

Resistance is Growing

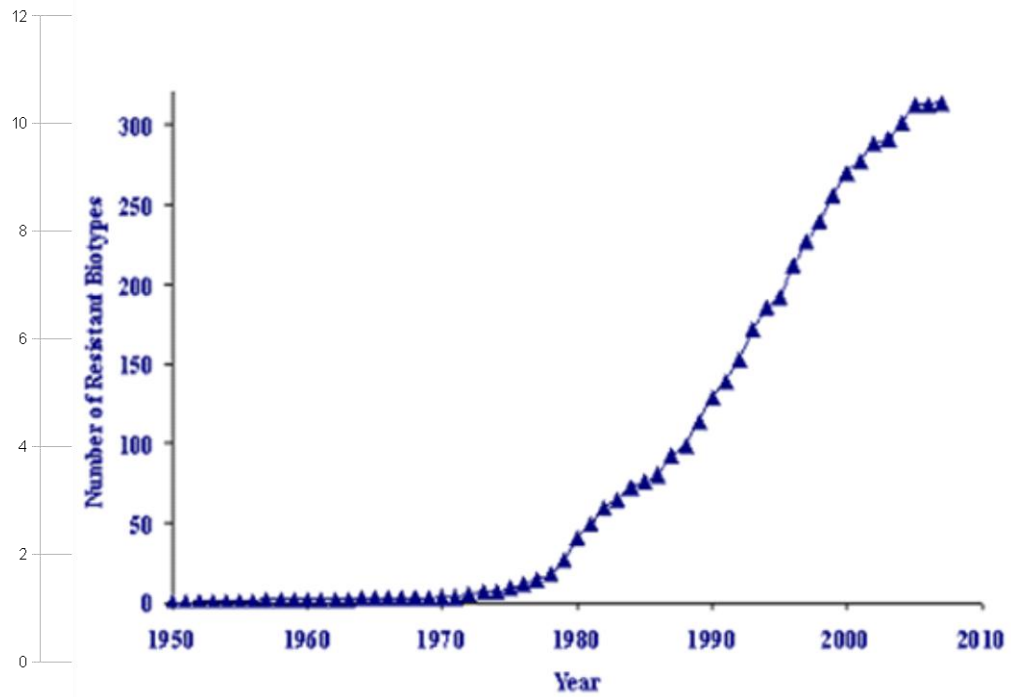
GM Crops and Herbicide resistance

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GM Freeze

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Accelerating Resistance Since 1980



olum 1
olum 2
olum 3

Herbicide Resistance

- Natural selection of existing resistance
- Natural selection of mutations
- Out crossing of HT crops to wild relatives
- Crop volunteers
- Herbicide resistance gene stacking over time eg in Canada canola volunteers

Herbicide Tolerant Crops

- Glyphosate (GM)
Monsanto
- Glufosinate(GM)
Bayer
- Imidazolinone (not GM) BASF
- 2,4 D (GM)Dow
- Sulphonylurea (both)
DuPont
- Haloxyfop (GM) Dow
- Sethoxydim (not GM)
BASF
- Triazines (not GM)
many
- Dicamba (GM)
Monsanto and Dow

Weed resistance in herbicides with tolerant crops

- Glyphosate 16 biotypes
- 2,4 D 27 biotypes
- Sulfonylurea 101 biotypes
- Triazines 68 biotypes

Roundup resistance

- “once in a century” weed killer
- 1996 Rigid ryegrass Australia
- Since 1997 seven new resistant weeds in USA, five in Brazil and two in Argentina
- *Because glyphosate is the herbicide most often used in no-till and minimum-till systems, GR [glyphosate resistant] volunteer crop plants and glyphosate-resistant or tolerant weeds will jeopardize the sustainability of those systems*
Mallory-Smith, C and Zapoilam, 2008.

Major Resistance to Roundup

- Palmer amaranth (*Amaranthus palmeri*)
- Appeared 2005
- Maize, cotton and soya USA
- 100000- 1million acres
- *If it ever germinates, we have no products that we can come over the top of, small cotton particularly, and take out glyphosate resistant Palmer Amaranth.” Dr Ken Smith University of Arkansas*

Major Resistance to Roundup

- Horseweed (*Conza canadensis*)
- Appeared 2000
- Soya, cotton and maize USA and soya Brazil
- 2 million seeds per plant
- >2million acres USA
- Within 3 years of using only glyphosate for weed control in continuous glyphosate-resistant soybeans, glyphosate failed to control horseweed in some fields.

Major Resistance to Roundup

- Johnsongrass (*Sorghum halepense*)
- Appeared 2005
- Soya in Argentina and USA
- Invasive weed introduced for fodder – banned in Argentina since 1936.
- Roundup usage up from 1 million to 18 million litres 1991-2007
- 100,000 acres Argentina
- First reported in 2003

The Solution -More Chemicals

- HT gene stacking
- Herbicide rotation
- Tank mixes to retain Roundup benefits
- Soil residuals eg Palmer amaranth in cotton

Multiple resistance 1

- Roundup plus resistance to other HT products
15 weed species globally.
- 2,4D (one), sulphonylureas (12) and triazines
(8)
- Resistance to 7 active ingredients in US soya
and 4 in USA maize.
- 26 weed species in soya (131 biotypes) and 29
(100 biotypes) in maize
- Multi resistances 14 biotypes in soya (7 inc
Roundup) and 7 in maize (3 inc Roundup)

Multiple Resistance 2

- Soil residuals – already resistance to 5 different modes of herbicide action.
- Residuals limited by long soil half-life damaging some following crops -up to 2 years.
- Hand pulling in some cotton crops in USA.
- Farmers complacent about Roundup- seven out of ten did not think Roundup resistant weeds was “a serious issue”.

Future Strategies 1

- Chemical control likely to become more complex and difficult and liable to breakdown.
- Stricter controls on using single herbicides over many seasons.
- No new herbicidal molecule in the pipeline.
- Costs of chemical weed control could double in Argentina.
- Pesticide use will continue to increase.
- Rapid spread of resistance still possible.

Future Strategies 2

- Volunteer oilseed rape and weed beet will create long-term problems.
- Crop rotations, crop breaks, mechanical weed control will come to the fore.
- Return of older chemicals eg 2,4D, will increase public concern about safety on farm in and residues in products.

Conclusions

- GM herbicide resistant crops are driving resistance to Roundup – perfect conditions.
- “It won't happen here” prevalent.
- Future options for chemical control limited due to multiple resistance and lack of new miracle chemicals
- Big opportunity for research and training in non-chemical weed control based on sound agricultural practice.