Agronomic & Fertilizer Management for Corn on Corn

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http://z.umn.edu/corn
More corn following corn in southern & central MN

Data from USDA-NASS (southern & central MN agricultural districts)
Faster yield gains for corn in southern & central MN

Data from USDA-NASS (southern & central MN agricultural districts)
Crop rotation increases yield & reduces N fertilizer needs for corn
1) Crop rotation increased yield (10-19% at highest N rate)
2) Crop rotation reduced N fertilizer needs for corn

From Stanger et al. (*Agronomy Journal*, 2008)
Crop rotation increased yield & reduced N needs

NE Iowa (2003-2006); loam soil

Crop rotation increased yield & reduced N needs

N Credit = MRTN_{(continuous corn)} - MRTN_{(rotated corn)}

Data from Mallarino & Pecinovsky, 2006; Slide courtesy of Michael Russelle, USDA-ARS
Yield penalty for corn following corn is less in high-yield environments.

20 corn entries in each rotation

Data from Crop Production Services

<table>
<thead>
<tr>
<th>Location</th>
<th>Corn after Corn</th>
<th>Corn after Soybean</th>
<th>Yield Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairmont, MN - 2011</td>
<td>211</td>
<td>220</td>
<td>+4%</td>
</tr>
<tr>
<td>Harmony, MN - 2011</td>
<td>203</td>
<td>213</td>
<td>+5%</td>
</tr>
</tbody>
</table>

Data from Crop Production Services
Potential for yield reduction when corn follows corn rather than soybean
The 3-year corn-corn-soybean rotation is a good compromise

12 site-years in northern & central Illinois (2004-2007)
silt loam & silty clay loam soils

<table>
<thead>
<tr>
<th>Crop and rotation</th>
<th>Yield (bu/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td></td>
</tr>
<tr>
<td>Corn-soy</td>
<td>197</td>
</tr>
<tr>
<td>1st-year corn in corn-corn-corn-soy</td>
<td>196</td>
</tr>
<tr>
<td>2nd-year corn in corn-corn-corn-soy</td>
<td>184 (-7%)</td>
</tr>
<tr>
<td>Continuous corn</td>
<td>178 (-10%)</td>
</tr>
<tr>
<td>Soybean</td>
<td></td>
</tr>
<tr>
<td>Corn-soy</td>
<td>54.9</td>
</tr>
<tr>
<td>Corn-corn-soy</td>
<td>58.3 (+6%)</td>
</tr>
</tbody>
</table>

From Emerson Nafziger (Illinois Agronomy Handbook, 2009)
Soybean benefits from more corn in the rotation

Lamberton MN – loam soil (2010)

<table>
<thead>
<tr>
<th>Cropping history (year)</th>
<th>% of soybean stem length with BSR symptoms</th>
<th>Soybean yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C C C C C C C S</td>
<td>6 d</td>
<td>68 a</td>
</tr>
<tr>
<td>C S C C C S C S</td>
<td>21 c</td>
<td>62 b</td>
</tr>
<tr>
<td>S C S C S C S C S</td>
<td>42 b</td>
<td>63 b</td>
</tr>
<tr>
<td>C S C S C S S S</td>
<td>55 a</td>
<td>55 c</td>
</tr>
</tbody>
</table>

Data from Bruce Potter

LSD (0.10)
Due to several factors, many of which are influenced by old corn residue:

- Seed placement
- Weeds
- Diseases
- Insects
- N immobilization
- Soil microbial community
- Soil structure (root extension, water infiltration)
- Autotoxic compounds
- Soil temperature
- Soil moisture
Yield drag for corn on corn is partially due to the residue

2 years in central Illinois; silty clay loam soil; 200 lb N/ac

<table>
<thead>
<tr>
<th>Cropping system</th>
<th>Yield (bu/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn after soybean</td>
<td>200</td>
</tr>
<tr>
<td>Corn after soy (corn residue added)</td>
<td>188 (-6%)</td>
</tr>
<tr>
<td>Corn after corn (residue removed)</td>
<td>176 (-12%)</td>
</tr>
<tr>
<td>Corn after corn</td>
<td>167 (-17%)</td>
</tr>
</tbody>
</table>

From Emerson Nafziger (Illinois Agronomy Handbook, 2009)
Corn residue over the row reduces soil temperature, which can...

• Cause delayed & uneven emergence

• Slow early root & shoot growth

• Slow nutrient uptake
  - Especially important for nutrients that are primarily taken up through diffusion (P, K, micronutrients)

• Early growth & nutrient uptake can affect yield
Corn residue in the row can cause autotoxicity

- Autotoxic compounds are released from corn residue
- Autotoxic compounds slow early growth & nutrient uptake by corn seedlings
Corn residue in the row can cause immobilization of N, leading to N deficiency

- Soil microbial populations increase as they feed on carbon-rich corn residue
- Due to limited N in corn residue, these growing microbial populations utilize N from the soil
- Less N is then available to corn
Minimize within-row residue problems when corn follows corn

– Distribute residue evenly behind the swath of combine

– If a full-width tillage system is used, *shred stalks & till early* in the *fall*

– Have good row cleaners & make sure they are working

– Monitor wear on double disc openers
Corn-on-corn residue management study

• 2011 & 2012 at Lamberton & Waseca, MN

• Clay loam soil (4-6% OM)

• All 4 trials were 2nd-year corn following soybean

• Fall disk-rip tillage system

• Soil fertility (excluding N & S) managed for 250+ bu/acr

• 30-inch rows; 35,000 seeds/acr
(Year 1-Soybean; Year 2-Corn; Year 3-Corn)

Corn residue treatments imposed in year 2

Residue chopped before fall tillage

Residue not chopped before fall tillage

9 combinations of N & S for 2nd-year corn

(in addition to 170 lb N/ac in spring)
• 2 main plot treatments (stalks chopped vs. not before fall tillage)

• 9 subplot treatments - in addition to 170 lb N/ac in spring
  1) Control
  2) 30 lb N/ac in fall
  3) 30 lb N/ac in spring
  4) 15 lb S/ac in fall
  5) 15 lb S/ac in spring
  6) 30 lb N/ac in fall + 15 lb S/ac in fall
  7) 30 lb N/ac in fall + 15 lb S/ac in spring
  8) 30 lb N/ac in spring + 15 lb S/ac in fall
  9) 30 lb N/ac in spring + 15 lb S/ac in spring

• Fall N = UAN    Spring N = urea    S = potassium thiosulfate (liquid)

• K applied to plots not receiving S – to maintain similar K levels
Results

• Emergence & plant population not affected by residue or fertilizer treatments

• Stalk chopping increased yield by 12 bu/ac (+8%) in 1 of 4 trials

• No yield response to N rates above 170 lb N/ac

• Sulfur (fall or spring) increased yield in 1 of 4 trials
Manage corn residue by removing it?
Considerations for harvest of corn residue

• Residue harvest best suited to continuous corn

• Sustainable harvest rates – soil organic matter & erosion

• Nutrient removal

• Soil compaction

• Effect on subsequent crop yields

• Effect on optimum tillage & fertilizer rates
Sustainable harvest rates for corn residue

• Continuous corn:
  - 40% with disk-rip tillage systems
  - Up to 50% with less intensive tillage systems

• Corn-soybean rotation:
  - 27% or less (about 15% of residue is cobs)

• Alternative: harvest a larger quantity of residue, but...
  - Only every other year in continuous corn
  - Only every 4th year in a corn-soybean rotation
  - Leave enough residue to protect against erosion
Nutrient replacement costs with 40% residue harvest in 200 bu/acre corn

<table>
<thead>
<tr>
<th>Nutrients removed with 40% residue removal (lb/acre)*</th>
<th>Nutrient price**</th>
<th>Nutrient replacement cost ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 lb N</td>
<td>$0.46/lb N</td>
<td>$12.88</td>
</tr>
<tr>
<td>11 lb P$_2$O$_5$</td>
<td>$0.66/lb P$_2$O$_5$</td>
<td>$7.26</td>
</tr>
<tr>
<td>48 lb K$_2$O</td>
<td>$0.50/lb K$_2$O</td>
<td>$24.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$44.14</td>
</tr>
</tbody>
</table>

*From Sawyer & Mallarino (2007).

**Nutrient sources were anhydrous ammonia, DAP, & potash. Cost of N in DAP was removed.
If residue is harvested in continuous corn, what is the optimum tillage system?

Do optimum N fertilizer rates differ with residue removal and tillage system?
1) Yield of continuous corn was lower with less tillage

2) Correlation between yield & surface residue coverage

Continuous corn - Rochester, MN (1997-2000)

Port Byron silt loam soil

Continuous corn residue removal study

• Established following corn in fall 2008 at Lamberton & Waseca, MN, yields measured from 2009 to 2012

• Treatments applied to the same plots each year

• Loam & clay loam soils

• Soil fertility (excluding N) managed for 250+ bu/ac

• Starter (5 gal/ac 10-34-0 in furrow)

• 102-day hybrid, 35,000 seeds/acre
Residue/tillage plots were subdivided into 6 N rate plots.

Residue retained

Disk-rip
Strip-till
No-till

Residue removed (baled)

Disk-rip
Strip-till
No-till

<table>
<thead>
<tr>
<th>Residue retained</th>
<th>Residue removed (baled)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk-rip</td>
<td>Disk-rip</td>
</tr>
<tr>
<td>Strip-till</td>
<td>Strip-till</td>
</tr>
<tr>
<td>No-till</td>
<td>No-till</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Residue retained</th>
<th>0</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residue removed</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>No-till</td>
<td>160</td>
<td>200</td>
</tr>
</tbody>
</table>
Residue removed + Disk-rip
Residue removed + Strip-till
Residue removed + No-till

Residue retained + Disk-rip
Residue retained + Strip-till
Residue retained + No-till
- When residue was removed, only no-till had at least 30% surface residue coverage, but strip-till was close
- 92 to 95% emergence across all tillage & residue treatments except for no-till with residue retained

Averaged across locations & years
Stover removal enhanced early-season growth, especially with reduced tillage systems.

Stover removed

Stover retained

No-till, 200 lb N/ac, V7 to V8 stage
- N deficiency was easily observed at the V7 to V8 stage

40 vs. 200 lb N/ac

Strip-till, Stover retained
- Residue removal increased yield by 4 to 12%
- Tillage system did not affect yield much

Averaged across locations & years; 200 lb N/ac

Corn grain yield (bu/ac)

<table>
<thead>
<tr>
<th>Method</th>
<th>Residue Removed</th>
<th>Residue Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk-rip</td>
<td>194</td>
<td>178</td>
</tr>
<tr>
<td>Strip-till</td>
<td>186</td>
<td>178</td>
</tr>
<tr>
<td>No-till</td>
<td>191</td>
<td>171</td>
</tr>
</tbody>
</table>

LSD (0.10)
- On average, residue removal increased yield by 13%
- Response to N did not differ among residue treatments
- On average, little difference among tillage systems
- Response to N did not differ among tillage systems

Averaged across locations, years, & residue treatments
- Optimum N rates were higher than expected
- Net return within $1/ac of maximum with 194 to >200 lb N/ac

Averaged across locations, years, residue treatments, & tillage systems

$6.50/bu; $0.50/lb N
**Take home points – continuous corn**

- Continuous corn yields less

- Consider a 3-year corn-corn-soybean rotation as an alternative to continuous corn

- High-input systems for managing crop residue in continuous corn do not guarantee high yields & they can be expensive
Take home points – residue management

• Yield reductions for corn on corn are due in part to residue, especially if it is not cleared out of the seed row.

• If full-width tillage is used for corn on corn, shredding stalks and tilling early in the fall should help, but research data does not strongly support.

• Applying N or S in the fall to stimulate residue decomposition is rarely effective.

• Focus on moving residue out of the row during planting & achieving excellent seed-to-soil contact.
Partial residue harvest appears sustainable on productive soils in the Corn Belt

Avoid residue harvest in drought-prone fields

Residue harvest is best suited to continuous corn

Reduce tillage following residue harvest

Optimum N rates do not differ much if residue is harvested
Take home points – tillage for corn on corn

• In general, yield of corn on corn has been greater with more aggressive tillage on poorly-drained fine-textured soils

• Conservation tillage for corn on corn can work well on:
  – medium- to coarse-textured soils
  – tile-drained fine-textured soils
  – fields where corn residue is harvested

• Optimum N rates do not differ much among tillage systems
Thanks!

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