VARIABLE-RATE LIME RESPONSE IN WISCONSIN

RICHARD WOLKOWSKI AND RANDALL ZOGBAUM

DEPARTMENT OF SOIL SCIENCE
UNIVERSITY OF WISCONSIN
CONSIDERATIONS FOR VARIABLE SOIL pH MANAGEMENT

- MANY FIELDS TEST HIGH IN P AND K: THEREFORE, LOW RESPONSE TO VRT
- SOIL TEST SUMMARY SHOWS MANY FIELDS NEED LIME
- GRID SOIL SAMPLING IDENTIFIES WITHIN FIELD pH VARIABILITY
CONSIDERATIONS FOR VARIABLE SOIL pH MANAGEMENT

- SOIL pH DISTRIBUTION VARIES BETWEEN FIELDS
- OTHER LIMING BENEFITS INCLUDE:
  - CROP QUALITY
  - PROTEIN CONTENT
  - STAND PERSISTENCE
  - IMPROVED NUTRIENT AVAILABILITY
OTHER LIMING CONSIDERATIONS

- **UNIFORM APPLICATION CRITICAL**
- **MIXING BY TILLAGE NEEDED**
- **HIGH RATES REQUIRE MULTIPLE APPLICATIONS**
- **RENTED LAND OFTEN OVERLOOKED**
- **REACTION TIME UP TO THREE YEARS**
EVALUATING THE POTENTIAL FOR VARIABLE LIME MANAGEMENT

- SIX FIELDS GRID SAMPLED ON ONE ACRE
- TARGET pH 6.3 (SOYBEAN) OR 6.8 (ALFALFA)
- PARTIAL BUDGET APPROACH FOR LIMING
- ASSUMPTIONS INCLUDE:
  1. MAX YIELD AT TARGET pH
  2. VARIABLE APPLICATION REACHED TARGET pH
  3. QUOTED COSTS AND RETURN
  4. RESEARCH BASED YIELD EQUATIONS
  5. COSTS SPREAD OVER FOUR YEARS
<table>
<thead>
<tr>
<th>SITE</th>
<th>MEAN pH</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FARM PROG.</td>
<td>6.6</td>
<td>5.8-7.4</td>
</tr>
<tr>
<td>CALDWELL</td>
<td>6.5</td>
<td>5.8-7.5</td>
</tr>
<tr>
<td>POST</td>
<td>5.8</td>
<td>5.0-7.2</td>
</tr>
<tr>
<td>STONE CORP.</td>
<td>6.5</td>
<td>5.9-7.0</td>
</tr>
<tr>
<td>WATZKE</td>
<td>6.5</td>
<td>5.3-7.7</td>
</tr>
<tr>
<td>FAULKNER</td>
<td>5.5</td>
<td>4.9-6.2</td>
</tr>
</tbody>
</table>
SOIL pH DISTRIBUTION FOR THE FARM PROGRESS DAYS FIELD (146 ACRES)

AVG. pH = 6.6
SOIL pH DISTRIBUTION FOR THE FARM CALDWELL FIELD (65 ACRES)

AVG. pH = 6.5
SOIL pH DISTRIBUTION FOR THE POST FIELD (50 ACRES)

AVG. pH = 5.8
<table>
<thead>
<tr>
<th>SITE</th>
<th>MEAN REC (6.3)</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FARM PROG.</td>
<td>1.0</td>
<td>0-6</td>
</tr>
<tr>
<td>CALDWELL</td>
<td>0.4</td>
<td>0-5</td>
</tr>
<tr>
<td>POST</td>
<td>2.9</td>
<td>0-6</td>
</tr>
<tr>
<td>STONE CORP.</td>
<td>0.3</td>
<td>0-4</td>
</tr>
<tr>
<td>WATZKE</td>
<td>1.0</td>
<td>0-10</td>
</tr>
<tr>
<td>FAULKNER</td>
<td>7.0</td>
<td>1-11</td>
</tr>
</tbody>
</table>
## Lime Requirement for Alfalfa Site

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean REC (6.8)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Prog.</td>
<td>3.0</td>
<td>0-11</td>
</tr>
<tr>
<td>Caldwell</td>
<td>3.1</td>
<td>0-13</td>
</tr>
<tr>
<td>Post</td>
<td>7.0</td>
<td>0-11</td>
</tr>
<tr>
<td>Stone Corp.</td>
<td>3.0</td>
<td>0-13</td>
</tr>
<tr>
<td>Watzke</td>
<td>4.0</td>
<td>0-19</td>
</tr>
<tr>
<td>Faulkner</td>
<td>14.0</td>
<td>6-21</td>
</tr>
</tbody>
</table>
LIME REQUIREMENT AT THE FARM PROGRESS DAYS FIELD

**pH 6.3**

**pH 6.8**
REALIZING A PROFIT FROM VARIABLE-RATE LIMING

YIELD

PROFIT FROM INCREASED YIELD

PROFIT FROM REDUCED INPUT COST

OPTIMUM pH

SOIL pH
PARTIAL BUDGET COMPARING VARIABLE RATE AND UNIFORM LIMING

WHAT IS A PARTIAL BUDGET RETURN - COST FOR SPECIFIC PORTION OF THE CROP PRODUCTION SYSTEM

COSTS
1 ACRE GRID SAMPLING AND RECS.: $ 20/a
TYPICAL SOIL SAMPLING: $ 3/a
VARIABLE RATE APPLICATION: $ 6/a
LIME: $ 11.50/t, ALFALFA $ 100/t, SOYBEAN $5/bu
PARTIAL BUDGET COMPARING VARIABLE RATE AND UNIFORM LIMING

STEP 1: LIME NEEDED - VRT METHOD

ESTIMATE ACREAGE IN 0.3 pH UNIT CATEGORIES FROM MAP CREATED FROM GRID SAMPLED DATA

CALCULATE LIME REQUIREMENT FOR EACH CATEGORY WITH THE VRT PRACTICE

ASSUME ALL VRT LIMING REACHES TARGET pH
PARTIAL BUDGET COMPARING VARIABLE RATE AND UNIFORM LIMING

STEP 2: LIME NEEDED - FIELD AVERAGE METHOD

CALCULATE FIELD-AVERAGE LIME RATE FROM ALL GRID SAMPLED DATA

MULTIPLY RATE x ACRES FOR TOTAL LIME REQUIREMENT

ESTIMATE SOIL pH REACHED BY FIELD-AVERAGE LIMING FOR ACREAGE IN EACH 0.3 pH CATEGORY

ESTIMATE UN-NEEDED LIME IN HIGHER pH AREAS
PARTIAL BUDGET COMPARING VARIABLE RATE AND UNIFORM LIMING

STEP 3: ESTIMATE YIELD

ESTIMATE CROP YIELD FOR EACH LIMING PRACTICE USING RESPONSE FORMULA

\[ \text{e.g. ALFALFA YIELD} = -81.5 +23.9 \times (\text{pH}) - 1.67 \times (\text{pH})^2 \]

YIELD FOR ALL ACRES SIMILAR WITH VRT

FIELD-AVERAGE LIMING RESULTS IN LOWER YIELD IN SOME ACREAGE CATEGORIES BECAUSE OF UNDER-LIMING
PARTIAL BUDGET COMPARING VARIABLE RATE AND UNIFORM LIMING

STEP 4 - CALCULATE NET RETURN

MULTIPLY ACREAGE BY YIELD FOR EACH PRACTICE FOR TOTAL FIELD PRODUCTION

AMORTIZE COSTS OF BOTH PRACTICES OVER 4 YEARS

SUBTRACT COSTS FROM RETURNS
### Partial Budget Comparing Variable Rate and Uniform Liming (Soybean, pH 6.3)

<table>
<thead>
<tr>
<th></th>
<th>Caldwell UNI</th>
<th>Caldwell VRT</th>
<th>FPD UNI</th>
<th>FPD VRT</th>
<th>Post UNI</th>
<th>Post VRT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RETURN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>YIELD</strong></td>
<td>325</td>
<td>330</td>
<td>326</td>
<td>330</td>
<td>314</td>
<td>330</td>
</tr>
<tr>
<td><strong>COST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLING</td>
<td>3</td>
<td>20</td>
<td>3</td>
<td>20</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>VRT</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>LIME</td>
<td>6</td>
<td>5</td>
<td>12</td>
<td>5</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>LIME (XS)</td>
<td>2</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td><strong>RETURN</strong></td>
<td>322</td>
<td>322</td>
<td>321</td>
<td>322</td>
<td>304</td>
<td>315</td>
</tr>
</tbody>
</table>
PARTIAL BUDGET COMPARING VARIABLE RATE AND UNIFORM LIMING (ALFALFA, pH 6.8)

<table>
<thead>
<tr>
<th></th>
<th>CALDWELL</th>
<th></th>
<th></th>
<th>FPD</th>
<th></th>
<th></th>
<th>POST</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UNI VRT</td>
<td>UNI VRT</td>
<td>$/a</td>
<td>UNI VRT</td>
<td>UNI VRT</td>
<td>UNI VRT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RETURN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YIELD</td>
<td>354 390</td>
<td>381 390</td>
<td>347 390</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLING</td>
<td>3 20</td>
<td>3 20</td>
<td>3 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VRT</td>
<td>- 6</td>
<td>- 6</td>
<td>- 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIME</td>
<td>36 35</td>
<td>35 30</td>
<td>80 75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIME (XS)</td>
<td>4 -</td>
<td>5 -</td>
<td>2 -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RETURN</td>
<td>343 375</td>
<td>370 376</td>
<td>326 364</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
USB/FAR VARIABLE-RATE LIMING STUDY

- FOUR SOUTHERN WISCONSIN FIELDS
- CORN/SOYBEAN ROTATION
- 1 ACRE GRID Sampled
- 3 SMALL PLOT AREAS PER FIELD
  - RESPONSE TO pH
  - 0 – 133 % LIME REQ.
- FIELD LENGTH STRIPS
  - COMMERCIAL LIME APPLICATION
  - NONE, UNIFORM RATE, VARIABLE RATE STRIPS
SOIL pH CHANGE FOLLOWING LIMING
(FAULKNER FIELD, ROCK CO., WIS. 1999-2000)

LIME REQ. (% OF 6.3 t/a)

1999

2000

DAYS AFTER APPLICATION

pH

LIME REQ. (% OF 6.3 t/a)

0 33 66 100 133

DAYS AFTER APPLICATION

0 60 120 180 410 470 530 590

5.2

5.4

5.6

5.8

6

6.2

6.4
YIELD RESPONSE TO LIMING
(FAULKNER FIELD, ROCK CO., WIS., 1999)
SOIL pH AND LIME REQUIREMENT
(FAULKNER FIELD, ROCK CO., WIS., 1999)
RESPONSE TO LIMING
(FAULKNER FIELD, ROCK CO., WIS., 1999)
SUMMARY

- GRID SAMPLE TO DETERMINE NEED FOR VARIABLE LIME
- SOIL pH “VARIABILITY PROFILE” DIFFERS BETWEEN FIELDS
- RETURN TO VARIABLE LIMING DEPEND ON:
  - TARGET pH
  - MANAGEMENT COSTS
  - CROP VALUE
  - YIELD RESPONSE TO LIMING
- INDIVIDUAL FIELD STUDIES VARIABLE