Aerial imagery future of water management

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Advanced aerial imagery technology is the future of crop water management in California, says David Goldhamer.

STUDYING A proposed flight plan for a robotic aircraft (pictured in rear) are members of a Spanish research team examining water stress in California pistachios, almonds, and table grapes. From left include Alberto Vera Toscano, David Notario Rosingana, Berni, and Bob Beede, UC farm advisor, Kings County.

Goldhamer, respected University of California (UC) water management specialist based at the Kearney Agricultural Center (KAC) in Parlier, is studying new methodology fine-tuned by Spanish university researchers that more accurately measures water stress in crops.

The scientists from the University of Cordoba in Cordoba, Spain brought their high-tech equipment arsenal to Central California in late June and early July. They flew robotic aircraft (remote-controlled planes) with sophisticated cameras onboard to snap thousands of photos of pistachio and almonds trees and table grape vines from an altitude of 1,000 feet. The high-flying aircraft can be flown under Federal Aviation Administration rules.

The photos captured the water stress level in every tree and vine, not just crop blocks typical in current satellite imagery. The researchers are perfecting software to convert the millions of data digits into usable information to assist growers in advancing water efficiency to the next level.

Goldhamer and the Spaniards tested the aircraft and cameras at three California farm operations. They included 320 acres of Kerman variety pistachios at AgriWorld Cooperative in Madera, 30-acres of Nonpareil and Monterey almonds at the Paramount Farming Co.ﬀs Belridge Ranch located south of Lost Hills, and five acres of Thompson table grapes at KAC.

The Spanish scientists hail from the Instituto de Agricultura Sostenible, Consejo Superior de Investigaciones Cientﬀficas; translated as the Spanish National Research Councilﬀs Scientific Investigations branch of the University of Cordoba. The groupﬀs aerial imagery development project is funded through a multi-million euro grant from the EU. The research group has spent three years perfecting the aerial image technology.

The researchers who conducted the tests in California included: Elias Fereres, former research council director and long-time collaborator with Goldhamer; Pablo Zarco, current council director who coordinated the flying team; and nine others from Spain and Goldhamerﬀs UC group.

Farmers in Spain and California grow similar crops and both face water restrictions. While Spanish farms have smaller, mostly non-irrigated acreage, the researchers wanted to test-drive the aircraft on larger, all-irrigated acreages, plus compare aerial stress indicators with ground-based stress measurements from existing irrigation experiments. Goldhamerﬀs test plots offered the opportunity for this joint, win-win research.

Goldhamer calls the week-long study the greatest professional experience and research accomplishment of his 30-year water management career.

The tests conducted in searing temperatures featured two fifth-generation robotic aircraft. Each electrically-powered plane with a 10-foot wingspan featured an autonomous flight control system with GPS for precise navigation.

One aircraft included a $60,000 infrared camera for recording canopy temperatures. A similarly-priced multi-spectral camera on the second plane collected water stress, nutrition, insect, and disease information.

The flight duration per plane was 35 to 40 minutes. Each plane snapped one photo per second or about 2,400 photos per flight. The photos were merged into a single-photo mosaic to evaluate tree and vine moisture levels.

ﬀI am convinced this technology will eventually become the future of on-farm water management of trees and vines,ﬀ Goldhamer said after the tests. ﬀWe made a quantum leap toward more future efficient orchard and vineyard water management in California.ﬀ

Goldhamer says deciphering water stress levels in individual trees and vines is crucial. He has championed the development of ground-based water stress technology for use in managing regulated deficit irrigation (RDI).

RDI has allowed growers of wine grapes, for example, to water stress vines to achieve premium-quality grapes and maximize profits without permanent vine damage. Notable RDI advances have also been made in citrus and pistachios.

With California's continuing water crisis, aerial imagery combined with RDI could give growers some breathing room amid increasing water restrictions.

Goldhamer also advocates the current use of infield pressure chambers that measure leaf water potential, plus the benefits of the statewide California Irrigation Management Information System (CIMIS) weather system.

In addition to soil-based measurements, Goldhamer says each technique has major shortcomings. No current technique can accurately characterize an entire field, orchard, or vineyard. Aerial imagery overcomes this problem allowing growers more precise irrigation options.

"With this technology a grower could walk into the office, go online, bring up their fields, and learn which individual trees, irrigation sets, or fields need irrigation, not just which sets are scheduled for irrigation based on a rotation schedule," Goldhamer said. "It's a fundamentally different process."

Different companies provide aerial imagery for various industries using drones and full-size aircraft. Goldhamer says the Spaniards' drone-mounted miniature cameras provide precise canopy temperatures of individual trees and vines which saves the expense of larger aircraft. While full-size aircraft are a viable option in California, they are not economically feasible in Spain.

The Spanish system is the only one, to Goldhamer's knowledge, that quantifies individual plant stress data with precision radiometrically-calibrated infrared. The drone has an inertial measurement unit to compensate for camera movement in flight to maintain precise canopy stress information.

"Most existing commercial imaging systems likely do not have all of the on-board equipment necessary to come up with accurate canopy temperatures nor do they convert these into water stress indexes on a per plant basis. The Spanish system offers this," Goldhamer said.

Preliminary results

The preliminary results of the California aerial tests reveal that pistachios could require 20 percent less water than current use, Goldhamer says. This could free up 8 to 10 inches of water annually.

"Most people would call this conservation; I call it water creation," Goldhamer said.

"This technology will determine how innovative growers manage fields for water stress in orchards and vines in California. Growers will use aerial imagery information to alleviate or manage water stress to build on current RDI practices."

Chris Wylie, ranch manager with AgriWorld, is ecstatic with the tests conducted on the company's pistachio operation.

"This means I could irrigate 20 days less per year; that's 20 days of less water, labor, and fuel," Wylie said. "I could even save the costs of one or two cultivations."

To gain aerial imagery's full benefit, growers would be required to fine-tune or install new irrigations systems capable of more flexible water applications.

In almonds, Goldhamer found major differences in water stress relations between cultivars.

"An orchard with two cultivars would work best with a separate irrigation system for each cultivar," Goldhamer said.

If orchards and vineyards have areas that stress faster than other locations, independently-operated irrigation would work best.

While citrus RDI can reduce evapotranspiration by 20 percent to 45 percent, Goldhamer believes aerial imagery to calculate stress would be very challenging. Citrus trees have different hourly water use patterns than other fruit and nut crops which complicate canopy temperature measurements.

The cost of aerial imagery technology to growers would depend on many factors including how frequently aerial images are taken. Golhamer says two to three flights per week would be ideal.

Other factors include the amount of information gleaned from the images, the level of data analysis, and how the information is provided to growers.

"I believe to be commercially viable for orchards the grower costs would be $25 to $75 per acre for the type of aerial sensing I envision," Goldhamer said. "The price could be slightly higher for high-value wine grape vineyards."

Commercial satellite operators offer aerial images for thousands of dollars for a single image with no analysis.

The next step

Goldhamer will travel to Spain soon to join the Spanish scientists for side-by-side detailed data analyses. He is thrilled with the opportunities that the new technology could place at growers' fingertips. Growers could use saved water for new crop plantings or sell the water surplus on the open market.

"This could create an entire new realm of water management in California, not just for agriculture but the entire state," Goldhamer said.

Better managing water stress is the first benefit from aerial imagery. Beyond that is plant energy information related to chlorophyll color and structure recorded by the multi-spectral camera. This information can help calculate stress based on the photochemical reflective index plus provide accurate nutrient content information on a per-tree basis. The data could also evaluate insect and disease damage.

"This creates a whole new paradigm for growers in what they can expect in the future," Goldhamer stated.

Goldhamer predicts plant stress information could be commercially available within several years.

Goldhamer's own research on aerial imagery is funded by the Prosser Trust through the UC Water Resources Center. The trust covered the Spaniards' expenses while in California.

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