

Approaching the silver anniversary of weed resistance in Manitoba

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Abstract

We are approaching the silver anniversary (2013) of weed resistance in Manitoba. Group 3-resistant green foxtail and group 2-resistant kochia were both confirmed in 1988. The most recent weed resistance survey conducted in Manitoba in 2008 (300 randomly-selected fields) indicated that 58% of annually-cropped land (5.41 million acres) was infested with a herbicide-resistant weed population (in millions of acres): group 1-resistant wild oat, 2.33; group 2-resistant wild oat, 0.31; group 1+2-resistant wild oat, 0.53, group 8-resistant wild oat, 0.16; group 1+8, 2+8, or 1+2+8-resistant wild oat, 0.50; group 1-resistant green foxtail, 1.24, and group 2-resistant broadleaves, 0.34. Therefore, group-1 resistance in wild oat and green foxtail is widespread, at 55 and 44% of fields, respectively. With patents expiring on various group 1 products, their increased usage will only be tempered by increasing incidence of resistance. Growers usually control such resistant grass weed populations with a group 2 product, where the incidence of resistance is relatively low (12% of fields for wild oat). Survey results indicate that multiple-group resistance in wild oat typically reduces crop yields by 10 to 20%. With limited in-crop herbicide options in wheat, the outlook for increased yields in that crop is not good. However, growers are managing grass weed resistance as best they can by rotating to crops such as canola (with different site-of-action herbicides) or inclusion of forages, and utilizing various non-herbicide weed management practices.

Introduction

Of the top 10 worst herbicide-resistant (HR) weeds worldwide (Heap 2011), wild oat and redroot pigweed are two HR species relevant to western Canada. Of about 360 HR biotypes worldwide, Canada has 51, good for third place after the United States and Australia (Heap 2011). Manitoba currently has 21 HR biotypes. Many of these biotypes were selected in cereal crops. However, since 2010, the proportion of cereals in annual cropping systems in western Canada has fallen below 50% for the first time in the history of agriculture (Statistics Canada 2011). The decline in cereal acres has been matched by the increase in canola acres.

In the Black soil zone of Manitoba, the top 10 weeds are (in decreasing order): green foxtail, wild oat, wild buckwheat, Canada thistle, lamb's-quarters, redroot pigweed, stinkweed, barnyardgrass, perennial sow-thistle, and Russian thistle (Leeson et al. 2005). Except for the two perennial weeds, Canada thistle and perennial sow-thistle, as well as the annual weeds, lamb's-quarters and barnyardgrass, HR biotypes of the remaining species occur throughout western Canada.

Susceptible Wild Oat Endangered in Manitoba

In 2008, 300 randomly-selected fields cropped to cereals, oilseeds, or pulses throughout Manitoba were surveyed in late summer. 371 grass weed seed samples and 145 broadleaf weed seed samples were collected just before harvest from the surveyed fields. Surveyed fields were cropped to cereals (59%), oilseeds (38%), or pulses (3%). These seed samples from 5 grass and 22 broadleaf weed species were planted in soil potting mixture and seedlings were screened in the greenhouse for resistance to herbicides belonging to groups 1, 2, 4, 8, 9, or 10. The good news – no populations were found to be resistant to herbicides from groups 4, 9, or 10.

Of 198 fields where wild oat samples were collected, 62% had an HR biotype. From 2002 (previous survey) to 2008, field frequency of group-1 resistance increased by 15 percentage

points (40 to 55% of fields) vs. 5 percentage points for group-2 resistance (13 to 18%); group-8 resistance in wild oat was found in 11% of fields. Since 2002, group 1+2-resistant wild oat has increased by 5 percentage points (8 to 13%); group 1+8-, 2+8-, and 1+2+8-resistant wild oat were found in 8, 5, and 4% of the 198 fields, respectively, where wild oat samples were collected (Figure 1a-g). Therefore, just over one-third of fields with wild oat in Manitoba have herbicide-susceptible populations. A survey in 2011 found that growers with group 1+2-resistant wild oat typically suffer a 10 to 20% yield loss, even after herbicide treatment. In many cases, frequent use of group-1 herbicides selected for group-1 resistance; when growers switched to a group-2 herbicide, resistance evolved after one or more applications of herbicides with this site of action.

Of 91 fields where green foxtail samples were collected, 44% had a group 1-resistant population (Figure 2). Thus, incidence of group-1 resistance in this weed had doubled in 6 years. Only 1 field each of group 2-resistant chickweed, cleavers, and wild mustard were confirmed; resistance in these weed species was not detected in the 2002 survey. Kochia was not included in this late summer survey. Overall, 141 of 300 (47%) fields surveyed in 2008 had an HR weed biotype, compared with one-third of fields in 2002. The results of this survey highlight the continuing rapid decline in field frequency of herbicide-susceptible wild oat and green foxtail, the two most abundant weeds in Manitoba.

When the frequency of fields with weed resistance in this random survey of 300 fields is extrapolated to the total annual-cropped land in Manitoba (3,763,000 ha; Statistics Canada 2008), it is estimated that 1.6 million ha (44%) is infested with HR weeds, in a total field area of 2.2 million ha (58%) (Table 1). In comparison, the weed resistance survey in 2002 indicated that 0.4 million ha was infested with HR weeds, in a total field area of 1.3 million ha. Therefore, the actual area infested with HR weeds has increased 4-fold, while the total field area affected has increased 1.7-fold over this intervening 6-year period.

Gp 1-resistant wild oat

Resistant ○ Not resistant •

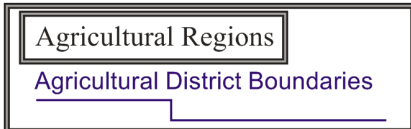
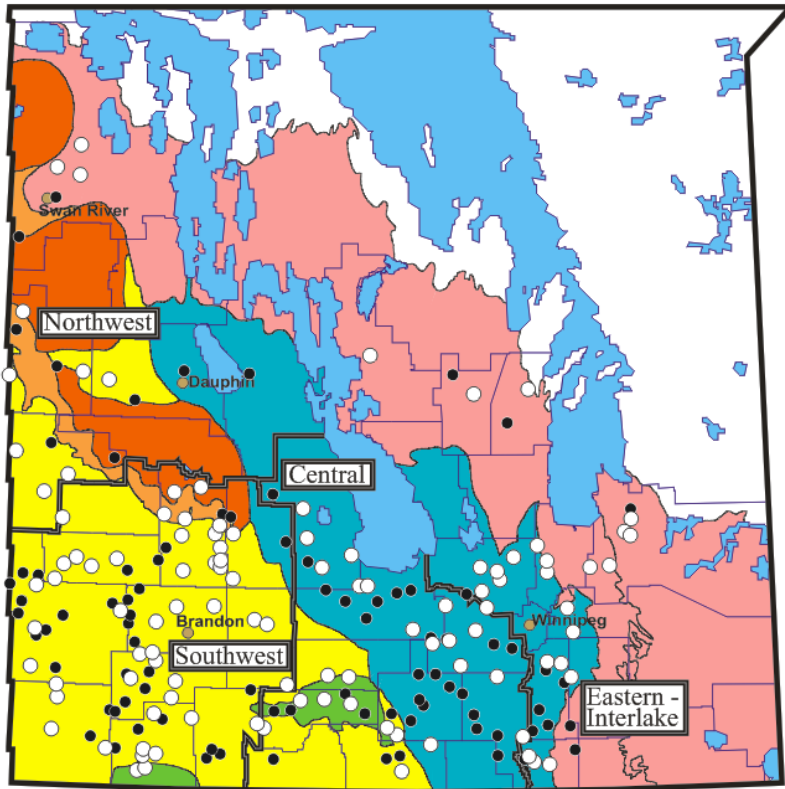


Figure 1a. Group 1-resistant wild oat in Manitoba in 2008

Gp 2-resistant wild oat

Resistant ○ Not resistant ●

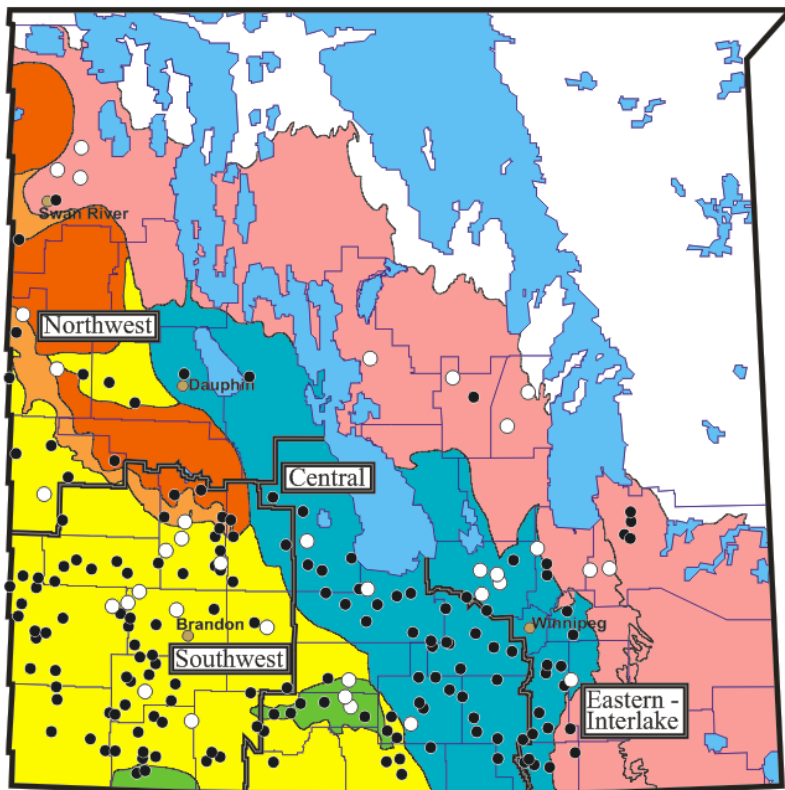


Figure 1b. Group 2-resistant wild oat in Manitoba in 2008

Gp 8-resistant wild oat

Resistant ○ Not resistant •

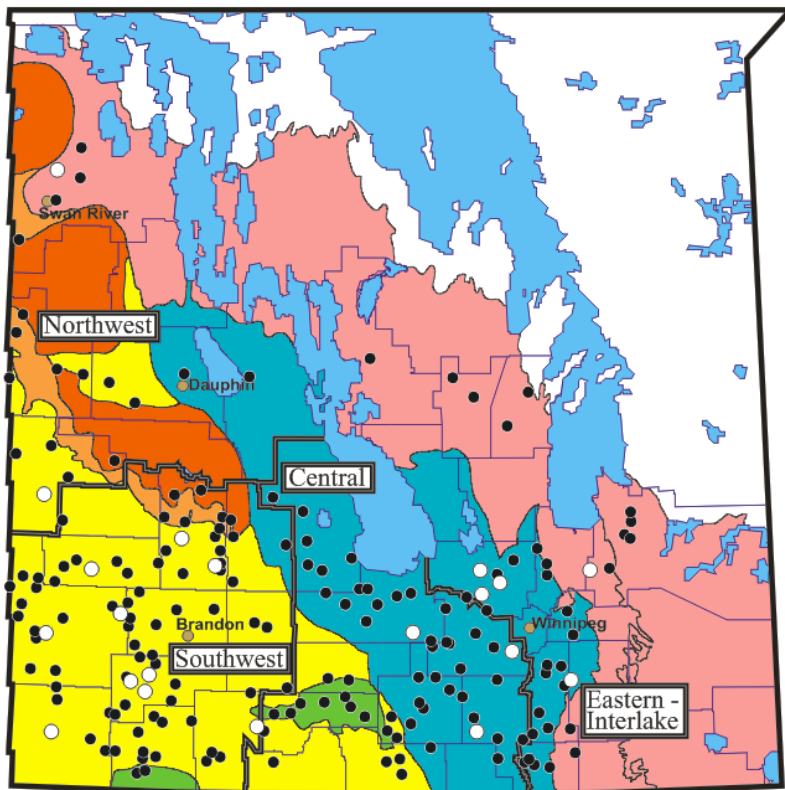


Figure 1c. Group 8-resistant wild oat in Manitoba in 2008

Gp 1- and 2-resistant wild oat

Resistant ○ Not resistant •

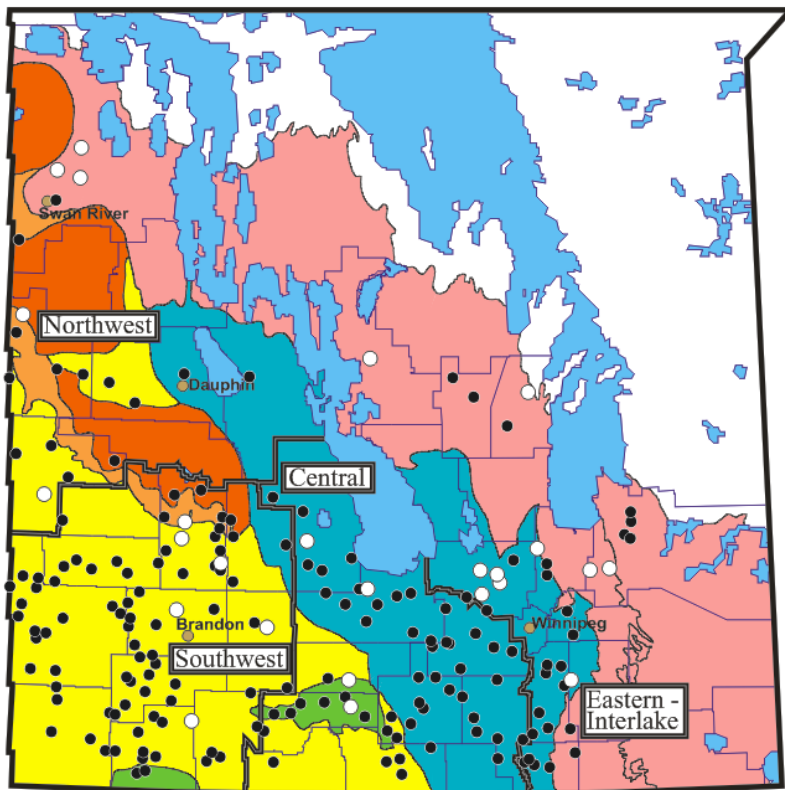


Figure 1d. Group 1+2-resistant wild oat in Manitoba in 2008

Gp 1- and 8-resistant wild oat

Resistant ○ Not resistant •

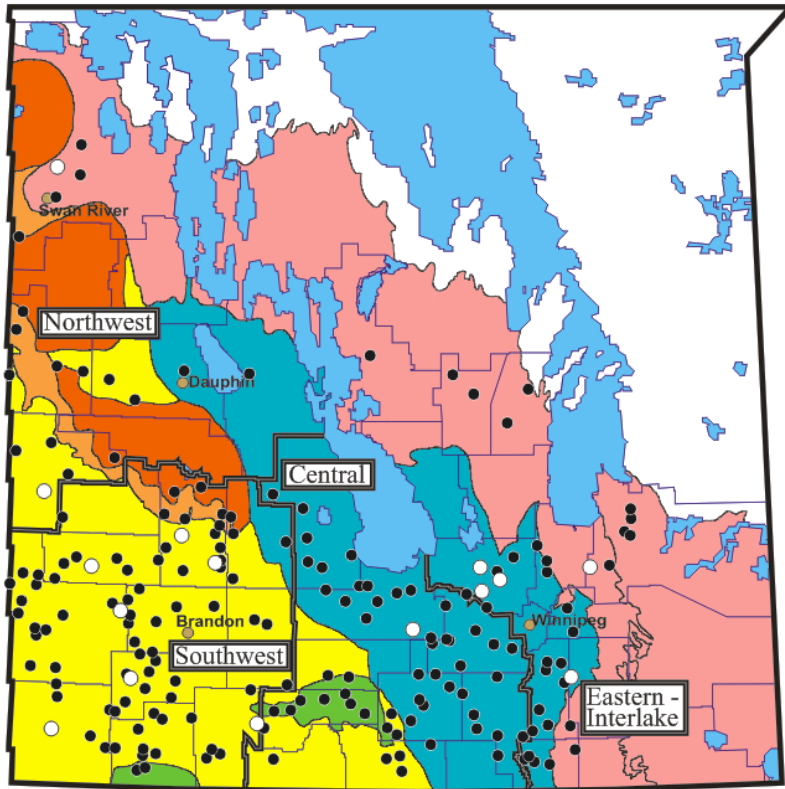


Figure 1e. Group 1+8-resistant wild oat in Manitoba in 2008

Gp 2- and 8-resistant wild oat

Resistant ○ Not resistant •

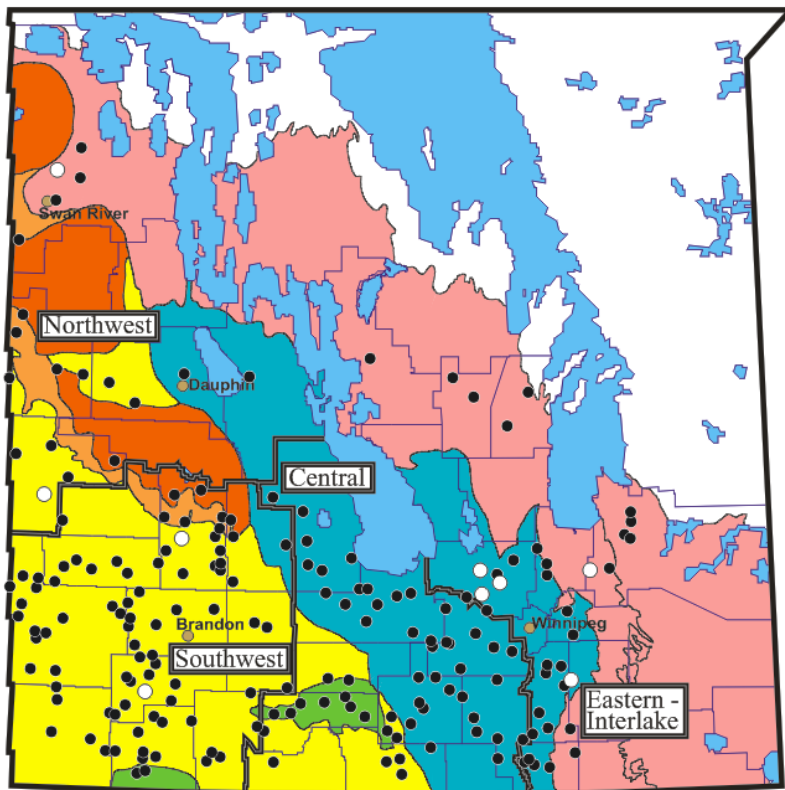


Figure 1f. Group 2+8-resistant wild oat in Manitoba in 2008

Gp 1- and 2- and 8-resistant wild oat

Resistant ○ Not resistant •

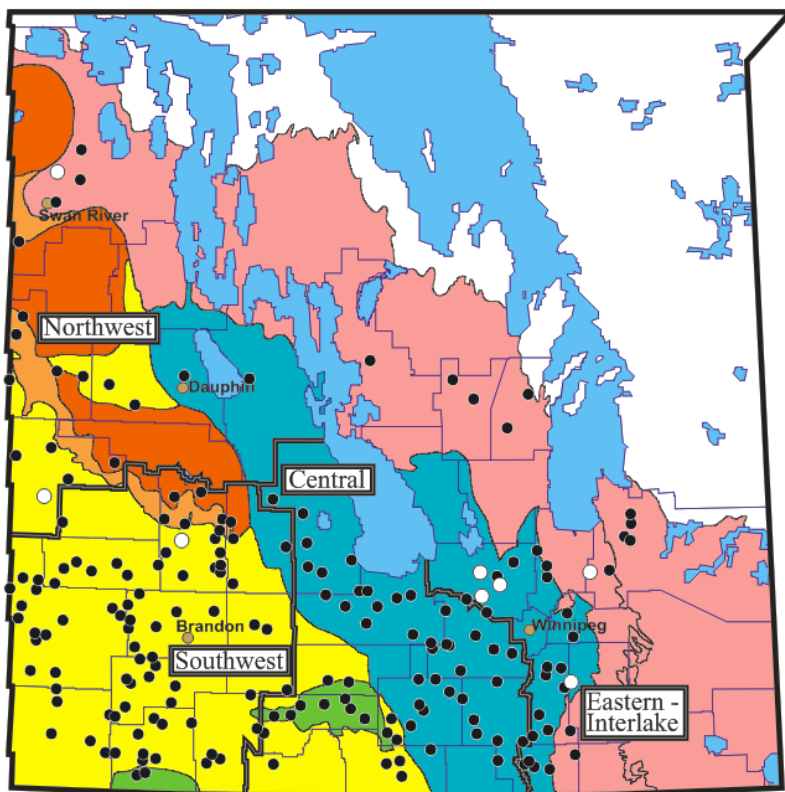


Figure 1g. Group 1+2+8-resistant wild oat in Manitoba in 2008

Gp 1-resistant green foxtail

Resistant ○ Not resistant •

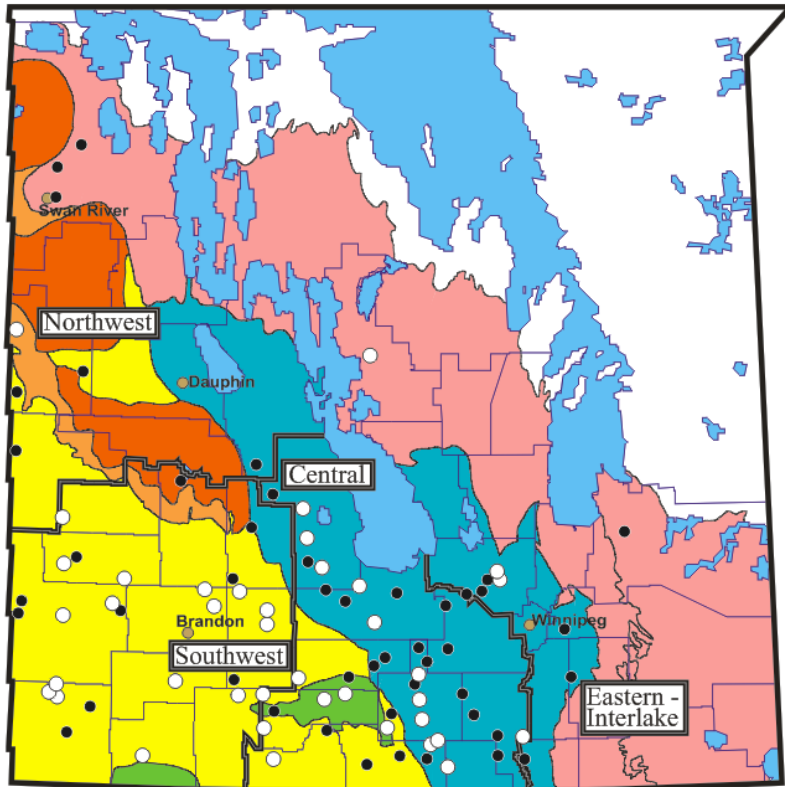


Figure 2. Group 1-resistant green foxtail in Manitoba in 2008

Table 1. Estimated annual-cropped land area in Manitoba impacted by herbicide-resistant (HR) weeds in 2008

Biotype	Infestation area (ac/ha)	Field area (ac/ha)
Gp 1-HR wild oat	1,582,180 / 640,560	2,331,660 / 943,990
Gp 2-HR wild oat	248,710 / 100,690	310,890 / 125,870
Gp 8-HR wild oat	93,740 / 37,950	155,440 / 62,930
Gp 1+2-HR wild oat	383,110 / 155,100	528,510 / 213,970
Gp 1+8-HR wild oat	139,180 / 56,350	217,620 / 88,110
Gp 2+8-HR wild oat	14,350 / 5,810	31,100 / 12,590
Gp 1+2+8-HR wild oat	248,710 / 100,690	248,710 / 100,690
Gp 1-HR green foxtail	1,025,930 / 415,360	1,243,550 / 503,460
Gp 2-HR broadleaves	310,890 / 125,870	341,980 / 138,450
Total	4,046,800 / 1,638,380	5,409,460 / 2,190,060

Best Management Practices

We still recommend herbicide group rotation, to the extent possible (see triangle on the back cover of the 2011 Guide to Crop Protection) (Beckie 2006). However, in wheat, in-crop wild oat herbicide options are group 1, group 2, and group 8 (difenzoquat or Avenge). Preemergence options are triallate or Avadex (group 8), glyphosate (group 9), paraquat (group 22), and trifluralin for wild oat suppression (group 3). Therefore, rotational options are very limited. In wild oat, group-1 resistance is mainly target site-based, with seven possible mutations each conferring a different cross-resistance pattern to fops (e.g., clodinafop), dims (e.g., sethoxydim or Poast), and dens (pinoxaden or Axial). Most or all mutations can confer fop resistance, some can confer dim or den resistance. Clethodim is the lowest-risk herbicide, with only two mutations conferring resistance. For group 2-resistant wild oat, our results indicate that enhanced metabolism is the dominant mechanism. Therefore, herbicide group rotation, with each group having a unique site of action, may not be effective for this type of resistance mechanism. The only rule of thumb is to rotate away from wheat-selective herbicides, as wild oat utilizes the same enzyme system, cytochrome P450 monooxygenases, as wheat does. Group 2 resistance in broadleaf weeds is target site-based, with six possible mutations. In many populations, resistance occurs across all group 2 herbicide classes, leading to loss of effectiveness of all herbicides with this site of action. For group 2 resistance in broadleaf weeds, the best way to delay or manage resistance is through mixtures (or herbicides applied sequentially within a growing season) (Beckie and Reboud 2009). For this strategy to work, the two mixing partners must have different sites of action (i.e., groups), but both effective on the key economic weeds targeted for delaying resistance. In the future, we will see more mixture options available to growers to proactively manage weed resistance.

The long-term solution to proactive or reactive HR weed management is a diversified crop rotation. HR canola has been widely used as a means to manage resistance because of the opportunity to introduce a different site-of-action herbicide into the cropping system. Hybrid canola is also very weed-competitive. Perennial forages in the rotation are an excellent option for driving down the weed seed bank. Along with crop rotation diversity and weed-competitive crops and varieties, enhanced cereal crop seeding rates (e.g., minimum 80 to 90 lb/ac for wheat), and banded or point-injected fertilizer placement can result in a weed-competitive crop stand. Additionally, patch management (when patches are relatively small), and any means of limiting weed seed spread within and among fields will lower the risk of or area affected by HR weeds.

Glyphosate is our most important herbicide, so preserving its effectiveness is paramount (Beckie 2011a). To assess your relative risk of glyphosate resistance, I encourage you to visit www.weedtool.com (for western Canada). This tool was developed by university and government weed scientists, in conjunction with Monsanto technology development personnel. There are 10 questions, each with four possible answers, related to crop production system, tillage system, and glyphosate usage. The decision-support tool indicates the relative risk of glyphosate resistance on a field-by-field basis, and provides best management practices based on your risk rating. Using an empirical model, I predict that kochia, wild oat, and green foxtail are the top three weeds at risk for glyphosate resistance in the Brown and Dark Brown soil zones, whereas wild oat, green foxtail, and cleavers are the top three weeds at risk in the Black and Gray soil zones (Beckie 2011b). In response to increasing occurrence of glyphosate resistance in the Americas, crop varieties with stacked HR traits, including glyphosate, glufosinate, HPPD inhibitors (group 27), and synthetic auxins (group 4) will be introduced soon. This strategy is generally viewed as giving enhanced flexibility to growers to manage resistance. Given the lack of new herbicide site-of-action chemistry in the pipeline, this really is the only road open at the moment to help manage weed resistance.

Conclusion

We need new site-of-action herbicides for many of our major crops in western Canada; canola is the exception. Increasing incidence of resistance has resulted in a resurgence in use of older preemergence soil-residual products such as triallate or dinitroanilines (e.g., trifluralin), and greater use of herbicides in sequences or mixtures to control HR weed species. Recent research indicates that herbicide mixtures are more effective than rotations in delaying herbicide resistance evolution in weeds. The solution is cropping system diversity and herbicide diversity both. Crops with stacked HR traits, with proper stewardship, will help manage HR weeds.

Acknowledgments

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