Soil Fertility and Plant Nutrition: Why?

Nourish, Replenish, Grow®
Topics

- Integrated Plant Nutrient Management
- Fertilizer use at smallholder level
- Fertilizer and Conservation Agriculture
- Nutrient levels and maize yields: observations on nutrients and closing the yield gap in maize
- Developing our thought processes for future fertilizer use.
Integrated Plant Nutrient Management

• Holistic approach to optimizing plant nutrient supply within a crop production system.

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Factors Considered For Integrated Plant Nutrient Management

- Residual nutrient supply
- Assess soil productivity potential
- Calculation of crop nutrient requirement for the particular site and crop yield
- Quantify nutrient value of on-farm nutrient sources
- Determine supplemental nutrient needs – specific nutrients and rates/ha
- Develop a program to optimize nutrient utilization through selection of appropriate fertilizer source(s), application timing(s) and placement.

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Science – Based Nutrient Management

- Measuring
- Defining relationships
- Investigating
- Inventing
- Implementing
- Educating
NOT Science Fiction

• A literary or cinematic genre in which the plot is typically based on speculative scientific discoveries, environmental changes, space travel, or life on other planets.

• Nutrients do not simply “appear” in degraded soils!
Integrated Plant Nutrient Management
Small-Holder Case Study - Guatemala

Cooperative Project between HELPS International, DISAGRO and MOSAIC
Update: Aug. 1, 2013
Kenneth Hylton, Manager, Agronomic Development
Northern Latin America for Mosaic

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Village Project Focus on Maize

Corn, coffee and cardamom

Basic food source

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Village Project Focus on Maize

- Corn is the basis for the rural Guatemalan diet (tortillas).
- Average family consumes 1.44 MT of corn per year. (FAO)
- Average corn production in Guatemala is ~0.68 MT/ha per year using traditional methods.
- Deficit on average is 0.76 MT per family assuming 1 ha to cultivate.
- Men leave their families and communities for extended periods to earn cash to purchase corn.
- Goal – become self-sufficient in corn production.
Soil and Plant Analysis

Science-Based

- Soil and plant tissue analysis
- Focus on N, P, K, Mg, Zn and B nutrition

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Fertilization

- Fertilizer blended by Disagro, carefully applied by growers and incorporated into the soil to maximize efficiency.
- Three applications: at planting, V6 and V10

- Demonstration plots
- Training in total crop management
- Agronomic field support

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Maize Production Program

Plant Population and Distribution

Plant in rows
Proper Spacing

Improved → planting

↑ Plant development from standard plant practice

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Results

Improved  Traditional  Field not in program
## Grower Economics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Area per Farmer (Ha)</td>
<td>0.5</td>
</tr>
<tr>
<td>Average Loan per Farmer ($USD)*</td>
<td>$320.99</td>
</tr>
<tr>
<td>Average yield 2012 (MT/ha)</td>
<td>3.9</td>
</tr>
<tr>
<td>Average total yield per Farmer (MT)</td>
<td>1.95</td>
</tr>
<tr>
<td>Average consumption per year (MT)</td>
<td>1.44</td>
</tr>
<tr>
<td>Surplus to sell (MT)</td>
<td>0.5</td>
</tr>
<tr>
<td>Cash Money Income ($USD)</td>
<td>$189.00</td>
</tr>
</tbody>
</table>

*Zero interest loans were made to growers*

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Fertilizers and Integrated Plant Nutrient Management

- Starting point for increasing yields when coupled with basic crop management practices of plant density and arrangement
  - Husband home because of adequate corn for family. Increased time to learn about improved farming practices
- Produce more residues
  - Available for conservation practices to retain water, reduce erosion, increase soil organic matter, INCREASE SOIL YIELD POTENTIAL OVER TIME!
  - Available for animal feed.
  - Building on-farm nutrient levels for future crops.
- Opportunity for income generation by selling grain
  - Education
  - Health care
  - Improved diets
  - Improved rural economies

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Fourth Principle of Conservation Agriculture*

1. Minimum tillage
2. Soil surface covered
3. Diversified crop rotations
4. Appropriate use of fertilizer

Nutrient Use, Stover Yields and Soil Cover for Conservation Agriculture*

Agronomic Efficiency: Fertilizer and Organic Resources with Integrated Soil Fertility Management*

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*Vanlauwe, 2009
Global and Historical Nutrient Use Efficiencies for Closing Maize Yield Gaps*

• Reviewed data on maize grain yields and plant nutrient content (N, P, K) from 150 studies with known plant densities.
• Compared data from different “Eras” (late 1800’s to 2012)
• Compared data from different “Geographies” – USA versus World.
  o Comparison was selected based on numbers of studies available and differences in yields

*Ciampitti and Vyn. 2014. Agron. J.
Maize

USA: Historical trend

Grain Yield

USDA Maize Grain Yield Trend

Plant K Uptake

Plant N Uptake

Plant P Uptake

Plant nutrient uptake (kg ha$^{-1}$)

Grain yield (Mg ha$^{-1}$)

Year

100-500 data points
(n=1411)

Ciampitti and Vyn. 2014. Agron. J.
Maize

Yield and Plant nutrient uptake historical trends

Geographic distribution (n)

Historical distribution (n)

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Ciampitti and Vyn. 2014. Agron. J.
Maize N Uptake Per Plant and Physiological Efficiency*

\[ PE = \text{g grain per g N} \]

*Ciampitti and Vyn, 2014
Maize P Uptake Per Plant and Physiological Efficiency*

*Ciampitti and Vyn, 2014
Maize K Uptake Per Plant and Physiological Efficiency*

*Ciampitti and Vyn, 2014
Major Observations
Ciampitti and Vyn, 2014

• Community Scale: USA data reflected a greater physiological efficiency (yield to plant nutrient content) for N, P, and K than data gathered from the rest of the World
  o Associated with improvements in integrated production practices

• Plant scale (adjusted by plant density) differences in physiological efficiency were negligible for both the historical and geographical analyses

• Historical physiological improvements in this analysis primarily associated with reductions in per-plant nutrient content
Major Observations
Ciampitti and Vyn, 2014

- Apparent nutrient budgets were near neutral for N and P for USA, but greater nutrient asynchrony was apparent for the rest of the World.

- Overall nutrient ratios for N:P (5-6:1) and N:K (1:1) were comparable across Eras and geographies with high yield maize.

- Closing the maize yield gap requires better balance and more nutrients in some regions coupled with improved total crop management programs.
Fertilizers and Integrated Plant Nutrient Management
Closing Maize Yield Gap

- More balanced nutrition integrated with residual and on-farm organic nutrient sources
- Use as part of improved total maize management production systems
- Expect higher total nutrient requirements
  - Higher Yields
  - Higher nutrient use efficiencies can be expected with higher yields and appropriate nutrient program
- Fertilizers needed to provide required nutrients if not available from on-farm sources
Integrated Plant Nutrient Management

• Maximize interactions
  o Fertilizers
  o Organic inputs
  o Biological N fixation
  o Improved germplasm
  o Enhanced planting techniques
  o Farmer knowledge and adaptation to local conditions

• Data appears to be available for maize at least with macronutrients
• Other crops???
Integrate All Nutrient Sources
Total Crop Production Program

YIELD BUILDING FACTORS

- VARIETY SELECTION
- HARVEST MANAGEMENT
- PLANT NUTRITION
- PRECISION PLANTING
- WEED CONTROL
- LODGING CONTROL
- DISEASE CONTROL
- INSECT CONTROL

YIELD YIELD EARS / ACRE

YIELD PROTECTING FACTORS

- KERNELS / EAR
- KERNEL WEIGHT

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