White Paper:

The Case for the Canadian Agriculture Industry to Proactively Engage in Pesticide Resistance Management

Prepared by: OPMC Organizing Committee from the Panel Discussion on Pesticide Resistance Management held at the OPMC 2018

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Preface

Passionate about agriculture—its value, productivity, opportunities—and producers, the Ontario Pest Management Conference (OPMC) Steering Committee commissioned this White Paper as a call to action, to stimulate focused dialogue and set in motion a compelling strategy to proactively engage Canadian agriculture stakeholders in pesticide resistance management (RM).

Its intention is to set out a coherent approach to align Canadian agriculture stakeholders in RM engagement. It is an agenda for renewing government, university, industry and producer investment in a RM framework — to strengthen the commitment, communication and implementation of RM at the farm level.

“We must not only think differently; rather, we must act differently” (Shaw, 2016).

Brief Outline of this White Paper

Chapter 1: The Issue:
   1. What is pesticide resistance?
   2. How does resistance develop?
   3. The nature of the problem

Chapter 2: What is Missing

   1. Need to be proactive with high risk markets
   2. Underutilizing grower organizations, commodity groups, processors that have influence over grower pest control decisions
   3. Industry aligned recommendations with technical accuracy in Canadian communications
   4. Money, research, personnel, empowerment, motivation
   5. Resistance management training programs on-line
   6. Need to change retailer and crop protection company behavior
   7. Trained end users (grower implementers)

Chapter 3: Largest Barriers and Gaps to Proactive Resistance Management

   1. Creating the technical foundation: principles, strategies, recommendations, pest monitoring
   2. Internal commitment: internal communication, education, adoption, business integration
   3. External communication and training: government and company effort to inform, educate and ally influencers/growers
   4. Alignment of the industry: an aligned and unified industry speaking with one voice
   5. Unwillingness to change: Convince the grower to act: offer innovative, integrated compelling solutions
Chapter 4: Key Areas to Focus Effort

1. Be Proactive! More boots in the field are needed
2. Raising awareness of resistance risk and management: communications and education of end users
3. Identify and reduce regulatory barriers to RM implementation
4. Conduct a national evaluation and prioritization of high-risk commodities for the development of fungicide, herbicide and/or insecticide resistance
5. Utilize the food production value chain to its full potential
6. Survey/evaluate why growers do not implement RM strategies in existing IPM programs
7. Collective roles in tackling resistance

Chapter 5: Examples from industry in Canada and Elsewhere

1. Western Grains
2. CropLife Canada Manage Resistance Now Campaign

Chapter 6: Conclusions

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Chapter 1: The Issue

What is resistance?
The development of resistance to a pesticide (e.g., insecticide, fungicide or herbicide) is recognized as a decrease or failure in the effectiveness of control of a pest (e.g., insects, pathogens, and weeds etc.) following its exposure to the appropriate chemical used according to label recommendations (CropLife Canada, 2018).

How does resistance develop?
Any pest resistant to an agricultural pesticide may be the result of a genetic mutation and/or natural selection. The change in the pest genetic code (genotype) can manifest itself in different ways making the pesticide harmless. When encountered in the field, pesticide resistance will appear as a measurable reduction in the efficacy of a pesticide. Once acquired in a pest population, resistance becomes transmissible genetically; it is a heritable change (CropLife Canada, 2018).

The nature of the problem
Resistance to pesticides is a complex problem and perhaps the term resistance management is an oxymoron. It is simply impossible to manage evolution. We are effectively increasing the speed of the evolutionary process by the selection pressure (pesticides) we are applying. Sociologists call this a ‘wicked problem’ which is defined as one without clear causes or solutions, and thus difficult or impossible to solve. Pesticide resistance is the epitome of a wicked problem: the causes are convoluted by a myriad of biological and technological factors and are fundamentally driven by the impulses of human decision making. Scientists have conducted research for decades, and resistance is more prevalent today than ever before because too little focus is spent on implementing RM programs and changing producer behavior. If we expect to achieve success in RM, different approaches are essential (Shaw, 2016; Beckerman et al., 2015).

Resistance evolution is a direct response to the producer decision making process. Essentially, where we are today is a direct result of individual producer decisions. The decision process is complex and impacted by factors that vary from producer to producer and field to field, for example:

a. The cost (economics) of management practices (pesticides)
b. Crop protection company marketing programs and retailer agronomist recommendations
c. Cropping options (what they can or cannot grow on their land)
d. Ability to access financing
e. Availability of equipment and labour
f. Contractual arrangements
g. Personal experiences
h. Ownership over farmed land
i. Awareness (or lack thereof) of pesticide resistant pest populations in the area

Producers may have misperceptions about the extent of the resistance problem. Unless producers are personally experiencing a devastating resistance issue on their farm, they tend to continue their current management program until there is a resistance issue that is beyond their control. Once this happens, some producers can no longer grow a specific crop or are
forced to move their crop production to a new parcel of land (often rented).

Producers may also feel a sense of helplessness. They often feel like it does not matter what they do, since their neighbours’ actions may cause them to have the problem regardless of what they do.

Historically, producers have been able to rely on the development of new technologies (pesticides, genetically modified crops) to combat resistance, which has provided a false sense of security that a ‘silver bullet’ will eventually come along (Shaw, 2016; Beckerman et al., 2015). This is no longer the case and a more focused effort is required on Integrated Pest Management (IPM) approaches, which includes RM. This is challenging for producers to implement because these methods tend to cost more in the first few years; even though it is known that IRM practices are almost always economically beneficial over the long term. However, a significant portion of cropland is rented, and renters may not be willing to invest in these long-term gains.
Chapter 2: What is Missing

1. Need to be proactive with high risk markets
   a. Most if not all RM is reactive
   b. We need to preserve the key crops that still have a high degree of pest susceptibility. Monitor them and prevent RM development.
      i. National survey programs to regularly monitor (biovigilance/biosurveillance) and report new cases of resistance.
         • This will require a platform to keep and share resistance information coming out of surveys (national and regional), making it accessible and trackable across Canada (e.g. The International Survey of Herbicide Resistant Weeds http://www.weedscience.org/default.aspx
         • We should not accept the thinking that only crops with RM issues should be addressed. It takes 100 times more energy to manage resistance than it takes to prevent or delay it.
   c. RM education and extension materials need to be included in current IPM programs

2. Underutilizing grower organizations, commodity groups, processors that have influence over grower pest control decisions
   a. Use producer organizations, commodity groups and processors to help train and implement RM. RM is most effective when large acreage is controlled by few decision makers and adopted over broad areas.

3. Industry aligned recommendations with technical accuracy in Canadian communications
   a. RM language needs to be aligned on all education, extension and marketing materials, as well as regulatory labels.
      i. Ontario Crop IPM pest profiles need to be updated with a RM section
      ii. Pest Control Guides need more detail in the RM section (to include mode of action numbers)
      iii. The Pest Management Regulatory Agency (PMRA) needs to be clearer on label language recommendations regarding RM (cannot cut and paste the same language for herbicides, insecticides and fungicides)
         • PMRA should allow companies to add additional detailed RM language to the labels to better tailor the recommendations with the chemistry
         • The maximum number of applications are by product not by mode of action
         • What is the impact of regulating the lowest effective rate on RM?
      iv. It would also be useful to reference Agriculture and Agri-Food Canada’s Pest Management Center Crop Profiles as a source of validated crop protection issues identified, citing specific pesticide resistance cases.

4. Money, research, personnel, empowerment, motivation
   a. Need commitment from the entire agriculture value chain to participate in RM
   b. Need to develop more RM programs to protect the key cropping systems that still have susceptible pests
      i. Research needs to be responsive to the eventuality of resistance development
ii. Promote integrated, big picture thinking amongst university, government and industry researchers to encourage solving real-world on farm problems

5. Resistance management training programs/modules on-line
   a. Need to pool resources (government, university, industry, regulatory) to create education and extension training courses on-line in one portal, e.g. the CropLife Canada Manage Resistance Now Campaign (http://manageresistencenow.ca) or the United States Environmental Protection Agency Slowing and Combating Pest Resistance to Pesticides (https://www.epa.gov/pesticide-registration/slowing-and-combating-pest-resistance-pesticides).

6. Ensure alignment of retailers and crop protection companies with RM
   a. Recognize RM and product stewardship as core corporate values
   b. Train employees on responsible product stewardship
   c. Ensure retailers and crop protection company field staff are aligned, support and implement RM based customer communication, sales, strategies and decisions
   d. Technically position crop protection portfolios to be compliant with RM strategies
   e. Incorporate RM principles and strategies into daily business decisions, and research and development programs
   f. Make RM-related activities a defined annual individual goal for employees
   g. Industry partners who share products with a common mode of action need to cooperate jointly and with local influencers to develop RM projects

7. Trained end users (grower implementers)
   a. Partnerships with industry leaders to modify producer behavior and influence adoption and implementation of RM strategies
      i. Producers need to understand the benefits of RM
      ii. Producers need to trust and motivate each other to follow product stewardship, sustainability, and RM recommendations
      iii. Retailers need adequate education to assist producers in their product selection
      iv. RM influencers need to understand the reasons why producers do NOT implement RM recommendations or strategies and alter programs to address them
      v. RM strategies can be more successful if they are implemented over a large area
Chapter 3: Largest Barriers and Gaps to Proactive Resistance Management

1. Creating the technical foundation: principles, strategies, recommendations, pest monitoring
   a. Lack of defined, clear and practical RM principles, strategies and recommendations for key crops and markets
   b. There is confusion amongst the disciplines – is it better to mix chemistries or rotate chemistries? Is it better to use full doses or reduced rates?
   c. Inadequate RM technical positioning by crop protection companies
   d. Insufficient number of product modes of action to address resistance problems
   e. Resistance monitoring is time consuming and the warning period is often short

2. Internal commitment: internal communication, education, adoption, business integration
   a. Crop protection companies need to lead RM best practices before they can be successful in changing producer behaviour:
      i. Make product stewardship and RM a core value
      ii. Train all field personnel on RM principles and recommendations. Incorporate RM into daily decision process, project planning, and field responsibilities
      iii. Marketing and sales division of crop protection companies need to own key components of the RM process. Do not depend solely on R&D personnel.
      iv. Understand that every sale is not a good sale: Sales compensation must include RM behavior
   b. Research (Government and Academic)
      i. No overall strategy – most research is ad hoc. Pest resistance typically requires an urgent response and forces researchers to chase available funding.
      ii. Producers to fund/support RM research projects proactively rather than waiting until there is a problem
   c. Education
      i. What effort is taking place to teach IPM – starting young through university?
      ii. What effort is being made to prepare students to understand RM challenges for ALL agriculture jobs? They are our future influencers!!
      iii. RM strategies are crop and pest specific, resulting in ad hoc education and extension training

3. External communication and training: government and company effort to educate and ally influencers/producers
   a. Crop protection companies’ insufficient incorporation of RM guidance into labels, marketing communications, technical positioning directions and customer training materials
      i. There is a need for universal crop pest guides and IPM pest profiles
   b. Inability to reach key influencers, advocacy groups and the end user
   c. Crop protection companies, CropLife, IPM programs, consultants, Co-ops, commodity groups, academics, regulatory and producer influencers need to improve RM communications, training and consequences of resistance to
producers, pesticide distribution channel, local influencers and government regulators

4. **Alignment of the industry: an aligned and unified industry speaking with one voice**
   a. Pesticide resistance is impacting multiple industries. How can we work together to unify our approach?
   b. Inactivity/indifference – lack of motivation from academic institutions, chemical companies and key industry influencers:
      i. Local grower groups – more focused on labour challenges, marketing and pricing versus RM
   c. Need to better align crop protection companies, academic experts, producer influencers and regulators on practical RM recommendations:
      i. Need more forums of industry interactions and technical exchange
      ii. Provide joint RM training
      iii. Institute a RM licensing or certification program
         E.g. the Ontario Pesticide Education Program (OPEP) or make RM part of the OPEP

5. **Convince the producer to act: offer innovative, integrated compelling solutions**
   a. Only producers and consultants can implement, the rest of the industry can only coordinate
   b. Continual need to improve producer behavior – many growers do NOT follow recommendations
   c. There are few, innovative, integrated RM offerings that motivate growers to adopt RM recommendations. Ideally RM is incorporated into company product positioning, product bundling programs, and pest control offerings making its implementation less onerous or even invisible. This practice needs to be rewarded and made more visible.
   d. Producers do NOT understand the basics of ‘product stewardship’
   e. RM coordinators do NOT understand why producers do NOT adopt RM
      i. Why producers do NOT adopt RM:
         - No other effective alternative product available for rotation
         - Difficult to find value in RM when neighbours ignore the issue (need a community approach)
         - Focus is on the current season and crop (short term versus long term thinking)
         - Economic – new products cost too much money
         - Relationships – producers trust their pesticide dealers, the pesticide purchase is secondary
         - Producers do not take responsibility – this is the crop protection company’s problem, they will develop new products
         - Lack of education – do not understand pest biology, the ideal time to spray, RM strategies, the true impact of resistance at the farm level
         - Do not follow the label – ‘underdosing’ because the label is difficult to understand or read...or the lower rates are cheaper
         - Depend on a few products that have provided the best efficacy on their farm
         - Field representatives are unprepared, unable or unwilling to enforce RM strategies
Chapter 4: Key Areas to Focus Effort

1. Be PROACTIVE! More boots in the field are needed. Determine which commodities DO NOT have RM issues. Work with these producers (survey) to understand what makes them successful.
   a. More government extension personnel to work with producer innovators to demonstrate proof of concept.
   b. More government extension personnel to survey the RM situation to ensure accurate reporting of RM challenges. This will ensure timely RM decisions.
   c. Increase availability of non-chemical (e.g. cultural, biological, mechanical) approaches and Best Management Practices (BMPs) to enable IPM and lower the need to use pesticides thus reduce the risks of pesticide resistance development.
   d. Prioritize highest value crops and commit resources to protect them.

2. Promotion of resistance management: communication and education of end users
   a. Increase awareness that everyone engaged in agriculture has a role in managing resistance. Everyone needs to be held accountable for their role in RM.
      i. Incentivize retailers/dealers to recommend the best RM tool to producers irrespective of cost or crop protection company loyalty programs
      ii. Incentivize crop protection companies to remove marketing programs that encourage producers to rely on single mode of action programs.
      iii. Incentivize producers through funding programs to develop crop specific RM plans (similar to nutrient management plans), which should include innovation in nonchemical practices
   b. Develop a RM certification program for decision makers and advisors (Certified Crop Advisor (CCA) Resistance Management Study Guide by Crop Life Canada 2018).
   c. Consistent messaging from all stakeholders: industry, government, university, crop advisors, retailers/dealers and regulators

3. Reduce regulatory barriers to RM implementation
   a. Allow emergency use registrations of pesticides – this is seldom done for weed resistance issues, even though recent Canadian estimates show that herbicide resistance costs producers from $1.1 to $1.5 billion annually in terms of increased herbicide use and decreased yield and quality (Beckie, 2018).
   b. Manage the pesticide re-evaluation process to ensure multiple modes of action remain available.
   c. Encourage the industry to support new product registrations through the federal minor use system.
   d. Agriculture and Agri-Food Canada’s Minor Use Program priority selection process should consider resistance related information for each of the candidate products to be selected for regulatory work.

4. Conduct a national evaluation and prioritization of high-risk commodities for the development of resistance.
   a. Develop commodity specific plans to address IPM and RM gaps through stakeholder representative working groups.

5. Utilize the food production value chain to its full potential.
a. Maximize the advocacy potential of producer commodity groups
b. Utilize processing company contracts with producers to dictate RM programs (Bonduelle Group, Michigan Sugar, Highbury Canco, Ocean Spray etc.)
c. Utilize retailers (Loblaw Companies, Metro Inc., Sobeys etc.) to dictate RM programs (include in the food safety audit process)

6. Survey/evaluate why growers do not implement RM strategies in existing IPM or RM programs and develop strategies to address this

7. Create a national RM working group with stakeholders from the entire agriculture value chain (government, university, producer groups, industry)
a. This working group would primarily focus on RM language to include in all front facing producer education, extension, regulatory and marketing material.

Chapter 5: Working Examples from Industry

1. Western Grains – Top 10 Herbicide-resistant weed management practices

Top 10 Herbicide-resistant weed management practices

1. Keep accurate records
   Maintain a database that chronicles your agronomic practices, particularly those that vary from field to field and year to year. Records should include cultural, mechanical, and herbicide weed management variables. Keeping accurate records will help you make informed crop management decisions, especially pesticide choices, for each field.

2. Practice strategic tillage
   Use tillage only when and when deemed necessary to manage herbicide-resistant (HR) weeds. The risk of weeds developing resistance to herbicides is shown to be highest in no-tillage, owing to greater herbicide use and weed seed bank turnover rates. In some regions, tillage is an essential method for managing some glyphosate-resistant weeds.

3. Customize weed management by field
   Weed management programs are not one size fits all—they should be customized on a field-by-field basis as weed populations are not uniform across your land. Even within a typical field they are not generally consistent. Survey your weed populations before herbicide application. It is also possible to detect and manage weeds in real time using sprayers equipped with sensors.

4. Use weed sanitation practices
   Equipment sanitation practices reduce both immigration of weed seeds and spores into a field and seed (weed or crop) dispersal across a field. Reducing weed seed load into the soil can be achieved directly by harvest weed control practices, which include chaffing, direct harvest crop residue burning, winter-windrow burning and seed pulvarization.

5. Rotate in-crop wheat and non-wheat herbicides
   Many HR grassy weed populations (e.g., wild radish) are able to tolerate herbicides using the same mechanism as wheat. Therefore, it is important to rotate in-crop wheat and non-wheat herbicides to delay or manage this type of resistance. Avoiding continuous over-crop rotations and including non-selective herbicides such as glyphosate or glufosinate in HR crops will help to achieve this objective.

6. Rotate herbicide groups
   Rotate herbicides based on their group (pale of active). The group number is identified on the front of each herbicide product. Where possible, across and within growing seasons, rotate the use of one herbicide group with other herbicide group(s) that control the same weeds in a field.

7. Use herbicide mixtures
   Herbicide mixtures, or tank mixes, can be effective in delaying resistance. They are most successful when herbicide mixtures that combine different sites of action meet the criteria of (1) similar efficacy, (2) similar soil residual activity, and (3) different propensities for selecting for resistance in the target species. For example, mixtures of Group 2 and 4 herbicides having overlapping control of some key broadleaf weeds have shown to delay or manage resistance.

8. Scout fields before and after herbicide applications
   Scout your fields before in-crop herbicide application to determine what weeds are present, their distribution and abundance in order to customize an effective weed management plan. Additionally, scouting post-herbicide application will inform you of how successful you have been in controlling the targeted weeds. Unwanted aerial vehicles have good potential for weed surveillance and monitoring. Whichever using spreadsheet or mapping software, recording data are important parameters to record annually.

9. Focus on crops and practices that promote competitiveness
   Employ crops and practices that can aggressively compete with weeds. Some tactics include rapid emergence (the first up wins) and ground cover, rapid and extensive canopy closure, and plant height. Crop competitiveness is optimized by good agronomic practices such as predawn fertilizer placement near or at time of seeding, optimum seed placement and seeded conditions, and high crop seeding rate. Adjust the ‘first up wins’ approach.

10. Ensure crop diversity is the foundation of your HRWM plan
    The core of an effective HRWM plan is crop diversity. Include weed competitive species and those with varied growth cycles and maturities in your crop plan—a mix of early and late-maturing, winter and spring planted, cool and warm season annuals and perennials. While this approach ensures herbicide diversity, it also helps to provide different seedling and flowering dates, and reduces pressure on weed communities.

This story is adapted from “Our top 10 herbicide-resistant weed management practices” by Hugh Bottom and Bill Hatter at Farm Management Science, Volume 7, June 2017.
2. Western Grains – Using beneficial insects as IPM tools

Learn More About Beneficial Insects in Your Crops
Field Heroes is a campaign just launched by the Western Grains Research Foundation to increase awareness of beneficial insects in cropping systems. The Field Heroes campaign encourages growers and agronomists to consider beneficial insects in production recommendations and decisions. Beneficial insects play a vital biological pest control role in cropping systems yet there is a lack of awareness by agronomists and growers. Significant information including photos, scouting techniques and best management practices on beneficial insects is available from various sources across western Canada. WGRF has compiled this information into one place www.fieldheroes.ca. This website holds key information on beneficial insects. With the support of researchers, government agencies and academics, technical information is available for commodity groups and agronomy organizations across Western Canada to get the word out.
3. CropLife Canada Manage Resistance Now Campaign
   www.manageresistantcenow.ca

Integrating Social Science into Managing Herbicide-Resistant Weeds and Associated Environmental Impacts

Training Module for teaching RM available on line on the UMass Scholarworks site:
http://scholarworks.umass.edu/cranberry_outreach_resistance/1/.


Reflection and Research Network on Pesticide Resistance (R4P) - Europe


Chapter 6: Conclusions and Proposed Actions

To ensure the RM recommendations and strategies in this paper are implemented at the farm level we need a national working group that is committed to coordinating a strategic approach involving all members of the national agricultural value chain (academics, research, government, crop protection companies, regulatory, retailers, producer organizations and producers themselves). Collectively, this national working group must:

1. Streamline all front facing producer RM communication material into one accessible website to have clear recommendations. All education, extension, marketing and regulatory material must be updated to include RM strategies.
2. Promote national and regional surveys of pests of significance across Canada focusing on crops that have susceptible pests.
   a. Create a repository of RM surveys that can be viewed in real time.
3. Work with the Pest Management Regulatory Agency (PMRA) and CropLife Canada to:
   a. Modernize pesticide labels with clear, consistent RM language.
   b. Adjust policies: lowest effective rate and maximum number of applications of a particular pesticide.

The Canadian agriculture industry must be proactive and realize the seriousness of pesticide resistance issues now if we want to continue to produce food in Canada.
Chapter 7: References

Andaloro, J. 2018. Ontario Pest Management Conference panelist speaking notes. *There is not a specific reference to this author in this paper; however, his notes were used throughout to organize the content.*


