## **Cover Crops and Nitrogen in Water**

Minnesota Nutrient Management Conference Morton, MN February 9, 2016



USDA-ARS National Laboratory for Agriculture and the Environment Ames, Iowa

Tom Kaspar Ben Knutson Keith Kohler Kent Heikens Dan Jaynes Tim Parkin Tom Moorman



Nitrates in rivers hit record levels May 10, 2013 Des Moines Register Friday May 10, 2013

Nitrate spike tests Des Moines water supplies Drought, heavy rain increase amount of chemical in rivers Des Moines Register Sunday June 30, 2013

Finding Fixes for Nitrates Des Moines Register Sunday Sept. 13, 2015

Chesapeake Bay cleanup: Is Iowa next? Des Moines Register Nov. 17, 2015

# Des Moines water quality suit slated for trial in 2016

Des Moines Register, July 15, 2015 Donnelle Eller, deller@dmreg.com *11:56 a.m. CDT July 15, 2015* 

The Des Moines Water Works lawsuit against three northwest lowa counties over water quality is scheduled to be heard by a federal trial judge, beginning Aug. 8, 2016, unless a continuance is sought, a court document indicates.

U.S. District Court Judge Mark Bennett expects the bench trial in Sioux City to last up to two weeks. The Des Moines utility is suing Buena Vista, Calhoun and Sac counties, claiming drainage districts there act as conduits for nitrates to move from farm fields into the Raccoon River, one of two sources of drinking water for 500,000 residents in the Des Moines metro area.

#### NO3-N Concentration in the Raccoon River at Des Moines



Data provided by Chris Jones

### It's the Golf Courses and Lawns!

 Corn & Soybean (Acres)
 24,507,219

 Golf Courses (Acres)
 49,172

 Lawns (Acres)
 154,064

Total 24,710,455

There are 120X more corn & soybean acres than golf courses and lawns in lowa.

#### It's the Sewage Treatment Plants!

Comparing the nonpoint (farmland) nitrate loads with the point source loads reveals that most of the nitrate load in the Raccoon River is derived from nonpoint sources (i.e. not cities or industries). .... Nonpoint sources comprise **89.6** % of the total nitrate load in the watershed.

Water Quality Improvement Plan for Raccoon River Iowa. Shilling, K.E. and C.F. Wolter. Iowa Dept. Natural Resources. 2007

#### Statewide Tile Nitrate Results

Statewide Tile Nitrate Results 2014



ISA RESEARCH Advancing Agricultural Performance<sup>®</sup> and Environmental Stewardship





Environmental Programs & Services IOWA SOYBEAN ASSOCIATION

Funded in part by the soybean checkoff

So why is this such a difficult problem?

# We just need to manage N fertilizer better.

**Right?** 



#### **IOWA STATE UNIVERSITY**

#### **Castellano and Helmers**

#### Soil Nitrate Production vs. Crop Nitrate Uptake



In the shaded areas, the soil produces nitrate, but there is no crop to use it. As a result, <u>some</u> nitrate is lost to waterways.

#### **IOWA STATE UNIVERSITY**

**Castellano and Helmers** 

## **Change in Land Use**





### Annual Flow-wt NO3 Concentration of Tile Drainage for Four

#### Corn and Soybeans have a 5 to 7 Month "BROWN" Gap



## Nitrate Loss in Tile Drainage



## **Water Flow Pathways**



Land management and land use impact evapotranspiration and infiltration, which in turn impact surface runoff, subsurface drainage, deep percolation

#### IOWA STATE UNIVERSITY

Castellano and Helmers

## Flow Meters & Sample Collectors



Kaspar et al. J. Environ. Qual. 36:1503-1511.



#### **Cumulative Annual Drainage**



#### **Nitrate-N Concentration**

Annual Flow-wt NO3 Concentration of Tile Drainage for Corn-Soybean Rotation near Ames, IA with or without a Cover Crop





#### Nitrate-N Loss in Drainage



## Total Nitrate-N Lost 2002-2015 in Tile Drainage

Nitrate-N Lost in Drainage		
14-yr total	14-yr avg.	
lbs/acre	lbs/acre	
485	35	
211	15	
274	20	
57		
	Nitrate-N Los 14-yr total Ibs/acre 485 211 274 57	

# Total Cover Crop Nitrate-N Uptake 2002-2015

	Cover Crop Shoot Biomass	Cover Crop Shoot N Concentration	Cover Crop Shoot N Content	Reduction of Drainage N Loss
	lbs/acre	%	lbs N/acre	lbs N/acre
Avg 02-15	1499	2.53	33	20
Sum 02-15	20970		458	274

# Estimated Change in Soil Total N Balance over 4 years (2002-2005)

Fertilizer N added - same Estimated N Fixation by Soybean - estimate relative to yield N in Rainwater - same N Removed in Grain – similar – more than fertilizer added N Lost in Drainage Water – less for cover crop Change in Inorganic Soil N – usually less for cover crop Gaseous losses of N - ???? – N<sub>2</sub>O not different – similar

Corn-Soybean with rye cover crop increased 73 lbs N/acre

Corn-Soybean without cover crop decreased -16 lbs N/acre

Change in total soil or SOM N - ??? - cover crop more Change in surface residue N - ??? – cover crop more

#### So where is the nitrogen the cover crops took up? Probably in soil OM and residue

Can N fertilizer rates be decreased at some point in the future? Maybe total will decrease but some additional N may be needed at planting - starter.

Will losses of N in drainage increase after cover crops have been used for many years? Doesn't look like it so far as long as there is a cover crop.

Do soybeans fix more or less N when following cover crops? ???

Good questions without complete answers.

## Rye Cover Crop Effect on Soil Quality in a Corn Silage System after 10 years

- A rye cover crop "increased" total soil organic matter (SOM) in the top 4 inches from 4.8% to 5.3% or ½% change in SOM
- Very rough estimates would say a ½% change in SOM would result in an additional ½ inch of water and 10 lbs N/acre of mineralized soil N.
- 48% greater Potential N mineralization
- Rough estimates would say this "potentially" would be 8-10 lbs N/acre of mineralized soil N per year

## Rye Cover Crop Effect on Plant Available Water after 12 years

- A rye cover crop increased soil water storage capacity or plant available water in the top 12 inches by 18%, which is equivalent to an extra 0.3 inches of water every time the upper 12 inches of soil was rewetted by rainfall.
- The rye cover crop does use water in the spring, but in 5 out of 7 years this was replenished by the time of main crop planting.
- In most years after cover crop termination water contents in the upper 30 cm were higher following a rye cover crop in the summer.

Basche et al. 2016

### Reduction of Nitrate Leaching with Rye – Four Other Iowa Sites

Nashua, Iowa 22 – 29%
Gilmore City, Iowa 15 - 20%
COBS Experiment, Kelly, Iowa 36%
Tim Smith farm, Eagle Grove, Iowa 48%

Data from Matt Helmers, Eileen Bader, Tim Smith, and A.L. Daigh



#### **Examples of Improvement**

- **Boone River Watershed** •
  - Corn/Soybean Rotation
  - Cover Crops



## Why Does Cover Crops Effectiveness Vary from Site-to Site?

- Would expect it to vary
- Different amounts of cover crop growth
- Different weather/climate at the sites
- Different soil types OM, texture
- Tile spacing, tile depth, effectiveness
- Different crop management
- Different field history

## **Cover Crop Summary**

• Winter cover crops reduce N losses in tile drainage by taking up N and reducing nitrate concentrations in soil and drainage water.

 There is some lag between cover crop N uptake and reduced water concentrations.

Cover crops have to grow to have a benefit.

• Winter cover crops don't seem to have a large impact on the total annual amount of drainage, but could have seasonal effects.

•Unlike other practices used to reduce N contamination of water, winter cover crops provide other benefits.

## **General Summary**

- Nitrate losses in drainage don't differ much between corn and soybean years
- A substantial portion of the nitrate in drainage water can come from soil mineralization
- N management alone won't completely solve nitrate losses in drainage – but still a good first step
- We are going to need to use multiple management practices to solve this problem – both in-field and off-field

## Future of Cover Crops

- Great untapped potential we are barely scratching the surface
- Cover crop cultivars/species that are better adapted to MN will need breeding effort.
- Cover crop mixtures could be even better but not there yet in MN corn-soybean
- More research on long-term benefits of cover crops and management – especially planting
- More seed, products, machinery, services, and consulting from agribusiness to help farmers implement cover crops.





#### **Questions?**

Tom.Kaspar@ ars.usda.gov

