Breaking Through Yield Barriers: Knowing What the Plant Needs and Meeting Those Needs

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North Carolina State University

Department of Crop Science
College of Agriculture and Life Sciences
The Environment of Corn

FIVE ESSENTIALS OF THE CORN ENVIRONMENT

1. Light
2. Water
3. Temperature
4. Nutrients
5. Genetics

Fred Below, Seven Wonders of the Corn World
University of Illinois

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
<th>Value</th>
<th>bu/acre</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weather</td>
<td>70+</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>Nitrogen</td>
<td>70</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Hybrid</td>
<td>50</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>Previous Crop</td>
<td>25</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Plant Population</td>
<td>20</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Tillage</td>
<td>15</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Growth Regulators</td>
<td>10</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total = 260 bu</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
Maximum Corn Yields are Obtained when:

the corn plant collects the maximum amount of light possible without stress.
The Good – Increasing Light Use
- Maximizing the length of Growth without stress
- Higher Plant Populations – Season Long Benefits
- Row Spacing – Early Benefits plus Reduced Stress

The Bad – Crop Stress
- Avoid Heat, Water, and Nutrient Stress at Critical Times

The Ugly – Balancing Light and Stress
Effect of Plant Population on Plant Height – 12” spacing

11,880 /acre

44”

43,560 /acre

12”
## Yield Enhancing Practices – Forsythe Co - 2014

<table>
<thead>
<tr>
<th>Management Practices</th>
<th>Grain Yield Bu/acre&lt;sup&gt;-1&lt;/sup&gt;</th>
<th>Yield Loss without Practice(s) Bu/acre&lt;sup&gt;-1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low – No Added Management</td>
<td>279.6</td>
<td>- 38.4 *</td>
</tr>
<tr>
<td>High – 42,000 seeds/a</td>
<td>318.0</td>
<td>------</td>
</tr>
<tr>
<td>100 lb N/a @ plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed Trmt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicide @ IF and V6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High with 33,000 seeds/acre</td>
<td>283.2</td>
<td>- 34.8 *</td>
</tr>
<tr>
<td>High without N at Plant</td>
<td>299.0</td>
<td>- 19.0 *</td>
</tr>
<tr>
<td>High without Seed Trmt</td>
<td>298.5</td>
<td>- 19.5 *</td>
</tr>
<tr>
<td>High without Fungicide</td>
<td>293.4</td>
<td>- 24.6</td>
</tr>
</tbody>
</table>
What Makes Growing 300 to 500 Bushel Per Acre Corn So Impossible?

1. Difficulty with Uniform Emergence and Early Growth
   a) The Impact of cold, wet soil on emergence and early growth

2. Limitations on Capturing Light with Higher Plant Population
   a) Water – too little or too much
   b) High Temperatures During Pollination
   c) Nutrients – Right amount, right place, right time, right uptake
   d) Nutrient Interactions

3. The Problems with Lengthening the Grain Fill Period
   a) Heat Hastens Maturity
   b) Premature Senescence
   c) N and K Become Limiting Factors
Factors Affecting Quick, Uniform Emergence and Early Growth

1. Soil Environment
2. Hybrid
3. Seeding Depth
4. Nutrient Availability
5. Weed Control
6. Pest Control
How Important is Emergence?

- DG57VC51
- DKC 67-44, DKC 64-35, AV 8915, AV9583, Pioneer 1870
- Pioneer 1442, Augusta 7767

Fractional Emergence vs. Days Following Emergence
How Important is Uniform Emergence?

- Canopy Cover, %
- Growing Degree Days

- P 1442
- DG 57VC51
- DKC67-44
How Important is Uniform Emergence?

Corn Yield, bu acre⁻¹

- 6-24-6 IF
- No Starter

Varieties:
- P 1870
- P 1442
- DKC67-44
- DKC64-35
- DG57VC51
- Aug 7767
- AV 9583
- AV 8915

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Managing Nutrients

Nutrient Uptake

BETTER NUTRIENT UTILIZATION

Grower Planted
DKC64-69
19-19-0 @ 20 gpa (2 x 2)
3-18-18 @ 5 gpa in-furrow

DIFFERENCE WAS

1 lb/a of Zn

DKC64-69
10-27-0 @ 20 gpa (2 x 2)
3-18-18 @ 5 gpa in-furrow

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Nutrients Need to be Available in the Soil
- Adequate Nutrient Concentration in Root Zone
- Nutrients in the Right Form for Plant Uptake
- Reduce Nutrient Tie-up and Loss

Root Development
- More Roots the More Successful Uptake is

Nutrient Interactions
- Mg and Ca; N and K; P and Zn
- Micronutrients
Managing the Light–Stress Balance With Roots

Growing Better Root Systems
Differences in Root Ball Mass

Fertility Treatments on Root Mass

Root Mass (oz/plant)

19-19-0 + K 19-19-0 0-0-60 No Starter

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### Managing Early Nutrient Concentration in the Seed Zone – 2017

#### Placement of Nutrients

<table>
<thead>
<tr>
<th>Treatment Description</th>
<th>Pamlico Yield</th>
<th>Surry Yield Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low – No Added Management</td>
<td>240.9</td>
<td>21.1</td>
</tr>
<tr>
<td>High – 42,000 plants 3-18-3 @ V3, 2 x 2 x 2 B</td>
<td>262.0</td>
<td></td>
</tr>
<tr>
<td>High with 34,000 seeds/acre</td>
<td>241.6</td>
<td>20.4</td>
</tr>
<tr>
<td>High without 3-18-3 @ V3</td>
<td>272.5</td>
<td>1.5</td>
</tr>
<tr>
<td>High with Starter on One Side of Row</td>
<td>253.1</td>
<td>18.9</td>
</tr>
<tr>
<td>High without B</td>
<td>262.8</td>
<td>-7.4</td>
</tr>
</tbody>
</table>

- **Managing Root Uptake**
### Nutrient Interactions

#### Pre-Season Soil Test

<table>
<thead>
<tr>
<th>Field</th>
<th>HM†</th>
<th>W/V</th>
<th>CEC</th>
<th>BS</th>
<th>Ac</th>
<th>pH</th>
<th>P-I</th>
<th>K-I</th>
<th>Ca</th>
<th>Mg</th>
<th>S-I</th>
<th>Mn-I</th>
<th>Zn-I</th>
<th>Cu-I</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(a)</td>
<td>0.81</td>
<td>1.32</td>
<td>3.8</td>
<td>82</td>
<td>0.7</td>
<td>6.0</td>
<td>257</td>
<td>76</td>
<td>55</td>
<td>17</td>
<td>36</td>
<td>56</td>
<td>53</td>
<td>55</td>
<td>0.1</td>
</tr>
<tr>
<td>H(b)</td>
<td>0.56</td>
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<td>77</td>
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<td>300</td>
<td>88</td>
<td>51</td>
<td>16</td>
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<td>41</td>
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</tr>
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</table>
2016 Corn Trial: What Nutrients Did We Lack?

Leaf Nitrogen - Planting 4/18/2016

Leaf Phosphorus - Planting 4/18/2016

Leaf Magnesium - Planting 4/18/2016

Leaf Boron - Planting 4/18/2016

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Mulder’s Nutrient Chart

High levels of a particular nutrient in the soil can interfere with the availability and uptake by the plant of other nutrients. Those nutrients which interfere with one another are said to be antagonistic.

Stimulation occurs when the high level of a particular nutrient increases the demand by the plant for another nutrient.
Calcium Interactions

4:1 to 2:1

7:1 Clay
4.5:1 Organic
3:1 Sand

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### Pre-Season Soil Test – Sandy Soil

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<tr>
<th>Field</th>
<th>HM †</th>
<th>W/V</th>
<th>CEC Meq 100 cm⁻¹</th>
<th>BS</th>
<th>Ac</th>
<th>pH</th>
<th>P-I</th>
<th>K-I</th>
<th>Ca</th>
<th>Mg</th>
<th>S-I</th>
<th>Mn-I</th>
<th>Zn-I</th>
<th>Cu-I</th>
<th>Na Meq 100 cm⁻¹</th>
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<td>50</td>
<td>41</td>
<td>56</td>
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</tr>
</tbody>
</table>

Ca to Mg Ratio = 3.2:1  
Ca to P Ratio = 1.4:1  
Ca to K Ratio = 2.8:1
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<tr>
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<th>K-I</th>
<th>Ca</th>
<th>Mg</th>
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<td>50</td>
<td>41</td>
<td>56</td>
<td>0.1</td>
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Mg to P Ratio = 1:3.9
Mg to K Ratio = 1:2
Phosphorus Interactions

1:1.2
1:1.5
35:1
30:1
1:1

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# Pre-Season Soil Test – Sandy Soil

<table>
<thead>
<tr>
<th>Field</th>
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<td>1.30</td>
<td>4.2</td>
<td>77</td>
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<td>51</td>
<td>16</td>
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<td>50</td>
<td>41</td>
<td>56</td>
<td>0.1</td>
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P to Zn Ratio = 135:1  
P to K Ratio = 2.1:1
Pre-Season Soil Test – Peanut Belt Station

<table>
<thead>
<tr>
<th>Field</th>
<th>HM†</th>
<th>W/V</th>
<th>CEC</th>
<th>BS</th>
<th>Ac</th>
<th>pH</th>
<th>P-I</th>
<th>K-I</th>
<th>Ca</th>
<th>Mg</th>
<th>S-I</th>
<th>Mn-I</th>
<th>Zn-I</th>
<th>Cu-I</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>g cc⁻³</td>
<td>Meq</td>
<td>%</td>
<td>-- index --</td>
<td>%</td>
<td>%</td>
<td>-- index --</td>
<td>Meq</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C2BE</td>
<td>0.66</td>
<td>1.38</td>
<td>4.7</td>
<td>75</td>
<td>1.2</td>
<td>6.0</td>
<td>244</td>
<td>41</td>
<td>60</td>
<td>10</td>
<td>36</td>
<td>73</td>
<td>55</td>
<td>43</td>
<td>0.1</td>
</tr>
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Ca to Mg Ratio = 9.9:1
Ca to P Ratio = 1.9:1
Ca to K Ratio = 7:1
Mg to P Ratio = 1:5
Mg to K Ratio = 1:1.4
P to Zn Ratio = 133:1
P to Cu Ratio = 339:1
P to K Ratio = 3.7:1
# Leaf Tissue Concentrations of Nutrients Following an Application of B, Zn, and Mg - Lewiston Top – V5-V6 Bottom Comparison – V9-V10

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Cu</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>No B or Zn</td>
<td>3.64</td>
<td>0.36</td>
<td>2.31</td>
<td>0.41</td>
<td>0.17</td>
<td>0.20</td>
<td>167.9</td>
<td>24.2</td>
<td>24.5</td>
<td>20.4</td>
<td>14</td>
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<tr>
<td>B + Zn+Mg</td>
<td>3.75</td>
<td>0.54</td>
<td>2.55</td>
<td>0.38</td>
<td>0.16</td>
<td>0.25</td>
<td>173.1</td>
<td>30.9</td>
<td>40.1</td>
<td>31.5</td>
<td>18.8</td>
</tr>
<tr>
<td>No Micro</td>
<td>3.28</td>
<td>0.34</td>
<td>1.68</td>
<td>0.81</td>
<td>0.23</td>
<td>0.21</td>
<td>1151</td>
<td>39.3</td>
<td>20.7</td>
<td>26.3</td>
<td>12.5</td>
</tr>
<tr>
<td>B + Zn + Mg</td>
<td>3.36</td>
<td>0.35</td>
<td>1.71</td>
<td>0.75</td>
<td>0.22</td>
<td>0.21</td>
<td>1151</td>
<td>40.6</td>
<td>22.6</td>
<td>22.1</td>
<td>16.4</td>
</tr>
</tbody>
</table>
Magnesium
20 lbs Mg/a

CHECK
Impact of Essential or MicroNutrients on Yield

Corn Yield, bu acre⁻¹

- Check
- Boron
- Boron 2x
- Zinc
- Zinc 2x
- Mg
- Mg 2x
- 3-18-18

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Avoiding BAD DAYS

LOOK AHEAD – NOT BEHIND
- Knowing the BIG 5 Things Corn Needs – Ask yourself, “Will Tomorrow Be a GOOD DAY?”
- IF not, know what to do to make it a GOOD day.
- Understanding what the plant needs can help you plan ahead

KNOW YOUR GENETICS
- Does your corn do emergence well?
- Does your corn do early growth?
- Why Are Nutrients Limiting Yield?
Questions