Group 4 (Growth regulator herbicides) Resistance in Weeds

Most people are aware that the next 'new' technology for managing weeds in corn and soybean will likely be facilitated by the introduction of crops resistant to group 4 herbicides (HG 4). Dow AgroSciences is developing corn, soybean and cotton resistant to 2,4-D (Enlist) whereas Monsanto is developing soybean resistant to dicamba (RR Xtend). Both traits are under review by the USDA, and the companies are hoping to have the new herbicide resistant crops on the market in 2015. A large demand is anticipated for these crops, largely due to the growing problem of evolved resistance to glyphosate and other herbicides.

This article will provide a brief review of the current state of resistance in weeds to group 4 herbicides.

Occurrence of HG 4 Resistance
According to the International Survey of Herbicide Resistant Weeds (www.weedscience.org), 30 species are known to have evolved resistance to group 4 herbicides. Eight of the resistant weeds are found in the United States. Three of the resistant weeds are grasses, including crabgrass and barnyardgrass. The resistant grasses were selected with repeated applications of quinclorac (Facet, Paramount). Quinclorac is a group 4 product used to control grasses in rice, sorghum and other sites. Group 4 resistant weeds of interest in Iowa are described in Table 1.

The discovery of a wild carrot population able to survive 2,4-D in 1957 was the first reported case of a weed resistant to a synthetic herbicide (Whitehead and Switzer, 1963). The population found in Canada was resistant to 2,4-D, but still sensitive to 2,4,5-T and silvex (two group 4 herbicides removed from the market in the 1980’s due to problems associated with dioxin contamination). 2,4-D resistant wild carrot has also been reported in Michigan and Ohio.

Characteristics of HG4 Resistant Weeds
Although it has long been known that group 4 herbicides mimic the activity of indoleacetic acid (IAA, auxin), the exact mechanism of how these herbicides kill plants was poorly understood until recently. Based on the complexity of their mode of action, it is not surprising that it has been difficult to identify the resistance mechanisms in weeds that have developed resistance to these herbicides (Mithila et al. 2011).

Wild mustard is the group 4 resistant species that has been most thoroughly researched. The resistant biotype is 10-, 18- and 104-fold resistant to MCPA, 2,4-D and dicamba, respectively. Resistance was not due to altered uptake, translocation or metabolism. Evidence suggests that differences in affinity to the auxin binding site may be responsible for resistance in this species.

Table 1. Partial list of weeds with evolved resistance to group 4 herbicides. Several of the resistant species are now present in other countries. The herbicide listed is the primary herbicide used resulting in resistance. Source (www.weedscience.org)

<table>
<thead>
<tr>
<th>Species</th>
<th>Herbicide</th>
<th>Site</th>
<th>Country</th>
<th>First Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild carrot</td>
<td>2,4-D</td>
<td>Roadside</td>
<td>Canada</td>
<td>1957</td>
</tr>
<tr>
<td>Canada thistle</td>
<td>MCPA</td>
<td>Cropland</td>
<td>Sweden</td>
<td>1979</td>
</tr>
<tr>
<td>Musk thistle</td>
<td>2,4-D</td>
<td>Pasture</td>
<td>New Zealand</td>
<td>1981</td>
</tr>
<tr>
<td>Common chickweed</td>
<td>MCPP</td>
<td>Wheat</td>
<td>United Kingdom</td>
<td>1985</td>
</tr>
<tr>
<td>Wild mustard</td>
<td>2,4-D et al.</td>
<td>Small grains</td>
<td>Canada</td>
<td>1990</td>
</tr>
<tr>
<td>Kochia</td>
<td>Dicamba</td>
<td>Wheat</td>
<td>USA</td>
<td>1995</td>
</tr>
<tr>
<td>Lambsquarter</td>
<td>Dicamba</td>
<td>Corn</td>
<td>New Zealand</td>
<td>2005</td>
</tr>
<tr>
<td>Waterhemp</td>
<td>2,4-D</td>
<td>Pasture</td>
<td>USA</td>
<td>2009</td>
</tr>
</tbody>
</table>
Group 4 resistant kochia biotypes were found to be resistant to dicamba, dichlorprop (2,4-DP), mepiquarr, MCPA and picloram. These herbicides represent the three chemical families making up the group 4 herbicides. As with the resistant wild mustard biotype, absorption and metabolism were not responsible for resistance, and evidence suggests the involvement of the target site in the differential response. A wild radish biotype in Australia was found to be resistant to 2,4-D and MCPA, but not dicamba. The level of resistance in this species was relatively low (2.5X).

The recent discovery of 2,4-D resistant waterhemp in Nebraska is probably the greatest concern to Cornbelt agronomists (Bernards et al. 2012). This population was found in an 80-acre field used for seed production of little bluestem. The field was treated annually with atrazine, Dual and 2,4-D for 13 years prior to 2,4-D resistance being observed. The resistant population was 100 fold less sensitive to 2,4-D and twofold less sensitive to dicamba.

The 2,4-D resistant waterhemp is of particular concern for several reasons. First, this is the sixth herbicide group to which waterhemp has evolved resistance (herbicide groups 2, 4, 5, 9, 14 and 27). Second, while it took the use of glyphosate on millions of acres planted to Roundup Ready crops to select many of the glyphosate resistant weeds (including waterhemp), the 2,4-D resistant waterhemp was found in a scenario where significant selection pressure was placed on limited acres. Finally, the herbicide program responsible for selecting the 2,4-D resistant waterhemp included two additional herbicides with activity on waterhemp.

Summary

The discovery of 2,4-D and MCPA in the 1940’s initiated the era of chemical weed management. While the group 4 herbicides continue to be important in many cropping systems, their use has declined with the discovery of new herbicides. The widespread occurrence of herbicide resistance and the development of crops resistant to these herbicides are likely to result in large increases in their use in the near future.

Compared to most herbicide groups, the probability of resistance to group 4 herbicides is considered to be low. However, this was also the case with glyphosate (HG 9). While the group 4 herbicides have been used for nearly 70 years in Iowa with no documented cases of resistant weeds, they have not been used in a way that places high selection pressure on weeds. This is likely to change with the release of Enlist and RR Xtend crops.

It will be imperative to adopt diversified management practices that utilize multiple effective herbicide groups and non-chemical control tactics. The Nebraska 2,4-D resistant waterhemp illustrates that simply using multiple herbicide groups does not prevent resistance. While both Dow AgroSciences and Monsanto will market products combining the Group 4 herbicide with glyphosate to accompany their new HR crops, it is important to remember that glyphosate will likely be ineffective on much/most of the waterhemp population when these new crops are available.

The Enlist and RR Xtend traits will provide farmers an additional tool to manage herbicide resistant waterhemp and other troublesome weeds. However, the effectiveness of these herbicides will be lost quickly if they are used in a similar manner to how we have used herbicides in the past.

References


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