How can Science help to Fight Weeds & Protect Yield?

Market reactions to weed resistance
Mode of action changes in herbicides used in soybeans and corn in the USA, Brazil and Argentina from 1996 to 2015

GHRC Denver 17 May 2017 / Harry Strek and Wolfgang Heep
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The company assumes no liability whatsoever to update these forward-looking statements or to conform them to future events or developments.
• Herbicide resistance development soybeans and corn in USA
• MoAs used in soybeans 1996-2015 in USA, Brazil, Argentina
• MoAs used in corn 1996-2015 in USA
• Conclusions
Number of unique resistant cases in soybean & corn

Data source: Heap, 2017
The International Survey of Herbicide Resistant Weeds
www.weedscience.org

**unique case:** resistance to MoA (or MoA combination) \( \times \) geographical location; first observation in a crop (soybean)

**9 individual MoAs + 12 MoA combinations:**

- A, AB, AG, B, BC, BC1, E, BC1EF, O, BC1EG, BC, FG, BE, BG, C1, C, G, C2, D, DG, E, EG, F2(+), G, K1, O
Number of resistant weed species in soybean and corn

Data source: Heap, 2017
The International Survey of Herbicide Resistant Weeds
www.weedscience.org
Changes in resistance in weeds

Data source: Heap, 2017
The International Survey of Herbicide Resistant Weeds
www.weedscience.org

* All 4 cases in 2016 multiple MoAs
Most information on herbicide resistance distribution and intensity is based on farmer surveys.

Farmers may have agronomic problems other than resistance that can result in decreased efficacy and thus perceived resistance.

Farmers generally react to resistance by changing herbicide program first.

Farmers must keep good records about what they sprayed.

Herbicide usage and intensity based upon independently contracted farmer surveys.

Growers: USA (4300), Brazil (3010 soybean, 4365 corn – both seasons), Argentina (1050 soybean, 800 corn); constant number with ~10% turnover per year.

Can we discern resistance trends?
Global herbicide market by MoA

- Market has doubled since 2004 based on farming intensity and product price
- Avg. 10.3% market growth over 2009-2015 years (62% total)
- Small shift to using more MoAs and decrease in Top 6
Soybean herbicide market USA by MoA

Drop and recovery of total market and in 2015 glyphosate share at < half of peak

Source: Bayer internal database 2016; total market value in €
Pie chart with all a.i.s market share in segment
Soybean herbicide market Brazil by MoA

1996 - 2015

Total Herbicide Value (€)


2004 2007 2009 2014

Does not include cost of trait

2.9x ↑ in area

Slower increase of total market with glyphosate peak share already reached in 2014?

Source: Bayer internal database 2016; total market value in €

Pie chart with all a.i.s market share in segment
Soybean herbicide market Argentina by MoA

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Herbicide Value (€)</th>
<th>ACCase (A)</th>
<th>ALS (B)</th>
<th>PSI1 (C1)</th>
<th>PSI1 (C2)</th>
<th>PSI1 (C3)</th>
<th>PSI (D)</th>
<th>PPO (E)</th>
<th>HPPD (F2)</th>
<th>DOXPS (F4)</th>
<th>EPSPS (G)</th>
<th>GLU (H)</th>
<th>MitAss (K1)</th>
<th>VLCPA (K3)</th>
<th>Uncoupler (M)</th>
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Recent rapid increase in total market with very high glyphosate share decreasing

Source: Bayer internal database 2016; total market value in €

Pie chart with all a.i.s market share in segment

Does not include cost of trait
Herbicide resistance in Argentina

Herbicide resistance in Argentina

Source: http://www.aapresid.org.ar/rem/
accessed 3 May 2017
Corn herbicide market USA by MoA

Total Market Value (M €/$)

Does not include cost of trait


Total value stable; diverse herbicide use; glyphosate peak share already passed

Source: Bayer internal database 2016; total market value in €
Pie chart with all a.i.s market share in segment
Conclusions

General

• Herbicide use in soybean in US, Brazil and Argentina appears to have responded to resistance evolution, both in total value and changes in MoAs
• Changes in the market (value & MoAs) can sometimes be relatively rapid
• Herbicide market in US corn more stable (total value) and diverse (MoAs)
• Market history illustrates the need to protect EVERY single MoA and keeping many MoAs (and compounds) in the market to permit suitable responses to weed dynamics
Thank you!

Any questions?

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