With 40 years of experience studying fertility issues — 28 with the International Plant Nutrition Institute and 12 with Purdue University — Harold Reetz says a lot of progress has been made in the area of fertilizer-use efficiency. However, the owner of Reetz Agronomics in Monticello, Ill., says there is some unfinished business yet to be completed. Reetz will share fertility lessons he’s learned over decades that no-tillers can bank on in their no-till management system, as well as things he sees no-tillers needing to adapt to or adopt in the next 20 years. Tips he’ll share involve maximizing the potential of today’s genetic improvements in corn, ways to boost the lagging yields of soybeans, site-specific technologies that aid in managing field variability and much more.
Dr. Harold Reetz
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Fertility Lessons Learned From The Past To Take Into The Future

National No-Till Conference
Cincinatti, Ohio
January 14, 2010
“...whoever makes two ears of corn, or two blades of grass to grow where only one grew before, deserves better of mankind, and does more essential service to his country than the whole race of politicians put together.”

--- from Gulliver’s Travels
Growing Population Means Growing Need for Food, Feed, Fiber, and Fuel from Crop Production

More efficient land use is essential
Sources of Increased Yield Potential

Corn Yield Trend & Need

\[ y = 1.829x - 3522 \]

\[ r^2 = 0.84 \]

3%/yr

1.8 bu/A/yr for 43 years

Breaking the 1.8 barrier will require our best agronomic science + best agronomic management
The Carbon Cycle
The Nitrogen Cycle

- **Nitrogen Fixation**
  - Nitrogen Fertilizer
  - Rhizobium
  - Capillary rise
  - Plant uptake
  - Microorganisms

- **Soil Organic Matter**
  - Mineral Matter
  - Ammonification
  - Chemical Reaction
  - Nitrification

- **Air-N₂**
  - N₂
  - N₂O

- **Nitrogen Cycle Components**
  - Removed from cycle by harvesting
  - Residues
  - Excreta
  - Loss
  - Virgin lands
  - Gaseous N
  - N₂O

- **Applications**
  - Dinitrification
  - Chemical Reaction
  - Leaching

- **Industrial**
  - Industrial

- **Examples**
  - Industrial
  - Nitrogen Fertilizer
  - Azotobacter

- **Nitrogen Cycle Processes**
  - N₂ → N₂O → N₂ → NO → NO₂ → NH₃ → NH₄ → N₂
Nitrogen Uptake by Growing Corn Plants

![Graph showing nitrogen uptake by corn plants with key stages labeled: Four-leaf stage, Nine-leaf stage, Shoulder high, Tassel, Blister, Late silk, Dent, Kernel black layer.]

Figure 1. Corn aboveground dry matter accumulation and N uptake for a 204 bu/acre corn crop (Mengel, 1995).
Early passion for high yield corn

Illinois 4-H High Yield Contest---1965
Iroquois County Winner
146 bu/A
“Fine tuning . . . removing the next limiting factor”  
W. L. Nelson
Purdue 300/100 Project
After 3 years 235/85
185 bu/A 1\textsuperscript{st} year --- previous high was 155 bu/A
Fred Welch
University of Illinois

307 bu/A
Herman Warsaw---
---World Record Corn Producer

370 bu/A = 23.2 metric tons/ha in 1985
Warsaw’s Secret ...

- Farm plan designed for specific soil, climate, and management system
- Plan was site-specific...doing the right things for the right reasons in the right place at the right time
- Concept fits anywhere in the world on any crop and soil management system
- “There is no better fertilizer than a farmer’s footsteps”
Reviving High Yield Management

- Increased world demand
- Increased farmer awareness
- Untapped research information
- Better awareness of opportunity through site-specific management
- Better-trained dealers and farmers
- On-farm research
- More efficient use of resources and inputs
Management “Team”

- Farmer
- Resource providers
  - Landowners, farm managers
  - Investors
- Input suppliers
  - Seed, fertilizer, chemicals, machinery
- Information suppliers
  - NRCS, Extension, industry
  - Publications, meetings, field days, internet
- Markets
  - Grain companies, other farmers, consumers
1960s and 1970s

- Build and maintenance
- Expansion of N fertilizer use
  - Started in 1960s—low rate per acre for corn
  - Rapid expansion and rate increase in 1970s
1980s

- “Surplus” production
- Low crop prices
- Cut-back on inputs
“Right” Nutrient Management

Precision farming ...and the various component technologies of precision farming...are essential to “Right” management...to the **4R System for Fertilizer BMPs**.

- Right Source
- Right Rate
- Right Place
- Right Time
4R Nutrient Stewardship: Performance Indicators

Environmental
- Biodiversity
- Soil erosion
- Nutrient balance
- Yield
- Net profit
- Productivity
- Quality
- Return on investment
- Yield stability
- Durability
- Profitability
- Working conditions
- Water & air quality
- Nutrient loss
- Adoption
- Soil productivity
- Ecosystems services
- Farm income

Cropping System Objectives
- Healthy environment

Economic
- Source
- Rate
- Time
- Place

Soil, Labor, Water, Nutrient, Energy

Right Source at Right Rate, Right Time, Right Place
Interactions are Important

The right source, rate, time, and place are *interdependent*.

The 4Rs interact---they *work together* for best management.
Implementing On-Farm Research for Your Farm

- Every farm should have a research program
- Try new management ideas under your conditions
Why do on-farm research

- Every farm should have an area devoted to research
  - Locate close to operations center
  - Visit it every day
  - Take notes and photos
- To learn more about your management
- To evaluate products and practices under your conditions
- Every field can be a research area
Strip till N Rates with field-scale equipment.
Precision Agriculture tools include more than equipment. The real power of precision ag is in decision support --- integrating data, models, GIS maps, etc., to support better-informed management decisions.
On-Farm Research

- Building a local database
- Fine-tuning recommendations

Plot Rate 1

Plot Rate 2
Are Our Soil Test Goals Adequate for High Yield Systems?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>( P_1 ) Soil Test (ppm)</th>
<th>K Soil Test (ppm)</th>
<th>Corn Yield (bu/A)</th>
<th>( P_1 ) Soil Test (ppm)</th>
<th>K Soil Test (ppm)</th>
<th>Soybean Yield (bu/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard P and K Soil Tests</td>
<td>20</td>
<td>161</td>
<td>152</td>
<td>32</td>
<td>184</td>
<td>57</td>
</tr>
<tr>
<td>High P and K Soil Tests</td>
<td>32</td>
<td>237</td>
<td>190</td>
<td>41</td>
<td>222</td>
<td>57</td>
</tr>
</tbody>
</table>

38 bu/A (2.3 T/ha) more corn!!
**Decision Support Systems**

- **Decision-support tools** help us to fully realize the value of the databases, whether generated on-farm or obtained from other sources.
InfoAg 2011
July 12-14, 2010
Springfield, Illinois
www.infoag.org

Speakers—Exhibits--Networking
Nutrient Use GIS
Acres of Total Cropland as a Percentage of Land Area

The acres of total cropland as a percentage of land area in acres. A value of zero may represent a zero data value or may mean that no data are available for the county. The percentage values may be greater than 100 because the land area in acres is calculated as the land within the county and the acres of total cropland are calculated for the entire farm, which may include parts of more than one county. (Source: National Atlas of the United States)
Figure 3.5. Estimated total N delivery to the Gulf of Mexico from different watersheds within the Mississippi River Basin. (Data source: USGS and Alexander et al., 2008).
Data Sources
- NASS — crop data (acres planted, acres harvested, yield, production)
- IPNI --- Crop removal rates
- NRCS --- recoverable manure
- AAPFCO --- county fertilizer sales

Calculations (by County)
- Total crop acres
- Acres by crop
- % acres by crop
- Ratio of cropland acres to total acres

Spatial Analysis
- Tabulate data and import into ArcGIS
- Join the data to the map
- Intersect with watershed map

Aggregating Data to Watershed Level
- Summing watershed county intersect (WCI) for fertilizer, manure, and removal
- Fertilizer + Manure - Removal

This is an example of the kind of nutrient use analysis that is possible where county-level data are available.
Figure 3.7. Nitrogen removal to use ratios for the U.S. and selected states, 1987-2007.
Figure 3.6. Trends in total N (TN) and nitrate N (NO\textsubscript{3} + NO\textsubscript{2} - N) flux to the Gulf of Mexico, annually and during the spring (April-June).

Figure 4.8. Estimated total P delivery to the Gulf of Mexico from different watersheds within the Mississippi River Basin. (Data source: USGS and Alexander et al., 2008).
Estimated P balance by watershed, 1987 as lb/planted acre.
Estimated P balance by watershed, 2007 as lb/planted acre.
1987 = 3.01
2007 = -10.37
Estimated K removal to use ratio by hydrologic region, 2007.
Application Rates of Nitrogen, Phosphate, and Potash Fertilizers on Corn Harvested for Grain 1964-2008

- Nitrogen
- Phosphate
- Potash


Crop Year
Illinois Cropland Data Layer 2005

The Cropland Data Layer (CDL) contains crop specific digital data layers, suitable for use in geographic information systems (GIS) applications. This Program annually produces CDLs of the following States: Arkansas, Illinois, Indiana, Iowa, Mississippi,

http://www.agr.state.il.us/gis/pass/nassdata/

Can we do a NuGIS on a field-scale basis?
---impact on profits
---impact on local downstream water resources
---document your stewardship
Think “Systems” Management

- **Right management**
  - Components interact for management decisions.
- **“System”** considers:
  - all component **practices**,  
  - the **data** (information).  
  - Results of the management decisions.  
    - **Agronomic** responses (yield).  
    - **Economic** evaluation.  
    - **Environmental** consequences.
Strip-Till Alternative

• Leaves most of the soil undisturbed
• Allows fertilizer placement below the surface
  • Reduced runoff and volatilization loss
• RTK allows specific placement relative to crop row
• High-speed systems available
Stratification

- Plants move nutrients to the surface
- Reduced tillage leaves nutrients near the surface
- Nutrient levels lower in the profile may be depleted

- Natural channels (soil structure) may help
- Earthworm burrows may help
- Tillage may be needed in some cases
Surface-Applied Nutrients

- Susceptible to run-off loss
- More denitrification or volatilization loss
- May be positionally unavailable to crop
Plant Uptake Varies with Depth

Percentage of Phosphorus Uptake by Corn from Different Depths in Selected Soils.

<table>
<thead>
<tr>
<th>Soil Depth (in)</th>
<th>Miami Silt loam</th>
<th>Dodge Silt Loam</th>
<th>Parr Silt loam</th>
<th>Kewaunee Silty-clay loam</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6</td>
<td>36.4</td>
<td>43.1</td>
<td>27.0</td>
<td>19.4</td>
</tr>
<tr>
<td>6-12</td>
<td>45.9</td>
<td>33.3</td>
<td>23.7</td>
<td>41.8</td>
</tr>
<tr>
<td>12-18</td>
<td>6.0</td>
<td>11.7</td>
<td>12.1</td>
<td>21.8</td>
</tr>
<tr>
<td>18-24</td>
<td>5.1</td>
<td>8.4</td>
<td>6.5</td>
<td>17.0</td>
</tr>
<tr>
<td>24-30</td>
<td>6.6</td>
<td>3.5</td>
<td>30.8</td>
<td>---</td>
</tr>
</tbody>
</table>

Source: Murdock and

35 to 64% of P comes from 6-18"

1. Affected by tillage, moisture/drainage, fertilizer placement, etc.
2. Genetic modification of root system since this research was done.
Conclusions

Sampling of prairie remnants and neighboring cultivated fields in central Illinois confirmed a large reduction in organic C and total N pools from poorly drained Mollisols undergoing cultivation (as well as artificial drainage).

Resampling of fields that had been sampled in two earlier time periods with varying land uses:
• Some decline occurred after 1908.
• No changes during the period of synthetic fertilizer use (1957–2002)

The reduction in organic matter stored by prairies occurred mostly in the top 50 cm of soil, although significant reduction in total N was observed in the 50- to 100-cm depth.

After 1957, significant increase in C and N in the subsoils that had been under cultivation,
• May be evidence of translocation of C and N from these upper layers to the 50- to 100-cm depth,
• Possibly enhanced by tile drainage.
• Smaller reduction (compared with prairie remnants) in C and N pools than in upper soil layers alone.

The most productive agricultural soils of Illinois are greatly altered from their prairie beginnings.
• The major declines in organic matter were likely completed by the 1950s.
• These soils seem to have been in a steady state from the late 1950s through 2002.
1967-1969 Soil Profile Survey

- 75 Counties
- Soil and plant analysis
- Set a baseline of nutrient levels in the profile
- Micronutrient focus
- 20 corn/soybean fields per county
- 0-6” 12-18” 24-30”
- Retest planned to monitor changes
New Challenges

- Deeper, more vigorous roots
- Subsoil nutrient depletion (?)
Long-term studies are an important scientific resource that should be protected... ...and used.
New Options from New Technology

- RTK—positioning of nutrients relative to seed.
- Controlled-traffic with RTK
- Drip irrigation with RTK
- Split application of nutrients
  - Base rate + sensor based VRT rate
- Detailed monitoring and mapping of rates
- Within-field Economics
Nanotechnology

- New options for sensors and reporting
- Plant health
- Water status of soil and plant
- Nutrient content of soil, plant, water resources
Drainage Water Management

Conventional Drainage
- Water table lowers to level of tile
- Water Flow

Controlled Drainage
- You can raise or lower the water table by adding or subtracting gates
- Control Structure
- Water Table
- Tile line
- Water Flow
Field-Average Management Is Not Good Enough

- Over-fertilize low yielding areas
- Under-fertilize high yielding areas
- Each year of field average management increases variability and potentially decreases productivity
Major Hurdles Ahead

- Lack of research on interactions
  - Correlation among layers of GIS
- Shortage of trained agronomists
  - Education
  - Continuing education
    - “Hands-on” field training
    - “Hands-on” computer training
  - Multi-tiered approach needed
- CCA program is helping
Objectives of a Nutrient Management Plan

- Provide nutrients required for crop production.
- Manage economics to improve profits.
- Minimize your “environmental footprint”.
Managing Spatial Variability

- Applying nutrients only where needed improves productivity and profitability, and protects environmental quality.
- Leads to a more sustainable system.
Provide nutrients required for crop production

- Meet plant requirements at all times.
- Right nutrients, right rate, right place, right time...
  ...every day...all day
- Any shortage at any time potentially limits yield.
To be sustainable, a production systems must be profitable.

Profits can be increased by reducing inputs or increasing output.

Build toward a more productive management system, with higher yields, to produce more, spread resources and fixed costs over more bushels to improve efficiency and sustainability.
Minimize your “environmental footprint”.

- Use 4R Nutrient Management
- Set reasonable yield goals; manage for optimum use of resources
- Use precision farming technology
- Keep records---include nutrient balance as part of your plan.
- High yields make best use of all resources and provide more residue to help reduce water quality problems.
Building a Local Management Database

HIGH-TECH TOOLS FOR SITE-SPECIFIC CROP NUTRIENT MANAGEMENT

Variable-rate nitrogen application can improve efficiency.

Variable-rate seeding; variety changes and cheat; can adjust for soil properties and productivity.

On-farm soil maps can help adjust nutrient variability in the field.

Reetz Agronomics
Better Technology – Better Data

Site-specific decision making

<table>
<thead>
<tr>
<th>Sensors</th>
<th>Guidance systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitors</td>
<td>Historical records</td>
</tr>
<tr>
<td>Sampling</td>
<td>Mapping systems</td>
</tr>
<tr>
<td>Controllers</td>
<td>GIS analysis</td>
</tr>
</tbody>
</table>

![Images of various agricultural technology equipment and data analysis tools.](image-url)
Imagery Map for Chlorophyll
Field Scale to Global Scale

--- One Field at a Time

- Adopting this approach at the field scale helps contribute to the outcome of providing sustainable cropping systems at state, regional, national, and even global scales. *Site-specific management applied at the local scale throughout the world creates aggregated benefits at the global scale.*

- As more farmers adopt better practices through site-specific management and **better-informed decision-making on each field**, the larger-scale results can be realized for *agriculture* and *society* in general, locally and globally.
Thank you!

Websites for more information

www.ReetzAgronomics.com
www.infoag.org
www.farmresearch.com
www.ipni.net
www.ADMCoallition.com

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Winter

Solar Panel

Water Line
Closed
Closed
Annual water Table Profile

Water Table Profile

Time of Year

Considerations:
- Location
- Soil Type
- Drainage Intensity
- Crop
- Planting Date