Strip Intercropping of Corn and Soybeans in the U.S. – Potential Profitability?

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Strip Intercropping Production Solution

Strip Intercropping Production Solution (SIPS)

- Background
- Economic Model
- Current Findings
- Key Insights
SIPS – Background
Changes in Production Practices

- Intercropping tall and short crops may allow for more efficient capture of sunlight to increase yields.
- Evidence suggests intercropping corn and soybeans increases corn crop yields, although degree of yield improvement varies with strip width.
- For farms using large equipment implementing SIPS will require:
  - Equipment solutions to accommodate narrower, 4 or 6 row strips (planters, sprayers, and combines)
  - Enhanced production planning as fields may be visited twice per function per season (i.e., once to plant corn, once for soybeans).

Table 1. Yield Effects for Corn and Soybean from the Extant Literature

<table>
<thead>
<tr>
<th>Source</th>
<th>Moisture Status/Management</th>
<th>Crop Year</th>
<th>Unit</th>
<th>Corn Outer Row</th>
<th>Corn 2nd Row</th>
<th>Corn Inner Rows</th>
<th>Soy Outer Row</th>
<th>Soy 2nd Row</th>
<th>Soy Inner Rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesoing and Francis 1991</td>
<td>Below normal moisture</td>
<td>1988 Bu/ac</td>
<td></td>
<td>107.9 (+10%)</td>
<td>NR</td>
<td>97.7</td>
<td>22.8</td>
<td>NR</td>
<td>24.1</td>
</tr>
<tr>
<td>Lesoing and Francis 1991</td>
<td>Below normal moisture</td>
<td>1989 Mg/ha</td>
<td></td>
<td>145.5 (+30%)</td>
<td>NR</td>
<td>111.7</td>
<td>29.6</td>
<td>NR</td>
<td>38.1</td>
</tr>
<tr>
<td>Lesoing and Francis 1991</td>
<td>Near normal moisture</td>
<td>1990 Mg/ha</td>
<td></td>
<td>138.6 (+16%)</td>
<td>NR</td>
<td>119.2</td>
<td>30.1</td>
<td>NR</td>
<td>39.2</td>
</tr>
<tr>
<td>Lesoing and Francis 1991</td>
<td>Irrigated</td>
<td>1991</td>
<td></td>
<td>175.3 (+19%)</td>
<td>NR</td>
<td>147.1</td>
<td>26.9</td>
<td>NR</td>
<td>27.6</td>
</tr>
<tr>
<td>Lesoing and Francis 1991</td>
<td>Irrigated</td>
<td>1989 Mg/ha</td>
<td></td>
<td>243.8 (+31%)</td>
<td>NR</td>
<td>186.4</td>
<td>29.6</td>
<td>NR</td>
<td>43.0</td>
</tr>
<tr>
<td>Lesoing and Francis 1991</td>
<td>Irrigated</td>
<td>1990 Mg/ha</td>
<td></td>
<td>219.9 (+28%)</td>
<td>NR</td>
<td>172.1</td>
<td>36.5</td>
<td>NR</td>
<td>55.9</td>
</tr>
<tr>
<td>West and Griffith 1992</td>
<td>Normal Moisture-Reg Mgt.</td>
<td>1986-1990</td>
<td>Mg/ha</td>
<td>213.7 (+20%)</td>
<td>186.1 (+5%)</td>
<td>177.6</td>
<td>37.3</td>
<td>46.4</td>
<td>47.6 (+51.0)%</td>
</tr>
<tr>
<td>West and Griffith 1992</td>
<td>Normal Moisture-High Mgt.</td>
<td>1986-1990</td>
<td>Mg/ha</td>
<td>227.8 (+27%)</td>
<td>183.2 (+22%)</td>
<td>179.1</td>
<td>37.3</td>
<td>46.4</td>
<td>47.6 (+51.0)%</td>
</tr>
<tr>
<td>Bullock and Bullock 2013b</td>
<td>Normal moisture</td>
<td>2009 Mg/ha</td>
<td></td>
<td>230.1 (+41%)</td>
<td>236.1 (+44%)</td>
<td>219.9</td>
<td>32.8</td>
<td>57.4</td>
<td>82.1</td>
</tr>
<tr>
<td>Bullock and Bullock 2013b</td>
<td>Below normal moisture</td>
<td>2010 Mg/ha</td>
<td></td>
<td>255.1 (+51%)</td>
<td>194.4 (+47%)</td>
<td>165.7</td>
<td>33.5</td>
<td>49.4</td>
<td>58.9</td>
</tr>
</tbody>
</table>
SIPS - Background

Yield Response

- Assumptions for 6-row system based on University of Illinois research.

<table>
<thead>
<tr>
<th>Potential Yield Effects (bu/ac)</th>
<th>Corn</th>
<th>Soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal Year</td>
<td>Dry Year</td>
</tr>
<tr>
<td>1st (edge)</td>
<td>310</td>
<td>255</td>
</tr>
<tr>
<td>2nd</td>
<td>250</td>
<td>195</td>
</tr>
<tr>
<td>Center</td>
<td>220</td>
<td>165</td>
</tr>
</tbody>
</table>

Source: Dave Bullock, University of Illinois (journal article submitted for review) and Bob Recker (Corn and Soybean Digest, 2012).

Gross Revenue Comparisons – Underlying Assumptions

- We created a spreadsheet to calculate total field yields and gross revenues assuming strip intercropping with various strip widths.
  - We used outer row, 2nd row, and center row estimates for corn and soybeans from University of Illinois.
  - A typical year and Dry year results were modeled separately.
  - Two levels of prices were used – Both reflect the long-term historical ratio of Soybean / Corn prices of 2.5
    - $4 and $10 - Lower Corn / Bean price scenario
    - $7 and $17.50 Higher Corn / Bean price scenario
### Gross Revenue Comparisons – Underlying Assumptions

- Gross revenue calculated by varying
  - # of 30” rows per strip (4 to 16)
  - Price levels
    - Lower: $4 corn, $10 bean
    - Higher: $7 corn, $17.50 bean
  - Yields effects (U. Illinois results)

#### Corn vs. Bean

<table>
<thead>
<tr>
<th>Row</th>
<th>Normal</th>
<th>Dry</th>
<th>Normal</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st (Edge)</td>
<td>310</td>
<td>255</td>
<td>52</td>
<td>34</td>
</tr>
<tr>
<td>2nd</td>
<td>250</td>
<td>195</td>
<td>57</td>
<td>49</td>
</tr>
<tr>
<td>Center/Single Crop</td>
<td>220</td>
<td>165</td>
<td>62</td>
<td>59</td>
</tr>
</tbody>
</table>

- Differences in costs for strip intercropping not yet considered.

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### Gross Revenue Comparisons: Typical Weather, Lower Prices\(^a\)

- Single crop yields modeled as equal to “center row” of strips
- Headlands for strip intercropping were all soybeans.

<table>
<thead>
<tr>
<th>Strip Width</th>
<th>4-row</th>
<th>6-row</th>
<th>8-row</th>
<th>12-row</th>
<th>16-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>1 field corn, 1 field bean</td>
<td>$747</td>
<td>$747</td>
<td>$747</td>
<td>$747</td>
</tr>
<tr>
<td></td>
<td>2 fields Intercropped</td>
<td>$827</td>
<td>$798</td>
<td>$782</td>
<td>$765</td>
</tr>
<tr>
<td>Absolute Difference</td>
<td>$80.00</td>
<td>$51.00</td>
<td>$35.00</td>
<td>$18.00</td>
<td>$8.00</td>
</tr>
<tr>
<td>% DIFFERENCE</td>
<td>10.71</td>
<td>6.83</td>
<td>4.69</td>
<td>2.41</td>
<td>1.07</td>
</tr>
<tr>
<td>headlands (passes x rows)</td>
<td>2X4</td>
<td>2X6</td>
<td>2X8</td>
<td>2X12</td>
<td>2X16</td>
</tr>
</tbody>
</table>

\(^a\) Corn (bean) prices per bushel are $4.00 and $10.00.
### Gross Revenue Comparisons: Typical Weather, Higher Prices\(^a\)

- Single crop yields modeled as equal to “center row” of strips
- Headlands for strip intercropping were all soybeans.

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<th>12-row</th>
<th>16-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Gross Revenue per acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 field corn, 1 field bean</td>
<td>$1,312</td>
<td>$1,312</td>
<td>$1,312</td>
<td>$1,312</td>
<td>$1,312</td>
</tr>
<tr>
<td>2 fields Intercropped</td>
<td>$1,447</td>
<td>$1,396</td>
<td>$1,369</td>
<td>$1,339</td>
<td>$1,321</td>
</tr>
<tr>
<td>Absolute Difference</td>
<td>$135.00</td>
<td>$84.00</td>
<td>$57.00</td>
<td>$27.00</td>
<td>$9.00</td>
</tr>
<tr>
<td>% DIFFERENCE</td>
<td>10.29</td>
<td>6.40</td>
<td>4.34</td>
<td>2.06</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Headlands (passes x rows) 2X4 2X6 2X8 2X12 2X16

\(^a\) Corn (bean) prices per bushel are $7.00 and $17.50.

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### Gross Revenue Comparisons: Dry Weather, Lower Prices\(^a\)

- Single crop yields modeled as equal to “center row” of strips
- Headlands for strip intercropping were all soybeans.

<table>
<thead>
<tr>
<th>Strip Width</th>
<th>4-row</th>
<th>6-row</th>
<th>8-row</th>
<th>12-row</th>
<th>16-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Gross Revenue per acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 field corn, 1 field bean</td>
<td>$625</td>
<td>$625</td>
<td>$625</td>
<td>$625</td>
<td>$625</td>
</tr>
<tr>
<td>2 fields Intercropped</td>
<td>$656</td>
<td>$644</td>
<td>$638</td>
<td>$632</td>
<td>$628</td>
</tr>
<tr>
<td>Absolute Difference</td>
<td>$31.00</td>
<td>$19.00</td>
<td>$13.00</td>
<td>$7.00</td>
<td>$3.00</td>
</tr>
<tr>
<td>% DIFFERENCE</td>
<td>4.96</td>
<td>3.04</td>
<td>2.08</td>
<td>1.12</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Headlands (passes x rows) 2X4 2X6 2X8 2X12 2X16

\(^a\) Corn (bean) prices per bushel are $4.00 and $10.00.
Gross Revenue Comparisons:
Dry Weather, Higher Prices

• Single crop yields modeled as equal to “center row” of strips
• Headlands for strip intercropping were all soybeans.

<table>
<thead>
<tr>
<th>System</th>
<th>Strip Width</th>
<th>4-row</th>
<th>6-row</th>
<th>8-row</th>
<th>12-row</th>
<th>16-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 field corn, 1 field bean</td>
<td></td>
<td>$1,094</td>
<td>$1,094</td>
<td>$1,094</td>
<td>$1,094</td>
<td>$1,094</td>
</tr>
<tr>
<td>2 fields intercropped</td>
<td></td>
<td>$1,147</td>
<td>$1,127</td>
<td>$1,117</td>
<td>$1,106</td>
<td>$1,099</td>
</tr>
<tr>
<td>Absolute Difference</td>
<td></td>
<td>$53.00</td>
<td>$33.00</td>
<td>$23.00</td>
<td>$12.00</td>
<td>$5.00</td>
</tr>
<tr>
<td>% DIFFERENCE</td>
<td></td>
<td>4.84</td>
<td>3.02</td>
<td>2.10</td>
<td>1.10</td>
<td>0.46</td>
</tr>
<tr>
<td>headlands (passes x rows)</td>
<td></td>
<td>2X4</td>
<td>2X6</td>
<td>2X8</td>
<td>2X12</td>
<td>2X16</td>
</tr>
</tbody>
</table>

* Corn (bean) prices per bushel are $7.00 and $17.50.

Gross Revenue Improvements
Compared to Single Cropping
Intercropping Equipment Assumptions
Baseline Scenarios

Traditional Complement (5313 ac corn/soybeans)
- 308 hp FWA tractor
- 248 hp FWA tractor
- 16-row folding planter (with splitters to plant beans)
- Self-propelled sprayer with 88.5 ft. booms
- 402 hp combine (8-row corn head, 36 ft small grain platform)
- 892 bu grain cart
- 46 ft pull-type fertilizer spreader
- 24 ft chisel plow
- 46.9 ft field cultivator
- 16-row N sidedress applicator

Small Scale Complement (5313 ac corn/soybeans)
- 5, 50 hp tractors
- 3, 6-row planters
- 5, 15 ft 3-point boom sprayers
- 3, 6.5 ft chisel plows
- 3, 15 ft field cultivators
- 2, 302 hp combines (6 row corn head, 30 ft small grain platform)
- 4, 200 bu grain carts
- 2, 22 ft fertilizer spreader
- 3, 6-row sidedress N applicators

SIPS – Economic Model
Approach and Assumptions

Approach
- Corn and soybean budgets used to compare SIPS vs. traditional equipment.
- Revenue comparison based on Illinois study findings and historical range of corn/soybean prices.

Assumptions
- 50-50 corn/soybean crop mix with rotation.
- Corn planted from 4/15 – 5/15.
- For SIPS
  - Machinery complement necessary to match traditional scale.
  - Requires multiple sets of tractors and implements to ensure timeliness of planting, spraying and harvest.
- 5% field efficiency improvement on strip operations from smaller equipment.
SIPS - Current Findings

- Incentive for farmers to adopt strip intercropping comes from estimating corn and soybean production in 6-row strips.
- Reference estimates are included for
  - Traditional mono-culture enterprise
  - Strip Intercropping Production System poly-culture
- Assumptions:
  - Yields and gross revenues as estimated in previous slides.
  - Other than labor and machinery costs, all other poly-culture costs are assumed the same as for mono-cultures.
  - Seed, fertilizer, pest control costs may differ
  - Scale chosen to match optimal scale of traditional mono-culture enterprise.

SIPS – Cost Comparisons

<table>
<thead>
<tr>
<th>Labor and Machinery</th>
<th>Standard</th>
<th>Strip</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparison</strong></td>
<td>2665</td>
<td>2665</td>
</tr>
<tr>
<td>Acres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total field hours</td>
<td>1187</td>
<td>2716</td>
</tr>
<tr>
<td>b/w field transition</td>
<td>181</td>
<td>383</td>
</tr>
<tr>
<td>Total Hours</td>
<td>1368</td>
<td>3098</td>
</tr>
<tr>
<td>hrs/ac</td>
<td>0.51</td>
<td>1.16</td>
</tr>
<tr>
<td>Total Wage Bill</td>
<td>$21,714</td>
<td>$40,278</td>
</tr>
<tr>
<td>Wage/ac</td>
<td>$8</td>
<td>$15</td>
</tr>
<tr>
<td>Machinery cost/ac</td>
<td>$79</td>
<td>$163</td>
</tr>
<tr>
<td>Fuel Price</td>
<td>$3.50</td>
<td>$3.50</td>
</tr>
<tr>
<td>Fuel cost/ac</td>
<td>$32.66</td>
<td>$44.66</td>
</tr>
<tr>
<td>Machinery, Fuel, Lub, On Machine Labor Costs/ac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$119.81</td>
<td>$222.77</td>
</tr>
<tr>
<td>ratio</td>
<td></td>
<td>1.86</td>
</tr>
<tr>
<td>difference (relative to standard)</td>
<td></td>
<td>$102.97</td>
</tr>
</tbody>
</table>
SIPS - Current Findings

Net Return Differences

Returns, net of Labor and Machinery Costs ($/ac)
6-row strip

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Gross Revenue Difference</th>
<th>Net Revenue Conventional Production in Strips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Weather, High Prices(^a)</td>
<td>$84</td>
<td>($6)</td>
</tr>
<tr>
<td>Typical Weather, Low Prices(^b)</td>
<td>$51</td>
<td>($39)</td>
</tr>
<tr>
<td>Dry Weather, High Prices(^a)</td>
<td>$33</td>
<td>($57)</td>
</tr>
<tr>
<td>Dry Weather, Low Prices(^b)</td>
<td>$19</td>
<td>($71)</td>
</tr>
<tr>
<td>Average of Above Cases</td>
<td>$47</td>
<td>($43)</td>
</tr>
</tbody>
</table>

\(^a\) Corn and soybean prices are $4/bu and $10/bu.
\(^b\) Corn and soybean prices are $7/bu and $17.50/bu.
\(^c\) Represents difference compared to monoculture with conventional 8-row equipment.

Next Steps

- Explore literature for different yield estimates
- Add Costs, including consideration of:
  - If crops planted on same date
    - Yields decrease as optimal plant dates missed
    - For planting, same date may allow for single pass planting by alternating seed type on existing planter
  - Added costs for higher seeding rates, higher fertilizer application rates, higher costs for pest control
  - If crops are planted at near optimal calendar dates
    - Multiple trips to same field will decrease efficiency
  - In some areas where soybeans mature first, headlands may always need to be in soybeans
  - Use of Small Autonomous Equipment may limit inherent cost-side inefficiencies associated with smaller equipment
- Consider different bean/corn price ratios
  - Long run average is 2.5
  - Ranges from 2 to 3, with lower more favorable to strips
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http://aede.osu.edu/research/osu-farm-management