Drainage Technology Research in Southwest Minnesota

Nutrient Efficiency and Management Conference

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Morton, MN

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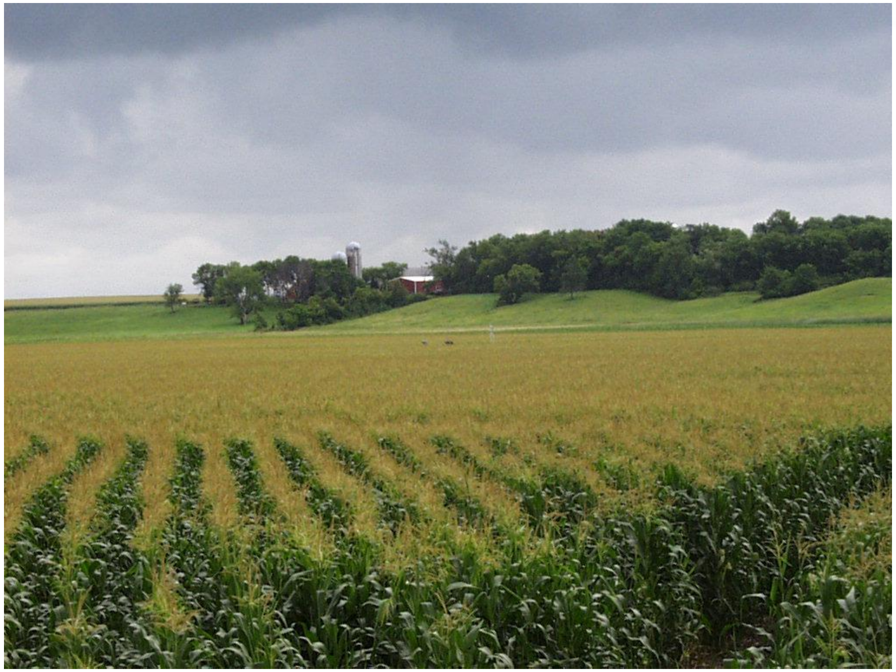
- OVERVIEW

- Land drainage
- Crop Production
- Drainage Water Management
- Examples

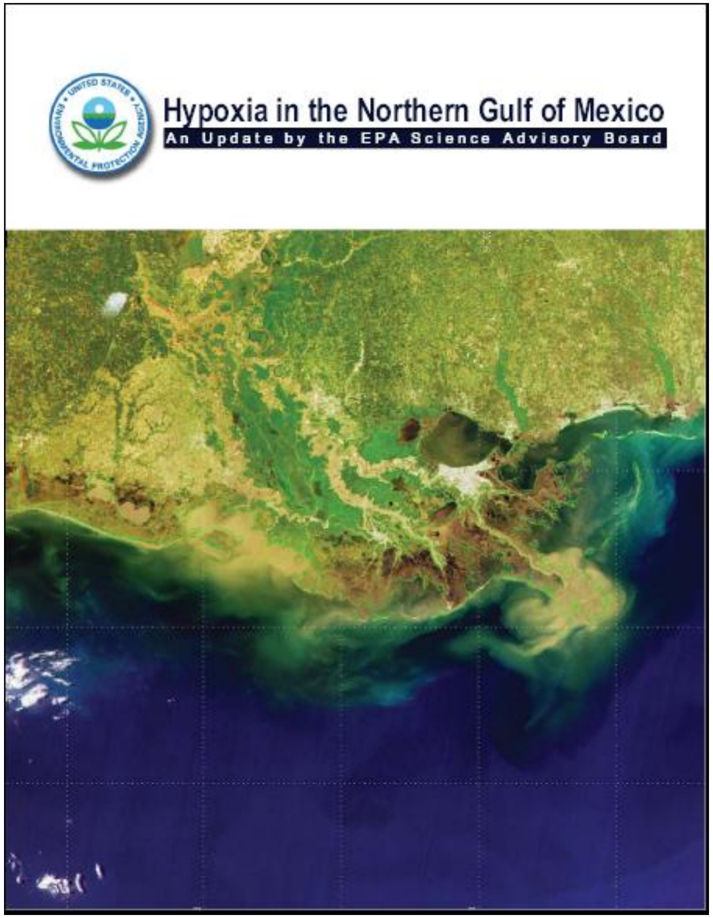
LAND DRAINAGE

Potential benefits of drainage

- Improved trafficability
- Warmer, drier conditions for planting
- Protection from excessive soil-water conditions
- Reduce yield variability
- Improved yield
- Salinity control



Potential drawbacks of drainage



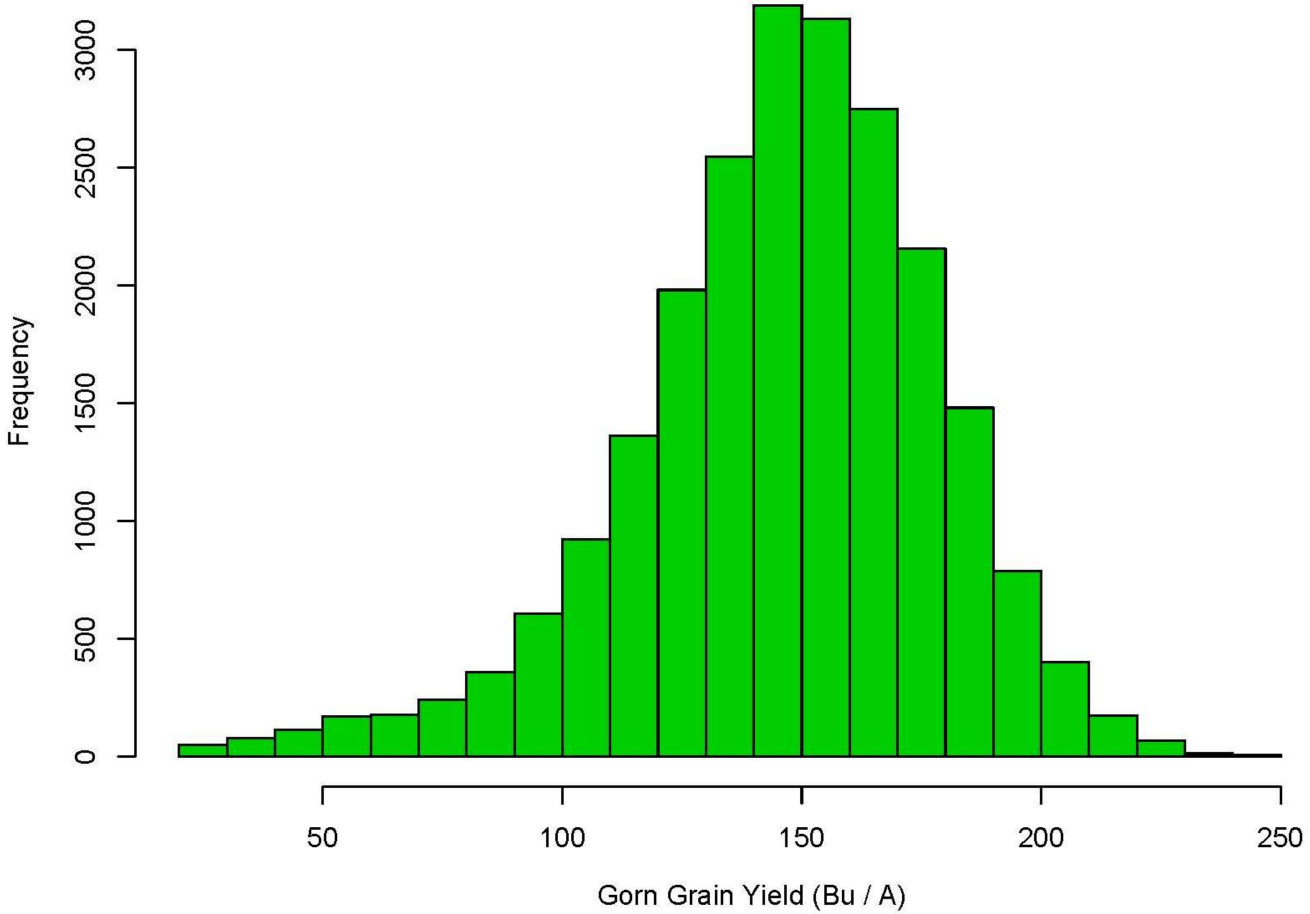
- Nutrients
  - Nitrogen
  - Phosphorus
- Sediments
- Some pesticides
- Fecal coliform
- Changes in hydrologic response

CROP PRODUCTION

Question 1

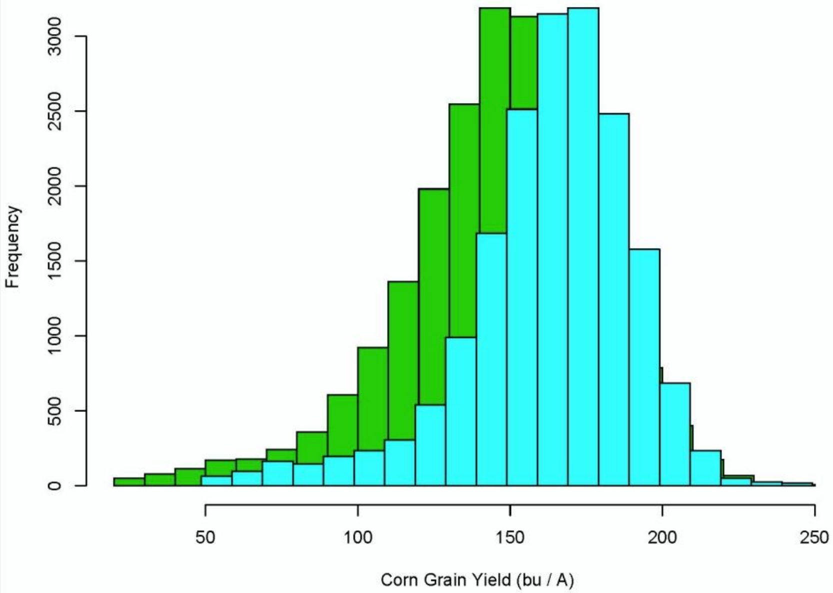
- Yield is a function of _______________?
  - Previous crop
  - Soil organic matter
  - Climate (temperature and precipitation)
  - Fertility (adequate P, K, Zn)
  - Pest control
  - Drainage
  - Tillage
  - Genetics

Yield variability

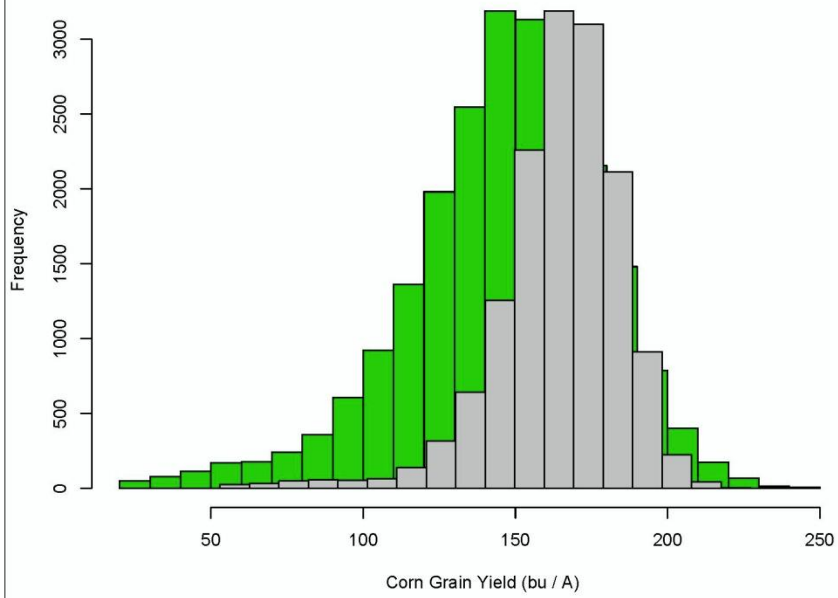


Yield variability (continued)

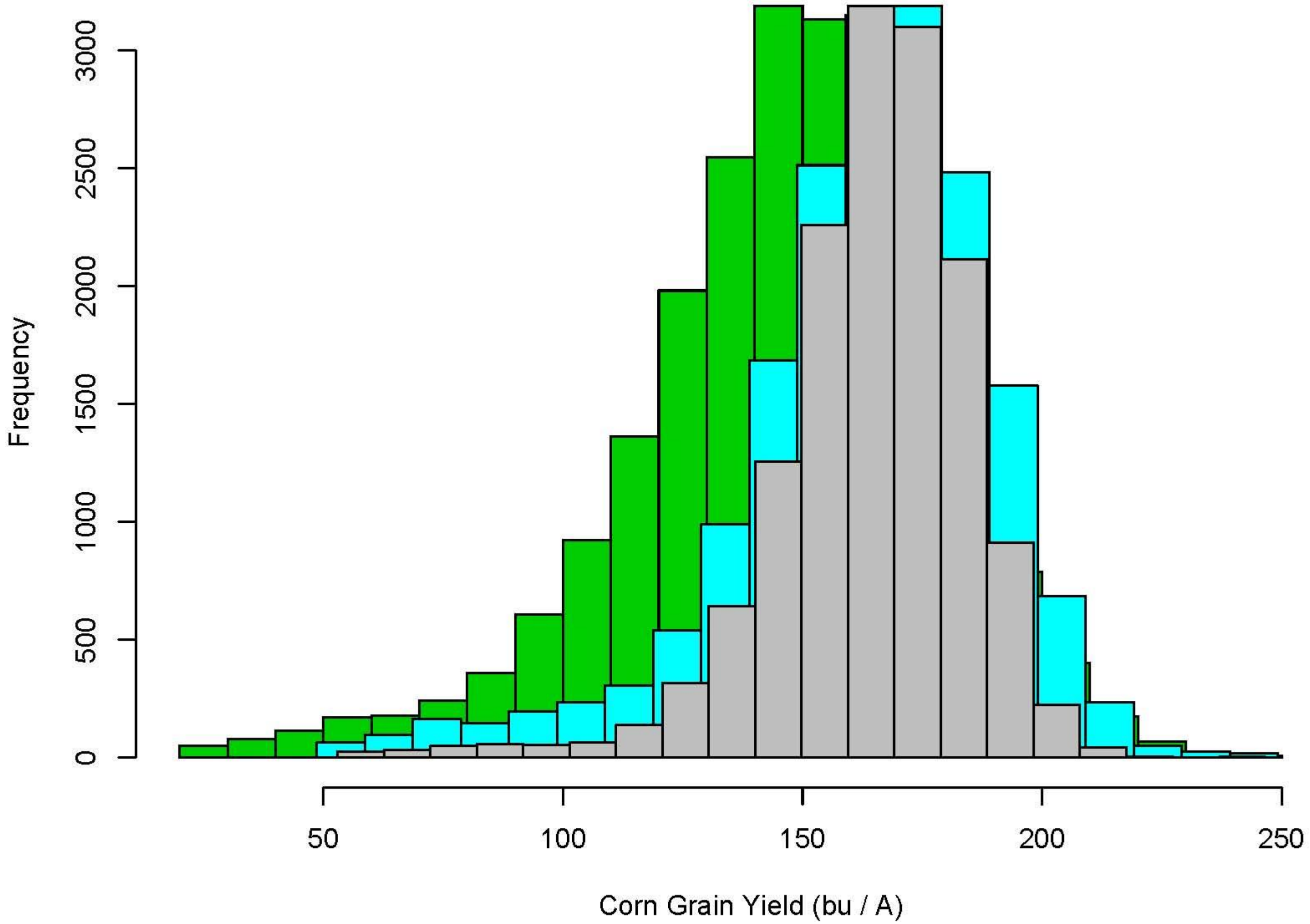
No drainage – Conventional drainage



No drainage – Controlled drainage



Yield variability



Question 2

- How much N does it take to produce 200 bu/A corn crop?

- Assumptions
  - 0.75 lb N removed with grain
  - 0.55 lb N removed with stover
  - 0.35 lb N removed by roots

The answer is -

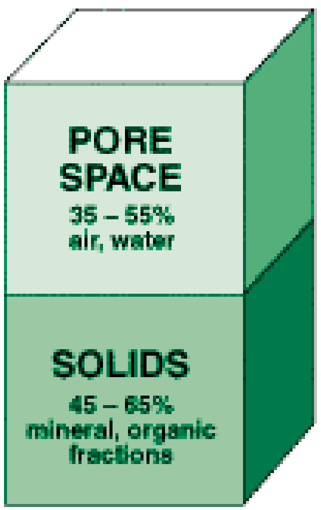
- **~330 lb N/acre**
- (200 x 0.75) + (200 x 0.55) + (200 x 0.35) = 330
- So where does it all come from?
- Typical N application rate for Southern MN = 150 lb N/acre
- 330 – 150 = 180 lb N/acre

- Mineralization of soil organic matter and residue
  - Estimates: 1% SOM = 40 lb N (+/- 25-50%)
  - So, 4.0% SOM = 160 lb N/ac
- Rainfall
  - ~ 10 lb/ac/yr
- Previous crop
  - 40 to 175 lb N/acre

Nitrate nitrogen

- 10 parts per million Nitrate-N (ppm)

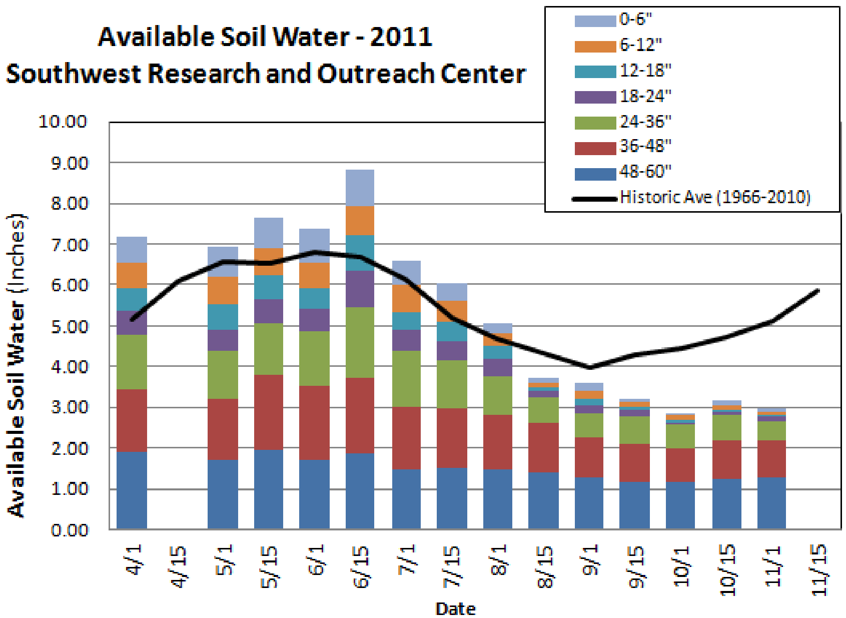
- In one gallon of water, 10 ppm equals 1.3 thousandths of an ounce of N.



<u>Assumptions</u>

- One foot of soil contains six inches of water
- Six inches of water = 1.35 million lb per acre
  (1 acre-foot = 27,154 gal; 1 gal water = 8.34 lb)
- So, it only takes13.5 pounds of nitrate-N per acre to reach 10 parts per million nitrate-N
- Every pound counts!

2011 Soil Water Content



2011 Soil Water Data								
	0-6	6-12	12-18	18-24	24-36	36-48	48-60	Sum
4/1	0.60	0.62	0.57	0.58	1.36	1.53	1.90	7.16
4/15								
5/1	0.75	0.67	0.61	0.53	1.18	1.48	1.72	6.93
5/15	0.74	0.67	0.60	0.59	1.28	1.85	1.93	7.66
6/1	0.81	0.63	0.54	0.55	1.32	1.83	1.70	7.37
6/15	0.87	0.74	0.85	0.90	1.74	1.84	1.87	8.81
7/1	0.60	0.64	0.44	0.51	1.39	1.52	1.49	6.58
7/15	0.47	0.48	0.50	0.47	1.15	1.46	1.53	6.05
8/1	0.25	0.29	0.35	0.41	0.97	1.31	1.48	5.05
8/15	0.11	0.14	0.07	0.15	0.65	1.21	1.39	3.72
9/1	0.19	0.20	0.15	0.19	0.61	0.98	1.27	3.59
9/15	0.08	0.14	0.07	0.16	0.65	0.97	1.14	3.21
10/1	0.01	0.10	0.07	0.06	0.57	0.85	1.15	2.81
10/15	0.11	0.13	0.04	0.09	0.64	0.93	1.23	3.17
11/1	0.05	0.08	0.05	0.11	0.50	0.91	1.26	2.96
11/15								

Due to a wet spring and early summer crops were planted later that normal.

Monthly precipitation (inch)

July: 3.59

August: 0.71

September: 0.05

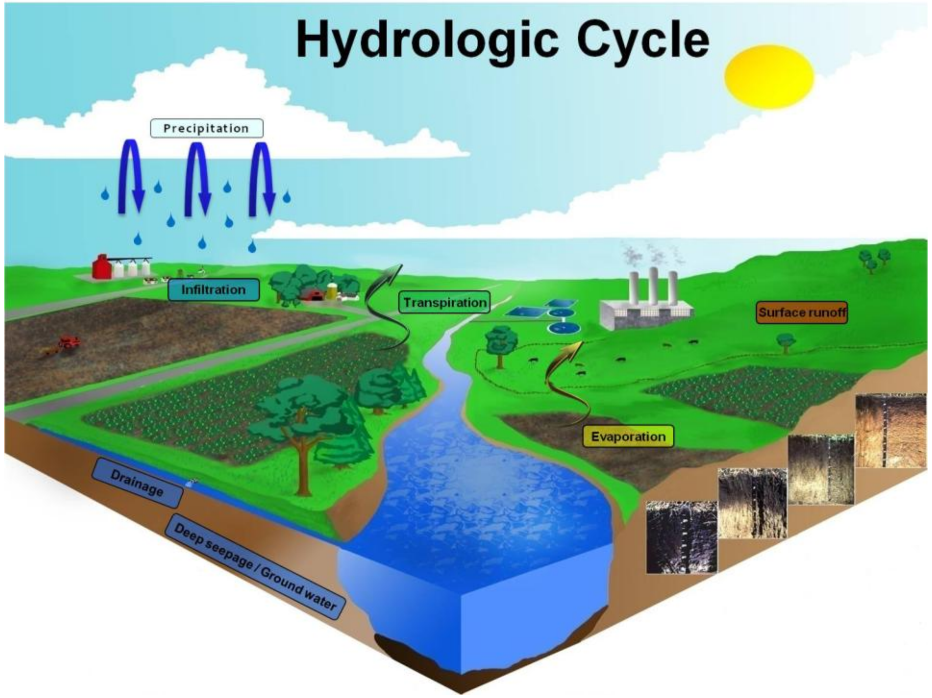
Soil Water Content

- One inch of rain on a one square foot of soil weighs 5.2 lbs.
- One inch of rain on one acre of land weighs 226,610 lbs.
- One acre-inch of water equals 27,154 gallons

- July 1, 2011: 5.1 inches equals 138,485 gallons
- October 1, 2011: 1.6 inches equals 43,446 gallons
- Precipitation between July 1 and October 1 equaled 4.35 inches or 118,120 gallons

Question 2

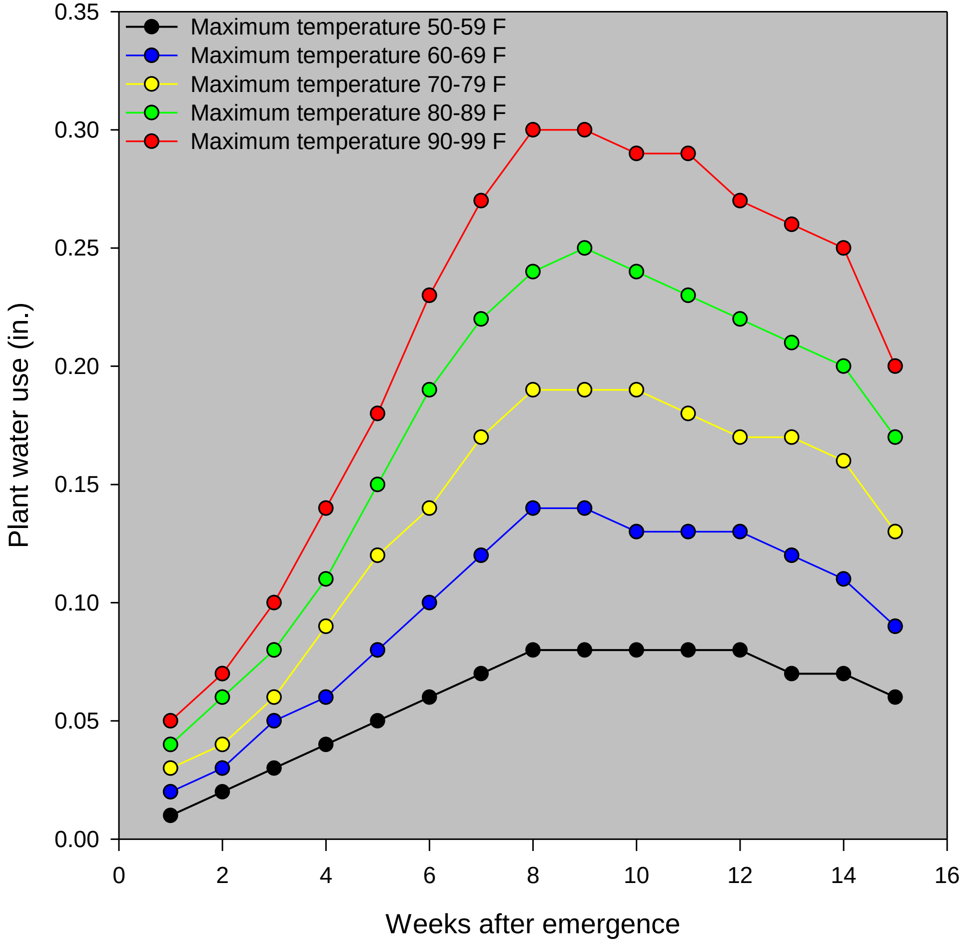
- How much **water** does it take to produce 200 bu/A corn crop?

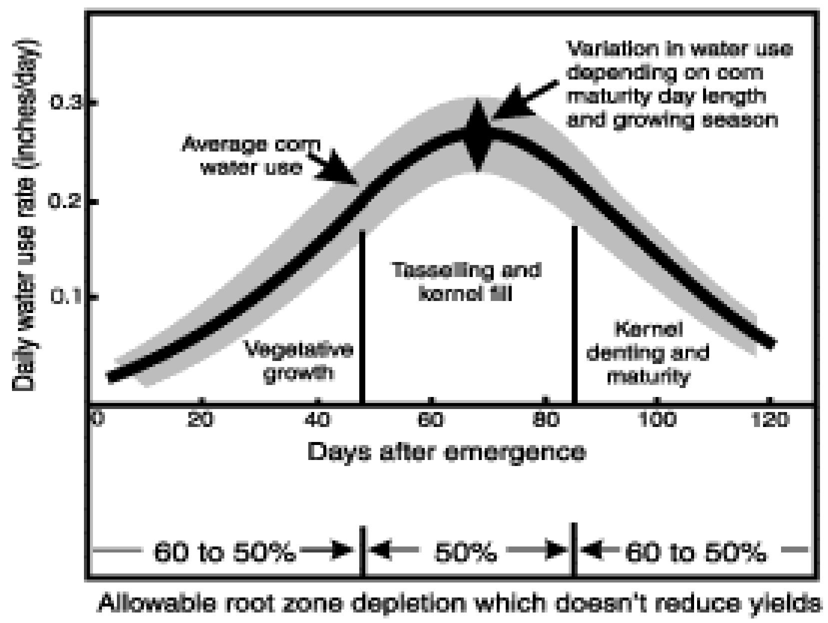


Soil Water Balance

$\Delta S = P + D + R + ET$

Estimates of soil water use





Source: NDSU

The answer is -

- Over the course of a growing season a 200 bu/A corn crop will use about **2,750** gal. water/bushel

or

- ~ 550,000 gallons/acre

$$\frac{550{,}000 \text{ gallons}}{1 \text{ acre}} \times \frac{1 \text{ acre-inch}}{27{,}154 \text{ gallons}}$$

= **20 inches**

(range 18 – 22 inches)

Depends on Frequency, Intensity, Duration, and Amount

DRAINAGE WATER MANAGEMENT

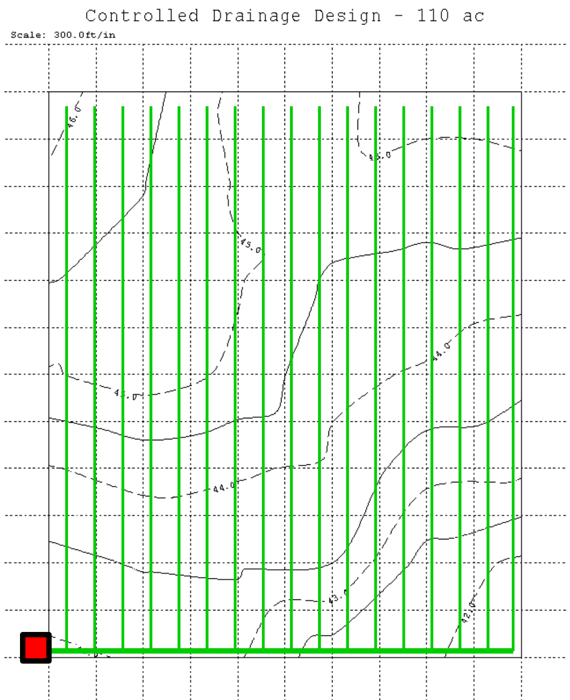
Definition

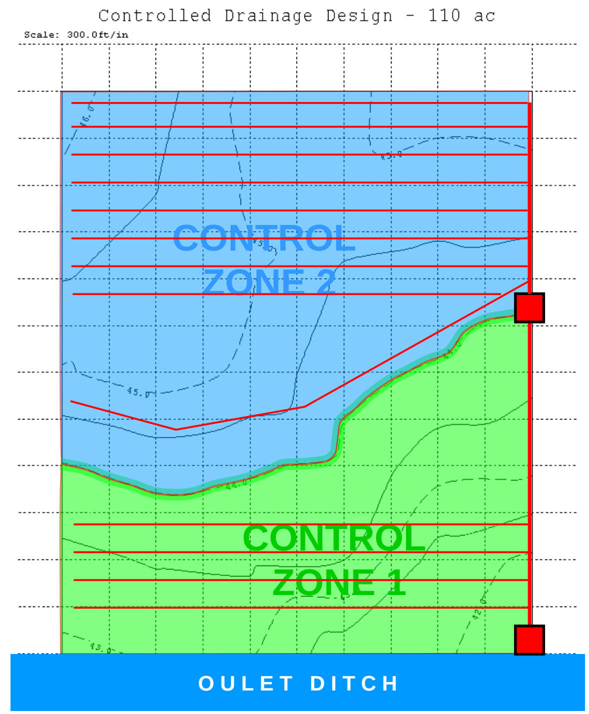
- ***Drainage Water Management*** is the use of drainage practices that are designed to ***provide benefits*** of drainage while ***minimizing negative impacts*** on the environment.

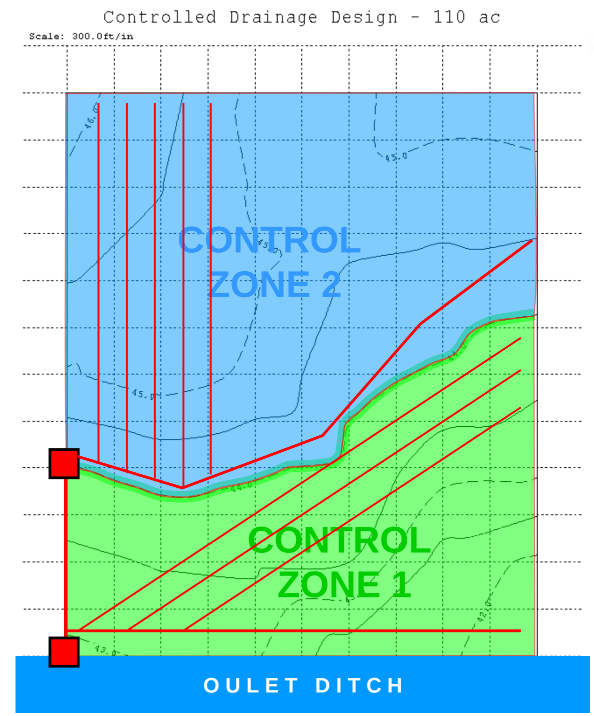
- Appropriate drainage system designs
- Controlled drainage
- Ditch design management
- Water storage / Wetlands
- Side inlet controls
- Bioreactors / Bio Curtains
- Buffers / Waterways
- Cropping Systems

DRAINAGE SYSTEM DESIGN

Drainage System Design



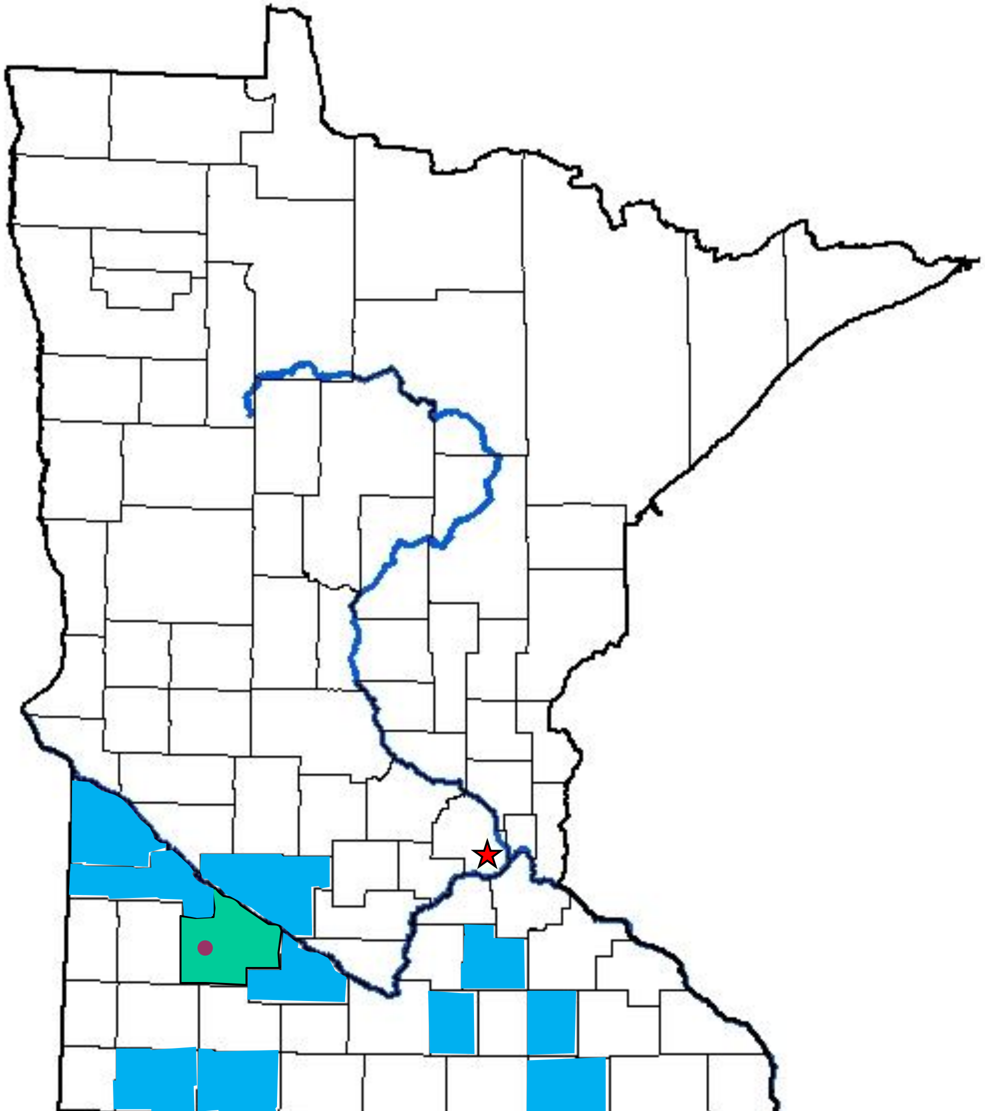




CONTROLLED DRAINAGE

Controlled Drainage

Redwood Co. Research Site



Corn & Soybean Digest
October 2009

COSTCUTTER

GAIN FROM A BETTER DRAIN

DRAINAGE WATER MANAGEMENT REDUCES NITRATE AND MOISTURE LOSS.

BY LIZ MORRISON

It was the drought of 1988 that got John Wilken thinking about the wisdom of draining his "liquid assets."

Wilken, who farms in east-central Illinois, had partly tiled a field before the season started. That dry summer, the undrained portion of his field produced significantly better corn than the drained portion. "That tripped a trigger in my mind, that we should be conserving some of our water for when it's needed," he says.

Today, Wilken does just that. He controls how much – and when – tile drainage water leaves 340 acres of flat cropland in Iroquois County.

Using eight outlet control structures in his main tile lines, Wilken can raise and lower the water table depth in two fields. He holds back water in the soil all winter, when drainage isn't needed for crop production, then releases it about two weeks before field operations begin in the spring.

After planting, he raises the outlet height above the tile depth in order to capture some of the rainfall that would ordinarily drain out. Just before harvest, he drops the outlet back down to the tile depth. In November, after fall strip-tillage and fertilizer application, Wilken raises the outlet height once more, lifting the water table almost to the surface.

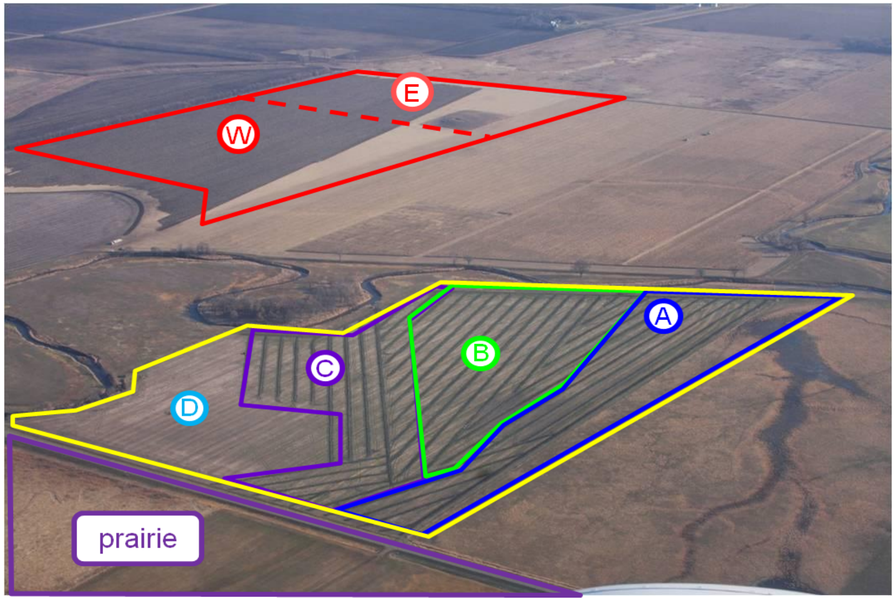
This practice – known as drainage water management, or controlled drainage – cuts nitrate loads flowing into surface waters through the tile system, especially during the fallow period, says Don Pitts, a drainage expert for the Natural Resource Conservation Service in Illinois. And during the growing season, controlled drainage stores moisture and nutrients for the crop, offering the potential for higher yields in dry years, he says.

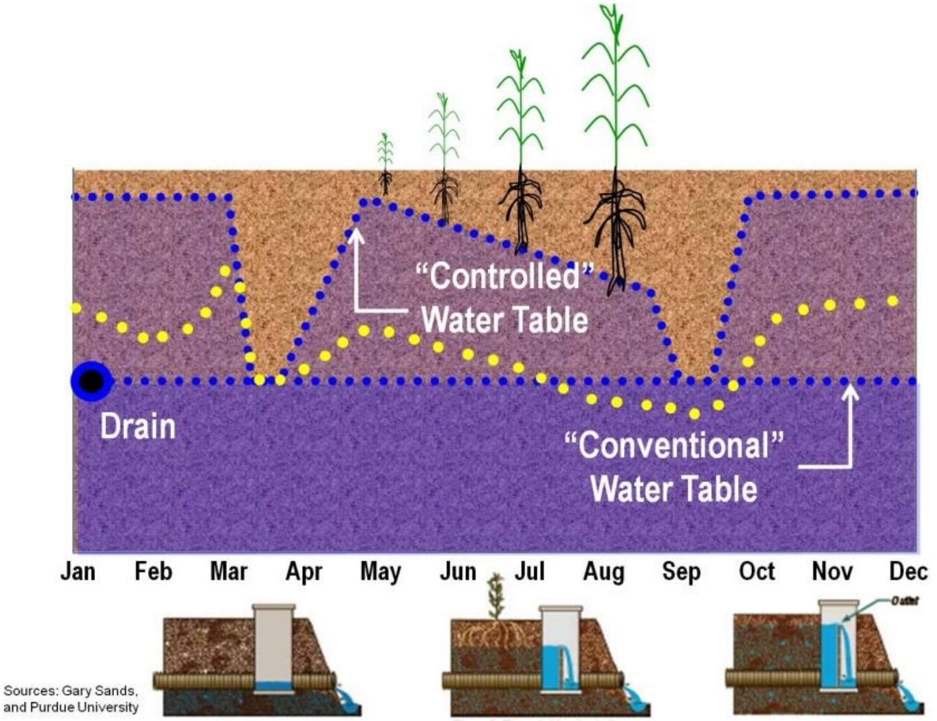
RESEARCHERS ALL AROUND the Midwest are looking for ways to cut pollutants in subsurface drainage water without lowering drainage efficiency. As public concern over water quality intensifies, there is "more interest in what we can do to minimize drainage water volumes and nitrate losses," says

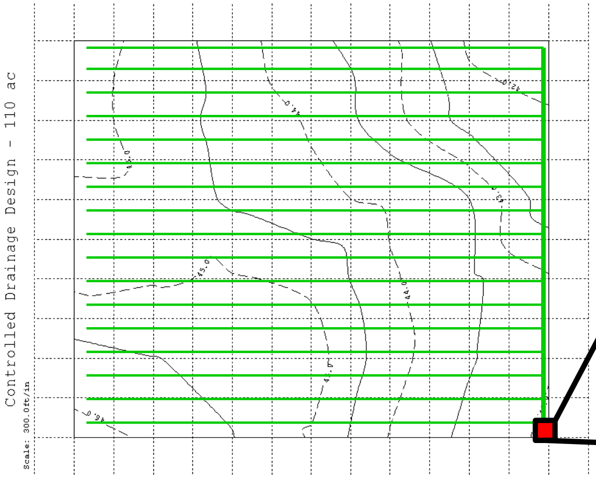
10 CORNANDSOYBEANDIGEST.COM OCTOBER 2009

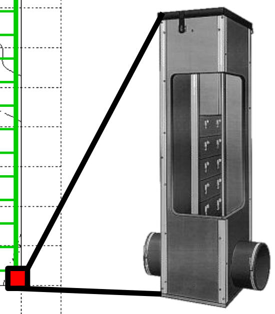
Controlled Drainage Research

Hicks Family Farm & Southwest Research & Outreach Center, Lamberton Dr. Jeff Strock

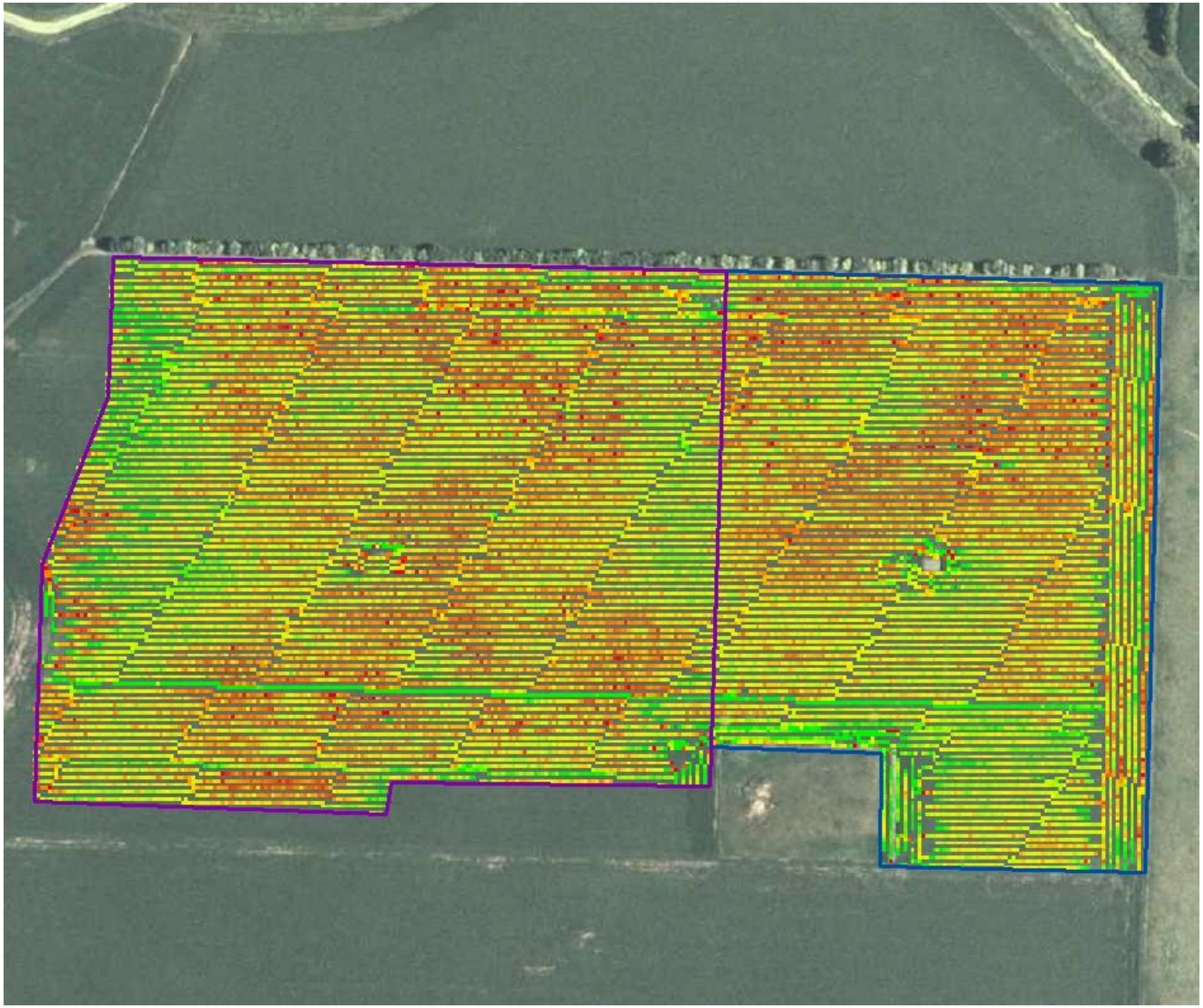








Redwood Co. Research Site
Hicks Family Farm – Field B



Yield results: Hicks Family Farm

paired-analysis design

	East	West	Undrained
Year		bu/A	
2006 (corn)	193†	193	149
2007 (corn)	158	162	145
2008 (soybean)	22	19	46
2009 (corn)	202	225	-
2010 (corn)	182	176	-
2011 (corn)	163	165	-

† Yield monitor data lost

calibration: 2006–2007

treatment: 2008–2011

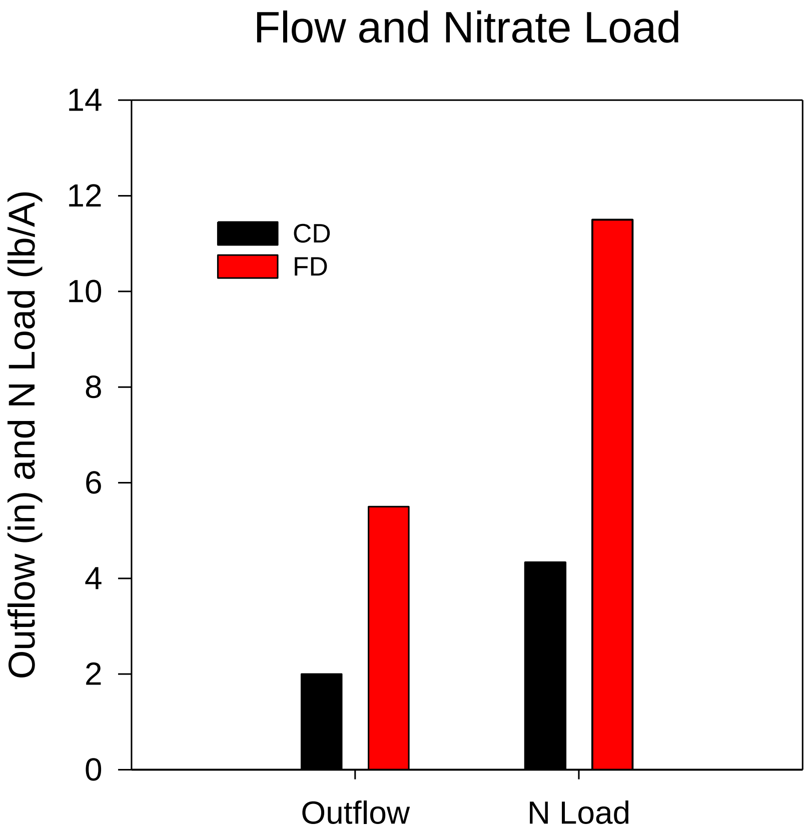
control: East

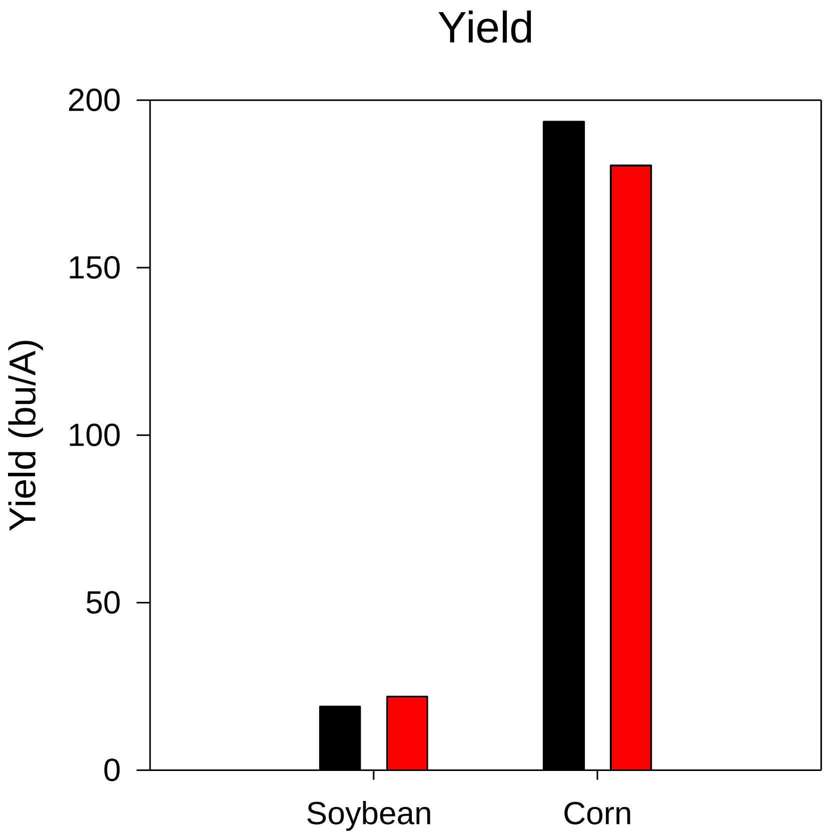
treatment: West

Source: Jeff Strock, UM SWROC, Lamberton

Controlled Drainage Research

Hicks Family Farm & Southwest Research & Outreach Center, Lamberton Dr. Jeff Strock





Economics

- On the relatively flat, 90 acre, Field B of the Hicks farm, the subsurface drainage installation consisted of the following:
  - Two drainage control structures ($1,250 each, including anti-seep collars and couplers). The capital investment is $2,500 or $27.78 per acre.
  - A main drain line ($5,250: 2100 ft. of 8-inch pipe ($2.50 per ft.) including outlets and couplers). The capital investment is $5,250 or $58.33 per acre.
  - A field of 4-inch lateral lines at 50-foot intervals and 1,200 feet in length (65,000 ft., including couplers, junctions, and end caps installed at $0.50 per foot). The capital investment is $32,500 or 361.11 per acre.
  - The total investment cost of the project, including structures would be $40,250 per 90 acres or 447.22 per acre.
  - The total investment cost of the project, without structures would be $37,750 per 90 acres or 419.44 per acre.

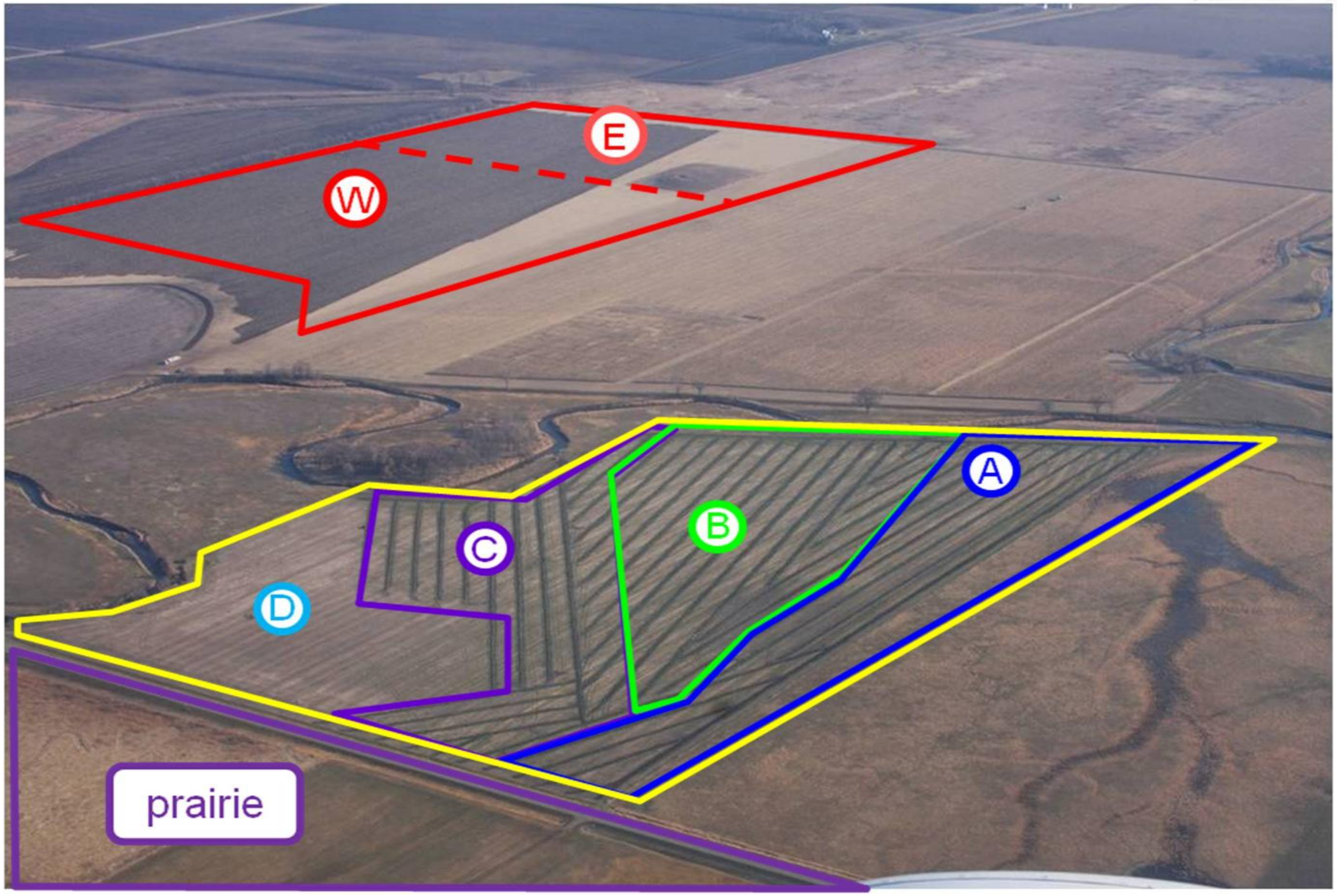
Controlled Drainage

Benefits

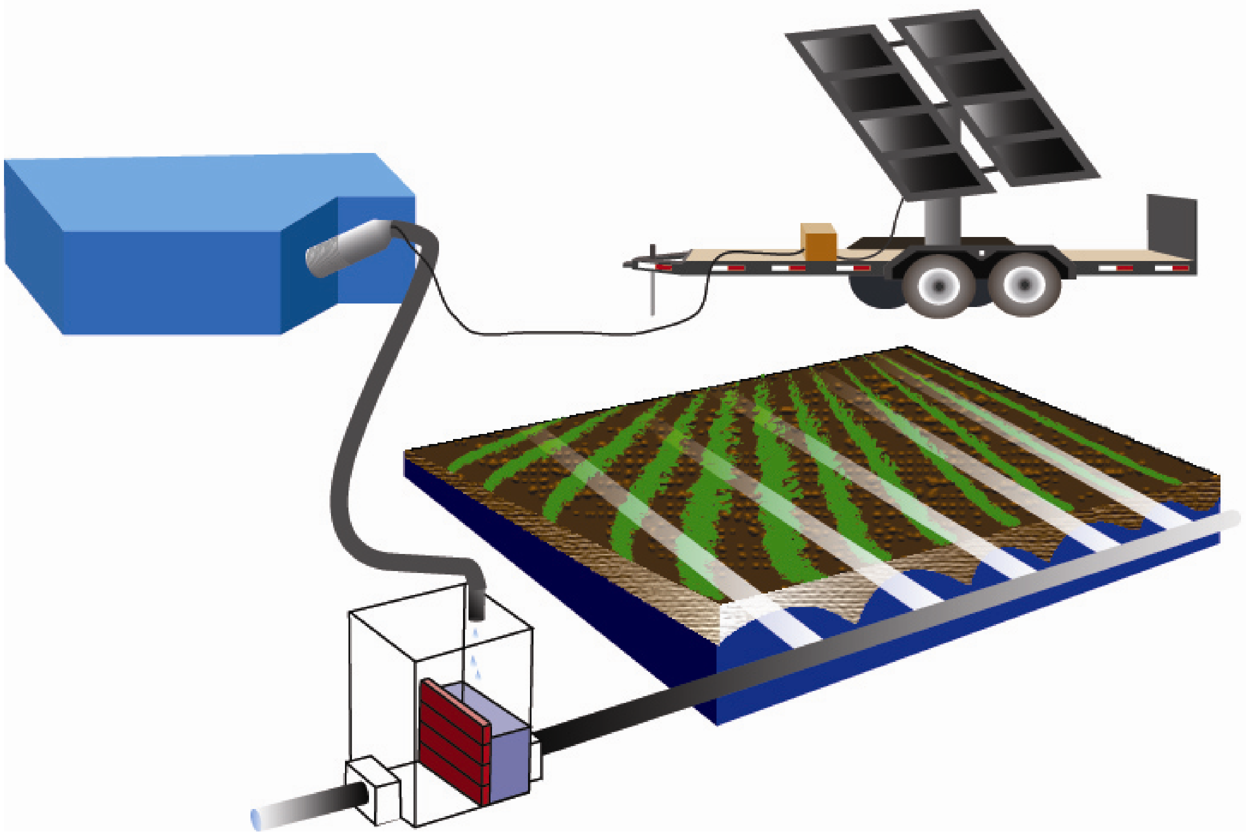
- Reduced drainage volume
- Reduced nitrate load
- Reduced phosphorus load
- Modest yield increase

SUBIRRIGATION

Field G: post-drainage system installation



Subirrigation




SWROC
ZOMEWORKS

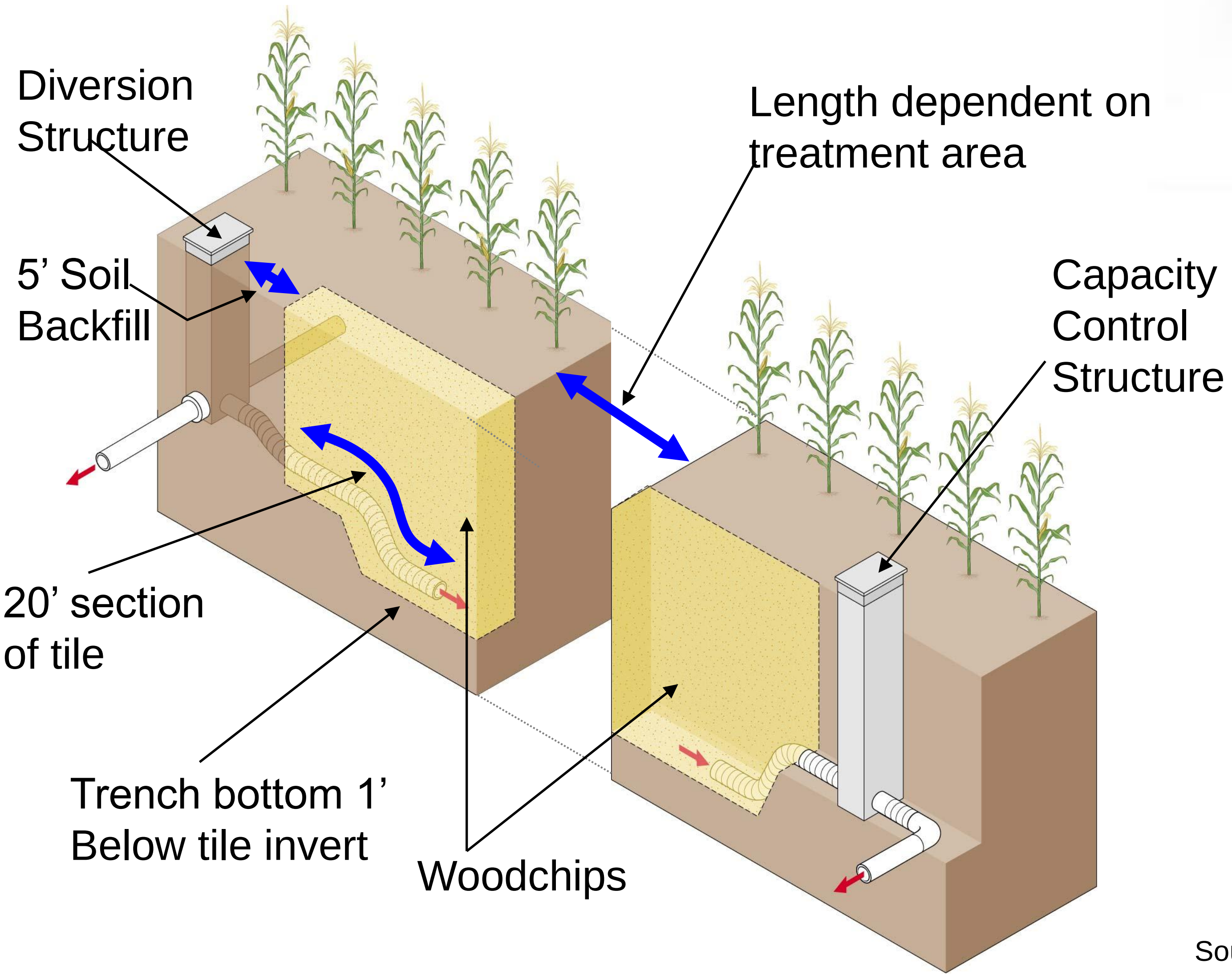
Redwood Co. Research Site
Hicks Family Farm – Field G

Yield results – Hicks Family farm

Drainage Zone	Yield (bu/A)
Conventional	32.6
Controlled	36.5
Subirrigated	39.7
No drainage	39.6

BIOREACTORS / BIO CURTAINS

Bioreactors

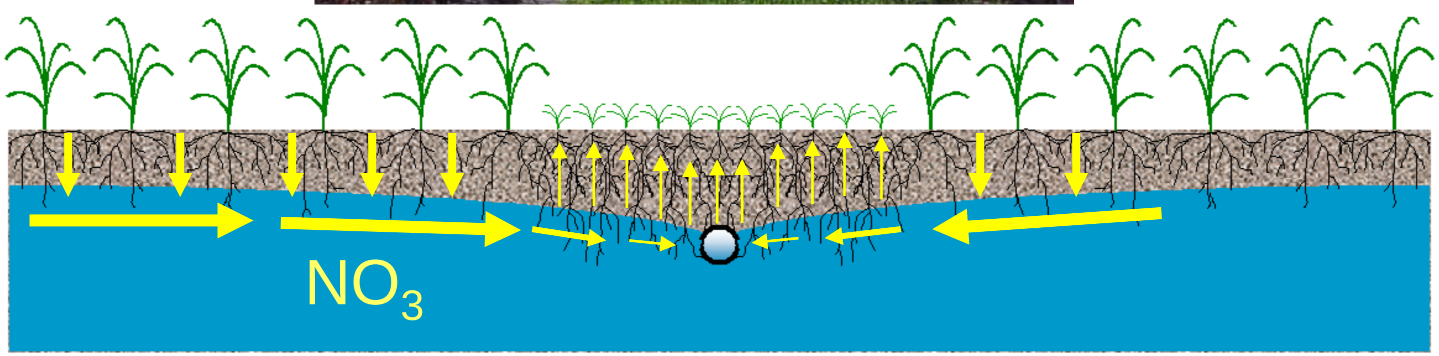


Source: Richard Cooke, UIUC

Bio Curtains

Nitrate removal when drainage is occurring

April



Source: Michael Russelle, USDA-ARS

Bioreactors / Bio Curtains

Benefits

- Emerging practice for reducing nitrogen and phosphorus from drainage water
  - In-field
  - Edge-of-Field
- Minimal crop land is taken out of production
- Require little maintenance
- Show high nitrogen removal capacity

Limitations

- Concerns about greenhouse gas emissions
- Concerns about methyl-mercury generation
- System by-pass during “high” flow conditions
- Questions about longevity of carbon source
- Scalability
- Market


THANK YOU!
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