HPPD-inhibitor resistance stewardship: The perspective of the HRAC HPPD-inhibitor Working Group

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HPPD-inhibitor Working Group

HRAC Purpose: To facilitate the effective management of herbicide resistance by fostering understanding, cooperation and communication between industry, government and farmers.

Result: HPPD-inhibitor Working Group (WG) was initiated by HRAC to specifically address HPPD-inhibitor resistance matters.

Objectives: Prolong useful life of HPPD-inhibitor herbicides

- Understand the current resistance situation
- Provide additional communication and education tools
- Provide consistent stewardship recommendations to stakeholders – including label stewardship alignment
- Provide guidance on potential research objectives
  - HPPD-inhibitor resistance understanding
  - HPPD-inhibitor stewardship recommendations (eg. weed size)
HPPD-inhibitor Working Group

HPPD-inhibitor WG was formed in 2012 and held face-to-face and multiple teleconference meetings over the past two years.

While the scope of the HPPD-inhibitor WG is global, the WG agreed to focus on North America.

<table>
<thead>
<tr>
<th>Company</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMVAC</td>
<td>Peter Porpiglia, Rich Porter</td>
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<td>BASF</td>
<td>Greg Armel, Andreas Landes, Walter Thomas</td>
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<td>Bayer</td>
<td>Roland Beffa, Arlene Cotie, Tom Kleven, Harry Strek</td>
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<td>DuPont</td>
<td>William Patzoldt</td>
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<tr>
<td>Syngenta</td>
<td>Deepak Kaundun, Les Glasglow, Brett Miller, Gordon Vail</td>
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HPPD-inhibitors: an important weed control tool

Very effective class of chemistry for control of important species including *Ambrosia*, *Amaranthus*, *Chenopodium*, *Kochia*, grasses and other weeds.

Herbicides that can be applied PRE or POST

- Greater utility and flexibility for growers

Excellent compatibility with other herbicides

- Allows growers to deploy effective weed management programs with multiple, effective modes of action

Excellent atrazine synergists for enhanced performance

Multiple registered active ingredients with this mode of action

- Isoxaflutole, mesotrione, pyrasulfotole, tembotrione and topramezone
# Background herbicide resistance to selected modes of action

<table>
<thead>
<tr>
<th>Mode of action</th>
<th>Herbicide group</th>
<th>Number of resistant species globally</th>
<th>Number of resistant species in North America</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALS-inhibitors</td>
<td>2</td>
<td>135</td>
<td>54</td>
</tr>
<tr>
<td>Glutamine synthase inhibitors</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Glycines</td>
<td>9</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>HPPD-inhibitors</td>
<td>27</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Photosystem II inhibitors</td>
<td>5</td>
<td>71</td>
<td>12</td>
</tr>
<tr>
<td>Synthetic auxins</td>
<td>4</td>
<td>31</td>
<td>12</td>
</tr>
</tbody>
</table>

Source: Ian Heap, weedscience.org
Confirmed cases of HPPD-inhibitor resistance in North America

Confirmation of resistant population reported via one of the following:

- International Survey of Herbicide Resistant Weeds
- Published in a peer reviewed journal

Palmer amaranth (*Amaranthus palmeri*)
- Kansas (2009) and Nebraska (2011)

Waterhemp (*Amaranthus tuberculatus* syn. *rudis*)
- Illinois (2009), Iowa (2009, 2011) and Nebraska (2011)

Other populations under evaluation by industry and universities

*Source: Ian Heap, weedscience.org*
Current knowledge of Amaranthus HPPD-inhibitor resistance mechanism

• Mechanism of resistance studies are ongoing
  • Not known for all confirmed resistant populations
• All confirmed resistant populations are also resistant to other herbicide modes of action
• Amaranthus spp. Can be multiple/cross resistant to herbicides with diverse modes of action (Heap, 2013)
• Non-target site mechanisms (Reichers, et al, 2013)
  • Target site resistance has not been found in resistant populations tested
• Enhanced metabolism contributes to resistance (Reichers, et al, 2013)
HPPD-inhibitor WG objectives

- Understand the current resistance situation
- Provide additional communication and education tools
- Provide consistent stewardship recommendations to stakeholders
  - Including label stewardship alignment
- Provide guidance on potential research objectives
  - HPPD-inhibitor resistance understanding
  - HPPD-inhibitor stewardship recommendations
Understanding the current resistance situation

The HPPD-inhibitor Working Group agreed to:

- Meet regularly (2 to 3 times per year)
- Review together and track the confirmed complaint cases
Provide additional communication and education tools

1. Post this HPPD-inhibitor WG presentation on HRAC website at hracglobal.com
2. Distribute HPPD-inhibitor WG fact sheet
3. Recommend incorporating resistance management recommendations into HPPD-inhibitor containing product labels
Provide consistent stewardship recommendations to stakeholders

The Working Group is developing and recommending a common language for HPPD-inhibitor stewardship which can be used in:

- Education programs (step 1)
- Labels (step 2)

Include mode of action labeling on all HPPD-inhibitor containing products.

In order to reduce the development of resistance, always use the full labeled rate for all applications PRE and POST.

Follow explicitly the recommendations for application volume(s), recommended nozzle(s) and other application parameters.
Provide consistent stewardship recommendations to stakeholders

In order to avoid the development of resistance, require PRE and POST HPPD-inhibitors to always be used in tank mix or premix

• When appropriate a residual herbicide should be used
• Use at least two compounds with efficacy against the target species

Applications should be made to small, actively growing weeds

• Recommend targeting weeds less than four inches in height

A recommendation to limit the number of HPPD-inhibitor applications is under consideration as additional research is completed
Provide consistent stewardship recommendations to stakeholders – label alignment

• Strengthen and align recommended resistance management language on all HPPD-inhibitor containing product labels
• Incorporate recommendations made by HPPD-inhibitor WG into product labels during label revisions
• Optimize product rate and weed size recommendations for post-emergence HPPD-inhibitor labels to be consistent with resistance management stewardship
• Recommend the use of tank mixtures or premixtures with a minimum of two effective modes of action against driver weeds
Provide guidance on potential research objectives

Continued investigation into resistance mechanisms

What is an effective tank mix partner(s)?

- Which herbicides work best as tank mix partners that would be least prone to metabolic degradation?
- Should tank mix partners have similar length of residual and soil behavior?
- Should sequential applications contain herbicides with multiple, different modes of action?

Is there an impact from limiting the number of applications?

- Within a season or between seasons
- How will this impact resistance evolution?

Does weed growth stage at application influence resistance evolution?

Encourage research collaboration
Conclusions and perspectives

• HPPD-inhibitor WG will continue with a goal of prolonging the useful life of HPPD-inhibitor herbicides
• HPPD-inhibitor WG needs the support of industry and university research and extension
• HPPD-inhibitor WG focus is on HPPD-inhibitor resistance but this is a larger issue encompassing all modes of action
• Key WG stewardship activities:
  • Understand the current resistance situation
  • Provide additional communication and education tools
  • Provide consistent stewardship recommendations to stakeholders
  • Provide guidance on potential research objectives
Thank you for your attention