Reducing Yield Variability Through Soil Health

WAYNE FREDERICKS, OSAGE, IA
DR. JERRY HATFIELD, USDA-ARS, AMES, IA

2020 PFI Annual Conference
January 17, 2020, Ames, IA
Journey to Where?
Any Rewards?
First Fork in the Road

NO TILL BEANS
Winter 1991-92
Froze early, no plowing
Second Fork in the Road

Strip Till Corn
Third Fork in the Road

Cover Crops
Charles City – June 9, 2008

Cedar Rapids

Gulf of Mexico

Rock Creek
Cedar Rapids – June 13, 2008

Gulf of Mexico
Elected to Iowa Soybean Association Board 2009

Heavily involved with On-Farm Network

Began Cover Crop trials in 2012
IOWA NUTRIENT REDUCTION STRATEGY

A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico

Prepared by:
Iowa Department of Agriculture and Land Stewardship
Iowa Department of Natural Resources
Iowa State University College of Agriculture and Life Sciences
May 2013
# Iowa Strategy to Reduce Nutrient Loss: Nitrogen Practices

This table lists practices with the largest potential impact on nitrate-N concentration reduction (except where noted). Corn yield impacts associated with each practice also are shown as some practices may be detrimental to corn production. If using a combination of practices, the reductions are not additive. Reductions are field level results that may be expected where practice is applicable and implemented.

<table>
<thead>
<tr>
<th><strong>Practice</strong></th>
<th><strong>Comments</strong></th>
<th>% Nitrate-N Reduction*</th>
<th>% Corn Yield Change**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing</strong></td>
<td>Moving from fall to spring pre-plant application</td>
<td>6 (25)</td>
<td>4 (16)</td>
</tr>
<tr>
<td></td>
<td>Spring pre-plant/sidedress 40-60 split Compared to fall-applied</td>
<td>5 (28)</td>
<td>10 (7)</td>
</tr>
<tr>
<td></td>
<td>Sidedress – Compared to pre-plant application</td>
<td>7 (37)</td>
<td>0 (3)</td>
</tr>
<tr>
<td></td>
<td>Sidedress – Soil test based compared to pre-plant</td>
<td>4 (20)</td>
<td>0 (22)</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>Liquid swine manure compared to spring-applied fertilizer</td>
<td>4 (11)</td>
<td>0 (13)</td>
</tr>
<tr>
<td></td>
<td>Poultry manure compared to spring-applied fertilizer</td>
<td>-3 (20)</td>
<td>-2 (14)</td>
</tr>
<tr>
<td><strong>Nitrogen Application Rate</strong></td>
<td>Nitrogen rate at the MRTN (0.10 N:corn price ratio) compared to current estimated application rate. (<a href="http://cnrc.agron.iastate.edu">ISU Corn Nitrogen Rate Calculator — http://cnrc.agron.iastate.edu</a> can be used to estimate MRTN but this would change Nitrate-N concentration reduction)</td>
<td>10</td>
<td>-1</td>
</tr>
<tr>
<td><strong>Nitrification Inhibitor</strong></td>
<td>Nitrapyrin in fall – Compared to fall-applied without Nitrapyrin</td>
<td>9 (19)</td>
<td>6 (22)</td>
</tr>
<tr>
<td><strong>Cover Crops</strong></td>
<td>Rye</td>
<td>31 (29)</td>
<td>-6 (7)</td>
</tr>
<tr>
<td></td>
<td>Oat</td>
<td>28 (2)</td>
<td>-5 (1)</td>
</tr>
<tr>
<td><strong>Living Mulches</strong></td>
<td>e.g. Kura clover – Nitrate-N reduction from one site</td>
<td>41 (16)</td>
<td>-9 (32)</td>
</tr>
<tr>
<td><strong>Land Use</strong></td>
<td>Energy Crops – Compared to spring-applied fertilizer</td>
<td>72 (23)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Land Retirement (CRP) – Compared to spring-applied fertilizer</td>
<td>85 (9)</td>
<td></td>
</tr>
<tr>
<td><strong>Extended Rotations</strong></td>
<td>At least 2 years of alfalfa in a 4 or 5 year rotation</td>
<td>42 (12)</td>
<td>7 (7)</td>
</tr>
<tr>
<td><strong>Grazed Pastures</strong></td>
<td>No pertinent information from Iowa – assume similar to CRP</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td><strong>Edge-of-Field</strong></td>
<td>No impact on concentration</td>
<td>33 (32)</td>
<td></td>
</tr>
<tr>
<td><strong>Drainage Water Mgmt.</strong></td>
<td>No impact on concentration</td>
<td>32 (15)</td>
<td></td>
</tr>
<tr>
<td><strong>Shallow Drainage</strong></td>
<td>Targeted water quality</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td><strong>Wetlands</strong></td>
<td>Only for water that interacts with the active zone below the buffer. This would only be a fraction of all water that makes it to a stream.</td>
<td>91 (20)</td>
<td></td>
</tr>
<tr>
<td><strong>Bioreactors</strong></td>
<td>Divert fraction of tile drainage into riparian buffer to remove Nitrate-N by denitrification.</td>
<td>50 (13)</td>
<td></td>
</tr>
</tbody>
</table>
# Iowa Strategy to Reduce Nutrient Loss: Phosphorus Practices

Practices below have the largest potential impact on phosphorus load reduction. Corn yield impacts associated with each practice also are shown, since some practices may increase or decrease corn production. If using a combination of practices, the reductions are not additive. Reductions are field level results that may be expected where practice is applicable and implemented.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Comments</th>
<th>% P Load Reduction</th>
<th>% Corn Yield Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phosphorus Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus Application</td>
<td>Applying P based on crop removal – Assuming optimal STP level and P incorporation</td>
<td>0.6⁴</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Soil-Test P – No P applied until STP drops to optimum or, when manure is applied, to levels indicated by the P Index†</td>
<td>17*</td>
<td>0</td>
</tr>
<tr>
<td>Source of Phosphorus</td>
<td>Liquid swine, dairy, and poultry manure compared to commercial fertilizer – Runoff shortly after application‡</td>
<td>46 (45)</td>
<td>-1 (13)</td>
</tr>
<tr>
<td></td>
<td>Beef manure compared to commercial fertilizer – Runoff shortly after application‡</td>
<td>46 (96)</td>
<td></td>
</tr>
<tr>
<td>Placement of Phosphorus</td>
<td>Broadcast incorporated within 1 week compared to no incorporation, same tillage</td>
<td>36 (27)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>With seed or knifed bands compared to surface application, no incorporation</td>
<td>24 (46)</td>
<td>0</td>
</tr>
<tr>
<td>Cover Crops</td>
<td>Winter rye</td>
<td>29 (37)</td>
<td>-6 (7)</td>
</tr>
<tr>
<td>Tillage</td>
<td>Conservation till – chisel plowing compared to moldboard plowing</td>
<td>33 (49)</td>
<td>0 (6)</td>
</tr>
<tr>
<td></td>
<td>No till compared to chisel plowing</td>
<td>90 (17)</td>
<td>-6 (8)</td>
</tr>
<tr>
<td><strong>Land Use Change</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perennial Vegetation</td>
<td>Energy Crops</td>
<td>34 (34)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Land Retirement (CRP)</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grazed pastures</td>
<td>59 (42)</td>
<td></td>
</tr>
<tr>
<td><strong>Erosion Control and Edge-of-Field</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terraces</td>
<td></td>
<td>77 (19)</td>
<td></td>
</tr>
<tr>
<td>Buffers</td>
<td></td>
<td>58 (32)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Sedimentation basins or ponds</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Blind Inlet</td>
<td>Sediment control</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
Cover crops improve soil health

Increased organic matter in soil, less erosion, fewer weeds, and even more beneficial insects

Published on August 16, 2017

Cover crops incorporated into a cash-crop rotation. (Courtesy of AgSource Laboratories)
What Has My Data Revealed?
Organic Matter % Change Over Time

Fence rows 6-9% OM

~ 2.5% Increase over 25 years

No-till
Strip-till

1984: 2.3 (Song), 2.5 (Strand), 3.3 (Fisera)
2007: 3.1 (Song), 4.3 (Strand), 4.8 (Fisera)
2012: 4.2 (Song), 5.4 (Strand), 5.2 (Fisera)
2015: 4.3 (Song), 5.6 (Strand), 6.1 (Fisera)

Conventional Tillage
VALUE OF SOIL HEALTH
Incremental Value of 1% (10 Tons) Soil Organic Matter (IA, NRCS)

- Enhanced water availability (20/80 rule)  
  - $18
- Mineralizable N and P  
  - $11
- Total value per 1% organic matter  
  - $29
- Value Our Farm (2.5% OM Change)  
  - $72 (Capitalized?)
What else have we learned from the study of 17 years of yield data on 10 different fields?

Dr. Jerry Hatfield, USDA ARS, Ames, IA
Data Availability

- Yield monitor data from 2003 to 2018
- Soil maps for each field
- Weather data
- Soil organic matter across fields and years
April - Sept. Rainfall

\[ y = 0.4532x - 884.42 \]

\[ R^2 = 0.1044 \]

+ 7”
Data Analysis

- Means and standard deviations of yield data by field and year
- Skewness and kurtosis of yield data segregated by soil within field
- Geospatial analysis to quantify field variability
- Water use efficiency
Corn Yields relative to Mitchell County

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>80</td>
</tr>
<tr>
<td>2004</td>
<td>100</td>
</tr>
<tr>
<td>2005</td>
<td>120</td>
</tr>
<tr>
<td>2006</td>
<td>140</td>
</tr>
<tr>
<td>2007</td>
<td>160</td>
</tr>
<tr>
<td>2008</td>
<td>180</td>
</tr>
<tr>
<td>2009</td>
<td>200</td>
</tr>
<tr>
<td>2010</td>
<td>220</td>
</tr>
<tr>
<td>2011</td>
<td>240</td>
</tr>
<tr>
<td>2012</td>
<td>220</td>
</tr>
<tr>
<td>2013</td>
<td>200</td>
</tr>
<tr>
<td>2014</td>
<td>220</td>
</tr>
<tr>
<td>2015</td>
<td>240</td>
</tr>
<tr>
<td>2016</td>
<td>260</td>
</tr>
<tr>
<td>2017</td>
<td>280</td>
</tr>
<tr>
<td>2018</td>
<td>300</td>
</tr>
</tbody>
</table>
Wayne's Whole Farm Corn Yields vs County Average

Purchased a side dress applicator 2007 to address better nitrogen management.
All strip-till
Soybean Yields relative to Mitchell County

![Graph showing soybean yields from 2003 to 2018 for Fredericks Farms Soybean. The graph indicates fluctuations in yield with some years showing higher yields than others.](image_url)
Wayne's Whole Farm Soybean Yields vs. County Average

No-till Tye Drill 8" rows 1992-2008
1790 JD planter 15" rows 2008-2018
Fredericks (East) Corn

Yield (Bu/acre)

Frequency (%)
Frederick's (West) Soybean

Frequency (%)

Yield (Bu/acre)

- 2004
- 2018
Increasing Uniformity

**2004 Corn: Soil 394**
- Skewness: -1.01
- Kurtosis: 2.30

**2018 Corn: Soil 394**
- Skewness: 0.19
- Kurtosis: 4.48

Soil 394 Ostrander loam
Increasing Uniformity

**2005 Corn: Soil 761**

- Skewness: -1.99
- Kurtosis: 2.21

**2017 Corn: Soil 761**

- Skewness: -0.86
- Kurtosis: 7.91

Soil 761 Franklin silt loam
Implications

Position of mean median mode

(a) Negatively skewed
(b) Normal (no skew)
(c) Positively skewed

Skewness

Kurtosis
Implications

- The shifts from negative to positive skewness and increasing kurtosis tightens the distribution about the mean.

- The more we shift to the right the greater the income in the field because we have less low yielding areas in the field, i.e., a greater portion of the field becomes a profit center.
Geospatial Analysis
Results

- Fields have become more uniform and the values of the yield monitor observations are more closely correlated across the field.
- Increase in uniformity across the field with time.
- Only in extreme years (2012) was there a lack of uniformity.

2012 Corn: Soil 761
Implications of the changes in soil

- Yield is negatively correlated with April and May rainfall at the county level.
- Yield is positively correlated with July-September rainfall at the county level.
- Water use efficiency (corn) Fredericks fields:
  - 2004 3.9 bu/inch 2018 5.5 bu/inch 41% increase
  - 2005 5.3 bu/inch 2017 7.9 bu/inch 49% increase
- Water use efficiency (soybean):
  - 2005 1.9 bu/inch 2017 2.4 bu/inch 26% increase
- Profitability of the field will increase because the yields have become more uniform.
Changes in water use efficiency

- Soil is capable of storing more water
- Greater infiltration of rainfall events
- More resilient in the years with uneven distribution of rainfall
- Reduction in the correlations with excessive spring and deficit summer rainfall
- Increased ability to convert the soil water into grain
Lessons Along the Journey

- Change the uniformity of the field with the combination of reduced tillage and cover crops
- Observe a shift in the distribution of yields around the mean to fewer lower yields and tighter distribution around the mean
- Increases in organic matter are coupled with change in water infiltration and availability
- Cultural operations are more timely because of improved soil conditions
- Fields become more resource use efficient, light, water, and nutrients
- Management is dynamic and there is constant adaptations and tweaks
Conversion from Conventional to No-till Cover Crop

At each sampling location:
- 1.2 m deep core
- 5,10 cm surface sample

Gridded soil sampling

Conversion to no-till w/cover crop

Doubled the microbial biomass in two years after conversion

Changed from negative to positive carbon balance in this two year period
Systems

- Genetics x Environment x Management
  - Oversee (M) to overcome (E) to optimize (G)
- Sometimes the genetics don’t respond the way we expect
- There needs to be constant attention to the nutrient management
- Management has to evolve to take advantage of the changing soil conditions
What are the Implications?

- How does this reduce risk and increase management options?
- Can this affect land values?
- What might this do to rental agreements?
- Could this broaden the offering of crop insurance discounts?
- How does this change the discussion of carbon sequestration?
- Can this create more engagement from the food industry?
- How might this affect state and federal farm policy?
- Can this lift the burden of water quality and quantity?
- Can these practices make farming more profitable?
Healthy, Resilient Soils

Cleaner Water

Profitable Farms

Less Variable Yields

Positive Carbon Message

Where Are You In Your Journey?

Questions?