Subsurface drip irrigation

Battling drought, water restrictions, and declining groundwater

By Tanner Ehmke
Crops & Soils magazine contributing writer

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Parched farm fields across huge swaths of the U.S. are a constant reminder of the importance of water-use efficiency at the farm level. With drought gripping much of the Great Plains and western states, and with groundwater reserves declining and water regulations increasing, growers and their CCAs are finding ways to get more crop per drop with precision irrigation.

Photo courtesy of USDA-NRCS

For CCA Bill Cox, agricultural consultant at CoxCo Ag Services in Las Cruces, NM, the journey of maximizing crop production from every drop of water for his 20 farmer-clients in south-central and southwestern New Mexico led to subsurface drip irrigation, or SDI.

Starting in 1993, Cox helped his clients convert thousands of acres of center-pivot irrigation to the more water-efficient system of SDI, which buries drip lines below the soil surface to deliver water and nutrients directly to the plant's root zone with minimal losses to surface evaporation or deep percolation.

Water use in arid New Mexico is no small challenge, says Cox, who has consulted farmers in the region for 41 years and is helping them remain productive with irrigation

Photo courtesy of Toro. See http://driptips.toro.com

scheduling and management through one of the worst droughts on record.

"We're in the desert of New Mexico, and we can't grow anything unless we can irrigate it," Cox explains. "And, we're locked in the same drought that California has been in, so water is a critical issue for us. Normally we irrigate with river water out of the Rio Grande, but we also supplement that with groundwater that we pump. But for the last three years, we've been relying almost 100% on groundwater because we haven't had any river water."

With SDI, Cox's growers are able to sharply reduce waste compared with other irrigation systems like furrow and center-pivot irrigation. That enables his growers to put more water to use for crop production, he says.

But don't confuse water use efficiency with water conservation, Cox stresses. The goal isn't necessarily to use less water, but to get more production with the water that you have.

"Does drip irrigation save you water? My answer to that is it doesn't," he says. "[The crop] still uses the same amount of water it did before you switched to drip. The difference is you're eliminating the waste. And if you can retrieve that waste, you're able to farm a lot more acres with the same amount of water you were using before. You just diverted it. You're putting it somewhere else to grow something with it."

With furrow irrigation, Cox's growers were only able to achieve up to 50% efficiency, meaning half of the water pumped on the field contributed to crop production while the other half was lost mostly to evaporation. But with SDI, his clients now achieve 90 to 95% efficiency, he says.

Resource use efficiency

Freddie Lamm, a veteran irrigation researcher at Kansas State University who has studied SDI at K-State's Northwest Extension Center in Colby, KS since 1989, sees similar levels of efficiency with SDI in the controlled laboratory setting.

Subsurface drip irrigation can generally achieve 95 to 98% water use efficiency, he says, compared with 80 to 90% for center pivot and 40 to 60% for furrow. Water use efficiency with any irrigation system depends on a multitude of factors like soil type, water quality, humidity, and crop residue, Lamm explains. Still, the efficiency of SDI is a noticeable improvement over furrow or center pivot because of SDI's ability to spoon-feed water to the plant and reduce waste.

Lamm explains that SDI contributes to water use efficiency by reducing or removing non-beneficial uses of water like evaporation, runoff, or deep percolation. And by spoon-feeding the water to the crop, other benefits are realized, as well, like more control over weather events.

"Since you're putting on very small amounts of irrigation, you have the opportunity to play the weather," he says. "As rainfall occurs, you're just putting on smaller amounts of water to replace what you think is not going to be replaced by rainfall. For us in western Kansas, when we do get rainfall, it's usually pretty intense thunderstorms. So, if we have drier soil surfaces, we can capture more of that rainfall that does occur. It doesn't run off. It basically infiltrates into the soils."

Improved water use efficiency isn't the only benefit that SDI offers, says Inge Bisconer, technical marketing and sales manager at Toro Micro-Irrigation in El Cajon, CA, and past president of The California Irrigation Institute. SDI excels in what she calls resource use efficiency—a broader term encompassing the efficient use of the typical farm inputs including water, energy, labor, machinery, chemicals, and nutrients.

Energy savings can be a significant benefit with SDI, she adds, noting that energy is naturally embedded in water if it has to be pumped or treated.

"When you go from a high-pressure sprinkler system to lower-pressure drip, or from an inefficient gravity system to a high-efficiency drip system, that's a big deal, especially with the price of energy these days," she says. Experiences will vary from farm to farm, she says, but

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growers consistently show lower kilowatt or fuel usage with improved water use efficiency and increased yields. In the case of a potato grower in Pennsylvania, she says, the grower cut his energy bill by a third using drip while increasing yield 25% and reducing runoff.

Cox, meanwhile, adds that improved fertilizer efficiency is a benefit he regularly sees with his growers' SDI systems. By running fertilizer with the water through the tape and applying it directly within the root zone, less fertilizer is lost to volatilization, runoff, or movement through the soil.

"Your fertilizer efficiency is only as good as your irrigation efficiency," Cox says. "On a crop like onions that are fairly shallow rooted and that you irrigate a lot, we cut our nitrate use by half because we're not leaching it away the way it happens with furrow irrigation."

Lamm's research at K-State also reveals a sizable increase in fertilizer efficiency. Farmers typically apply about 220 lb/ac of nitrogen for irrigated corn, he says. But with SDI, fertilizer usage falls to about 190 lb/ac with 160 lb applied through the drip system and another 30 lb applied as a pre-plant treatment.

Field operation efficiency also improves considerably under SDI, Bisconer notes. Burying the drip system beneath the soil surface means farmers can access the field as the system is operating without having to contend with above-ground pipes, pivots or ditches, mud, or pools of water.

"Most of the growers really like SDI once they've adopted it because they can access the field 24/7," she says. "You haven't flood-irrigated the ground, so you don't have to wait for

Onions in drip-irrigated plots in Colorado. Photo by Bill Cotton and courtesy of USDA-ARS.

Photo courtesy of USDA

it to dry down to get the tractor in the field. You can be irrigating and do your field operations at the same time."

Even tillage operations can continue uninterrupted with SDI, she adds. With the tape buried 12 inches to 18 inches deep, the system is a safe distance from the tillage zone and allows farmers to till without it coming into contact with the implement.

However, growers who adopt drip will often reduce or eliminate tillage to build organic matter in the soil, she says.

That's frequently been the case with Cox's clients who have converted to drip.

"We used to moldboard plow everything, and now with the buried drip, we're semi no-till. We're strip tilling it," he says, adding that the conversion to strip-tillage has dramatically reduced farmers' machinery costs. Farms that once had three or four 250-hp tractors, he says, now only have one tractor.

"It's just because we don't do that heavy tillage work anymore," he says.

Growers have also slashed machinery costs by having to control fewer weeds, Bisconer adds. Since SDI systems deliver water directly to the plants' root zone and leave the soil surface dry, fewer weeds are germinated compared with furrow or center-pivot irrigation systems that wet the surface, she says.

"We have one grower who said he used to cultivate three or four times when he had sprinklers, but he only cultivates once now with drip after planting," she says. "And that saved him $60 per acre."

With less tillage also comes less labor, she adds. Farmers can then perform more value-added activities with workers by eliminating the need to move pipe, maintain ditches and furrows, or service pivots.

But that doesn't mean SDI requires no labor. It still presents challenges for growers that require time, management, and attention to detail. The major workload with SDI comes with monitoring the filtration station, pressure gauges, and flow meters as well as checking and repairing leaks in the drip tape.

Maintenance

Simon Van Donk, irrigation engineer at the University of Nebraska–Lincoln's West Central Research and Extension Center in North Platte, NE, says rodents frequently burrow deep into the ground and chew holes through the thin irrigation tape. The rodent issue, he says, typically is the biggest management concern for farmers with SDI systems.

"Quite a few farmers have problems with the tape being damaged by rodents like gophers and mice," Van Donk explains. "When that happens, you need to find those leaks and close up the hole. It's a recurring challenge."

Managing rodent damage is a full-time job for some of Cox's clients with thousands of acres of drip line to manage. On bigger farms, one person is responsible for checking each drip line for leaks, which are often caused by gophers, he says. Traps are set to capture the rodents throughout the year. In a single year, Cox estimates his clients set many hundreds of traps to manage rodents.

"The rodent problem is one thing we didn't really expect," he says. "We've always had gophers, but when we were furrow irrigating we would drive them out of the field when we saturated the ground. But with drip, we don't really saturate it that much. So instead of driving them away, it makes a perfect environment for them because it's just the right humidity. Then, they start chewing on the drip line. I think they're basically getting water that way. Or, maybe they do it just to aggravate us."

Various types of rodents, mammals, and even insects like wire worms and crickets can and will damage a drip line, Bisconer adds. But the gopher issue, she notes, typically is the most challenging. Solving the problem requires diligence and planning and must be on the agenda for the management team, she stresses.

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An integrated pest management plan includes chemical control, trapping, physical exclusion from the field, or encouraging rodent-killing raptors like hawks and owls to nest near the field, she says. Being preventative is the most important part of an integrated pest management plan, especially for rodents, Lamm adds.

“Try to keep them from entering the field to begin with. If they encroach upon the field around the field margins, properly deal with them,” he says. “Tilling the field will get rid of a lot of rodents. And farmers that do have rodent problems typically will run the system early enough in the year so they can discover the problems and fix them before they get into the irrigation season. They try to be proactive and not wait till it gets out of hand.”

Water quality is the other major management issue growers often contend with, Lamm adds. Three different types of water contaminants can clog the system: Physical contaminants like soil particles, plant material, and PVC filings; biological contaminants like slimes and bacteria; and chemical contaminants like calcium carbonate. Installing the correct filtration system and having it properly sized and maintained is critical for avoiding water quality hazards, Lamm stresses. Chemically treating or chlorinating the water also helps keep the system in working order.

“With subsurface drip, we’re typically talking about systems that we want to last multiple years, so that requires water treatment and maintenance to keep the clogging down,” Lamm advises. “It’s vitally important to take care of it because clogging is probably the number one reason that systems fail. It’s an issue farmers should be on top of from day one. They should have a plan of how they’re going to manage and maintain clogging before the system goes into the ground.”

Investing for the future

While SDI promises significant improvements in efficiency of water use and other resources, growth has been limited because of high investment, Lamm says. An SDI system generally costs around $1,400 per acre compared with a center-pivot system at around $600 per acre,

Workers lay subsurface drip irrigation lines at Colorado State University for a seedless watermelon crop. Photo by Mark Bartolo and courtesy of Flickr/SARE Outreach.

Photo by Pete Mortimer (USDA-ARS)

Lamm estimates. Depending on the spacing between drip tape laterals, the thickness of the tape, the level of filtration and amount of system automation, Bisconer says cost can range from $1,000 to $2,000 per acre.

To help growers and CCAs figure costs, Lamm points them to the SDI on the Great Plains website at www.ksre.ksu.edu/sdi for cost comparison of SDI and center-pivot irrigation, while Bisconer recommends the Toro Micro-Irrigation Payback Wizard at http://driptips.toro.com/?p=554 to estimate the rate of return of SDI.

The most economical way to use SDI on field crops has traditionally been on limited irrigation wells or small or irregularly shaped fields, Lamm explains.

"One of the advantages it has over center pivots is it is well suited to irregularly shaped fields. In other words, if you can't do a full-sized center pivot, then the cost of that center pivot goes up quite a bit," Lamm says. "There, SDI can be competitive relatively quickly because the center-pivot cost per acre goes up dramatically."

Proper management also prolongs the life of the system, Lamm adds, noting that some drip lines he has studied have lasted 25 years, while lifespans of 10 to 20 years are more common.

Cox also has seen drip lines last more than 20 years. But to achieve that longevity in a system, farmers and CCAs have to be consistent in their care and management.

"It's a function of how good your water is, how good your filtration is, flushing the system on a regular basis, periodic treating with chlorine, repairing leaks when they happen. It's just like a tractor or anything else," he says. "The better you maintain it, the better off you're going to be."

That's where CCAs are important, Cox notes. With technology evolving and water issues becoming more complex, growers will need informed and educated CCAs to help coordinate crop rotations, schedule irrigation, and manage fertility programs. The CCA's role in states experiencing increased fertilizer regulation will be particularly important in advising clients on nutrient management plans, Bisconer adds.

It's the consistency in management and the CCA's support in implementing the technology that make SDI worth the investment in the long run, Lamm stresses.

"It doesn't necessarily take a rocket scientist to manage a subsurface drip irrigation system," Lamm says. "But it does require a consistent manager." &

Digital Extra

Slideshow of microirrigation components

Check out the Enhanced Digital Version of *Crops & Soils* magazine (at www.agronomy.org/publications/crops-and-soils or via the app) to view a slideshow of drawings of microirrigation components. Courtesy of Kansas State University.