



What's a herbicide program without residuals?

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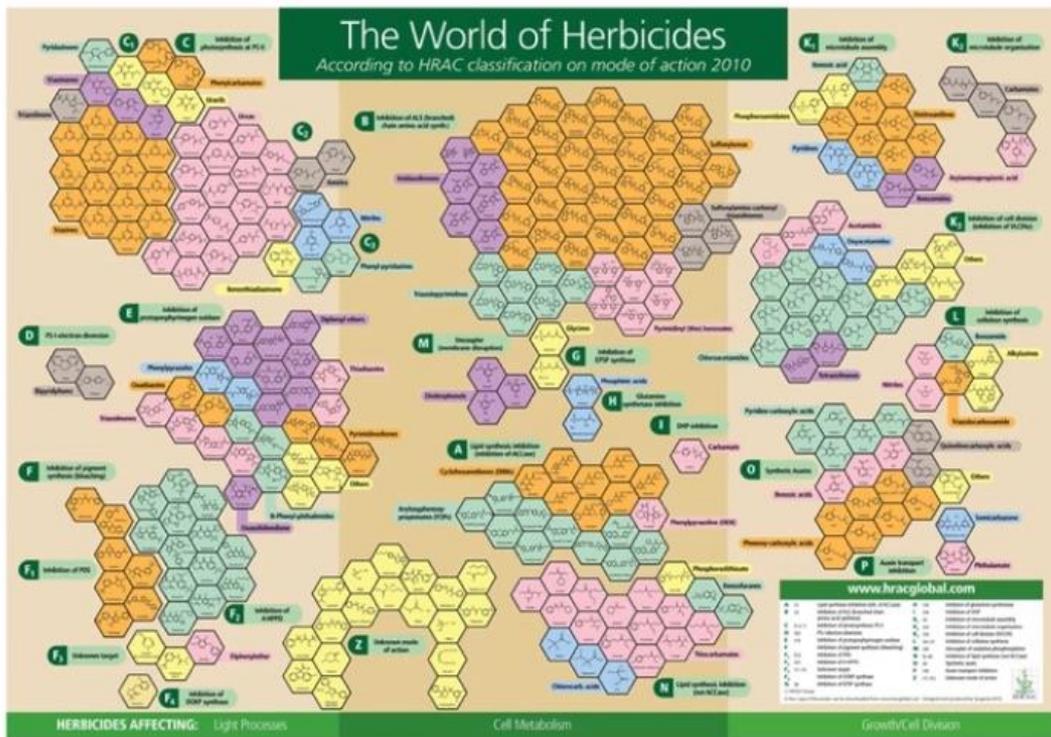
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Herbicides have revolutionized weed control, but the treadmill is no longer working.

Herbicide resistance
Scope
Integrated weed management



- Weeds are winning the evolutionary arms race
- Herbicide discovery has stalled
- Regulation has tightened

Dr. Paul Neve



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Why is this weed so bad?

- Dioecious
- Huge seed production
- Germinates practically all spring, summer, and part of fall
- Many times shows up to new places with baggage



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What is waterhemp resistant to?

- ALS herbicides-1993
 - Classic
 - Pursuit
- Atrazine-1994
- PPO-2001
 - Cobra
 - Flexstar



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What is waterhemp resistant to?

- Glyphosate-2005
- HPPD-2009
 - Callisto
- 2,4-D-2009
- Group 15-2016
 - Dual
 - Warrant



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So how do we manage our soybeans?

Four steps

1. Use residuals PRE
2. Use effective herbicides POST
3. Use overlapping residuals
4. Alter Cultural Practices/Other

1. Use Residuals PRE



NT

Group 5

Group 14

Group 3

Group 15



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2. Use effective chemistries POST



NT



Glyphosate



Cobra



Reflex



Cadet

- XtendiMax or Engenia in dicamba-tolerant soybeans
- Use Liberty in glufosinate-tolerant soybeans
- Enlist in 2,4-D tolerant soybeans



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Dicamba or 2,4-D Soybeans

- What they are not: Good residual herbicides!!!!
 - Conventional PRE herbicides are key
- What they are: A tool!!!!
- Spray waterhemp when small



Liberty used correctly

- It can be a fickle herbicide
 - Application technique and timing is important
- Just because you have to use it right, that doesn't mean you shouldn't be using it!



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3. Use overlapping residuals

- Warrant
- Dual



The easiest weed to control is a weed that never emerges!

- Even if switching to other technologies
 - LibertyLink, Xtend, Enlist



Group 15



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Cultural Practices/Other

- Change Rotation
- Planting Date
- Row Spacing
- Herbicide timing
- Cultivators????
- Rope wick applicators????



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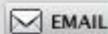


What if we don't....

How to protect new technologies from resistant weeds

Bob Scott, University of Arkansas | *Delta Farm Press*

Jan 28, 2016



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What is in this article?:

How to protect new technologies from resistant weeds

Out of options?



Photo: *Delta Farm Press*

Weed scientists at the University of Arkansas System Division of Agriculture have created quite a stir with news that through experimentation in the greenhouse, researchers selected for a population of pigweed — Palmer amaranth — that is tolerant to the herbicide dicamba at a field rate. This

pigweed population did not evolve resistance in the field, but there is much we can learn from the artificial selection that took place in the greenhouse.

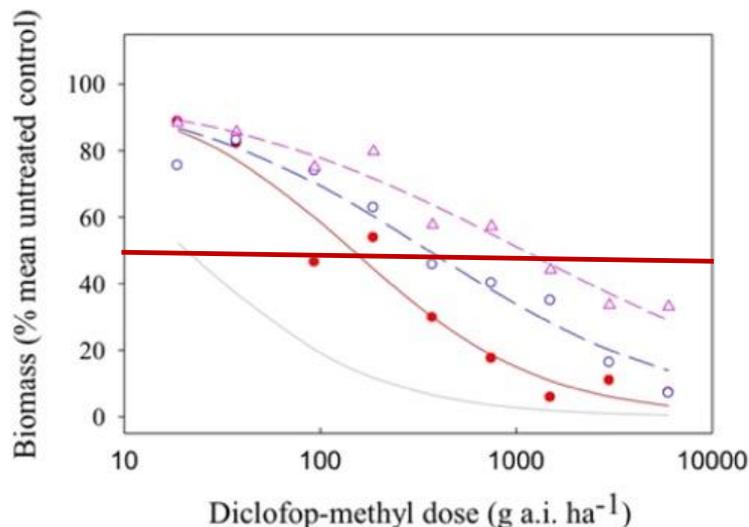
The researchers exposed three generations of pigweed to sub-lethal doses of dicamba, a recipe for resistance development. We started with pigweed collected from the field that was susceptible to dicamba. By the third generation, we were able to select for seedlings capable of surviving an application at one-time rate that should've provided effective control.

This type of selection experiment with pigweed was done previously with glyphosate in Arkansas and with other weeds and other herbicides in Australia



Herbicide resistance from standing genetic variation

Herbicide resistance
Applied evolutionary biology



GR₅₀ values

VLR1	22g
VLR1 (year 1)	147g
VLR1 (year 2)	357g
VLR1 (year 3)	1089g

This work demonstrates that herbicide resistance can be rapidly selected from standing genetic variation in weed populations.

Emerging insight suggests that this is based on the subtle 're-programming' of existing stress-responsive pathways

Neve & Powles 2005,
Theoretical & Applied Genetics

An almost **50-fold** increase in GR₅₀ values following three generations of recurrent selection on additive genetic variation in 39 plants.



Dr. Paul Neve

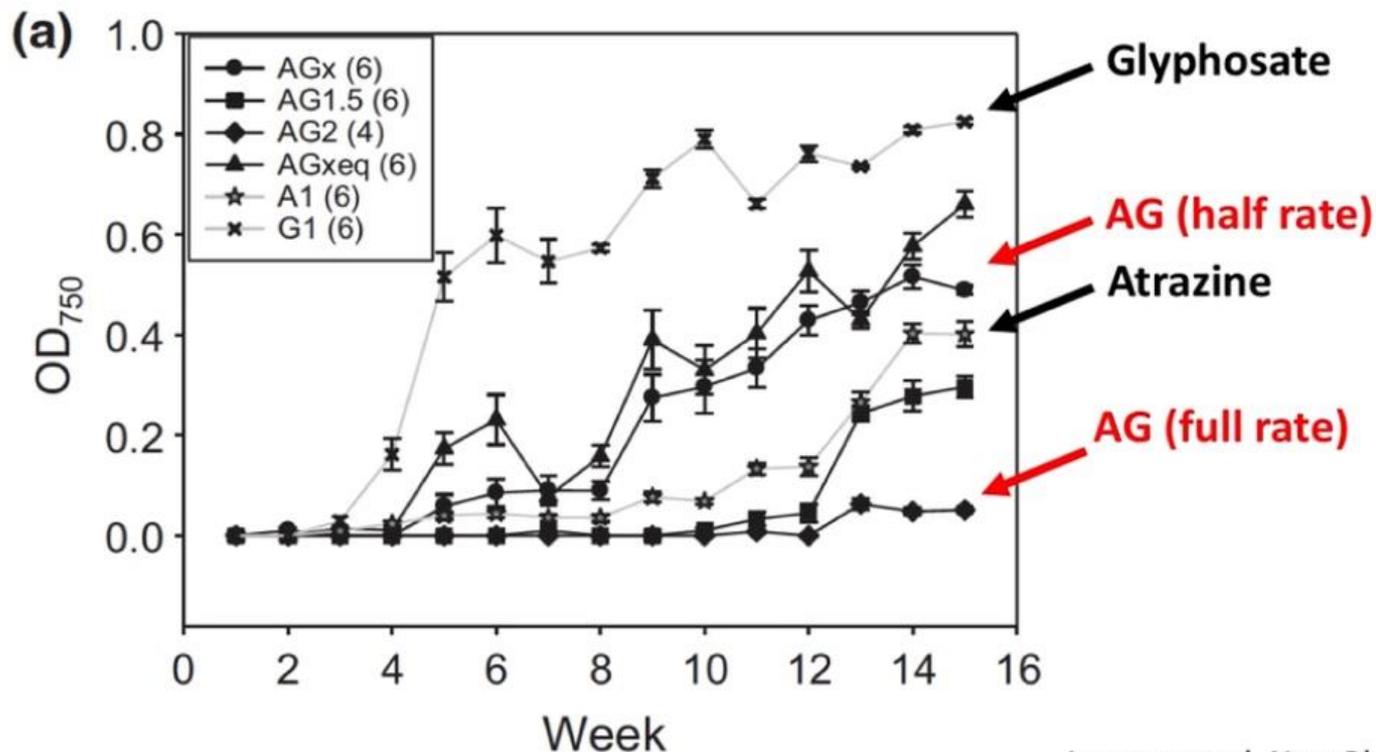


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Herbicide mixtures slow evolution of resistance.

Herbicide resistance
Applied evolutionary biology



Herbicide mixtures slow evolution of herbicide resistance, but only when mixture components are used at FULL RATES.

Lagator et al. *New Phytologist*. 2013



Dr. Paul Neve



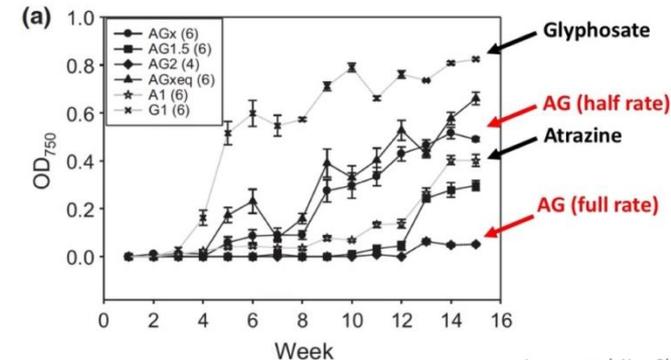
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Multiple MOA

- What options do we have?
 - WH has lots of resistance
 - ALS???
 - Glyphosate??
 - PPO??
- Use Multiple MOA PRE
 - Group 3, Group 5, Group 14, Group 15
- POST
 - Group 4 and 10

Herbicide mixtures slow evolution of resistance.



Single MOA vs Multiple MOA

- Single MOA- increases selection pressure on Pesticide
 - Using pesticide over and over without use of other MOA expedites the evolution of resistance
- Research study:
 - Single MOA to failure followed by another single MOA to failure VS. tank mixture of both MOA
 - Delayed evolution of resistance by 8X



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We add another herbicide MOA stack for resistance every 5.6 years.

-Dr. Pat Tranel 2019



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How would you feel if

- I gave you \$50?



- What about \$50 an acre?
 - This is the value of weed free acres

Effect of Duration of Waterhemp Interference

Removal Timing	Soybean Yield (bu/A)	Yield Reduction (% of weed free)
Weed-free	51	-
2	50	1
4	44	13
6	41	19
8	36	34
10	29	43
LSD _{0.05}	4	8



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Source: University of Illinois



ROI Analysis with 70 bu yield goal

Application scenario at 2" vs 4"

Yield Loss	Soybean Price	Net income Loss	Herbicide Cost	Net Return of Application
8.4/A	\$8/Bu	\$67.2/A	\$15/A	\$52.2/A

Application scenario at 2" vs 6"

Yield Loss	Soybean Price	Net income Loss	Herbicide Cost	Net Return of Application
12.6/A	\$8/Bu	\$100.8/A	\$15/A	\$85.8/A



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Summary

- Have to use effective PRE herbicide
 - Will fail without one
- POST herbicide and timing are important
- Overlapping residual will get you to crop canopy
- Other options besides herbicides!



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A photograph of a field filled with tall, green weeds, likely Amaranth species, with numerous seed heads. The plants are densely packed and reach varying heights. In the center of the image, there is a semi-transparent, light-colored rectangular box containing the word "Questions?" in a black, italicized serif font. The background shows a line of dark green trees under a bright sky.

Questions?