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CONSERVATION ON THE

Rocky Dutt tends drip irrigated wine grapes near Elgin, Arizona. L.G. Ketchum

FARM by Don Dale

The theme runs through the College of Agriculture and on out into other colleges of the University of Arizona: runs even further, out to the land management agencies, the state's decision-making bodies, farm groups, businesses and down to individual growers of Arizona's dozens of crops.

The theme is that the research done here must not be done in a vacuum. It must not only be pertinent to the needs of the agricultural community, but also interconnect with other parts of that community. Thus, it isn't surprising that when a research project is completed it sheds light on other projects and results, leading to an ever-expanding source of light.

The theme is nowhere more evident than in the context of water conservation. From economics to biotechnology, from whiz-kid gadgetry to crop selection, so much of it touches on water.

"The issue of the availability and quality of water is of extreme importance," says Dr. L.W. Dewhirst, Vice Dean and Acting Associate Director of the Experiment Station. "Increasingly we find they are more important, these valuable resources like water. We are living in an arid land and need to be aware of the limiting factors.

In the context of water, one of the words a visitor hears often around the college is "players." It's a catchy word, kind of fad, perhaps. But as he goes around and talks to people called the prime "players" in the fight to conserve water, the visitor is soon struck by its relevance. The research networks of the college are like many stages of actors rehearsing the future of the state.

"We are not the only actors," Dewhirst says. Other parts of the university like microbiology, architecture, engineering and microbiology and immunology are involved in College of Agriculture water projects. Those projects involving farming are centered on increasing efficiency of irrigation, developing better-adapted cultivars of traditional crops and searching out alternative crops.

"As water costs go up, it will be a matter of economics— whether farmers can afford the cost of production," Dewhirst says.

With that in mind, agricultural economist Paul Wilson's work on profitability seems particularly relevant.

"Can a grower make a *profitable* investment in irrigation technology?" Wilson asks. That question is the basis of his work, in collaboration with other economists, on the economics of drip irrigation, lateral move sprinklers and the new-to-Arizona surge irrigation.

Wilson's premise is that it is irrelevant for the grower to pursue new irrigation technologies if he can't afford them, yet farmers are desperately seeking new alternatives in order to stay in business. "The impetus for all this is the groundwater law of 1980. It's causing people to ask themselves how they can maintain yields and apply less water."

In order to test the feasibility of spending as much as $1,500 per acre for a new irrigation system, Wilson had to develop crop budgets for traditional furrow irrigation systems and compare them to budgets for new technologies. He relied heavily on prior work by fellow economist Scott Hathorn and others, and discovered one central theme.

"The critical thing in all of these technologies is some kind of yield increase," Wilson notes. "A water savings alone isn't going to pay for the systems."

Which led to another discovery: only adaptive farmers who intensively manage their irrigation systems will get those increased yields. That's where UA staff may be of utmost importance, especially in Cooperative Extension, where the rubber meets the road.

Pinal County agent Rick Gibson is only one example of people trying to reach out with the information. Over the years since water has become such a burning, and legalistic issue, Gibson and his office have sponsored many meetings where farmers and other interested parties could bone up. One series focused on the installation of water-measuring devices on their delivery systems.

"We were hoping that as people put these devices into service they would get a handle on the amount of water they were putting on per acre," Gibson says. "Then we could devise means of making them more efficient."

The farmers of Pinal County, with the advice of the university, help from the Soil Conservation Service and rationale from the water laws of the Arizona Department of Water Resources, have a reputation of cutting their per-acre water use more each year.

Before new irrigation information becomes available to the public, however, it must pass rigorous testing by researchers who are looking for both flaws and benefits. Agricultural engineer Dr. Del Fangmeier has been doing this for 19 years at the UA.

"It seemed that one of the things we needed was a better mechanism for irrigation management," Fangmeier says of his tests on several types of irrigation systems. It isn't so much a question of which system to use, but how to use it efficiently.

Development by the U.S. Department of Agriculture of a crop water stress index was a pivotal event that has led to a new generation of irrigation research at the university. Fangmeier's work with Extension plant and water relations specialist Don Garrot has led to revelations about the crop water stress indices (CWSI) of several crops, including cotton, still the state's big moneymaker.

"If we're going to have an impact, that's where to start," Fangmeier says of cotton, which has traditionally been a high water user.

His years of research have already revealed that smaller and more frequent irrigations, whether through innovative systems or normal sloped furrows, give better efficiency. But the CWSI gives new meaning to the word efficiency.

"Last year we reduced the water use by about half an acre foot—and upped the yield," Garrot says, speaking of his irrigation tests on cotton in cooperation with a Pinal County grower. Using a hand-held infrared thermometer gun, which is available commercially, he can derive the CWSI of a crop at any time in the season. Immediately, on the spot.

Having developed normal CWSI's for cotton and wheat—the points at which the plants have their ideal moisture level and growing potential—Garrot can immediately see from the current reading how close the crop is to needing an irrigation. All a grower has to do is learn to gauge the interval between different CWSI readings and irrigation time, and he has the perfect scheduling mechanism. This leads to water savings, since growers tend to water a couple of days early to be safe.

"That's two irrigations saved over the season" by using precision scheduling, Garrot says. He is also working on good CWSI charts for watermelons, pecan trees and turf grass.

Ultimately, he envisions a completely automated system whereby thermometers placed permanently in fields will relay readings to farm office computers, which will interpret the data, calculate scheduling and regulate irrigation systems.

Dr. Lloyd Gay, a professor of watershed management, is taking another tack in this area, using electronic monitoring equipment he developed to measure air temperature and vapor concentration gradients above the canopies of crops to give a readout of evapo-transpiration. A "vest-pocket" computer calculates these values, which gives a running tabulation of plant water use.

"If you know the daily water use you reach a point where you can regulate the irrigation," Gay says. "It has even more application if you input that water with a drip irrigation system. What you're doing is squirting in the water you lost the day before."

Gay is working with agricultural engineer Dr. Muluneh Yitayew, who is developing irrigation schedules for crops. These will be tested on alfalfa and

L.G. Ketchum

There are several alternatives being tested by researchers and growers around the state—either to save water, to increase profit potential or to meet new market demands.

(opposite) Agricultural engineering graduate student Reinaldo Gomide installs an electronic probe into an apple tree. (left) Linked to a computer, the probe measures transpiration by monitoring the sap flow. Knowing the transpiration and water consumption rates will help growers schedule irrigations.

cotton in 1988 using automated drip systems.

This information is coming at a good time in the world of cotton. It coincides nicely with the computer modeling work done by several research facilities around the nation, one of which is being tested for possible use in Arizona. Dr. Wally Hofmann, in the Department of Plant Sciences, is part of a College of Agriculture committee studying use of the Comax-Gossym model for cotton developed at Mississippi State.

"It will predict what will happen if I irrigate right now— right down to yield at the end of the season," Hofmann says. "It allows the grower to ask 'what if'."

Using a Casa Grande cotton grower's field to test the Comax-Gossym model, the UA researchers will be taking their data to the Mississippi State/USDA computer modelers so that it can be incorporated into a system designed for the wetter Southeast. The potential water savings for a system that simulates cotton growth and gives ideal irrigation schedules are substantial, especially if combined with a water use detection system.

According to Dr. David Kittock, a longtime plant sciences researcher who is near retirement, cotton is a crop whose death has been grossly exaggerated. His own irrigation strategy tests and the advent of practices like laser leveling of cotton fields tell him it can be grown compatibly with new groundwater regulations.

"I came here in 1965, and the first year I was here I heard there would be no cotton acreage in the state in 20 years," Kittock says. "I just don't really believe it's ever going out."

Yet, there are several alternatives being tested by researchers and growers around the state—either to save water, to increase profit potential or to meet new market demands. Again, the university can save farmers a lot of time and money by giving them unbiased information on these unusual crops before they try commercial acreages.

"I think water is the whole key," says Gene Wright, an economist in the Office of Arid Lands Studies. The fact that Arizona cities are buying up huge agricultural areas for their underground water rights, and that high energy costs of pumping have made a lot of acreage unirrigatable (70 percent of the farmland in Cochise County in the last 10 years, for example), means that low water users are more attractive.

But Wright issues a warning based on his economic studies of alternative crops:

"You've got to sit down and put a pencil to that. We can grown them, but right now they don't make you any money."

For example, guayule has been tested for the last decade and found to be readily adaptable to Arizona's low desert growing conditions. But in order to push its rubber production to a commercial level, guayule requires over 4 acre feet of water—as much as cotton in

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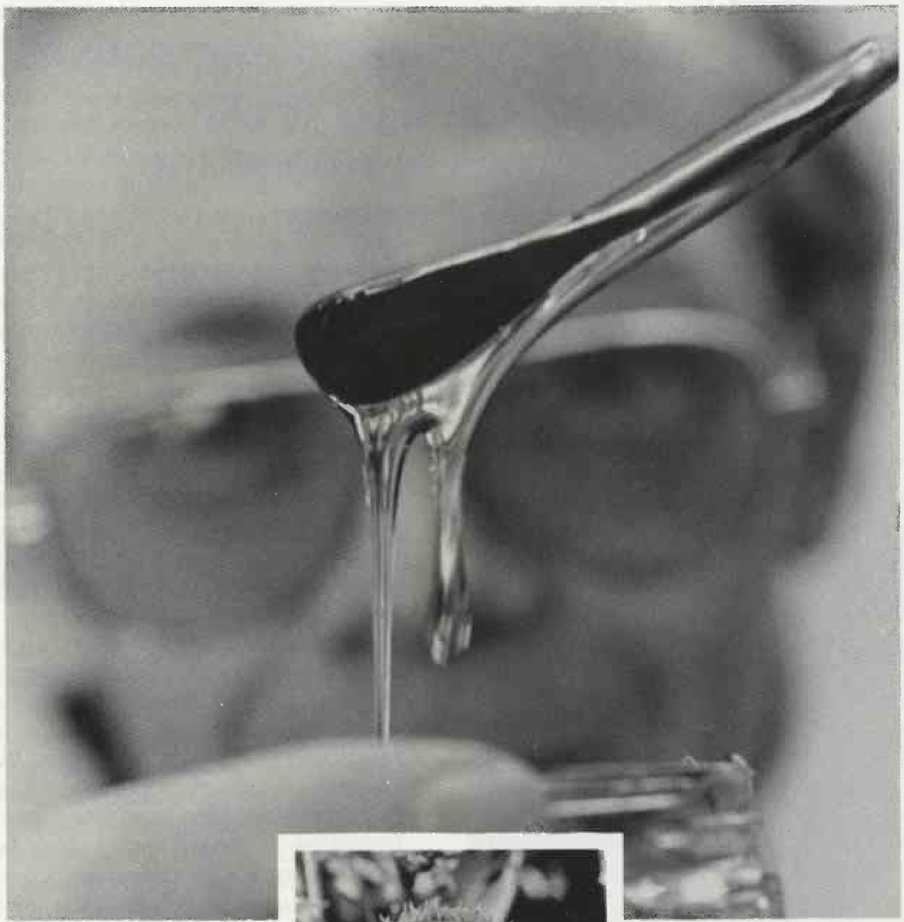

L.G. Ketchum

Gumweed is a promising "industrial" crop. The plant produces a substance similar to pine rosin.

some cases. There are other problems, such as a price of about $.42 per pound for rubber, but these could be overcome if what seems to be a push by the U.S. Department of Defense to make domestic rubber production a strategic priority succeeds.

More well-known alternatives, such as apple orchards in southeastern Arizona, may pay off even though they require up to $10,000 per acre of cash flow over a 12- to 15-year payback period.

"It takes a lot of money, but the payback is high too," Wright says. Grapes also fit into this high profit potential scheme, and they can get by on less water than apples.

The apple tree may also be wired to require less water, however. Work on transpiration rate of the tree by agricultural engineer Dr. Don Slack and a graduate student has determined a water consumption rate; electronic probes placed in the xylem measure sap flow and, thus, transpiration, giving potential means of scheduling irrigations.

Drought-tolerant crops like jojoba, a source of liquid wax now obtained from the sperm whale, may one day also achieve greater yields with low water application. Assistant professor Dr. David Palzkill is concentrating on selection and propagation of jojoba plants, reproduced asexually, which will produce beans more uniformly and at a higher yield than plants currently available from the wild.

"The potential per-acre value could be higher than cotton," Palzkill says, and he is using cuttings and tissue cultures to try to produce genetic strains with higher yields.

Another promising "industrial" crop for arid areas may be gumweed. Gumweed consists primarily of diterpenoid resin acids similar to those in pine rosin. Rosin is used in the manufacture of inks, paper sizing and adhesives. Research scientist Dr. Steven McLaughlin's test plots at the UA Office of Arid Lands

Studies' Bioresources Facility have produced yields up to 1,050 pounds of resin per acre with 26 inches of applied water.

McLaughlin's research suggests that gumweed's potential return, based on per unit of applied water, may be higher than most food or fiber crops.

The ultimate overseer of such crops could be someone in Dr. Chuck Hutchinson's Arizona Remote Sensing Center. Whether it be looking at images taken from a LANDSAT satellite 570 miles up or using a multi-spectral video camera from a light plane, remote sensing has a lot of possibility in the game of water conservation.

"If you monitor reflectance over time you can tell how healthy a plant is," Hutchinson says, and by charting a crop's health over a season and comparing it to other seasons' data you can tell whether a plant is stressed by water need, disease or insect damage. "This information is used now by USDA to develop national crop estimates."

Hutchinson foresees private companies providing Arizona farmers a remote sensing service, with almost immediate alerts of crop problems and irrigation needs. The USDA Water Conservation Lab in Phoenix is trying to differentiate between the different causes of stress, and Hutchinson has nine researchers working on remote sensing possibilities. Overseas, the techniques have been applied to fields as divergent as locating ancient underground streams in the Sahara for UA anthropologists and surveying gardens and agricultural capability in Mauritania for US AID. At home, the state Department of Water Resources uses remote sensing to lasso rustlers of underground water.

Dewhirst outlined the university's water position as he gave the reasons why the college had 41 water research projects going in 1986 (these didn't even include peripheral projects such as those in watershed management or specific crop tests), comprising 9.2 percent of the college's human effort.

"We need to do everything we can to retain agriculture in an uncertain climate," Dewhirst says. "I think the value of a university is to provide factual information which can be used to make decisions."

Thus, the "players" who act on this research stage now will carry the theme of water conservation on the farm down to the future—right down to the farmers who utilize their ideas to make a living from the land and its water.

More Water Information . . .

The UA Water Resources Research Center (WRRC) works to transfer information from the state's academic institutions to the larger water community. The center produces two newsletters: ***Arroyo***, a quarterly publication providing coverage of water issues of state-wide interest and ***The Arizona Water Research News***, a monthly publication produced during the academic year and distributed to the university water community.

The WRRC also publishes issue papers. Two current papers are: ***Central Arizona Project Water Quality: An Examination of Management Options*** by K. James DeCook and Marvin Waterstone. This publication evaluates the relative advantages and disadvantages, strengths and weaknesses, and costs and benefits of various CAP water quality management methods available to water managers. ($7.50) ***Water Farming: The Promise and Problems of Water Transfers in Arizona*** by Elizabeth Checchio. The author presents a general review of the issues and concerns relating to water transfer. Of use to professionals, the publication is also intended for a general, non-specialized audience, with material presented in a question-and-answer format. ($2)

Copies of these issue papers are available from: Librarian, Water Resources Research Center, Geology 318, The University of Arizona, Tucson, AZ 85721.

And from the Office of Agricultural Sciences Communications an educational videotape entitled ***"Water: An Endangered Natural Resource".*** Produced by Dr. Jack Watson, Extension Water Quality Specialist, the 17 minute tape presents an overview of major water issues such as conservation, water transfer and water contamination. VHS copies are available for $25 from: Electronic Media Group, The Office of Agricultural Sciences Communications, The University of Arizona, Nugent Bldg., Rm. 20, Tucson, AZ 85721.