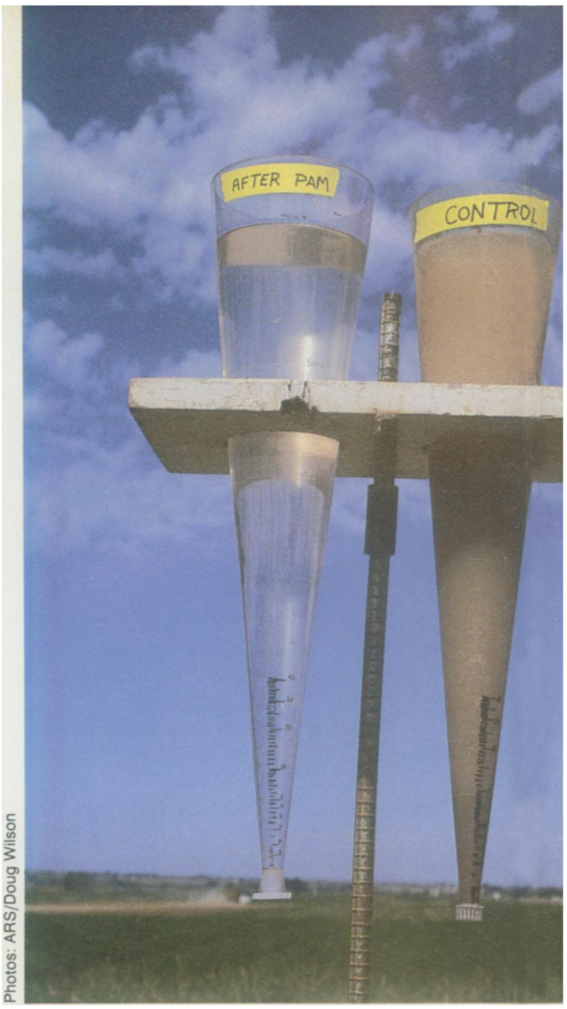
HOLDING on to the EARTH

Off-the-shelf chemical halts erosion of irrigated fields

By JANET RALOFF



Photos: ARS/Doug Wilson

Farmers in southern Idaho's Magic Valley have demonstrated some pretty dramatic sorcery since settling into the region about 90 years ago. They've transformed a high-altitude desert into fields of alfalfa, wheat, barley, potatoes, sugar beets, beans, and corn.

The trick, however, depends on delivering reliable supplies of water to land that receives only about 7 inches of precipitation a year – none of it during the summer.

Though local potato growers have begun irrigating their fields with costly overhead sprinklers, farmers slake the thirst of most area crops with inexpensive irrigation furrows – dirt ditches that run along each planted row. For instance, Charles Coiner Jr. depends on furrows to water all but 200 of the 1,600 acres he farms outside of Hansen.

Farmers buy into potentially dangerous trade-offs, however, when they irrigate via furrows. As water runs along a ditch, it erodes valuable topsoil. How much varies with the crop, the soil, and the weather. But amounts lost tend to run between 2.8 and 28 tons per acre during a 24-hour watering, according to soil scientist Robert E. Sojka of the Agricultural Research Service (ARS) in Kimberly, Idaho. So serious is the problem, he says, that some area farms have already lost one-third of their topsoil.

This erosion can also rob fields of any fertilizers or pesticides applied to the soil and deposit them as unwanted pollutants in nearby lakes and streams. Moreover, some share of the fine, clay-size dirt particles picked up from the head of a furrow eventually settles out and begins clogging soil pores at the end of the furrow. This reduces the amount of water that can filter through the furrow's floor – and thus to plants.

Over the past three years, however, the ARS Soil and Water Management Research Unit in Kimberly has coordinated the field testing of another kind of agronomic legerdemain. By adding a handful of special crystals to the irrigation water, they've all but halted erosion in treated fields.

The magic ingredient? Polyacrylamide (PAM), a long-chain molecule commonly used to clean waste water.

There are potentially thousands of PAMs, each differentiated by electrical charge, by the number of building blocks – or molecules of acrylamide – linked together, and by the extent to which the individual acrylamide units have been chemically cross-linked.

The particular negatively charged compound that Sojka's team has begun focusing on possesses about 30,000 acrylamide units in each molecule, notes Donald Valentine Jr. of Cytec Industries in Stamford, Conn., manufacturer of the chemical. (Cytec, a business unit of American Cyanamid Co., is due to become a separate company later this year.)

One reason ARS chose to test this particular polymer, Sojka says, is its low toxicity. To date, the primary market for this compound has been municipal wastewater treatment facilities. It makes the fine solids in treated water glom onto one another, until they become big enough to settle out or be captured by filters to make sewage sludge.

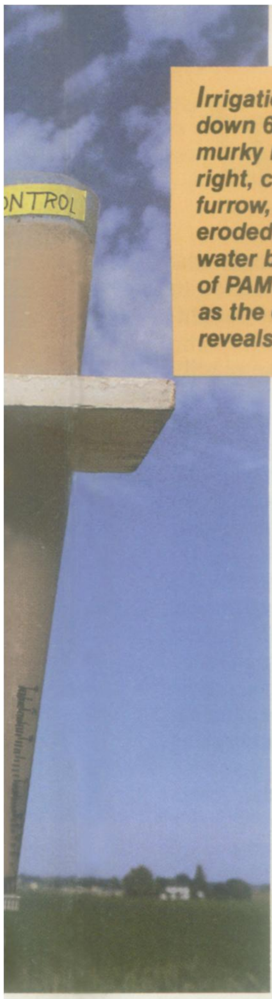
At the International Erosion Control Association meeting in February, Rick D. Lentz, another soil scientist at the Kimberly lab, reported new data indicating that the type and density of a PAM's electrical charge play a role in the polymer's ability to control erosion. A negatively charged PAM limited erosion better than a neutrally charged one, which in turn proved more effective than a positively charged polymer.

To date, no one knows exactly why the negatively charged PAM works so well on soils that tend overall to possess a negative charge. However, Lentz and his coworkers interpret their charge data to indicate that a PAM's effectiveness does not trace primarily to its ability to flocculate, or clump, suspended silt or to form stable aggregates of soil particles.

Rather, they suspect that the negatively charged PAM seeks out and binds to the broken edges of crystalline clay particles – which carry a positive charge. By somehow increasing the cohesiveness of soil particles at the surface of a field, the PAM appears to make dirt more resistant to the highly erosive shear forces exerted by water flowing over it, the Kimberly studies indicate.

Sojka credits Isaac Shainberg with first realizing that low concentrations of PAMs might halt erosion. A researcher with the Israeli government's Institute of Soils and Water at the Volcani Center in Bet Dagan, Shainberg spent a sabbatical three years ago at an ARS erosion lab on the campus of Purdue University in West Lafayette, Ind.

Since the mid-1980s, Shainberg had



Irrigation water that has traveled down 600-foot-long furrows. The murky brown water in the cone at right, collected from an untreated furrow, contains about 40 grams of eroded soil per liter. Treating the water before irrigation with 10 ppm of PAM nearly eliminated erosion, as the clear runoff in the left cone reveals.

been exploring PAMs' ability to reduce soil compaction and crust formation by rain. Together, these processes can cut by 90 percent or more the ability of water to percolate into soils. And while his studies proved that the chemical is quite effective, the costs associated with applying useful amounts of the compound suggested that the stratagem wouldn't win any farmer's favor.

So when Shainberg came to the States, he turned his attention to another application: furrow erosion. After completing some very promising small-scale experiments, Shainberg phoned the Kimberly researchers, trying to interest them in field testing the polymer.

"When we heard how enthusiastic he was and the claims that he was making, we were rolling our eyes," Sojka recalls. "We thought we were being asked to look at snake oil. But he made us eat our words," Sojka adds. "It turned out that the stuff was fantastic." Indeed, he observes, "it changed the direction of our erosion control program here."

It takes very little PAM to dramatically cut erosion. Just 10 parts per million (ppm) added to water during the first hour or so of an irrigation – or until water has been running off the bottom of a field for about 20 minutes – can reduce erosion by 70 to 99 percent, the ARS studies indicate. After that, the irrigation can continue for another 12 to 24 hours without further treatment.

At the current cost of the PAM he's testing – about $1.25 per pound – each treatment costs farmers only about $2 to $3 per acre, Sojka notes.

Moreover, as long as the soil has not been disturbed by foot traffic or cultivators, the next irrigation can be delivered PAM-free and still hold erosion to about half the loss seen in never-treated plots, Sojka says. For full protection that second time around, farmers can "refresh" their undisturbed furrows by beginning the next watering cycle with a mere 1 ppm PAM treatment.

Though this PAM should improve erosion control wherever farmers irrigate with furrows, it may offer special benefits in fields that slope sharply. Here, water races through a furrow, accelerating erosion. The excessive soil loss and poor water infiltration that can result sometimes cause plants in steeply sloped regions to go thirsty despite frequent irrigation.

But Sojka says that the greater infiltration associated with PAM-treated furrows can boost crop yields in sloping areas to the point where "it's almost like giving the farmer the [yield] equivalent of another four or five acres." Indeed, he maintains, "this aspect alone can more than pay for the cost of [PAM treatment] on the rest of the field."

Shainberg believes PAMs might pay even richer dividends in California's highly productive Central Valley. There, as in Israel, he says, PAMs' advantages would stem more from maintaining the porosity of the soil than from saving soil per se.

The fine sediment that erodes from the head of a furrow often settles out toward the middle and end of a furrow, forming a tight, nearly waterproof seal on the surface of the soil.

At the beginning of a growing season, Central Valley farms can drain water at the rate of 50 to 100 millimeters per hour, Shainberg notes. By June or July, however, sediment eroded from the head of a furrow and deposited downstream can reduce water infiltration in a furrow to just 1 or 2 mm per hour, he says.

But if Central Valley farmers could prevent furrow erosion, "there would be no formation of depositional crust, so the [water infiltration rate] will remain much the same as it was at the beginning of the season," Shainberg maintains. And that could translate into 20 percent larger harvests, he predicts. If so, he continues, the value of such yield improvements would greatly exceed the cost of treating the water.

Currently, Shainberg is working on treating the irrigation water delivered by overhead sprinklers. Like rainwater, the falling droplets of irrigation water can loosen fine sediment and allow it to compact and seal the soil surface. But adding only about 10 ppm of PAM to the sprinkler-fed water, he says, retains soil permeability.

Shainberg's research team also has begun experimentally spraying the dry walls of gullies with PAM-treated water. The goal: to stabilize the banks against the threat of serious erosion once Israel's short winter rainy season arrives.

In Idaho, Sojka and Lentz are working to refine the delivery of PAM-treated water to furrows. The polymer works well in clean water. But when added to water clouded with sediment, it flocculates the fine particles, causing them to settle out – sometimes to the point of filling up the head of a furrow.

The ARS team also is attempting to develop formulas for customizing PAM administration to different soils, furrow lengths, field slopes, and irrigation-water velocities.

Though this past summer was only the third during which Sojka's group has tested PAMs, word of the polymer's promise has gotten out. Coiner and a number of other Idaho farmers have begun buying a PAM to use when irrigating beans and other erosion-fostering crops – plants that don't develop a dense mat of soil-grabbing roots. Indeed, Coiner notes, one neighbor told him that his bean fields proved so erodible this year that he wouldn't have been able to farm them without the polymer.

The new treatment has its drawbacks. The extra steps it takes to meter out and mix in the proper concentrations of PAM "can be a bit of pain," Coiner notes. Moreover, he says, at least in the desert soils he farms, the cost of treating a field throughout the season may approach the profit its crops would ordinarily yield.

But "conservation-minded" farmers tend to view PAM treatment as a long-term investment, Coiner says. By reducing the loss of topsoil, they hope this additive may buy them and future generations the ability to farm their land indefinitely. □

This handful of PAM would treat almost 27,000 gallons of irrigation water – enough water to cover 1 acre of land to a depth of 1 inch.