4R Nutrient Stewardship for Florida Agriculture

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The foundation of fertilizer BMPs and efficient nutrient management can be aptly described as following the “4Rs”...

Applying the **Right Source** at the **Right Rate** at the **Right Time** and in the **Right Place**

www.IPNI.net/4R
Source, rate, time, and place describe any nutrient application.
Equal attention to all 4Rs

• Balance attention to all 4Rs

• Rate: easily overemphasized

• Source, Time, Place: often require major changes and investments
The 4Rs Interconnect

- with each other
- with local soil and climate factors
- with management of soils and crops
- other factors can limit productivity even when levels of plant nutrients are adequate
Right means Sustainable

Accommodating the growing demand for production without compromising the natural resources upon which agriculture depends.

• The concept of sustainability is multi-dimensional ... applies to social, economic, and environmental simultaneously.
Various crop production systems in Florida
“When it comes to fertilizer regulations, Florida is in a league of its own.”

Rep. Clay Ingram, R-Pensacola

Urban too!
What do we do?
Stakeholders have a say on performance indicators

- Stakeholders define goals
- Producers choose practices
- Indicators relate to goals
The 4Rs influence many performance indicators

- social, economic and environmental performance
- influenced by crop and soil management as well
- whole system outcomes
BMP adoption and evaluation – farm level

- Adaptive management

**DECISION**
Accept, revise, or reject

**ACTION**
Change in practice

**EVALUATION of OUTCOME**
Cropping System Sustainability Performance

**LOCAL SITE FACTORS**
- Climate
- Policies
- Land Tenure
- Technologies
- Financing
- Prices
- Logistics
- Management
- Weather
- Soil
- Crop demand
- Potential losses
- Ecosystem vulnerability

Farm Level
Producers, Crop advisers
BMP adoption and evaluation – regional level

- Logistics and science

Regional Level
Agronomic Scientists, Agri-service Providers

Farm Level
Producers, Crop advisers

DECISION SUPPORT based on scientific principles

OUTPUT
Recommendation of right source, rate, time, and place (BMPs)

DECISION
Accept, revise, or reject

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EVALUATION of OUTCOME
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BMP adoption and evaluation – policy level

- Infrastructure and incentive

- Policy Level – Regulatory, Infrastructure, Product Development
  - Regional Level
    - Agronomic Scientists, Agri-service Providers
  - Farm Level
    - Producers, Crop advisers

- Decision Support based on scientific principles
  - Output
    - Recommendation of right source, rate, time, and place (BMPs)
  - Decision
    - Accept, revise, or reject
  - Action
    - Change in practice
  - Evaluation of Outcome
    - Cropping System Sustainability Performance

- Local Site Factors
  - Climate
  - Policies
  - Land Tenure
  - Technologies
  - Financing
  - Prices
  - Logistics
  - Management
  - Weather
  - Soil
  - Crop demand
  - Potential losses
  - Ecosystem vulnerability
SOURCE, RATE, TIME, AND PLACE

• Every application has all 4

• Get all 4 right!

• Completely interconnected

• 4R Nutrient Stewardship emphasizes impact on outcomes

• Ensure practices are in accord with scientific principles
## Examples of Key Scientific Principles

<table>
<thead>
<tr>
<th>The Four Rights (4Rs)</th>
<th>Source</th>
<th>Rate</th>
<th>Time</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Scientific Principles</strong></td>
<td>• Ensure balanced supply of nutrients</td>
<td>• Assess nutrient supply from all sources</td>
<td>• Assess dynamics of crop uptake and soil supply</td>
<td>• Recognize crop rooting patterns</td>
</tr>
<tr>
<td></td>
<td>• Suit soil properties</td>
<td>• Assess plant demand</td>
<td>• Determine timing of loss risk</td>
<td>• Manage spatial variability</td>
</tr>
</tbody>
</table>
Scientific Principles for Right Rate

- Consider source, time and place
- Assess plant nutrient demand
- Assess soil nutrient supply
- Assess all available nutrient sources
- Predict fertilizer use efficiency
- Consider soil resource impacts
- Consider economics
## Nutrient uptake per unit of yield: U.S.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Harvested unit</th>
<th>N</th>
<th>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</th>
<th>K&lt;sub&gt;2&lt;/sub&gt;O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermudagrass</td>
<td>ton</td>
<td>46</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>Corn</td>
<td>bu</td>
<td>1</td>
<td>0.54</td>
<td>1.4</td>
</tr>
<tr>
<td>Rice</td>
<td>bu</td>
<td>0.71</td>
<td>0.38</td>
<td>1.1</td>
</tr>
<tr>
<td>Soybean</td>
<td>bu</td>
<td>4.9</td>
<td>1.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Wheat, spring</td>
<td>bu</td>
<td>2.2</td>
<td>0.76</td>
<td>1.5</td>
</tr>
<tr>
<td>Wheat, winter</td>
<td>bu</td>
<td>1.9</td>
<td>0.68</td>
<td>2</td>
</tr>
</tbody>
</table>
Assessing soil nutrient supply

Right rate is a function of nutrient contribution from indigenous sources

<table>
<thead>
<tr>
<th>Factor</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca and Mg</th>
<th>Micros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Moisture</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Temperature</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Aeration</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Amount of clay</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Type of clay</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Crop residues</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Soil compaction</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrient status of soil</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Other nutrients</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Crop type</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Cation exchange capacity (CEC)</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>% CEC saturation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

- Availability of nutrients are governed by soil physico-chemical environment
Mechanisms influencing soil supply

- Mineralization/immobilization
- Adsorption/desorption
- Precipitation/dissolution
- Reduction/oxidation
- Root interception, mass flow, diffusion
Research is important
Right Rate – Drip-irrigated Tomato Yield Response to N

Tomato response to N, Live Oak, S2004

Hochmuth, 2015
Consider all available nutrient sources

Adjust rates of externally applied nutrients for:

- Native soil supply
- Organic manure
- Irrigation water
- Crop residues
- Biological N fixation
Principles Supporting Right Time

- Consider source, rate, and place of application
- Assess timing of plant uptake
- Assess dynamics of soil nutrient supply
- Recognize dynamics of soil nutrient loss
- Evaluate logistics of field operations
Crop Uptake Dynamics and Fertilizer Timing

Nutrient uptake and dry matter accumulation follow S shaped or sigmoid pattern for most crops.
Typical plant growth curve

Days

growth (%)

Preplant

1.0 lb/A/day

1.5 lb

2.5 lb

1.5 lb

1.0 lb

Hochmuth, 2015
Assessing Dynamics of Soil Nutrient Loss

Loss of N and P have the most potential for environmental impact

Mechanisms of loss for N and P are very different

P normally lost through runoff, making placement important in avoidance
Logistics of Field Operations Affect Timing Decisions

• Application timing decisions are governed by practicality

• As farm size has increased, logistics of planting and input timing have changed

• Fall input, where reasonable, can save valuable time in the spring

• P and K by nature lend themselves to early application, but precautions should be taken with fall N application
Enhanced Efficiency Fertilizer Technology May Ease Timing Pressure

- Where logistics demand a single, one-time application, EE fertilizer technologies may be useful.
- These technologies include:
  - Slow and controlled release fertilizer
  - Nitrification and urease inhibitors
Troubadour Watermelon, polymer-coated fertilizer 2013, Citra, FL

![Season yield (cwt per acre)](chart)

- LSD 0.05 = 185

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (cwt/acre)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control, no N</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>IFAS standard, fertigation, 150N, 150K2O</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>120 lb N/A CRF/20% soluble (CRF = D120 NPK)</td>
<td>1000</td>
<td>80%</td>
</tr>
<tr>
<td>150 lb N/A CRF (CRF = D120 NPK)</td>
<td>1200</td>
<td>100%</td>
</tr>
</tbody>
</table>

Hochmuth, 2015
Principles Supporting Right Place

- Consider source, rate, and time of application
- Consider where plant roots are growing
- Consider soil chemical reactions
- Suit the goals of the tillage system
- Manage spatial variability
Examples of Differences in Root Architecture

corn: 36 days old

sugarbeet: 2 months old

12 in.
Root Plasticity

zone of low P concentration

zone of high P concentration

zone of low P concentration
The Right Placement
Fertilizer in the root zone

Note fertilizer particles in center of bed where moisture and roots are.

Hochmuth, 2015
Early Season Crop Needs

Banded nutrients near the seed:

- Are in close proximity to a limited root system
- Provide concentrated supplies when influx rates are highest
- Increase the rate of nutrient diffusion to roots
Nutrient Interactions within Bands

Miller and Ohlrogge, 1958

Graph showing the percentage of plant phosphorus from band as a function of soil phosphate level $P_2O_5$ added per acre. The graph includes three treatments: phosphorus alone, phosphorus plus nitrogen mixed, and phosphorus plus nitrogen separate. The data points are plotted to illustrate the decreasing trend in phosphorus uptake as the soil phosphate level increases.
Factors To Consider for Seed-Placed Fertilizer

Adjust rates of externally applied nutrients for:

• Seed sensitivity
• Fertilizer salt index
• Width of seed furrow
• Soil texture
• Soil moisture
• Amount of tolerable stand loss
VR Phosphorus Map

<table>
<thead>
<tr>
<th>Product</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition/Deduction(lbs/ac)</td>
<td>None Entered</td>
</tr>
<tr>
<td>Percent of Original App</td>
<td>100%</td>
</tr>
<tr>
<td>Minimum Application Rate</td>
<td>50.0 lbs/A</td>
</tr>
<tr>
<td>Maximum Application Rate</td>
<td>130.0 lbs/A</td>
</tr>
<tr>
<td>Field Average Rate</td>
<td>97.64 lbs/A</td>
</tr>
<tr>
<td>Total Applied Acreage</td>
<td>20.50</td>
</tr>
<tr>
<td>Total Field Acreage</td>
<td>32.29</td>
</tr>
<tr>
<td>Total Field Acreage(lbs)</td>
<td>2001.6</td>
</tr>
<tr>
<td>Total Field Acreage(tons)</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Automatic Section Control

- **Automatic ON / OFF** of sections on application equipment
  - GPS-based technology
  - Sections turn OFF: previously treated areas or unwanted areas
- **Reduces 1) overlap/skips and 2) application in unwanted areas** (waterways, buffer strips, etc.).
Automatic Section Control

Manual Errors

– Overlaps (blue)
– Skips (red)

BSC Errors

– Overlaps reduced (blue)
– Skips eliminated
Preservation of Conservation Features
Example during Herbicide Application

Automatic Section Control

Nozzles OFF
Buffer Strip
Improved Field Management
Preservation while Maintaining Production
Steps to Develop a Nutrient Stewardship Plan

• Identify stakeholders

• Set sustainability goals

• Gather needed production information

• Formulate the plan

• Implement the chosen practices

• Monitor the effectiveness of the practices employed
Right means Sustainable

- Applying the *Right Source* at the *Right Rate*, at the *Right Time*, and in the *Right Place* can help meet the environmental, economic, and social goals of sustainable agricultural systems.
Thank You

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