Impact of Cover Crops on Soil Residual Herbicides

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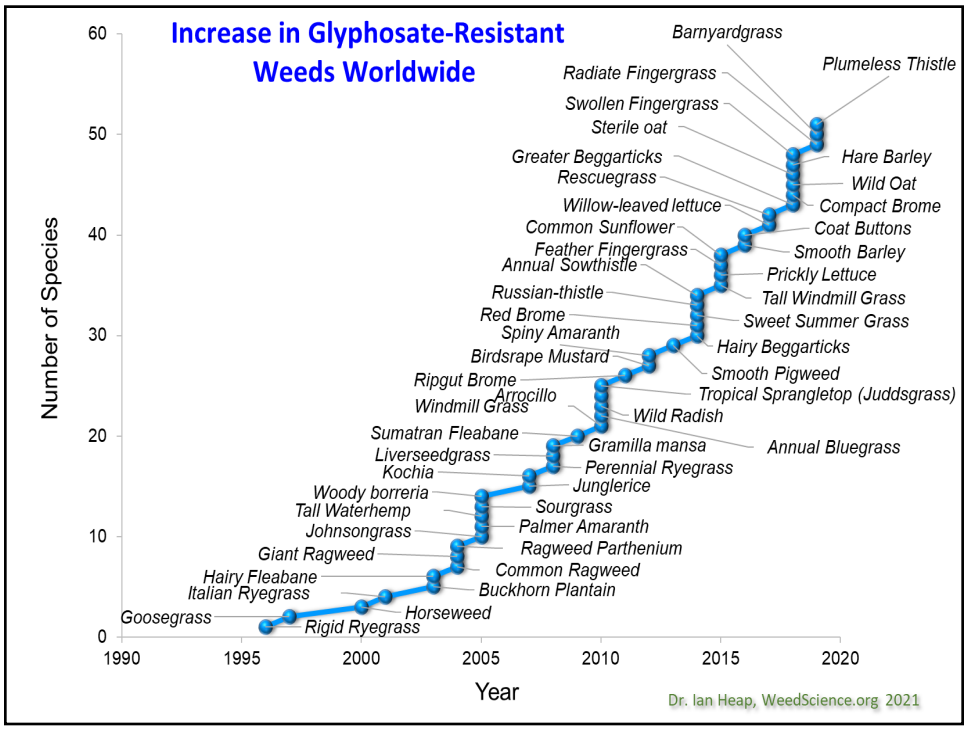
Increase in Glyphosate-Resistant Weeds Worldwide
Number of Species
Year
Barnyardgrass
Plumeless Thistle
Radiate Fingergrass
Swollen Fingergrass
Sterile oat
Greater Beggarticks
Hare Barley
Rescuegrass
Wild Oat
Willow-leaved lettuce
Compact Brome
Common Sunflower
Coat Buttons
Feather Fingergrass
Smooth Barley
Annual Sowthistle
Prickly Lettuce
Russian-thistle
Tall Windmill Grass
Red Brome
Sweet Summer Grass
Spiny Amaranth
Hairy Beggarticks
Birdsrape Mustard
Smooth Pigweed
Ripgut Brome
Tropical Sprangletop (Juddsgrass)
Arrocillo
Windmill Grass
Wild Radish
Sumatran Fleabane
Annual Bluegrass
Gramilla mansa
Liverseedgrass
Perennial Ryegrass
Kochia
Junglerice
Woody borreria
Sourgrass
Tall Waterhemp
Palmer Amaranth
Johnsongrass
Ragweed Parthenium
Giant Ragweed
Common Ragweed
Hairy Fleabane
Buckhorn Plantain
Italian Ryegrass
Horseweed
Goosegrass
Rigid Ryegrass
Dr. Ian Heap, WeedScience.org 2021

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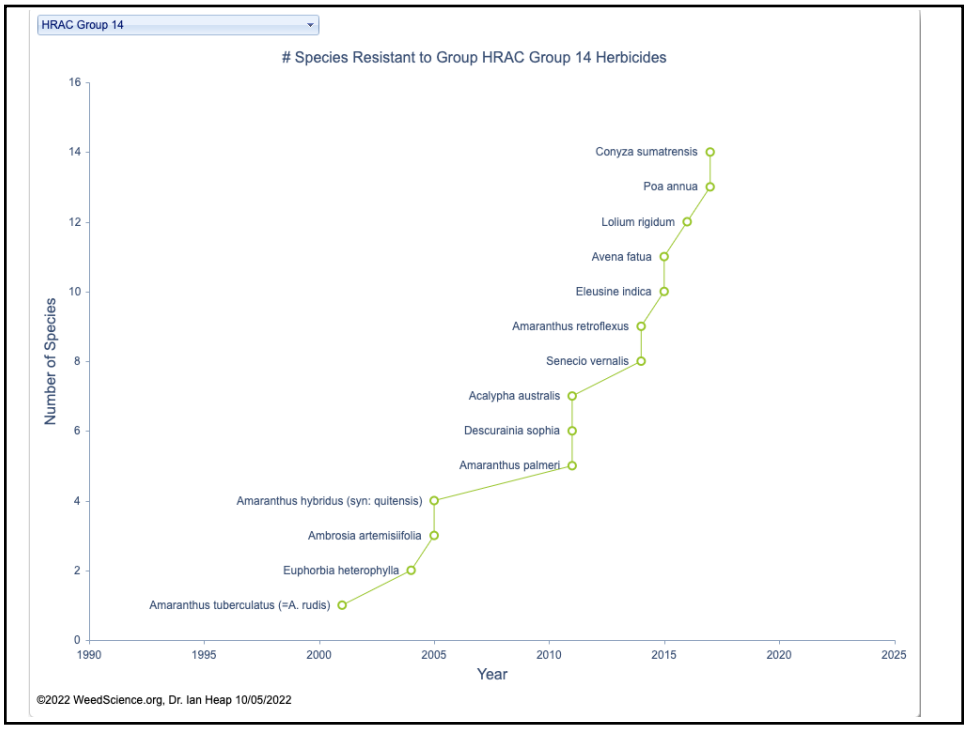
HRAC Group 14
Species Resistant to Group HRAC Group 14 Herbicides
Number of Species
Year
Conyza sumatrensis
Poa annua
Lolium rigidum
Avena fatua
Eleusine indica
Amaranthus retroflexus
Senecio vernalis
Acalypha australis
Descurainia sophia
Amaranthus palmeri
Amaranthus hybridus (syn: quitensis)
Ambrosia artemisiifolia
Euphorbia heterophylla
Amaranthus tuberculatus (=A. rudis)
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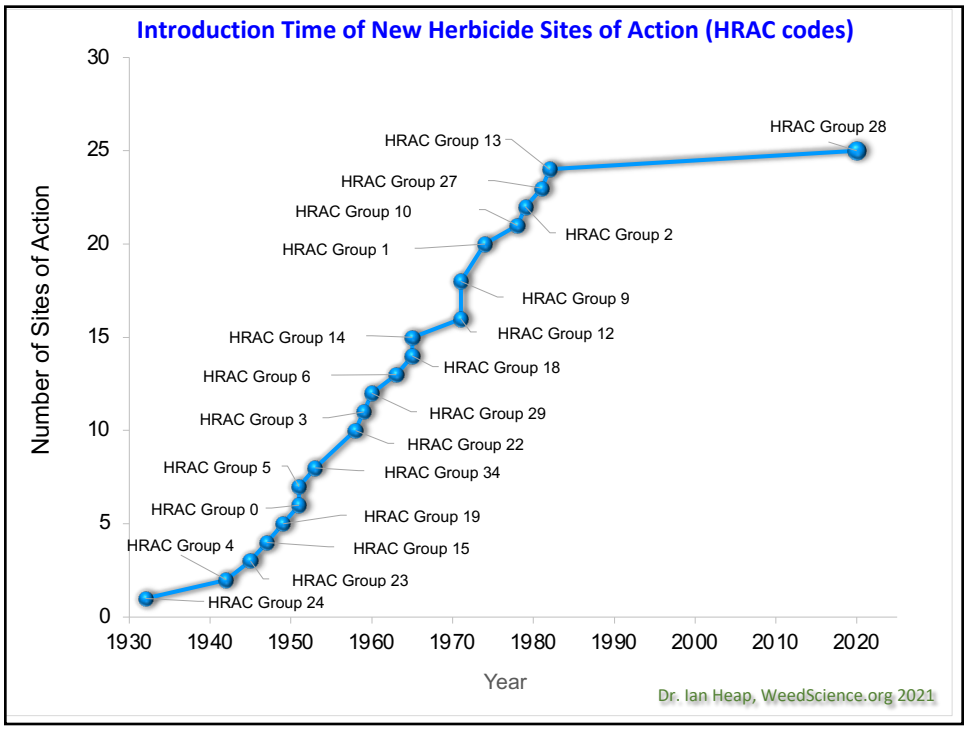

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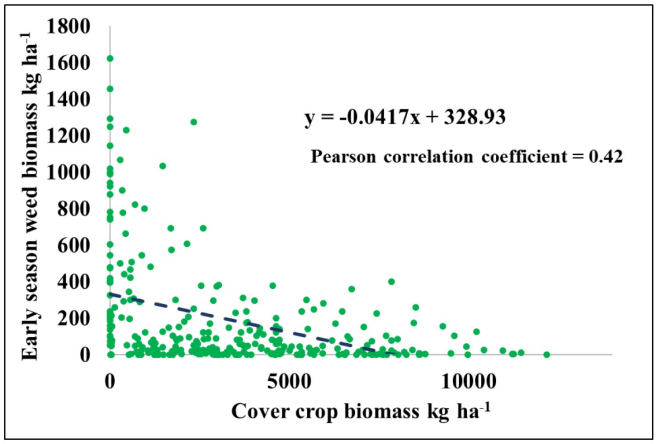

Figure 1. Correlation of early season (April and May) weed biomass by cover crop biomass across three sites in Indiana in 2018 and 2019. Data collected when the termination herbicide treatments were applied. Sites included the Throckmorton Purdue Agricultural Center (TPAC, 8343 US-231, Lafayette, IN 47909), the South East Purdue Agricultural Center (SEPAC, 4425 County Rd 350 N Butlerville, IN 47223), and the Davis Purdue Agriculture Center (DPAC, 6230 N State Rd 1 Farmland, IN 47340-9340).

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Horseweed at Planting – Mid May 2018 - SEPAC

No cover crop Cereal rye

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Horseweed at Planting - Mid May 2018 - SEPAC

No cover crop Cereal rye

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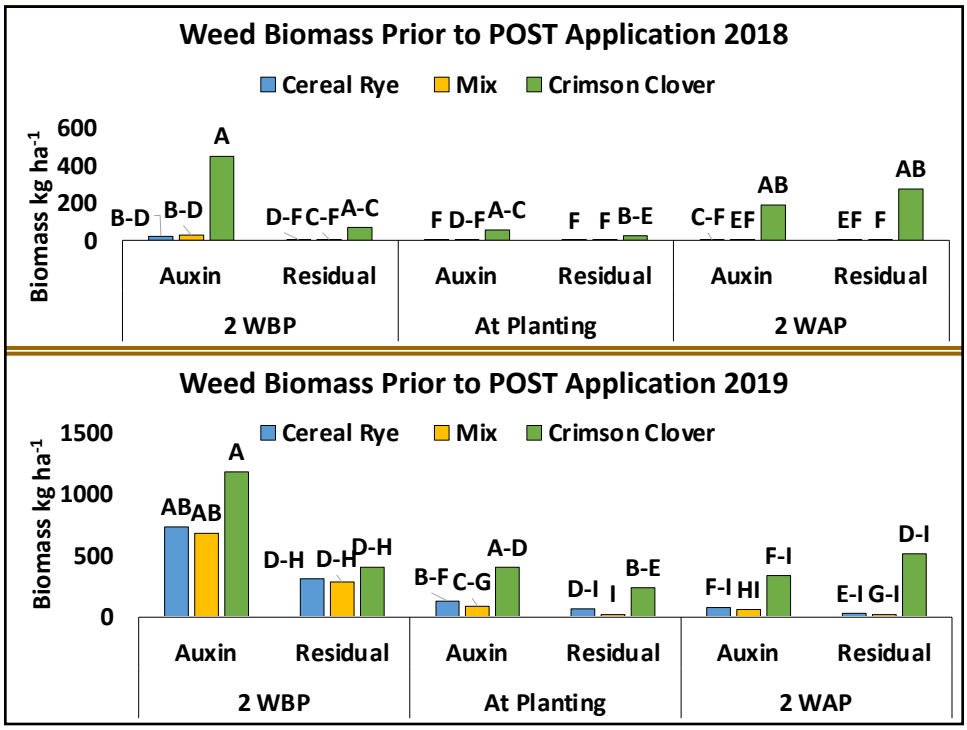

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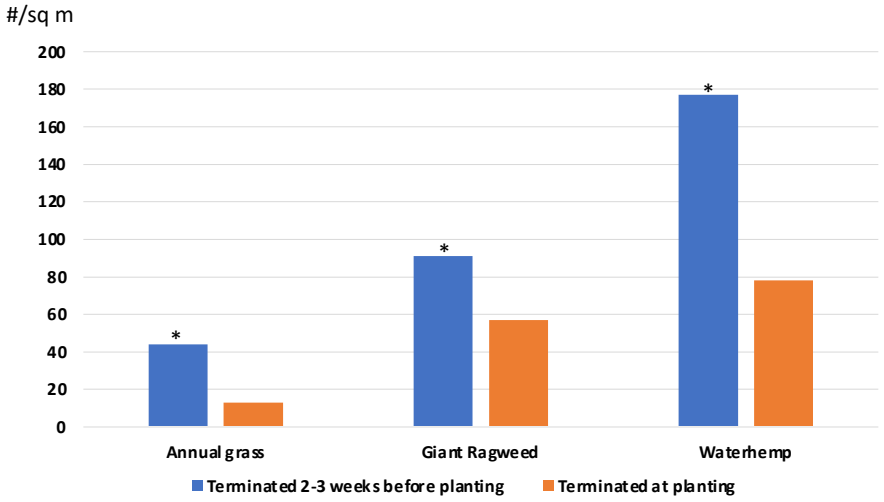
Influence of CC Termination Timing on August Weed Density in the Absence of Residual Herbicides



No residual herbicide used at termination.
Weed density recorded in August and pooled over 4 site yrs (grasses and giant ragweed), and 2 site years (waterhemp).

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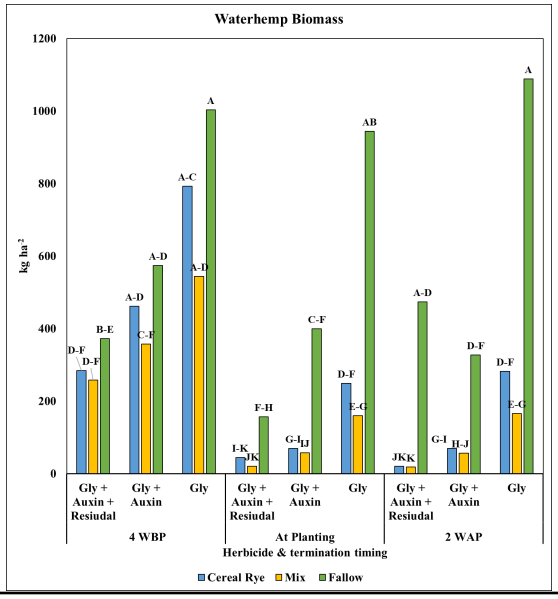
Cover Crops, Residual Herbicides, and Waterhemp Control in August



SEPAC 2018 and 2019

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Cover Crop and Herbicide Interaction on Palmer Amaranth Control

Influence of cover crop and termination strategy on Palmer amaranth density at 28 days after termination.

	Palmer amaranth density	
	June 16, 2014	June 2, 2015
	——— Plants m^{-2} ———	
Annual ryegrass plus residual	2 bc	9 bc
Annual ryegrass without residual	160 a	42 ab
Cereal rye plus residual	9 b	6 c
Cereal rye without residual	31 b	18 bc
None plus residual	1 c	10 bc
None without residual	125 a	100 a
P value	< 0.0001	0.0276

[a] Burndown treatment with flumioxazin: 89 g ai ha^{-1} of flumioxazin plus 1,682 g ae ha^{-1} of glyphosate plus 560 g ae ha^{-1} of 2,4-D; burndown treatment without flumioxazin: 1,682 g ae ha^{-1} of glyphosate plus 560 g ae of 2,4-D.

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Materials & Methods

Herbicides	Termination (TER)	POST Application
No residual applied	glyphosate	glyphosate + dicamba + diflufenzopyr
Late residual applied	glyphosate	glyphosate + dicamba + diflufenzopyr + atrazine + S-metolachlor
Early residual applied	glyphosate + S-metolachlor + atrazine + mesotrione + bicyclopyrone	glyphosate + dicamba + diflufenzopyr
Full residual applied	glyphosate + S-metolachlor + atrazine + mesotrione + bicyclopyrone	glyphosate + dicamba + diflufenzopyr + atrazine + S-metolachlor

Herbicide	Rate (kg ai/ae ha^{-1})
atrazine	1.58
bicyclopyrone	0.04
glyphosate	1.54
mesotrione	0.16
s-metolachlor	1.43

Herbicide	Rate (kg ai/ae ha^{-1})
atrazine	1.82
dicamba	0.14
diflufenzopyr	0.056
glyphosate	1.54
s-metolachlor	0.35

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Materials & Methods

- Summer annual weed biomass collected 3 weeks after planting (WAP) corn
  - 0.25 m^2 square area in front and back of plot
  - Densities recorded for giant ragweed and summer annual (SA) grasses (*Setaria* spp., *Panicum dichotomiflorum, Echinochloa crus-galli*)
- Pre-harvest weed biomass was collected in early October using similar methods
- Weed control ratings (0-100%) at the POST application and in early August

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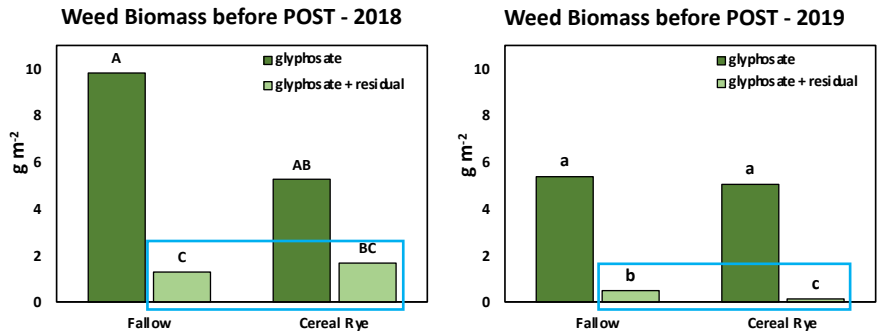
Results – Weed Biomass



2018 – cereal rye biomass 3500 kg ha^{-1} **2019 – cereal rye biomass 6200 kg ha^{-1}**

- Cereal rye did not reduce overall weed biomass in glyphosate-terminated plots
- Weed biomass was lower in cereal rye plots that were terminated with a residual herbicide premix + glyphosate in 2019

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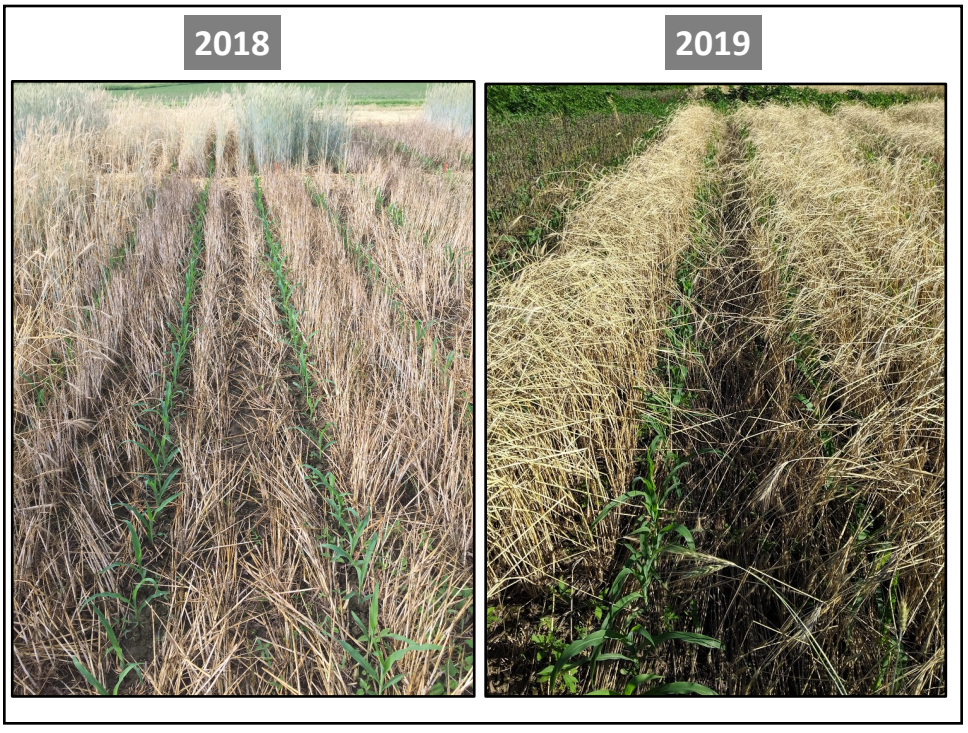

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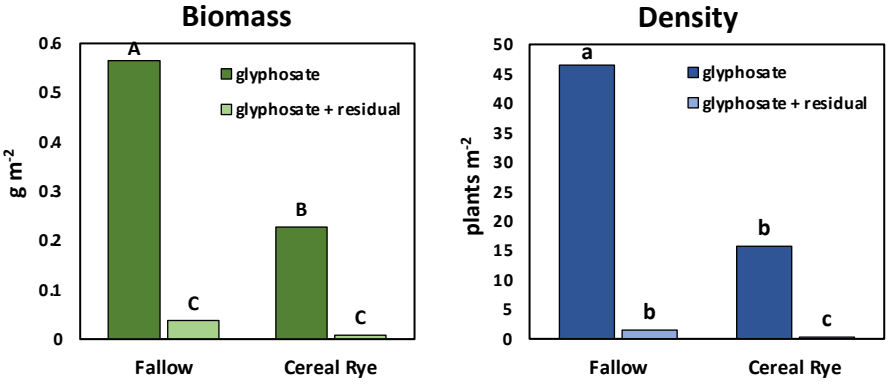
Results – Annual Grass Control in Corn – 6 site years



- Both cereal rye and the residual herbicide premix lowered grass biomass and density
- Cereal rye residue + residual herbicide premix reduced grass density more than all treatments

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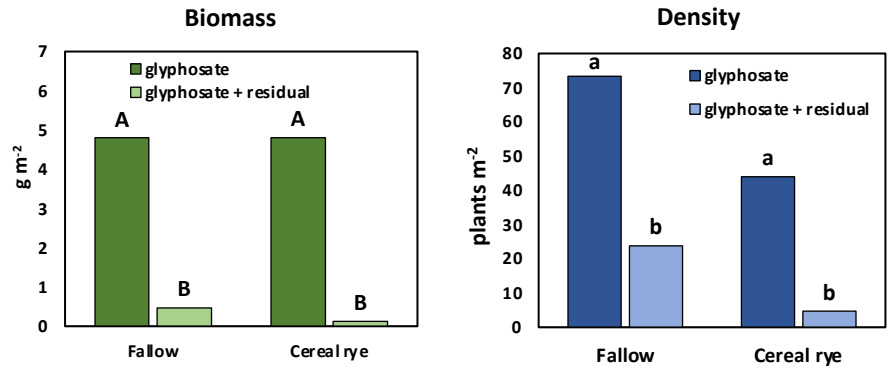
Results – Giant Ragweed Control in Corn – 6 site years



- Giant ragweed biomass and density were similar in cereal rye and fallow treatments
- No impact of rye residue on residual herbicide efficacy

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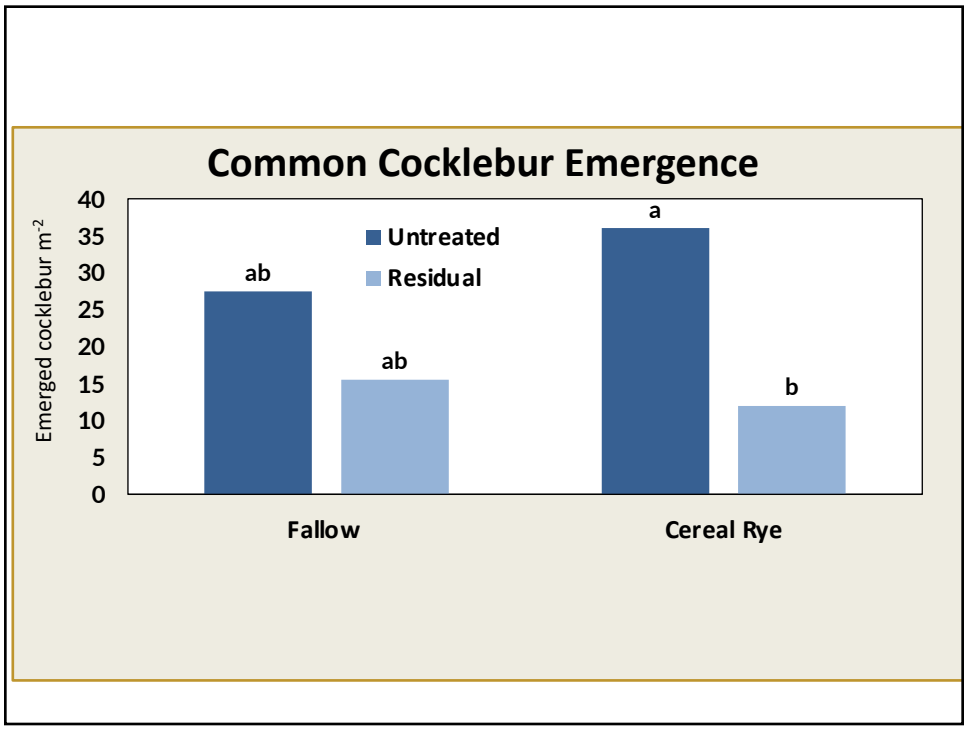
Common Cocklebur Emergence
Emerged cocklebur m-2
40
35
30
25
20
15
10
5
0
Untreated
Residual
ab
ab
a
b
Fallow
Cereal Rye

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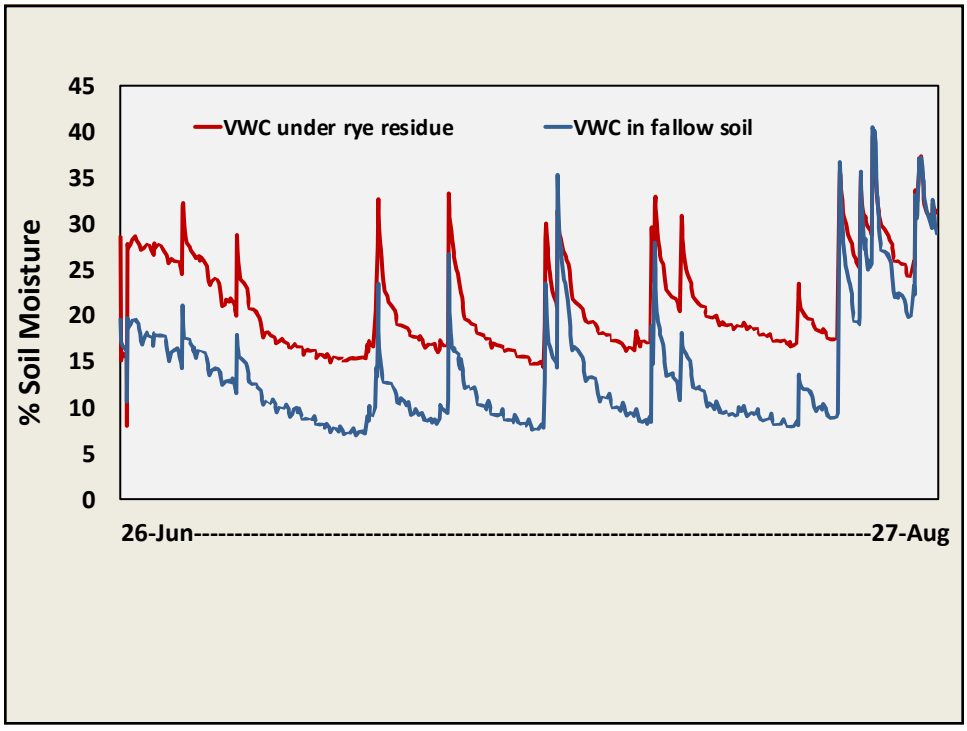
% Soil Moisture
45
40
35
30
25
20
15
10
5
0
VWC under rye residue
VWC in fallow soil
26-Jun----------27-Aug

20

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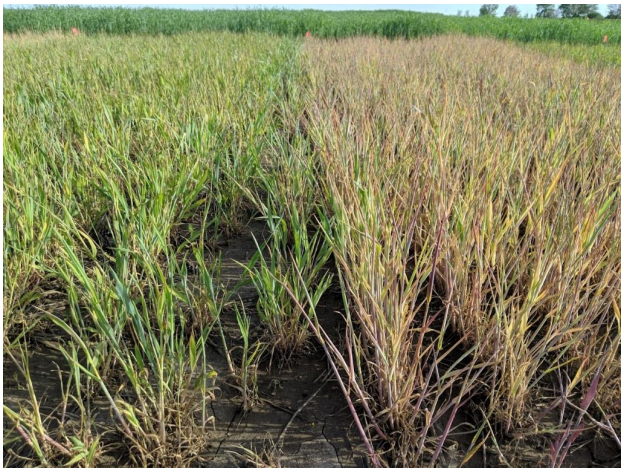
Herbicide antagonism is a real concern with termination in cool weather



Left - Roundup (1 qt/acre) + Acuron (2.5 qt/acre) vs. Right - Roundup (1 qt/acre)

Cereal rye on left eventually died, but much slower than on the right.

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Influence of Cover Crops on Residual Herbicide Degradation

Do claims of ”increased soil biology” result in more rapid herbicide degradation in soil?

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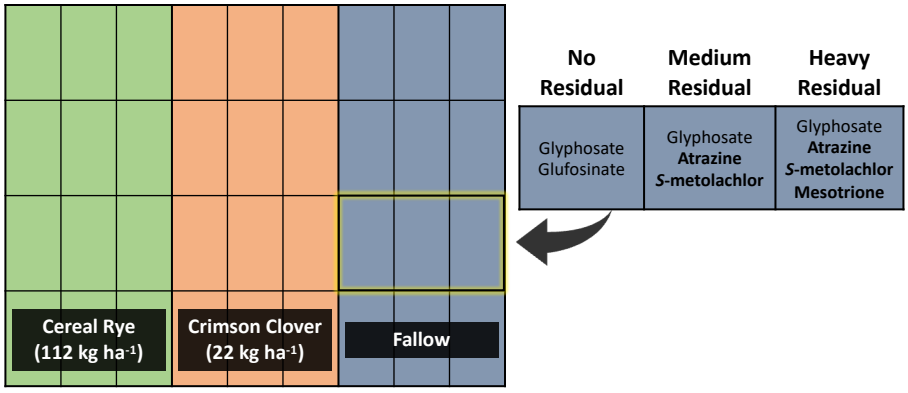
Materials and Methods

- Field trials established at Pinney and Throckmorton (TPAC) Purdue Agricultural Centers in the Fall of 2019
- Experimental design: split-plot with 4 replications



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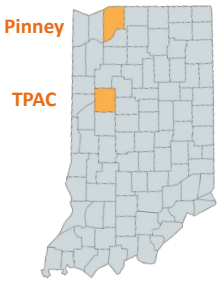
Materials and Methods



Soil chemical and physical properties from PPAC and TPAC

Site	Organic matter (%)	Classification
Pinney	1.8	sandy loam
TPAC	3.0	silt loam

Herbicide programs used at cover crop termination and rates for TPAC and Pinney

Herbicide programs	Herbicide	Rate (g ae ai ha^{-1})
No residual	Glyphosate	1750
	Glufosinate	737
Medium residual	Atrazine	2241 (TPAC) 1681 (Pinney)
	S-metolachlor	1790 (TPAC) 1420 (Pinney)
	Glyphosate	1750
Heavy residual	Atrazine	2241 (TPAC) 1681 (Pinney)
	S-metolachlor	1790 (TPAC) 1420 (Pinney)
	Mesotrione	104
	Glyphosate	1750

2020	2021	2022	2023
Corn	Soybean	**Corn**	Soybean

- Cover crop termination: 2 weeks before corn planting
- All herbicides within each treatment were applied in tank-mix and at cover crop termination
- 2 POST applications at 4 and 8 WAP
  - ➢ Same as no residual treatment

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Materials and Methods

Data collection

1. Cover crop biomass assessed the day before termination (0.25 m^2)
2. Weed biomass at 4 weeks after corn planting (WAP) – prior to 1st POST
3. Soil samples taken at: -5 , 0, 10, 14, 28, 56, 84, and 112 days after termination (DAT)
   - 0 to 5 cm depth
   - Soil microbial activity: β-glucosidase and dehydrogenase activities
   - Herbicide concentration (samples from 0 to 112 DAT)
     - ➢ QuEChERS method - Ultra-performance liquid chromatography

Statistical analysis

- Proc GLIMMIX in SAS – mean separation using Tukey's HSD ($P \leq 0.05$)
- Data was transformed as appropriate

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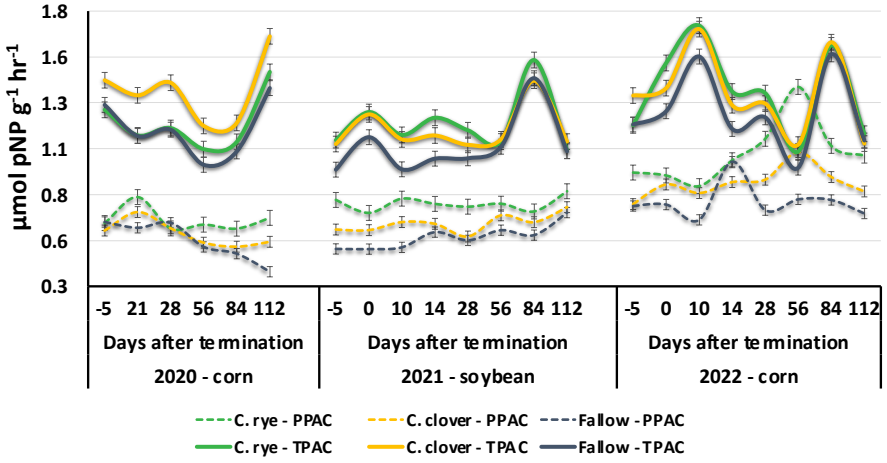
Results and Discussion

β-glucosidase activity



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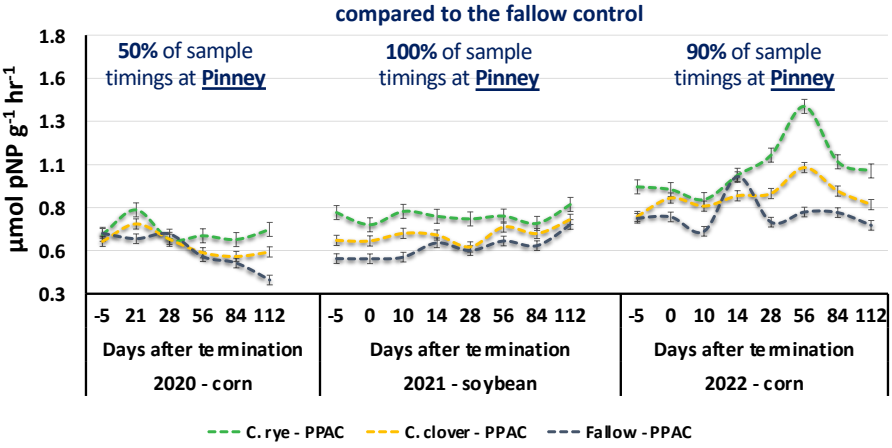
Results and Discussion

β-glucosidase activity

Use of cover crops resulted in greater β-glucosidase activity compared to the fallow control



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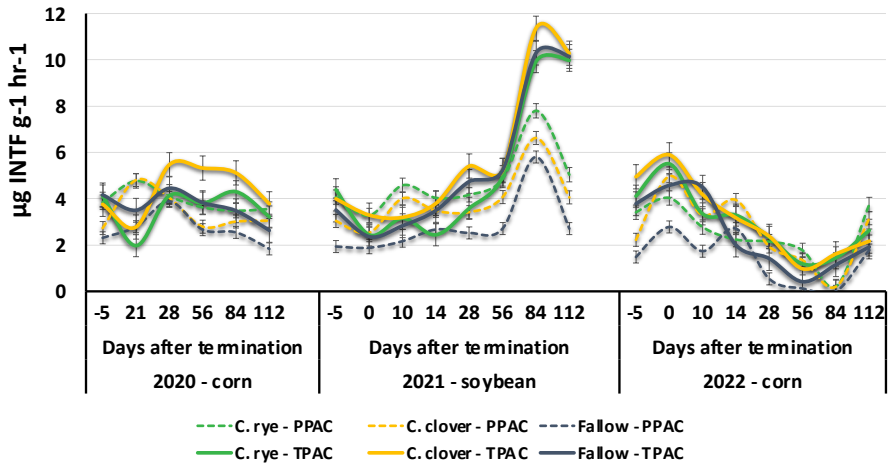
Results and Discussion

Dehydrogenase activity



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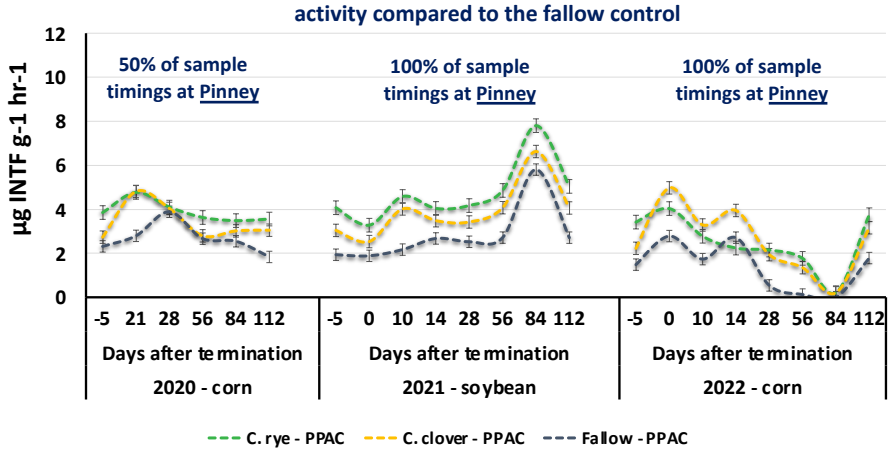
Results and Discussion

Dehydrogenase activity

Use of cover crops resulted in greater dehydrogenase activity compared to the fallow control



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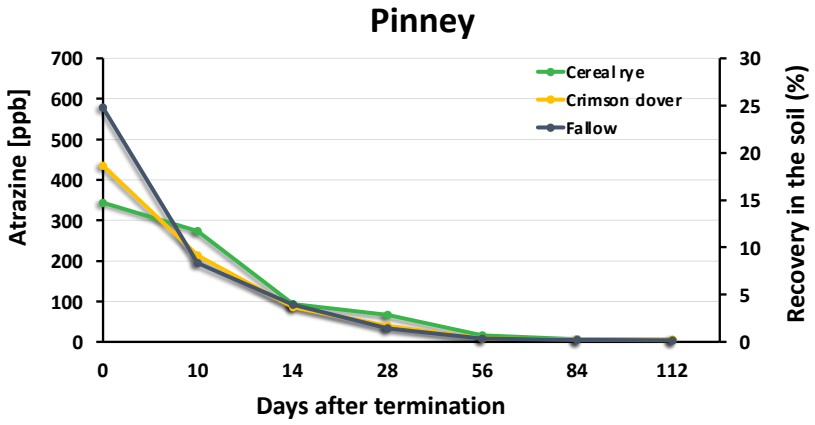
Results and Discussion

Atrazine concentration in the soil



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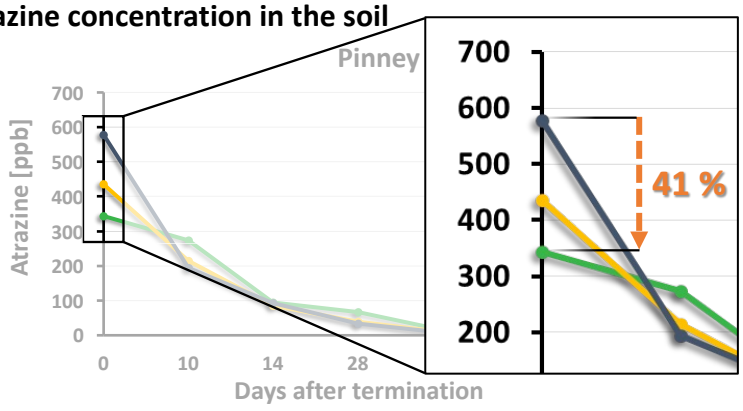
Results and Discussion

Atrazine concentration in the soil



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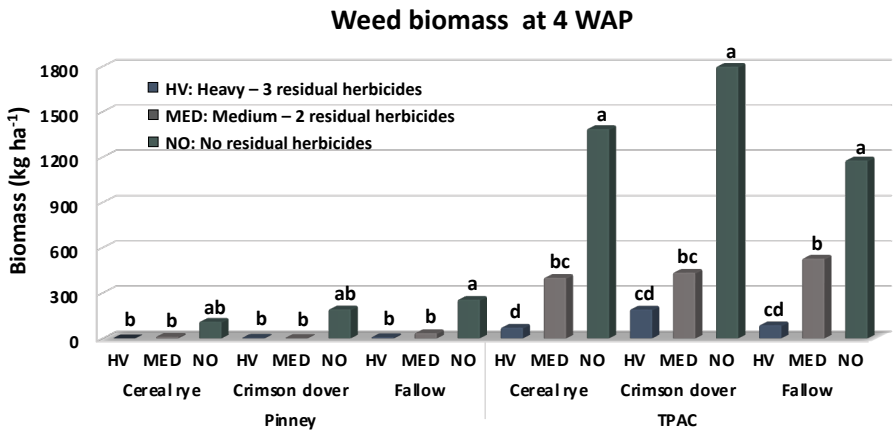
Results and Discussion



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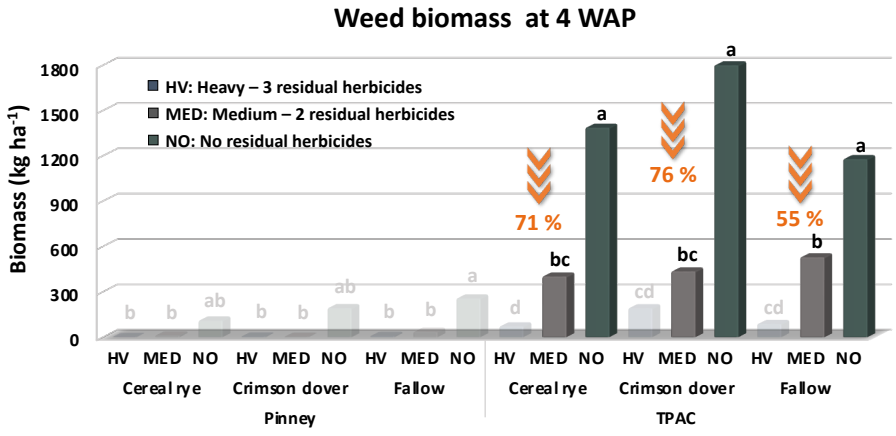
Results and Discussion



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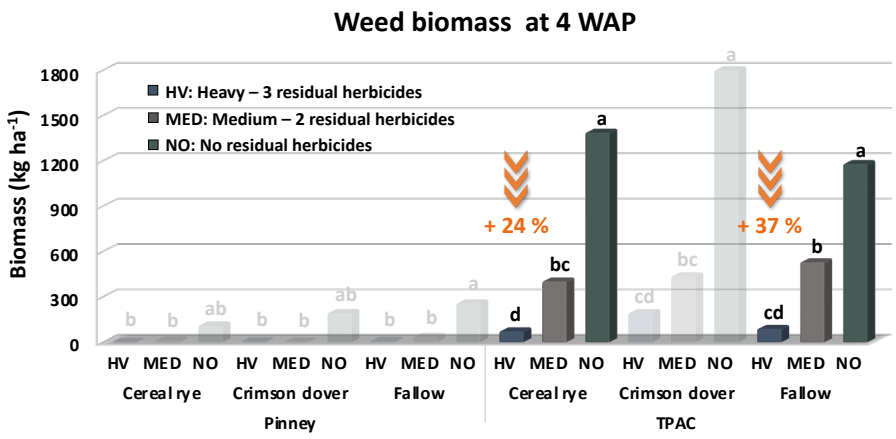
Results and Discussion



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Conclusions

Soil enzymatic activity

- The use of cereal rye for three years increased β-glucosidase and dehydrogenase activities by an average of 23 and 76%, respectively, compared to the fallow control

Herbicide concentration in the soil

- The increase in soil microbial activity as result of cereal rye use did not increase atrazine or mesotrione degradation
- The presence of 4027 kg ha^{-1} of cereal rye biomass at Pinney reduced the initial concentrations of atrazine and mesotrione in the soil by 41 and 36%, respectively, compared to the fallow control

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Conclusions

Weed control

- The application of 3 residual herbicides at cover crop termination provided up to 83 and 95% reduction in weed biomass compared to the termination with two or no residual herbicides, respectively.

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Impact of simulated rainfall on atrazine wash off from roller crimped and standing cereal rye residue onto the soil

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Materials and Methods

- Field trial: Throckmorton Purdue Agricultural Center

Split-plot design with 4 replications		
Main plot	Rainfall	0, 12.5, and 25 mm
Subplot	Cover crop orientation	Standing, roller crimped, and fallow

- Herbicide: atrazine at 2,241 g ai ha^{-1}
- Rainfall simulation started 30 minutes after atrazine application and lasted for 20 minutes.
- Samples collected after rainfall simulation:
  - Plant: 4 samples (2 whole plants each) per plot
  - Soil: one composite sample per plot (10 soil cores)
- Atrazine concentrations measured in a UHPLC

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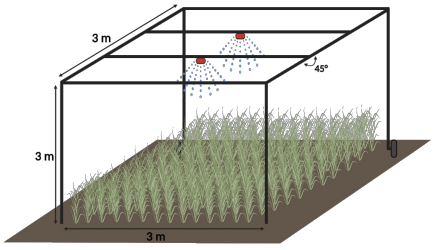
Materials and Methods

Rainfall simulator structure

Nozzle type by rainfall treatment

Rainfall treatment	Nozzle	PSI	GPM
25 mm	AI 8006	30	0.52
12.5 mm	AI 8003	30	0.26

Ultra coarse droplet size >622 microns



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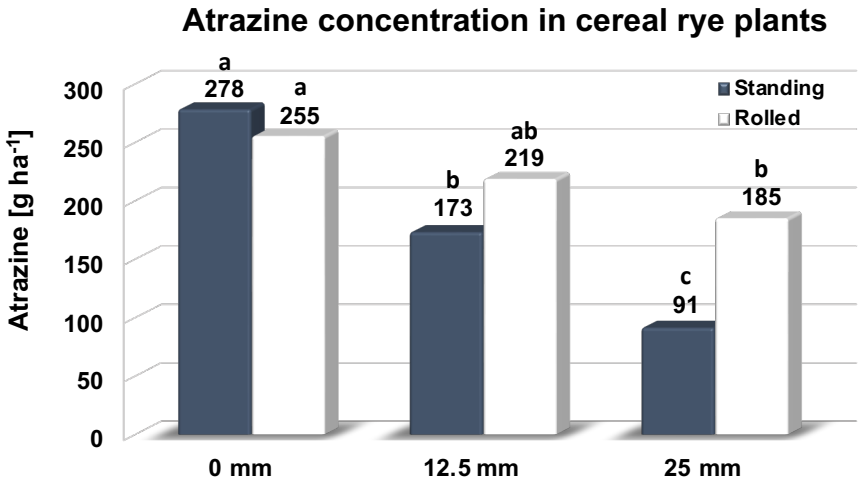
Results and Discussion



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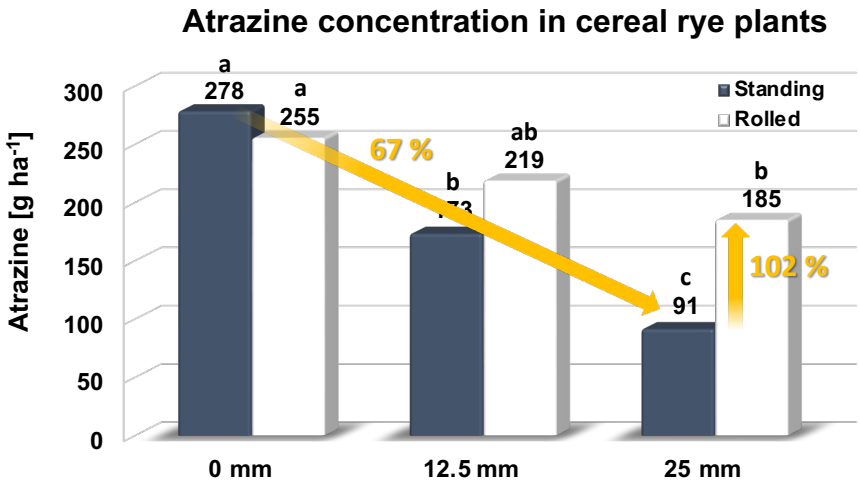
Results and Discussion



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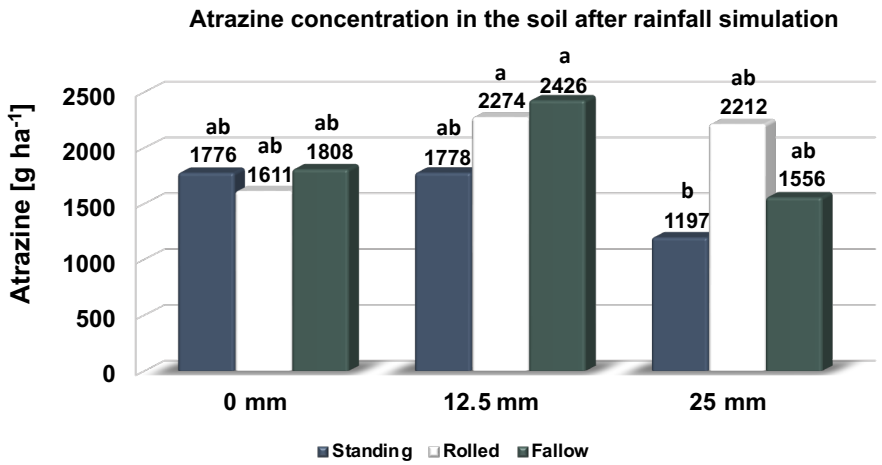
Results and Discussion



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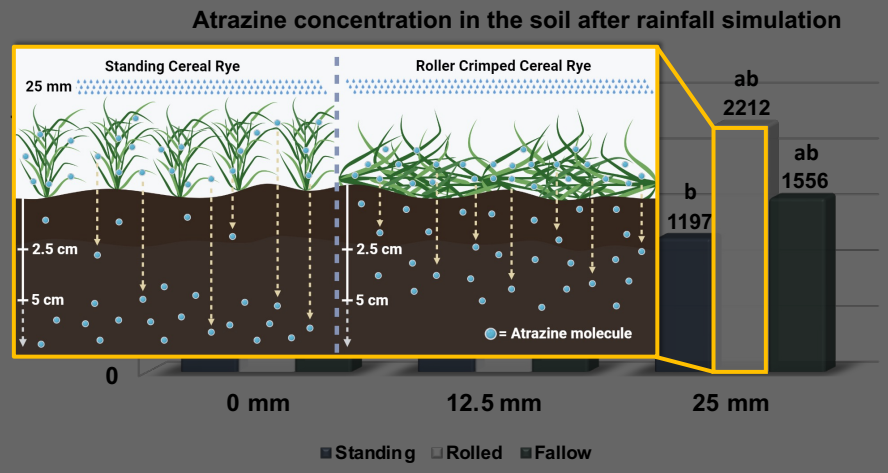
Results and Discussion



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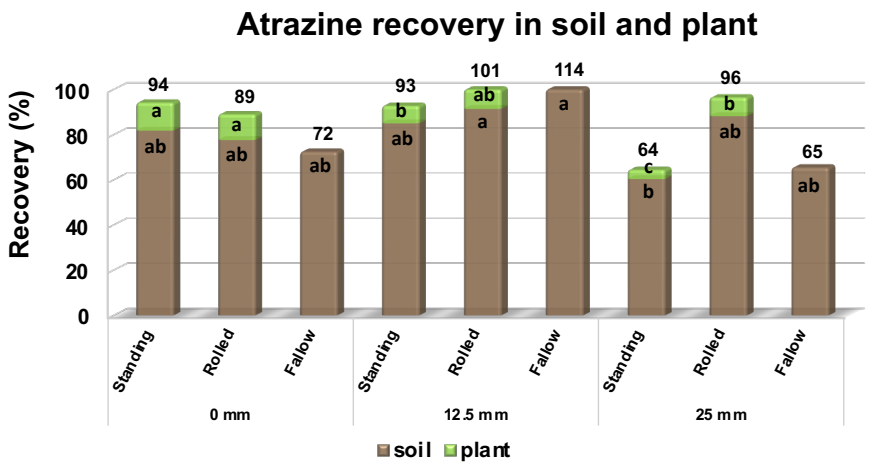
Results and Discussion



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Conclusions

- Roller crimped cereal rye residue is acting as a slow release mechanism for atrazine onto the soil during rainfall.

Practical implications:

(+) Roller crimped cereal rye residue protects the soil and reduces herbicide leaching.

(-) Reduced atrazine concentrations in the soil due to interception by cereal rye is likely to impact weed control efficacy.

(-) The slow release of the residual herbicide can be a concern for crop safety depending on the residual herbicide used (e.g. sulfentrazone injury in newly emerged soybean).

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Influence of Cover Crop Termination Strategies on Weed Suppression and Residual Herbicide Availability in the Soil

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Materials and Methods

- **Field Research**
  - Cereal rye broadcasted at 78 kg ha^{-1} in a tilled soil
  - XtendFlex soybeans were planted at 345,000 seeds ha^{-1} in 30" row spacing at cereal rye anthesis
  - Cereal rye was roller crimped (only in plots from roller crimper treatment) immediately after soybean planting
  - Herbicide treatments were applied 3 days after soybean planting
  - One POST application of glyphosate + glufosinate was made 4 weeks after planting (WAP) (same rates as no residual trt.)

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Materials and Methods

- **Treatments**
  - Experimental design: RCBD with 4 replications
  - Two cereal rye orientations: standing or roller crimped

Herbicide treatments applied to cereal rye and fallow treatments

Herbicide program	Herbicides	Rate (g ae ai ha^{-1})
No residual	Glyphosate	1540
	Glufosinate	737
With residual	Glyphosate	1540
	Glufosinate	737
	Sulfentrazone	280
	S-metolachlor	1790
	cloransulam	44

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Materials and Methods

Roller crimped cereal rye

Standing cereal rye

Soybean planting green

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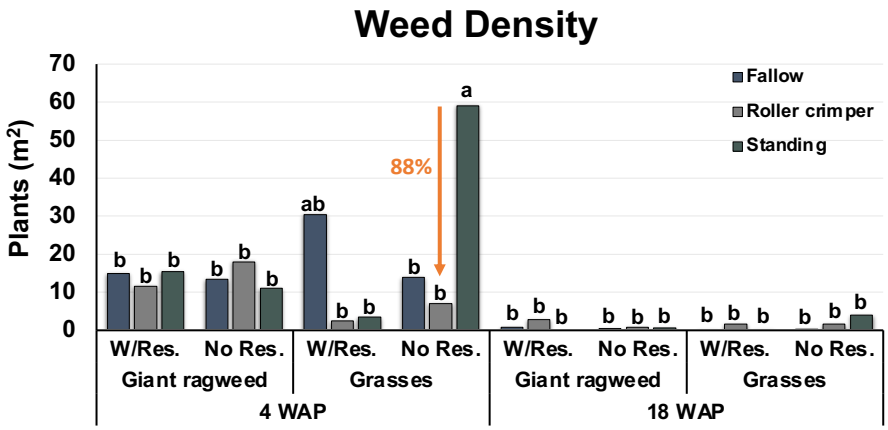
Results and Discussion



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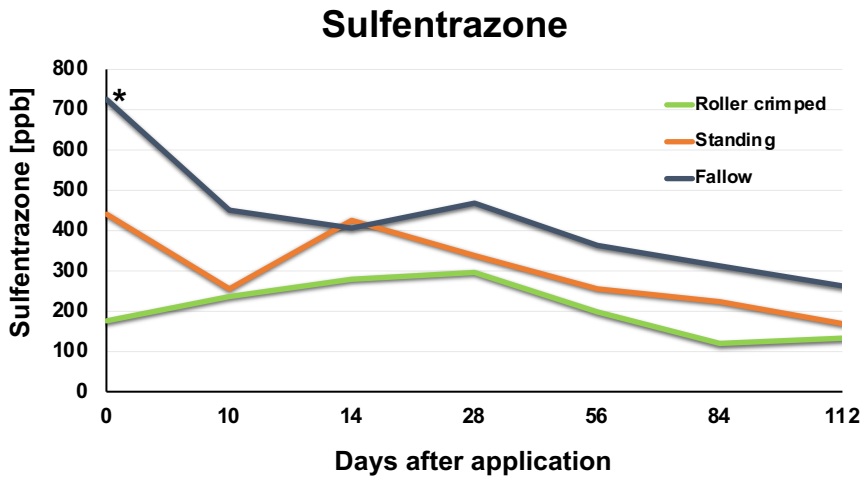
Results and Discussion



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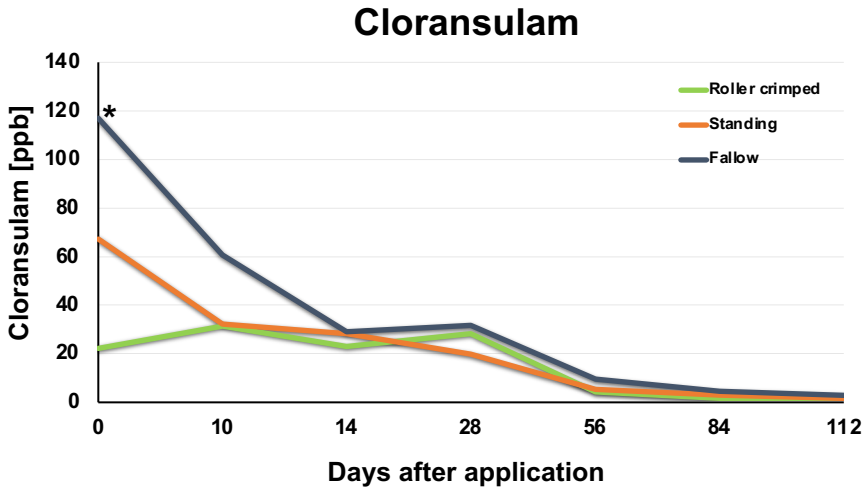
Results and Discussion



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Conclusions

- Soil residual herbicides should be applied at cover crop termination even under high levels of accumulated biomass.
- The use of roller crimper is an alternative for grass suppression when the application of residual herbicides is not an option, but not for giant ragweed.

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Final Thoughts

- The good news is that with the active ingredients evaluated in our research, there seems to be minimal negative interactions between cover crops and residual herbicides.
- Probability of ***additive*** effects on weed suppression provided by cover crops plus residual herbicides is nearly 100%.
  - Notable exception is common cocklebur
  - Full rates of residuals are needed because residue will intercept some of the herbicide
- Can cover crops replace residual herbicides?
  - For marestail and annual grasses – probably if residue levels are high
  - For every other weed we have evaluated - no

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