4R PRACTICE IMPLEMENTATION: ENVIRONMENTAL AND ECONOMIC IMPACTS

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The Fertilizer Institute

TFI is the voice of the fertilizer industry, representing the public policy, communication, stewardship and sustainability and market intelligence needs of fertilizer producers, wholesalers and retailers as well as the businesses that support them with goods and services.
It’s A Priority

Better crop performance, improved soil health, and cleaner air and water.

**RIGHT SOURCE**  
Matches fertilizer type to crop needs.

**RIGHT RATE**  
Matches amount of fertilizer to crop needs.

**RIGHT TIME**  
Makes nutrients available when crops need them.

**RIGHT PLACE**  
Keeps nutrients where crops can use them.
What is 4R Nutrient Stewardship?

- Actively considering all management practices and site specific characteristics when making the right source, right rate, right time, and right place nutrient management decisions
<table>
<thead>
<tr>
<th>Company</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coca-Cola</td>
<td>Reduce GHG emissions across value chain by 25% by 2020</td>
</tr>
<tr>
<td>Unilever</td>
<td>Halve GHG impact of products across the lifecycle by 2020</td>
</tr>
<tr>
<td>Walmart</td>
<td>Fertilizer optimization on 14 M acres of U.S. farmland by 2020</td>
</tr>
<tr>
<td>Kellogg's</td>
<td>Responsibly source top 10 ingredients &amp; materials by 2020</td>
</tr>
</tbody>
</table>
Industry Updates

• Walmart – Gigaton Challenge
  > “The adoption of best-in-class agricultural practices, including precision agriculture and feed optimization, can help reduce farmer input costs, improve water quality and reduce greenhouse gas (GHG) emissions.”
    • Recommend 4R practices to reach goals

https://www.walmartsustainabilityhub.com/project-gigaton/agriculture
Nutrient Loss Reduction Challenges

- MN nitrate rule
- SD and IA contributions to the Gulf of Mexico
- Minimizing nutrient loss from field and maximizing nutrient use efficiency in field
- Conservation in combination to reach goals
2013 Meta-analyses – 4 Papers

2013 4R Research and Demonstration – 7 projects in Corn and Soybean Rotations

2017 NutriNet collaboration – 5 states and 1 Ontario Site

2019 4R Research Awarded Projects- 5 projects in Almonds, Cotton, Tree Crops, Alfalfa, Vegetable Crops
A Meta-analysis of 4R Nutrient Management in U.S. Corn-Based Systems

- Rate, Source, Time, and Place – Crop yield, nitrate (NO$_3^-$) leaching, and nitrous oxide (N$_2$O) emissions response to N rates
- Learn how differences in climate and soil across North America affect these responses.
## A Meta-analysis of 4R Nutrient Management in U.S. Corn-Based Systems


<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>Strong positive relationship to yield, NO$_3$ leaching, and N$_2$O air loss.</td>
<td>2.9 to 11.9% increase for each each 8.9 lb N/ac increase</td>
</tr>
<tr>
<td>Source</td>
<td>N$_2$O losses are highest with Anhydrous Ammonia &gt; Urea = Polymer Coated Urea = Urea Ammonium Nitrate (UAN) = UAN + Agrotain PLUS® &gt; Super U</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Side dress fertilizer reduced N$_2$O emissions 30 to 39%</td>
<td></td>
</tr>
<tr>
<td>Place</td>
<td>Broadcast placement of N fertilized decreased N$_2$O losses by 25 to 33% compared to injecting or banding</td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>Nitrous oxide emissions dependent on temperature</td>
<td>1.8°F increase in average July temperate = increased emissions from additional application of 89.2 lb N/ac</td>
</tr>
</tbody>
</table>
4R and Conservation Practices

Qian and Harmel. 2016. JAWRA.

With conservation practices

Without conservation practices

59% reduction through combination of incorporation of P and conservation

Qian and Harmel. 2016. JAWRA.
Minimizing P Loss with 4R Stewardship and Cover Crops

• Different combinations of time and place of P fertilizer with and without cover crops
• Working with soil physics, cropping systems, agronomy, economics, and extension staff to collect results that cross disciplines
• Cover Crop use in Kansas decreases sediment loss, changes type of P loss
Cover Crops – Reduce Particulate P, Increase Dissolved P

Particulate P ~40%

Dissolved P ~65%

Project is ongoing.

Slide modified from Nathan Nelson, KSU.
Injecting P Reduces Total and Dissolved P

Total P ~30%

Dissolved P ~45%

Project is ongoing.
Slide modified from Nathan Nelson, KSU.
Evaluating the 4R Nutrient Stewardship Concept in the Western Lake Erie Basin

- Field level monitoring of implementation of 4R practices
- Analysis of the social and economic impacts
- USDA-ARS, Ohio State University, Heidelberg University, LimnoTech, IPNI, The Nature Conservancy, Private Farmers
- **Placing P below the soil surface decrease P loss**
Efficiency, Environment, and 4R

• Strong, positive linear relationship between N$_2$O and net N balance

• N$_2$O response to N management systems related to net N balance

(Vyn, Halvorson, & Omonode – http://research.ipni.net/project/IPNI-2015-USA-4RN27)

• Intermediate: Reduce N Balance by 33% resulting in additional 7% reduction in N$_2$O emission

• Advanced/Emerging: Reduce N Balance by 66% resulting in 14% reduction to N$_2$O emission
<table>
<thead>
<tr>
<th>Performance Level</th>
<th>Right Source</th>
<th>Right Rate</th>
<th>Right Time</th>
<th>Right Place</th>
</tr>
</thead>
</table>
| Basic*            | - Ammonia (NH₃) -based (fall)  
                  - Any source for non-fall N.  
                  - Rate considers how much residual N the growers expects to have.  
                  - Apply recommendations recognized by regional soil fertility specialists.  
                  - Account for previous crop N credits.  
                  - Use manure N credits.  
                  - Ammonia-based if in fall  
                  - Apply fall N when soils cool (as defined by local guidelines) or as spring pre-plant.  
                  - Manure timing based on nutrient management plan.  
                  - Subsurface band application or broadcast- incorporated.  
                  - If broadcast w/o incorporation do prior to precipitation of minimum of quarter inch.  |
| Intermediate      | - Use NI (nitrification inhibitor) for fall-applied N.  
                  - Use UI (urease inhibitor) for surface-applied UAN/Urea.  
                  - Include polymer-coated urea in a urea blend.  
                  - Use recommendations recognized by regional soil fertility specialists.  
                  - N recommendations made with an accounting for residual soil nitrate in the upper 2 feet.  
                  - Apply fall N when soils cool (as defined by local guidelines) or as spring pre-plant.  
                  - No fall N on soils susceptible to loss (e.g., sandy soils, clay soils).  
                  - On these susceptible soils, apply split application of N.  
                  - Manure timing based on nutrient management plan.  
                  - NH₃ (anhydrous ammonia) application of at least 4 inches deep.  |
| Advanced/ Emerging| - Apply NI on susceptible soils (e.g., sandy or clay soils) in the spring.  
                  - Accounting for within-field variability using concepts and tools such as zone or landscape position management, and N sensors (e.g., Crop Circle™, Greenseeker®).  
                  - Split application is directed with in-season sensors.  
                  - No fall application of N.  
                  - Accounting for within-field variability using concepts and tools such as zone or landscape position management, and N sensors (e.g., Crop Circle™, Greenseeker®).  |
4R Research Fund Common Findings

• Timing of N application has a large impact on yield and N loss
• Timing of N application when using an EEF can impact air and water losses
• Improved NUE can indicate decreased air losses of N
• The placement of P fertilizer influences P loss
• P application based on crop need and soil test has potential to reduce P losses
**2019 4R Advocates**

- Brian Herbeck, Deweese, NE – Corn, Wheat, Soybean, Alfalfa
  Bill Nejezchleb, Fairfield Non Stock Coop, Fairfield, NE
- Danny Basham, Madisonville, KY - Corn
  Phillip Osborn, Nutrien Ag Solutions, KY
- Dustin Grooms, Plant City, FL - Strawberries
  Jerrod Parker, Chemical Dynamics, INC, FL
- Jonathan Quinn, Warwick, MD – Corn, Soybeans, Wheat, Barley, and Spinach
  Kenny Glenn, Southern States Cooperative, INC, DE
- Michael Ganschow, IL – Corn and soybean
  Malcolm Stambaugh, Growmark FS, IL
Soil Health as Driver of Change

Getting the 4Rs right means:

67% Improving soil health, and that means improving crop performance

50% Minimizing impact on environment & retaining nutrients in the field

45% Action now may reduce the need for regulation later

39% Reducing risks associated with good & bad weather, improving yield

37% Doing more to improve our crop yields and profit
Farmer Information Sources

76%
Frequently speak to other farmers about fertilizer practices

76%
Agronomist & retailers top fertilizer information source
SD 4R Advocate

- 1,500 ac
  - Corn grain
  - Soybeans
  - Wheat
  - Alfalfa
  - Cow/Calf

- No-till and strip-till for over 20 years

Joel Erickson, Farmer
Andrew Kappes, Crop Consultant
4R Practices and Conservation

- Zone Management – based on soil texture, organic matter, salts, elevation and yield potential
- Soil samples by zone
- Fertilizer prescriptions by zone to achieve yield goals, avoid fertilizer waste and ensure plants have the right amount of nutrients available
- Tissue analyses guide foliar nutrient application
- Cover crops capture nutrients and provide grazing for cattle
Joel on the 4Rs:

• “Closely following the 4R practices has helped us farm better than before. We’ve seen a lot of yield increases.

• The 4Rs, advanced genetics and improved farming practices are all parts of the plan to continually improve. Combined, they make for a better running, more sustainable farm.”
Cox Land and Cattle Co.

- 3,000 ac
  - Corn grain
  - Soybeans
  - Corn silage
  - Hay and cover crops
  - 750 cattle – cow/calf
  - No-till since 1988
  - Strip-till in corn

Maria Cox, Farmer
Kyle Lake Crop Consultant
Soybeans

• **Cereal Rye Cover crop**
  • Plant soybeans into green standing rye

• **4R Practices**
  • 2.5 ac grid sampling
  • Variable rate nutrient prescriptions using grid samples and yield maps
  • All P and K spring applied
  • Test manure for crediting

• **Performance**
  • 2016 – 71 bu/ac
  • Plus cereal rye hay production
Corn

• Strip-Till planting into cereal rye terminated at 10”
• No-till 25%
• Strip-till 50%
• Tillage on 25% that has hog manure
• 4R Practices
  • Variable rate N, P, K
  • Use N-serve (nitrification inhibitor) on all anhydrous ammonia
  • Split application
• Performance
  • 2016 – 190 bu/ac
Other Conservation

- Dry Dams
- Conservation Reserve Programs
  - Pollinator Program
  - 80 acres CRP long-term
- Buffer strips around feed lots
- Grassed waterways
- Buffer Strips
Maria says:

• “We use cover crops as a way to build organic matter, prevent erosion, lessen weed pressure, and potentially lower fertilizer application rates long-term.”

• “4Rs can be implemented in all tillage situations, but we feel a no-till system on fields keeps the fertilizer from eroding and washing away.”
Economics of 4R stewardship

- **Basic**: spring pre-plant AA w/ inhibitor, liquid starter w/ seed, early post-plant w/ herbicide, liquid N side-dress with Y-drop

- **Intermediate**: Liquid starter w/ seed, early post-plant w/ herbicide, side-dress AA with inhibitor

- **Advanced**: Liquid starter w/ seed, early post-plant w/ herbicide, side-dress AA with inhibitor, liquid side-dress w/ Y-drop (V10)
## On Farm Data – IL Corn

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4R Practice Level</strong></td>
<td>Basic</td>
<td>Basic</td>
<td>Intermediate</td>
<td>Advanced</td>
</tr>
<tr>
<td><strong>Corn Grain Yield (bu/ac)</strong></td>
<td>229</td>
<td>220</td>
<td>246</td>
<td>256</td>
</tr>
<tr>
<td><strong>N Application Rate (lbs/ac)</strong></td>
<td>253</td>
<td>208</td>
<td>253</td>
<td>204</td>
</tr>
<tr>
<td><strong>Nitrogen Use Efficiency (lb N applied/bu corn grain)</strong></td>
<td>1.11</td>
<td>0.95</td>
<td>1.03</td>
<td>0.80</td>
</tr>
<tr>
<td><strong>N Balance (lb N applied – lb N harvested)</strong></td>
<td>69.5</td>
<td>31.9</td>
<td>56.6</td>
<td>-1.14</td>
</tr>
<tr>
<td><strong>CO2e Emissions per bu</strong></td>
<td>9.4</td>
<td>8.43</td>
<td>8.17</td>
<td>6.14</td>
</tr>
<tr>
<td><strong>Percent reduction</strong></td>
<td>-</td>
<td>10.3</td>
<td>13.1</td>
<td>34.7</td>
</tr>
</tbody>
</table>
NUE (N harvested/N applied)

- Risk of mining soil N
- Desirable range for NUE
- Risk of inefficient N use

Graph showing NUE (N harvested/N applied) from 2014 to 2017, with the blue line representing Zone and the red line representing Grid.
No-Till Corn - Ohio

- **Practices Changed from Basic to Advanced:**
  - Removed ammonia sulfate from fall strip-till application
  - Variable rate seeding and starter fertilizer application
  - Sidedress N with inhibitors applied at a variable rate and knifed-in
  - Phosphorus and potassium applications with strip-till and variable rate
# OH Corn – Efficiency and Environment

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
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<th>2016</th>
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</tr>
</thead>
<tbody>
<tr>
<td>4R Practice Level</td>
<td>Basic</td>
<td>Basic</td>
<td>Intermediate</td>
<td>Advanced</td>
</tr>
<tr>
<td>Corn Grain Yield (bu/ac)</td>
<td>178</td>
<td>193</td>
<td>170</td>
<td>175</td>
</tr>
<tr>
<td>N Application Rate (lbs/ac)</td>
<td>204</td>
<td>224</td>
<td>195</td>
<td>184</td>
</tr>
<tr>
<td>Nitrogen Use Efficiency (lb N applied/bu corn grain)</td>
<td>1.18</td>
<td>1.19</td>
<td>0.94</td>
<td>0.99</td>
</tr>
<tr>
<td>N Balance (lb N applied – lb N harvested)</td>
<td>61.3</td>
<td>68.6</td>
<td>58.4</td>
<td>43.4</td>
</tr>
<tr>
<td>CO2e Emissions per bu</td>
<td>10.3</td>
<td>10.2</td>
<td>9.67</td>
<td>8.34</td>
</tr>
<tr>
<td>Percent reduction</td>
<td>-</td>
<td>-</td>
<td>6.12</td>
<td>19.0</td>
</tr>
</tbody>
</table>
## OH Corn – 4R versus Rate

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield (bu/ac)</th>
<th>N Rate (lbs/ac)</th>
<th>N rate difference for 14% reduction</th>
<th>Practice Level</th>
<th>CO2e Reduction with 4R Practice Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>177.5</td>
<td>204</td>
<td></td>
<td>B</td>
<td>-</td>
</tr>
<tr>
<td>2014 R*</td>
<td>177.5</td>
<td>165</td>
<td>39</td>
<td>B</td>
<td>-</td>
</tr>
<tr>
<td>2015</td>
<td>193.3</td>
<td>224</td>
<td></td>
<td>B</td>
<td>-</td>
</tr>
<tr>
<td>2015 R</td>
<td>193.3</td>
<td>180</td>
<td>44</td>
<td>B</td>
<td>-</td>
</tr>
<tr>
<td>2016</td>
<td>170.1</td>
<td>195</td>
<td></td>
<td>I</td>
<td>9.67</td>
</tr>
<tr>
<td>2016 R</td>
<td>170.1</td>
<td>155</td>
<td>40</td>
<td>I</td>
<td>8.23</td>
</tr>
<tr>
<td>2017</td>
<td>174.9</td>
<td>184</td>
<td></td>
<td>A</td>
<td>8.34</td>
</tr>
<tr>
<td>2017 R</td>
<td>174.9</td>
<td>145</td>
<td>29</td>
<td>A</td>
<td>7.07</td>
</tr>
</tbody>
</table>

*R = N rate reduction for 14% decrease in FieldPrint New Calculations emissions
4R and Tomatoes

- **Reason for practice changes:**
  - Challenges with inputs
  - Environmental nutrient loss concerns
  - Labor

- **Practices Changed from Basic to Intermediate:**
  - Starter fertilizer mixed with soil in bed versus surface placement
  - Addition of new nutrient sources to fertilizer blend
  - N fertilizer in starter treated with inhibitor
  - Soil testing and nutrient recommendations before each crop
  - In-season tissue testing
4R NUTRIENT STEWARDSHIP CERTIFICATION PROGRAM

Voluntary program in Western Lake Erie Basin (WLEB) and entire state of Ohio for agricultural retailers & nutrient service providers implementing the 4Rs

- 52 CERTIFIED BRANCH FACILITIES
- 40 FACILITIES IN WLEB
- 7,070 CLIENTS SERVICED
- 3.07M TOTAL ACRES
- 1.9M ACRES IN WLEB

GOALS
- Maximize crop nutrient uptake and minimize crop loss
- Positively impact local water bodies
- Provide up-to-date information on nutrient stewardship
- Help the agricultural sector adapt to new research and technology

REQUIREMENTS
- Initial training and on-going education
- Monitoring of 4R implementation
- Nutrient recommendation and application

THIRD-PARTY VERIFIED
- Audits, review training and education, recommendations to growers and application records
- Third-party auditor verification occurs each year

RIGHT SOURCE - RIGHT RATE - RIGHT TIME - RIGHT PLACE

For more information, visit 4rcertified.org
2018 Farm Bill

- **Research Title**
  - Fertilizer Nutrient Research
    - High Priority

- **Conservation Title**
  - TSP and CCA
  - More EQIP $ for nutrient management
  - CEAP Reports
Resources

nutrientstewardship.org
4RFarming.org
@4Rnutrients

4R Nutrient Stewardship

https://www.youtube.com/user/1fertilizer/videos
Questions?