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# Wireless Water Sensing

Sensor network saves water and improves grape quality

By Thomas Ulrich

Ridge Vineyards uses a sap-flow meter from Fruition Sciences to evaluate the health of vines at its Monte Bello Vineyard property near Cupertino.

**D**avid Gates, vice president of vineyard operations at Ridge Vineyards, has installed a sophisticated tool for tracking field conditions and measuring the transpiration rates of vines planted at the winery's Monte Bello Vineyard in Cupertino, Calif. The vineyard team collaborated with technicians from Fruition Sciences to build a network of sensors that reduces water consumption and improves the quality of the grapes.

The simple but powerful design helps vineyard managers create a comprehensive vision for determining the health of a vineyard and irrigating much more efficiently. Sensors measure sap flow and wirelessly transmit data to a modem that relays information to a web server in staccato-like bursts. The server calculates transpiration rates, gathers data from a Ranch Systems weather station located at Ridge Monte Bello and remotely sends information that Gates can access from his desktop computer or other web-connected device. From there, Gates can evaluate the health of the vines by analyzing charts and tables that the sensors and the Fruition Sciences server update hourly.

"The results are a perfect integration of soil, root system and atmospheric conditions," he says.

Gates began collecting sap-flow rates from five acres of Cabernet Sauvignon in 2009. The vineyard team strapped sensors to four vines planted on a southeasterly facing slope. "We chose the block because I thought that the vines could need water between veraison and harvest," he says.

The sensors send electricity through a resistor that transmits heat to the vine as sap rises from the roots to the leaves. Several thermocouples embedded in a sleeve that wraps around the arm of a vine record a change in temperature as the resistor heats the sap.

"The thermocouples measure precisely how much heat is displaced by the sap," explains Thibaut Scholasch, vice president of research and development at Fruition Sciences. "Knowing how much heat is being displaced due to the motion of water, it is then possible to calculate how much water is flowing inside the vine."

A slow sap-flow rate signifies that water is moving slowly through the vine, a condition that translates into a high vine water deficit that can weaken the plant and dehydrate the fruit. A fast sap-flow rate is a sign that water is passing quickly through the vine, a condition that indicates a low vine-water deficit, which can invigorate the plant but dilute the color, flavor and varietal character of the grapes.

Gates regulates irrigation from veraison until harvest to produce grapes with a high surface area-to-volume ratio. (The skin contains most of the color and flavor-producing compounds.)

## Highlights

- Data from sap-flow meters and weather stations create a comprehensive vision for determining the health of a vineyard and how much to irrigate.
- Sophisticated electronic tools can measure transpiration rates of the vines and keep track of field conditions.
- Vineyard managers can access field and weather data using any web-connected device.

David Gates,  
Ridge Vineyards



"I'm comfortable getting the vine through veraison without additional water," he says. "But I have questions about irrigating between veraison and harvest, so I rely on the sensors."

#### Field work

From his cell phone, desk or laptop computer, Gates studies the one variable he cannot control: the weather. He prompts the control panel, evaluates water loss from the vine data and analysis panel, updates the vine-management log and records field measurements.

The control panel displays a map of the vineyard blocks and color-coded icons to alert him to the conditions of the wired vines. It contains data fields for sending and receiving text messages and recording and reviewing recently completed vineyard tasks. From the vine data and analysis panel, he tracks the transpiration rate and evaporative demand. The vine management and measurement logs store information about field activities including irrigating, pruning and thinning,

plus measurements such as anthocyanin concentration and Brix levels.

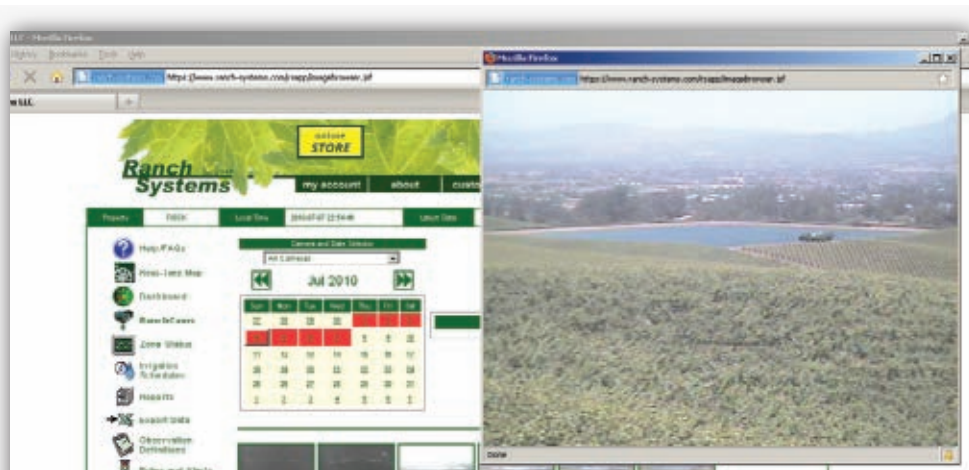
Data from the sap-flow rate sensors and the weather station record the smallest changes to the transpiration rate of the vines. During the dry summer of 2009, Gates tracked the vapor pressure deficit

(VPD) closely. "VPD and sap flow should mirror one another," he explains. "If it is a cloudy day, the sap flow follows the vapor pressure deficit. If not, you need to irrigate."

The sap flow fell below a critical threshold when both the VPD and sap-flow rate should have remained high, so Gates irrigated each vine with 20 gallons of water shortly before harvest. "The fact that the vines did not react to the irrigation meant that the root zone was filled with enough water to compensate for evaporative demand," he says.

The sap-flow rate fell because the atmospheric and seasonal demand diminished irrigation requirements for the vines. "It looks like we can dry farm this block most years, allocating water to vineyards that need it," Gates says.

Gates can retrieve hourly, daily or monthly reports that guide irrigation and maintenance schedules, present field data, forecast the weather and alert him of changes to the well-being of the vineyard. A watchful eye allows him to irrigate with enough water to avoid dehydrating the grapes, yet not so much that the grapes swell.



A weather station from Ranch Systems tracks vineyard climate by sampling the atmosphere and then sending field data to a server that relays the information to Gates' cell phone or computer, via the Internet.

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"Getting the berry size right," Gates says, "ensures that your vines are balanced."

Too little water can reduce yield. Too much water can reduce alcohol, color and pH while increasing titratable acidity. Irrigation patterns affect the aroma, astringency, balance, body, color, taste and texture of the wine.

"The wireless sensor network is the best vision of what the vines are seeing," Gates says. "It's better than leaf water potential, stomatal conductance or pressure bombs."

The network has limits, though. At Ridge's Monte Bello property, sensors from four vines measure the transpiration rates for a five-acre block of Cabernet Sauvignon. The sensors are limited to sleeves that wrap around an arm with a diameter of 30mm or less. And many factors besides soil moisture and weather conditions affect the transpiration rate—cultural practices, health of the vine, insect damage and vine cultivar, for example.

"I wait until the vine needs water, then irrigate to the soil profile," he says. "I might irrigate a shallow clay soil for 12 hours or a clay-loam soil for up to 24 hours."

"Water is precious," Gates says, "so we are trying to figure out the best time and how much to water."

Before Gates installed the sap-flow rate sensors and the weather station, he irrigated the vines from the Cabernet Sauvignon test block with up to 45 gallons of water per vine in dry years. During the wet growing season of 2010, he did not irrigate at all.

"For 2010, yields were average for Monte Bello at 2.5 tons per acre, and the quality looked excellent," Gates says.

### Programming the remote

While sensors from Fruition Sciences keep a close watch on transpiration rates and fieldwork, a weather station from Ranch Systems keeps track of the climate of the vineyard by sampling the atmosphere and then sending field data to a server that relays the information to Gates' cell phone or computer via the Internet.

The weather station measures leaf wetness, solar radiation, temperature and wind speed. It reduces water consumption by reporting weather conditions that allow Gates to closely manage the vineyard and stores indices for Botrytis and powdery mildew.

A Ranch System server calculates the indices based on data gathered from the vineyard and formulas developed by researchers at the University of California, Davis. Gates can review the powdery mildew index



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## Delay water as long as you can

**A**ccording to Dr. Mark Greenspan of Advanced Viticulture, vineyard managers should delay irrigation as long as possible, especially in areas of high winter rainfall. "Vine roots are very ephemeral in that they emerge and die or go dormant in a relatively short amount of time," he says. "Drip irrigation tends to shift the rooting patterns from the natural rain-fed state into a confined soil volume, thus adding potential nutrient and water stress on the vines."

(PMI), for example, from an electronic dashboard and specify that the application alert him via text message when the index approaches an unacceptable level.

"In 2010 it rained during the spring," Gates says. "It was a good year for ripening and powdery mildew."

Gates manages four ranches on Monte Bello Ridge that range between 1,600 and 3,600 feet above sea level. Early in the season he could spray the lower vineyard, which can sit in the fog every seven to 10 days while spraying the vines in the upper vineyard every 14 days.

"As long as I have access to the Internet," he says, "I can punch up the PMI module from my laptop or desktop computer, and Ranch Systems alerts me when crew members need to spray the vineyard."

Whether the vineyard team is tracking field or atmospheric conditions, Ranch Systems' and Fruition Sciences' web-based tools can help shape the harvest.

"Vineyard managers make irrigation decisions continuously during the season, so a continuous stream of measurements using radio telemetry is the best way to support those decisions," says Mark Greenspan from Advanced Viticulture. "Whether measuring sap flow, gathering weather data or gauging soil moisture, actual patterns of change can provide tremendous insight into the water balance of the vineyard."<sup>W&V</sup>

*Thomas Ulrich has written about science and technology for several magazines and newspapers. He wrote a story about optical sorters for the January 2011 issue of Wines & Vines. He teaches journalism at San Jose State University.*

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