Evaluation of Herbicide Programs for the Termination of Cover Crop Species in the Spring
Materials and Methods

General: Identical field experiment conducted in Columbia, MO in 2013, 2014 and 2015

Planting Dates: September 11, 2012; September 11 2013 and September 13, 2014

Termination Dates: Early April and early May each year

Seeding Rates (lbs/A):

- Wheat 120
- Cereal Rye 110
- Italian rye grass 25
- Oats 70
- Crimson Clover 30
- Austrian Winter Pea 50
- Hairy Vetch 30
- Cereal Rye + Hairy Vetch 70 + 30
Some species will winter kill....

Tillage Radish 12/3/2013
Columbia, Missouri

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Influence of Herbicide Treatments and Application Timings on the Control of a Wheat Cover Crop (results averaged across 3 years)

- Early Timing (early April)
- Late Timing (early May)

- 28 ozs Roundup
- 28 ozs Roundup + 1 pt 2,4-D
- 28 ozs Roundup + 16 ozs Clarity
- 28 ozs Roundup + 1 oz Sharpen
- 28 ozs Roundup + 1 qt Aatrex
- 28 ozs Roundup + 4 ozs Canopy
- 4 pts Gramoxone
- 4 pts Gramoxone + 1 pt 2,4-D
- 4 pts Gramoxone + 1 qt Aatrex

% Visual Control 28 Days after Treatment
Influence of Herbicide Treatments and Application Timings on the Control of a Cereal Rye Cover Crop (results averaged across 3 years)

% Visual Control 28 Days after Treatment
Influence of Herbicide Treatments and Application Timings on the Control of a Annual Ryegrass Cover Crop (results averaged across 3 years)
Influence of Herbicide Treatments and Application Timings on the Control of a Crimson Clover Cover Crop (results averaged across 3 years)

- 28 ozs Roundup
- 28 ozs Roundup + 1 pt 2,4-D
- 28 ozs Roundup + 16 ozs Clarity
- 28 ozs Roundup + 1 oz Sharpen
- 28 ozs Roundup + 1 qt Aatrex
- 28 ozs Roundup + 4 ozs Canopy
- 4 pts Gramoxone
- 4 pts Gramoxone + 1 pt 2,4-D
- 4 pts Gramoxone + 1 qt Aatrex

% Visual Control 28 Days after Treatment
Influence of Herbicide Treatments and Application Timings on the Control of a Hairy Vetch Cover Crop (results averaged across 3 years)

<table>
<thead>
<tr>
<th>Herbicide Treatment</th>
<th>Early Timing (early April)</th>
<th>Late Timing (early May)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 ozs Roundup</td>
<td>90%</td>
<td>70%</td>
</tr>
<tr>
<td>28 ozs Roundup + 1 pt 2,4-D</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>28 ozs Roundup + 16 ozs Clarity</td>
<td>92%</td>
<td>80%</td>
</tr>
<tr>
<td>28 ozs Roundup + 1 oz Sharpen</td>
<td>88%</td>
<td>70%</td>
</tr>
<tr>
<td>28 ozs Roundup + 1 qt Aatrex</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>28 ozs Roundup + 4 ozs Canopy</td>
<td>85%</td>
<td>70%</td>
</tr>
<tr>
<td>4 pts Gramoxone</td>
<td>85%</td>
<td>60%</td>
</tr>
<tr>
<td>4 pts Gramoxone + 1 pt 2,4-D</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>4 pts Gramoxone + 1 qt Aatrex</td>
<td>90%</td>
<td>80%</td>
</tr>
</tbody>
</table>

% Visual Control 28 Days after Treatment
Influence of Herbicide Treatments and Application Timings on the Control of a Austrian Pea Cover Crop (results averaged across 3 years)

% Visual Control 28 Days after Treatment

- Early Timing (early April)
- Late Timing (early May)

- 28 ozs Roundup: 95%
- 28 ozs Roundup + 1 pt 2,4-D: 90%
- 28 ozs Roundup + 16 ozs Clarity: 92%
- 28 ozs Roundup + 1 oz Sharpen: 91%
- 28 ozs Roundup + 1 qt Aatrex: 93%
- 28 ozs Roundup + 4 ozs Canopy: 94%
- 4 pts Gramoxone: 96%
- 4 pts Gramoxone + 1 pt 2,4-D: 97%
- 4 pts Gramoxone + 1 qt Aatrex: 98%
The Effect of Herbicide Application Timing on Biomass Reduction of Various Cover Crop Species
(results summarized across 3 years in Missouri)

- Austrian winter pea
- Crimson Clover
- Hairy Vetch
- Annual ryegrass
- Wheat
- Cereal rye + hairy vetch
- Cereal rye

% Biomass Reduction 28 Days After Treatment

*Bars followed by the same letter are not different, LSD$_{0.05}$*
Influence of Glyphosate + 2,4-D on Burndown of Various Cover Crops

Winter Wheat
- early
- late

Cereal Rye
- early
- late

Annual Ryegrass
- early
- late

Crimson Clover
- early
- late

Hairy Vetch
- early
- late

Austrian Winter Pea
- early
- late
Influence of Selected Herbicide Treatments on Cover Crop Biomass Reduction

(results averaged across 7 cover crop species and 3 years in Missouri)

<table>
<thead>
<tr>
<th>Herbicide Treatment</th>
<th>Biomass Reduction 28 Days After Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate + Clarity</td>
<td>a</td>
</tr>
<tr>
<td>Glyphosate + 2,4-D</td>
<td>a</td>
</tr>
<tr>
<td>Gramoxone Inteon + 2,4-D</td>
<td>a</td>
</tr>
<tr>
<td>Glyphosate + Sharpen</td>
<td>ab</td>
</tr>
<tr>
<td>Gramoxone Inteon + Atrazine</td>
<td>ab</td>
</tr>
<tr>
<td>Glyphosate + Canopy EX</td>
<td>bc</td>
</tr>
<tr>
<td>Glyphosate + Atrazine</td>
<td>bc</td>
</tr>
<tr>
<td>Gramoxone Inteon</td>
<td>c</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>c</td>
</tr>
</tbody>
</table>

*Bars followed by the same letter are not different, LSD_{0.05}
Conclusions:
Biomass reduction in response to application timing

The early application timing resulted in significantly greater biomass reduction for all cover crops except:

• Austrian Winter Pea
• Hairy Vetch
Conclusions:
Most effective herbicide program across all cover crop species

In general, herbicide programs that contained a growth regulator resulted in the most consistent control across all cover crop species:

Biomass Reduction:
• Glyphosate + 2,4-D: 83%
• Glyphosate + Clarity: 85%

Visual Control:
• Glyphosate + 2,4-D: 90%
• Glyphosate + Clarity: 90%
All cover crops should not be viewed equally...
Annual Ryegrass
Lolium multiflorum
a.k.a. “Italian Ryegrass” or just “Rye grass”
NOT Annual Rye NOT Cereal Rye

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Top 15 Resistant Weeds According to # of Herbicide Modes of Action

1. Rigid Ryegrass - 11
2. Barnyardgrass - 9
3. Annual Bluegrass - 9
4. Goosegrass - 7
5. Blackgrass - 6
6. Waterhemp - 6
7. Junglerice - 6
8. Annual Ryegrass - 5
10. Common Ragweed - 5
11. Wild Oat - 5
12. Horseweed - 5
13. Redroot Pigweed - 4
14. Downy Brome - 4
15. Common Lambsquarters - 4

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Glyphosate-resistant ryegrass is now one of the most significant weed problems in many southern states.

Photo courtesy of Dr. Larry Steckel
### Influence of Herbicide Treatments and Timings on the Control of an Annual Ryegrass Cover Crop (Columbia, Missouri 2013)

<table>
<thead>
<tr>
<th>Herbicide Treatment</th>
<th>Application Timing</th>
<th>Rate</th>
<th>Early (April 2)</th>
<th>Mid (April 22)</th>
<th>Late (May 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-product/A-</td>
<td>---% Ann. Ryegrass Biomass Reduction 28 DAT---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax</td>
<td>36 fl ozs</td>
<td>93</td>
<td>80</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax + 2,4-D</td>
<td>36 fl ozs + 1 pt</td>
<td>92</td>
<td>75</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax + Clarity</td>
<td>36 fl ozs + 1 pt</td>
<td>87</td>
<td>65</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax + Sharpen</td>
<td>36 fl ozs + 1 fl oz</td>
<td>90</td>
<td>76</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax + Aatrex</td>
<td>36 fl ozs + 1 qt</td>
<td>91</td>
<td>81</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax + Canopy</td>
<td>36 fl ozs + 4 ozs</td>
<td>88</td>
<td>79</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Roundup PowerMax + Basis Blend</td>
<td>36 fl ozs + 1.25 ozs</td>
<td>83</td>
<td>78</td>
<td>56</td>
<td></td>
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<tr>
<td>Roundup PowerMax</td>
<td>72 fl ozs</td>
<td>90</td>
<td>78</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Gramoxone Inteon</td>
<td>4 pts</td>
<td>78</td>
<td>77</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Gramoxone Inteon + 2,4-D</td>
<td>4 pts + 1 pt</td>
<td>90</td>
<td>77</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Gramoxone Inteon + Aatrex</td>
<td>4 pts + 1 qt</td>
<td>87</td>
<td>82</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Gromoxone Inteon + Lorox</td>
<td>4 pts + 24 ozs</td>
<td>89</td>
<td>83</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Gromoxone Inteon + Sencor + 2,4-D</td>
<td>4 pts + 4 ozs + 1 pt</td>
<td>90</td>
<td>87</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Liberty</td>
<td>29 fl ozs</td>
<td>35</td>
<td>50</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Liberty + Atrazine</td>
<td>29 fl ozs + 1 qt</td>
<td>71</td>
<td>50</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

**LSD**<sub>0.05</sub> (treatments x timings): 15
36 fl ozs Roundup PowerMax + 1 qt Aatrex

April 2\textsuperscript{nd} application

April 22\textsuperscript{nd} application

May 16\textsuperscript{th} application

photos taken on June 1\textsuperscript{st}

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Effective Kill of Cover Crop Species

• Proper herbicide timing (late March/early April) is important for most species

• Proper temperature/environment before and after application may be just as important

• Species that are likely to winter kill in central Missouri = tillage radish, sometimes oats

• Species that have proven difficult to control = wheat, crimson clover, Italian ryegrass

• Species that are fairly easy to control = cereal rye, Austrian winter pea,