Variable Rate Starter Fertilization Based on Soil Attributes

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Justification

• On calcareous (pH>7.4) P fixing soils a fluid starter fertilizer, like ammonium poly phosphate (APP), applied in-furrow may be an efficient and economic alternative to a traditional broadcast application.
  – Especially, on short-term rented land, where the farmer is not necessarily interested in building soil test levels (if, pH>7.7 hard to build soil test).
  – Instead the primary goal is to maximize yield and profit while minimizing risk.
Justification continued

• Widespread adoption of variable rate fertilization and availability of variable rate controllers has raised new questions.
  – Does the optimum rate of starter fertilizer vary enough within a field to require variable rate application of starter?
  – What soil or landscape attributes can be used to make variable starter rate application recommendations?
The objectives of this study were to:

1) measure the effect of APP rate on early growth of corn, grain yield and fertilizer use efficiency;
2) determine if the optimum rate of APP varies within a typical Minnesota field;
3) develop and calibrate an algorithm for making variable rate starter applications based on soil attributes; and
4) compare and contrast the effects of a traditional broadcast P application on the response(s) observed in objectives 1, 2 and 3.
Experimental design

- Modified strip trial design
- Treatments randomized within replications in a split-plot arrangement
  - Main plot: Broadcast P rate (2)
  - Sub plot: APP starter rates (4)
- 16 replications per location
  - 16 reps × 8 treatments = 128 plots
- Response data from replications with similar soil attributes are pooled together

Funding provided by the Fluid Fertilizer Foundation
Methods and timeline

• Study initiated by Dr. Daniel Kaiser in 2012 (two sites) in south-central Minnesota, 3 sites in 2013.
• Soil samples analyzed for Bray P1, Olsen P, pH, CaCO$_3$ and exchangeable K
  – 0-6 inch samples: one composite (8 cores) sample from two neighboring plots or an area about 15 ft. by 35 ft.
  – 6-12 inch samples: one composite (16 cores) for each replication or an area 40 ft. by 130 ft (0.12 ac).
• Broadcast-apply P at 0 and 120 lb P$_2$O$_5$/ac as TSP
• Broadcast-apply N, K, S and Zn as needed to optimize corn production, incorporate with tillage.

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Methods and timeline (continued)

• Plant corn and apply APP in-furrow at 0, 2.5, 5 and 7.5 gal/ac or about 0, 10, 20 and 30 lb P₂O₅/ac

• Farmer cooperator managed: weeds and pests as needed along with the rest of field

• At V5, harvest 8 whole plants for yield, P conc., P uptake; NDVI (GreenSeeker™ sensor); stand counts - calculate plant populations

• Combine harvest center two rows 45 ft long in two 22.5 ft segments; at harvest collect grain sample analyze for total P
May 2, 2013 SC and SE Minnesota
2013 “Spring” weather at Waseca

Daily precipitation, inch
0.0
0.5
1.0
1.5
2.0
Max Air Temp., deg F.
40
60
80
100

Apr-Jun 19.34”
100° 10” snow

102°

planting

Funding provided by the Fluid Fertilizer Foundation

University of Minnesota
Driven to Discover™
# Summary of soil test attributes

<table>
<thead>
<tr>
<th>Loc.</th>
<th>SOM</th>
<th>Bray</th>
<th>K</th>
<th>pH Min</th>
<th>pH Avg</th>
<th>pH Max</th>
<th>Olsen-P Min</th>
<th>Olsen-P Avg</th>
<th>Olsen-P Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>G12</td>
<td>5.8</td>
<td>25</td>
<td>209</td>
<td>5.9</td>
<td>6.8</td>
<td>7.8</td>
<td>4</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>S12</td>
<td>5.0</td>
<td>19</td>
<td>208</td>
<td>6.4</td>
<td>7.6</td>
<td>8.0</td>
<td>4</td>
<td>13</td>
<td>28</td>
</tr>
<tr>
<td>NR13</td>
<td>5.7</td>
<td>16</td>
<td>251</td>
<td>6.2</td>
<td>7.3</td>
<td>7.8</td>
<td>5</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>W13</td>
<td>3.3</td>
<td>12</td>
<td>176</td>
<td>6.1</td>
<td>7.2</td>
<td>8.0</td>
<td>4</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>J13</td>
<td>5.8</td>
<td>27</td>
<td>171</td>
<td>5.3</td>
<td>5.8</td>
<td>6.5</td>
<td>6</td>
<td>19</td>
<td>38</td>
</tr>
</tbody>
</table>
### Statistical significance of treatment main effects for V5 corn plants by location.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Broadcast P</th>
<th>Starter P</th>
<th>Bdct*Starter</th>
</tr>
</thead>
<tbody>
<tr>
<td>V5 Plant Mass</td>
<td>Gaylord</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Stewart</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>New Richland</td>
<td>NS</td>
<td>&lt;0.001</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Willmar</td>
<td>0.045</td>
<td>0.015</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Janesville</td>
<td>0.004</td>
<td>&lt;0.001</td>
<td>0.079</td>
</tr>
<tr>
<td>V5 P Uptake</td>
<td>Gaylord</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Stewart</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>New Richland</td>
<td>0.007</td>
<td>&lt;0.001</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Willmar</td>
<td>0.011</td>
<td>0.043</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Janesville</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>NS</td>
</tr>
</tbody>
</table>
Summary: V5 whole plants

- Plant populations were NOT affected by treatments (data not shown).
- Early growth of corn (V5 plant mass) and P uptake were not affected by treatments in 2012, a very warm spring.
- Broadcast P increased V5 mass in 2 of 3 sites and P uptake in 3 of 3 sites in 2013, a very cool and wet spring.
- Starter (APP) increased V5 mass and P uptake in 3 of 3 sites in 2013.
Significance of treatment main effects for grain yield and moisture by location.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Location</th>
<th>Broadcast P</th>
<th>Starter P</th>
<th>Bdct*Starter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Yield</td>
<td>Gaylord</td>
<td>0.090</td>
<td>NS</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>Stewart</td>
<td>0.050</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>New Richland</td>
<td>0.004</td>
<td>0.029</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Willmar</td>
<td>&lt;0.001</td>
<td>NS^</td>
<td>NS^</td>
</tr>
<tr>
<td></td>
<td>Janesville</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Grain Moisture</td>
<td>Gaylord</td>
<td>NS</td>
<td>0.051</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Stewart</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>New Richland</td>
<td>NS</td>
<td>0.007</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Willmar</td>
<td>0.053</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Janesville</td>
<td>0.031</td>
<td>0.003</td>
<td>0.049</td>
</tr>
</tbody>
</table>
## Corn yield as affected by broadcast P

<table>
<thead>
<tr>
<th>Location</th>
<th>Yield (bu/ac)</th>
<th>None</th>
<th>120-lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaylord</td>
<td>NS</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Stewart</td>
<td>7 bu</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>New Rich.</td>
<td>9 bu</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>Willmar</td>
<td>25 bu</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Janesville</td>
<td>NS</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>
Grain yield at Gaylord in 2012

Funding provided by the Fluid Fertilizer Foundation
Summary: corn grain yield

• Broadcast P increased grain yields at 3 of 5 sites ($a=0.05$).
  – Yields were 7, 9, and 25 bu/ac greater at Stewart, New Richland and Willmar, respectively.

• Starter (APP) increased grain yields at 1 of 5 sites.
  – 5-10 bu/ac at New Richland

• APP increased grain yields (7-10 bu/ac) at Gaylord when no broadcast P was applied.
Relative yield as affected by treatment main effects including soil test P levels, when analyzed across locations (Willmar excluded).

<table>
<thead>
<tr>
<th>Treatment Effects</th>
<th>P Soil Test Used to Delineate Zones</th>
<th>Olsen P</th>
<th>Bray P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil Test P Level</strong></td>
<td>-----------------------------------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>Low</td>
<td>98.0 a</td>
<td>97.9 a</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>98.8 a</td>
<td>97.9 a</td>
<td></td>
</tr>
<tr>
<td>High/Very High</td>
<td>99.4 a</td>
<td>99.5 a</td>
<td></td>
</tr>
<tr>
<td><strong>Broadcast Rate</strong></td>
<td>0 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/ac</td>
<td>97.5 b</td>
<td>97.1 b</td>
</tr>
<tr>
<td></td>
<td>120 lb</td>
<td>99.9 a</td>
<td>99.8 a</td>
</tr>
<tr>
<td><strong>Starter (10-34-0) Rate</strong></td>
<td>0 gal/ac</td>
<td>97.4 b</td>
<td>97.1 b</td>
</tr>
<tr>
<td></td>
<td>2.5 gal</td>
<td>98.6 ab</td>
<td>98.4 ab</td>
</tr>
<tr>
<td></td>
<td>5.0 gal</td>
<td>99.7 a</td>
<td>99.3 a</td>
</tr>
<tr>
<td></td>
<td>7.5 gal</td>
<td>99.3 a</td>
<td>99.0 a</td>
</tr>
<tr>
<td><strong>Interactions, (P &gt; F)</strong></td>
<td>Broadcast Rate*Starter Rate</td>
<td><strong>0.013</strong></td>
<td>0.110</td>
</tr>
</tbody>
</table>
Relative yield as affected by broadcast and starter P across locations.

<table>
<thead>
<tr>
<th>Broadcast P2O5 Rate</th>
<th>0 lb</th>
<th>120 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative corn yield, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 gal/ac APP</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>2.5 gal</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>5.0 gal</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>7.5 gal</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Summary: relative yield

- Broadcast P increased relative yields about 2.5 percentage points (Willmar site excluded).
- 5 and 7.5 gal/ac of APP increased grain yields about 2 percentage points compared with 0 gal/ac of APP
  - 2.5 gal/ac was intermediate
- A significant broadcast P rate*starter rate interaction showed:
  - APP increased grain yields when no broadcast P was applied.
Acknowledgements

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  – the Fluid Fertilizer Foundation, Minnesota Corn Growers, Corn Research and Promotion Council for funding this project
  – *FFF partnering labs for “in-kind” support*
  – research crews at the Department of Soil, Water, and Climate and Southern Research and Outreach Center for their assistance
  – farmer cooperators for their assistance and the use of land
QUESTIONS

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http://sroc.cfans.umn.edu/People/Staff/JeffreyVetsch/index.htm