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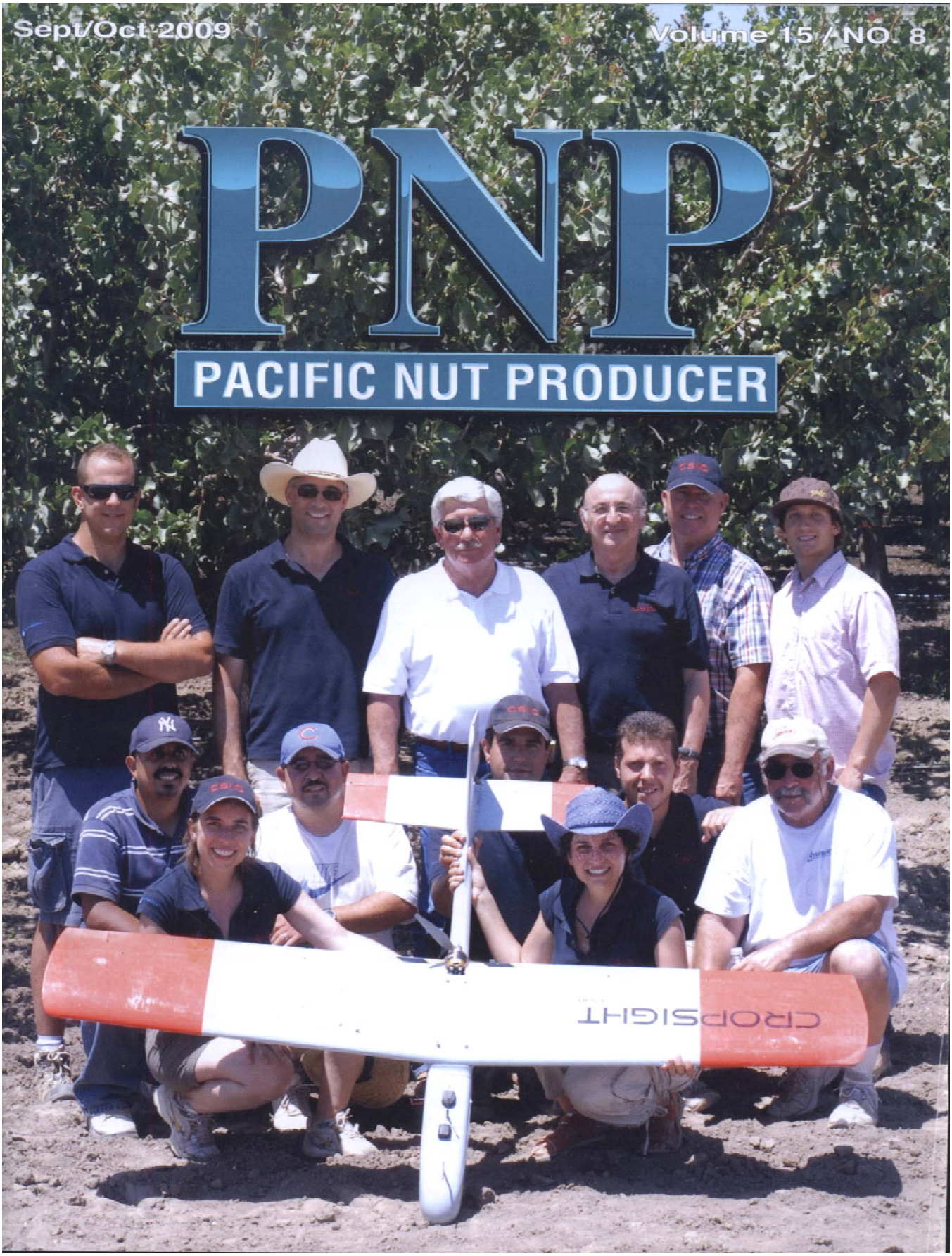
PACIFIC NUT PRODUCER



A Spanish researcher prepares a drone for another flight over Agri-World Cooperative in Madera.

Drones Over Pistachio Orchard

Remote Sensing, Overhead Technology, Tracks Stress

***By Patrick Cavanaugh,** Editor*

Long time collaborators Dr. Elias Fereres, a professor at the University of Cordoba, Spain and Dr. David Goldhamer, a Water Management Specialist with the University of California, witnessed one of their long-term goals in Madera County, at Agri-World Cooperative, a major pistachio operation. Fereres, a former UC Davis Irrigation Specialist was in California in early July to test an important next step in technology in managing water in crops.

With him was a team of researchers and students from Spain's Institute of Sustainable Agriculture, (ISA), Scientific Research Council of Spain, and University of Cordoba, Spain, as well as Goldhamer's UC group, and Agri-World managers.

The idea is to use an unmanned aerial drone, with sophisticated cameras snapping images every 1 second as it flies up down the pistachio (or other crop) rows at a maximum of 1000 feet (due to FFA regulations), traveling about 50 miles an hour.

At 1000 feet, the camera's field of view covers about a 100 yard-wide area, while capturing a detailed image of individual tree canopies.

A technician inputs GPS coordinates into pre-flight plan software. The program dictates where the plane flies to gather all the images it requires, which are stored on a microcomputer also placed in the plane. The images are recorded on flash cards normally seen in a small, common, digital camera.

In the Madera trial, two drones were used at different times because of camera

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Drones

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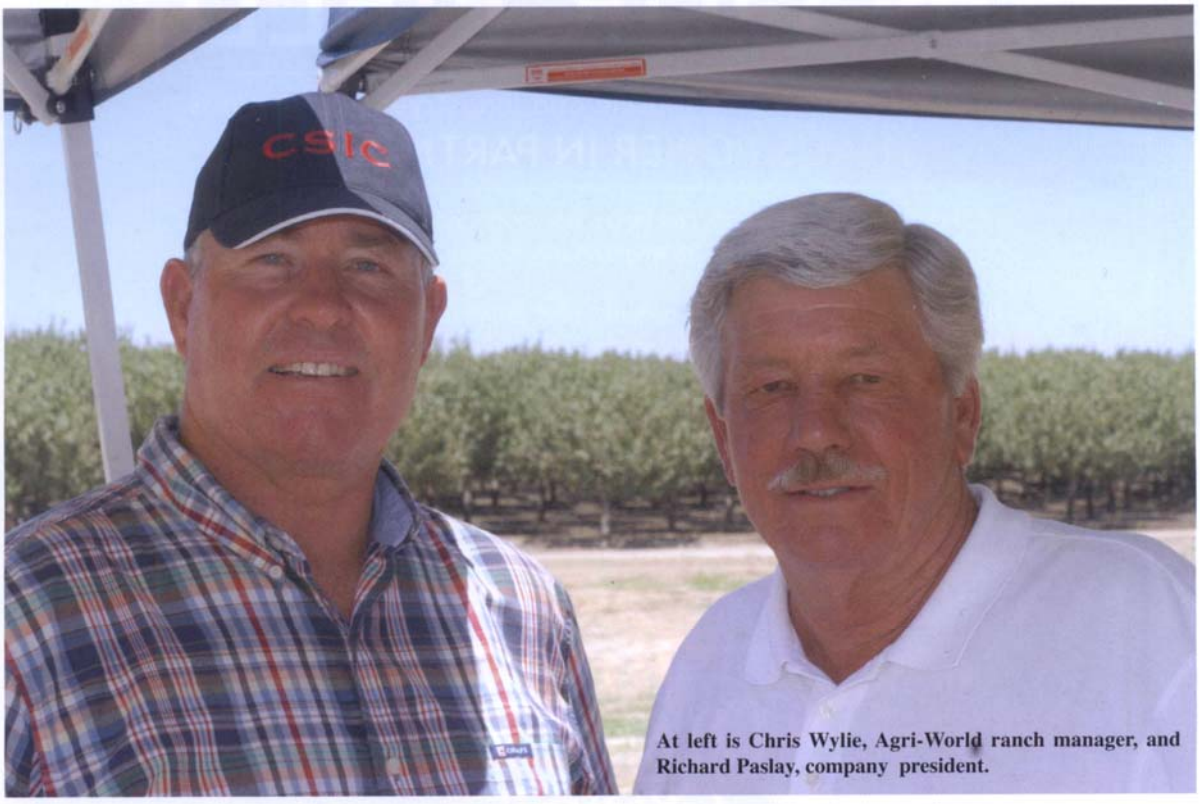
weight limits. One had a thermal infrared camera, which measures temperature by thermal imagery, which can determine canopy temperatures and how it relates to stress. The second drone had a multi spectral camera with lenses that could measure six different wavelengths or bands, that relate to several indicators including the photochemical reflectance index, an indicator of photosynthetic activity in the trees, which is considered a stress indicator. Other tree indicators may be obtained from this camera and may be useful in the future to diagnose nutrition problems or even pest outbreaks. The flights that day were for validation and calibration purposes.

"We measured the temperature of the trees, on a tree-by-tree basis, and we were able to get the state of that tree, how much water they may need, and what level of stress they may be under," said Fereres. "The purpose of the system is to produce maps of an entire orchard with a resolution that was before, impossible."



At left is Chris Wylie, Agri-World ranch manager, and Richard Paslay, company president.

"The infrared concept has been around for decades, however the technology has not been able to measure temperatures in very small pixel sizes," said Goldhamer, adding, "Satellite pixels are much larger, at best they can get several square meters, which is not adequate for orchards because it would pickup tree canopy as well as soils, which interferes with the data. Moreover, they only come over every 16 days or so and then at different times of the day."

Goldhamer noted that the drone camera technology is much better than the currently available pressure cham-

ber which measures water stress, but on a single leaf rather than the entire canopy.

"The primary goal of the overhead cameras in the drones is to accurately find tree water stress on every tree in the entire orchard. The cameras have such a high resolution, and small pixels, we can characterize an entire orchard for the first time, not just a single leaf or one point in the field," said Goldhamer.

"With our resolution at 10 to 20 inches, we are able to get accurate information from the tree crown, free from interference from the soil, weeds in the rows, or any other variations," noted Fereres.

Fereres said the ISA team in Cordoba has been developing the drone technology for the last three years. Leading the overall work is Dr. Pablo Zarco-Tejada, the director of ISA and previously a contract faculty member in remote sensing the UC Davis.

While the multi-spectral imaging technology is promising, the infrared data is most readily usable in the U.S.," said Goldhamer.

Goldhamer explained that the work with the drones is being done in crops where stress at a certain time is not harmful such as in pistachios, almonds and citrus. There are times when the technique of Regulated Deficit Irrigation (RDI) is possible.

One practical area for its use is in pistachios is from mid-May to early July---Stage 2 of the tree's summer growth, when the nut's hull and shell have already attained maximum size and before rapid kernel growth begins. "This is a time when we can moderately stress the tree and not have negative effects on production," noted Goldhamer. "But at the beginning of Stage 3 in early July, when the growth really takes off, a grower does not want water stress. We want to treat these two stages very differently with water."

"The key is to manage stress. In order to manage stress, we have to *know* the stress. And with the images from the overhead drones, we can accurately know the stress on individual trees," Goldhamer said.

Currently, there are limitations of the stress information because of how irrigation systems are set up in orchards. In a perfect world, each tree would have it's own on and off irrigation valve, but that's not practical. The more flexible the system is, the better.

Goldhamer envisions irrigation systems with smaller irrigated units at Agri-World, for example, the smallest irrigated unit is seven rows wide and about 150 trees long, thus containing about 1000 trees. "Within each of these large irrigation sets are trees that for whatever reason—shallower soil, soil salinity, different canopy size, different crop load, relatively low operating pressure of the emitter/microsprinkler—are stressed and then tend to be in small pockets of 50-100 trees. If we designed or retrofitted the irrigation systems so that each of these pockets could be irrigated independently AND we knew the stress in each of these pockets, as we would with the aerial imagery, we could irrigate much more efficiently," Goldhamer said.

The drones can also find where irrigation leaks may be present in an orchard, if the data shows that the orchard area is generally stressed and one or two

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Someday orchard irrigation decisions may be made with the use of detailed data gathered by drones flying high above the trees.

Drones

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trees are not. "This happened earlier this summer in an almond orchard during the flight of a drone in Kern County," Goldhamer said. "The manager would have been able to go to the specific tree and fix the drip irrigation leak, adding, often times the leak is never noticed in the middle of the orchard in a timely way."

"When the system is full developed, which is getting close, we anticipate that irrigation districts, or larger farming operations may be able to provide this overhead mapping service to growers so that every three or four days, growers can have an accurate image of their orchard," said Fereres. "They can know the water status of each plot and they can predict their tree's water needs. It can also identify leaks or other irrigation problems."

"It can be used in many areas that allows a more efficient use of a limited water supply," said Fereres

Editor's note: If you would like more information on the air drone and see it flying, log onto CaliforniaAgNet.com and find the 7/23 video entitled Using Air Drones to Farm. PNP