Kochia Working Group
Education & Social Science Sub-Committee
Education / Social Science Sub-Committee

• MEASURING CURRENT MANAGEMENT PRACTICES
  • Summarize knowledge on current management practices
    • Compile available survey results & case studies regarding weed resistance management practices specific to or applicable to kochia
    • Complete additional survey to add to the knowledge base specific to resistant kochia management

• EDUCATION & INFORMATION RESOURCES
  • Benchmark currently available weed resistance and specific kochia resistance resources
  • Complete a gap assessment of current resources specific to kochia

• SOCIAL SCIENCE
  • Why do farmers follow or not follow advice on resistance management?
  • Objective to support development of more effective methods of knowledge dissemination, educational materials and approaches
  • Evaluate Cooperative/Community approaches to Resistance Management
  • Longitudinal Survey case study – correlate education and other activities to changes in management practices to determine best implementation
Measuring Current Management Practices

• Documenting current kochia resistance or applicable general weed resistance management practices being employed by farmers as a baseline

• Several studies have been conducting over the past 5 years
  • A few relevant results from other studies will be shared
  • Dr. Ervin et. al - Farmer Attitudes Toward Cooperative Approaches to Herbicide Resistance Management: A Common Pool Ecosystem Service Challenge
  • Three detailed market research studies were conducted in Canada from 2016 - 2018 – with Certified Agronomists and 2 with farmers

• A short farmer survey was conducted for this conference – management practices, level of concern, resource materials (kochia regions of W. Canada & USA)
## Previous Studies

### 2014 – 2016 Farmer Attitudes Toward Cooperative Approaches to Herbicide Resistance Management: A Common Pool Ecosystem Service Challenge

<table>
<thead>
<tr>
<th>Method</th>
<th>Question</th>
<th>Response</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating herbicides</td>
<td>Over the past two years, on what percentage of your fields on your entire farming operation did you use each of the following methods to control weeds? Rotating herbicide modes of action annually. 6-point scale: 1 = did not use, 2 = less than 20%, 3 = 20-39%, 4 = 40-59%, 5 = 60-79%, and 6 = 80-100%</td>
<td></td>
<td>4.31</td>
</tr>
<tr>
<td>Concern about HR weeds spreading from nearby operations</td>
<td>I am concerned about herbicide resistant weeds spreading to my farming operation from nearby farming operations: Binary variable = 1 for somewhat agree or strongly agree, = 0 for strongly disagree, somewhat disagree, or neither agree nor disagree.</td>
<td></td>
<td>0.716</td>
</tr>
<tr>
<td>Discuss HR weed problems with neighbors</td>
<td>Have you ever discussed with the owner/manager of a field abutting or near one of yours whether herbicide resistant weeds are becoming a problem in your region? Binary variable =1 for yes. = 0 for no.</td>
<td></td>
<td>0.550</td>
</tr>
<tr>
<td>Disagree that HR weeds can be managed w/o cooperation</td>
<td>Weed resistance can be managed effectively without cooperation amongst farmers in a community. Binary variable = 1 for somewhat disagree or strongly disagree, = 0 for strongly agree, somewhat agree, or neither agree nor disagree.</td>
<td></td>
<td>0.603</td>
</tr>
</tbody>
</table>
I am concerned about herbicide resistant weeds spreading from one farming operation to another.

I am concerned about herbicide resistant weeds spreading to my area from neighbouring municipalities or other regions.

*Herbicide Resistance Attitudes & Opinions, ©Dow AgroSciences Canada Inc. (now Corteva Agriscience Canada, 2017*
2017 Study W. Canada - Conclusions & key take-aways

Perceptions & Opinions
- 50% perceive they have resistant weeds / 50% do not have resistant weeds
- Recognize the problem in their area, but urgency is not high
- Believe I am managing well/very good 66%; believe others are managing well only 30%

Knowledge
- Good understanding of practices that cause weed resistance
- Confusion with weeds & modes of action; gap in understanding of Multi-mode of action

Information Sources
- Lots of information sources, variable perception of quality. Written comments by respondents would indicate need for better clarity & direction on what to do

Education
- MMOA, Herbicide Rotation, Herbicide Mode & Site of Action, Practical IWM
- Preferences: website, app, written information, training; not webinars

*Herbicide Resistance Attitudes & Opinions, ©Dow AgroSciences Canada Inc. (now Corteva Agriscience Canada, 2017
# Kochia Working Group – Education Sub-Committee

## 2017 Study W. Canada

### What Resistant Weeds to you have on your farm?

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 9</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 10</th>
<th>Group 8</th>
<th>Group 27</th>
<th>Group 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild Oats</td>
<td>389</td>
<td>199</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Green Foxtail</td>
<td>33</td>
<td>28</td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kochia</td>
<td>30</td>
<td>151</td>
<td>37</td>
<td>3</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cleavers</td>
<td>11</td>
<td>94</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Wild Mustard</td>
<td>8</td>
<td>33</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Canada Thistle</td>
<td>1</td>
<td>19</td>
<td>1</td>
<td>15</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wild Buckwheat</td>
<td>14</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hemp-Nettle</td>
<td>7</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Stinkweed</td>
<td>9</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Volunteer Canola</td>
<td>3</td>
<td>5</td>
<td>11</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sow Thistle</td>
<td>10</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Lamb's Quarters</td>
<td>7</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Redroot Pigweed</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total by Group</strong></td>
<td>526</td>
<td>599</td>
<td>59</td>
<td>38</td>
<td>34</td>
<td>17</td>
<td>11</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total by Gr - Gras</strong></td>
<td>422</td>
<td>227</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total by Gr. BLF</strong></td>
<td>104</td>
<td>372</td>
<td>52</td>
<td>28</td>
<td>26</td>
<td>14</td>
<td>7</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

*Herbicide Resistance Attitudes & Opinions, ©Dow AgroSciences Canada Inc. (now Corteva Agriscience Canada, 2017*
Among the RM practices that increased significantly from 2014 to 2017, ‘Use multiple herbicide groups in the same year’ had the greatest increase.

On an unaided basis, farmers report crop rotation the most often as a weed RM practice used on their farm.
Measuring Current Management Practices

• The Education Sub-committee designed and executed a farmer survey asking questions about level of concern, quality and quantity of resources available on kochia resistance management and current management practices being employed specifically for resistant kochia management.
  • Guide – Dillmans Internet, mail and mixed mode surveys 3rd edition
  • Qualtrix software was utilized to execute the survey
  • Emailed to 4000 farmers in western Canada
  • All Kochia working group committee members asked to send to farmers and via twitter
  • Link sent to Wheat Board, Dry Bean Commission, and Western Sugar asking them to share with their growers. Nebraska CropWatch to send link via Twitter.

• Preliminary results – over 230 responses as of yesterday morning!
Q1 - Which State or Province contains the majority of your operation?

- Alberta
- Arizona
- British Columbia
- California
- Colorado
- Idaho
- Kansas
- Manitoba
- Montana
- Nebraska
- Nevada
- New Mexico
- North Dakota
- Oklahoma
- Oregon
- Saskatchewan
- South Dakota
- Texas
- Utah
- Washington
- Wyoming
- Not Listed
Q2 - Do you have herbicide-resistant Kochia on your operation?

Yes Confirmed: 37% n=80
No: 11% n=24
Suspected: 52% n=113

89% confirmed or suspected

Q3 - Please rate your level of concern of herbicide-resistant Kochia.

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Kochia Concern</td>
<td>0.00</td>
<td>100.00</td>
<td><strong>74.55</strong></td>
<td>23.84</td>
</tr>
</tbody>
</table>
Q4 - Have you attended a weed-resistance management program put on by University, Extension, local agronomist, association or industry?

Yes: 68%  n=146
No: 32%  n=69

Q5 - Have you accessed online weed management resources to help specifically with Kochia resistance management?

Yes: 54%  n=116
No: 46%  n=100
Q6 - Please rate the ease of access of the online resources you have used.

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Access</td>
<td>0.00</td>
<td>100.00</td>
<td>65.06</td>
<td>22.10</td>
<td>116</td>
</tr>
</tbody>
</table>

Q7 - Please rate the usefulness of the online resources you have used.

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>0.00</td>
<td>100.00</td>
<td>62.28</td>
<td>23.29</td>
<td>116</td>
</tr>
</tbody>
</table>
Q8 - Which weed management resources do you most commonly use?

- Field Days: n=105
- Webinars: n=41
- University or Extension Workshops: n=71
- University or Extension Bulletins: n=87
- Seminars or Trade Shows: n=59
- Retail bulletins or workshops: n=109
- Herbicide manufacturer bulletins or workshops: n=151
- Other: n=35
Q9 - What management practices have you used on your farm specifically to manage Kochia weed resistance?

- Herbicide Rotation (n=192)
- Multiple MOAs (n=196)
- Tillage of suspect areas (n=99)
- Mowing of suspect areas (n=81)
- Forage crops in rotation (n=35)
- Increased seeding rate (n=47)
- Changing seeding timing (n=19)
- Controlling Kochia in non-crop border areas (n=104)
- Other (n=15)
Q9 - What weed management resources are missing that you would find useful?

**Herbicides:**

- Try to use some of the newest kochia targeted herbicides too; New herbicides; Need a new mode of action
- I feel there is too much focus on herbicides even at resistance presentations. The other tools are mentioned but not discussed in enough depth to provide good results. For example, I hear tillage recommended for resistant weeds but what is meant by tillage? plow? chisel plow? vertical tillage? What about tillage timing? frequency? and what about the potential for soil loss?
- Something that will kill kochia in pulse crops
- **Herbicide that will kill at least 95% of emerged kochia.**
- BASF Liberty Label restrictions on Adjuvants that are providing better performance for control of resistant Kochia
- **More published data on herbicides and rates that are effective on Kochia**
- More minor use registration. Even if certain herbicides hurt a crop it may be worth having that option. Such as sulfentrazone in canola
- **More effective products that don’t increase our cost of production**
- Keeping up to date with which groups have resistance and what groups are good options.
- **Guidance on integrated rotational herbicide/crop plans**
Other control methods:
• Control the seed not the weed
• Biological Control
• Cover crops and reduced fertility
• Crop rotation
• Specific strategies to implement on my farm.

Tillage / Land Management:
• County based workshops and broader tillage
• Salt research / Better saline tolerant forages to put into saline areas of field
• Bring back the old 9 bottom plow to bury the seeds
• We are going back to tillage starting next year. We cannot kill resistant Kochia economically. It is blowing in from other locations.

Other:
• Control by RR and neighbors. Currently my seed source is from RR right of ways and neighbors who do nothing but allow seed to be spread.
• Financial resources. Our farm got resistant kochia from neighbors poor management.
• Get rid of NDSU roundup 1 soybeans other farmers raising them r the problem
• Online data
• Let me know where the problem areas are and where are they spreading to
Information and Education Resources

• Documenting and cataloging current resource materials available to farmers to educate and inform on kochia weed resistance management practices.

• Canada – input from various stakeholders – summary of materials

• USA – Abstracts from past 3 years from weed science society; additional input required on State by State extension materials to complete project

• Incomplete: Initial identification of gaps and review of quality & effectiveness of materials from a farmer perspective

• Incomplete – farmer review of individual resource materials to assess relevance, usability, ease of access, ease of use of material – complete after harvest
Google search

• Search “kochia resistance western Canada”
  • About 65,600 results (0.32 seconds)
  • Documented first 20 pages – 288 information hits
  • Lots of articles, fact sheets, scientific papers, presentations, surveys, general reference guides, etc. Canada and USA sources

• Search “kochia resistance United States”
  • About 60,000 results (0.70 seconds)
  • Much the same
  • Scan looks like many are the same as previous search – USA and Canada sources

• A bit overwhelming
Canada - Request to industry – scientists, university, industry associations, etc

• Responses were ~95% links to websites, ~5% guides and reference materials available both hard copy and/or app and/or website download

• Relative to Google search, resources identified were relatively small in number
  • 24 “top-of-mind” sites or resources with resistance information – government, commodity associations
    • 10 sites/resources had information specifically regarding kochia
  • 7 mid to major herbicide manufacturers – only one manufacturer has a significant amount of information on resistance management. Only one article was found on resistance management that mentioned kochia.
  • CropLife site “Manage Resistance Now” – industry funded collaboration with scientific and industry experts - site dedicated to resistance management – weeds, disease, insects – not specific to kochia
Information and Education Resources

• Survey – only 54% of initial respondents indicated they have used online resources for kochia resistance management

• Sheer volume of hits from Google searches could seem daunting - much of the material is very scientific or general + repetition

• Despite hundreds of hits from internet search, when asked about resources, knowledgeable people only highlighted 26 resources
Information & Education Resource: Recommendations

It appears part of the problem is lack of awareness or difficulty to find good resources for resistance management education / instruction.

- 68% of respondents attended information sessions, but only 54% used online resources and rated them 65% and 62% for ease of access and usefulness.

Resources are limited that are specific to kochia resistance management

Do we know what materials resonate with farmers? What is the proper structure of information for an adult, ag learner? What format will get the best uptake?

How do we address availability and easy access to good, practical materials for farmers?

How do we convince farmers to take action?
Information & Education Resource: Recommendations

- Test some of the perceived best materials with farmers and have them assess them for usefulness, accessibility and relevance.
- Have an adult education expert assess the same materials.
Information & Education Resource: Recommendations

• Test some of the perceived best materials with farmers and have them assess them for usefulness, accessibility and relevance.
• Have an adult education expert assess the same materials
• How can the industry create single source location for LINKS to all materials? – categorized for easy access

Discussion...
• What do farmers’ really need for information resources?
• How do we get farmers to utilize information made available
  • Regional kochia control guide that covers different scenarios (Excel tool or app or worksheet)
• What are short term options for management practices education?
• What are longer term options that may require additional research before promoting?
Social Science & Regional Approaches to Resistance Management

Education/Social Science Sub-Committee
- Kelly Bennett, Corteva
- Rand Merchant, BASF
- Cody Creech, Univ. of Nebraska
Social Science

• Examine current knowledge on the Social Science and psychology of why farmers do or more importantly do not implement beneficial management practices of which they are fully aware.

• Contributors / resources:
  Katherine Dentzman, Univ. of Idaho
  George Frisvold, Univ. of Arizona
  Eric Johnson, Univ. of Saskatchewan
Evaluate Cooperative/Community approaches to Resistance Management

• Significant work has been completed over the years by Dr. David Ervin, Portland State Univ., and others on Cooperative Approaches to Herbicide Resistance Management.

• Due to the mobile nature of Kochia, this is a topic worth exploring for current knowledge and for future education implementation.

• Eric Johnson, Univ. of Saskatchewan volunteered to lead this part of the project and has some experience in this area.
  • Eric is currently in Australia
Community Based Resistance Management

Materials referenced & examples considered:

• Farmer Attitudes Toward Cooperative Approaches to Herbicide Resistance Management: A Common Pool Ecosystem Service Challenge

• Investigated the scope for cooperative management for HR weed issues to test a recursive model of three preconditions for collective action:
  (1) Concern about HR weeds migrating from nearby lands
  (2) Communication with neighbors about HR weeds
  (3) Belief that cooperation is necessary for effective resistance management
Community Based Resistance Management

Farmer Attitudes Toward Cooperative Approaches to Herbicide Resistance Management: A Common Pool Ecosystem Service Challenge

Key Results:

• Farmers who relied more on Extension educators regarding weed management were more likely to satisfy each precondition.

• Concern about weeds resistant to multiple herbicides as well as concern about HR weed mobility positively influence concern about migration and views toward cooperation.

• Farmer time constraints and “techno-optimism” (a belief that herbicide discoveries will solve resistance problems) detract from the perceived need for cooperative approaches.
Community Based Resistance Management

• The Harrison County Project, is part of the Iowa Pest Resistance Management Program (IPRMP), an initiative to slow pest resistance by building community relationships, spreading awareness and finding workable solutions to local pest issues.
  • Participants include a wide range of stakeholder groups involved in Iowa agriculture
  • Develop and implement programs that are cost effective and sustain yields
    • Developed for specific areas and cropping systems
    • Community effort
Community Based Resistance Management

• Zero Tolerance Program to control HR Palmer amaranth in Clay County, Arkansas
Zero Tolerance: A Community-Based Program for Glyphosate-Resistant Palmer Amaranth Management

L. Tom Barber
Associate Professor - Extension Weed Scientist

Kenneth L. Smith
Former Extension Weed Scientist

Robert C. Scott
Professor - Extension Weed Scientist

Jason K. Norsworthy
Professor - Weed Science

Andy M. Vangilder
County Extension Agent - Staff Chair, Clay County

Herbicide-resistant Palmer amaranth (pigweed) is the greatest pest facing cotton and soybean producers in Arkansas. This weed is resistant to three major herbicide modes of action (WSSA groups) in Arkansas including the dinitroanilines (group 3), acetolactate synthase (ALS) inhibitors (group 2) and glycine (group 9). It has also been confirmed resistant to triazine (group 5) herbicides in Georgia and four (group 27) herbicides in Kansas. When introduced into one square meter of a weed-free field and treated with glyphosate only, glyphosate-resistant Palmer amaranth expanded to infest over 20% of the total field area in less than 60 days, resulting in a loss from the soil seedbank (Jha et al., 2014); thus a program to promote the elimination of Palmer amaranth seed production and reduce the soil seedbank is critical to success.

Zero Tolerance Is Based on Science
Community Based Resistance Management - Rationale

• **Producer engagement is required to develop practical solutions.**
  • Eg. Many solutions to resistance issues in Australia are farmer initiated or collaborative between scientists and producers (Eg. Harrington seed destructor, crop-topping, etc.)

• **Benefits from Harrison County Project:**
  • Adapt solutions to local concerns.
  • Bring the issue to life
  • Promote proactivity
  • Talk it up – create awareness
  • Involve a diverse group – landowners, CCA’s, retail agronomists, industry, marketing, extension, commodity groups, research.

• **Zero Till Adoption in Western Canada Prairies in 1990 – 2000**
  • Successful through collaborative government / NGO (eg. Saskatchewan Soil Conservation Association) partnerships
  • Kitchen table meetings highly effective in adoption.
Community Based Resistance Management - Proposal

Pilot projects/focus groups

• 1 per prairie province / state ??
• Relatively small geographic area – County, Municipality with known HR kochia issues or adjacent to area with HR kochia issues (preventative approach)
• Identify key contact person / leader for the group (industry, government, or grower)
• Organize start-up meeting
  • Provide basic information on kochia biology, herbicide resistance, potential management issues (1 to 2 hours).
  • Conduct short producer survey on perceptions, extent of problem, and management practices they are trying. (Best to do this as a presentation where farmers can use clickers or cell-phones to provide answers). (30 minutes)
  • Break into small groups / have facilitator to promote discussion / brainstorming on issues, barriers, and solutions.
• Development of a “Manual of Operations” for Regional groups would be desirable
• If successful, could expand to more groups in the future.
Final Thoughts:

• Identify recipes for success
  • Seeing is believing

• Grower driven/organized – must be involved

• Economics of decisions – dictate what we do

• What are the constraints?
  • Short-run economics
  • Long-run economics

• Must be persuasive/intelligible
Social Science

• Identify recipes for success
  • Seeing is believing
• Grower driven/organized – must be involved
• Economics of decisions – dictate what we do
• What are the constraints?
  • Short-run economics
  • Long-run economics
• Must be persuasive/intelligible

Information/Education

• What do farmers’ really need for information resources?
• How do we address availability and easy access to good, practical materials for farmers?
• How do we get farmers to utilize information made available?
• Regional kochia control guide that covers different scenarios (Excel tool or app or worksheet)
• What are short term options for management practices education?
• What are longer term options that may require additional research before promoting?
Thank you!!

Co-chairs: Kelly Bennett (Corteva), Cody Creech (Univ. of Nebraska), Rand Merchant (BASF)

Primary Sub-Committee Members:
Eric Johnson, University of Saskatchewan
Katherine Dentzman, Univ. of Idaho
George Frisvold, Univ. of Arizona

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Sherrilyn Phelps, Pulse Growers Association
Harry Brook, Alberta Ag
Dr. Brianne Tidemann, Ag Canada
Eric Johnson, University of Saskatchewan
Clark Brenzil, Gov’t of Saskatchewan
CropLife Canada
Corteva Canada
Thank you!!

This project was funded in part by the USDA National Institute of Food and Agriculture through the Western Integrated Pest Management Center, grant number 2018-70006-28881
Longitudinal Survey Case study

• Rand’s doctoral dissertation involved creating a longitudinal survey on Palmer Amaranth management practices – tracking how practices changed over time.
• Key purpose – longitudinal survey vs. point in time survey. 3 years to establish a good longitudinal survey with valid results.
• Potential to use as a case study to correlate what actions/efforts were implemented that caused the changes as an indicator of what approaches could be effective.
• Rand – potential approach
  • First step – have committee members complete a 3-year self-assessment of research and extension materials and extension work that has been completed in their state regarding kochia management.
  • Discuss efforts and trends in various regions in a workshop format (remote) to mimic info from a longitudinal survey and start identifying what appears to be working or not working.