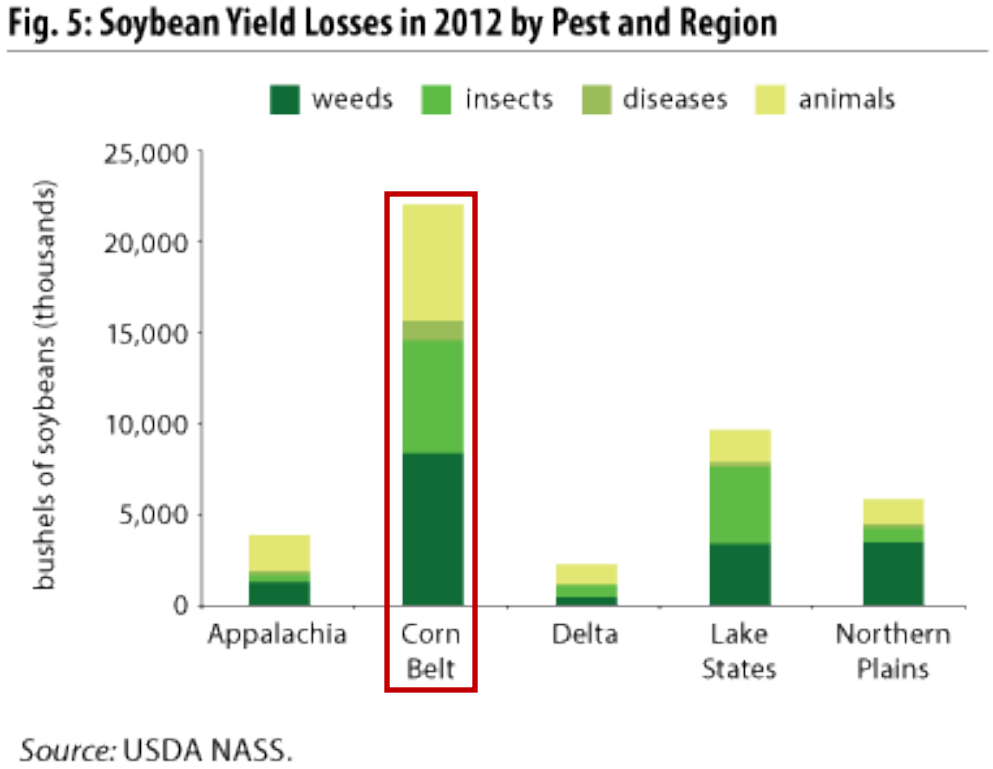
Battling Herbicide-Resistant Weeds with Cover Crops

Alyssa Essman

Weed control

- Up to 80% yield loss when uncontrolled
- Cause of up to 39% yield loss in soybean in the Midwest
- More than insects, diseases, & animals combined

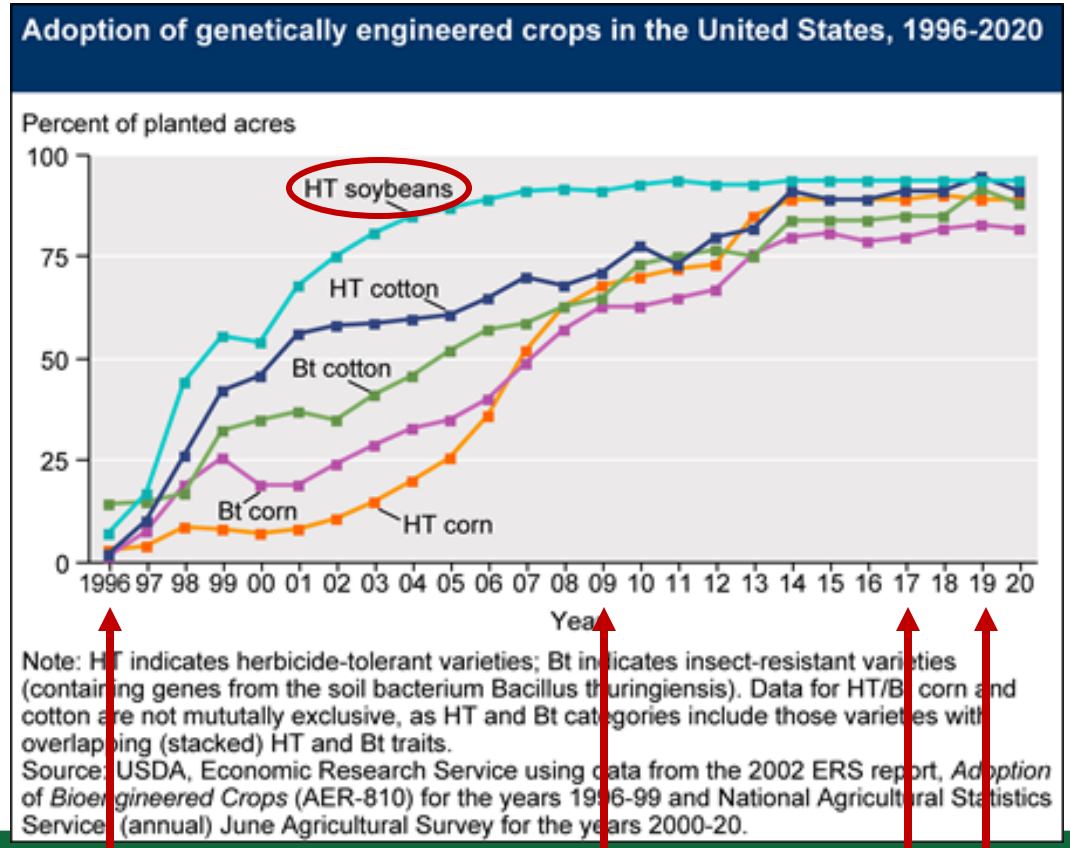


Oerke and Dehne 2004; USDA-NASS 2014

The Big Five

The most common & troublesome weeds in Ohio

How have we addressed this in soybean production?



RR LL RR2Xtend Enlist

Stacked traits…
same herbicides

What's the result of repeated use of the same herbicide sites-of-action, applied multiple times a year over many years?

What's the result of repeated use of the same herbicide sites-of-action, applied multiple times a year, over many years?

HERBICIDE RESISTANCE

Herbicide Resistance

Repeated use of same herbicide

Selection pressure

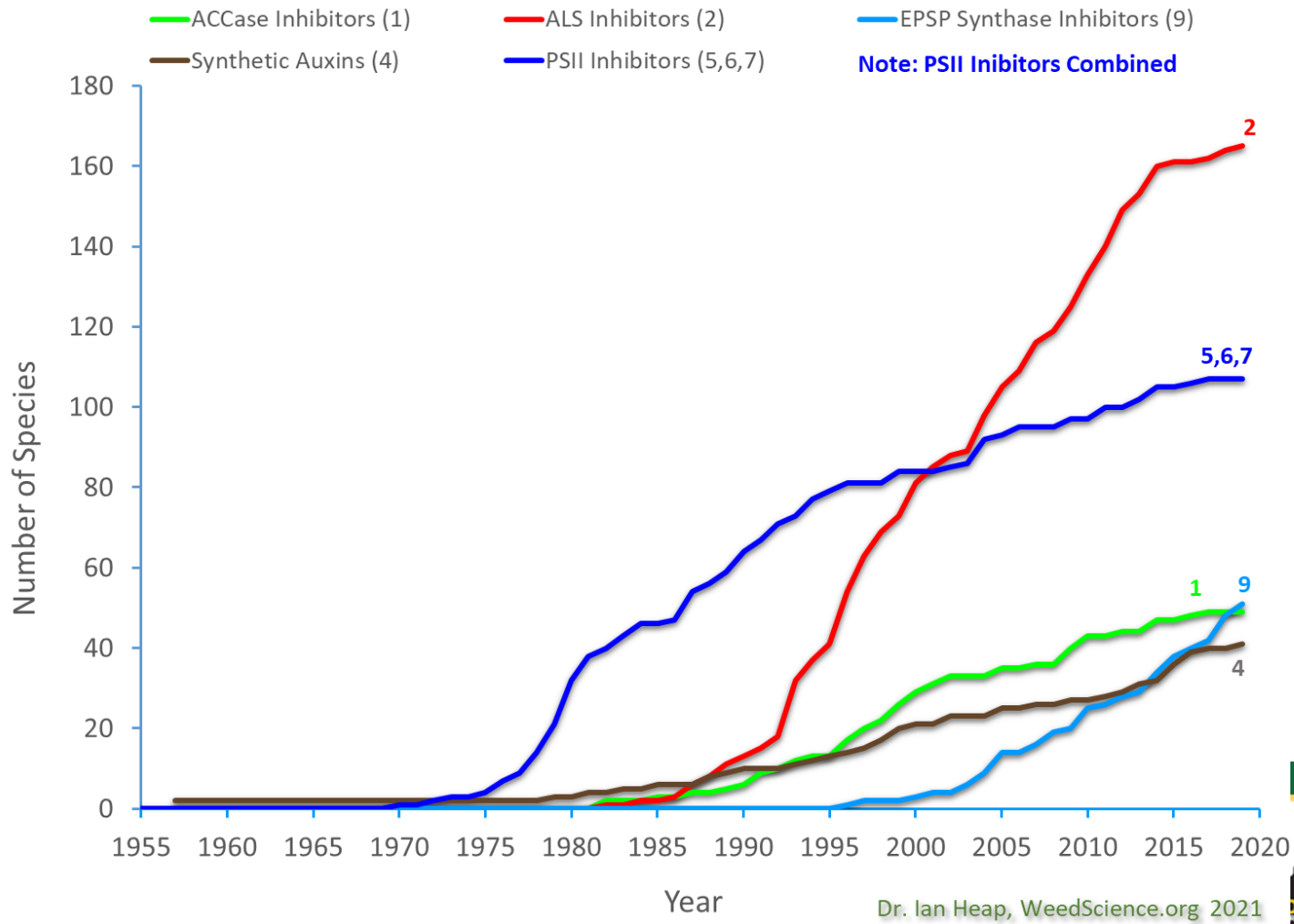
Lack of crop rotation

Narrows herbicide options

Limited sites of action (SOA)

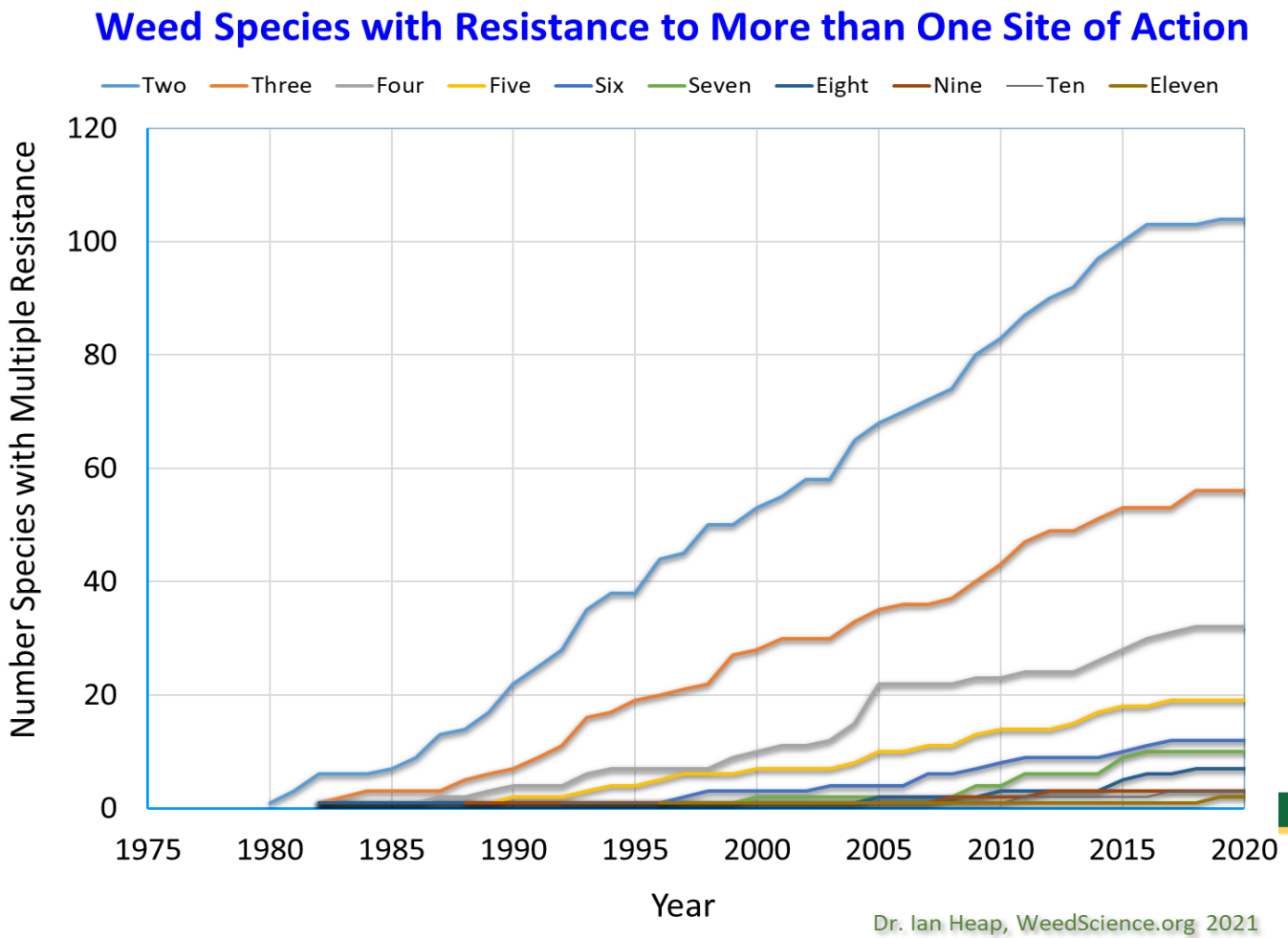
Reduced rates

Number of Herbicide Resistant Weeds by SOA



Dr. Ian Heap, WeedScience.org 2021

Weed Species with Resistance to More Than One SOA



Dr. Ian Heap, WeedScience.org 2021

Herbicide Resistance in Ohio

Species	Common Name	Site of Action
Chenopodium album	Common lambsquarters	2, 5
Daucus carota	Wild carrot	4
Amaranthus tuberculatus/rudis	**Tall waterhemp**	**2, 9**
Amaranthus powellii	Powell amaranth	2
Ambrosia artemisiifolia	**Common ragweed**	**2, 2 & 9, 2 & 14**
Ambrosia trifida	**Giant ragweed**	**2, 9, 2 & 9**
Xanthium strumarium	Common cocklebur	2
Sorghum bicolor	Shattercane	2
Conyza canadensis	**Horseweed**	**2, 9, 2 & 9**
Amaranthus hybridus/quitensis	Smooth Pigweed	2
Amaranthus palmeri	**Palmer amaranth**	**9, 14**

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Sorghum bicolor	Shattercane	2
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Amaranthus palmeri	**Palmer amaranth**	**9, 14**

Dealing with Herbicide Resistance

Proactive vs *reactive*

How do we combat the current situation and prevent future instances of resistance?

Integrated pest management

“Many small hammers”

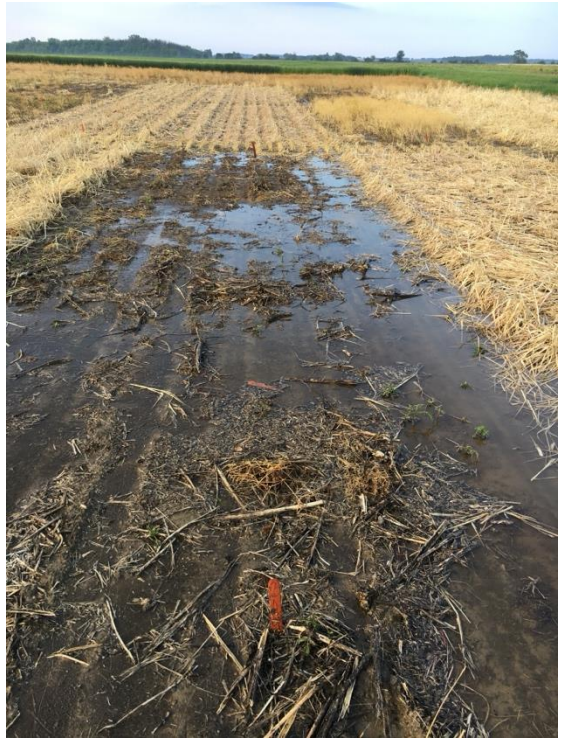
Biological control
Cultural controls
Mechanical controls
Chemical control

Cover crops

One of many small hammers needed in fighting herbicide resistant weeds

Cover crop benefits

- Reduce erosion
- Build organic matter
- Decrease nutrient losses
- Improve infiltration
- Increase soil biodiversity
- Habitat for beneficial insects & fungi
- **Suppress weeds**



How cover crops suppress weeds

Physical suppression

Mulch layer hinders germination & growth

Competition

Lights, nutrients, water

Allelopathy

Chemical compounds inhibit germination & growth

Termination

Spraying, mowing, tilling cover crop

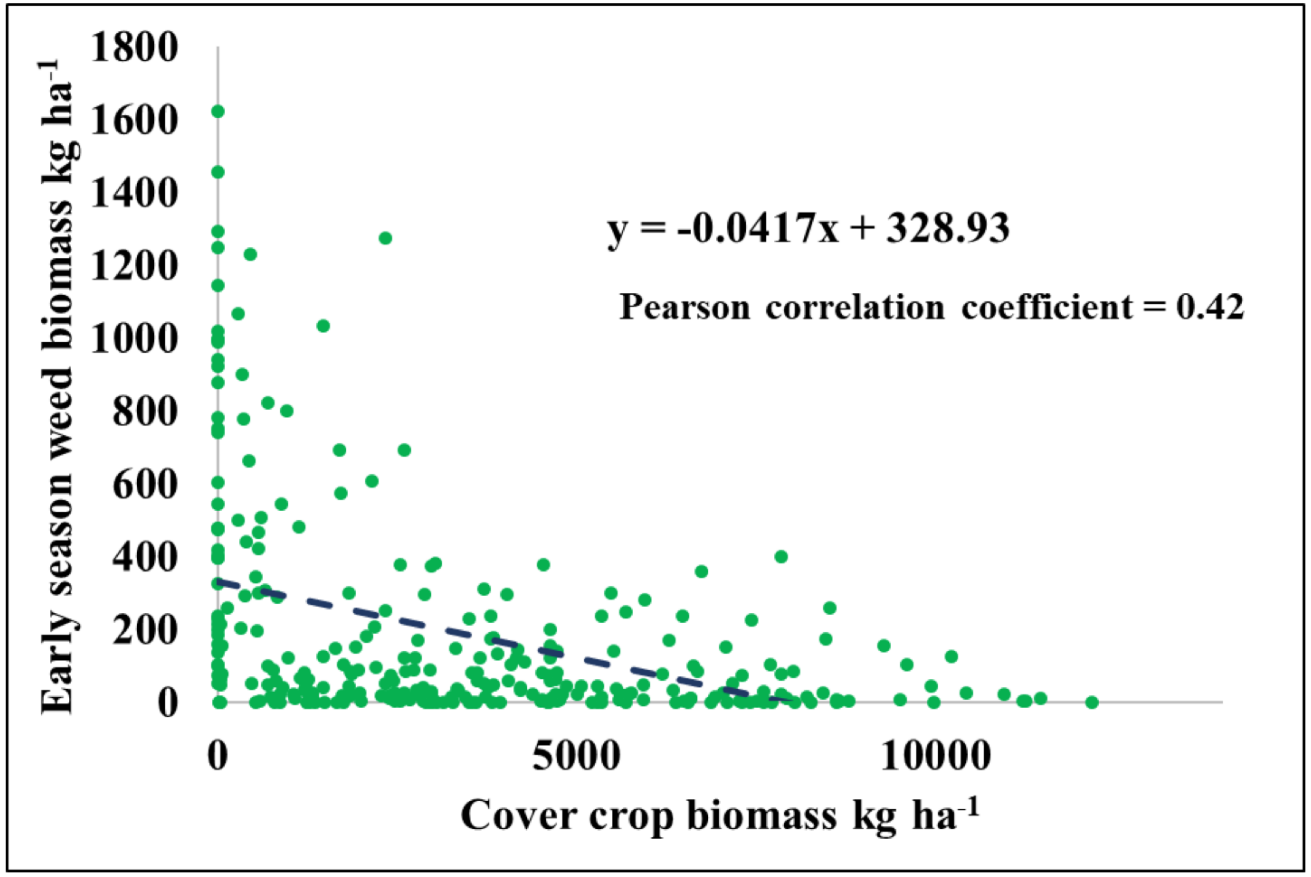
Alter seed environment

Soil moisture, temperature, light, pests

How cover crops suppress weeds

Two main drivers

Biomass (lb/A)



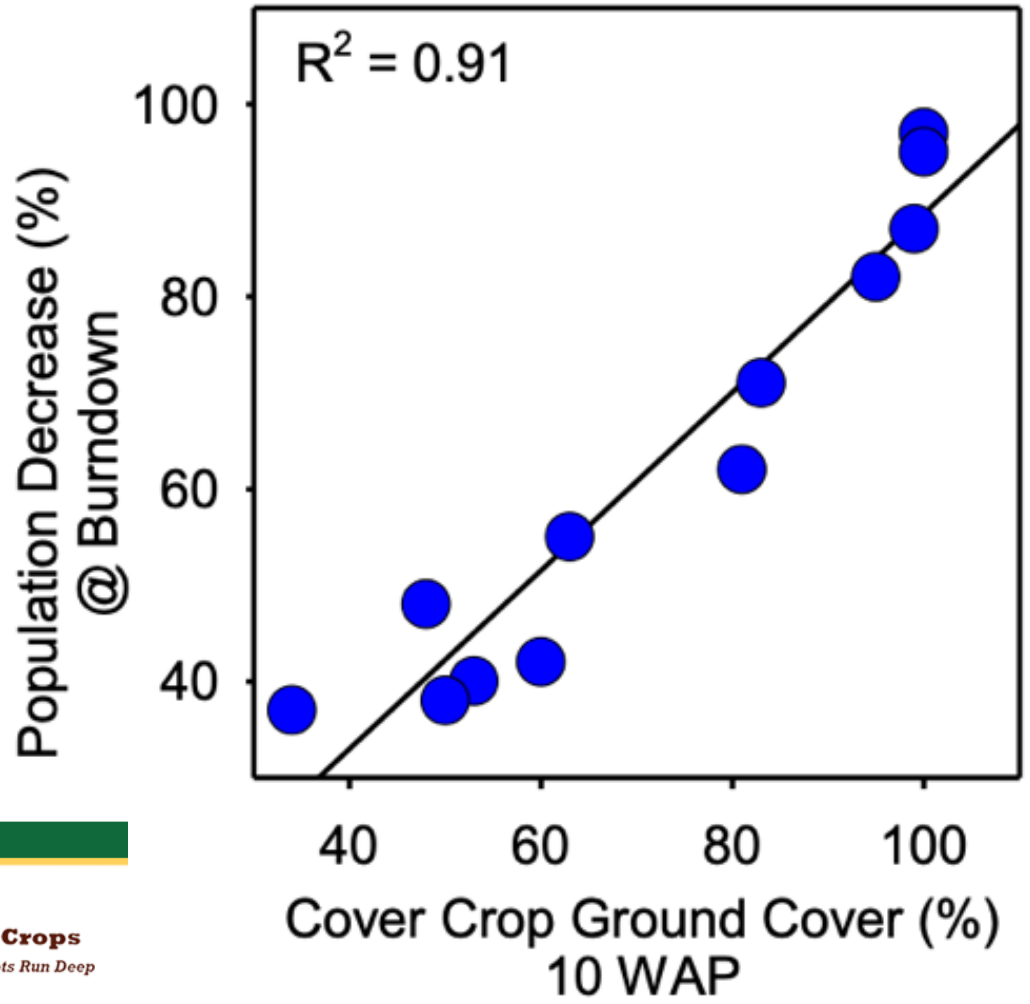
Hodgskiss et al. 2021

How cover crops suppress weeds

Two main drivers

Biomass (lb/A)

Ground cover (%)



Wallace et al. 2019

How cover crops suppress weeds

Reduction in number and size of weeds

Herbicide-resistance management

Lower weed density = less exposed to herbicides

Smaller weeds = longer window of control

Potential to reduce herbicide inputs

No cover crop vs. cereal rye

Hodgskiss et al. 2020; Wallace et al. 2019

Management factors

Species selection

Establishment

Planting date
Planting method
Seeding rate

Termination

Method
Timing

Carryover

Species selection

First consider goals

Species selection will depend on goals

What are your priorities?

Prevent soil erosion
Conserve soil moisture
Protect nearby waterways
Enhance soil health
Cut fertilizer costs
Reduce the need for herbicides




Species selection for weed control

For weed control, cereal rye is the gold standard

Cereal rye

Cold hardy
Flexible plant window
Inexpensive
Quick growing
Biomass

Studies show rye to be key contributor to weed suppression even in species mixes

Establishment

Planting date

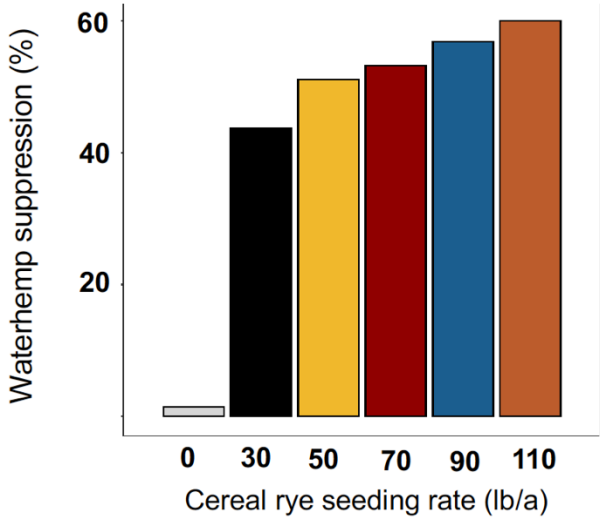
Species dependent
Before vs after harvest
Greater effect on fall emerging weeds

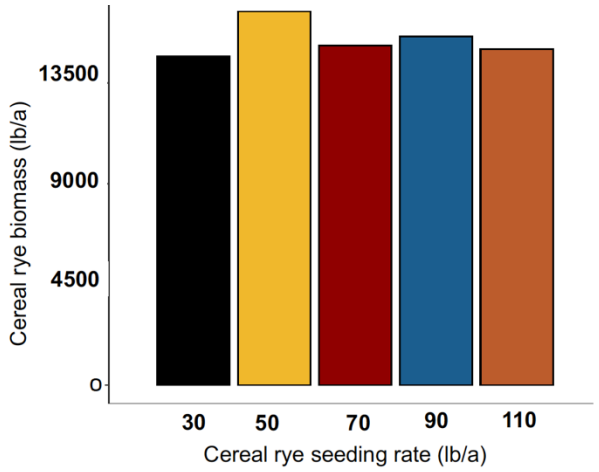
Planting method

Drilling vs broadcast

Seeding rate

Depends on planting method
For rye, little impact on weed suppression





Bish et al. 2021

Termination

Considerations for planning termination method and timing

Cover crop species
Growth stage
Weather
Cover cropping goals

Requires a balance

Growing the cover long enough to maximize benefits
Terminating in time to prevent potential penalties to the following cash crop

Termination method

Natural

Use of winter killed cover crops

Chemical

Herbicides

Mechanical

Tillage, mowing, roller-crimping

Termination of rye

Generally easy to kill
Glyphosate up to 18 inches

Base rate: 0.75 lb. ae/A
Increase the rate on tall rye or in cool conditions
Possible antagonism with residual herbicides

Roller-crimper after pollen shed

Termination timing
Greatest impact on biomass production

Later termination = greater biomass
Inconsistent effect on weed control

Hodgskiss et al. 2021

Before crop planting

Historically recommended

After crop planting

“Planting green”

Herbicide carryover

- Soybean herbicides that tend to be most injurious: fomesafen, pyroxasulfone, imazethapyr, acetochlor and sulfentrazone.
- Corn herbicides that tend to be most injurious: topramezone, mesotrione, clopyralid, isoxaflutole, pyroxasulfone and nicosulfuron.
- Residual herbicides that control grass weeds can hinder the establishment of grass cover crop species
- Broadleaf cover crop species tend to be most affected by groups 2 (ALS inhibitors), 5 (photosystem II inhibitors), 14 (PPO inhibitors) and 27 (HPPD inhibitors) herbicides

Environmental factors

GDD

Cover crop growth, time of weed emergence

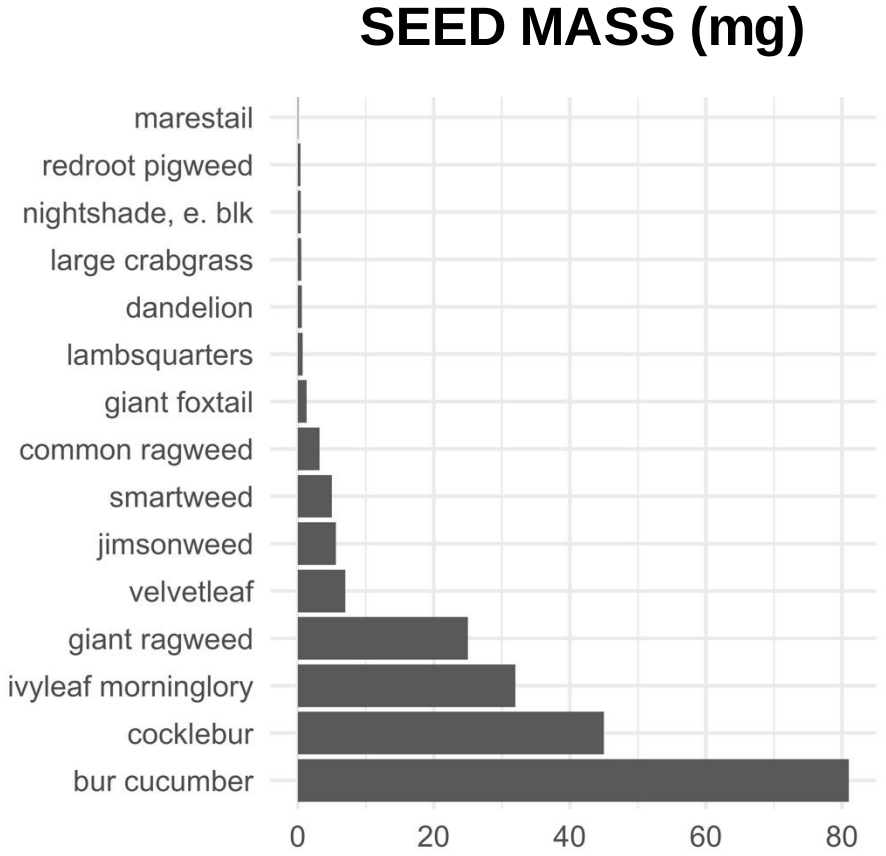
Weather patterns

Cover crop growth, field operations

Soil fertility

Weed species

Life cycle, seed characteristics, emergence patterns



Wallace 2020

Cover Cropping Trends

Shorter-season cash crop varieties

Cover crop drills chasing combines

Interseeding (drill, high-boys, aerial)

Cover crop mixtures (grasses, legumes, mustards)

Variable termination timings

Termination Timing

Management factors that influence cover crop biomass accumulation

Cover crop planting date

Cover crop seeding rate

Cover crop termination date

Greatest effect

Termination Timing

Greatest impact on biomass production

Later termination = greater biomass

Inconsistent effect on weed control

Before crop planting

Historically recommended

After crop planting

“Planting green”

Hodgskiss 2021

Planting Green

Termination of cover crops after cash crop planting

Increases biomass
Can increase weed suppression
Potentially better planting conditions
Can be harder to terminate
Variable effect on soybean yield

Termination Timing

Growers have been experimenting with **planting green** in an attempt to maximize weed suppression and potentially reduce herbicide inputs

These termination systems need to be evaluated for effects on weed control and yield

Planting Green Treatments

Determine the effects of

1. Rye seeding rate (0, 50, and 100 kg ha^{-1})
2. Rye management program (preplant, post plant, and delayed)
3. Residual herbicide use (flumioxazin + chlorimuron ethyl or none)

Rye Management Programs

Field operation	Preplant	Post plant	Delayed
April saflufenacil application	No	No	Yes
Rye termination timing	7 DBP	7 DAP	21 DAP
Late June POST application	Yes	Yes	No

Measurements

Cover crop biomass at each termination timing

Weed population density

Soybean planting through final POST application

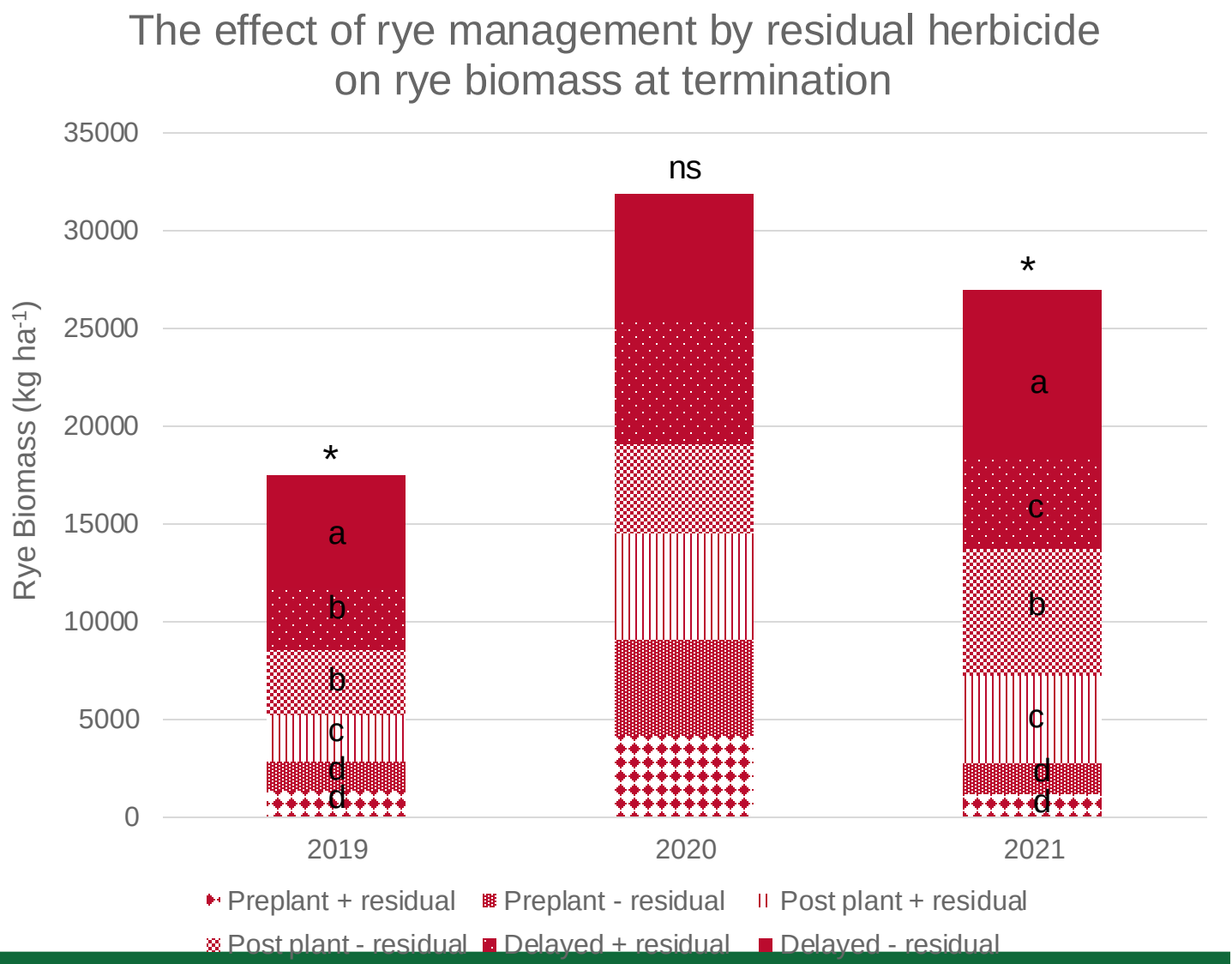
Giant ragweed & giant foxtail

Soybean density & yield

Rye Biomass

Seeding rate – NS

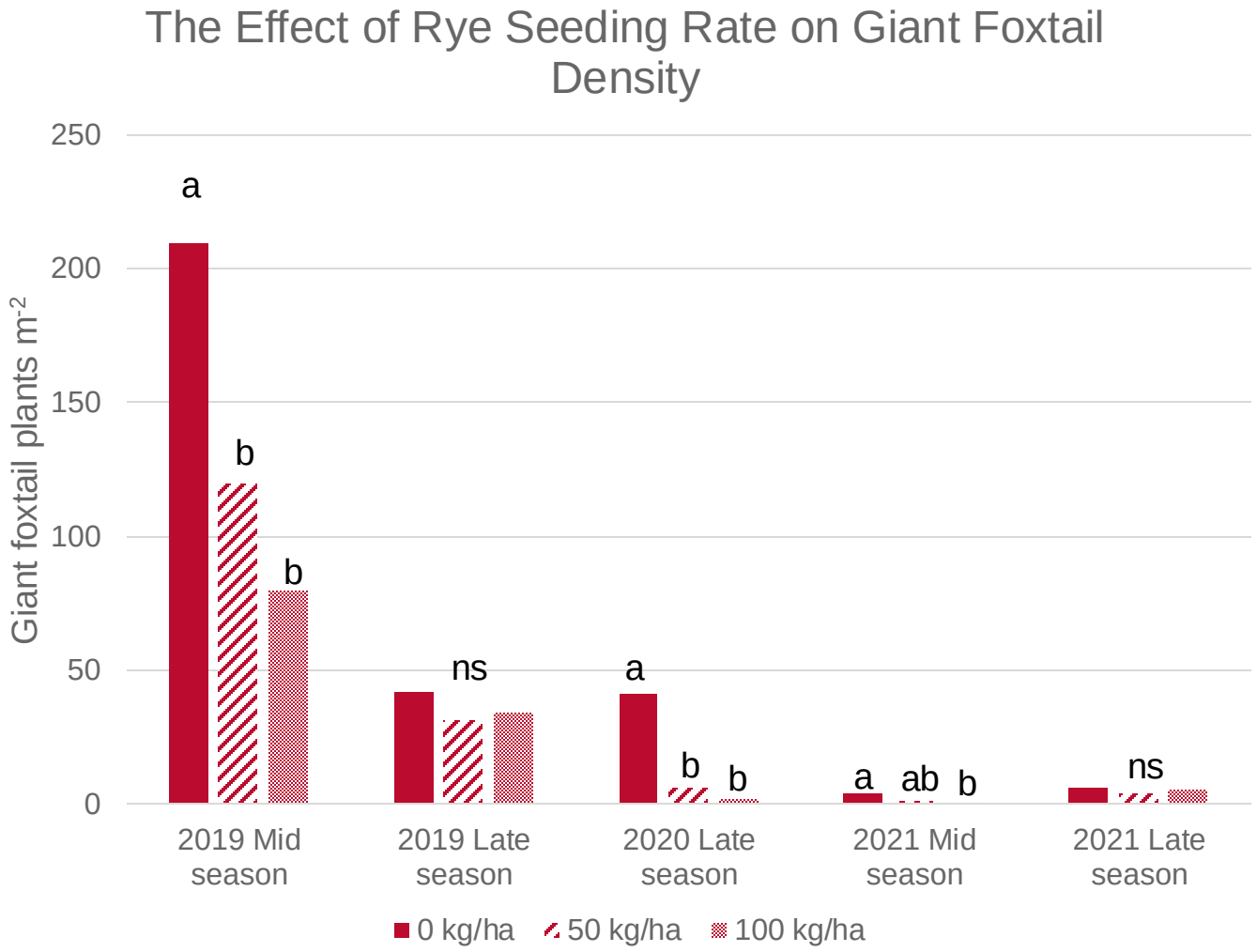
Rye management X residual herbicide interaction



Weed Density

Seeding rate

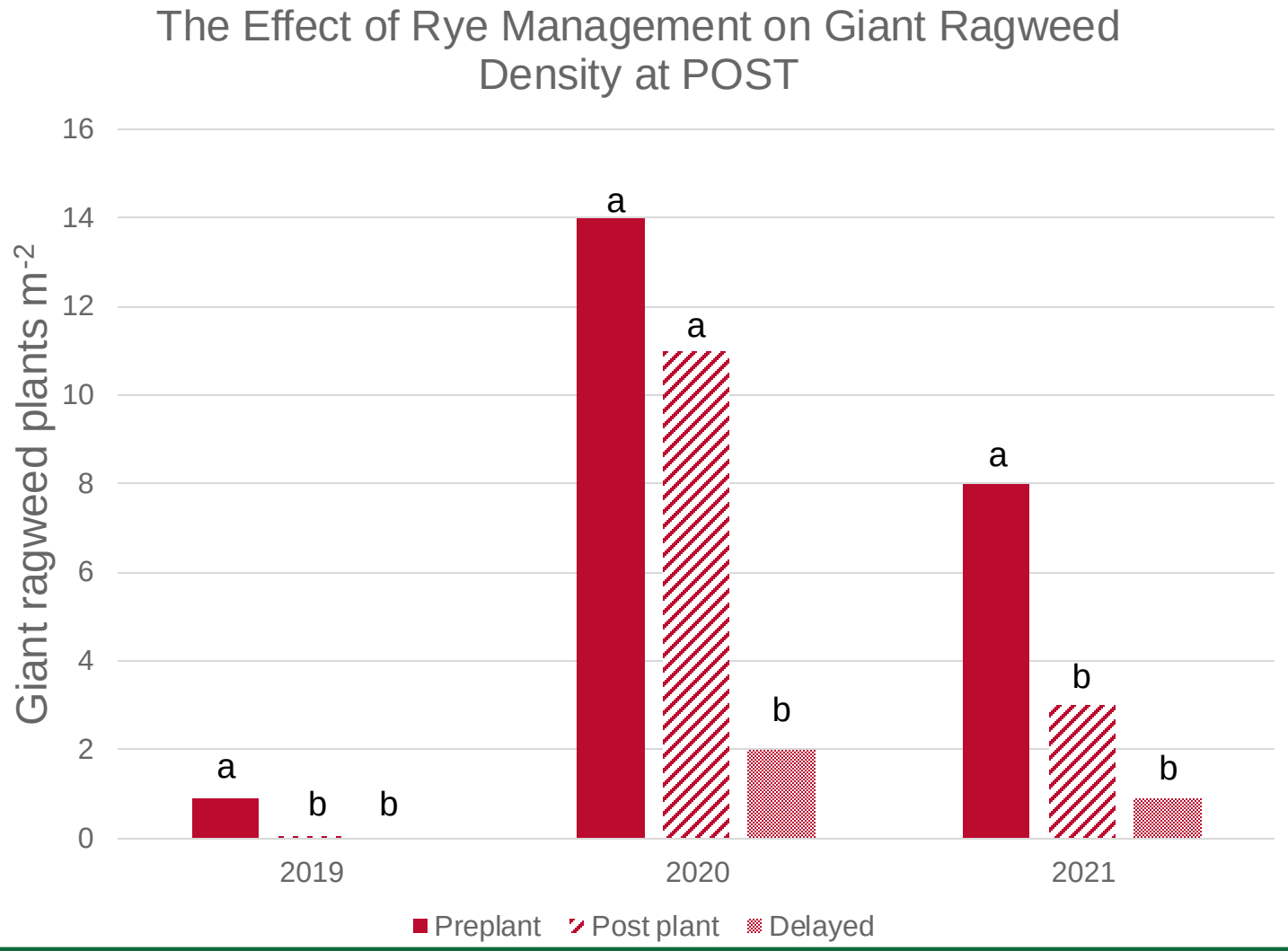
- Giant ragweed NS
- Giant foxtail
- -Density lower in treatments with rye compared to absence



Weed Density

Rye management

- Delayed program generally lowest
- Not always different than post plant



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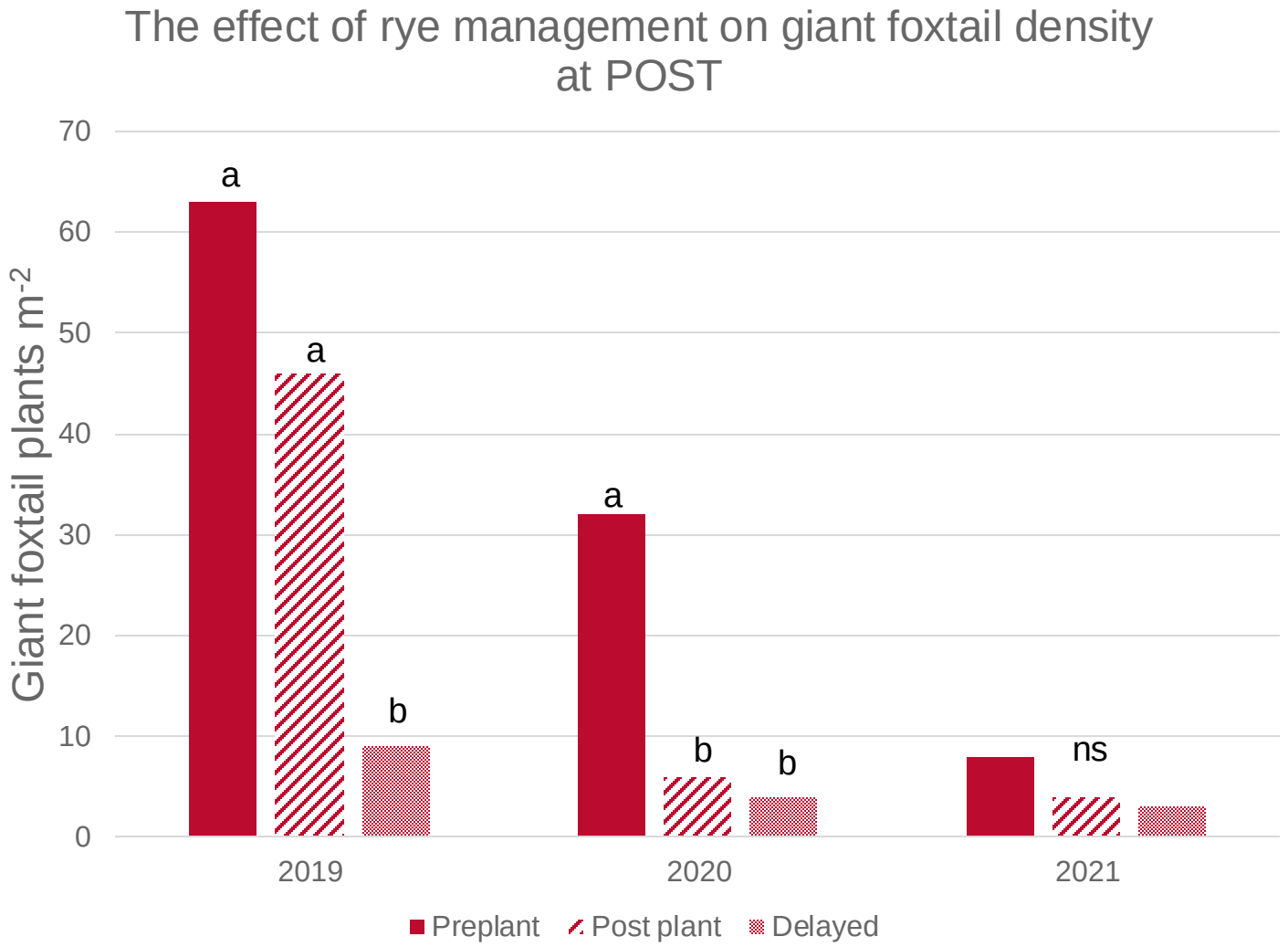
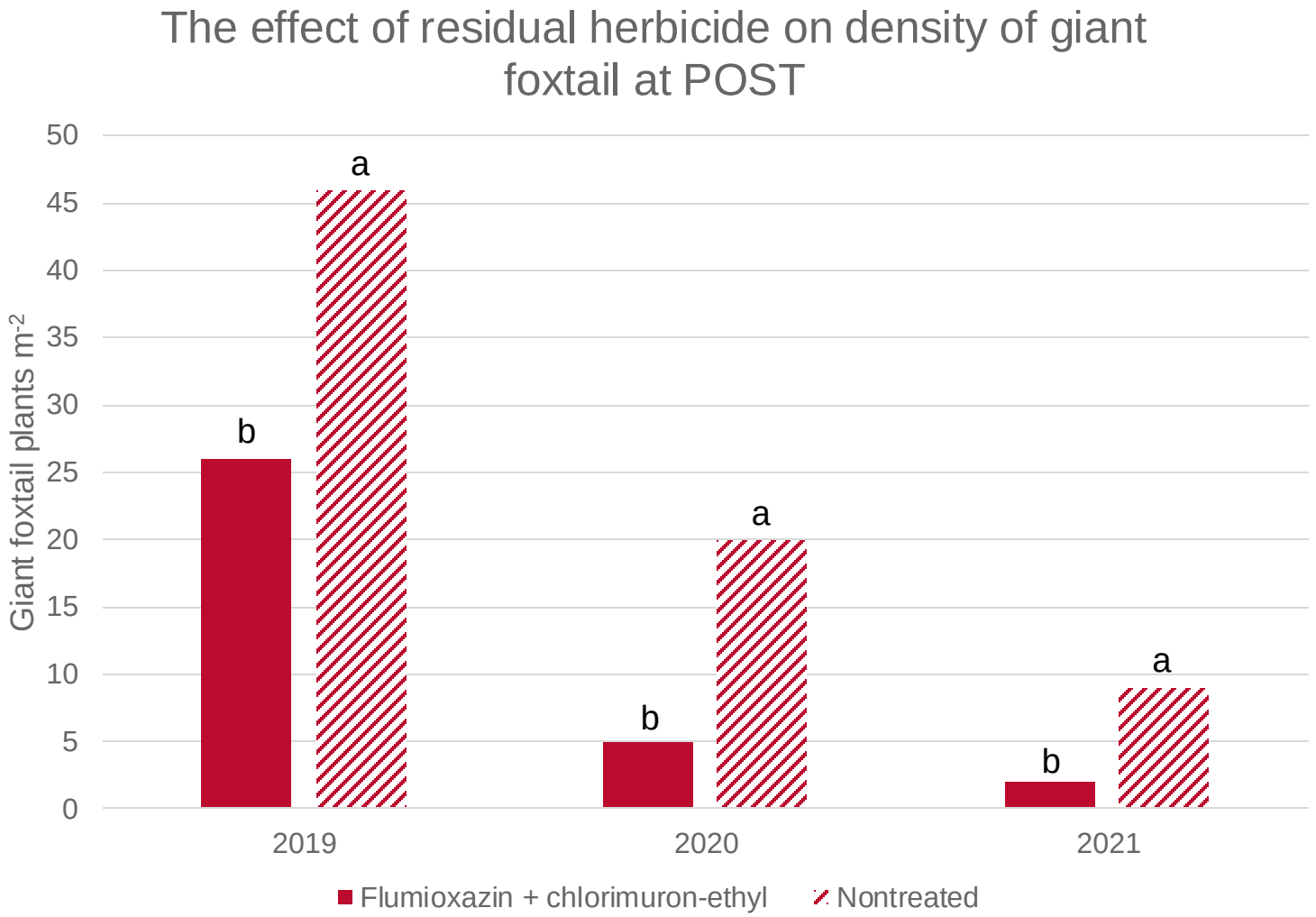


Weed Density

Residual herbicide

- Giant ragweed - NS
- Reduced density of giant foxtail



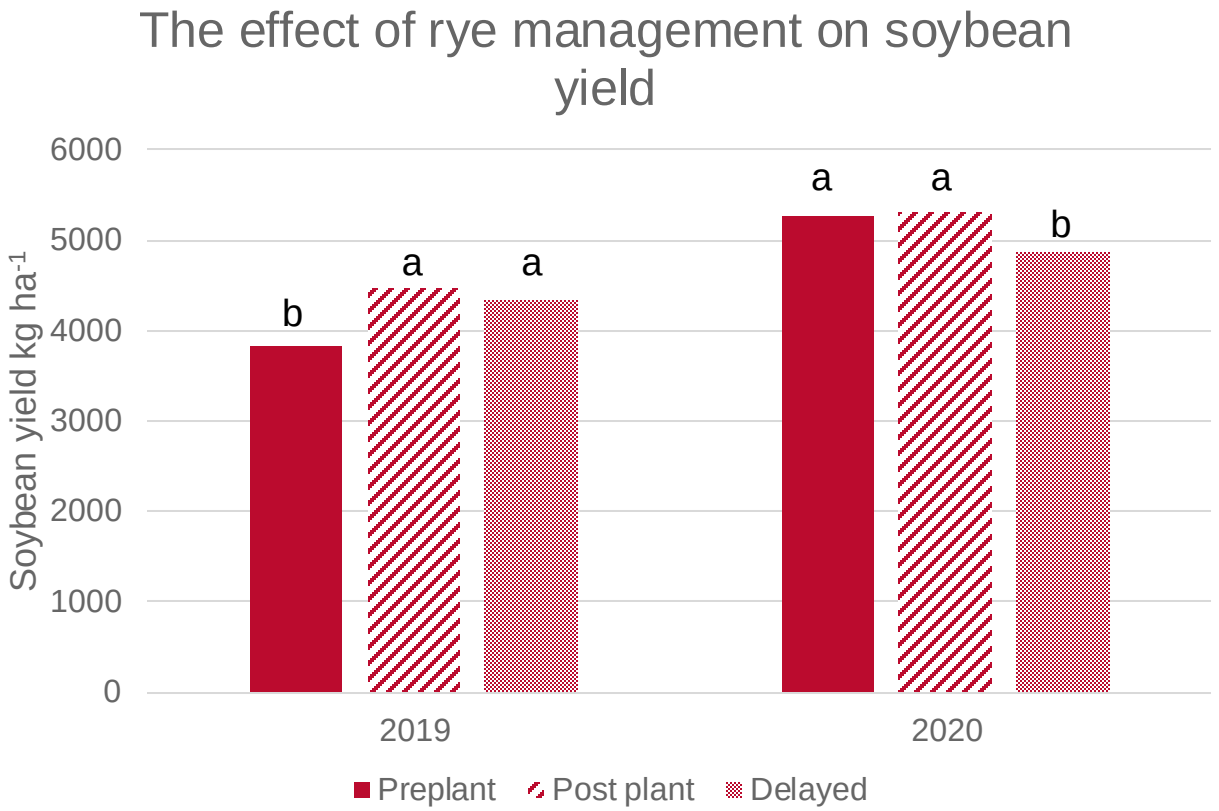
Soybean Yield

Seeding rate

- 2019 highest with rye at either rate
- 2020 – NS
- 2021 – NA (voles)

Management program

- 2019 highest in post plant & delayed
- 2020 lowest in delayed
- 2021 NA



Conclusion

A rye cover crop can reduce weed density

- Still need chemical control

Rye management program and residual herbicides influence biomass production and weed suppressive potential

In Summary

Cover crops

One part of a comprehensive weed management program

IPM and chemical control strategies

Systems approach needed to manage herbicide resistance

Effectiveness depends on management and environmental factors

Most successful when implemented in a tailored plan

Year by year, field by field

The effects of cover cropping compound over time, benefits realized with continued use

A 401k for your fields

Cover crop fact sheet series

Cover Crops for Weed Management: Species Selection

Overview

- Cover crops are grown in rotation with cash crops during periods when a field would otherwise be fallow. Most cover crops in the United States are seeded after cash crop harvest, but they can also be interseeded or broadcast before harvest.
- Most often utilized for their ecological benefit to the cropping system, cover crops can also be grazed or harvested, assuming herbicide rotation restrictions are followed, or grown for seed. Some herbicides allow cover crops to be fed to cattle, while others don't.

Cover Crop Benefits

- Reduce erosion and protect soil from wind and rain.
- Build organic matter and biodiversity in the soil.
- Decrease nutrient loss from leaching and runoff.
- Improve infiltration of water into the soil profile.
- Provide habitat for beneficial insects and fungi.
- Suppress weeds.

Species Selection

- When planning for cover crops in a rotation, it is important to first identify goals of using the cover crop. Species selection will largely depend on the desired outcomes. There is often more than one reason a grower decides to use cover crops. In this case, it's helpful to make a list of priorities and select a species or mix of species that addresses the primary goals of cover cropping.
- The main objectives for cover cropping may vary based on conditions at different field sites, crop rotation sequence, length of growing season and time of year. Although many species have overlapping benefits, a primary objective of fixing nitrogen, for example, may ultimately lead to a different species than aiming to suppress weeds.
- Much like contributing to a 401(k), the benefits of cover crops are compounded and accumulate with increasing value over time.

Weed Suppression

- Weed suppression is one of the most highly reported reasons growers use cover crops, second only to soil health.
- As herbicide-resistant weeds become an increasing concern, cover crops can be an additional tool for implementing integrated pest management strategies. By reducing the size and number of weeds present at the time of the POST application, cover crops can reduce the selection pressure on effective herbicide sites of action, which could delay the development of resistance.
- Cover crops compete with weeds for resources such as light, nutrients and water. Some cover crop species produce high levels of biomass capable of physically suppressing the germination and growth of weeds. Allelopathy, or the effect of phytotoxic compounds created by some cover crops, may play a role in suppressing small-seeded weeds.

Biomass Production

- In general, weed suppression by cover crops increases as biomass levels and ground cover increase. Different species have different biomass production potentials.
- Termination timing is one of the most important factors in determining biomass production. The later a cover crop is terminated, the more biomass is produced.
- Planting a crop just before or after cover termination leads to a reduced rate of biomass degradation.
- Biomass production is also dependent on environmental factors such as soil fertility and soil moisture.

Species Impacts

- Species selection is one of many management strategies that can impact a cover crop's ability to suppress weeds. Some species, such as legumes and brassicas, are most beneficial when planted early after small grain or corn

Figure 1. Soybeans growing through cereal rye residue in Ohio. Photo credit: Alyssa Essman, The Ohio State University.

Continued

Cover Crops for Weed Management: Establishment

Overview

- Timely cover crop establishment allows for the higher biomass production and ground cover necessary to suppress weeds. Weather, primarily temperature and precipitation, though unpredictable, has a major effect on cover crop establishment and growth.
- Planting method and seed quality are two factors a farmer can control that contribute to successful cover crop establishment. Test seed for germination and screen for weed seed to avoid potential contamination.
- Along with planting date and method, seeding rate is an important management factor to consider in cover crop establishment.
- Herbicide carryover from the previous crop can interfere with cover crop establishment. For more information on the effect of herbicide residues, see the Take Action fact sheet "Cover Crops for Weed Management: Herbicide Persistence and Carryover to Cover Crops."

Figures 1 and 2. Cereal rye established in Ohio (left) and a crimson clover stand in Missouri. Photo credit: Dr. Mandy Bish, University of Missouri (right).

Cover Crop Planting Date

- The planting date that will maximize weed suppression is highly dependent on cover crop species.
- Cover crop planting date will also depend on location, crop rotation, tillage system and weather.
- Grass species such as cereal rye and wheat have a relatively flexible planting window and can tolerate planting dates after harvest.
- Species that winter kills, such as forage radish, should be planted in late summer to early fall to produce sufficient biomass and ground cover before the first frost. Brassica and legume species require planting by early fall to establish before winter.
- Brassica and legume species may benefit more from earlier planting dates than winter-hardy grass species, and winter-hardy grass species can dominate late-planted species mixes.
- Earlier planting dates can increase the biomass of fall-planted winter annual cover crops, but this does not always translate to greater weed suppression.

Before Harvest

- Planting methods such as interseeding or aerial seed application (broadcast) allow for establishment prior to cash crop harvest.
- Cover crops can be established before crop canopy closure when sunlight still reaches the soil surface to facilitate germination but should be planted late enough that they don't compete with the cash crop.
- Cover crops can also be established after canopy closure and before harvest. Farmers can broadcast seed into soybeans around leaf drop or into corn nearing maturity.

After Harvest

- Cover crops planted after cash crop harvest can be drilled into no-till ground with cash crop residue, into a prepared seedbed or broadcast on the soil surface.
- Depending on crop rotation, some cover crop species can also be established in early spring or summer. In cool regions, some species (such as red clover) can be frost

Figures 3 and 4. Cereal rye drilled in late September (left) and late October before no-till soybeans in Ohio. Photo credit: Alyssa Essman, The Ohio State University.

Continued

Cover Crops for Weed Management: Termination

Overview

- Terminating, or killing, cover crops using the right methods in the right time frame is important to ensure maximum cash crop yield. Excessive competition from the cover crops can hinder early growth of cash crops and increase risk of yield reduction.
- Cover crops can be terminated before or after cash crop planting, depending on crop rotation and grower preference.
- Cover crop species, growth stage, weather and cover cropping goals should all be considered when planning a termination method and timing. These decisions require a balance between growing the cover long enough to maximize benefits and terminating in time to avoid negatively affecting the following cash crop.

Figure 1. Soybeans growing through cereal rye residue. Photo Credit: Maryhan Anderson, Iowa State University.

- Biomass and ground cover are two main drivers of weed suppression by cover crops. Studies have shown that out of all the management factors, termination timing has the greatest influence on biomass production.
- Delayed termination in the spring can increase cover crop biomass production. Planting the cash crop as close to termination as possible can increase cover crop residue persistence by slowing the rate of degradation. The high carbon-to-nitrogen ratios found in the vegetation of cereal crops such as rye can also increase longevity of residue, which can lengthen the window of weed suppression.

Termination Method

Natural

- The use of winter-killed cover crop species can simplify spring management. Summer- and fall-planted cover crops that die naturally over the winter in much of the Midwest include oats, sorghum-sudangrass, tillage and oilseed radish, turnips and winter peas (if planted before September in cool regions). On occasion, some species, such as radish and winter pea, can survive the winter. It is best to have a management plan for termination of these species in the event of survival.
- The use of species that winter-kill provides a shorter period of soil protection, especially if planted after a late harvest. Weed suppression is also primarily limited to winter annual weed species. For this reason, species that winter-kill are often included in some sort of species mixture with grass or legume species that overwinter in order to provide weed suppression and soil protection in the spring.

Mechanical

- Mechanical means of cover crop termination include tillage, rolling/crimping and mowing.
- Tillage from field cultivators can terminate a cover crop by burying the plant residue and cutting the roots. Vertical tillage is a less effective termination option, and many types of tillage may require multiple passes to achieve the desired level of control. Strip-tillage can be performed to break up residue and increase soil warming in the row. Termination via tillage speeds up the breakdown of residue and incorporates it into the soil. In general, this method of termination can negate some of the benefits associated with using cover crops.

Continued

Cover Crops for Weed Management: Herbicide Persistence and Carryover to Cover Crops

Overview

- Herbicide-resistant weed issues have been escalating in agronomic crop production across the U.S. As a result, farmers have increased their reliance on residual herbicide programs. These programs often include layered residuals with multiple sites of action.
- In addition to residual herbicides, cover crops can be a tool for suppressing herbicide-resistant weeds. Cover crops have the potential to reduce the density and size of weeds early in the growing season, improving herbicide effectiveness and reducing selection for resistance.[1]
- Successful establishment is one of the most important factors in cover crop adoption. However, herbicide carryover from the previous summer cash crop to susceptible cover crop species can hinder establishment and cause reductions in biomass, variable stands or death of the cover crop.
- Any residual herbicide program used before fall cover crop establishment should be taken into account when selecting cover crop species.
- More research is needed to fully understand the response of interseeded cover crops (planted in late June through July into cash crops) to residual herbicides.
- When unsure of how an herbicide will interact with a species in a particular climate and location, a field bioassay can help determine possible outcomes. Collect soil from areas that were treated and areas that were not treated in August. Plant desired cover crop species in the soil, water frequently, and monitor emergence and growth of the cover crop species. This should indicate whether or not fall seeding will be successful. Be sure to do this early enough in the fall so the outcomes are known before seeding cover crops in questionable fields later in the fall.

Figure 1. Horseweed collected from plots with no cereal rye (left) and with cereal rye. Photo credit: Wyatt Peterson, Purdue University.[2]

Carryover Risk Factors: External

Herbicide Properties

- Herbicides with higher water solubility are more likely to be moved by water deeper into the soil profile following precipitation or irrigation, thus reducing concentration at the soil surface.
- The inherent characteristics of an herbicide can also influence its ability to be degraded to inactive metabolites by microbial activity or chemical reactions.[3]
- Herbicide half-life, or the amount of time it takes for 50% of the active ingredient to degrade, can be useful when deciding which herbicide within a family to use.
- The product with the lowest half-life may reduce damage to susceptible cover crop species, especially within site of action groups 2 (ALS inhibitors), 14 (PPO inhibitors), 15 (very long-chain fatty acid synthesis inhibitors) and 27 (HPPD inhibitors). More research is needed to better understand cover crop sensitivities to specific herbicide active ingredients.

Soil Characteristics

- Risk of herbicide carryover tends to increase with increasing organic matter and clay content of soils. As a result, higher cation exchange capacity (CEC) levels are also associated with increased carryover.
- Low or high soil pH can increase or decrease herbicide persistence depending on herbicide characteristics.
- Soil microbial activity is one of the most important factors in herbicide breakdown and is highest in warm, fertile, aerated soils with relatively neutral pH.[3]

Weather

- Warmer temperatures and increased rainfall lead to increased rates of herbicide degradation.[3]
- Conversely, herbicide carryover tends to increase under drought conditions or when temperatures are cooler than normal in the months following application.

These factors vary from year to year and field to field and are all interrelated, which can make herbicide persistence difficult to predict. For this reason, half-lives — while helpful for comparing the relative persistence of herbicides — are estimates rather than reliable predictors.

Continued

https://iwilltakeaction.com/news/cover-crop-fact-sheet-series

Where to find weed management information

- OSU Weeds Website - https://u.osu.edu/osuweeds/
- C.O.R.N newsletter - http://corn.osu.edu/
- Social media - X, Facebook, YouTube, Instagram, TikTok
- War Against Weeds podcast - https://waragainstweeds.libsyn.com
- Take Action website - https://iwilltakeaction.com/weeds/
- Crop Protection Network - https://cropprotectionnetwork.org
- GROW Network - https://growiwm.org/weeds/

Website

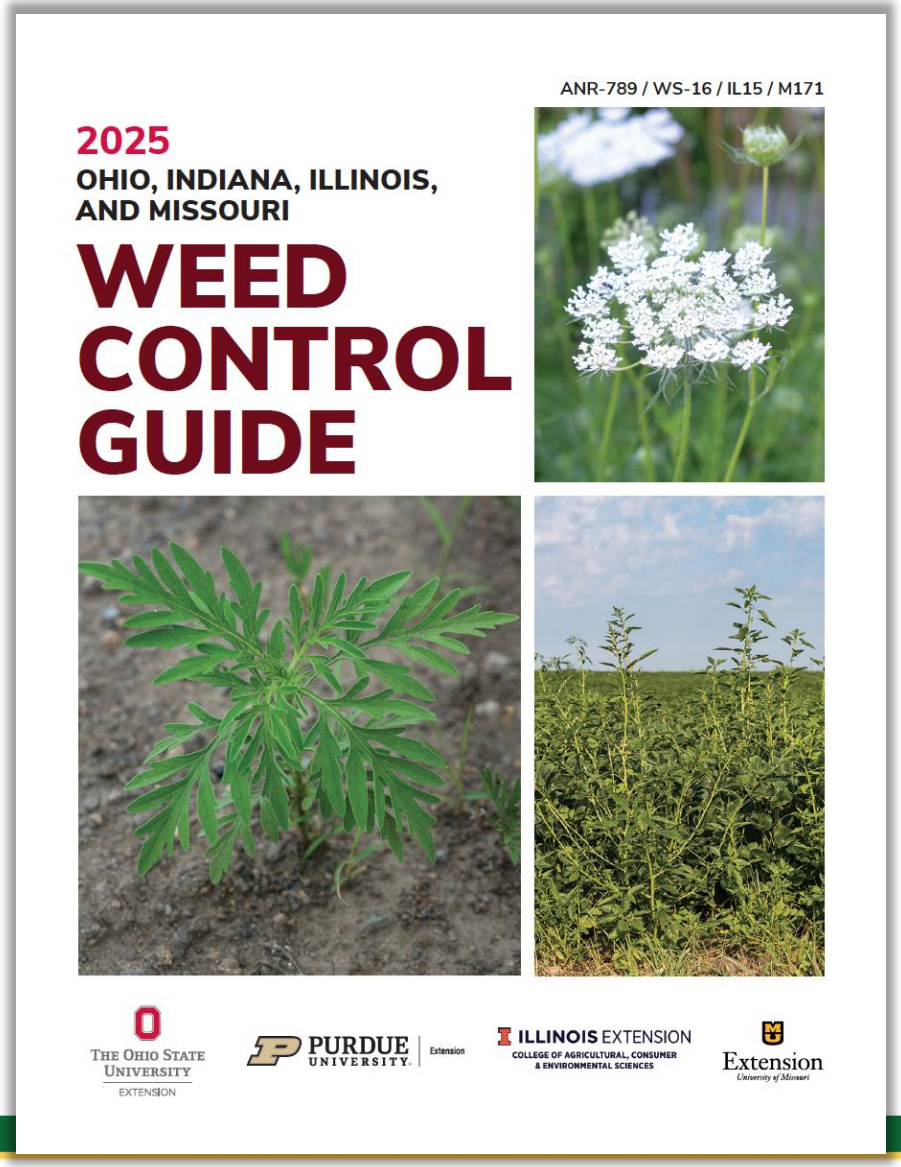
2025 Weed Control Guide

Ohio, Indiana, Illinois, and Missouri

OSU Extension eStore:
https://extensionpubs.osu.edu
OSU Pub Office: 1-800-678-6114

or

Local OSU Extension Office






Questions?

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