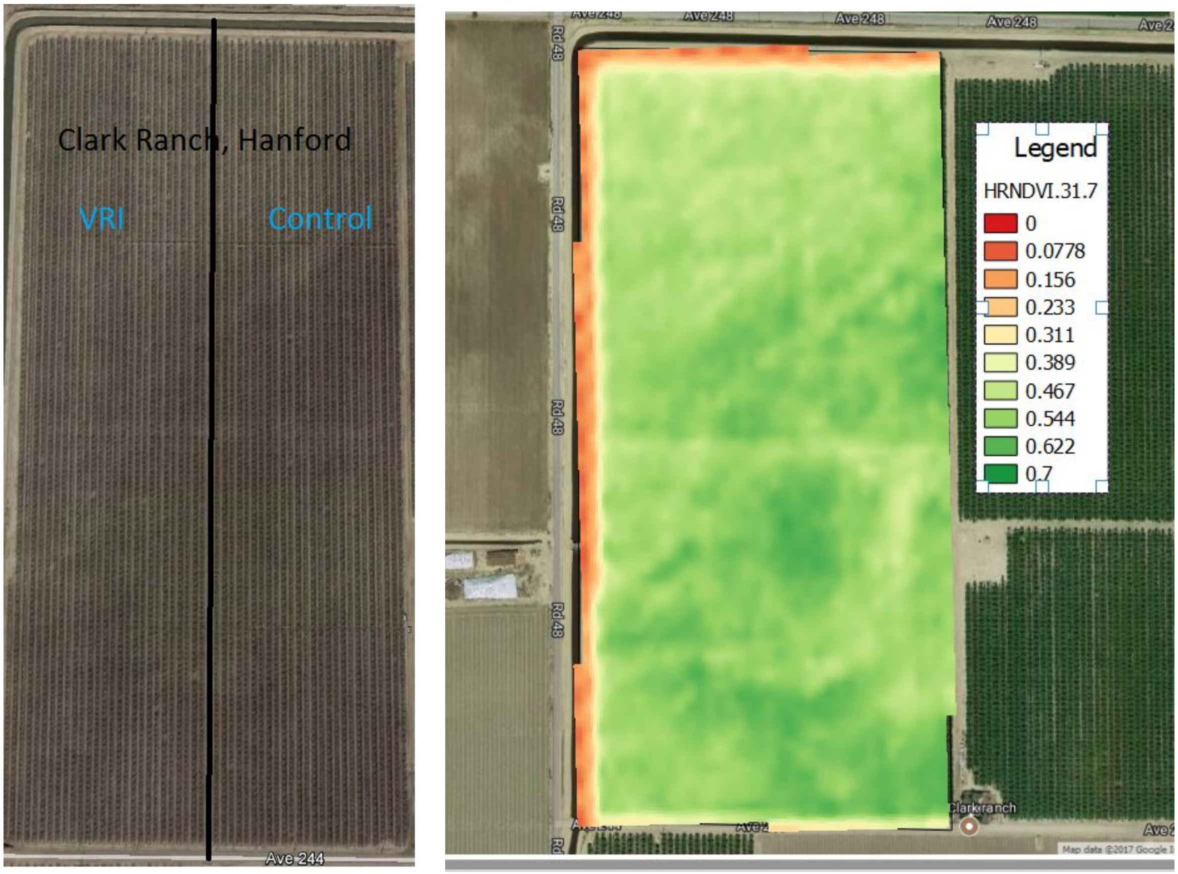

Figure 1. Clark Ranch, Hanford, CA.

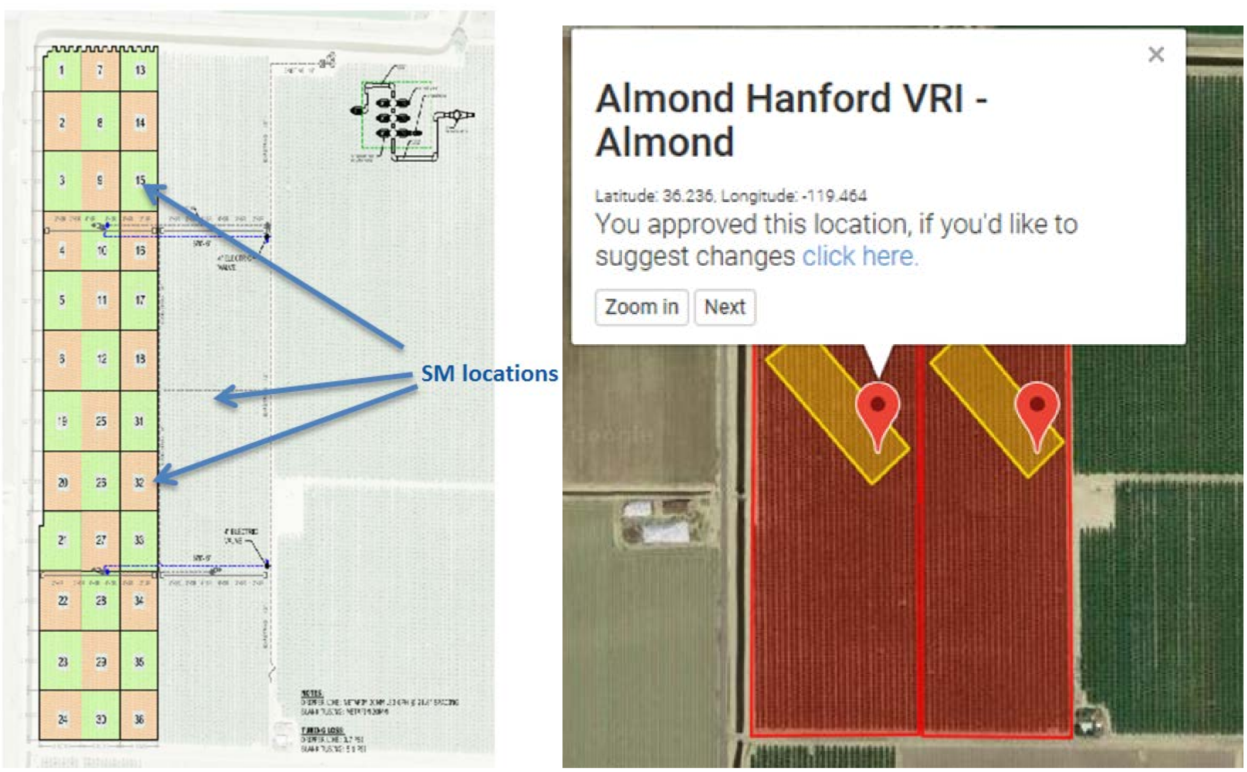

Figure 2. Soil moisture and Tule locations**.**

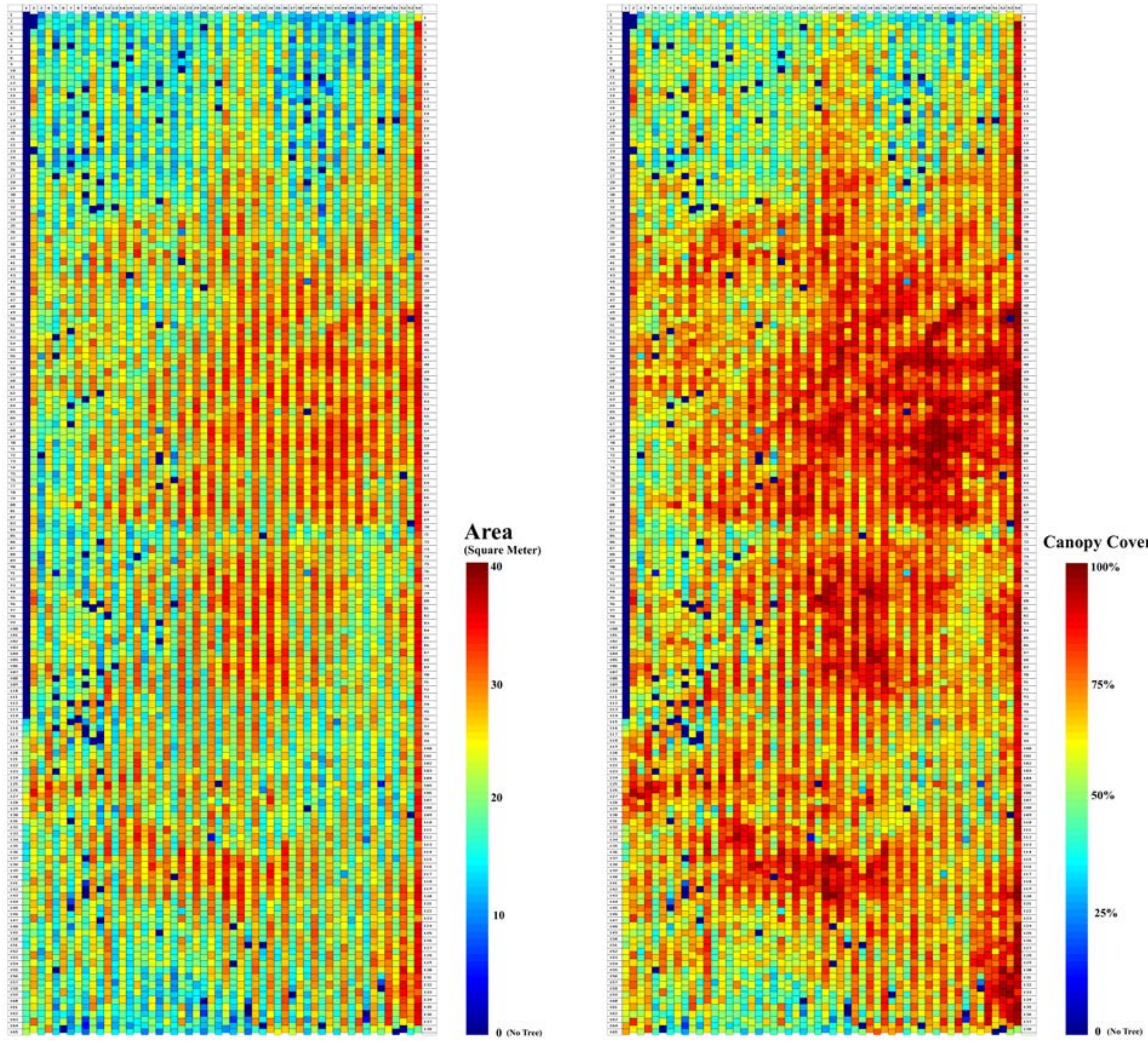

Figure 3. Clark Ranch individual tree area and canopy cover

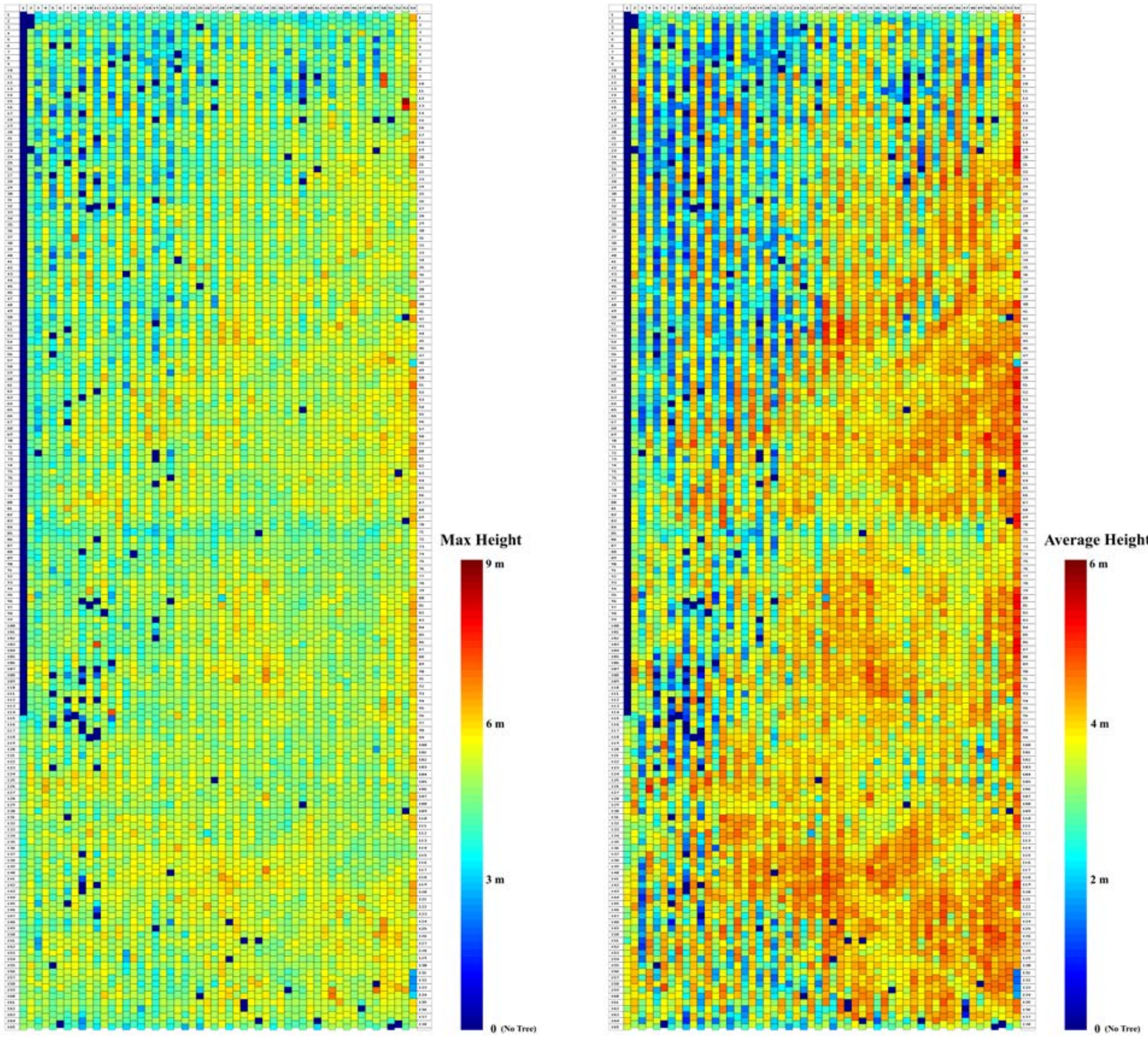

Figure 4. Clark Ranch individual tree maximum and average height.

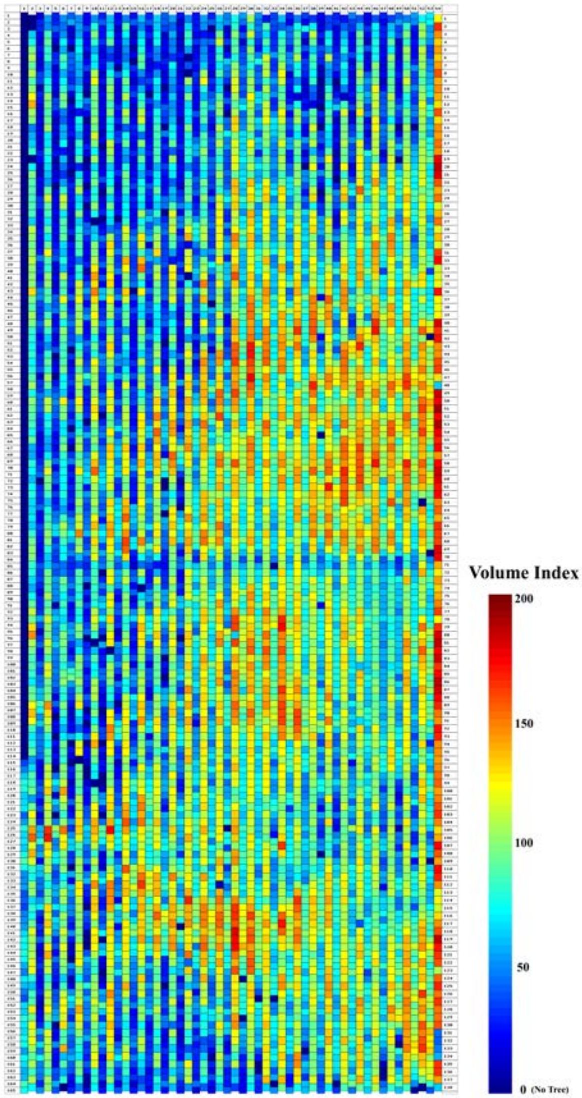

Figure 5. Clark Ranch individual tree volume index.

Figure 6. Pressure chamber.

Figure 7. Clark Ranch average stem water potential from May to July 2018 (blue line) compared to the baseline (orange line) as determined by temperature and RH%.


Figure 8. Image depicting Clark Ranch almond block water infiltration issues.