The Science of Integrated Crop – Livestock Systems

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Watkinsville GA
Integrated Crop–Livestock Systems

**Why?**

**Production**
- Farms operating on marginal profit
- Economic vulnerability with specialized production
- High cost of fuel and nutrients
- Pests become greater with monocultures
- Yield decline could be overcome with rotation

**Environment**
- Nutrient recycling could be improved in both systems
- Conservation of soil and water possible with sod-based management systems
Integrated Crop–Livestock Systems

Issues to be addressed

1. In an *integrated crop–livestock system*, there are many levels of subsystems that interact with each other. How do we study the science of integrated crop–livestock systems at multiple scales?

2. Are there any areas of research that can
   a. Improve our understanding of integrate crop–livestock systems?
   b. Increase the system’s output while reducing input?

3. What do we know about managing cropping patterns, manure management, and grazing to optimize nutrient cycling within an integrated crop–livestock system?

4. What do we know about the benefits and trade-offs of a mixed livestock and crop system and how to optimize the system?
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Cropping issues and their scale of investigation

Field level
- Tillage choice
- Plant population
- Fertilizer rate / timing
- Pest control

Root level
- Fertility
- Compaction
- Pests
- Beneficials

Farm level
- Crop support base
- Land capability
- Culture
- Capital / liability

Watershed level
- Nutrient planning
- Water use / quality
- Transportation

Regional level
- State regulations
- Labor availability
- Processing
- Storage

National level
- Federal regulations
- Government support
- Commodity price
- Supply / demand
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Livestock component

Stocker cattle production

Dairy production

Poultry production

Swine production

Cow / calf production
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Environmental component
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Socio-economic component

www.tilbookkeeping.com
www.calhounproduce.com
www.ronboswell.com

http://blog.americanfeast.com

Come and get it
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How can research help?

...through analysis of systems; well-defined boundaries and goals, consisting of different parts that convert inputs into outputs and that work together towards a common goal

Both component- and system-level research needed

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How can research help?


Sod-based crop rotations are needed to maintain fertility and soil quality.
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How can research help?

Sod- and legume-based rotations are important for maintaining productivity through nutrient cycling.


Compared with continuous corn

<table>
<thead>
<tr>
<th></th>
<th>Rye</th>
<th>Vetch</th>
<th>Alfalfa</th>
<th>Bermuda</th>
<th>Fescue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen savings (kg ha(^{-1}))</td>
<td>7</td>
<td>120</td>
<td>17</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Rotation effect (% yield increase)</td>
<td>17</td>
<td>1</td>
<td>17</td>
<td>10</td>
<td>23</td>
</tr>
</tbody>
</table>

How might responses change if grazed by cattle?
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How can research help?

Crop-specific responses to rotations and integrated systems will be important.

# Integrated Crop–Livestock Systems

## How can research help?

### Data from Wilkinson et al. (1987) Agron. J. 79:685-690

<table>
<thead>
<tr>
<th>Management System</th>
<th>Corn Grain Yield (Mg·ha⁻¹)</th>
<th>Forage Yield (Mg·ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Tillage</td>
<td>100% kill</td>
<td>40% kill</td>
</tr>
<tr>
<td>No Tillage</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

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To meet changing farm needs, sod-grain intercropping can provide flexibility.

Data from Wilkinson et al. (1987) Agron. J. 79:685-690
## Integrated Crop–Livestock Systems

### How can research help?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Pairs of obs.</th>
<th>Conventional</th>
<th>No Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>19</td>
<td>6.82</td>
<td>7.12</td>
</tr>
<tr>
<td>Corn silage</td>
<td>5</td>
<td>15.3</td>
<td>16.1</td>
</tr>
<tr>
<td>Cotton lint</td>
<td>18</td>
<td>1.04</td>
<td>1.06</td>
</tr>
<tr>
<td>Cotton seed</td>
<td>9</td>
<td>2.59</td>
<td>2.69</td>
</tr>
<tr>
<td>Peanut seed</td>
<td>6</td>
<td>3.37</td>
<td>3.43</td>
</tr>
<tr>
<td>Soybean seed</td>
<td>18</td>
<td>2.05</td>
<td>2.12</td>
</tr>
<tr>
<td>Wheat grain</td>
<td>9</td>
<td>3.00</td>
<td>3.11</td>
</tr>
</tbody>
</table>

Under a diversity of conditions, conservation tillage can produce successful crops.

Integrated Crop–Livestock Systems

How can research help?

<table>
<thead>
<tr>
<th>Cropping system</th>
<th>Years</th>
<th>Conventional</th>
<th>No Till</th>
<th>Mg ha⁻¹</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum (corn) / rye</td>
<td>2002-2005</td>
<td>3.20</td>
<td>3.39</td>
<td></td>
<td>+6%</td>
</tr>
<tr>
<td>Wheat / pearl millet</td>
<td>2002-2005</td>
<td>2.76</td>
<td>2.62</td>
<td></td>
<td>-5%</td>
</tr>
<tr>
<td>Rye / sorghum (corn)</td>
<td>2003-2005</td>
<td>6.03</td>
<td>7.02</td>
<td></td>
<td>+16%</td>
</tr>
<tr>
<td>Pearl millet / wheat</td>
<td>2002-2005</td>
<td>7.59</td>
<td>10.19</td>
<td></td>
<td>+34%</td>
</tr>
</tbody>
</table>

In an integrated crop-livestock system, conservation tillage can produce successful grain crops and even better cover crops!

## Integrated Crop–Livestock Systems

### How can research help?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Years</th>
<th>Ungraazed</th>
<th>Grazed</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum grain</td>
<td>2002-2004</td>
<td>2.07</td>
<td>1.82</td>
<td>-12%</td>
</tr>
<tr>
<td>Corn grain</td>
<td>2005-2007</td>
<td>3.64</td>
<td>3.32</td>
<td>-9%</td>
</tr>
<tr>
<td>Wheat grain</td>
<td>2003-2008</td>
<td>2.96</td>
<td>3.09</td>
<td>+4%</td>
</tr>
</tbody>
</table>

**Cattle grazing days**

<table>
<thead>
<tr>
<th></th>
<th>2002-2005</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>352 ± 104</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cattle gain**

<table>
<thead>
<tr>
<th></th>
<th>2002-2005</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>290 ± 142</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Crop yields may be somewhat negatively affected, but grazing cover crops can increase diversity and productivity of system.

### Integrated Crop–Livestock Systems

**How can research help?**

- Diversity of crop and cattle system can improve economic bottom line, more so than tillage system.

<table>
<thead>
<tr>
<th>Item</th>
<th>Ungrazed cover</th>
<th>Grazed cover crop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conv. Till</td>
<td>No Till</td>
</tr>
<tr>
<td>Variable cost</td>
<td>258</td>
<td>267</td>
</tr>
<tr>
<td>Cover crop cost</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>Value of crop</td>
<td>275</td>
<td>307</td>
</tr>
<tr>
<td>Value of cattle gain</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net return</td>
<td><strong>−74</strong></td>
<td><strong>−51</strong></td>
</tr>
</tbody>
</table>

**Integrated crop-livestock system in Watkinsville GA**

With short-term grazing of cover crops (48 ± 16 days), compaction was not a problem and soil organic C was not affected.

Manure can be effectively applied to meet crop demand, and can limit leakage to the environment due to organic phase.
### Integrated Crop–Livestock Systems

#### Benefits and trade-offs

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer against climate fluctuations</td>
<td>Risk of disease and crop damage</td>
</tr>
<tr>
<td>Diversified income sources</td>
<td>Continuous labor requirement</td>
</tr>
<tr>
<td>Source of security and savings</td>
<td>Requires investment</td>
</tr>
<tr>
<td>Investment option</td>
<td>Requires capital</td>
</tr>
<tr>
<td>Buffer against trade and price fluctuations</td>
<td>Requires multiple expertise; less economies of scale</td>
</tr>
<tr>
<td>Alternative use for low-quality roughages</td>
<td>Competition for crop residues with other uses</td>
</tr>
</tbody>
</table>

Integrated Crop–Livestock Systems

Example systems research

Wisconsin Integrated Cropping Systems Trial

Cash grain systems
1. Continuous corn, high fertilizer and pesticide input, chisel plow
2. Corn-soybean, medium input, no tillage
3. Corn-soybean-wheat/clover, organic, chisel plow

Integrated crop-livestock systems
4. Corn-alfalfa (3 yr), high fertilizer and pesticide input, chisel plow
5. Corn-oat/alfalfa, low fertilizer + manure input, chisel plow
6. Mixed pasture, low fertilizer + manure input, no tillage

<table>
<thead>
<tr>
<th>Corn grain</th>
<th>Soy bean grain</th>
<th>Wheat grain</th>
<th>Alfalfa forage</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.7</td>
<td>3.4</td>
<td>3.2</td>
<td></td>
</tr>
</tbody>
</table>

Livestock production component should be included

Weeds reduced crop yield in organic systems by 26% in 1/3 of years (wet spring conditions), while in the remaining 2/3 of years organic production yielded the same as conventional production systems.

Data from Posner et al. (2008) Agron. J. 100:253-260
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Example systems

Integrated Crop-Livestock with Zero Tillage in Brazil

<table>
<thead>
<tr>
<th>Basic ICLZT systems in Brazil are comprised of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Winter stubble grazing on summer cropland</td>
</tr>
<tr>
<td>2. Summer crops with winter pastures (undersown or oversewn)</td>
</tr>
<tr>
<td>3. Summer crop plus second crop plus stubble grazing in winter</td>
</tr>
<tr>
<td>4. Crop production for feed supplement (silage, sugarcane, elephant grass, hay, green forage), usually a minor area within another system</td>
</tr>
<tr>
<td>5. Some combination of these</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enterprises:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solely beef cattle</td>
</tr>
<tr>
<td>Solely crops</td>
</tr>
<tr>
<td>Beef on pasture x crops</td>
</tr>
<tr>
<td>Beef cattle in yards x cut forage from crop area</td>
</tr>
</tbody>
</table>

**FIGURE 3:** A comparison of gross margins at different levels of crop x livestock integration

*Source: R. Merola, unpublished farm data.*

Integrated Crop–Livestock Systems

Example systems

No-till drilling on upland sods in Mississippi

Benefits of no-tillage planting of crops into pasture

• Elimination of wild forms of E+ tall fescue
• Control of problem weeds in pastures
• Greater income from upland sites
• Greater labor efficiency

Information provided by Glover Triplett (personal communication)
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Example systems

Short-term grazing of cover crops in Georgia

Benefits of cover crops

- Controlling soil erosion
- Providing high quality forage
- Reducing water and nutrient runoff
- Improving soil tilth, structure, and nutrient cycling
- Modifying soil moisture through ↑ uptake and ↓ evaporation
- Contributing to soil C sequestration and soil biodiversity
- Controlling weeds through competition, allelopathy, etc.
- Controlling insect and disease pressures more ecologically
- Serving as a nutrient trap in high-fertility systems
- If leguminous, providing biologically fixed N
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Summary and outlook

Conservation of soil and water resources is a necessity in our world of ever-changing and competing human activities.

Meeting the food and fiber demands of a growing world population will only become more difficult with competing energy and natural resource commitments.

Integration of crops and livestock has great potential to improve resource efficiency of agricultural production around the world.

Sod-based crop rotations effectively improve soil and water quality.

Cover crops offer unique opportunities to integrate livestock grazing with cropping systems.

Some cases of integration have been developed, but much more research is needed to optimize systems within unique local and regional conditions.