Innovations in Water Management
to Improve Crop Productivity and Water Quality

Several key innovations are coming on line to dramatically improve both agricultural productivity and water quality by management of water flowing through tile lines. The first of these is Drainage Water Management where water is held in the field during the dry periods of the growing season and during fallow periods to improve productivity, and water quality. The second is Sub-Irrigation, which uses the same subsurface tile lines used for drainage to irrigate crops. These two systems can dramatically improve farm economic viability and cost-effectively reduce nutrient loss to waterways.

With the exceptional growth in demand for agricultural production to meet growing populations, higher expectations on diet, and provide fiber and fuel for the 21st Century we will see a massive intensification of agricultural lands. To achieve these objectives of protecting environmental quality and raising agricultural productivity we have to revolutionize our agricultural production systems. We simply have to be more efficient in our use of land and water.

Automated instrumented DWM site - note how little land is taken out of production.

Drainage Water Management Overview

Of the 300 million acres of row crops in the Continental US, approximately 100 million acres have artificial drainage. This is not drainage of wetlands, but systems to reduce the amount of water in the field, particularly during early season for planting and initial plant growth, and harvest. Drainage removes water that could impede germination and allows the soil to warm earlier, improves field trafficability during wet periods and significantly increases yield. While there may be some environmental benefits like reduced rill erosion and resulting soil and phosphorous loss, these systems can foster increased loss of nitrogen from fields and reduce the water holding capacity of a watershed.

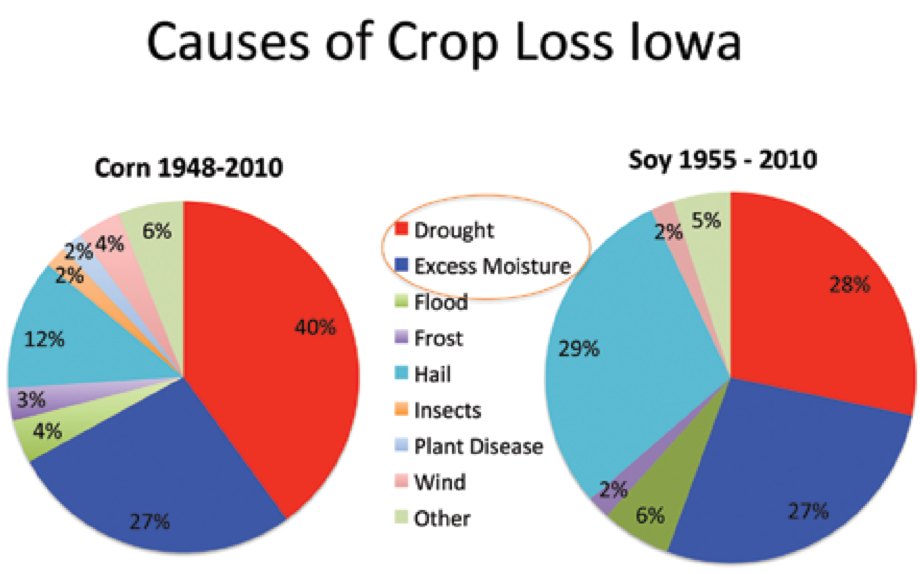
The Natural Resources Conservation Service (NRCS) has identified that with existing technology, over 30 million acres in ten Midwestern states alone would benefit from Drainage Water Management. (DWM) DWM has been shown to be one of the most cost effective techniques to reduce nutrient loss from agricultural lands.[1] This practice also has the advantage of increasing yields, particularly in drought years.

DWM refers to controlling the flow of water discharged from tile lines to improve environmental performance and agricultural production. Without controls, tile lines drain water and associated materials from fields around the clock year round. However, drainage typically is only needed during part of the year, and closing off drainage during most of the year will significantly reduce nutrient loss and improve yields.

The golden rule of drainage management is "Drain only what is necessary to ensure trafficability and crop production – and not a drop more." That means during the fallow season, tile lines should be shut off. This allows water to stay in the field, nitrogen uptake to occur by any cover crop or residual in the field and denitrification to occur by bacteria in the soil. In addition, after the crop has become established, it is prudent to reduce water (and nutrient loss) by selectively managing tile outflow to hold water in the field just below the root zone of the crop. This increases agricultural productivity and reduces nutrient loss.

By managing tile lines typical nutrient loss can be reduced by about half. Less nutrient application is required as the nutrients are held in the field instead of lost through water drainage. Production is increased, particularly during dry years when crops are stressed by lack of water and nutrient availability. It's a "win win" for both the producer and the environment. Input cost can be reduced, yield increased and water quality protected. Secondary ecosystem service benefits like flood reduction, wildlife habitat improvements and greenhouse gas emission reductions can also be achieved.

DWM does not require land to be taken out of production. An automated system can be monitored and managed remotely. The capital investment to install DWM has a life cycle of fifty to one hundred years making it one of the best production and environmental management investments available. Design and installation of controlled drainage is eligible for financial assistance from the NRCS. This practice can be implemented on over 30 million acres with existing technology – as identified by NRCS.



Charts courtesy of Chad Hart, Managing Risk in Agriculture, Iowa State University, June 2013

Sub-Irrigation

A new emerging practice is to use the same tile lines to also provide irrigation. The same infrastructure that removes water during times of excess can be used to put water into fields during periods of drought. Sub-Irrigation requires only modest changes from DWM: 1) a slightly upgraded tile system that allows for more close management of flow, and 2) a pump to raise water to the highest point in the filed where it can be introduced into the tile system.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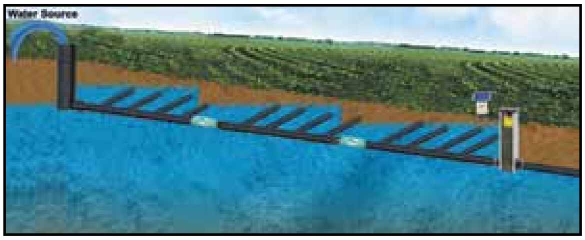
Sub-Irrigation has several advantages over conventional irrigation. First, it uses about half the water. There is no evaporation as the water is sprayed on the crop because water is put proximate to the root zone where it is needed instead of on the surface. Second, Sub-Irrigation uses less than half the energy. Less water is moved to meet plant requirements so less water is pumped. In addition, the only energy required is to deliver water to the highest point in the field for introduction into the tile system. With Sub-Irrigation gravity rather than an "energized" system distributes water through the field. Control structures within the field (I.E. float operated valves that require no separate management or energy inputs) provide for even water distribution. Third, the same infrastructure system that removes excess water is used to provide irrigation removing the need for two water management systems.



Schematic of sub-irrigation distribution of water into cropped field. Graphic courtesy of AgriDrain.

Sub-Irrigation can be economically implemented with existing technology on up to six million acres today. If water drained from fields during wet periods can be stored on site, the economics and environmental outcomes of this practice can be further improved. Nutrient rich drainage waters can be treated in wetlands or ponds and can be reused for irrigation.

On Farm Benefits

In addition to reducing environmental impact, these practices have significant economic benefit for producers. DWM and Sub-Irrigation can contribute to substantial yield increases. They can reduce input costs from savings in nutrient, energy and water. These practices can also take a huge bight out of the risks farmers face every time they plant a crop.

By utilizing these water management systems, tremendous risk can be taken out of crop production. For example, 65% of corn loss in Iowa since the Second World War has been from either not enough water or so much that the crop is flooded out. 55% of crop loss since 1950 for soybeans is from the same causes.

Another on farm benefit is to deliver enhanced ecosystem services. Ecosystem services are the goods and services provided by nature like clean water, abundant wildlife and other valuable "products" that make life possible or increase our enjoyment of it. There is growing acceptance that people are willing to pay for these services and some markets are emerging. Hunters are commonly willing to pay for the right to hunt on a farm and greenhouse gas markets are operating around the world. There are many ecosystem services delivered by DWM and Sub-Irrigation like flood reduction, water quality, greenhouse gas reduction and wildlife habitat improvements that are highly quantifiable and readily can enter into ecosystem service markets. As markets develop and are more broadly operated, ecosystem service products may offer a new class of assets that farmers can produce and derive income from.

Conclusion

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including but not limited to increased agronomic production, reduced input costs and reduced risk. There are also significant off site benefits including reducing nutrient loss to waterways, reduced flooding and other ecosystem services. If ecosystem service markets develop it may be possible to for commerce in those activities to add to the economic viability of farm operations. Likewise, early voluntary action that reduces environmental impact can help reduce pressure for regulation and reflect positively on agricultural producers. **L&W**

by Dave White & Alex Echols

Dave White, President, Ecosystem Services Exchange

Dave was Chief of the Natural Resources Conservation Service from January 2009 to December 2012, where he led, directed, and managed the nation's largest private lands natural resource conservation organization. In addition to his work with NRCS, White was detailed to Iowa Senator Tom Harkin's office in Washington, D.C., where he helped craft the conservation title of the 2008 Farm Bill and to Indiana Senator Richard Lugar and helped develop the conservation title of the 2002 Farm Bill.

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Alex started his career working for the Senate for 12 years, writing key conservation programs like the Conservation Title of the Farm Bill and an extensive rewrite of bilateral and multilateral foreign aid programs. He spent six years at the National Fish and Wildlife Foundation as Deputy and then Acting Executive Director. In 2001, he set up a consulting firm to help industry, landowners, the conservation community and government deliver more conservation for dollars invested.

[1] Kieser et al noted just the environmental benefits (not including agronomic benefits) to be substantial. "Assuming a 30-percent nitrogen load reduction, the costs for a retrofit would be \$0.66/lb to \$0.93/lb and the costs for a new installation would be \$2.86/lb to \$4.17/lb.xii Jaynes et al.xiii estimated at of \$1.23/lb when the costs were applied over a 20-year lifetime at a 4% interest rate, and found this price to be cost-competitive with other nitrogen removal practices. For example, constructed wetlands cost \$1.48/lb, fall cover crops cost \$5.02/lb, and bioreactors cost \$1.08/lb to \$6.88/lb.xivAdvances in technology are likely to reduce the cost of DWM implementation."