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Irrigation System Maintenance, Groundwater Quality, and Improved Production

John Selker

Lack of irrigation system maintenance can waste water, nitrogen, and energy and can lead to degradation of groundwater. Simply replacing nozzles on sprinklers can go a long way toward having efficiently operating systems.

The Connection between Poor Irrigation and Poor Groundwater Quality

Suppose that a farmer takes pure water from an aquifer and applies it to her land, but she applies a bit too much or applies it unevenly. How can this common event contaminate the aquifer?

We first need to note that the soil nitrogen that makes plants green is primarily in the form of nitrate, and this nitrogen is accessible to plants specifically because it stays dissolved in the soil water. In a typical corn field, where the bulk of the roots are in the top 18 inches of soil and the soil has a water-holding capacity of 25 percent, the corn root zone can hold 4.5 inches of water. If the farmer adds an *extra* 4.5 inches of water during the year on top of what is needed to wet the soil, essentially all the soluble nitrogen will be pushed out of the root zone.

Four and one-half inches of water is about 15 percent of the annual water requirement of corn in the Willamette Valley, so overwatering by only this much over the entire growing season is a very easy error to make. Figure 1 shows how nitrate concentrations below the root zone responded to irrigation-driven percolation as mint fields were irrigated. Similar data were obtained under row crops (Feaga and Selker, 2004).

If a farmer overirrigates each year, he will think that to keep the crop green requires much more nitrogen than anticipated. It's not surprising, then, that many farmers apply more nitrogen than the crop would require under controlled irrigation. Thus, overirrigation leads to excess nitrogen applications and at the same time drives the mobile nitrate to the aquifer.

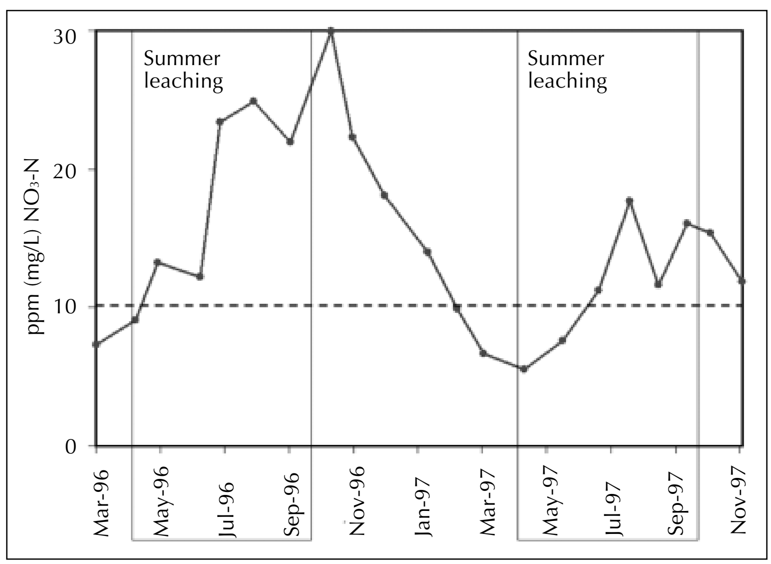

Figure 1. *Observed average nitrate (NO_3^--N) concentrations in percolating soil water at a 3-foot depth under seven commercial mint fields in Lane County, OR. The drinking water standard is 10 ppm.*

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Excess irrigation is not only applying too much water to the *whole* field. What about a farmer who is applying just enough to keep the field well watered: could this farmer have a problem? Yes, if the irrigation system is applying water unevenly.

It is not unusual to see one section of a line sprinkler applying 20 percent more than the average output and another section applying 20 percent less than the average (Figure 2). To get full production on all parts of the field, the farmer will set the system at a 20-percent higher rate to compensate for the section that's underapplying water. That means the overirrigated area will get 40 percent too much water, and even the part of the field that was receiving the average amount will get 20 percent too much water.

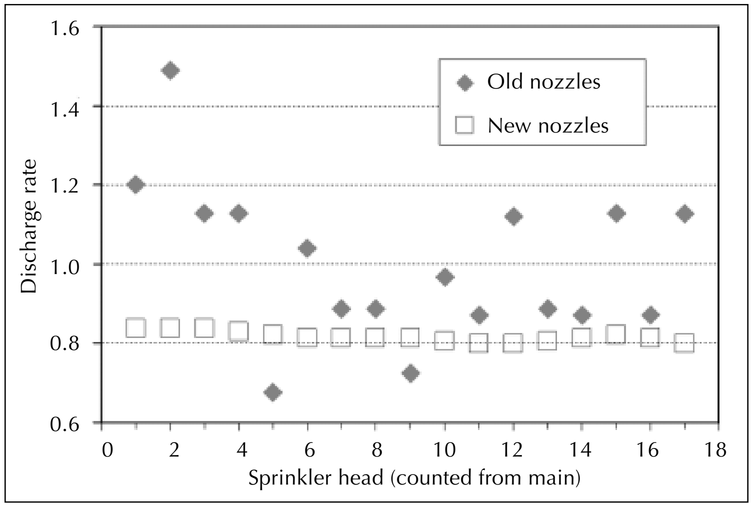

Figure 2. *Sprinkler output before (filled diamonds) and after (open squares) nozzle replacements on a typical commercial farm in the Willamette Valley (from Louie et al., 2000).*

The farmer is wasting large amounts of water and energy; furthermore, this excess water flushes the nitrate out of the root zone. So, to get full yield off the most overirrigated area, the farmer must apply additional nitrogen during the season (or simply apply significant excess at the start of the season). Given the poor irrigation system, this farmer is doing only the absolute minimum in irrigation and nitrogen application sufficient to get full yield.

Thus, it is clear that nonuniform water application is at least as problematic as overirrigation in requiring excess nitrogen application.

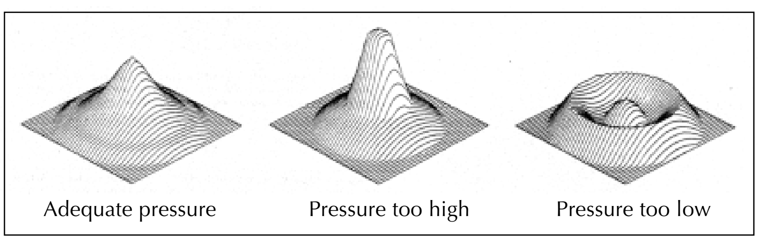

Figure 3. *Patterns of water application by sprinklers with correct, excess, and insufficient water pressure (from Trimmer and Hansen, 1986). The conical pattern at left overlaps with neighboring sprinklers to create a nearly uniform pattern.*

What Happens When Nozzles Wear Out?

Why would a well-designed irrigation system apply water irregularly? One would hope that on the first day of operation the spray was acceptably uniform, but let's consider how this system might evolve. Each year, some components will be used more hours than others, and some components will fail and be replaced. In addition, a successful farmer often adds new land to the production area and may add new, compatible components to an older system.

As water shoots through a nozzle, it enlarges the orifice, letting more water out and reducing the pressure in the system. A system with a mix of nozzle ages therefore will not apply water uniformly. Even if all nozzles are the exact same size, if the openings wear to a size much larger than when installed, the system pressure drops too quickly along the line as it goes farther from the water source, which also leads to poor uniformity (Figure 3). Of 12 systems studied, half were operating below the pressure required for uniform application, and every one of them showed significant improvement in uniformity with new nozzles (Louie et al., 2000).

Recommendations

A poorly functioning or poorly managed irrigation system wastes water, wastes energy, wastes nitrogen, and reduces crop production. We recommend:

- Replacing all nozzles at least every 4 years (suggest each presidential election November or each leap year)
- Check system operating pressures periodically. If below optimal range, check that the pump is working correctly, that the number of sprinklers is not in excess of pump capacity, and that nozzles are not worn.
- Make sure that sprinklers are discharging at the correct angle and that impact sprinkler heads are rotating properly. A riser that is tilted rather than vertical or a rotating sprinkler head that spends more time discharging in one direction over another will result in nonuniformity.
- Schedule irrigation using climate and direct observation. First, look at how much the crop should demand and then check weekly that the soil is neither too wet nor too dry. For more information, refer to publications listed below under "About irrigation scheduling."
- Have everyone who works with the irrigation system understand the importance of correct function to the farm's productivity.

Additional Resources

About irrigation in general

English, M.J., R. Mittelstadt, and J.R. Miner. 1996. Irrigation Management Practices Checklist for Oregon. Oregon State University Extension Service. Publication EM 8644.

Jensen, L. and C.C. Shock. 2001. Strategies for Reducing Irrigation Water Use. Oregon State University Extension Service. Publication EM 8783.

Trimmer, W.L. and H.J. Hansen. 1986. Offsets for Stationary Sprinkler Systems. Extension Services of Oregon State University, Washington State University, and University of Idaho. Publication PNW 286.

About irrigation scheduling

Trimmer, W.L. and H.J. Hansen. 1994. Irrigation Scheduling. Extension Services of Oregon State University, Washington State University, and University of Idaho. Publication PNW 288.

Niederholzer, F. and L. Long. 1998. Simple Irrigation Scheduling Using the "Look and Feel" Method. Oregon State University Extension Service. Publication EM 8716.

Cuenca, R.H. 1999. Oregon Crop Water Use and Irrigation Requirements. Oregon State University Extension Service. Publication EM 8530.

Smesrud, J., M. Hess, and J.S. Selker. 2000. Western Oregon Irrigation Guides. Oregon State University Extension Service. Publication EM 8713.

About irrigation system maintenance

Louie, M.J. and J.S. Selker. 2000. Sprinkler head maintenance effects on water application uniformity. *ASCE Journal of Irrigation and Drainage* 126:142–148.

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