Phosphorus Loss with Surface Irrigation

Authors: David Bjorneberg and April Leytem, USDA-ARS, Kimberly, Idaho

Definition:

Surface irrigation uses gravity to deliver water across the field, contrary to sprinkler or drip irrigation that uses pipe or tubing as the conveyance system. Water flows across the field in small streams for furrow irrigation or in a sheet for border and basin irrigation.

Problem:

In some surface irrigation systems, runoff is desirable to improve the uniformity of water infiltration between the upper and lower ends of the field. Containing all runoff from sloping fields (>1 percent) is also impractical. During the irrigation event, water flowing over soil detaches, transports and deposits sediment and nutrients that are often attached to sediment. Phosphorus (P) can also desorb from the soil and transported sediment, increasing soluble P in surface irrigation runoff. Therefore, there are two main mechanisms that influence P transport in these systems: erosion and desorption of P into runoff water.

Transport Mechanisms:

Water flowing in furrows tends to detach sediment from the upper (or inflow) end of a field with uniform slope. As the water moves across the field, the flow rate decreases, which not only decreases sediment detachment, but causes sediments to deposit in lower portions of the field. As water infiltrates, dissolved P is carried into the soil so the total amount of dissolved P leaving the field may be less than the amount in the inflow.

Total P in runoff water is highly correlated to the concentration of sediment. Approximately two pounds of total P are transported with each ton of sediment. When row crops are surface irrigated and there is significant erosion, approximately 90 percent of the total P is particulate (attached to sediment). In close-seeded crops like alfalfa and small grains, where there is little erosion, typically less than 20 percent of the total P in runoff is particulate.

Reduction Strategies:

Best management practices that control erosion also control P loss from surface irrigation. Controlling erosion reduces contact between water and detached sediment, which can reduce soluble P losses in some situations. Practices such as good inflow management, conservation tillage, polyacrylamide (PAM) application, filter strips and sediment ponds can reduce sediment and nutrient losses from fields and reduce the amount of sediment and nutrients transported in return flows.

Inflow management can minimize the amount of runoff water while achieving acceptable infiltration uni-

Furrow irrigated sugar beets using siphon tubes from a concrete ditch.

Protecting Water Quality

Author's email
leytem@nwisrl.ars.usda.gov

Editing and Design:
Forbes Walker
Wanda Russell
Gary Dagnan
Anne Dalton

University of Tennessee Extension

Developed by SERA-17, Minimizing Phosphorus Losses from Agriculture
http://sera17.ext.vt.edu/

NRCS

This project was funded in part under an agreement with the USDA-NRCS.

formity. Management is subjective and will vary by field. The main cost is labor to check runoff and adjust flow rates periodically during irrigation.

Conservation tillage can reduce soil erodibility and increase residue in furrows, both of which reduce soil loss to irrigation return flow.

Applying PAM with irrigation water or directly to furrow soil can reduce sediment losses in runoff by 50-80 percent for production fields. This decrease in erosion translates to a decrease in total P losses from treated fields. Retail cost of PAM is about $2/lb. Applying 1 lb/acre with the first irrigation after the field is cultivated will cost less than $10/acre.

Vegetative filter strips (10 to 30 feet wide) on the bottom end of the field reduce erosion in the tail ditch and filter out 40 to 70 percent of transported sediment and nutrients. Effectiveness is variable because excessive sediment deposition can cover and kill vegetation in the filter strip, reducing its effectiveness. Therefore, filter strips should be used in combination with other practices such as PAM application and conservation tillage to reduce sediment loading to these strips. Filter strips can be established with no cost by eliminating herbicide application on the bottom end of the field, which allows annual grasses to grow in the tail ditch.

Sediment ponds placed at the end of irrigated fields remove suspended material from the irrigation water by reducing the flow velocity and allowing particles to settle. Sediment ponds also remove nutrients associated with sediment particles. Well-constructed ponds can potentially remove 65-75 percent of the sediment and 25-33 percent of total P entering the pond. Total P reduction will depend on the relative amounts of dissolved and particulate P in the pond inflow.

Avoiding over-application of P, both as fertilizer and manures, will prevent soil test P from increasing and therefore reduce the potential for total and soluble P losses. Nutrient management plans should be developed to insure that application of P does not exceed crop removal for extended periods of time. This will not only save money on P inputs, but will reduce the potential of elevating soil test P levels, which can lead to P losses through erosion and soluble P in runoff.

Untreated (left) and PAM-treated furrows. Note how deep the water has cut into the soil in the untreated furrow.

References:

Berg, R.D. and D.L. Carter. 1980. *Furrow erosion and sediment losses on irrigated cropland.* Journal of Soil and Water Conservation 35:267-270.

Bjorneberg, D.L., D.T. Westermann and J.K. Aase. 2002. *Nutrient losses in surface irrigation runoff.* Journal of Soil and Water Conservation 57:524-529.

Brown, M.J., J.A. Bondurant and C.E. Brockway. 1981. *Ponding surface drainage water for sediment and phosphorus removal.* Transactions of the ASAE 24:1478-1481.

Carter, D.L. and R.D. Berg. 1991. *Crop sequences and conservation tillage to control irrigation furrow erosion and increase farmer income.* Journal of Soil and Water Conservation 46:139-142.

Westermann, D.T., D.L. Bjorneberg, J.K. Aase and C.W. Robbins. 2001.*Phosphorus losses in furrow irrigation runoff.* Journal of Environmental Quality 30:1009-1015.

For Further Information:

Contact your local conservation district, USDA-NRCS or USDA-ARS. Further information on the use of PAM can be found on the USDA-ARS-NWISRL. Web site at nwisrl.ars.usda.gov/pampage.shtml