Water Drives Everything!!

So Make Every Drop Count

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Food, Fibre and Fuel

70% +
Plants are continuously exposed to environmental stresses that negatively influence growth and development and therefore cause yield losses.

Source: Buchanan, Gruissem, Jones: Biochemistry and Molecular Biology of Plants; American Society of Plant Physiologists, 2000
**Corn grain**

**Yield Goal**

503

bu/A

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Removal (lb/A)</th>
<th>Uptake (lbs/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>337.0</td>
<td>563</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>176.0</td>
<td>256</td>
</tr>
<tr>
<td>K₂O</td>
<td>125.7</td>
<td>679</td>
</tr>
<tr>
<td>S</td>
<td>40.2</td>
<td>75</td>
</tr>
</tbody>
</table>

GEORGIA FARMER RANDY Dowdy topped 503 bushels per acre in 2014, the highest ever yield for the National Corn Yield Contest.
Spread Nutrients Out Over Time & Space

• Time
  - Fall/winter
  - Spring
  - At Seeding
  - In crop

• Space
  - With seed
  - Near seed
  - Mid row
  - On top
  • Broadcast
  • Streams/band
Timing is everything.
WUE, NUE

Water use efficiency values and limits

The Keystone Center (2009) surveyed US farm WUE in 2007 and reported values of 5 kg/ha/mm for wheat, 8 kg/ha/mm for soybean and 13 kg/ha/mm for maize. These values appear low when compared with the modern tomato varieties studied by Hanson and Calif irrigation study (X. Zhang et al. 2011), when WUE under the leading technology reached 15 kg/ha/mm for wheat and 22 kg/ha/mm for maize. Additionally, in a comprehensive study of irrigated maize in the central part of southern Nebraska, USA, Grassini et al. (2011b) measured WUE to be 19 kg/ha/mm for surface irrigation and 32 kg/ha/mm for centre-pivot irrigation. The average of these two figures is 26 kg/ha/mm, which agrees with results for other studies of maize under optimal management, such as in Texas, USA (Howell 2001).

1” of rain N grows 130 lbs of wheat grain

1 lb of fertilizer N grows 40 lbs of wheat grain.
Re-Allocation of Scarce Resources

Cost per Unit of Production
Three most essential, *but often unmanaged*, inputs to crop production?
Maximizing Photosynthetic Efficiency

\[6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\]
Our Job...

- Maximize the conversion of solar energy into energy stored in agricultural produce.

But it's more than that...

- Optimize the amount of the other essential nutrients like protein, minerals and vitamins that ends up in the foods we produce.
Water Use Efficiency

• 1\textsuperscript{st} 4” goes to the factory unless you’re corn & the 1\textsuperscript{st} 8” goes to the factory

• Every 1“ after that goes to yield

• Prof. Les Henry

  “Water in the soil is $$ in the Bank!”

Nobody measures it!!
Crop Water Use Efficiency & Management

The diagram compares water use efficiency across different crops: Wheat, Canola, Barley, Oats, and Peas. The efficiency is categorized into three levels: Good, Average (Ave), and Poor. Oats have the highest water use efficiency, followed by Barley, Wheat, Canola, and Peas. The diagram visually represents the proportion of each category for each crop.
The Right 7 Factors

4R’s

Balance & Synergy

1
ROOTS
Root Dominance

2
SHOOTS
Optimal Density

N S Cl B PK Ca Mg Cu Fe Mn Zn
Which Fish do we Fry 1st?
Compaction in Field Near You

2 compacted layers

Disk pan

Plow pan

http://www.maes.msu.edu/ stringstream/lowvalley/Research/Sec_images/plow_pan.jpg
Biggest Fish

Sub Field
pH
Variability
4.2 – 6.8
Buffer pH

%BS Ca
Al
Mn
Mo

Root Growth

NUE, WUE
Effect of pH on Al\(^{3+}\) in solution

- Y-axis: Al in soil solution, ppm
- X-axis: Soil pH

The graph shows a downward trend, indicating that the concentration of Al\(^{3+}\) in the soil solution decreases as the soil pH increases.
3 days wheat

Mike Dolinski
Senior Agri-Coach
High Al, wheat 15 days  52 F
High Al, wheat 15 days  52 F
The 7R’s of Yield, Quality, Maturity, Profitability and Sustainability

1. Right Mind Set: Think like a plant
2. Right Start: Create a Root Dominant Crop
3. Right Canopy: Build an Early Large Solar Panel
4. Right Engine: Recognize that Water Drives Everything
5. Right Focus: Start with the Most Limiting Factor
6. Right Source, Rate, Placement & Timing: Utilize the 4NRs Concept for ALL Nutrients
7. Right Combinations: Find the Synergies
1 Right Mind Set: Think like a plant
Think Like a Plant
The 1<sup>st</sup> thing a young plant wants to do is . . . . . GROW ROOTS!!
Growing Roots

- 80% of a plant's biomass is in below the soil surface.

Each plant only explores ~2% of the soil volume that supports it.

Success

It's not always what you see.

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Nutrient Mobility

**In Soil:**

- **Very Mobile:** Nitrate, Sulfate, Chloride & Boron
- **Moderately Mobile:** Ammonium, Potassium, Calcium, Magnesium, Molybdenum
- **Immobile:** Phosphorus, Copper, Iron, Manganese & Zinc

**In Plant:**

- **Mobile:** Nitrogen, Phosphorus, Potassium, Magnesium, Molybdenum, Chloride
- **Immobile:** Boron, Calcium, Copper, Iron, Manganese, Nickel, Sulfur
Nutrient Uptake

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Root interception</th>
<th>Mass Flow</th>
<th>Diffusion movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen N</td>
<td>1</td>
<td>99</td>
<td>0</td>
</tr>
<tr>
<td>Phosphorus P</td>
<td>2</td>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>Potassium K</td>
<td>2</td>
<td>20</td>
<td>78</td>
</tr>
<tr>
<td>Calcium Ca</td>
<td>12</td>
<td>88</td>
<td>0</td>
</tr>
<tr>
<td>Magnesium Mg</td>
<td>27</td>
<td>73</td>
<td>0</td>
</tr>
<tr>
<td>Sulphur S</td>
<td>4</td>
<td>94</td>
<td>2</td>
</tr>
</tbody>
</table>

(Havlin et al. 2005)
The 2\textsuperscript{nd} thing a young plant wants to do is . . . . .

GROW SHOOTS!!
Planting Considerations

More Plants = More Photosynthesis

Other Considerations

- Row Spacing
- SBU
- Yield Environment
Spike Count/ft²
Think of Your Crop as a Solar Panel

Focus on:
Early Rooting
Early Chlorophyll

Results in:
Improved WUE & NUE
More yield & quality
Rapid Maturity

Radiation Adsorption
$CO_2$ Assimilation
Think Solar Panels!!

• Think Early Chlorophyll! Find Synergy!!

• Think Magnesium (Mg)
  – Think Cu and Mn catalysts

• A big solar panel:
  • hastens maturity,
  • competes with weeds,
  • hedges bets to higher yield & quality
Leaf Green Area Index

• What the heck is this??

• How much solar panel is created quickly per unit area of soil surface being cropped/
GAI & WUE
Right Engine:
Recognize that Water Drives Everything

Water Drives Everything!! So Make Every Drop Count
Let’s Connect a Few Thoughts
AquaCheck with Cellular Telemetry

- Real time information delivered to web-based application
- Name & Password security on each device
- Data capture configurable from 15 minute to 2 hour increments
- Multiple Telemetry Options
Crop Available Water per Foot of Wet Soil

CEC: 5, 10, 15, 20, 25, 30

Soil types: Sand, Sandy Loam, Loam, Silt Loam, Clay Loam, Clay

Chart shows the increase in available water with higher CEC values for different soil types.
Crop Water Use Efficiency and Management

The diagram illustrates the water use efficiency of different crops: Wheat, Canola, Barley, Oats, and Peas. The efficiency is categorized into Good, Average (Ave), and Poor. The water use for each crop is represented by the height of the bars, with the color indicating the efficiency level.
Breton No-Till
est. 1982, sampled 1999

OM %

0-3 in

3-6 in

6-12 in

OM

0 N

75 N