GROWING SEASON WATER MANAGEMENT ON FIELDS RECEIVING MANURE

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ABSTRACT

Liquid and solid manure are valuable resources for crop nutrients and organic matter for soil tillth improvement. However, these nutrients may be moved off-site by surface runoff or below the crop root zone by deep percolation of soil water. In either case, they can become environmental pollutants. Irrigation water, applied correctly, can supply crop water needs while retaining the water-soluble nutrients in the portion of the crop root zone for best nutrient uptake by crops.

INTRODUCTION

Nutrient-rich liquid and solid manure is one by-product of the growing dairy industry in Southern Idaho. With daily manure production of about 150 lb/head, and average nutrient content of about 1, 0.17 and 0.23 lb/day of N, P and K, respectively (ASAE, 2005), this manure has significant economic value. Managed properly, manure can be a major component of a sustainable food production system. However, water can transport soluble or sediment-bound nutrients offsite by surface runoff or move water-soluble nutrients below the crop root zone by deep percolation, resulting in potential for water quality degradation. Precipitation events during the growing season are rarely large enough to produce offsite movement from farm fields since average annual precipitation is less than 10 inches in most Southern Idaho locations and most occurs during the non-growing season (USBR, 2012). This provides a unique opportunity to manage application of irrigation water to meet crop water needs while minimizing nutrient losses by both surface runoff and deep percolation.

IRRIGATION SYSTEM CONSTRAINTS

State and federal requirements for cropland receiving manure specify that irrigation water should be applied so that no offsite movement of nutrients by surface runoff or deep percolation occurs. Therefore, the irrigation system should be designed and managed to apply water only at a rate the soil can absorb without runoff occurring, and in timing and amount to meet crop water needs without over-filling the crop root zone. Because manure application rates are based on crop uptake of the limiting nutrient at a specified target yield, it is essential to manage the irrigation system to avoid crop water stress and the associated reduction in crop yield and nutrient uptake. Water application should be as uniform as possible for uniform application of liquid manure and subsequent water application to prevent areas of local over-watering and deep percolation.

SYSTEM DESIGN / OPERATING PRACTICES

A complete discussion of irrigation system design and operating practices to protect surface and ground water is beyond the scope of this paper. In general, the goal of irrigation water management is to uniformly supply water to meet crop needs without surface runoff or over-filling the crop root zone. A “checkbook” or water balance approach is outlined in Ashley et al., 1996, and a soil water sensor approach in Reddy et al., 2007. The following topics are
given to provide an overview of additional management practices. More information is available at the Idaho, Oregon, Washington Irrigation website: http://irrigation.wsu.edu. For additional information, the reader should contact the author.

Practices to minimize surface runoff in sprinkler irrigation
- Match system application rate to soil intake rate
- Enlarge water application pattern by appropriate sprinkler selection (and in some cases, the additional use of booms on outer pivot spans) to reduce application rate
- Minimize soil compaction from working or trafficking soil too wet
- Do not over-till and break down soil structure during seedbed preparation

Practices to minimize deep percolation in sprinkler irrigation
- Apply water frequently enough to minimize crop water stress but only enough water to re-fill the crop root zone. Be mindful of actual soil depth and how root zone depth changes during the season.
- Apply water uniformly to avoid areas of local ponding and deep percolation
- Fix leaks
- Minimize runoff and subsequent ponding in low areas

Practices to minimize surface runoff in surface irrigation
- Use cutback or surge irrigation
- Avoid excessively long set times
- Inject liquid manure in the last portion of set

Practices to minimize deep percolation in surface irrigation
- Set furrow flow to achieve advance in about 1/3 of the set time
- Do not over-irrigate (adjust set time)
- Consider using surge irrigation on appropriate sites
- Irrigate every furrow or alternate furrows periodically throughout the growing season

**FURROW IRRIGATION PROTOCOL TO MINIMIZE DEEP PERCOLATION**

Furrow irrigation practices such as irrigation of every, or every-other furrow can have a significant impact on nitrate movement and crop utilization of nitrate applied by either commercial fertilizer (Lehrsch et al., 2000, 2008) or manure. The prevailing furrow irrigation practice for corn in the Magic Valley is to irrigate alternate furrows and irrigate the same furrows for the entire season. This is generally true for both 22 and 30-inch row spacing. In this manner, labor is minimized and water is supplied to one side of each corn row, with alternate furrows remaining dry all season. Lehrsch et al., 2008 showed that alternate furrow irrigation was beneficial when a significant portion of nitrogen was banded in or near the crop row because of reduced potential for deep leaching losses. However, their study did not address the situation where all the N was broadcast on the soil surface and tilled in.

Post-season soil sampling to a depth of 5 feet was conducted at sites in surface, surface drip, and sprinkler - irrigated forage corn plots in the fall of 2011 to evaluate nitrate leaching and nitrate utilization resulting from each of these irrigation practices. At each site, one sample was taken in the crop row, and in both adjacent furrows at each indicated depth. The sampling sites were all within the east half of a 17-acre field at the University of Idaho Kimberly R&E Center. The soil was Portneuf silt loam. The entire field was cropped the same the previous year and multiple spring soil samples were composited to obtain the fertilizer recommendation. All plots received the same broadcast fertilizer application (450 lb/ac urea, or 207 #/ac actual N) and were
planted the same day. Irrigation on all plots was managed to apply water to meet ET. Irrigation on the surface irrigated plots occurred about weekly with gated pipe. Irrigation on the sprinkler plots occurred about every three days through a solid set system with 12-foot risers. Drip irrigation was applied by tape placed on the soil surface in every-other-furrow, with an irrigation interval about the same as for the surface irrigated plots. Soil samples were taken about 100 feet from the head end (upslope) and bottom end (downslope) of the 300-foot length surface irrigated plot area, and at the center of one replication of sprinkler and drip treatments. Furrow and drip plots showed visible N deficiency symptoms by late season and crop yield was reduced about 15-20% relative to the sprinkler irrigated plots.

Post-season soil nitrate results are shown in Figures 1-4. In both furrow-irrigated sampling locations (Figures 1 and 2), nitrate content was less than 5 ppm at all depths below the furrow receiving irrigation water. The furrow which never received irrigation had a nitrate content of 18 ppm at the upslope site and 35 ppm at the downslope site in the top foot of soil. Although in-row nitrate content in the upper foot of soil was between 24 and 26 ppm, the crop showed visible symptoms of late-season nitrate deficiency.

The same pattern of low nitrate at all depths below the furrow receiving water and higher nitrate levels in the furrow area which never received water also held for drip-irrigated plots (Figure 3). Drip tape was used in this case to simulate water addition by surface irrigation so large irrigations occurred at about one week intervals rather than the more frequent, smaller irrigation events characteristic of drip irrigation.

![Graph](image)

**Figure 1.** Upslope post-harvest soil nitrate-N for samples taken in the irrigated furrow, the non-irrigated furrow and in the crop row. Sampling location was about 1/3 of the distance down a 300-foot plot.
Figure 2. Downslope post-harvest soil nitrate-N for samples taken in the irrigated furrow, the non-irrigated furrow, and in the crop row. Plot area sampled was about 2/3 of the distance down a 300-foot plot.

Post-season nitrate under plot sprinkler conditions shows nearly uniform concentration across all sampling locations (Figure 4). Sites sampled were in the crop row, and in the center of the adjacent inter-row areas. Crop yield was high and nitrates were uniformly low below 3 feet, suggesting uniform crop utilization of nitrates and no deep percolation losses.

These samples were taken after harvest to help explain visible differences in plant N deficiency and crop yield when fertility and all other production factors were constant. Because the sample sites were not replicated, no statistical observations can be made. However, these data do provide some information about N movement and availability under these specific furrow, sprinkler and drip conditions and are consistent with our current understanding of irrigation / nitrogen interactions in corn.

Our in-field observations and these data do explain why surface and drip plots showed late-season N deficiency while the sprinkler plots did not:

- Water flow from the source (furrow or surface drip tape) moved nitrate laterally into the crop row.
- The wetting front never advanced more than 2-4 inches past the row into the non-irrigated row middle. This advance concentrated nitrate in the top foot in the row.
- Because of the long irrigation interval, the top foot of soil remained dry much of the time, reducing both root water extraction and therefore, N extraction. It appears that even though N was present, it was not available to the crop.
- Although water content of the post-harvest samples was near field capacity at a depth of 5 feet under the irrigated furrow, which might suggest some deep leaching of N, the amount of deep leaching cannot be quantified based on our limited sampling.
Figure 3. Post-harvest soil nitrate for samples taken in the drip irrigated (tape) furrow, the non-irrigated (no tape) furrow, and the crop row following harvest. Points sampled were in the center of a 100-foot length plot.

Figure 4. Post-harvest soil nitrate for samples taken in the sprinkler irrigated crop row and both adjacent furrows following harvest. Plot area sampled was in the center of a 100-foot length plot.

Water supply and irrigation scheduling limitations for furrow irrigation may require alternate furrow irrigation. However, field observations and this limited data set suggest that if N is broadcast applied over the entire field area, growers should strongly consider alternating
irrigated and non-irrigated furrows periodically through the growing season to best utilize applied N. If significant N is applied as side dress during the growing season, alternate furrow irrigation should be sufficient. This issue should be more important with 30-inch row spacing than with 22 inch row spacing since lateral water movement will occur farther past the crop row with reduced row spacing.

REFERENCES


