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# Institute of Ag Professionals

Proceedings of the

## 2015 Crop Pest Management Shortcourse &

### Minnesota Crop Production Retailers Association Trade Show

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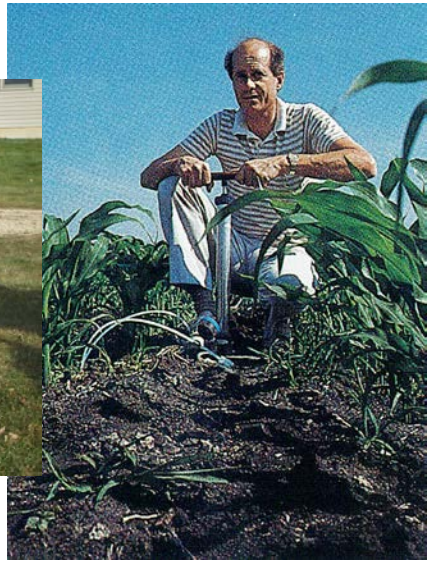
# Nitrates in Drainage Water in Minnesota

**BRAD CARLSON, JEFF VETSCH, GYLES RANDALL**





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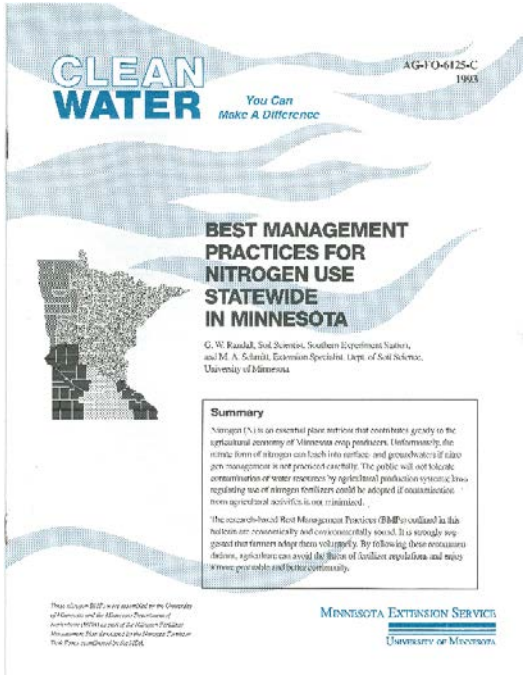
# THE SITUATION

- Nitrates identified as a health issue long ago
- USEPA set standards of 10ppm for drinking water long ago


CLEAN WATER
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AG-FO-6125-C
1993

BEST MANAGEMENT PRACTICES FOR NITROGEN USE STATEWIDE IN MINNESOTA

G. W. Randall, Soil Scientist, Southern Experiment Station, and M. A. Schmitt, Extension Specialist, Dept. of Soil Science, University of Minnesota

Summary

Nitrogen (N) is an essential plant nutrient that contributes greatly to the agricultural economy of Minnesota crop producers. Unfortunately, the nitrate form of nitrogen can leach into surface- and groundwaters if also gets mismanagement is not practiced carefully. The public will not tolerate contamination of water resources by agricultural production systems; thus, regulating use of nitrogen fertilizers could be adopted if contamination from agricultural activities is not minimized.

The research-based Best Management Practices (BMPs) outlined in this bulletin are economically and environmentally sound. It is strongly suggested that farmers adopt them voluntarily. By following these recommendations, agriculture can avoid the blame of fertilizer pollution and enjoy farming profitably and better continuously.

MINNESOTA EXTENSION SERVICE
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- MN moved to address nitrates in drinking water in the late 1980s
- Voluntary BMPs established in early 1990s



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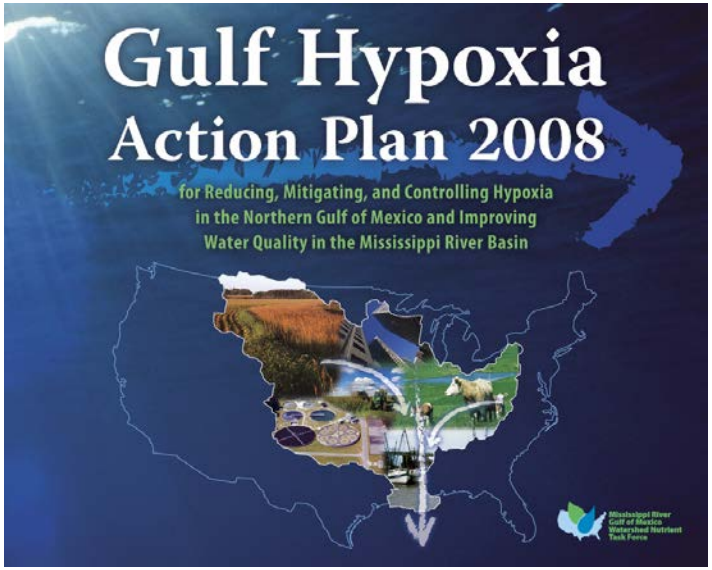
# BRINGING IT FORWARD

- Non-point source pollution in surface water addressed beginning in the mid-late 1990s (nitrates not part of this)
- Hypoxia in the Gulf of Mexico makes the news in the late 1990s
- USEPA develops report on dealing with Hypoxia putting onus on states



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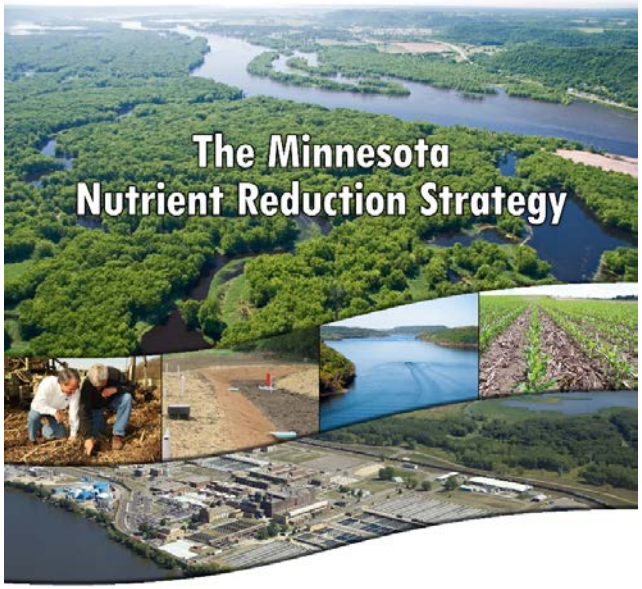
# TODAY

- 45% reduction targeted in Mississippi River watershed
- Minnesota's plan in draft form
- Public "concern" about ag drainage
- Surface water standards currently in development

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# HOW DOES WATER (NITRATES) GET TO STREAMS?

- Runoff
- Shallow Ground Water Flow
- Artificial Drainage

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# HOW TO REPORT THE DATA

- Nitrate-N
- lb./A
- Multiple year totals
- Flow Weighted concentrations

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# LITERATURE REVIEW

- Loss via drainage tile
- Randall and Goss (2008) world wide
  - 0 lb/A – 124 lb/A
- Majority in the 10 lb/A – 40 lb/A

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# THE UNIVERSITY OF MINNESOTA

- Drainage plots established at Waseca and Lamberton in 1975

- Plots kept devoid of vegetation lost an average of 20 lb nitrate-N/A
- This is from soil organic matter



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# A FIRST LOOK

| Crop Rotation | N Rate | N Time | Nitrate-N | |
|---|---|---|---|---|
| | | | 4-Yr Avg. Conc. | 4-Yr Total |
| | lb/A | | ppm | lb/A |
| C-S-Corn | 0 | | 6.1 | 37.7 |
| | 60+40 | SPL | 7.8 | 44.8 |
| | 120 | PP | 8.2 | 52.1 |
| S-C-Corn | 0 | | 4.6 | 34.0 |
| | 60+80 | SPL | 7.9 | 64.2 |
| | 160 | PP | 8.8 | 62.8 |
| C-C-Soybeans | 0 | | 5.5 | 30.5 |
| | 0 | | 8.4 | 40.9 |
| | 0 | | 8.7 | 38.3 |

SPL – Split Applied, PP – Pre-Plant Application

**Four year nitrate-N loss from a corn-corn-soybean cropping system at Waseca from 2007 – 2010. Nitrate losses calculated for the crop last in the Crop Rotation column. (Randall and Vetsch, 2011)**



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# TAKE HOME

- Corn receiving no N fertilizer lost 10 lb/A
- Soybeans in that rotation lost 10 lb/A
- Typical losses using recommended rates ≈ 15 lb/A
- BMP says application only after soil temp is below 50° F

- Mother nature doesn't know this!



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# BUT OTHER YEARS

| Cropping System | Total Discharge 4-Yr. Cumulative | Nitrate-N 4-Yr Avg. Conc. | 4-Yr Total |
|---|---|---|---|
| | Inches | ppm | lb/A |
| Continuous corn | 30.4 | 28 | 194 |
| Corn – soybean | 35.5 | 23 | 182 |
| Soybean – corn | 35.4 | 22 | 180 |
| Alfalfa | 16.4 | 1.6 | 6 |
| CRP | 25.2 | 0.7 | 4 |

**Effect of cropping system on cumulative drainage volume, nitrate-N concentration and N loss in subsurface tile drainage during a 4 – year period (1990 – 1993) at Lamberton. (Randall, et. al., 1997)**



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# TAKE HOME

- Numbers following the 1987-88 drought
- Loss rates as high as ≈ 40 lb/A
- Loss rates reduced to near 0 under perennials

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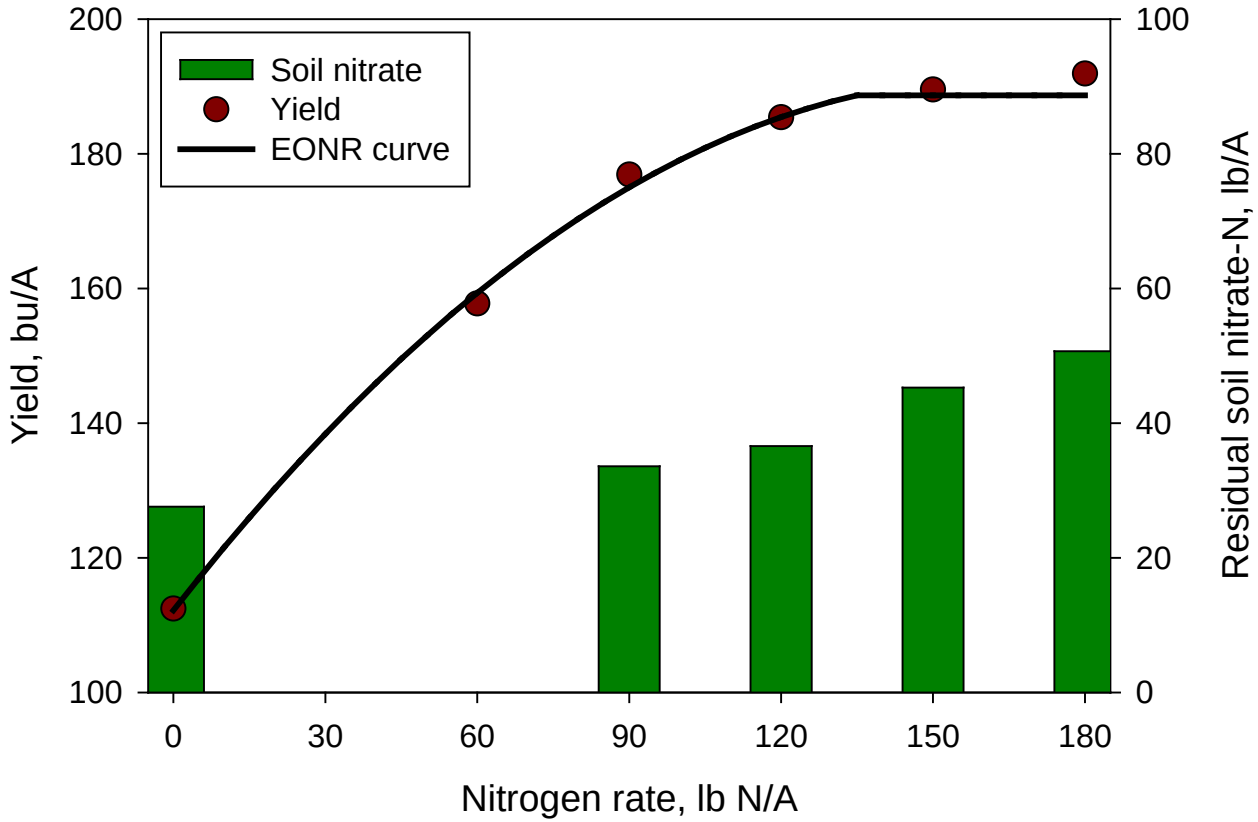
# THE EFFECT OF RATE




**Corn grain yield and residual soil nitrate-N response as affected by fertilizer N rate on a Webster clay loam soil near Waseca, MN, averaged from 2001 - 2003 (Vetsch and Randall).**



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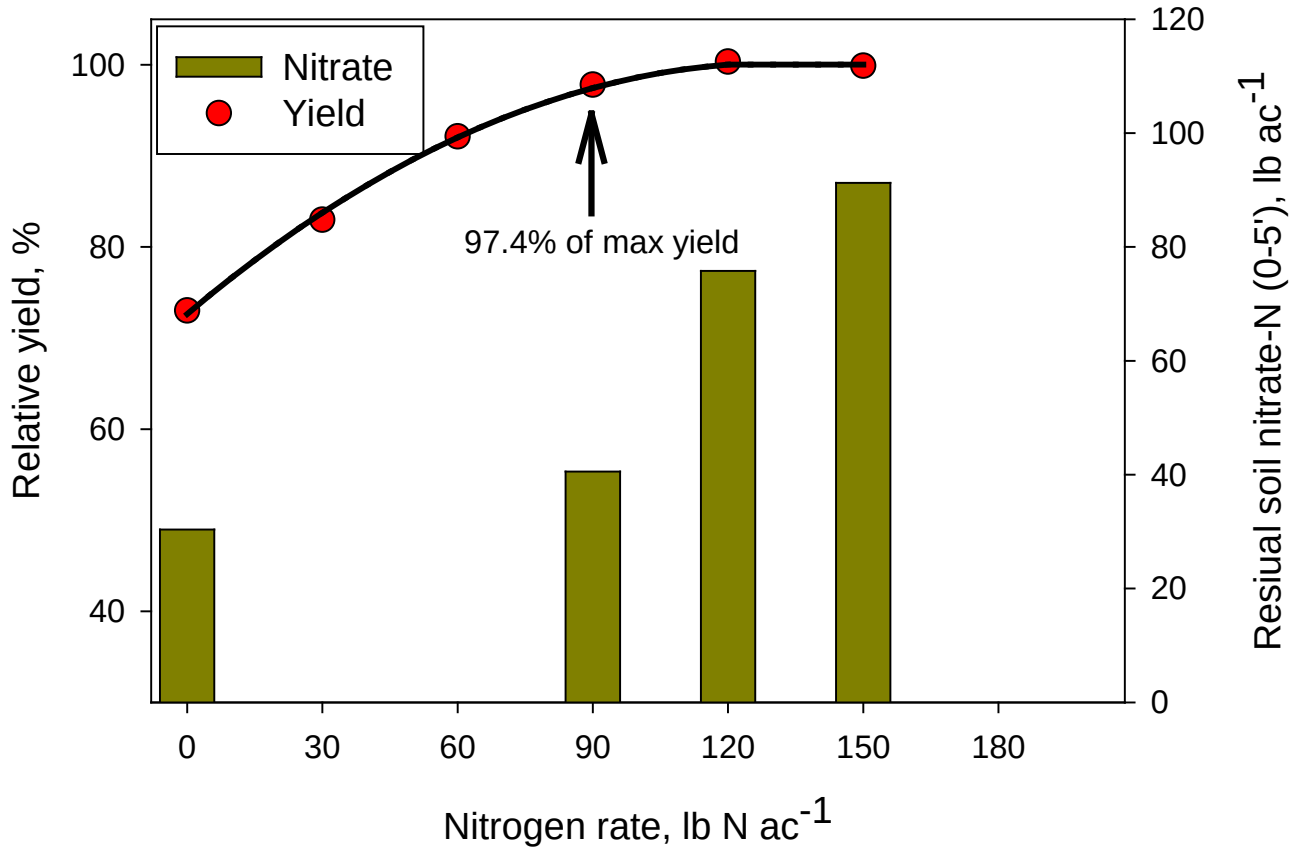
# FOR REFERENCE




**The same study, but at Rochester.**



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# TAKE HOME

- Residual (loss) curve follows similar but inverse relationship to yield and rate
- At the plateau a 4 bu./A yield increase resulted in a 40 lb/A increase in residual N at Waseca
- At Rochester a 1% yield increase resulted in 100% increase in residual N
- We don’t have drainage losses to go along with residual nitrate


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# APPLICATION TIMING AND INHIBITORS (BMP REVIEW)

- No fall N in SE MN or sandy soils
- No fall urea in SC/C MN
- Use Inhibitor in SC/C MN

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# APPLICATION TIMING AND INHIBITORS

| application | | | FW $NO_3$-N | 2000-2003 $NO_3$-N Lost | | | 4 Year Corn Yield |
|---|---|---|---|---|---|---|---|
| Rate | Time | N-Serve | Conc. | C | Sb | Total | Avg. |
| b N/A | | | mg/L | -- lb/A/4 cycles - - | | | bu./A |
| 80 | Fall | Yes | 11.5 | 115 | 90 | 205 | 144 |
| 120 | Fall | Yes | 13.2 | 121 | 99 | 220 | 166 |
| 160 | Fall | Yes | 18.1 | 142 | 139 | 281 | 172 |
| 120 | Spr. | No | 13.7 | 121 | 98 | 219 | 180 |

**Nitrate-N concentrations, losses in tile water, and corn grain yield as affected by rate and time of N application (as anhydrous ammonia) at Waseca (2000–2003). (Randall, Unpublished)**



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# TAKE HOME

- Fall N application with inhibitor has similar loss to spring application
- Under applying has a big yield penalty with relatively little environmental benefit
- Trend toward higher yield with spring application

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# NITRATE-N MOVEMENT

- Requires free nitrate in the soil
- Water in excess of field capacity (saturation) to run through drain tile

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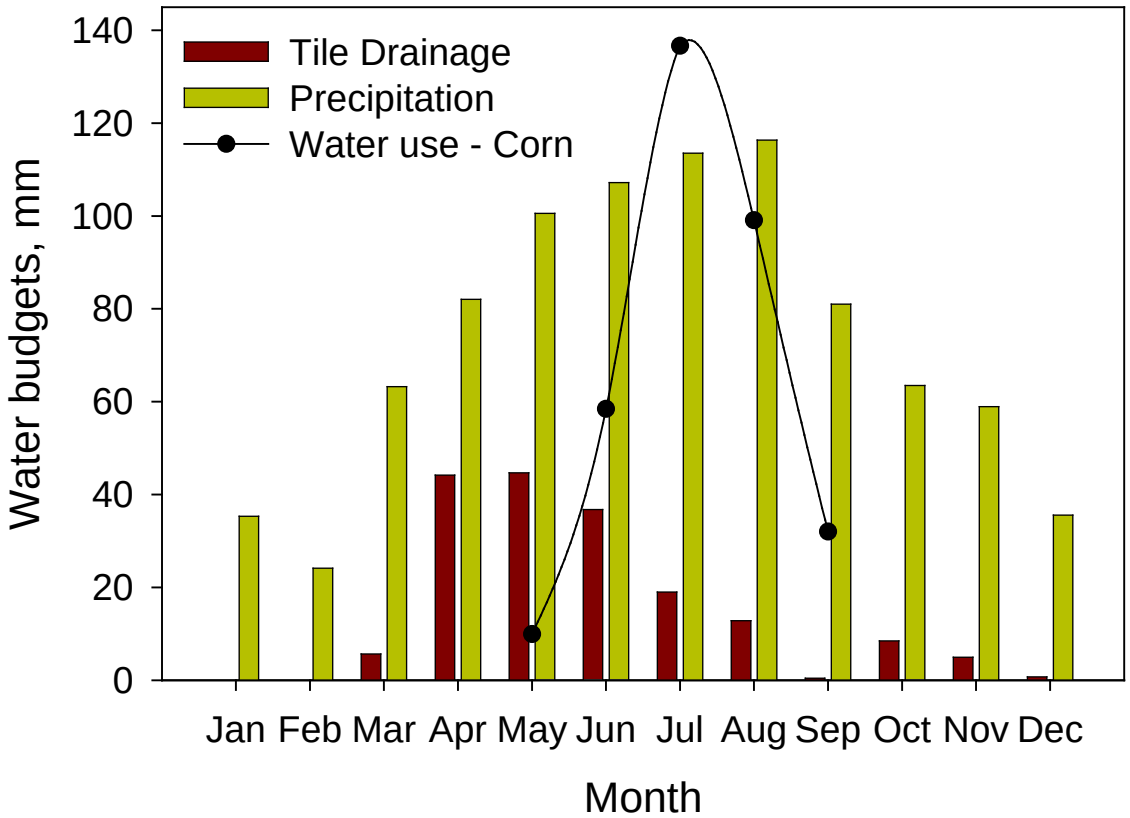
# THE SEASONAL CYCLE




**Relationship between monthly subsurface tile drain flow from facility B in 1987 – 2001 and 30 year normal monthly precipitation and water use (ET) by corn at Waseca, MN. (Randall, 2004)**



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# FLOW BY MONTH

| Month | Drain Flow | Nitrate Loss |
|---|---|---|
| | ----------% of Annual Total---------- | |
| January | 0 | 0 |
| February | 0 | 0 |
| March | 3 | 2 |
| April | 25 | 17 |
| May | 25 | 29 |
| June | 21 | 27 |
| July | 11 | 14 |
| August | 7 | 6 |
| September | <1 | <1 |
| October | 5 | 3 |
| November | 3 | 2 |
| December | <1 | <1 |

**Monthly Distribution of annual subsurface tile drainage and nitrate–N losses for corn in a corn/soybean crop rotation for a 15 yr (1997 – 2001) period at Waseca, MN (adapted from Randall, 2004).**



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# TAKE HOME

- Most flow is in April – July
- Nitrate loss mirrors drainage
- On average 50% of drainage occurs on just 7 calendar days

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# WHAT ABOUT MANURE?

- No different than commercial fertilizer
- Use recommended rates and an inhibitor
- Timing is key

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# PUTTING IT ALL TOGETHER

- Soil Organic Matter mineralizes the equivalent of 20 lb nitrate-N/A per year
- Corn and soybeans lose about 10 lb nitrate-N/A per year even though not fertilized
  - A relatively high Nitrogen Use Efficiency (NUE)
- Corn at BMP rates lose about 15 lb nitrate-N/A per year
  - 2/3 from naturally mineralized N


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# IN ADDITION

- The Nitrogen BMPs are accurate with their recommendations
  - Fall N, Inhibitors
- Environmental hazard goes up significantly when N is over-applied
  - This relationship needs to be explored in more detail
- Movement depends on excess water and free nitrate



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# REMEMBER

- Numbers vary based on climatic cycles (numbers go very high post-drought)
- You might get away with some things some years, but….

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# MANAGEMENT

- We can not afford “insurance N”
- Use an inhibitor when fall applying
- Logically applications closer to the time of crop use decrease the likelihood of loss
- We don’t know the rate of BMP adoption – therefore how much is to be gained

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# FUTURE N TECHNOLOGY

- In season N test (soil, tissue, light)
- Better inhibitors
- Application technology (in season or too wet)
- Increased NUE of corn hybrids
- Stay in touch with the science

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# FUTURE RESEARCH DIRECTIONS

- Loss vs. Rate curves
- Evaluate new technology
- Precision management
- Post-drought management
- Cover Crops

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# WHERE WE ARE TODAY

- Our crops leak N
- Perennials do not, but there is no market
- Movement <u>not</u> via drain tile is by shallow groundwater flow (just because it isn't going through the tile doesn't mean it won't get to the stream anyway)
- Therefore drain tile provides the opportunity to capture the water before it reaches the rivers


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# THE FUTURE

- Tightening up on N management is essential (we must be honest about what is going on) – it is the cheapest and easiest thing to do
- Reducing N rates below recommendations might not produce much result
- Cover crops provide a great opportunity to capture free nitrate so it is held in the field


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# THE FUTURE

- All the tools are laid out in the MPCA plan
  - N management
  - Drainage Water Management
  - Wetland Treatment
  - Cover Crops
  - Perennial Vegetation

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# STAY TUNED

- Every farmer will need to address this issue in some way
- Incremental progress is acceptable
- Solutions can be customized to meet local conditions

- But that is a different talk for a different day



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# Thank You

MinnesotaCorn

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