Dairy Manure Application Methods: N Credits, Gaseous N Losses, and Corn Yield

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Objective

• Evaluate the effect of liquid dairy manure application method and timing, and time of incorporation on:
  – Corn yield and manure N availability/N credits
  – Ammonia losses
  – Nitrous oxide emissions
Field Site

• Marshfield Ag Research Station
• Withee silt loam
  – Somewhat poorly drained, 0-2% slope
• Previous crop was corn
  – New site each year
• Plot size: 15’ x 50’
Treatments

• Pre-plant manure (mid to late May)
  – Surface application with disk incorporation
    • Immediate (<1 h)
    • 1-day
    • 3-day (surface)
  – Injection
    • S-tine (Kongsgilde Vibro-flex)
    • 15-inch spacing
    • 2-3-inch diam. band, 4-6 in. deep
  – All plots chisel plowed 3-5 days after manure application
Treatments

• Sidedress manure (V5-V6)
  – Injection
  – S-tine (Kongsgilde Vibro-flex) with shields
  – 30-inch spacing
  – 4-6 inches deep
  – Surface (Yr 2 and 3)

• Fertilizer N
  – 6 pre-plant rates (0 to 200 lb/acre)
Injected Manure Placement
Manure Source

- Liquid dairy manure
  - 6500 gal/acre (target rate)
  - Solids content: 14% (avg.)
  - Sand bedding
  - N application rate (avg.)
    - 2009-2012
      - 146 lb total N/acre
      - 58 lb NH₄-N/acre
    - 2009-2011 (years NH₃ measured)
      - 158 lb total N/acre
      - 62 lb NH₄-N/acre
    - Large variability
Gas Measurements

N\textsubscript{2}O  \quad \text{NH}_3
Results
2009-2011 Average NH$_3$ Emissions

- Most loss 6-12 hours after application
- Total 3-day average losses >40 lb/acre for surface application
- NH$_3$ loss reduced by injection (>90%) or immediate disk incorporation (75%)
Cumulative \( \text{N}_2\text{O} \) Emission

Annual \( \text{N}_2\text{O} \) Loss

- **2010**
  - PP-Inj: 1.0 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - PP-1 h: 0.6 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - PP-3-d: 0.4 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - SD-Inj: 0.2 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - SD-Surf: 0.1 lb/\( \text{N}_2\text{O}-\text{N} \)/acre

- **2011**
  - PP-Inj: 0.8 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - PP-1 h: 0.4 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - PP-3-d: 0.2 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - SD-Inj: 0.1 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
  - SD-Surf: 0.05 lb/\( \text{N}_2\text{O}-\text{N} \)/acre
N$_2$O Emission

• Peak in N$_2$O flux after manure application at PP and/or SD
  – Injection most pronounced
  – 6 to 12-day lag time

• Low levels of N$_2$O late July to Oct.

• Magnitude and timing (PP vs. SD) varied by year
  – May be explained by combination of rain events/soil moisture, soil temperature, and manure characteristics and N content
Grain response to preplant incorporated urea

<table>
<thead>
<tr>
<th>N rate</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>EONR_{0.10} N rate, lb/a</td>
<td>126</td>
<td>149</td>
<td>133</td>
<td>94</td>
<td>126</td>
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<tr>
<td>Yield, bu/a</td>
<td>149</td>
<td>156</td>
<td>155</td>
<td>189</td>
<td></td>
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</tbody>
</table>
Silage response to preplant incorporated urea

![Silage yield vs. N rate graph]

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>EONR$_{0.10}$ N rate, lb/a</td>
<td>124</td>
<td>149</td>
<td>118</td>
<td>92</td>
<td>121</td>
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<tr>
<td>Yield, bu/a</td>
<td>6.8</td>
<td>6.8</td>
<td>7.0</td>
<td>12.9</td>
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</table>
Effect of manure application timing and method on grain yield

<table>
<thead>
<tr>
<th>Timing</th>
<th>Method &amp; days to incorp.</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>Preplant</td>
<td>Injected</td>
<td>144 ab</td>
<td>123 a</td>
<td>107</td>
<td>179 a</td>
</tr>
<tr>
<td></td>
<td>Surface broadcast (&lt; 1 hour)</td>
<td>134 bc</td>
<td>124 a</td>
<td>110</td>
<td>158 bc</td>
</tr>
<tr>
<td></td>
<td>Surface broadcast (1 day)</td>
<td>133 c</td>
<td>122 a</td>
<td>112</td>
<td>159 bc</td>
</tr>
<tr>
<td></td>
<td>Surface broadcast (3 days)</td>
<td>137 bc</td>
<td>105 ab</td>
<td>103</td>
<td>166 ab</td>
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<tr>
<td>Sidedress</td>
<td>Injected</td>
<td>147 a</td>
<td>98 b</td>
<td>114</td>
<td>175 a</td>
</tr>
<tr>
<td></td>
<td>Surface band (no incorporation)</td>
<td>-</td>
<td>89 b</td>
<td>108</td>
<td>150 c</td>
</tr>
</tbody>
</table>
2012 grain yield response to preplant urea

If a manure treatment yielded 175 bu/a

% N availability = NFEV ÷ total N applied
## Manure N availability

<table>
<thead>
<tr>
<th>Timing</th>
<th>Method &amp; days to incorp.</th>
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<th>2010</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Manure N Availability †</strong></td>
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<tr>
<td></td>
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<td>NFEV as a % of total N applied</td>
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<tr>
<td>Preplant</td>
<td>Injected</td>
<td>48</td>
<td>53</td>
<td>38</td>
<td>63</td>
<td>51</td>
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<td></td>
<td>Surface broadcast (&lt; 1 hour)</td>
<td>22</td>
<td>50</td>
<td>42</td>
<td>31</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Surface broadcast (1 day)</td>
<td>19</td>
<td>51</td>
<td>46</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Surface broadcast (3 days)</td>
<td>30</td>
<td>33</td>
<td>31</td>
<td>43</td>
<td>34</td>
</tr>
<tr>
<td>Sidedress</td>
<td>Injected</td>
<td>39</td>
<td>42</td>
<td>60</td>
<td>72</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Surface band (no incorporation)</td>
<td>-</td>
<td>26</td>
<td>48</td>
<td>23</td>
<td>32</td>
</tr>
</tbody>
</table>

† Manure N availability = (NFEV / total N rate applied in manure and starter) x 100
Conclusions

• Injection resulted in less NH$_3$ volatilization and greater N availability (50% of total N)

• For broadcast applications,
  – NH$_3$ volatilization for <1 hr incorporation was 75% less than incorporation at 3 days
    • But N availability did not always match this trend in individual years
  – Averaged over all years, general trend for lower availability with greater time to incorporation
    • ~30% of total N for no incorporation

• Weather conditions and actual manure N rate affected results in individual years
Conclusions

• Sidedress application of manure is a viable N source for corn
  – Another window of time for manure application
  – May be lower N loss
  – Can use PSNT
  – Practical limitations
    • Equipment: Injection or direct incorporation preferred
      – Capture more N, reduce burning
    • Field issues: equipment turning, plant damage

• Data support recent changes to UWEX manure N availability
  – 50% injected or broadcast incorporated <1 hr
  – 40% broadcast incorporated 1 to 72 hr
  – 30% broadcast incorporated >72 hr or not incorporated
Thank You!

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