# Lessons Learned from Dealing with Resistant Waterhemp

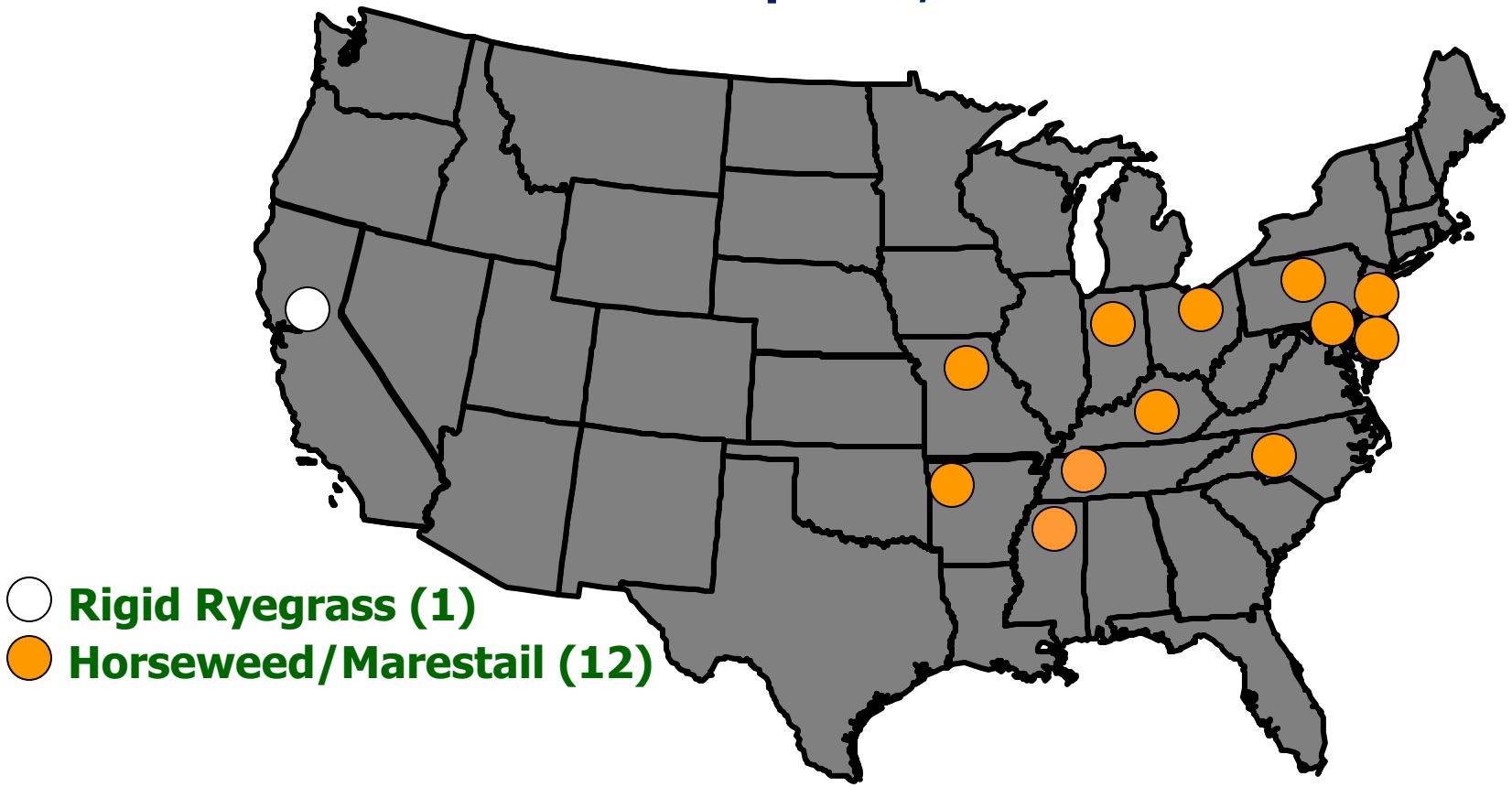
# A case study with Waterhemp…

**Platte County, Missouri Site:**

- called to site in fall 2003; started field trials in 2004
- continuous gly-R soybean since 1996; 1-2 apps gly/year
- 1st confirmed case of gly-R waterhemp in the world

# Glyphosate-resistant Weeds in the U.S.

## 2003: 2 species; 13 states



○ Rigid Ryegrass (1)

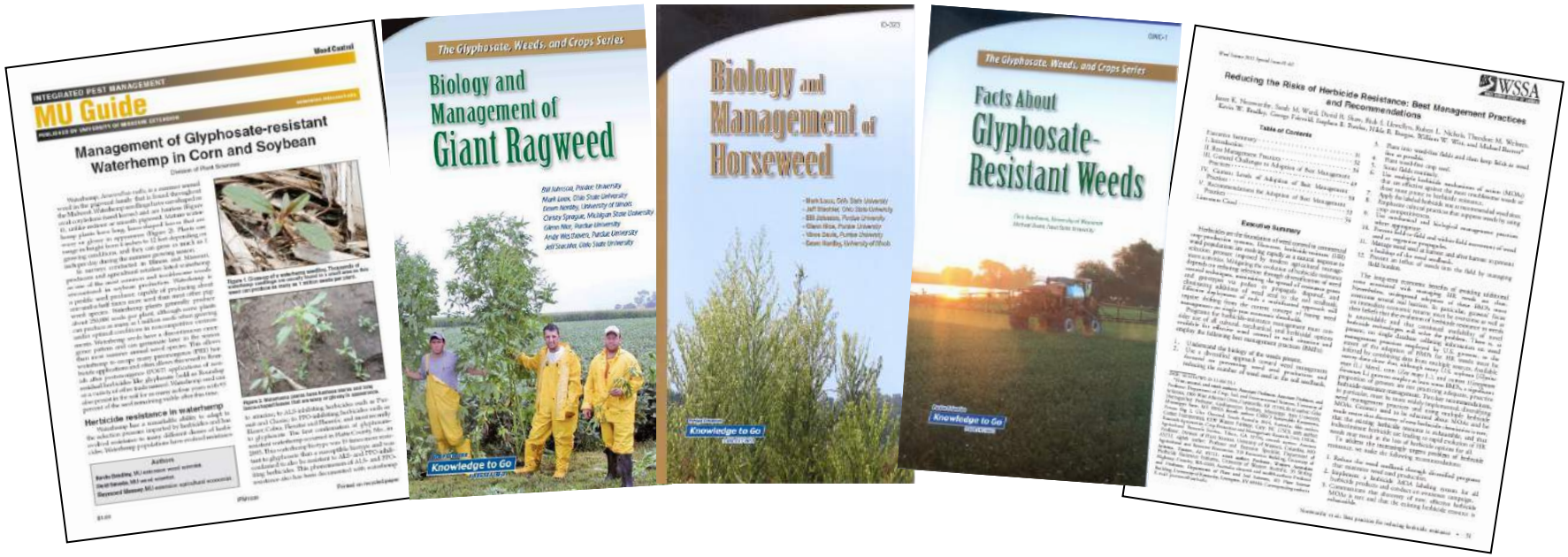
● Horseweed/Marestail (12)

*Parentheses indicate the number of states in which that resistant weed occurs

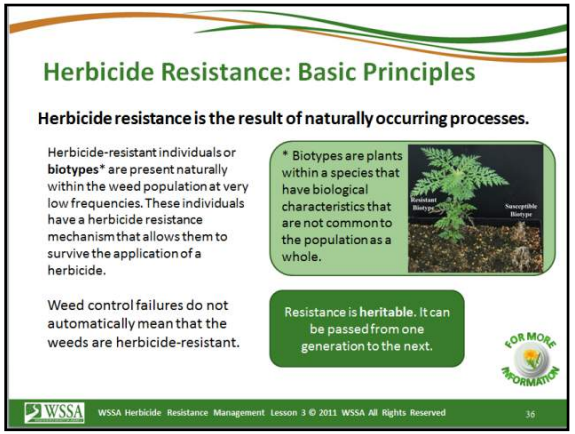
# What has been our primary response to the problem of herbicide resistance?

# Increased educational efforts.

## Publications…




## Training Modules…

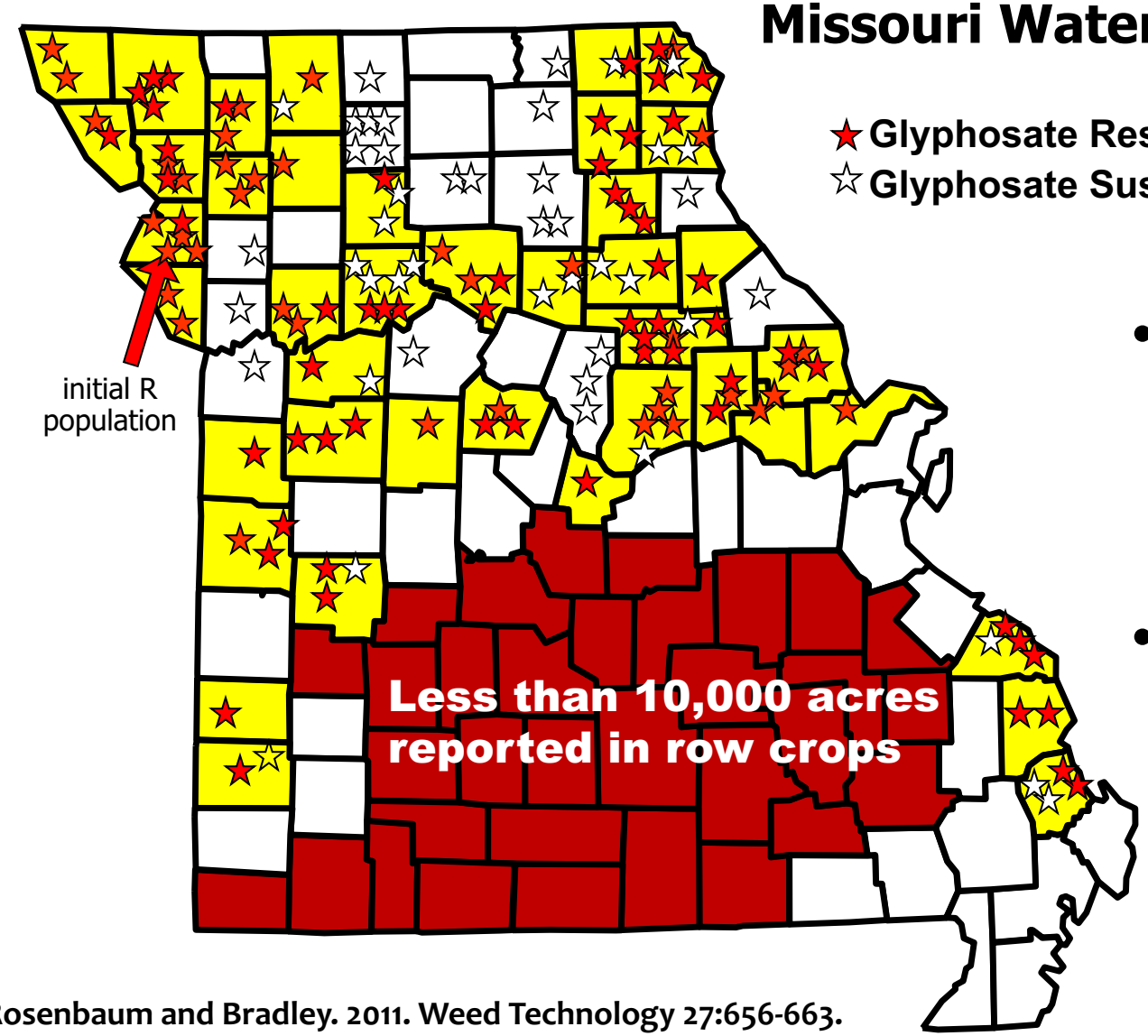



## Field Days…

## Videos…

# And yet…

## Results from a 2008 Survey of Missouri Waterhemp Populations

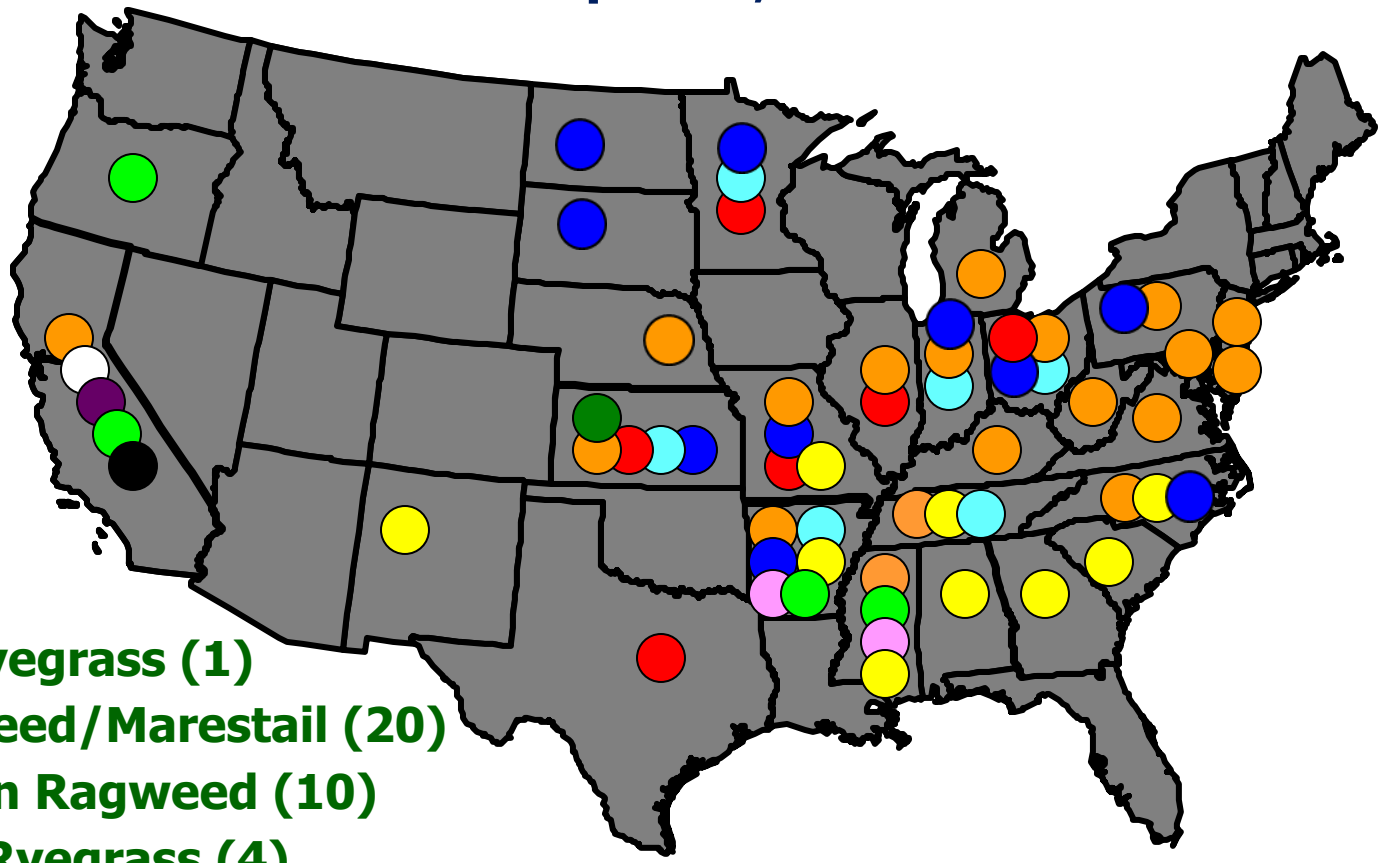



- 99/144 (69%) of the waterhemp populations confirmed to be gly-resistant
- 41 counties in Missouri with gly-resistance in waterhemp

Rosenbaum and Bradley. 2011. Weed Technology 27:656-663.

# Glyphosate-resistant Weeds in the U.S.

## 2008: 11 species; 28 states



- Rigid Ryegrass (1)
- Horseweed/Marestail (20)
- Common Ragweed (10)
- Italian Ryegrass (4)
- Giant Ragweed (8)
- Waterhemp (8)
- Palmer amaranth (9)
- Hairy Fleabane (1)
- Johnsongrass (2)
- Kochia (2)
- Junglerice (1)

*Parentheses indicate the number of states in which that resistant weed occurs

# I WILL

## TAKE ACTION AGAINST HERBICIDE-RESISTANT WEEDS.

I will know my weeds. When they grow. When they pollinate.
And I will stop them before they go to seed.

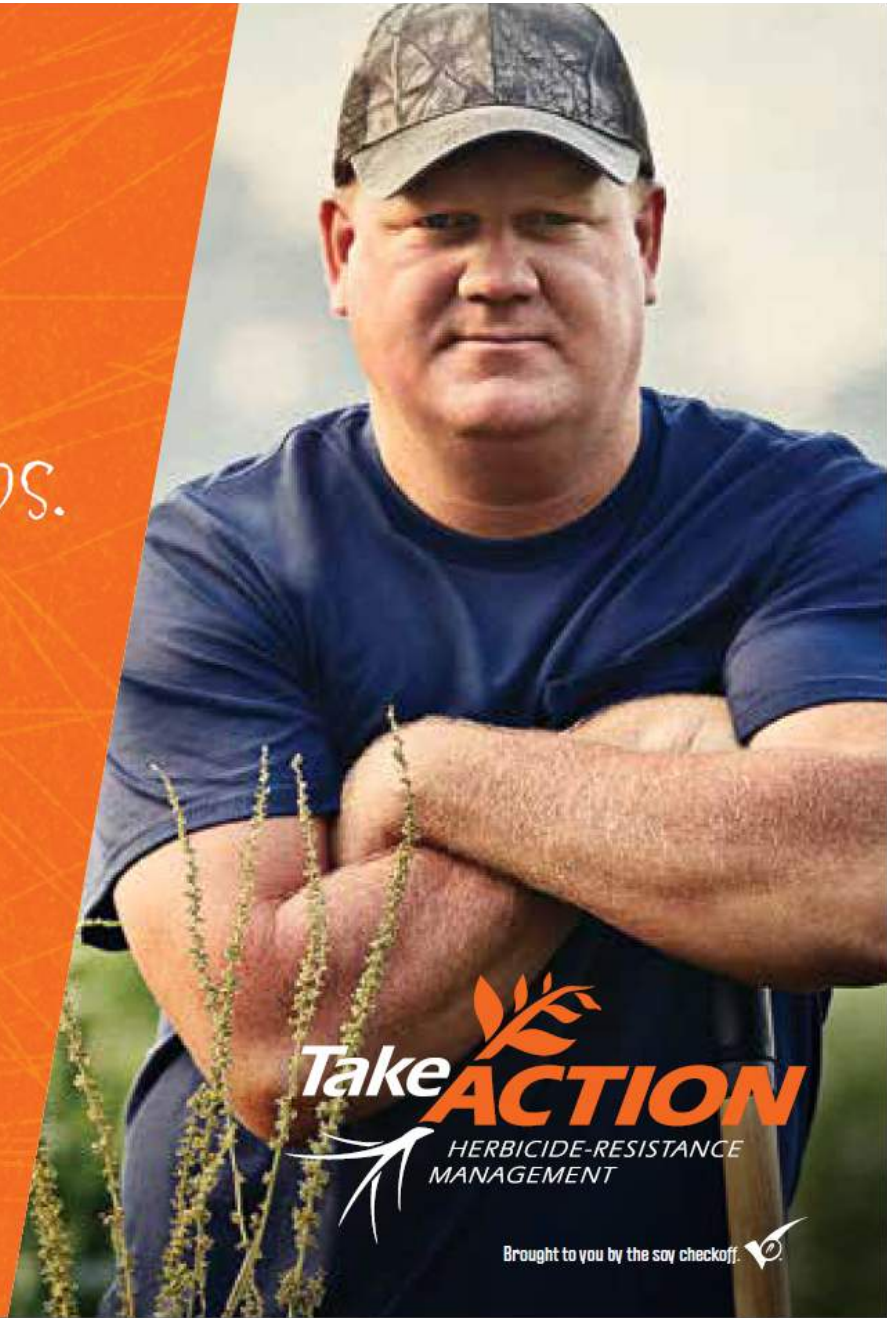
I will take action in the field and do whatever it takes
to give my crops the upper hand against weeds.

I will take action with careful herbicide management and use
multiple herbicide sites of action, because every action counts.

I will take action because it's my bottom line.
It's not about this year or the next. It's about the long term.

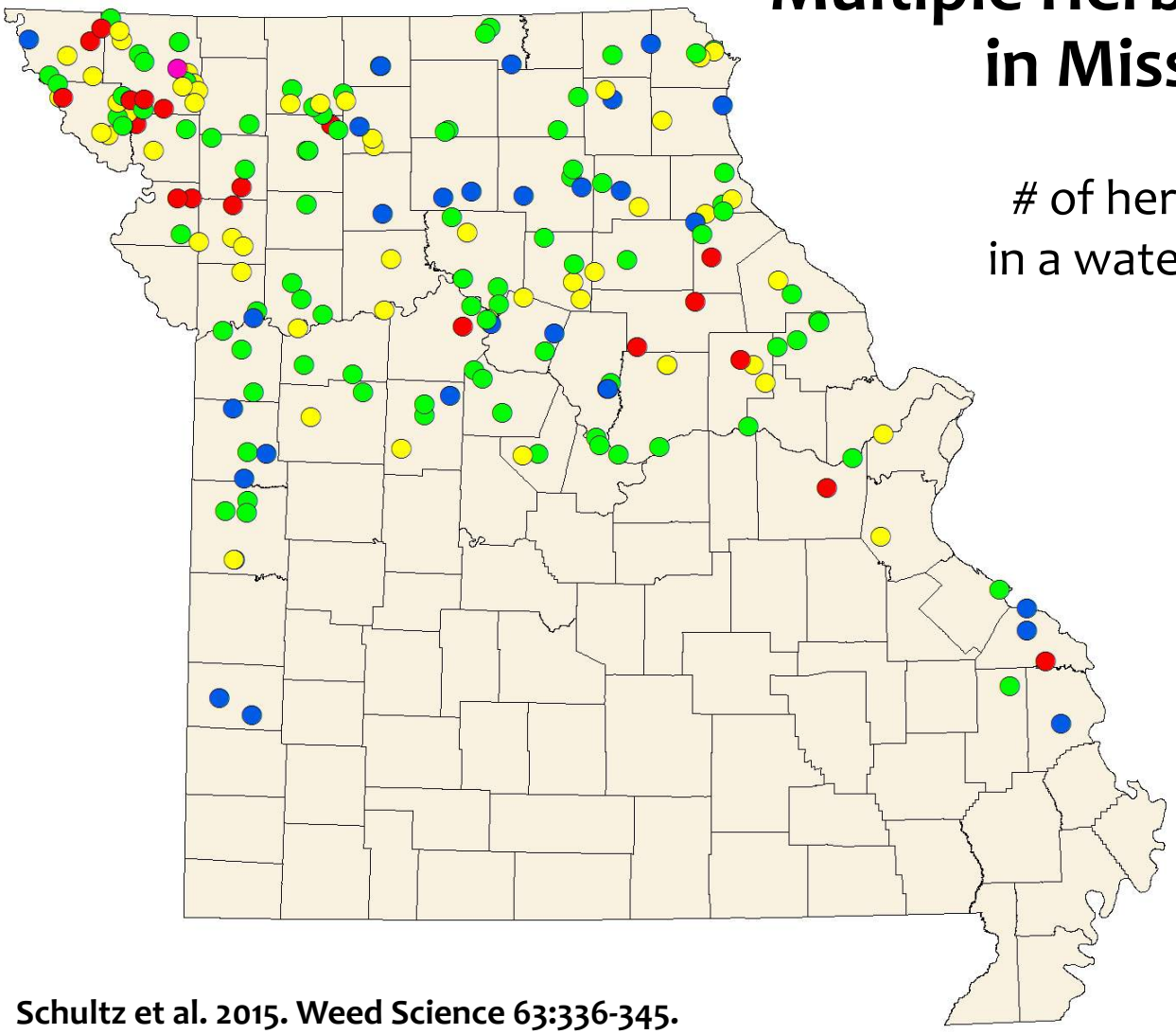
I will take action. This time. For all time.

Now is the time to take action against herbicide-resistant weeds. Visit www.TakeActionOnWeeds.com to learn how you can prevent herbicide-resistant weeds from spreading.



# And yet…

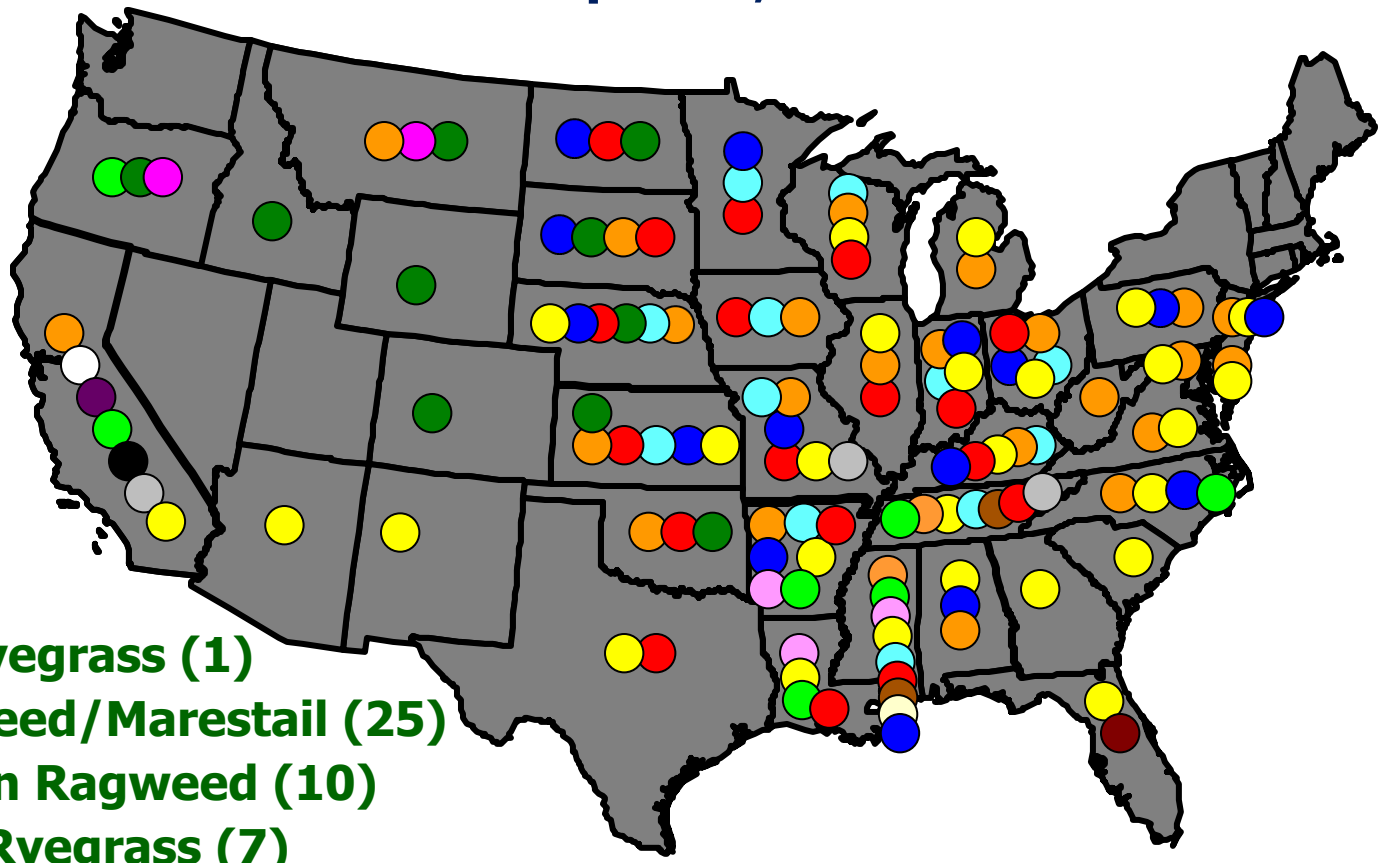
## Distribution of Waterhemp with Multiple Herbicide Resistances in Missouri, 2014




Schultz et al. 2015. Weed Science 63:336-345.

# Glyphosate-resistant Weeds in the U.S.

## 2016: 16 species; 38 states



- Rigid Ryegrass (1)
- Horseweed/Marestail (25)
- Common Ragweed (10)
- Italian Ryegrass (7)
- Giant Ragweed (12)
- Waterhemp (18)
- Palmer amaranth (27)
- Hairy Fleabane (1)
- Johnsongrass (3)
- Kochia (10)
- Junglerice (1)
- Annual Bluegrass (3)
- Goosegrass (2)
- Spiny Amaranth (1)
- Russian Thistle (2)
- Ragwd Parthenium (1)

*Parentheses indicate the number of states in which that resistant weed occurs

# I WILL

## THINK BEYOND HERBICIDES TO CONTROL WEEDS.

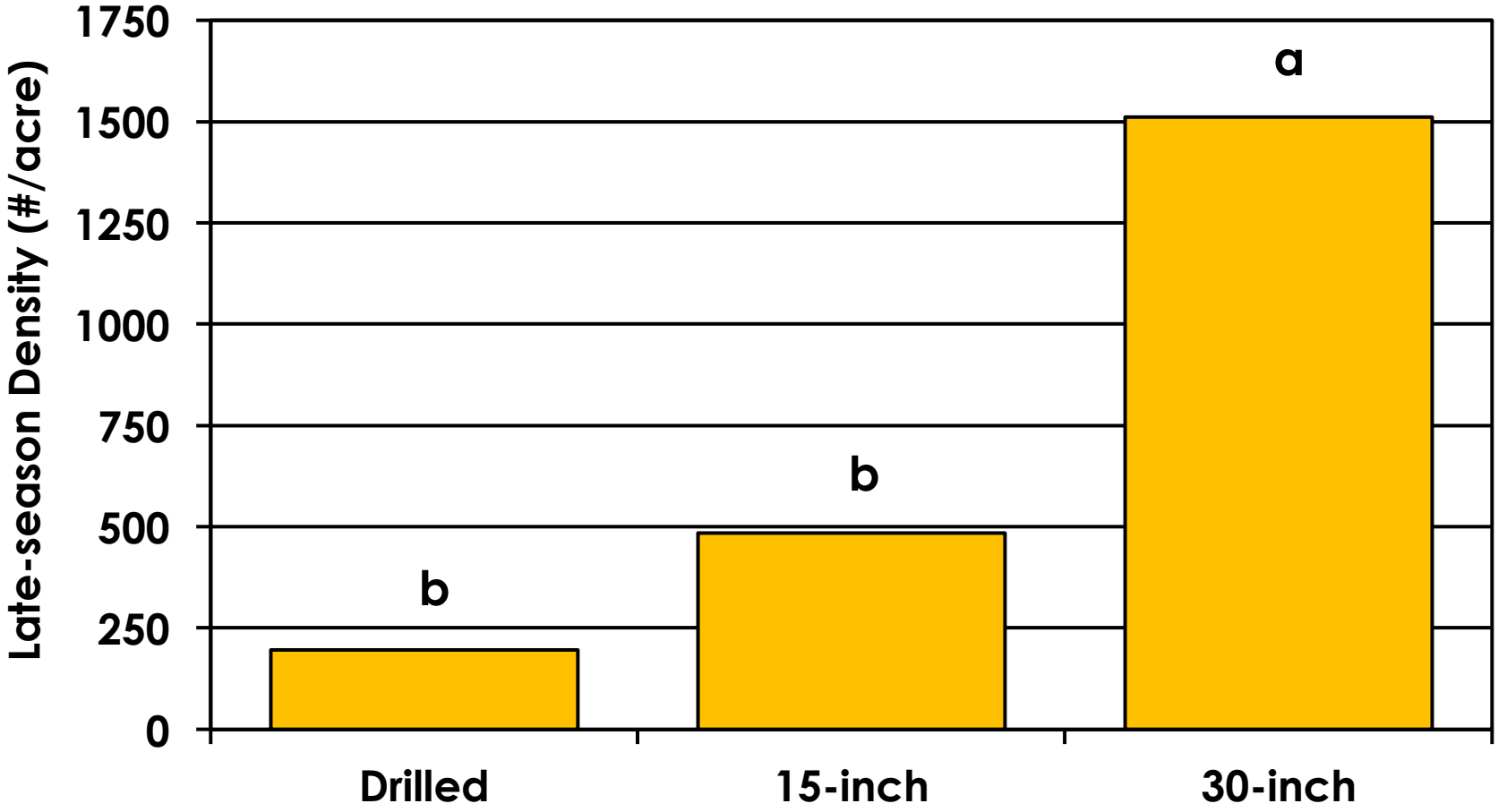
I will take action against herbicide-resistant weeds. Every action I can. I will do whatever I can to defend this ground. They aren't ordinary fields. They're battlefields. And I'm fighting a war on weeds.

I will think beyond herbicides and expand my arsenal. I will crowd weeds out and knock them down. I will smother them with foliage. I will farm to win.

Mistakes will be made, and weeds will emerge. But I will emerge on top. And I will continue to take action. Because every action counts.

Now is the time to take action against herbicide-resistant weeds. Visit www.TakeActionOnWeeds.com to learn about diversified weed management strategies.

# What effect does soybean row spacing have on waterhemp control?




*End-of-season resistant waterhemp density after an overlapping residual herbicide program.

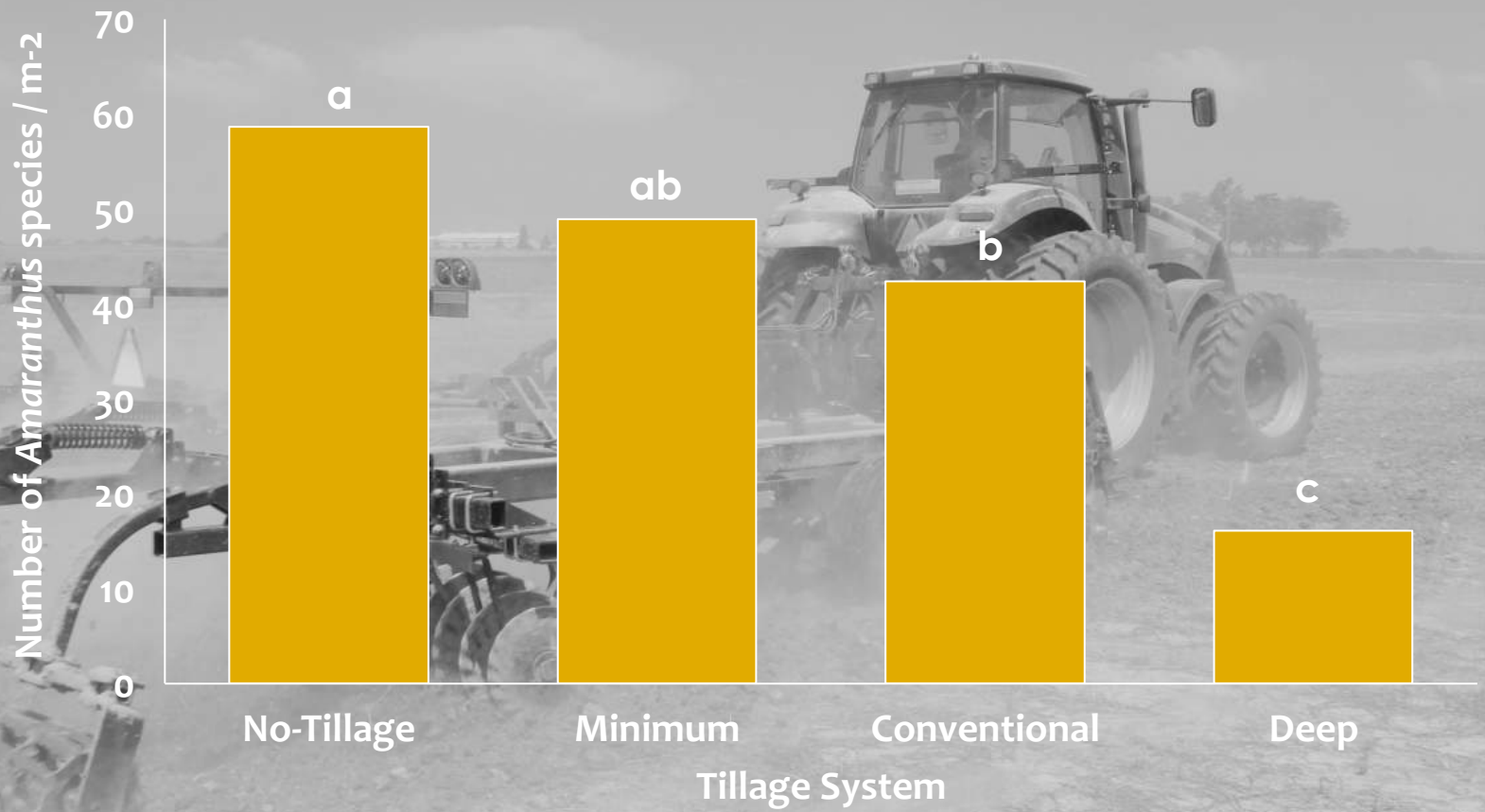
**Means followed by the same letter are not different, P≤0.05

Schultz, J. and K.W. Bradley, 2015. Weed Technol. 29:169-176.

# What effect does tillage have on the Pigweed species?

Farmer, J. and K.W. Bradley, 2016. Weed Technol.: submitted for publication

# What effect does tillage have on the Pigweed species?

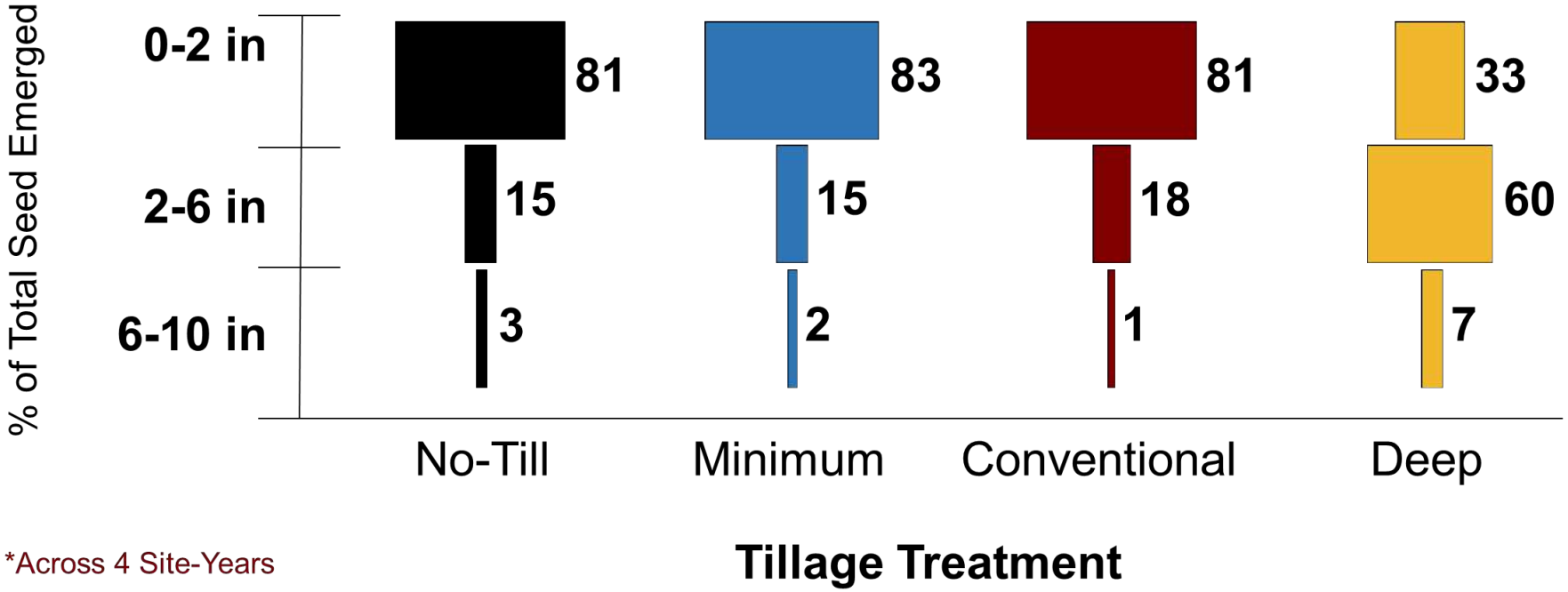



*Results summarized across 10 site-years in AR, IL, MO, OH, and TN.

**Means followed by the same letter are not different, P≤0.05

Farmer, J. and K.W. Bradley, 2017. Weed Technol.: in press

# Effects of Different Tillage Types on the Vertical Distribution of Pigweed Seed in the Soil Profile



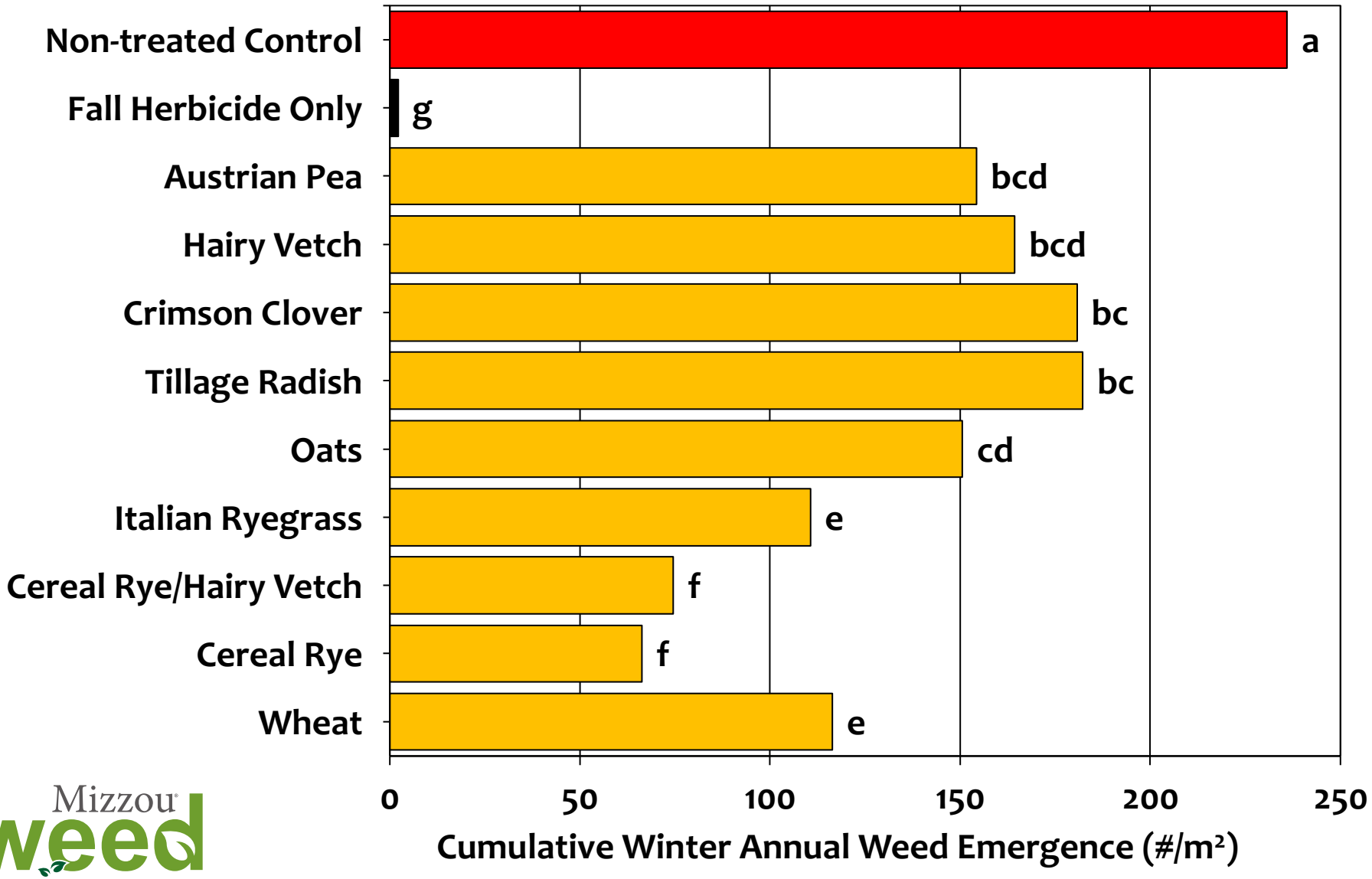

*Across 4 Site-Years

# What effect does cover crops have on waterhemp management?

Cornelius, C. and K.W. Bradley, 2016 M.S. Thesis

# Influence of Cover Crops vs. Herbicide Treatments on Cumulative Winter Annual Weed Density

(results summarized across 9 site-years in Missouri)

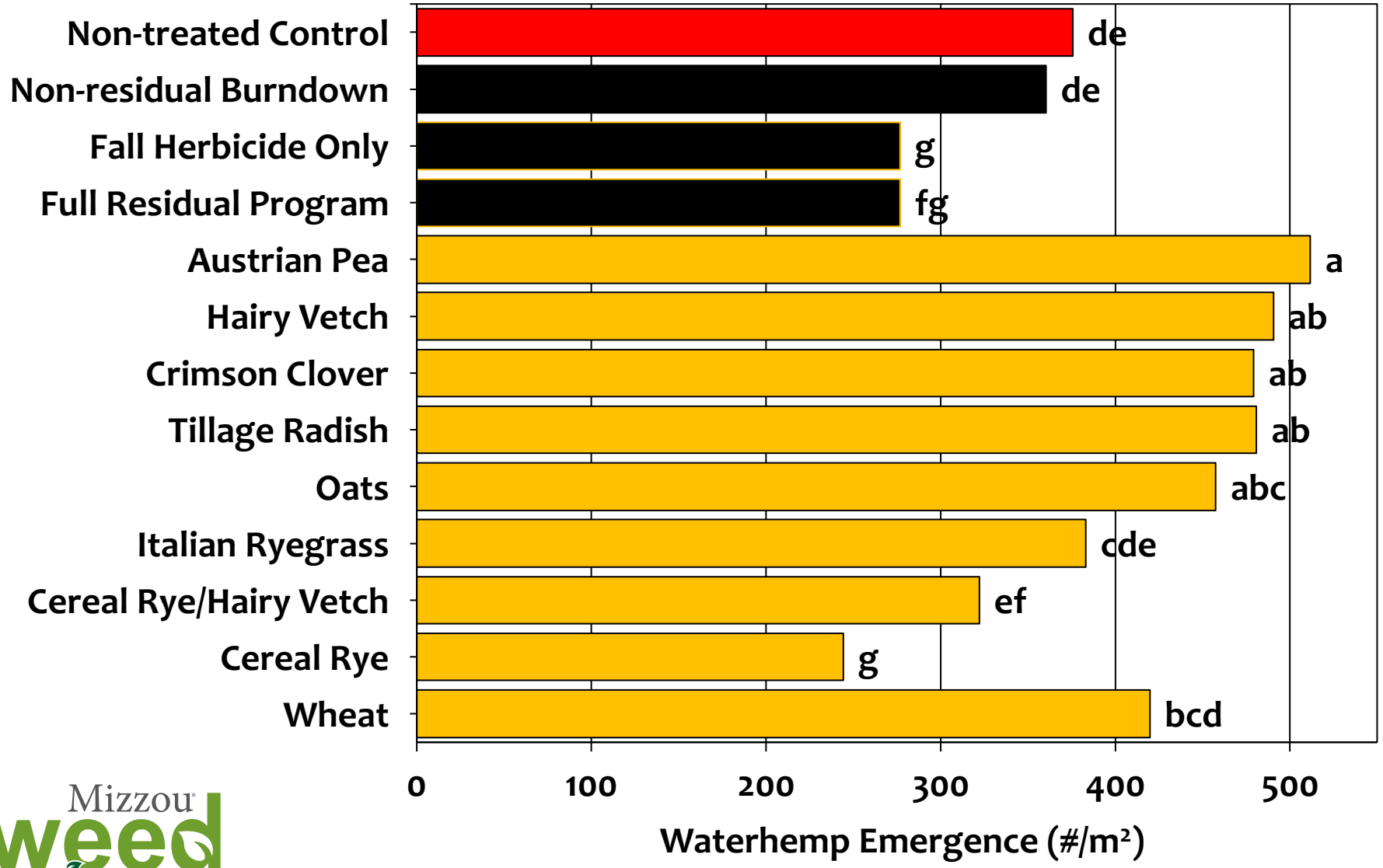



Mizzou weed science

*Bars followed by the same letter are not different, $LSD_{0.05}$

# Influence of Cover Crops vs. Herbicide Treatments on Early Season Waterhemp Emergence

(results summarized across 9 site-years in Missouri)




Mizzou weed science

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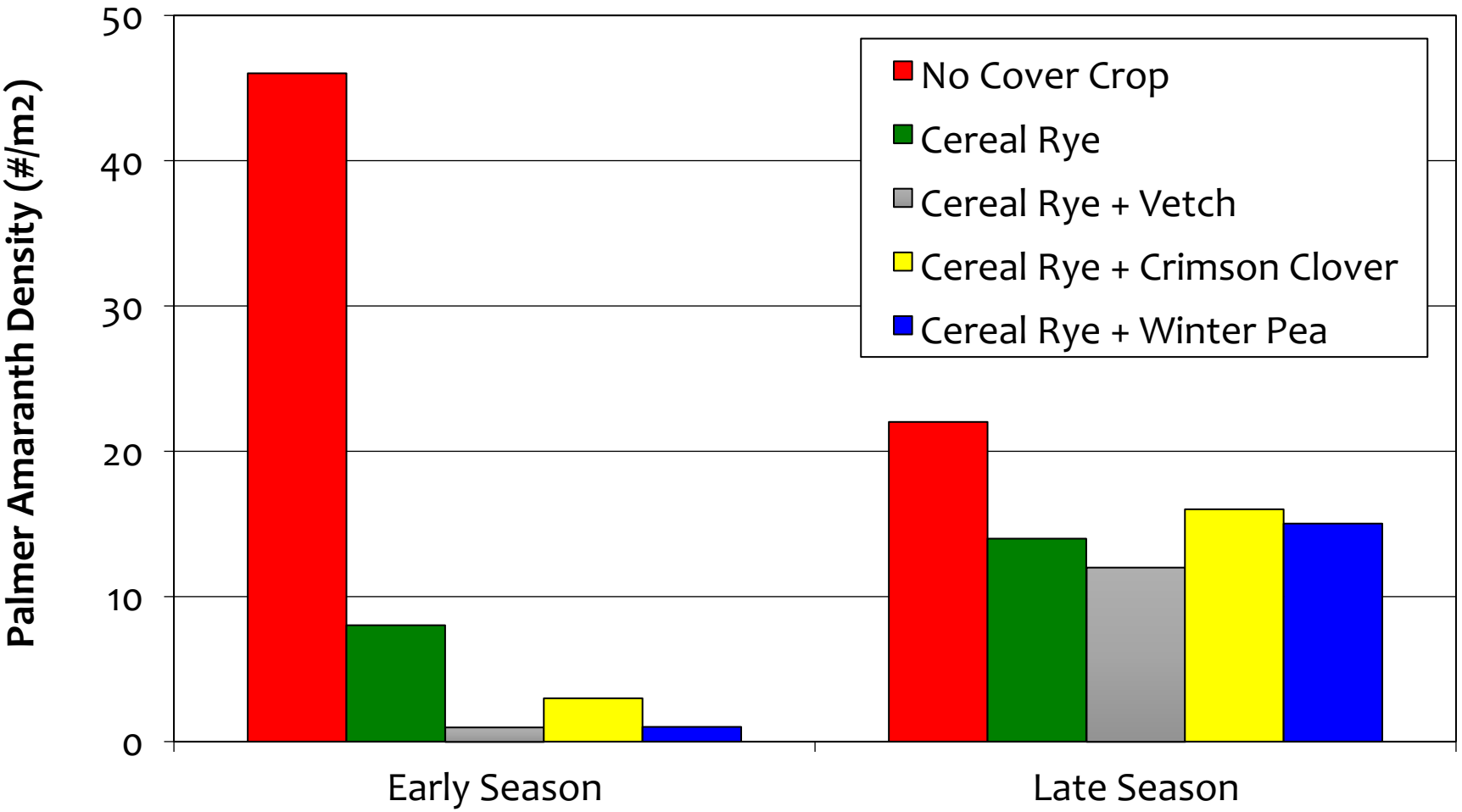
# Influence of Cover Crops on Palmer Amaranth Emergence in Georgia




Webster et al. 2013. Crop Protection 52:130-135.

# What's the future of waterhemp management look like?

A 5-state study revealed that >98% of waterhemp and Palmer amaranth seed are retained on the plant at the time of soybean harvest (Schwartz et al. 2016)

# Harvest Weed Seed Management:

## The next major emphasis area in the fight against resistant weed species.


Source: Dr. Stephen Powles. Professor, University of Western Australia

# Harvest Weed Seed Management:

## The next major emphasis area in the fight against resistant weed species.

### Investigating Windrow Burning in Missouri

# I WILL USE MULTIPLE HERBICIDE SITES OF ACTION.

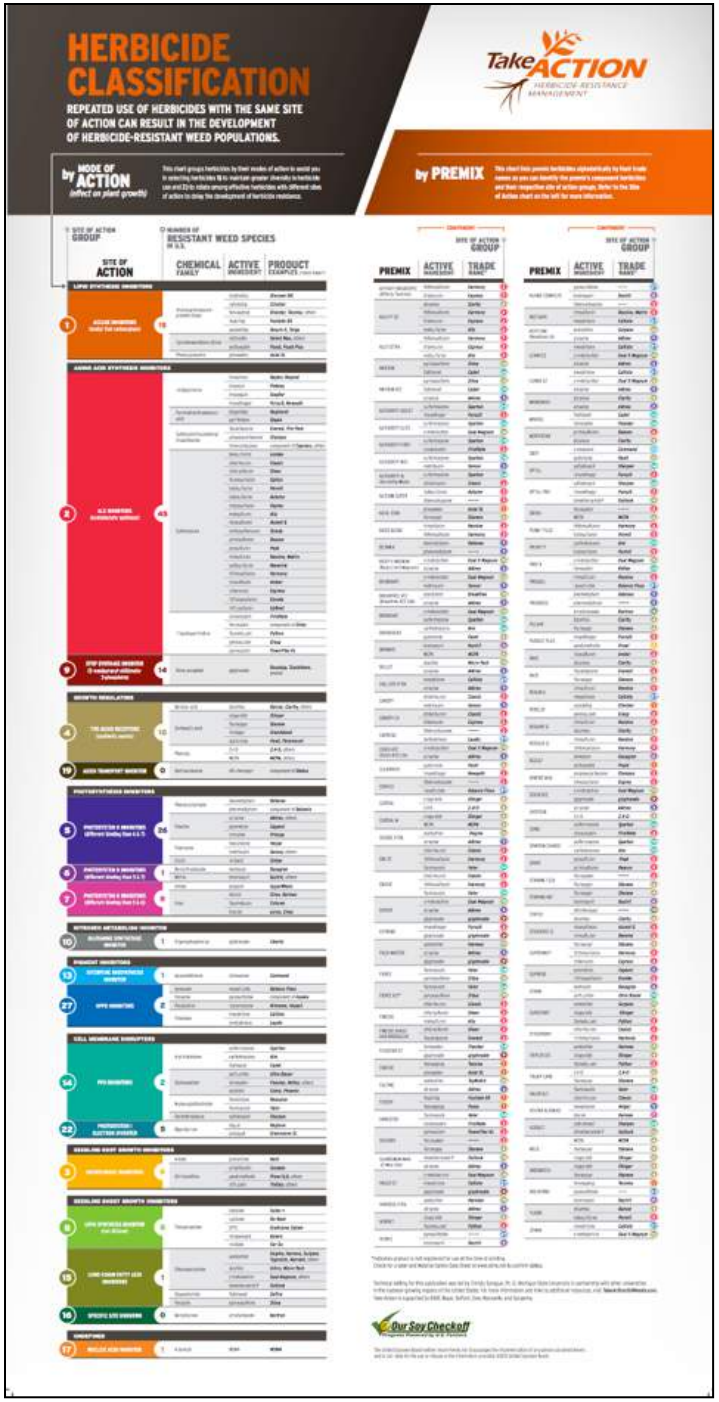
I will take action against herbicide-resistant weeds.

I will defend my crops with careful herbicide management. And I will use multiple herbicide sites of action because every action counts.

I will take action before weeds outgrow control. I will apply the right herbicide at the right rate at the right time.

I will take action. This time, for all time.

Now is the time to take action against herbicide-resistant weeds. Visit www.TakeActionOnWeeds.com to learn how you can preserve herbicide technology.




# Our success with weed management in the future will be dependent on our ability to really understand the importance of effective herbicide mechanism of action mixing and rotation.

# Rotate or Mix Herbicides?

- Analysis of spray records from 105 Illinois fields from 2004 to 2010.
- The occurrence of glyphosate-resistant waterhemp was greatest…
  - where glyphosate was used ≥75% of the time
  - **where herbicide rotation occurred annually!**
- Growers that mixed 3 herbicide modes of action (MOA's) were **51 times less likely to have glyphosate-resistant waterhemp** than growers that mixed 2 MOA's
- **MIXING EFFECTIVE HERBICIDE MOA'S IS THE BEST OPTION!**

Evans et al. 2015. Pest Manag. Sci.

# Specific Thoughts on Waterhemp Management in Soybean:

# #1. Use full use rates and/or combinations of pre-emergence residual herbicides as close to planting as possible.

**But there are still some product labels that talk about reduced rates!!!**

## FULL USE RATE (25)

**Rate Table 1:**

**Fall Application, Early Pre-plant, Preplant Burndown, Pre-plant Incorporated, and Preemergence:**

**No-Till, Minimum-till, Conventional tillage**

| Soil Texture | Organic Matter | |
|---|---|---|
| | 0.5 – 2% | 2 – 4% |
| | Ounces Product Per Acre | |
| **Coarse:** Loamy Sand, Sandy loam | 5.0 – 6.0 | 6.0 – 7.0 |
| **Medium:** Loam, Silt Loam, Silt, Sandy clay loam | 6.5 – 7.5 | 7.0 – 8.0 |
| **Fine:** Silty Clay Loam, Clay Loam, Clay | 7.0 – 8.0 | 8.0 – 9.6 |

## REDUCED RATE FOR GMO SOYBEAN (ROUNDUP READY, LIBERTY LINK etc.) (26)

**Rate Table 2:**

**Use rates in Table 2 are to be used in conjunction with a planned POST herbicide program; AUTHORITY XL at these reduced rates will provide early season control or suppression to reduce early season weed competition.**

**Fall application, Early Pre-plant, Early Pre-plant Burndown, Pre-plant Incorporated, Preemergence:**

**No-Till, Minimum-till, Conventional Tillag**

| Soil Texture | Organic Matter | |
|---|---|---|
| | 0.5 – 2% | 2 – 4% |
| | Ounces Product Per Acre | |
| **Coarse:** Loamy Sand, Sandy loam | 3.0 – 4.0 | 3.2 – 4.0 |
| **Medium:** Loam, Silt Loam, Silt, Sandy clay loam | 3.2 – 4.0 | 3.2 – 4.8 |
| **Fine:** Silty Clay Loam, Clay Loam, Clay | 4.0 – 5.0 | 4.0 – 5.0 |

# Effective PRE Active Ingredients

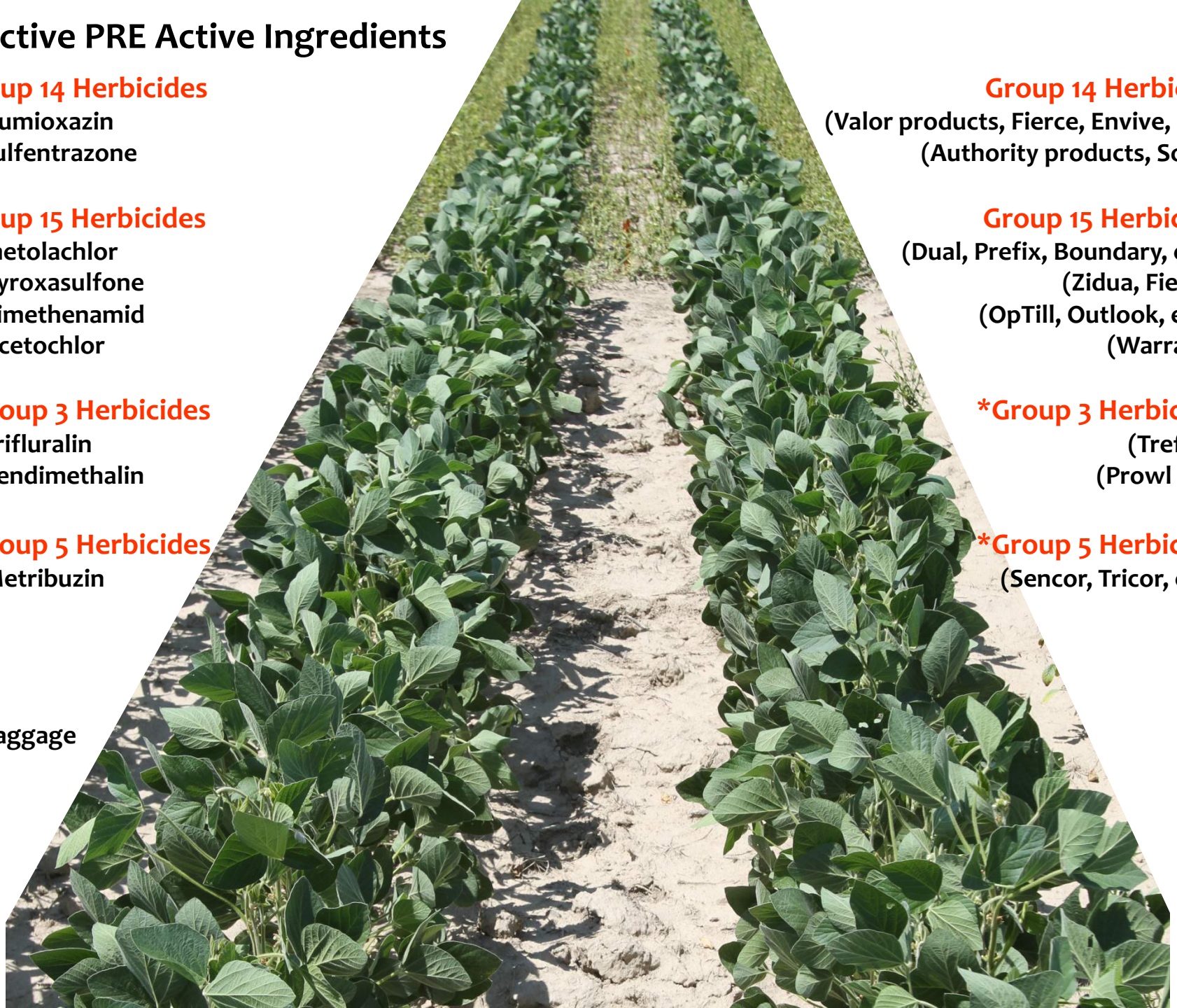
## Group 14 Herbicides
- flumioxazin
- sulfentrazone

## Group 15 Herbicides
- metolachlor
- pyroxasulfone
- dimethenamid
- Acetochlor

## *Group 3 Herbicides
- Trifluralin
- Pendimethalin

## *Group 5 Herbicides
- Metribuzin

*=baggage



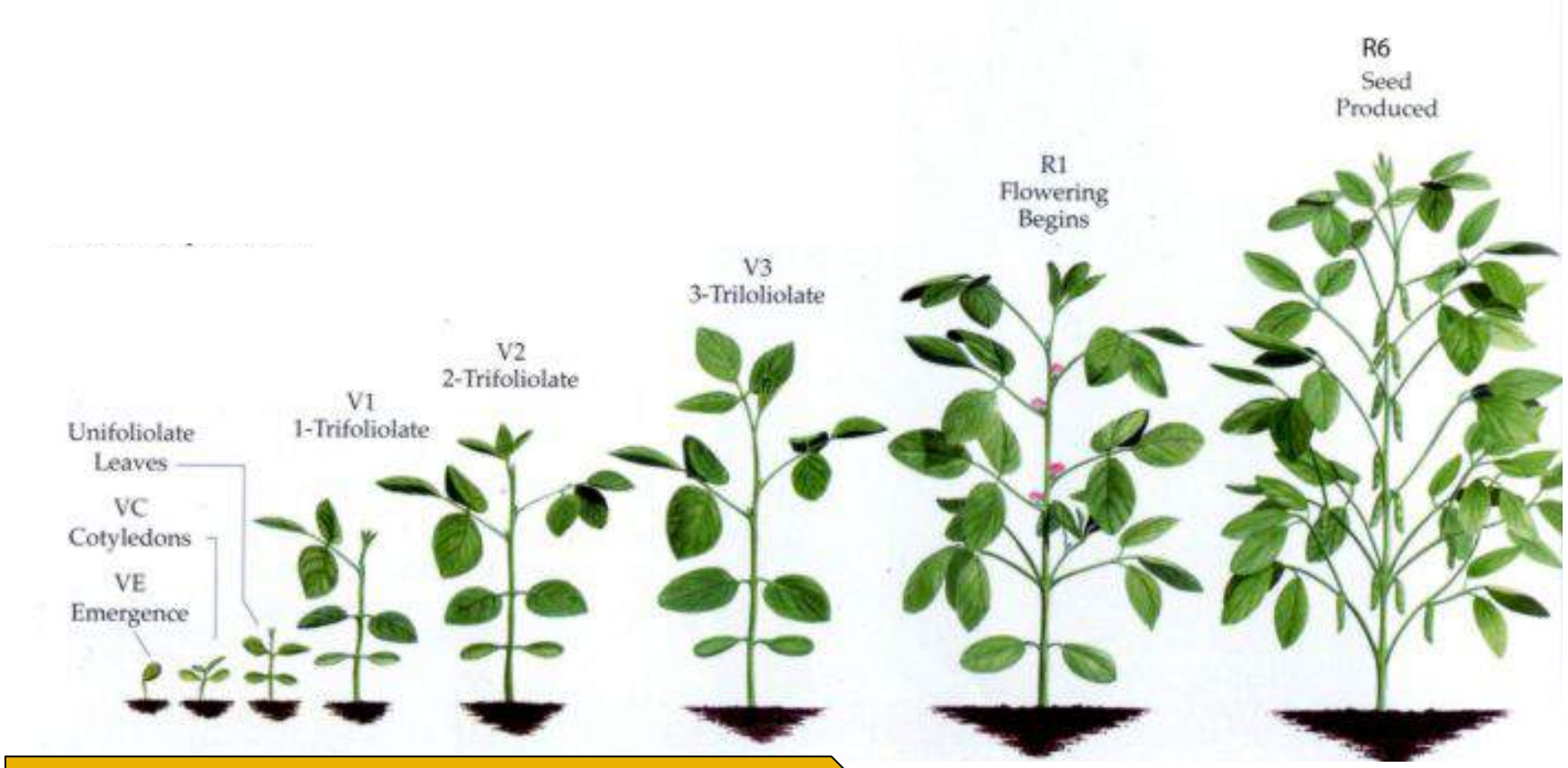
## Group 14 Herbicides
(Valor products, Fierce, Envive, etc.)
(Authority products, Sonic)

## Group 15 Herbicides
(Dual, Prefix, Boundary, etc.)
(Zidua, Fierce)
(OpTill, Outlook, etc.)
(Warrant)

## *Group 3 Herbicides
(Treflan)
(Prowl H2O)

## *Group 5 Herbicides
(Sencor, Tricor, etc.)

# #2. Overlapping residuals is a program that fits the pattern of waterhemp emergence.




Residual, Pre-emergence Herbicide

Contact + Residual Herbicide

# #3. Liberty provides a site of action that still works, but if we abuse it we will break it.

Only with a pre-emergence herbicide
Only with timely POST applications of Liberty

# #4. New technologies will not "solve" the problem of resistant waterhemp, or change the emphasis that we should place on good weed management practices.

Roundup® XTEND

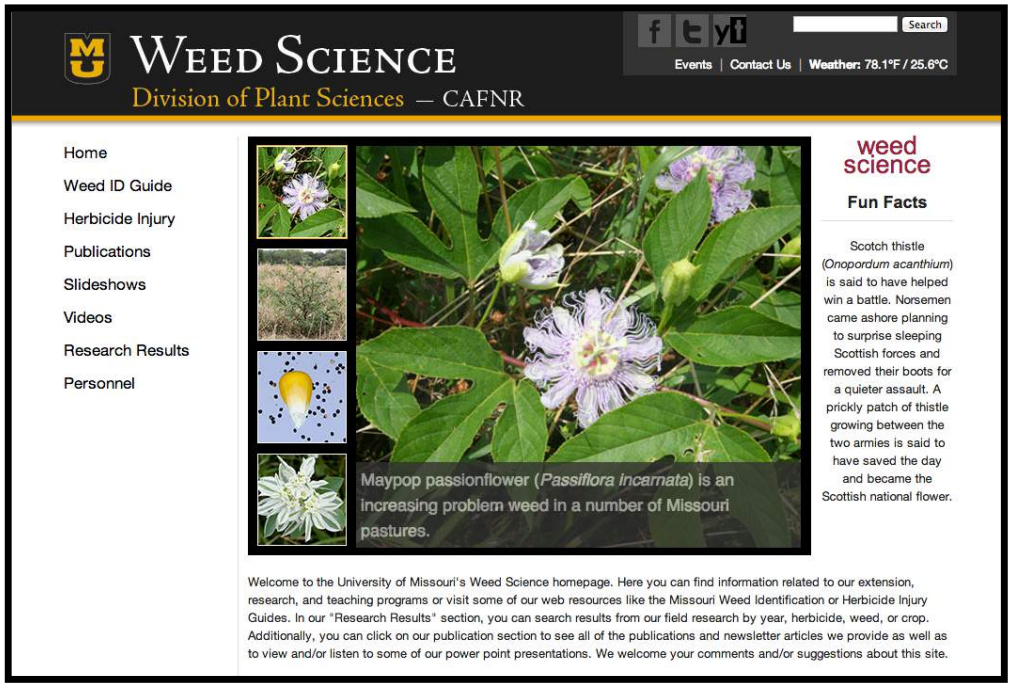
Enlist™ Weed Control System

Mizzou®

# weed science

**Email: bradleyke@missouri.edu**

Website: weedscience.missouri.edu

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