Perspectives of herbicide-resistant weeds in agriculture and the need for greater management diversity

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8th International Integrated Pest Management Symposium
Salt Lake City, Utah March 26, 2015

Introduction

- Weed management tactics, in a general sense, have not changed appreciably in several decades
  - Tactics include cultural, mechanical, herbicidal and biological
  - Specific tactics however have seen many changes reflecting not only technological improvements but also the need to address social and economic considerations

Introduction

- Despite the fact that evolved resistance to herbicides has been a concern for at least four decades, new herbicide resistances have "tipped the cart"
- There are a number of issues/problems in managing herbicide-resistant weeds
  - Grower knowledge
  - Time management
  - Economic concerns
  - Lack of new herbicides

Important glyphosate-resistant weeds found in glyphosate-resistant crops[1]

Common waterhemp

Horseweed

Palmer pigweed

Giant ragweed

Common ragweed

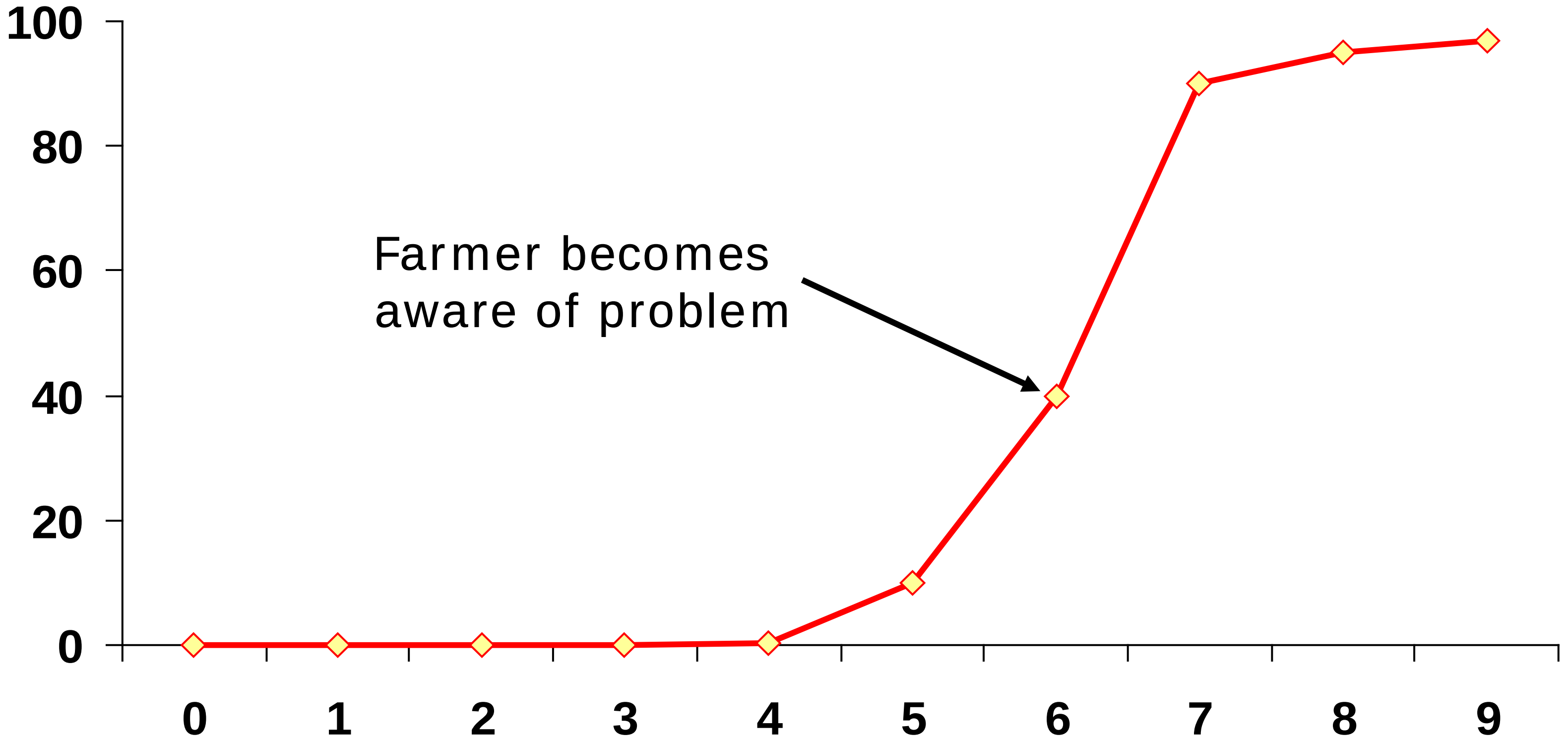
Johnsongrass

[1]Multiple herbidie resistances are found in these weeds

The grower perception of herbicide resistance

The reality of herbicide resistance

Hypothetical development of weed population shift



Adapted from Gunsolus (U of Mn, 1993)

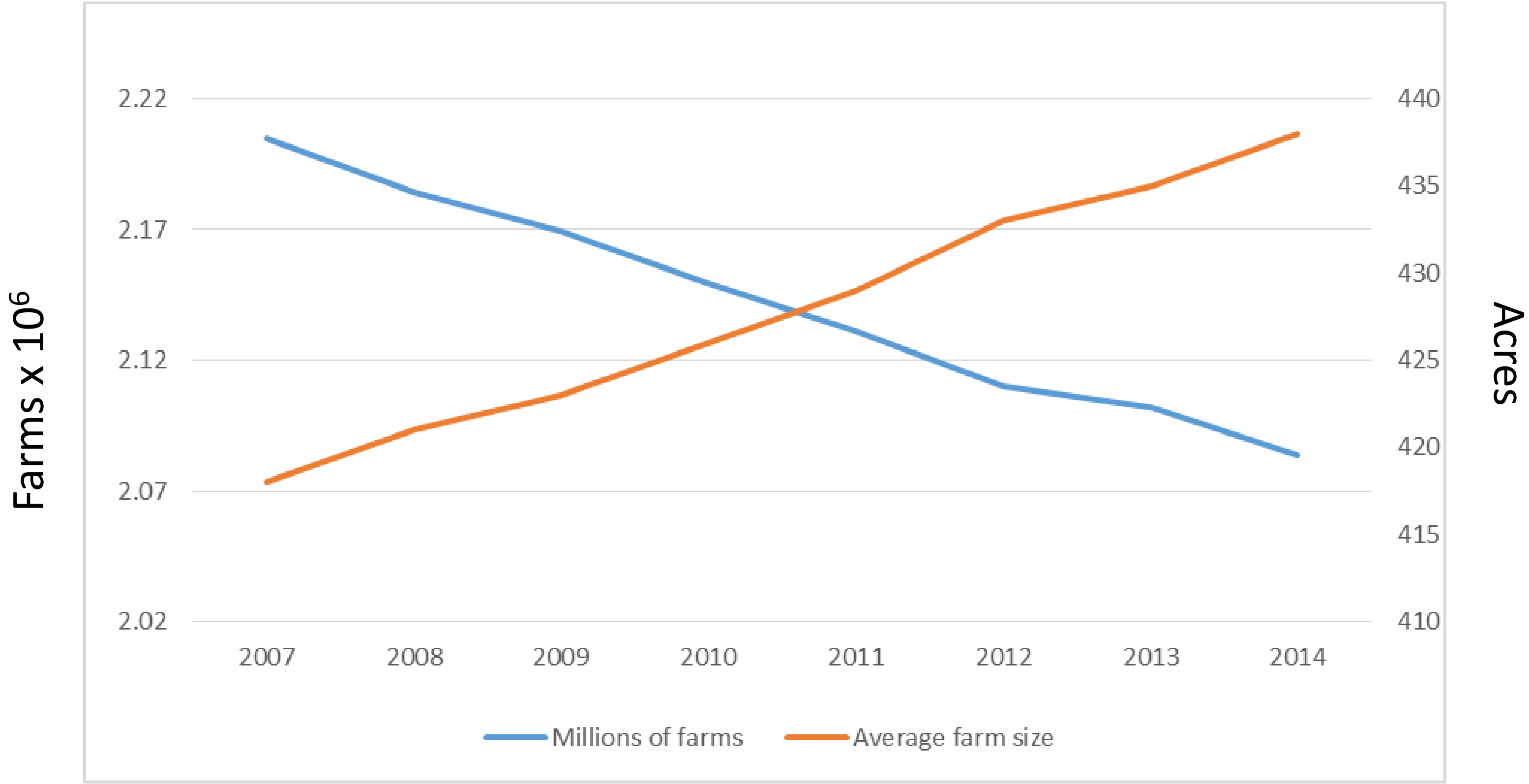
Estimated multiple resistances based on 2011 waterhemp population collections and inclusionary probability from the 2013 collections[1]

Herbicide resistance(s)[2]	Number of 2011 populations	Estimated herbicide resistance frequency in Iowa fields (95% Confidence Limit)
None	2	1.3% to 1.5%
1 way	9	5.8% to 6.7%
2 way	26	16.7% to 19.3%
3 way	33	23.2% to 24.5%
4 way	19	12.2% to 14.1%
5 way	10	6.4% to 7.4%
Total multiple	88	56.7% to 65.3%

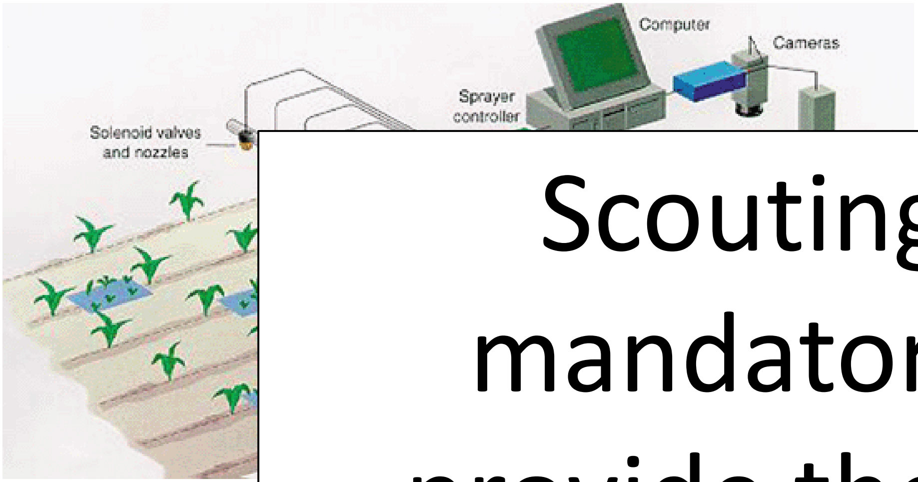
[1]Project sponsored by the Iowa Soybean Association

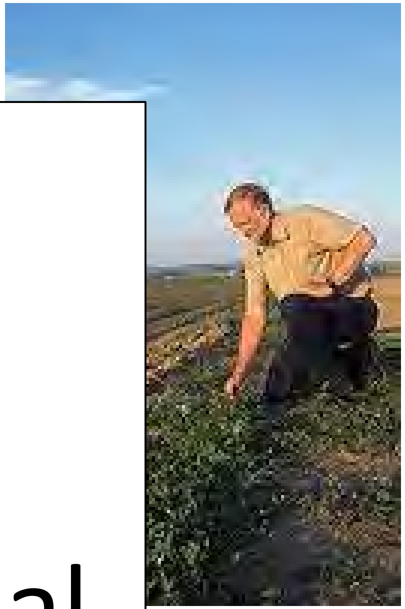
[2]Assessment of Herbicide Groups 2, 5, 9, 14, and 27

Number of farms and average farm size in the US



Site-specific weed management





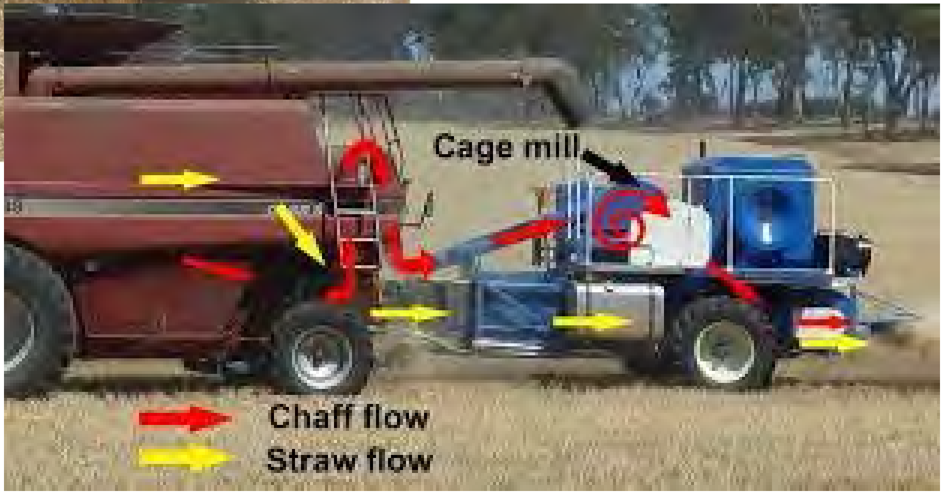
Scouting is mandatory to provide the best tactics for individual fields

Mechanical tactics






Weed seedbank management



PAGMan – USDA-ARS & SDSU

Four-row grit applicator has 8 nozzles, one for each side of four rows
Grit application rate is about 500 kg/ha
Air is pressurized at about 500 kPa

Before & after grit application

(note level of in-row control)

Weedy V3

Treated at V1 (June 15) + V3 (June 23)

Cultural tactics

- Increase crop rotation complexity
- Temporal changes in crops
  - summer annuals (corn and soybean) vs. spring grains
- Date of planting
- Row spacing to improve crop competitiveness
- Inclusion of perennial forages

Cover crops and management within the crop systems

Soybean row spacing

30” rows V2

15” rows V2

Biological control tactics

Robotics

‘Omics’ in weed management

the plant journal

SEB Society for Experimental Biology

The Plant Journal (2014) 78, 865–876

doi: 10.1111/tpj.12514

RNA-Seq transcriptome analysis to identify genes involved in metabolism-based diclofop resistance in *Lolium rigidum*

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Received 15 October 2013; revised 10 March 2014; accepted 13 March 2014; published online 22 March 2014.

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SUMMARY

Weed control failures due to herbicide resistance are an increasing and worldwide problem that significantly affect crop yields. Metabolism-based herbicide resistance (referred to as metabolic resistance) in weeds is not well characterized at the genetic level. An RNA-Seq transcriptome analysis was used to find candidate genes that conferred metabolic resistance to the herbicide diclofop in a diclofop-resistant population (R) of the major global weed *Lolium rigidum*. A reference cDNA transcriptome (19 623 contigs) was assembled and assigned putative annotations. Global gene expression was measured using Illumina reads from untreated control, adjuvant-only control, and diclofop treatment of R and susceptible (S). Contigs that showed constitutive expression differences between untreated R and untreated S were selected for further validation analysis, including 11 contigs putatively annotated as cytochrome P450 (CytP450), glutathione transferase (GST), or glucosyltransferase (GT), and 17 additional contigs with annotations related to metabolism or signal transduction. In a forward genetics validation experiment, nine contigs had constitutive

RNAi technology is an example

resistance, transcriptional markers, *Lolium rigidum*.

INTRODUCTION

Weed control in modern cropping systems is vital to protect crop yields, maintain profitable farming, and meet global food demands. Herbicides are major tools to control weeds and weed control failure caused by herbicide resistance is an increasing and significant problem worldwide (Heap, 2013). The evolution of herbicide resistance has rapidly occurred when large and genetically variable weed populations have been subjected to intensive herbicide selection (reviewed in Powles and Yu, 2010). While in many cases target-site-based herbicide-resistance mechanisms endow resistance only to a selecting herbicide chemistry/mode-of-action, the greatest threat is posed by metabolic resistance mechanisms, as there can be resistance across diverse herbicide classes. Metabolic resistance, while evident in several species, has been documented repeatedly in the important grass weed *Lolium rigidum*. Since first apparent (Heap and Knight, 1986), subsequent studies have established that herbicide cross-resistance in *L. rigidum* involves enhanced rates of herbicide metabolism that can be reversed *in vivo* by known

The key to herbicide resistance management: Many little hammers

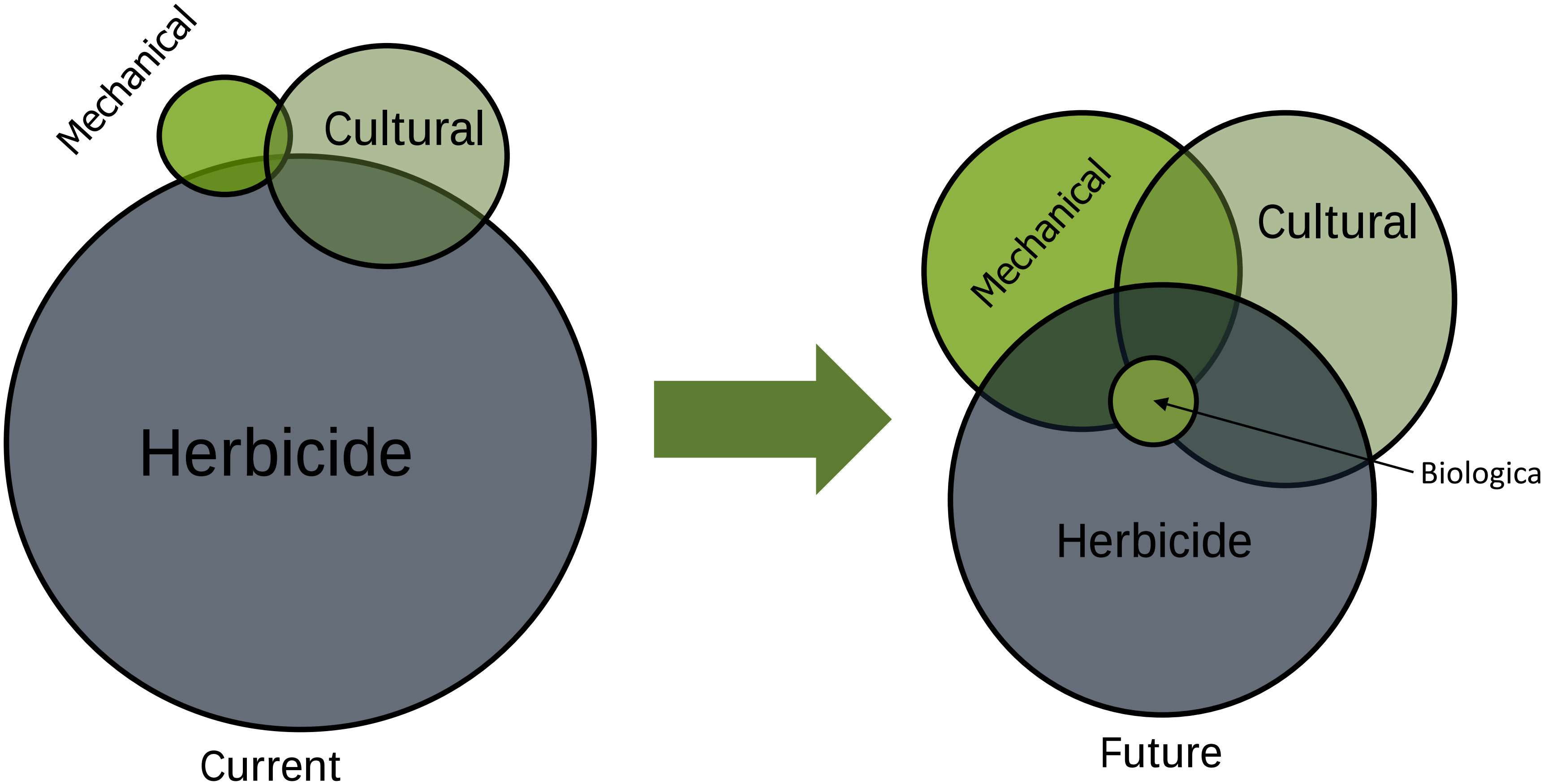
Seedbed prep tillage

Cover crops

Post-plant tillage

Field border management

“Ideal” Integrated Weed Management



Conclusions

- Diversity means adopting weed management tactics designed to address field-specific problems
- Diversity means that weed management must include long-term planning using many tactics **based on field scouting**
- Diversity means that individual growers recognize weed escapes and use multiple tactics to achieve control
- Diversity means that action is taken immediately

Call to action

- Use scouting of individual fields to integrate biological, mechanical and cultural tactics to increase weed management diversity
- Develop public and private programs to control weed escapes prior to seed maturity thus improving weed seedbank management and reducing herbicide-resistant weed population densities
- Incentivize innovation in non-chemical weed management practices