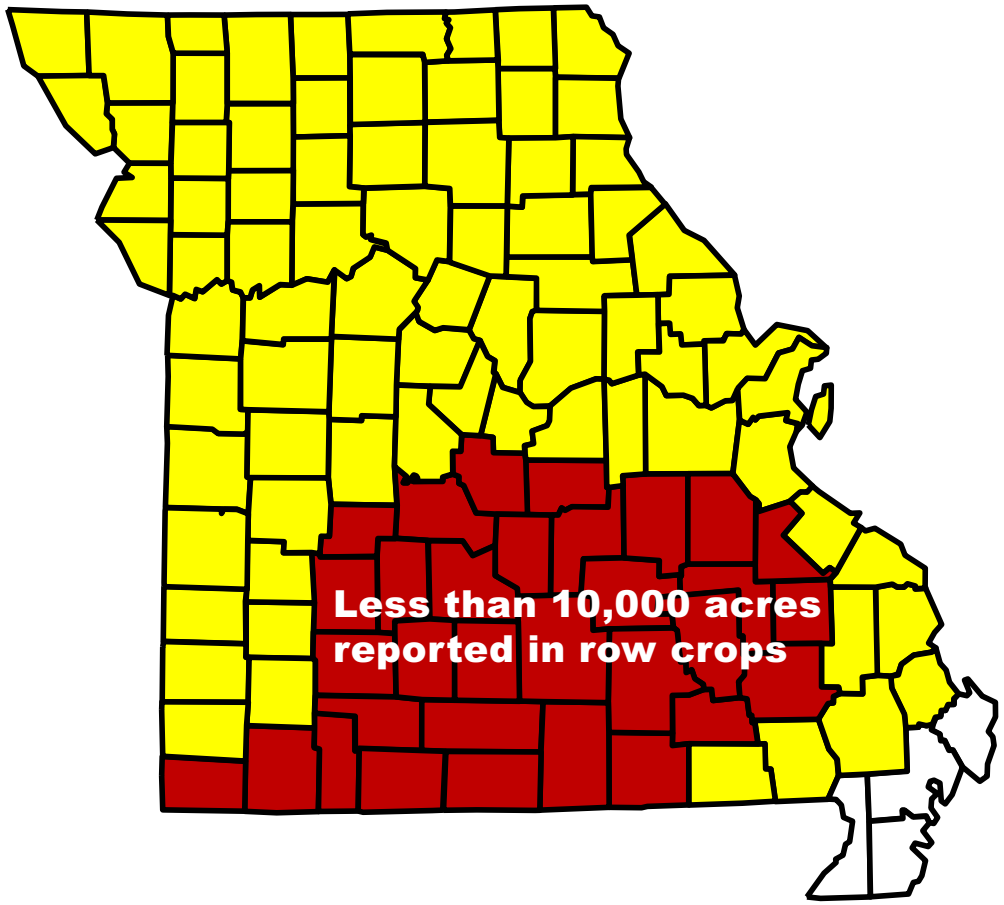
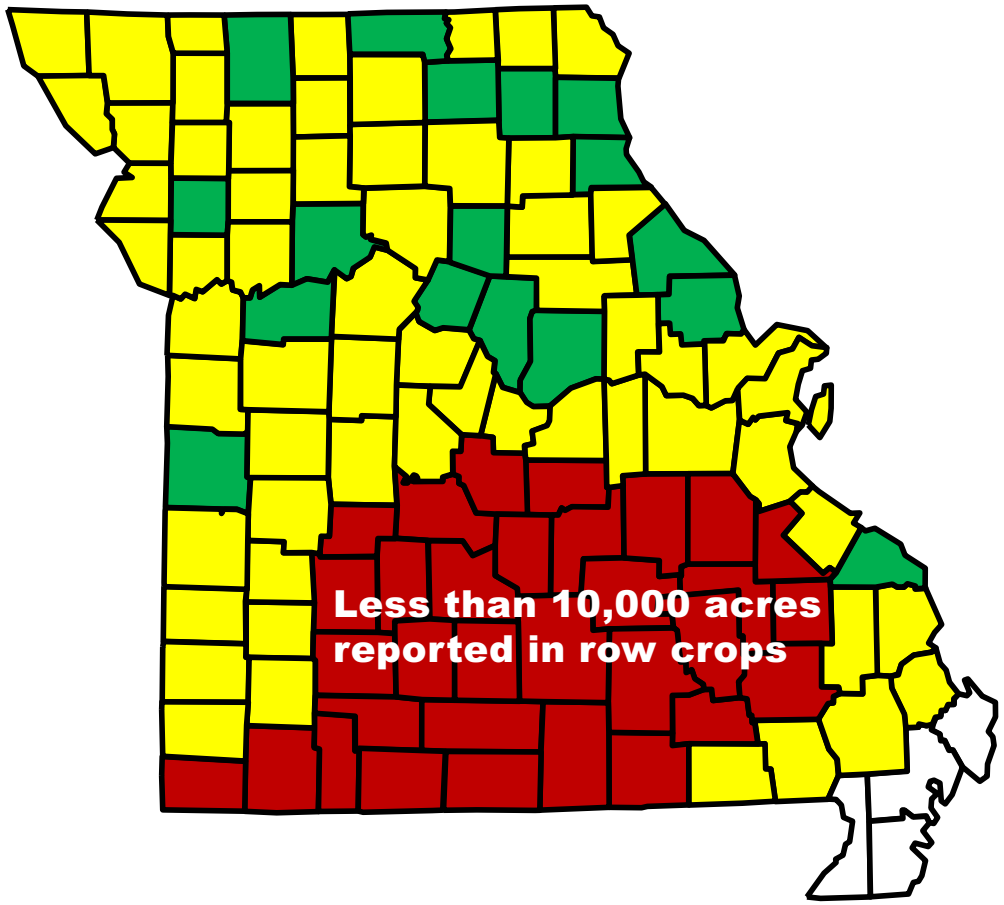
What else can I say about waterhemp resistance?

Herbicide-resistant Waterhemp in Missouri



ALS (2) + Glyphosate (9) + PPO (14)

Herbicide-resistant Waterhemp in Missouri



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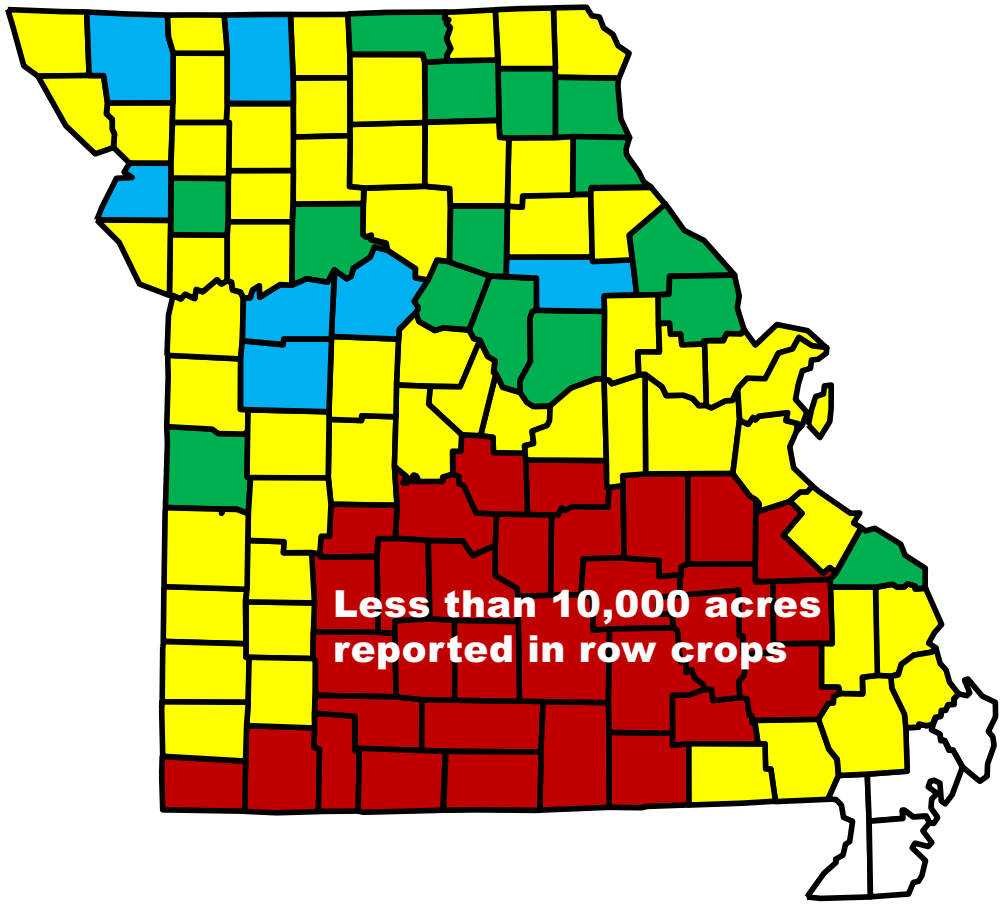
ALS (2) + Glyphosate (9) + PPO (14) + PSII (5)

Herbicide-resistant Waterhemp in Missouri



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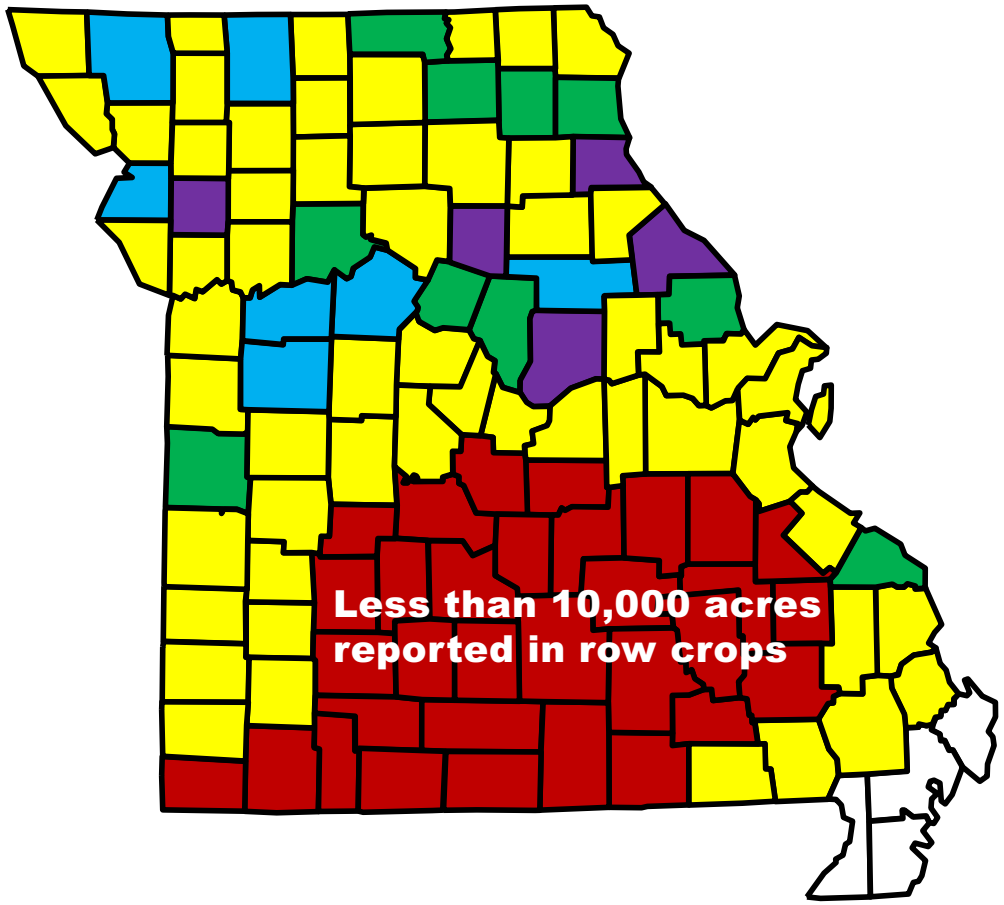
ALS (2) + Glyphosate (9) + PPO (14) + PSII (5) + HPPD (27)

Herbicide-resistant Waterhemp in Missouri



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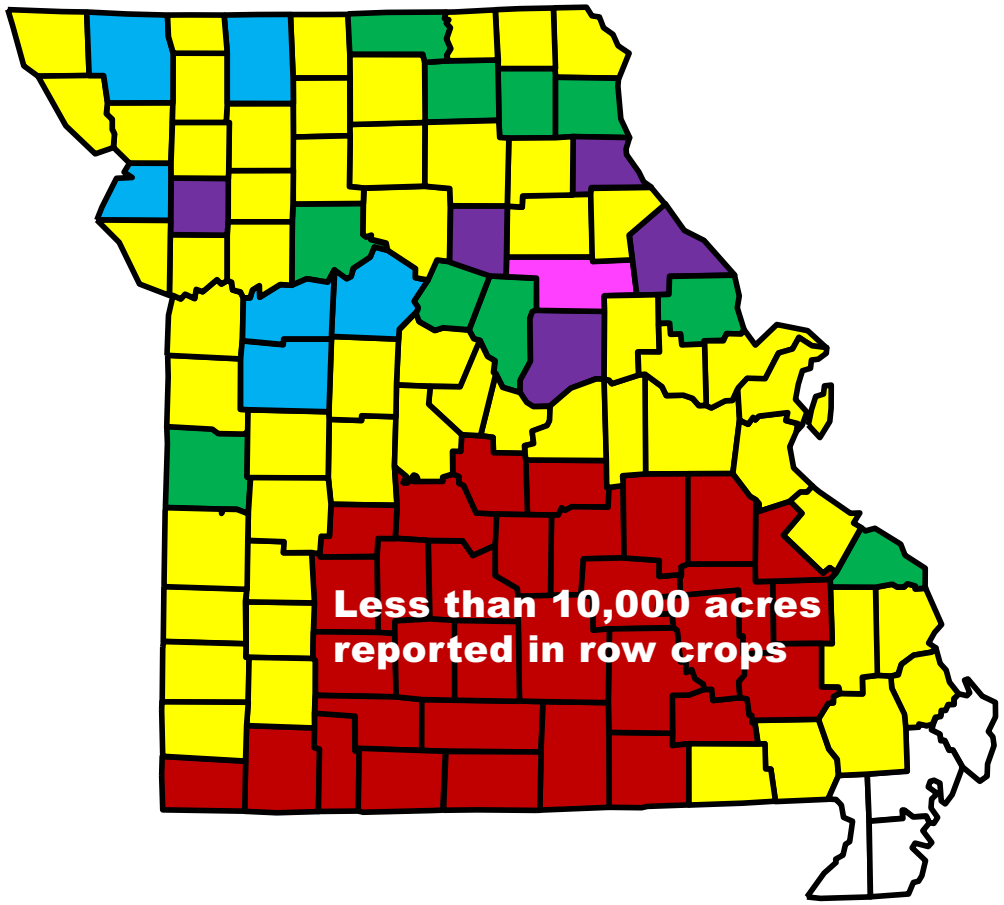
ALS (2) + Glyphosate (9) + PPO (14) + PSII (5) + 2,4-D (4)

Herbicide-resistant Waterhemp in Missouri



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ALS (2) + Glyphosate (9) + PPO (14) + PSII (5) + HPPD (27)

ALS (2) + Glyphosate (9) + PPO (14) + PSII (5) + 2,4-D (4)

ALS (2) + Glyphosate (9) + PPO (14) + PSII (5) + 2,4-D (4) + HPPD (27)

Which one's pulling the load when it comes to a POST treatment of waterhemp that is resistant to 2,4-D?

Fomesafen + Glyphosate (Flexstar GT, etc.)

Fomesafen + Glufosinate (Cheetah Max, etc.)

Glyphosate + 2,4-D Choline (Enlist Duo)

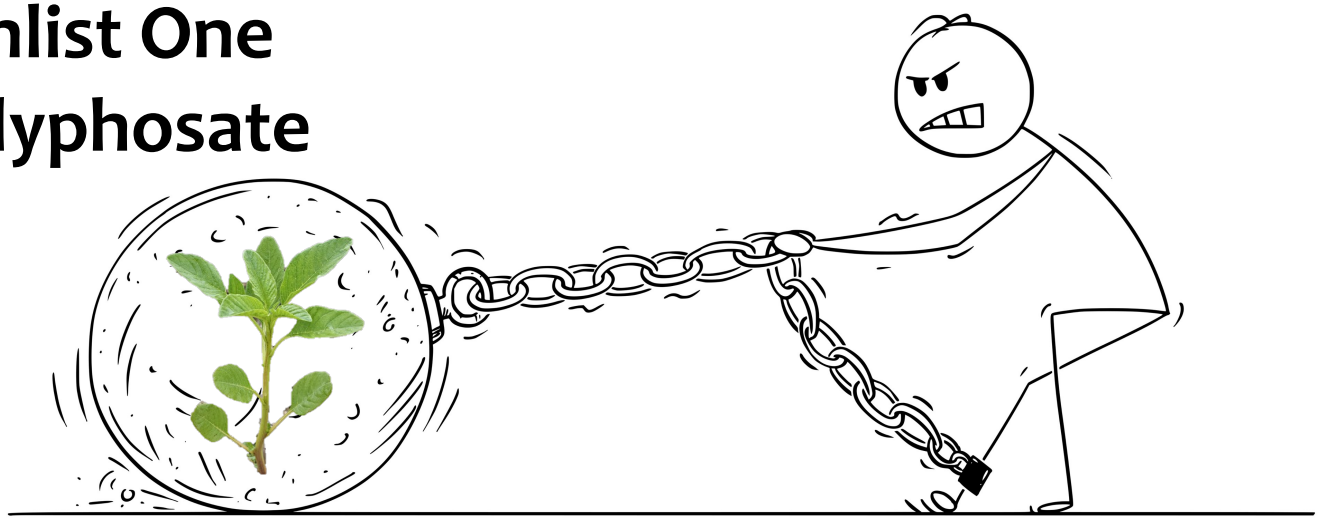
Glufosinate + Enlist One

Glufosinate + Glyphosate

Enlist One

Glufosinate

Glyphosate



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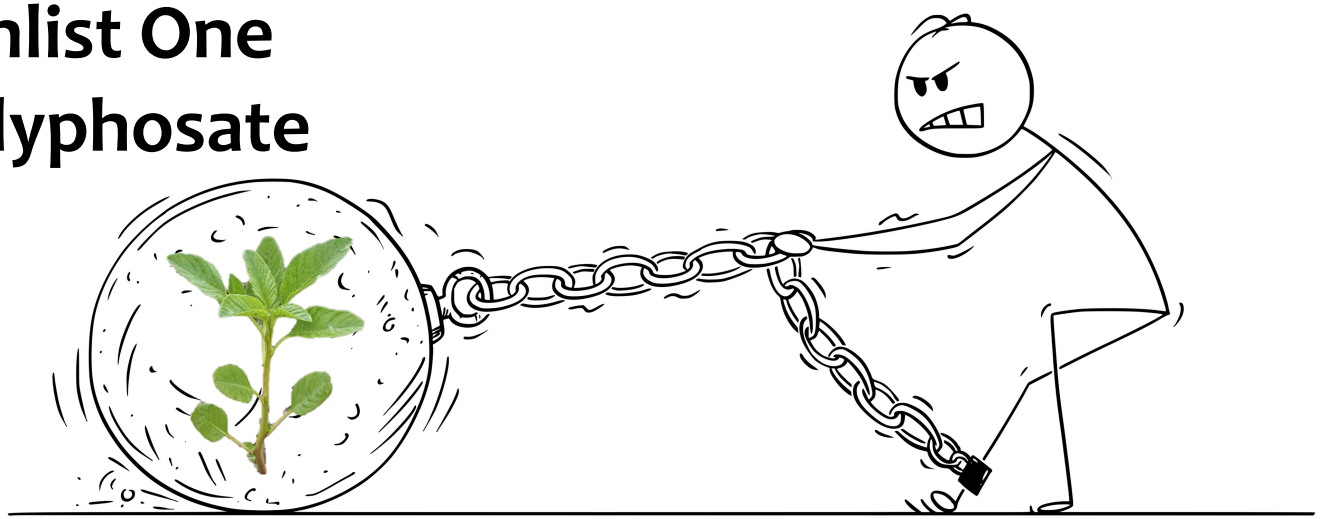
Glufosinate + Glyphosate

Enlist One

Glufosinate

Glyphosate



Investigating Potential Waterhemp Resistance in a Soybean Field in Frankford, Missouri after Previous Failed Applications of Liberty and Enlist One

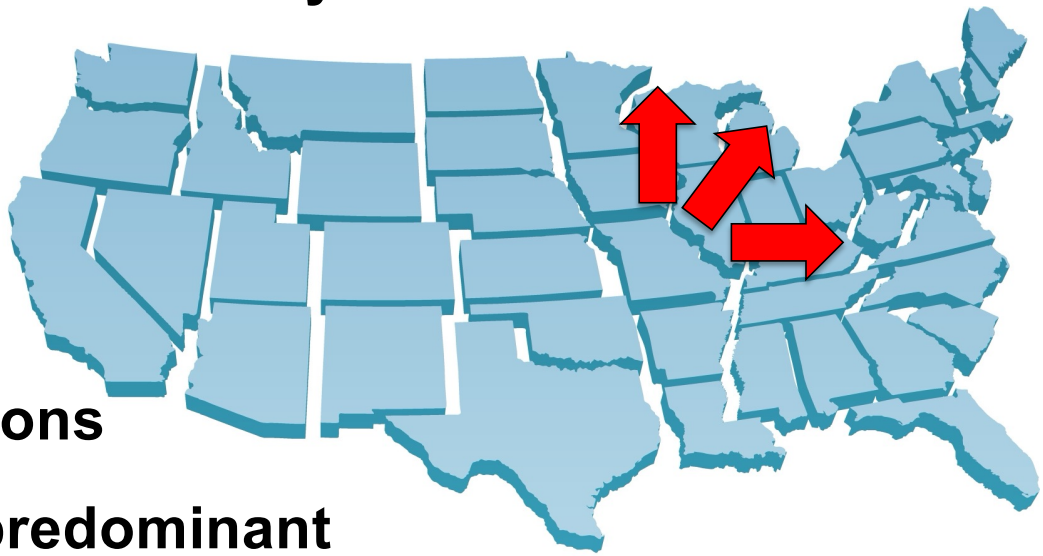
Treatments	Rate/Acre	Waterhemp Control	
		1 Week after Application	3 Weeks after Application
		---------- % ----------	
Liberty	43 fl ozs	60 b	90 b
Liberty	86 fl ozs	94 a	98 a
Liberty	172 fl ozs	95 a	100 a
Enlist One	64 fl ozs	35 c	44 d
Enlist One	128 fl ozs	53 b	52 c

*Means within a column followed by the same letter are not different, LSD=0.05

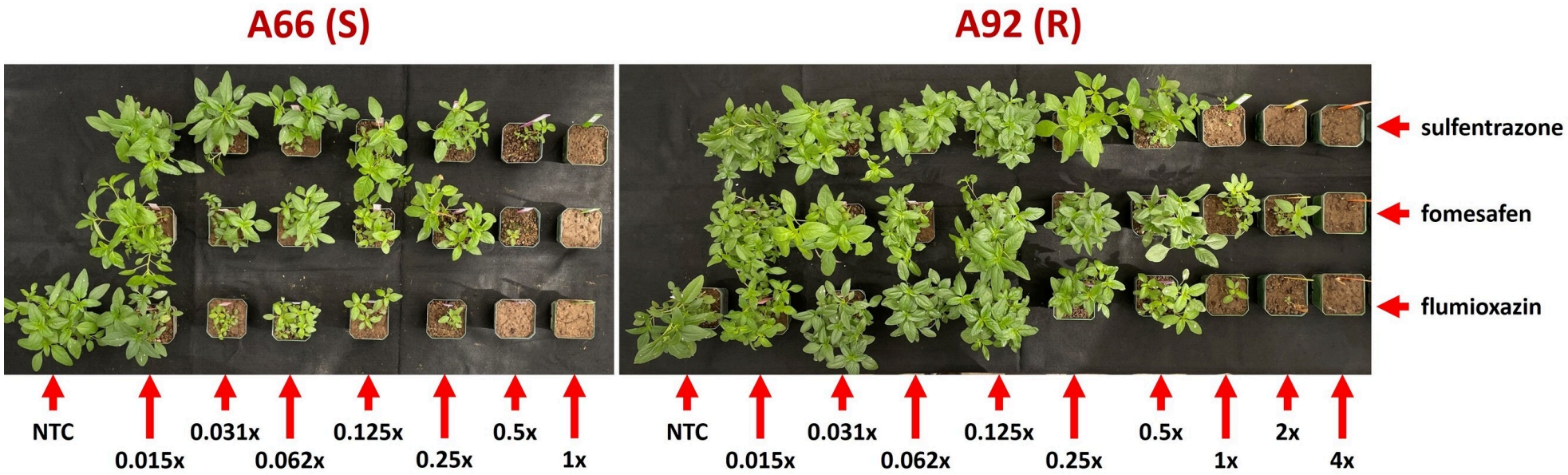
Herbicide-resistant Waterhemp in the U.S.

(recent trends)

- Herbicide-resistant waterhemp is being documented further north and east in the U.S.
- ↑ incidences of 2,4-D resistance in many locations
- ↑ Group 15 resistance in IL
- Dicamba resistance in IL, IA
- No “official” glufosinate resistance yet but several states investigating populations
- Metabolic resistance is the predominant mechanism in these “newest” type of resistances



Pre-emergence Applications of Group 14, PPO-inhibiting Herbicides



- **Leads us closer and closer to resistance to PPO inhibitors applied PRE.**
- **Increases the likelihood that the first waterhemp to emerge will be PPO-res.**
- **Means tank-mixes w/ group 14s are that much more important**

Wuerffel et al. 2015; Faleco et al. 2025


What’s on the horizon
for waterhemp?

Future Herbicide and Trait Options?

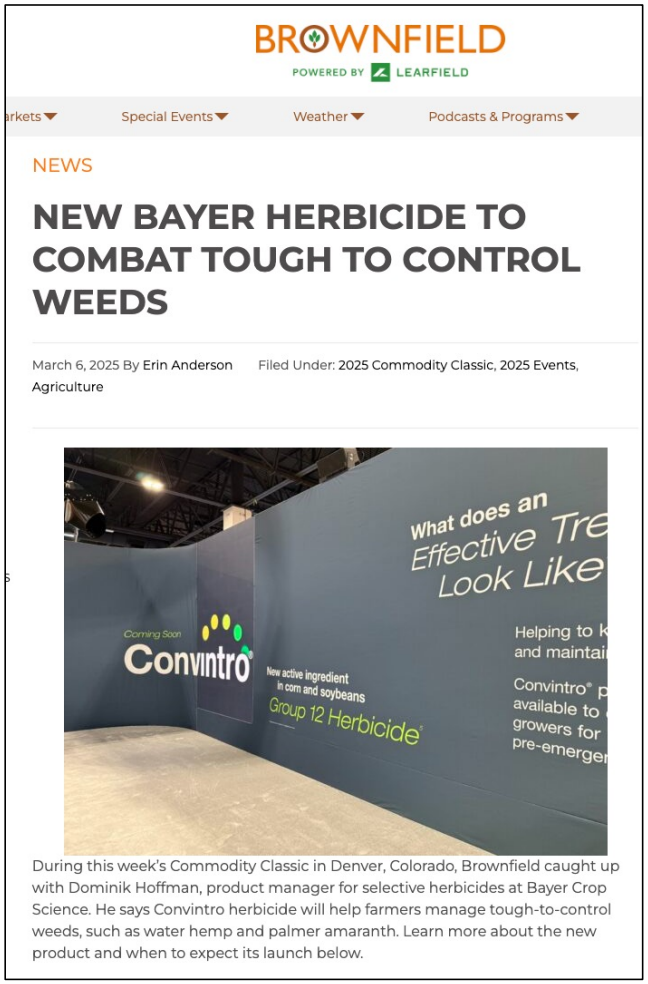
Active Ingredient: diflufenican

Company: Bayer

MOA: Group 12 herbicide, inhibits phytoene desaturase (PDS), a key enzyme in the carotenoid biosynthesis pathway. A "bleaching" herbicide. Sonar and Zorial also in this group.

Expected Release: 2026

Other: Has been registered in Europe since the 1990s. Would represent a new MOA not currently used in corn or soybean.



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NEWS

NEW BAYER HERBICIDE TO COMBAT TOUGH TO CONTROL WEEDS

March 6, 2025 By Erin Anderson Filed Under: 2025 Commodity Classic, 2025 Events, Agriculture

During this week's Commodity Classic in Denver, Colorado, Brownfield caught up with Dominik Hoffman, product manager for selective herbicides at Bayer Crop Science. He says Convintro herbicide will help farmers manage tough-to-control weeds, such as water hemp and palmer amaranth. Learn more about the new product and when to expect its launch below.

Future Herbicide and Trait Options?

Active Ingredient: Icafolin-methyl

Company: Bayer

MOA: Group 23 herbicide, “Inhibitors of Microtubule Organization”. Inhibits a process essential for cell division in plants. Similar MOA to dinitroaniline (group 3) herbicides.

Activity: Non-selective herbicide with post-emergence activity on a variety of grass and broadleaf weeds

Expected Release: late 2020s / early 2030s?

16 | NOV 2025
MissouriRuralist.com

New Bayer herbicide ‘freezes’ weeds in field

BY GIL GULLICKSON
gil.gullickson@farmprogress.com

AT THE FARM Progress Show in Decatur, Ill., Brian Naber, who heads the North America and Australia-New Zealand region for Bayer Crop Science, discussed a new herbicide with a site of action that’s truly new.

Called Icafolin, the compound is a postemergence product that Bayer has developed for several crops, including soybeans. Naber expects it to be commercialized in the next four to five years.

“Since it’s a completely new mode of action, you see a completely different set of visual symptomology about how it kills and controls the weed,” Naber said.

Bayer scientists observe treated weeds becoming “frozen” in the fields, meaning they stop competing with crops for water, nutrients and sunlight. However, the dead weeds remain in the field longer because they largely maintain their structure. This creates a mulch layer that helps prevent erosion and trap moisture in the soil, Bayer officials say. By providing effective weed control, it reduces the need for tillage and supports regenerative practices that can improve soil health, they say.

KEY POINTS
- Icafolin is a postemergence product developed by Bayer.
- Scientists say it causes weeds to stop competing with crops.
- Convintro will be a product aimed at controlling weeds in soybeans.

> “Since it’s a completely new mode of action, you see a completely different set of visual symptomology about how it kills and controls the weed.” – BRIAN NABER

NEW GROUP 12 HERBICIDE

Bayer also is planning to bring a new Group 12 herbicide to market. Diflufenican herbicide, which will be marketed under the brand name Convintro, will be a soybean burndown and preemergence product primarily aimed at waterhemp and Palmer amaranth.

Diflufenican is not new chemistry, as it has been used for years in Europe to manage broadleaf weeds in crops such as lentils and winter cereals. However, it will be new to the U.S. Bayer expects this chemistry to be available to U.S. farmers in 2026, pending regulatory approval.

POTENTIAL DICAMBA COMEBACK

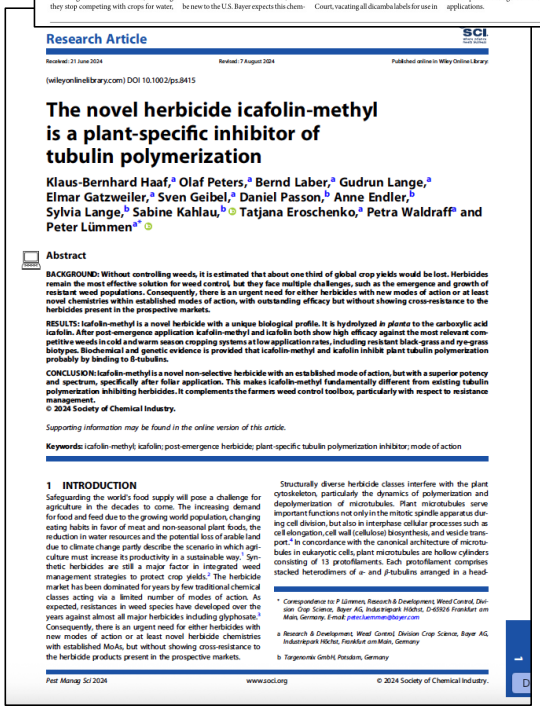
In 2017, dicamba-tolerant soybeans were matched to EPA-approved dicamba formulations in the Roundup Ready 2 Xtend System. Although good-to-excellent weed control resulted from applications, state departments of agriculture soon reported an uptick in off-target dicamba complaints.

This coincided with legal action taken by environmental groups. Eventually, they were successful in an Arizona U.S. District Court, vacating all dicamba labels for use in soybeans in February 2024. This led to the unavailability of dicamba formulations for dicamba-tolerant soybeans in 2025.

This may change, though. This summer, EPA opened a comment period for potential use once again of dicamba products used in dicamba-tolerant soybeans.

Naber said he is optimistic dicamba may return for use as a preplant and post-emergence herbicide for dicamba-tolerant soybeans in 2026. He said there are indications that the rate of volatility reduction agents will be increased and that states may use temperature as a guideline for dicamba applications.

NEW CHEMISTRY: Bayer is launching a new chemistry, including a new compound called Icafolin, that will feature a truly new herbicide site of action for row crops – the first in several decades.



Research Article

Received: 21 June 2024 Revised: 7 August 2024 Published online in Wiley Online Library

(wileyonlinelibrary.com) DOI 10.1002/ps.8415

The novel herbicide icafolin-methyl is a plant-specific inhibitor of tubulin polymerization

Klaus-Bernhard Haaf,[a] Olaf Peters,[a] Bernd Laber,[a] Gudrun Lange,[a] Elmar Gatzweiler,[a] Sven Geibel,[a] Daniel Passon,[b] Anne Endler,[b] Sylvia Lange,[b] Sabine Kahlau,[b] Tatjana Eroschenko,[a] Petra Waldraff[a] and Peter Lümmen[a]*

Abstract

BACKGROUND: Without controlling weeds, it is estimated that about one third of global crop yields would be lost. Herbicides remain the most effective solution for weed control, but they face multiple challenges, such as the emergence and growth of resistant weed populations. Consequently, there is an urgent need for either herbicides with new modes of action or at least novel chemistries within established modes of action, with outstanding efficacy but without showing cross-resistance to the herbicides present in the prospective markets.

RESULTS: Icafolin-methyl is a novel herbicide with a unique biological profile. It is hydrolyzed *in planta* to the carboxylic acid icafolin. After post-emergence application icafolin-methyl and icafolin both show high efficacy against the most relevant competitive weeds in cold and warm season cropping systems at low application rates, including resistant black-grass and ryegrass biotypes. Biochemical and genetic evidence is provided that icafolin-methyl and icafolin inhibit plant tubulin polymerization probably by binding to ß-tubulins.

CONCLUSION: Icafolin-methyl is a novel non-selective herbicide with an established mode of action, but with a superior potency and spectrum, specifically after foliar application. This makes icafolin-methyl fundamentally different from existing tubulin polymerization inhibiting herbicides. It complements the farmers weed control toolbox, particularly with respect to resistance management.

Supporting information may be found in the online version of this article.

Keywords: icafolin-methyl; icafolin; post-emergence herbicide; plant-specific tubulin polymerization inhibitor; mode of action

1 INTRODUCTION

Safeguarding the world’s food supply will pose a challenge for agriculture in the decades to come. The increasing demand for food and feed due to the growing world population, changing eating habits in favor of meat and non-seasonal plant foods, the reduction in water resources and the potential loss of arable land due to climate change partly describe the scenario in which agriculture must increase its productivity in a sustainable way.[1] Synthetic herbicides are still a major factor in integrated weed management strategies to protect crop yields.[2] The herbicide market has been dominated for years by few traditional chemical classes acting via a limited number of modes of action. As expected, resistances in weed species have developed over the years against almost all major herbicides including glyphosate.[3] Consequently, there is an urgent need for either herbicides with new modes of action or at least novel herbicide chemistries with established MoAs, but without showing cross-resistance to the herbicide products present in the prospective markets.

Structurally diverse herbicide classes interfere with the plant cytoskeleton, particularly the dynamics of polymerization and depolymerization of microtubules. Plant microtubules serve important functions not only in the mitotic spindle apparatus during cell division, but also in interphase cellular processes such as cell elongation, cell wall (cellulose) biosynthesis, and vesicle transport.[4] In concordance with the canonical architecture of microtubules in eukaryotic cells, plant microtubules are hollow cylinders consisting of 13 protofilaments. Each protofilament comprises stacked heterodimers of α- and β-tubulins arranged in a head-

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b Targenomix GmbH, Potsdam, Germany

Future Herbicide and Trait Options?

Active Ingredient: Rimisoxafen

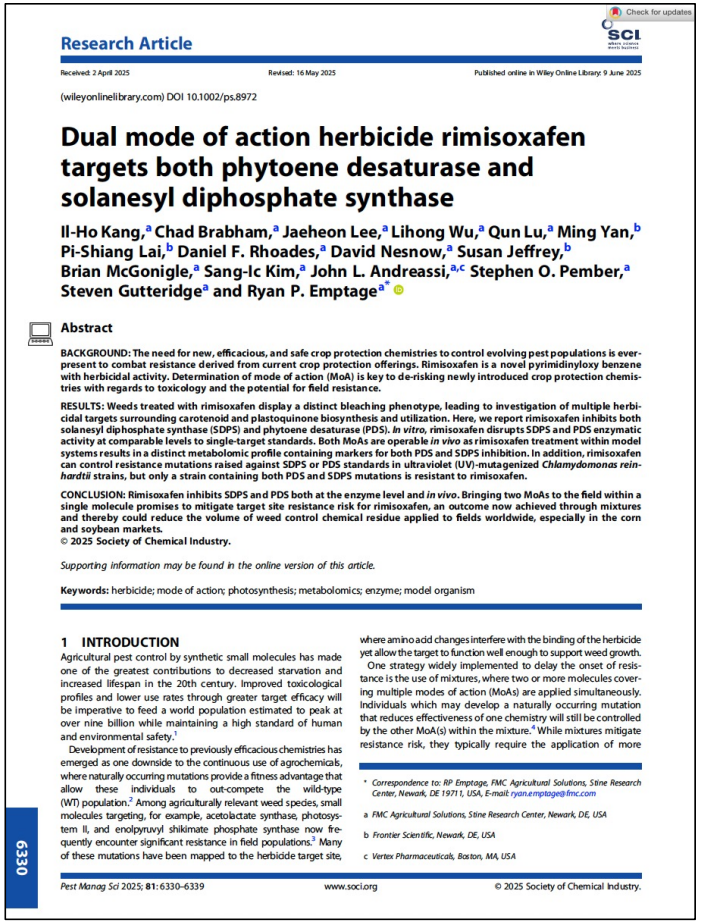
Company: FMC

MOA:

- Group 12 (like Convintro, Sonar, Zorial), a bleaching herbicide
- and also a Group 32 herbicide

Activity: grass and broadleaf weeds

Expected Release: late 2020s/early 2030s?



Research Article

Received: 2 April 2025 Revised: 16 May 2025 Published online in Wiley Online Library: 9 June 2025

(wileyonlinelibrary.com) DOI 10.1002/ps.8972

Dual mode of action herbicide rimisoxafen targets both phytoene desaturase and solanesyl diphosphate synthase

Il-Ho Kang,[a] Chad Brabham,[a] Jaeheon Lee,[a] Lihong Wu,[a] Qun Lu,[a] Ming Yan,[b] Pi-Shiang Lai,[b] Daniel F. Rhoades,[a] David Nesnow,[a] Susan Jeffrey,[b] Brian McGonigle,[a] Sang-Ic Kim,[a] John L. Andreassi,[a,c] Stephen O. Pember,[a] Steven Gutteridge[a] and Ryan P. Emptage[a]*

Abstract

BACKGROUND: The need for new, efficacious, and safe crop protection chemistries to control evolving pest populations is ever-present to combat resistance derived from current crop protection offerings. Rimisoxafen is a novel pyrimidinyloxy benzene with herbicidal activity. Determination of mode of action (MoA) is key to de-risking newly introduced crop protection chemistries with regards to toxicology and the potential for field resistance.

RESULTS: Weeds treated with rimisoxafen display a distinct bleaching phenotype, leading to investigation of multiple herbicidal targets surrounding carotenoid and plastoquinone biosynthesis and utilization. Here, we report rimisoxafen inhibits both solanesyl diphosphate synthase (SDPS) and phytoene desaturase (PDS). *In vitro*, rimisoxafen disrupts SDPS and PDS enzymatic activity at comparable levels to single-target standards. Both MoAs are operable *in vivo* as rimisoxafen treatment within model systems results in a distinct metabolomic profile containing markers for both PDS and SDPS inhibition. In addition, rimisoxafen can control resistance mutations raised against SDPS or PDS standards in ultraviolet (UV)-mutagenized *Chlamydomonas reinhardtii* strains, but only a strain containing both PDS and SDPS mutations is resistant to rimisoxafen.

CONCLUSION: Rimisoxafen inhibits SDPS and PDS both at the enzyme level and *in vivo*. Bringing two MoAs to the field within a single molecule promises to mitigate target site resistance risk for rimisoxafen, an outcome now achieved through mixtures and thereby could reduce the volume of weed control chemical residue applied to fields worldwide, especially in the corn and soybean markets.

Supporting information may be found in the online version of this article.

Keywords: herbicide; mode of action; photosynthesis; metabolomics; enzyme; model organism

1 INTRODUCTION

Agricultural pest control by synthetic small molecules has made one of the greatest contributions to decreased starvation and increased lifespan in the 20th century. Improved toxicological profiles and lower use rates through greater target efficacy will be imperative to feed a world population estimated to peak at over nine billion while maintaining a high standard of human and environmental safety.[1]

Development of resistance to previously efficacious chemistries has emerged as one downside to the continuous use of agrochemicals, where naturally occurring mutations provide a fitness advantage that allow these individuals to out-compete the wild-type (WT) population.[2] Among agriculturally relevant weed species, small molecules targeting, for example, acetolactate synthase, photosystem II, and enolpyruvyl shikimate phosphate synthase now frequently encounter significant resistance in field populations.[3] Many of these mutations have been mapped to the herbicide target site, where amino acid changes interfere with the binding of the herbicide yet allow the target to function well enough to support weed growth.

One strategy widely implemented to delay the onset of resistance is the use of mixtures, where two or more molecules covering multiple modes of action (MoAs) are applied simultaneously. Individuals which may develop a naturally occurring mutation that reduces effectiveness of one chemistry will still be controlled by the other MoA(s) within the mixture.[4] While mixtures mitigate resistance risk, they typically require the application of more

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c Vertex Pharmaceuticals, Boston, MA, USA

Future Herbicide and Trait Options?

Quite a bit of activity in the discovery of new Group 14, PPO-inhibiting herbicides that control PPO-resistant pigweeds with known mutations.

Figure 8. PPO-inhibitor resistant Palmer amaranth field trial. Early-post application. Spray volume: 189 L ha^{-1}. Crop oil concentrate added at 0.5% (v/v).

Epyrifenacil, *Rapidicil (Valent), Trifludimoxazin, *Voraxor (BASF), others from Bayer, etc.

*** = pending registration**

Sada et al. 2024 Pest Manag. Sci; Barker et al. 2023 Weed Sci

Future Herbicide and Trait Options?

Company: Syngenta/M.S. Technologies

Herbicide Resistance Stacks:
Glyphosate, glufosinate, 2,4-D choline and certain HPPD-inhibiting group 27 herbicides (mesotrione, bicyclopyrone, isoxaflutole).

Expected Release: 2029

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NEW SOYBEAN TRAIT TO ALLOW SAME HERBICIDE PROGRAM IN CORN AND SOYBEANS

September 5, 2025 By Jared White Filed Under: 2025 Events, 2025 Farm Progress Show, Crops, Crops, News, Soybeans

Jared Benson with Syngenta at FPS25. (Photo by Jill Makovec / Brownfield)

The head of soybean portfolio strategy with Syngenta says farmers will soon have a new tool to battle herbicide-resistant weeds.

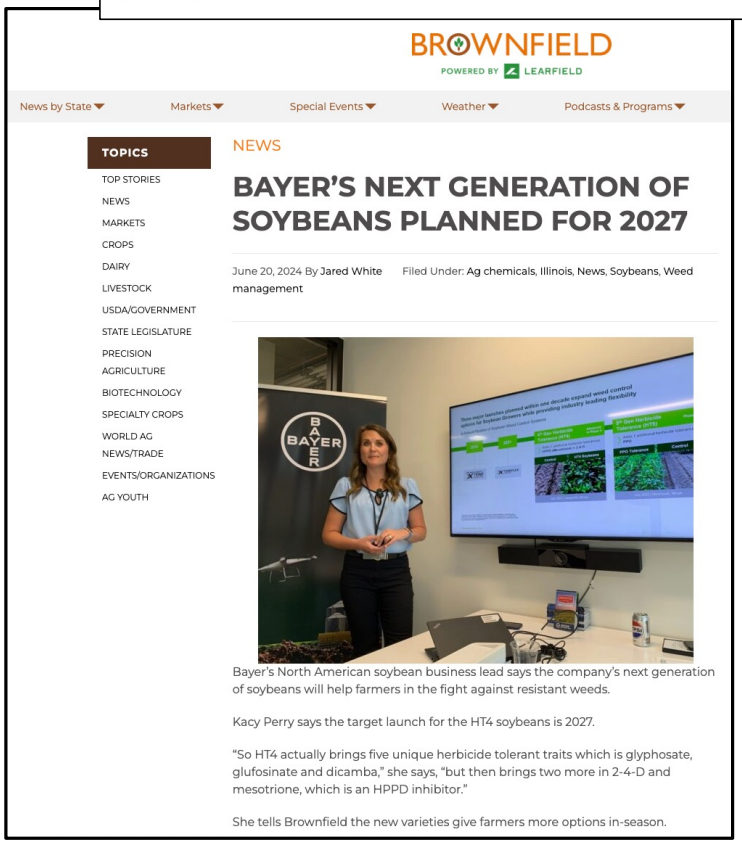
Future Herbicide and Trait Options?

Company: Bayer

Trait/Name: HT4 / Vyconic

Herbicide Resistances: Glyphosate, glufosinate, dicamba, 2,4-D, and mesotrione.

Expected Release: 2027



Future Herbicide and Trait Options?

Quite a bit of activity in bringing forward new PPO-resistant traits.

Business & Financial News | August 30, 2022

Joint News Release

BASF and Corteva Agriscience collaborate to deliver the future of weed control to soybean farmers

- **Industry-first multigenerational soybean weed management by cross-licensing new technologies and complementary herbicides**
- **Development of multiple products expected to offer farmers expanded options for herbicide-tolerant soybeans in the early 2030s**
- **Trait stack with four modes of action and new herbicides will help address problematic weeds**

Julian Prade
External Communications
Agricultural Solutions
Media Inquiries
+49 172 62-70719
Send email

Joint News Release
Preview
PDF (209.04 KB)

Limburgerhof, Germany and Indianapolis, Indiana. BASF and Corteva Agriscience today announced a long-term collaboration to develop new soybean weed control solutions for farmers around the world. The two companies agreed to cross-license soybean traits, while developing complementary herbicide technologies, enabling both companies to offer innovative soybean weed management solutions. Through the collaboration, BASF and Corteva aim to meet farmers' demand for tailored weed control options differentiated from those on the market or in development. As a result, both companies anticipate a spark in novel product offers with increased access to the global $7.1 billion soybean seeds and traits market, as well as the $5 billion soybean herbicide market.[1] The first market introduction is planned in North America with additional geographies to follow.

Corteva will combine a proprietary PPO (protoporphyrinogen oxidase) gene licensed from BASF with its portfolio of herbicide tolerant traits, including Corteva's proprietary 2,4-D choline gene, to develop a new trait stack for soybeans. The stack will include tolerance to four herbicide modes of action, or distinct mechanisms to achieve control. Together they will provide a new, effective and flexible option to help control the most problematic weeds. This innovative herbicide tolerance stack is expected to be available in all Corteva seed brands. Corteva has licensed the stack to BASF for use in BASF seed brands and also anticipates licensing the trait stack to additional seed companies.

In the early 2030s, Bayer expects to launch its HT5 trait, which adds PPO tolerance to HT4. "It is a fairly broad tolerance to many PPO products that can be used on soybeans today, as well as some new novel PPOs that we plan to bring to the market for crop protection," Wes said. "We are adding one more tool into that toolbox for growers to have the flexibility to help control tough-to-control weeds."

R&D Pipeline: The Future of Ground-Breaking Corn, Soybean and Cotton Traits

Bayer traits' unparalleled R&D pipeline brings transformative technologies to fields and puts innovation into action for farmers.

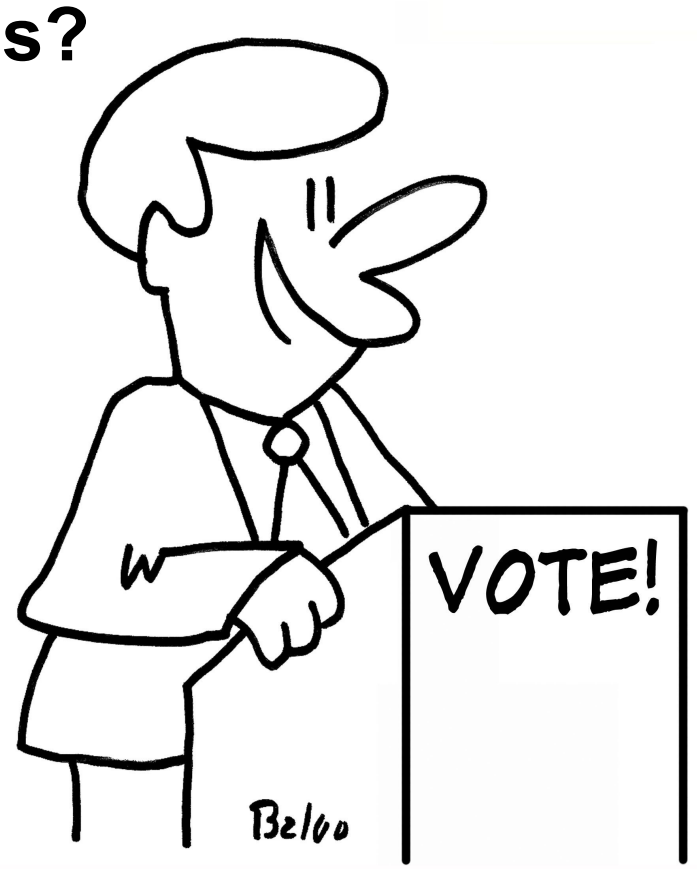
GET TRAIT INNOVATION UPDATES >

The Decade Ahead — Transformative Corn, Soybean and Cotton Traits To Watch For.

8 blockbuster traits in the next 10 years that will allow farmers to take their yields and options to the next level.

Future Herbicide and Trait Options?

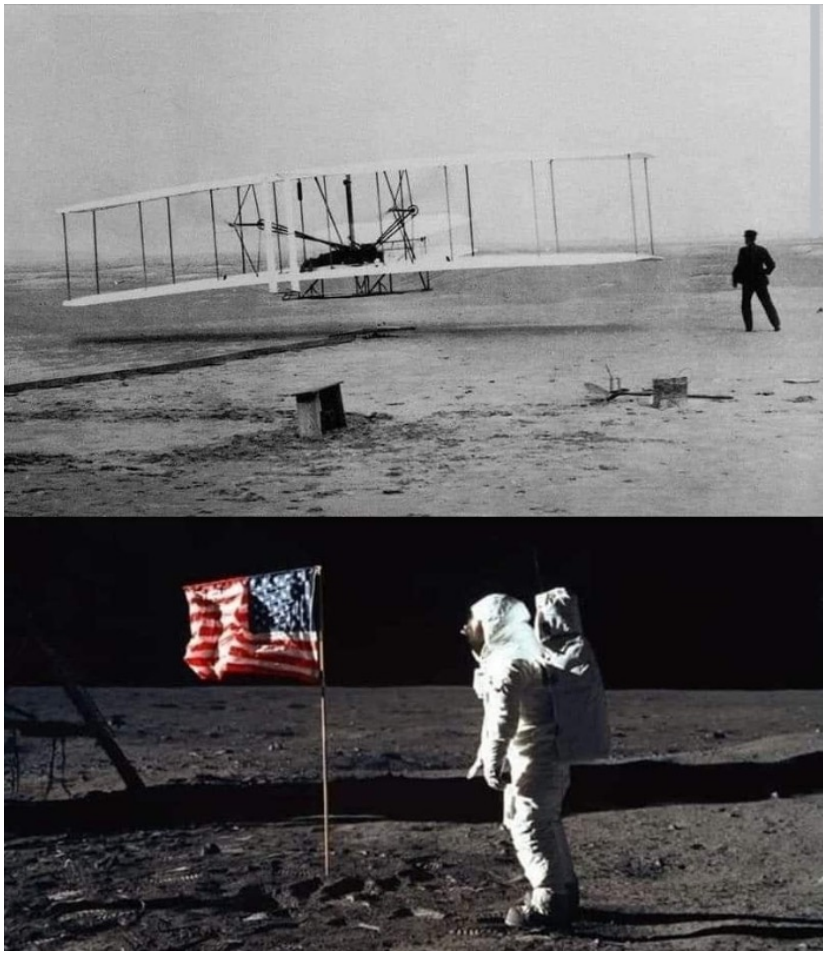
That's what you wanted to hear. Now what I want you to listen to.



"I'm here today to tell you what you want to hear...."

Our History
(in my opinion)

Where are we headed?



Reasons I think we are headed for a future with reduced dependence on herbicides:

1. Technology

Future:
Targeted (and autonomous) Weed Removal

Robot dog can stifle weeds by blasting them with a blowtorch

A Spot robot equipped with a blowtorch can locate weeds on farms and precisely heat them up to stop them growing, offering a possible alternative to herbicides

By Alex Wilkins

23 July 2024

A Spot robot equipped with a blowtorch for tackling weeds
Dezhen Song et al. (2024)

Bosch's Giant Robot Can Punch Weeds to Death

By Evan Ackerman
Posted 12 Nov 2015 | 20:00 GMT

Photo: Deepfield Robotics

At IROS last month, researchers from a Bosch startup called Deepfield Robotics presented a paper on "Vision-Based High-Speed Manipulation for Robotic Ultra-Precise Weed Control," which has like four distinct exciting-sounding phrases in it. We wanted to write about it immediately, but Deepfield asked us to hold off a bit until their fancy new website went live, which it now has. This means that we can show you video of their enormous agricultural robot that can autonomously detect and physically obliterate individual weeds in a tenth of a second.

Given the scale of farming today, treating weeds chemically is really the only practical way for humans to keep them under control, because you can use tractors or airplanes to cover large areas in a short amount of time. But all of those necessarily deadly (to weeds) chemicals then get on the plants we don't want to kill (because we want to eat them), as well as getting washed into the soil. The most organic and eco-friendly way of dealing with weeds is the old-fashioned way: physically removing them. "Physical removal" can mean

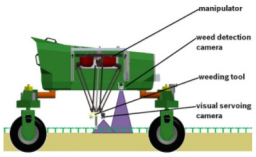


Image: Deepfield Robotics

FarmWise launches autonomous weeding robot

JANUARY 7, 2019 BY SAM FRANCIS

Deere is paying over $300 million for a start-up that makes 'see-and-spray' robots

- Blue River's robots affix to tractors and can precisely identify and spray herbicides, pesticides or fertilizers to plants in need.
- The start-up had raised about $31 million in venture funding.

Lora Kolodny | @lorakolodny
Published 8:08 PM ET Wed, 6 Sept 2017 | Updated 10:22 PM ET Wed, 6 Sept 2017

CNBC

Michael Newberg | CNBC

Sam Allen, CEO of John Deere at CONEXPO in Las Vegas on March 7, 2017.

Deere is bringing more robots to the farm.

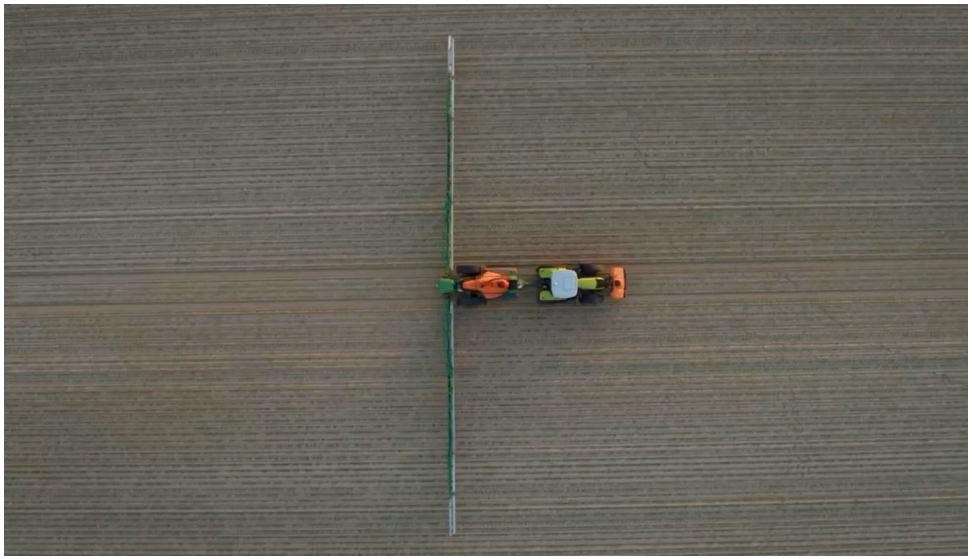
The maker of John Deere agricultural equipment said on Wednesday that it's acquiring robotics start-up Blue River Technology for $305 million. The deal is expected to close in September.

Where are we now… with “technology” and weed management?

Smart sprayers.

ONE SMART SPRAY

A Joint Venture of Bosch and BASF



Where are we now… with “technology” and weed management?

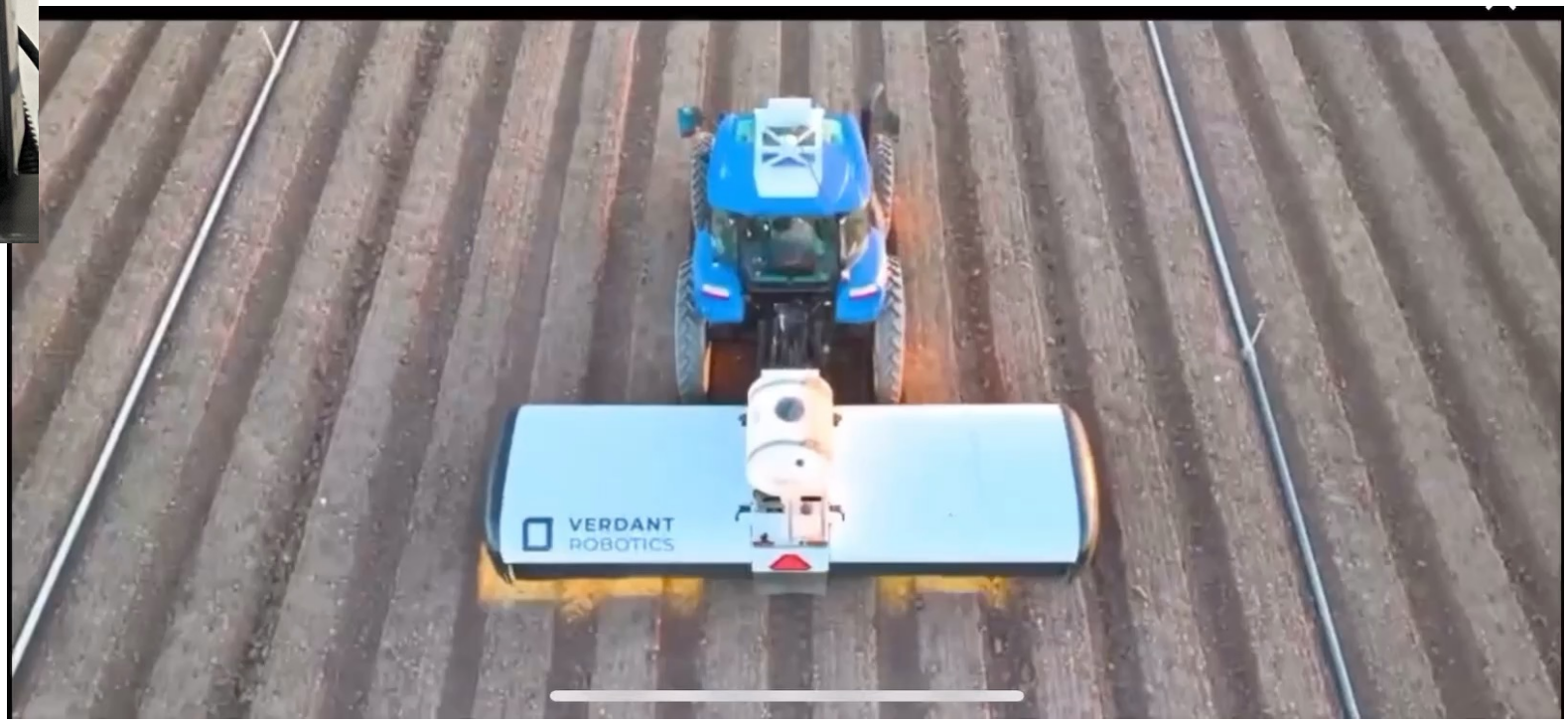
Smart sprayers.

ecorobotix

Where are we now… with “technology” and weed management?

Smart sprayers.

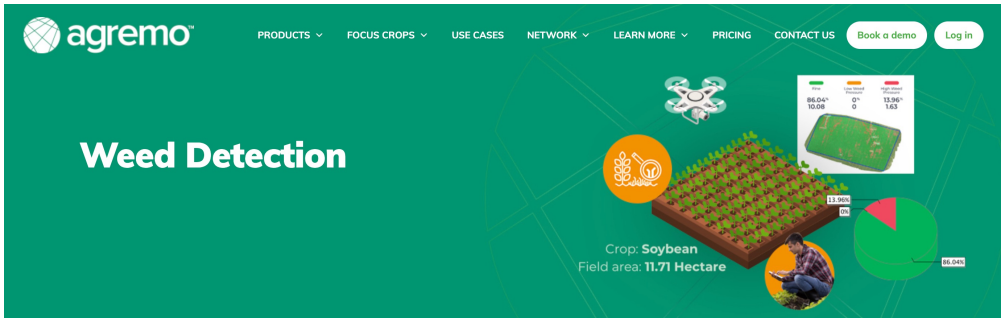
VERDANT ROBOTICS

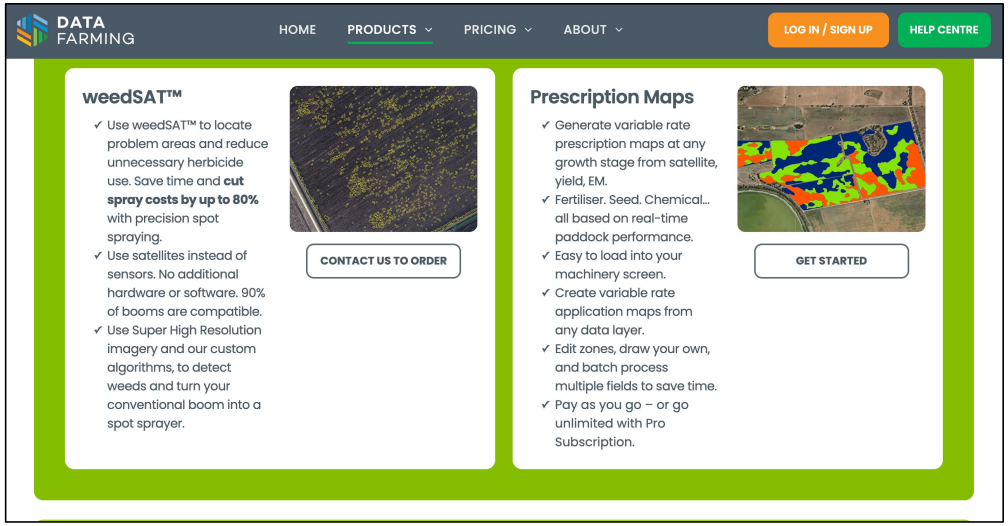


Where are we now… with “technology” and weed management?

Drone/satellite mapping. Then spraying.

sentera





The method of weed removal doesn't necessarily have to involve herbicides

Robot dog can stifle weeds by blasting them with a blowtorch

A Spot robot equipped with a blowtorch can locate weeds on farms and precisely heat them up to stop them growing, offering a possible alternative to herbicides

By Alex Wilkins

23 July 2024

A Spot robot equipped with a blowtorch for tackling weeds
Dezhen Song et al. (2024)

Farmers aren’t afraid of technology. But…

MISSOURI SCIENTISTS FIND WATERHEMP RESISTANT TO 6 HERBICIDE MODES OF ACTION

A group of scientists recently reported a population of waterhemp in Missouri resistant to a record-breaking six herbicide modes of action.

Their findings were recently published in the Weed Science Society of America's journal, Weed Science. The authors included Lovreet Shergill, Blake Barlow, Mandy Bish and Kevin Bradley, all with the University of Missouri's Weed Science Department.

It all started when growers in Randolph County, Missouri, reported a population of waterhemp that appeared to be resistant to 2,4-D.

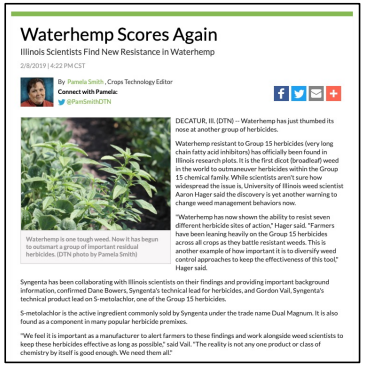
University of Missouri researchers conducted field experiments that confirmed 2,4-D resistance. But they also found the same waterhemp population was resistant to atrazine, chlorimuron, fomesafen, glyphosate and mesotrione. Of the eight herbicides applied, only dicamba and glufosinate provided acceptable control, according to a WSSA news release.

Waterhemp — photo courtesy University of Missouri

The results are sobering – especially for anyone waiting on the approval of 2,4-D–resistant corn and soybeans as a way to manage glyphosate resistance. If we're already seeing 2,4-D resistance now, what will happen when use of the herbicide becomes even more commonplace?

Researchers say six-way resistant waterhemp demands a diversified approach. Rather than relying on glyphosate, 2,4-D or any other single herbicide, it's time to focus on a variety of appropriate cultural, mechanical and biological control tactics.

Print Friendly



Waterhemp Scores Again

Illinois Scientists Find New Resistance In Waterhemp

2/8/2019 | 4:22 PM CST

By Pamela Smith, Crops Technology Editor

Connect with Pamela: @PamSmithDTN

DECATUR, Ill. (DTN) -- Waterhemp has just thumbed its nose at another group of herbicides.

Waterhemp is one tough weed. Now it has begun to outsmart a group of important residual herbicides. (DTN photo by Pamela Smith)

Waterhemp resistant to Group 15 herbicides (very long chain fatty acid inhibitors) has officially been found in Illinois research plots. It is the first dicot (broadleaf) weed in the world to outmaneuver herbicides within the Group 15 chemical family. While scientists aren't sure how widespread the issue is, University of Illinois weed scientist Aaron Hager said the discovery is yet another warning to change weed management behaviors now.

"Waterhemp has now shown the ability to resist seven different herbicide sites of action," Hager said. "Farmers have been leaning heavily on the Group 15 herbicides across all crops as they battle resistant weeds. This is another example of how important it is to diversify weed control approaches to keep the effectiveness of this tool," Hager said.

Syngenta has been collaborating with Illinois scientists on their findings and providing important background information, confirmed Dane Bowers, Syngenta's technical lead for herbicides, and Gordon Vail, Syngenta's technical product lead on S-metolachlor, one of the Group 15 herbicides.

S-metolachlor is the active ingredient commonly sold by Syngenta under the trade name Dual Magnum. It is also found as a component in many popular herbicide premixes.

"We feel it is important as a manufacturer to alert farmers to these findings and work alongside weed scientists to keep these herbicides effective as long as possible," said Vail. "The reality is not any one product or class of chemistry by itself is good enough. We need them all."

HOME > CROPS > DICAMBA-RESISTANT WATERHEMP IDENTIFIED IN ILLINOIS, TENNESSEE

Dicamba-Resistant Waterhemp

Dicamba-Resistant Waterhemp Identified in Illinois, Tennessee

11/11/2021 | 8:07 AM CST

By Emily Unglesbee, DTN Staff Reporter

Connect with Emily: @Emily_Unglesbee

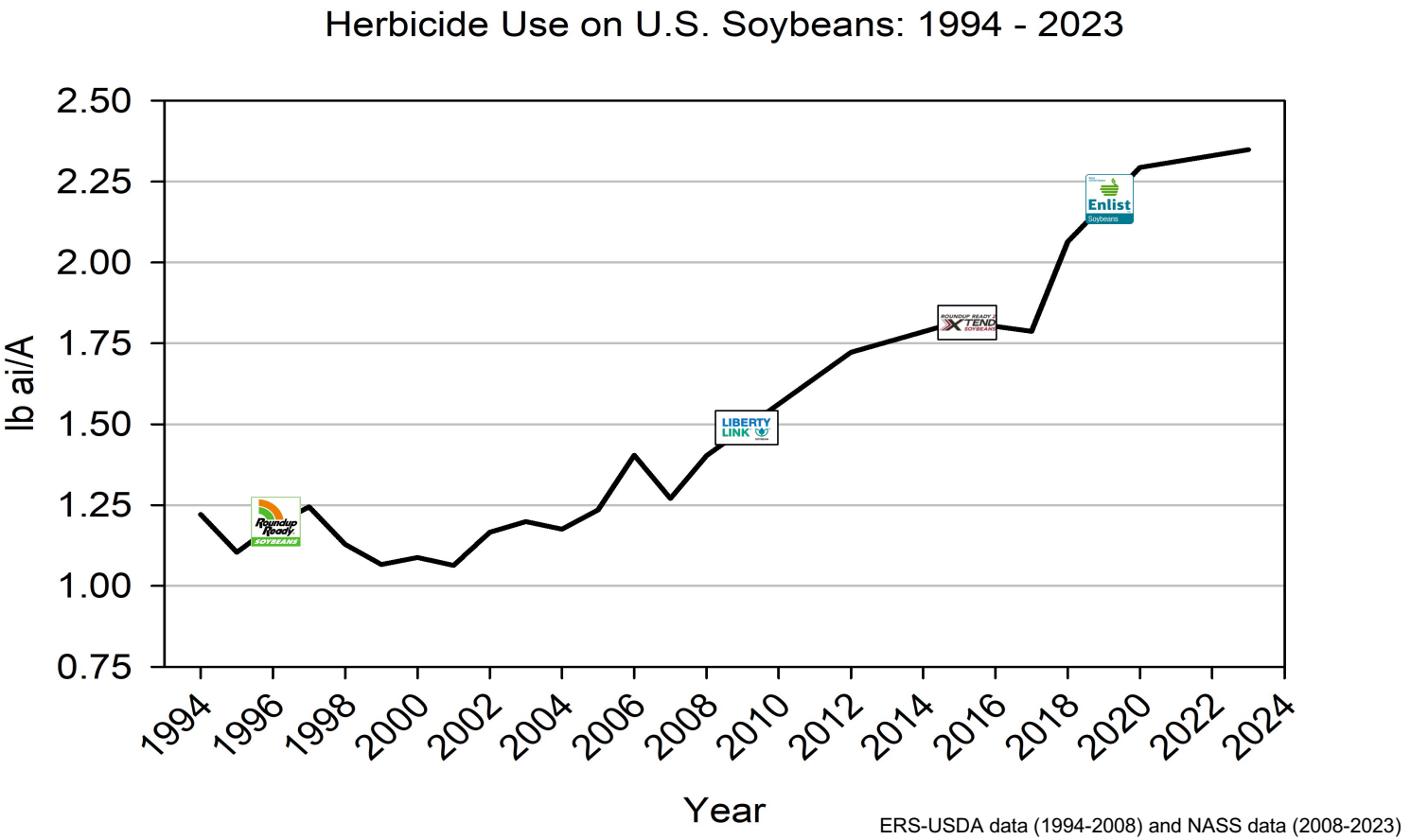
ROCKVILLE, Md. (DTN) -- Scientists from both Tennessee and Illinois have confirmed dicamba-resistant waterhemp in their respective states this week.

The country's first confirmed dicamba-resistant waterhemp populations hail from Champaign County, Illinois, and Montgomery County, Tennessee. (DTN Photo by Pamela Smith)

The Illinois weed population, collected from Champaign County, shows 5- to 10-fold levels of resistance to dicamba compared to susceptible populations, said University of Illinois weed scientist Aaron Hager. Overall, it is a 6-way resistant weed population, with resistance to Group 4 (auxins, including dicamba and 2,4-D), Group 2 (ALS-inhibitors), Group 5 (triazines), Group 14 (PPO-inhibitors), Group 27 (HPPD-inhibitors) and Group 15 (VLCFA-synthesis inhibitors, such as S-metolachlor).

In Montgomery County, Tennessee, waterhemp collected from fields in the Cumberland River bottoms are showing roughly 4.5-fold levels of resistance to dicamba, said Larry Steckel, University of Tennessee Extension weed scientist, who worked with Purdue University scientists to confirm his findings. The Tennessee waterhemp populations are also resistant to Group 9 (glyphosate), Group 14 (PPO-inhibitors) and Group 2 (ALS-inhibitors), although surprisingly, 2,4-D is still effective on them, Steckel said.

…U.S. Agriculture isn't convinced it needs "technologies" other than herbicides for weed management



ERS-USDA data (1994-2008) and NASS data (2008-2023)

Reasons I think we are headed for a future with reduced dependence on herbicides:

1. Technology
2. Regulations

EPA United States Environmental Protection Agency

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Endangered Species

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- Assessing Pesticides Under the Endangered Species Act
- Endangered Species: Information For Pesticides Users
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Contact Us about Protecting Endangered Species from Pesticides

Strategy to Protect Endangered Species from Herbicides

The Herbicide Strategy is designed to provide early mitigations that minimize impacts to over 900 federal endangered and threatened (listed) species and designated critical habitat for conventional herbicides (chemicals used to control weeds) used in agriculture, before completing effects determinations and, where necessary, consultation under the Endangered Species Act (ESA). EPA will use the strategy to identify measures to reduce the amount of herbicides exposure to these species when it registers new herbicides and when it re-evaluates registered herbicides under a process called registration review. The strategy also focuses mitigation only in situations where species need protection by considering the location, biology, and habitat of those species. EPA focused this strategy on conventional herbicides used in agriculture in the lower 48 states because of the large percentage of herbicides applied there. In 2022, approximately 264 million acres of cropland were treated with herbicides, according to the Census of Agriculture from the U.S. Department of Agriculture (USDA). The number of cropland acres treated with herbicides has remained fairly consistent since the early 2010s. EPA is also focusing this strategy on species listed by the U.S. Fish and Wildlife Service (FWS) because herbicides generally impact those species. For species listed by the National Marine Fisheries Service, EPA is addressing pesticide impacts through

Mitigation Measures			Credits
Reduce number of applications - Reduced number of applications of Enlist products per year. Applications may be made at any time during crop development but must maintain a minimum 12-day retreatment interval.		3 applications	0
		2 applications	2
		1 application	4
Residue Tillage Management: no till, strip-till, ridge-till and mulch-till			4
Vegetative Filter Strips	30 ft off-field vegetative buffer on down slope	HSG A or B	2
		HSG C or D	0
	100 ft off-field vegetative buffer on down slope	HSG A or B	4
		HSG C or D	1
Field border: border with dense vegetative stands with a minimum width of 30 ft.			2
Cover Crop			2
Vegetative Barrier: Permanent strips of dense vegetation along the contours of the field with a minimum width of 3 ft.			2
Contour Buffer Strips or Terrace			2
Grassed Waterway			2
Water and Sediment Basin			1
Contour Farming or Contour Strip Cropping			1

*Hydrologic Soil Group (HSG) definitions: A = Sand, loamy sand, or sandy loam; B = Sandy clay loam; C = Silt loam or loam; D = Clay loam, silty clay loam, sandy clay, silty clay or clay.

Applicators/Land Managers must meet minimum criteria described for each mitigation measure as outlined on Enlist.com/mitigationmeasures to receive credits.

FarmProgress

SIGN UP TODAY

MissouriRuralist

How EPA's new AEZ rule affects your farm

Get out your notepad. It's time to document spraying in application exclusion zones to meet new buffers and rules.

Mindy Ward, Editor, Missouri Ruralist
January 9, 2025

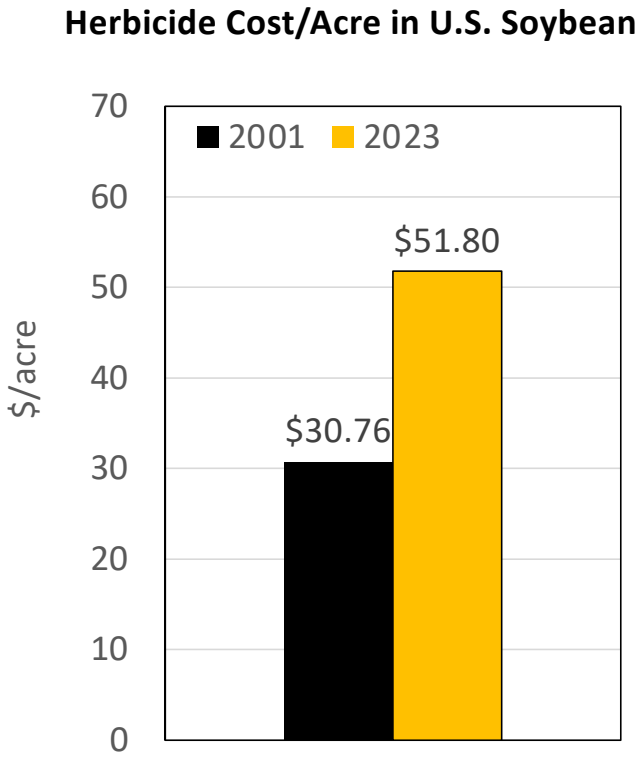
3 Min Read

TOO CLOSE? Spraying in a field next to a rural road is common across much of the country. However, the new AEZ rule requires farmers to pay attention to cars or people on those roads and suspend spraying when they come within 25 to 100 feet, depending on spray droplet size. MINDY WARD

Reasons I think we are headed for a future with reduced dependence on herbicides:

1. Technology
2. Regulations
3. Metabolic Resistance
4. Public Perception
5. Economics

Are “future technologies” like robotics really more expensive than what we’re doing now?



*Costs adjusted for inflation; graph adapted from Singh and Jhala (2025)

In the meantime, let's not forget about *integrated* weed management practices that involve things other than just herbicides.

Integrated Weed Management: Cover Crops

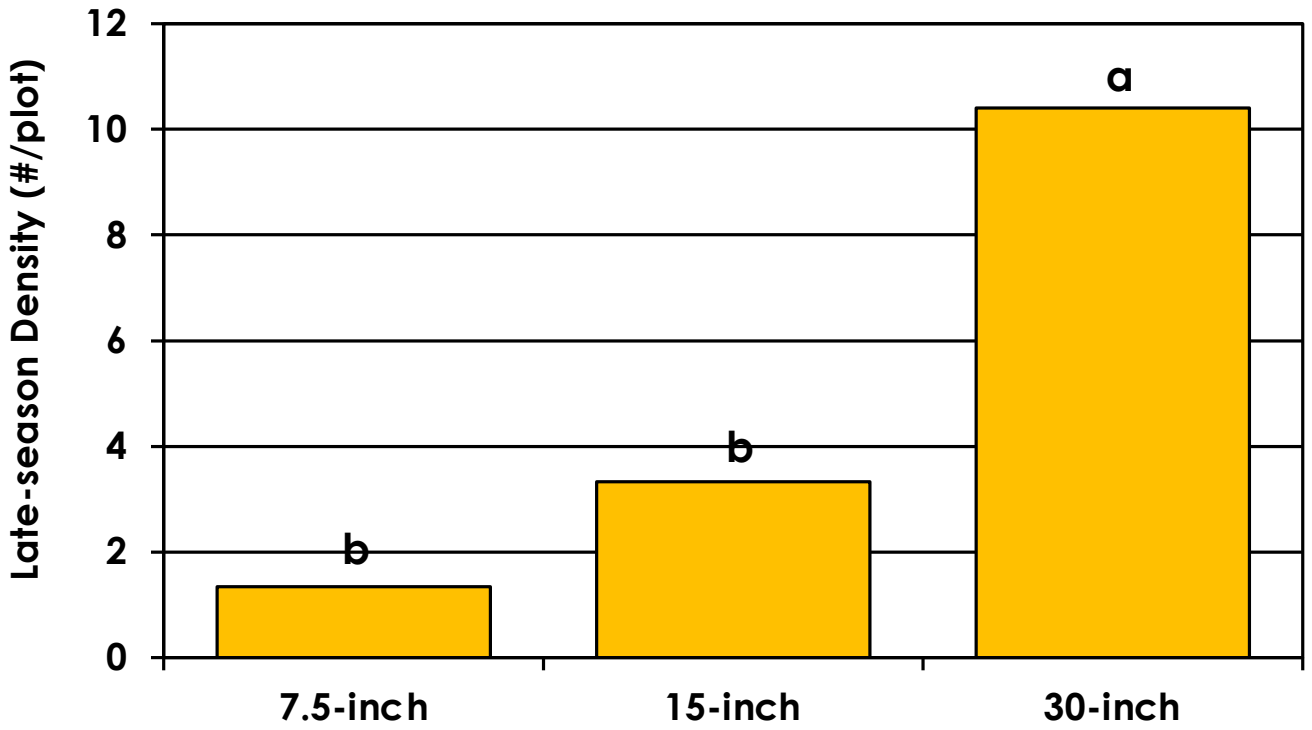
Planting Green???

- Study conducted across 19 site-years in 11 states in 2021 and 2022
- Terminating cereal rye 2 weeks before planting resulted in a 16% reduction in pigweed density compared with no-till.
- Delaying cereal rye termination and planting green provided a 44% reduction in pigweed density compared with no-till.

Nunes et al. 2024. Weed Science 72:615-629

Integrated Weed Management: Row Spacing

49% less seed produced

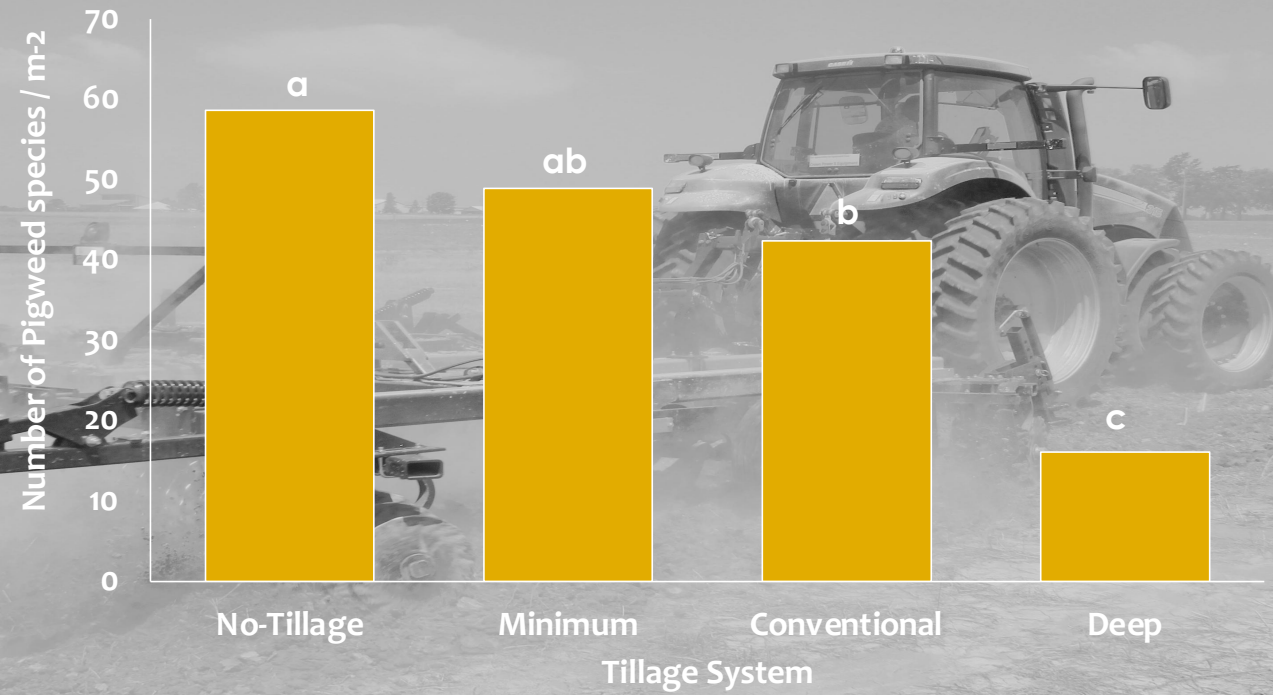


*Results summarized across herbicide programs, tillage types, and planting populations.

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

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

Integrated Weed Management: Tillage



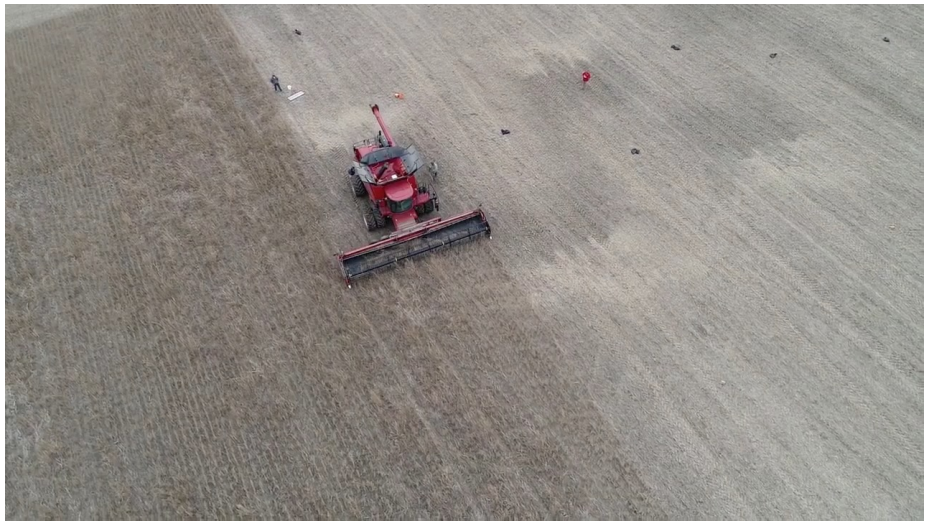
*Results summarized across 10 site-years in AR, IL, MO, OH, and TN.

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

Farmer, JA, KW Bradley, et al. (2017) Weed Technology 31:10-20

Integrated Weed Management: Inter-row Cultivation

Integrated Weed Management: Harvest Weed Seed Control



MISSOURI SOYBEANS

Winans, T, R Massey, H Schreier, M Bish, KW Bradley (2023) Harvest weed seed control in soybean with an impact mill. Weed Technol. 37:113:122

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