Herbicides: Past, Present, and Future
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Background

• Presentation based on paper:
History of herbicide use

• Early days 1920’s to 40’s: Focused on persistent perennial control with inorganic compounds. Sodium chlorate, sodium arsenite, sodium metaborate tetrahydrate.
  – High rates, highly residual, and high cost
History of herbicide use

• Early attempts at selective weed control in cereals
  – Sulphuric acid, copper nitrate, iron sulphate, sodium chloride, sodium dichromate, sodium chlorate, ammonium thiocyanate, ammonium bisulphate.
  – Only copper nitrate, copper sulphate and sulphuric acid provided selective control.
  – Sulphuric acid (4% soln.) applied at 840-1,120 L/ha controlled mustards, stinkweed, wild radish, false flax, and wild buckwheat.
  – Copper compounds less efficacious but less crop injury and higher yield responses.
History of herbicide use

• Selective weed control
  – 1940’s – attention turned to organic compounds due to less crop injury, lower corrosiveness and lower toxicity;
  – Sinox (Sodium dinitro-o-cresylate) introduced in 1944 for cereals and flax - applied in 420 – 560 L of water/ha. Provided excellent control of wild mustard, stinkweed and lamb’s quarters and suppressed wild buckwheat.
  – Sometimes resulted in “spectacular” yield increases.
Applying Sinox at Scott Research Farm, 1948.
Modern Herbicide Era begins in 1945 with introduction of 2,4-D

<table>
<thead>
<tr>
<th>Year</th>
<th>Ha Treated</th>
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<tbody>
<tr>
<td>1946</td>
<td>40</td>
</tr>
<tr>
<td>1947</td>
<td>200,000</td>
</tr>
<tr>
<td>1949</td>
<td>3.2 M</td>
</tr>
<tr>
<td>1962</td>
<td>10 M</td>
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# Herbicide Mode of Action Development in Western Canada

## Table: Herbicide Mode of Action (MOA) Development

<table>
<thead>
<tr>
<th>Decade</th>
<th>1940s</th>
<th>1950s</th>
<th>1960s</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
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<tbody>
<tr>
<td>MOA</td>
<td>Gr 4</td>
<td>Gr 8</td>
<td>Gr 3</td>
<td>Gr 1</td>
<td>Gr 2</td>
<td>Gr 10</td>
<td>Gr 28</td>
</tr>
<tr>
<td></td>
<td>Gr 11</td>
<td>Gr 5</td>
<td>Gr 9</td>
<td></td>
<td></td>
<td>Gr 14</td>
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<td></td>
<td>Gr 6</td>
<td>Gr 20</td>
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<td>Gr 15</td>
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<td></td>
<td>Gr 7</td>
<td>Gr 25</td>
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<tr>
<td></td>
<td>Gr 22</td>
<td>Gr 27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total MOA Development:** 19
Number of Herbicide Resistant Weeds – World 2010

Source: Ian Heap
http://WeedScience.com
Glyphosate introduced in 1976

• Transformed agriculture in the Prairies

• About 50% of the herbicide market share in North America; 30% world-wide.
Adoption rate of glyphosate-resistant crops in the United States
Where Weedkiller Won’t Work

Farmers' wide use of Roundup, also known as glyphosate, a popular herbicide, has led to the spread of Roundup-resistant weeds across the country. At least 10 species of Roundup-resistant weeds have infested millions of acres in 22 states since 2000.
Non-GMO path opens for flax and canola

Faster, cheaper, natural development of new traits has been commissioned to a San Diego company

Written by John Dietz

Somewhere in San Diego, future Canadian canola and flax products are being developed right now in high-tech laboratories and greenhouses. Cibus Global, a trait development company formed in 2001, is developing canola varieties and is doing research on behalf of the Flax Council of Canada. The initial task for Cibus is to build-in herbicide tolerance, without GMO technology, for flax, canola and potato.
Confirmed Group 2 resistant Weeds in Western Canada

1. kochia
2. Russian thistle
3. spiny annual sow-thistle
4. redroot pigweed
5. wild mustard
6. wild oat
7. green foxtail
8. hemp-nettle
9. stinkweed
10. cleavers
11. chickweed
12. ball mustard
13. wild buckwheat
14. shepherd’s purse.
2007 spring survey: 100 fields almost 90% resistant
Predicted increase of HR individuals over time

Herbicide A or B used alone
Rotation of herbicide A and B
Mixture of herbicide A and B

(Powles et al. 1997)
Kochia control in cereals

• Unless you know otherwise assume your kochia has some group 2 resistant types
• Group 2 mixes with another mode of action may not always be effective for controlling kochia.
• Group 2 tank-mixes that control group 2 resistant kochia
  –Triton K, Stellar and Benchmark
Present and Future

• Present: PPO inhibitors – Group 14
  – Carfentrazone (CleanStart); Saflufenacil (Heat); Sulfentrazone (Authority)

• Future:
  – Aminocyclopyrachlor – Group 4 (auxin)
  – Pyroxasulfone – Group 15 ?
Authority

- Recently received full registration.
- Crops: chickpea, flax, field pea, and sunflower.
- Label details to be available soon.
- Very effective on kochia, lambs-quarters, wild buckwheat, and redroot pigweed.
- Soil applied; requires moisture for activation.
Sulfentrazone Application Rates and Restrictions (from conditional label)

- Use on medium or fine textured soils only. NOT FOR USE ON COARSE (Sand, Loamy Sand) TEXTURED SOILS.
- Do not use on soils with a pH of 7.8 or greater.
- Do NOT apply to fine textured soils with less than 1.5% organic matter or any soil type with more than 6% organic matter.

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>&lt; 7.0</th>
<th>&gt; 7.0</th>
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<tbody>
<tr>
<td>ml/acre</td>
<td>118</td>
<td>89</td>
</tr>
<tr>
<td>(g ai ha(^{-1}))</td>
<td>(140)</td>
<td>(105)</td>
</tr>
<tr>
<td>Acres/jug</td>
<td>32</td>
<td>43</td>
</tr>
</tbody>
</table>
Effect of sulfentrazone rate on control of wild mustard and kochia.
2003-2006
Scott, SK.
Effect of sulfentrazone rate on control of wild buckwheat, lamb’s-quarters. 2003-2006 Scott, SK.
Sulfentrazone dose-response curves in ten soils as determined by shoot length inhibition of sugar beet.
Sulfentrazone dose-response curves in ten soils as determined by shoot length inhibition of sugar beet

Sand, Clay, OC %, pH

Central Butte (2), SK
14, 67, 3.0, 7.5

Central Butte (3), SK
24, 51, 2.6, 6.3
d

Clavet, SK
60, 26, 2.4, 6.7

Melfort, SK
9, 72, 6.6, 6.1

46, 38, 1.7, 7.7

k

Clay, Sand, OC %, pH
Effect of soil pH on shoot length inhibition from sulfentrazone
Effect of Sulfentrazone rate and soil organic matter on control of cleavers

- **> 5% SOM**
  - 420
  - 210
  - 140

- **3 to 5% SOM**
  - 280
  - 140
  - 105

- **<3% SOM**
  - 140
  - 105

% control
Aminocyclopyrachlor

- A new pyrimidine carboxylic acid herbicide under development by E.I. DuPont Canada Co.
- Activity on a wide range of non-cropland broadleaf weed species.
- Attributes include low use rates, low animal toxicity, and low environmental impact.
- It is formulated as a methyl-ester (DPX-KJM44) or free-acid (DPX-MAT28).
Effect of aminocyclopyrachlor on leafy spurge in rangeland

• Three studies conducted near Battleford, Sk in 2007, 2009, and 2010.

• Objectives:
  – To determine the optimum rate of aminocyclopyrachlor required for long-term control of leafy spurge in non-cropland;
  – To determine if the DPX-MAT28 and the DPX-KJM44 formulations provide equivalent control of leafy spurge
2007 Study

Figure 1. Control of Leafy Spurge with DPX-KJM44 and Tank-Mixes. Battleford, SK 2007

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2 WAA</th>
<th>6 WAA</th>
<th>58 WAA</th>
<th>110 WAA</th>
</tr>
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<tbody>
<tr>
<td>15 g ai/ha DPX-KJM44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 g ai/ha DPX-KJM44</td>
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<td></td>
</tr>
<tr>
<td>60 g ai/ha DPX-KJM44</td>
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</tr>
<tr>
<td>120 g ai/ha DPX-KJM44</td>
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</tr>
<tr>
<td>240 g ai/ha DPX-KJM44</td>
<td></td>
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</tr>
<tr>
<td>30 + 15 g ai/ha DPX-KJM44 + Metsulfuron</td>
<td></td>
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<td></td>
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<tr>
<td>2135 g ai/ha Grazon™</td>
<td></td>
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</tbody>
</table>
Figure 2. Control of Leafy Spurge with DPX-MAT28 and Tank-Mixes. Battleford, SK 2009
2010 Study

**Figure 3.** Control of Leafy Spurge with DPX-MAT28 and Tank-Mixes. Battleford, SK 2010
Untreated (left) and DPX-MAT28 @ 60 g ai/ha 58 WAA (right)
Aminocyclopyrachlor

• Injury to grasses is acceptable at all rates studies
• The 60 g ai ha\(^{-1}\) rate of both formulations of aminocyclopyrachlor is required for long-term control of leafy spurge in mixed grassland.
• Tank-mixes with SU’s had minimal effect on efficacy.
Pyroxasulfone

- Group 15 herbicide
  - Inhibitor of VLCFA
  - Seedling inhibitor / soil applied / activated by moisture
- Developed by Kumiai America
- Currently evaluating its potential
<table>
<thead>
<tr>
<th>Weed Species</th>
<th>ED$_{85}$ (g ai ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45 DAA</td>
</tr>
<tr>
<td>Lambs quarters</td>
<td>284</td>
</tr>
<tr>
<td>Cleavers</td>
<td>60</td>
</tr>
<tr>
<td>Redroot pigweed</td>
<td>34</td>
</tr>
<tr>
<td>Wild mustard</td>
<td>298</td>
</tr>
<tr>
<td>Green Foxtail</td>
<td>35</td>
</tr>
<tr>
<td>Wild oat</td>
<td>25</td>
</tr>
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Herbicide Research Focus 2010-14

• Pulse Cluster
  – Managing Group 2 resistant kochia, cleavers, and wild mustard using a multiple mode of action strategy

• Innovative Mustards
  – Herbicide resistance in condiment mustard, and Ethiopian mustard (*Brassica carinata*)
Summarize

• Don’t expect new modes of action to solve problems;
• Use tank-mixes of more than one mode of action, when possible;
• Integrate herbicides with good agronomy (listen to what Neil says!)
Thank you!