Nutrient stewardship innovations for increased cereal system resilience

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Can’t manage what we can’t measure
A global focus of fertilizer management on 4R Nutrient Stewardship

Right Source @ Right Rate, Right Time, Right Place

“Right” is influenced by contribution to sustainability goals

Knowing the contribution requires scalable performance indicators
4R Plant Nutrition – Decision Cycle

Policy Level

Regional Level
Agronomic scientists

Farm Level
Producers, Crop advisers, Dealers

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
Outcomes resulting from nutrient management practices are greatly influenced by crop and pest management and by soil and water conservation practices.
Nutrient use efficiency – a key indicator
Defined and calculated in many ways ... examples

<table>
<thead>
<tr>
<th>NUE term</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial factor productivity</td>
<td>$PFP = \frac{Y}{F}$</td>
</tr>
<tr>
<td>Agronomic efficiency</td>
<td>$AE = \frac{(Y-Y_0)}{F}$</td>
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<tr>
<td>Partial nutrient balance</td>
<td>$PNB = \frac{R}{F}$</td>
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<tr>
<td>Recovery efficiency</td>
<td>$RE = \frac{(U-U_0)}{F}$</td>
</tr>
</tbody>
</table>

$Y =$yield, $F =$fertilizer, $R =$removal, $U =$uptake

In all cases a ratio of output/input

Dobermann, 2007
Efficiency & effectiveness ... Nutrient performance

- Efficiency is one aspect of performance; effectiveness drives farmer decisions
- Nutrient performance encompasses impacts on:
  - productivity, potential losses to the environment, change in soil nutrient status

IPNI Issue Review Ref #14061, August 2014
All cereals N PNB by country

Biological N fixation and manure use are not considered.

GPNM Task Team Tech Paper 01/2015.
N output versus N surplus (input-output) for cereals in selected countries

Biological N fixation and manure use are not considered.
Regional and yearly variation in N output versus N surplus (input-output) in the US

Input-Output = Fertilizer N + Recoverable manure N + BNF – Harvest removal.

US average for these same years.
Tracking efficiency and productivity relative to a benchmark ... approaching performance
The ultimate is to scale down to the environment of individual plants ... recognizing the role of genetics, culture, and available technology.

Managing soil conditions & nutrition of each plant.

Photo by Bill Pan
Precision services offered by US input suppliers

Purdue Univ. and Crop Life, 2015.
Adapting nutrient management to climate change
Scalable performance metrics can facilitate adoption of nutrient management practices with the potential for adapting cereal systems to climate change.
Thank you!

University of Idaho

Washington State University

Oregon State University

USDA

NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Pacific Northwest Farmers Cooperative

Monsanto