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Long-term Weed Management Using Diverse Crop Rotation Systems

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Introduction
Now that the elevators are filled with grain, farm life is slowing down, and farmers in Iowa can look back at a year with generally good yields, it is important to recognize that our wealth and prosperity are not without a cost. Nationwide, herbicide use has not diminished, despite the use of glyphosate resistant genetically engineered crops (http://www.epa.gov/oppbead1/pestsales/), and intensive row-cropping in combination with the use of high rates of synthetic fertilizer and drainage tiles contributes to high concentrations of nitrate in surface waters (Randall et al., 1997; Schilling and Libra, 2000) and hypoxia in the Gulf of Mexico (Burkart and James, 1999). Is it possible to run a profitable farm that better promotes human and environmental health? We are conducting an experiment in which three crop management systems are being compared with respect to weed management, crop yield, net return, labor and energy use. Two of the three systems receive reduced rates of herbicide and fertilizer inputs, while the third one is managed with conventional inputs.

Crop rotation experiment
The three rotations that are being studied are 1) the conventional 2-year system (corn-soybean) commonly used in the Corn Belt; 2) a 3-year system suitable for producers with a need or a market for small grains (corn-soybean-triticale/red clover); and 3) a 4-year system suitable for producers who have ruminant livestock (corn-soybean-triticale/alfalfa-alfalfa). Non-Roundup Ready soybeans were used. The experiment started in 2002 and continues to the present day. It consists of thirty-six 60’x 275’ plots. Every phase of each rotation is present every year in four replicate blocks. The population dynamics of velvetleaf and giant foxtail are studied intensively, by measuring weed seed longevity in the soil, weed seedling emergence and survival, weed seed production, and weed seed loss to vertebrate (rodent) and invertebrate (insect) seed predators. In November 2002, an initial pulse of 185 giant foxtail seeds and 45 velvetleaf seeds per square foot was added to 23’ x 23’ areas within each plot.

Comparison of inputs
Compared with the 2-yr rotation, nitrogen fertilizer use in the 3-yr and 4-yr rotations has been reduced 50% and 73%, respectively (Table 1). These reductions were possible by using cattle manure and legume residues as alternative sources of N for corn, as well as lower frequencies of corn in the rotations. The late spring nitrate test (LSNT) was used for corn in each of the three rotation systems. Herbicide use was 71% lower in the 3-yr rotation and 78% lower in the 4-yr rotation, compared with the 2-yr rotation. Reductions in herbicide use in the longer rotations were made possible by combining banded applications with rotary hoeing and interrow cultivation in corn and soybean, as well as eliminating applications in triticale and alfalfa.
Table 1. Comparison of inputs, weed seedbank densities, yields and resource use by crop rotation system, 2003-2005

<table>
<thead>
<tr>
<th></th>
<th>2-yr rotation corn-soybean</th>
<th>3-yr rotation corn-soybean-tritiale+red clover</th>
<th>4-yr rotation corn-soybean-tritiale+alfalfa-alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td>N fertilizer use (lb N acre⁻¹ yr⁻¹)</td>
<td>56</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>Herbicide use (lb a.i. acre⁻¹ yr⁻¹)</td>
<td>1.96</td>
<td>0.57</td>
<td>0.43</td>
</tr>
<tr>
<td>Velvetleaf seedbank density in spring 2005 (# acre⁻¹; initial 44 acre⁻¹)</td>
<td>11</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Giant foxtail seedbank density in spring 2005 (# acre⁻¹; initial 175 acre⁻¹)</td>
<td>12</td>
<td>142</td>
<td>92</td>
</tr>
<tr>
<td>Corn yield (bu acre⁻¹)</td>
<td>199</td>
<td>207</td>
<td>207</td>
</tr>
<tr>
<td>Soybean yield (bu acre⁻¹)</td>
<td>52</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>Triticale yield (bu acre⁻¹;56 lb bu⁻¹)</td>
<td>63</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Alfalfa yield (tons acre⁻¹)</td>
<td></td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>Energy use (gal. diesel acre⁻¹ yr⁻¹) *</td>
<td>38</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Labor for field work (hr acre⁻¹ yr⁻¹) *</td>
<td>0.75</td>
<td>1.19</td>
<td>1.36</td>
</tr>
<tr>
<td>Cost of production ($ acre⁻¹ yr⁻¹) *</td>
<td>183</td>
<td>140</td>
<td>131</td>
</tr>
</tbody>
</table>

* prepared by Craig Chase, ISU Extension.

**Weed management**

Weed densities in a field continually change in response to management practices. Many factors other than herbicides influence these shifts, including timing and intensity of tillage, row spacing, crop rotation, and so on. Velvetleaf and giant foxtail seed densities declined in each of the three rotation systems, though declines were greatest in the 2-year system (Table 1). Plant densities and seed production tended to be greater in corn and soybean in the 3-yr and 4-yr rotations where herbicides were partially replaced by mechanical control practices. Triticale with a legume companion crop and the alfalfa hay crop reduced velvetleaf seedbanks in the 3-yr and 4-yr rotations by restricting mature plant densities and by greatly limiting the production of new seeds. Giant foxtail was less restricted by small grains and forage crops. Seed predation experiments suggest that observed declines in weed seedbanks in the 3-yr and 4-yr rotations may result from high rates of destruction of seeds by seed predators.

**Comparison of outputs**

Despite differences in fertilizer and herbicide inputs, corn and soybean yields have been similar or slightly higher in the longer rotation systems compared to the 2-yr rotation (Table 1). Triticale yields in the 3-yr rotation (with a red clover companion crop) and the 4-yr rotation (with an alfalfa companion crop) have been similar.

**Comparison of resource use and economics**

Average returns to land, labor, and management were greatest in the 4-yr system ($192 acre⁻¹), least in the 3-yr system ($160 acre⁻¹), and intermediate in the 2-yr system ($173 acre⁻¹). Labor requirements have been 59% and 81% higher in the 3-yr and 4-yr rotations, respectively, compared with the 2-yr system (Table 1). Energy use, however, has 39% and 45% lower in the
3-yr and 4-yr rotations, respectively, compared with the 2-yr system. Production costs in the 3-yr and 4-yr rotations were 23% and 28% lower, respectively, compared with the 2-yr rotation system. Moving toward use of Roundup Ready soybean would reduce production costs about $20 per acre in the 2-yr rotation. However, adding an additional year of alfalfa to the 4-yr system to create a 5-yr system (C-SB-T/A-A-A) would lower production costs.

**Conclusions**

Our crop rotation experiment shows that herbicides and fertilizer inputs can be greatly reduced compared to conventional practices, without jeopardizing farm income. In fact, the 4-yr rotation, which received the lowest amounts of inputs, was the most profitable over the three years of our study. We observed a trade-off between energy and labor requirements, which may favor the less energy-demanding 4-yr rotation in times of high energy prices. Key to successful weed management with fewer herbicides is more diverse crop rotations that affect weeds at multiple stages in their life cycles.

**References**

