Crop Rotation, Tillage, and Weed Management Effects on Weed Communities After 12 Years

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Research Objective

- Determine long-term effects of crop sequence, tillage system, and glyphosate use frequency on weed community composition and management risks in glyphosate-resistant corn and soybean cropping systems

Methods

- Research conducted at the University of Wisconsin Arlington ARS from 1998-2009
  - Species number and diversity in the weed seedbank and plant communities
    - Weed seedbank density
    - Early- and late-season weed plant density
  - Late-season weed shoot mass
  - Crop yield

Cropping Sequence and Tillage Treatments

- Cropping sequence
  - Continuous corn (CC)
  - Corn-soybean rotation (CS)
- Primary tillage system
  - Moldboard plow (MP)
  - Chisel plow (CP)
  - No-tillage (NT)

Fall Moldboard Plow

Fall Chisel Plow

Weed Management Treatments

Continuous Corn

Treatment	Acronym
Glyphosate POST	GLY
Glyphosate POST and LPOST	GLY/GLY
Glyphosate POST fb inter-row cultivation	GLY/CULT
Metolachlor PRE fb glyphosate POST	PRE/GLY
Glyphosate POST rotated annually with non-glyphosate herbicides	GLY // NON-GLY
Non-glyphosate herbicides	NON-GLY

NON-GLY Herbicide Programs in Continuous Corn

Year	Herbicide program	Rate
		kg ai ha^{-1}
1998–2001	*S*-metolachlor + atrazine + flumetsulam PRE	1.4 + 1.1 + 0.028
2002	[clopyralid + flumetsulam + nicosulfuron + rimsulfuron] + atrazine POST	[0.11 + 0.039 + 0.013 + 0.013] + 0.56
2003	[clopyralid + flumetsulam + nicosulfuron + rimsulfuron] + atrazine POST / nicosulfuron + [diflufenzopyr + dicamba] LPOST	[0.11 + 0.039 + 0.013 + 0.013] + 0.56 / 0.035 + [0.056 + 0.14]
2004–2006	[*S*-metolachlor + atrazine + mesotrione] PRE / nicosulfuron + [dicamba + diflufenzopyr] POST	[2.25 + 0.84 + 0.23] / 0.035 + [0.14 + 0.056]
2007	*S*-metolachlor + simazine + mesotrione PRE	2.25 + 0.84 + 0.23
2008–2009	[*S*-metolachlor + atrazine + mesotrione] PRE / nicosulfuron + [dicamba + diflufenzopyr] POST	[2.25 + 0.84 + 0.23] / 0.035 + [0.14 + 0.056]

Weed Management Treatments

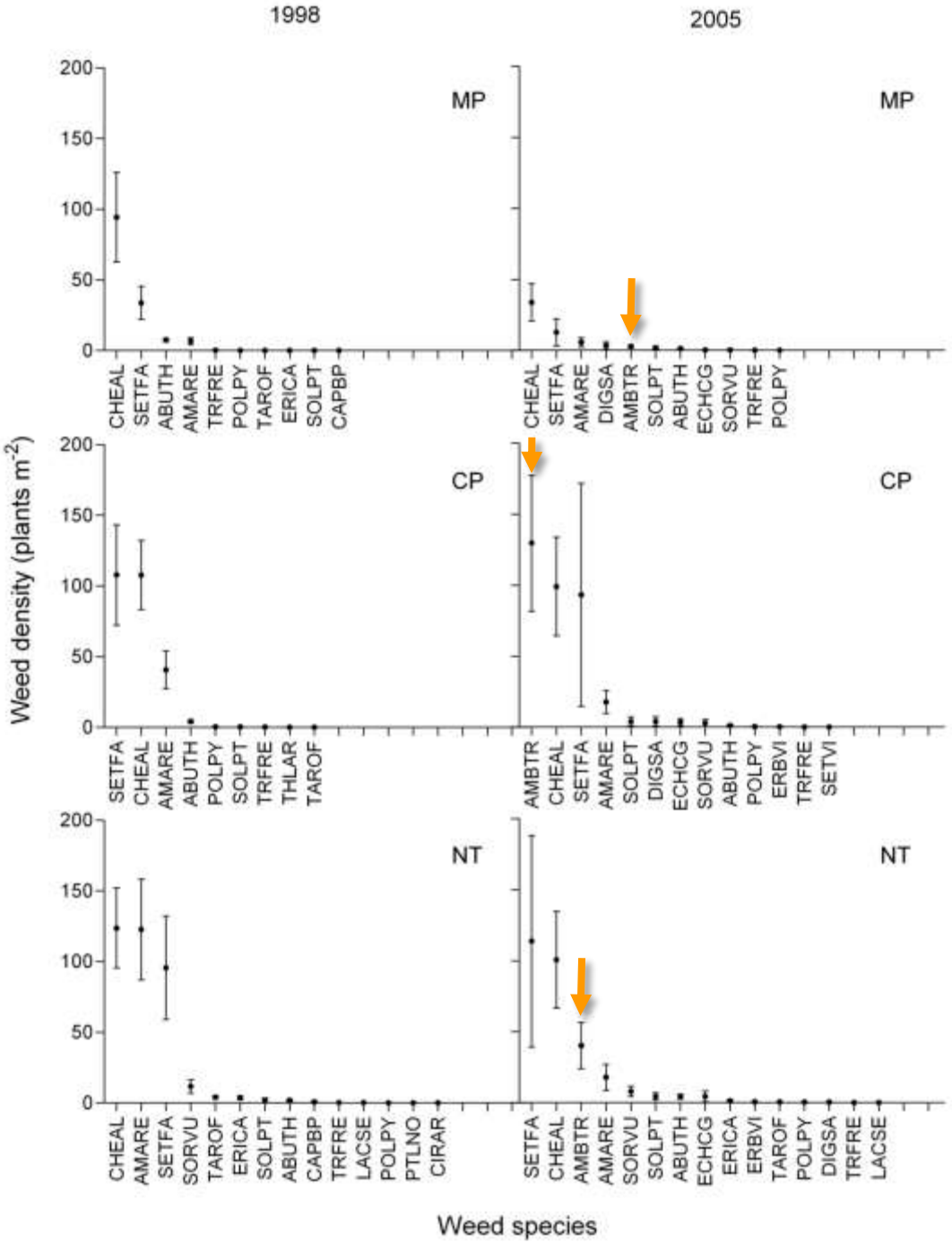
Corn-Soybean Rotation

Corn Treatment (odd years)	Soybean Treatment (even years)	Acronym
Glyphosate POST	Glyphosate POST	GLY
Glyphosate POST and LPOST	Glyphosate POST	GLY/GLY
Glyphosate POST fb inter-row cultivation	Glyphosate POST	GLY/CULT
Metolachlor PRE fb glyphosate POST	Metolachlor PRE fb glyphosate POST	PRE/GLY
Glyphosate POST	Non-glyphosate herbicides	GLY // NON-GLY
Non-glyphosate herbicides	Non-glyphosate herbicides	NON-GLY


Results

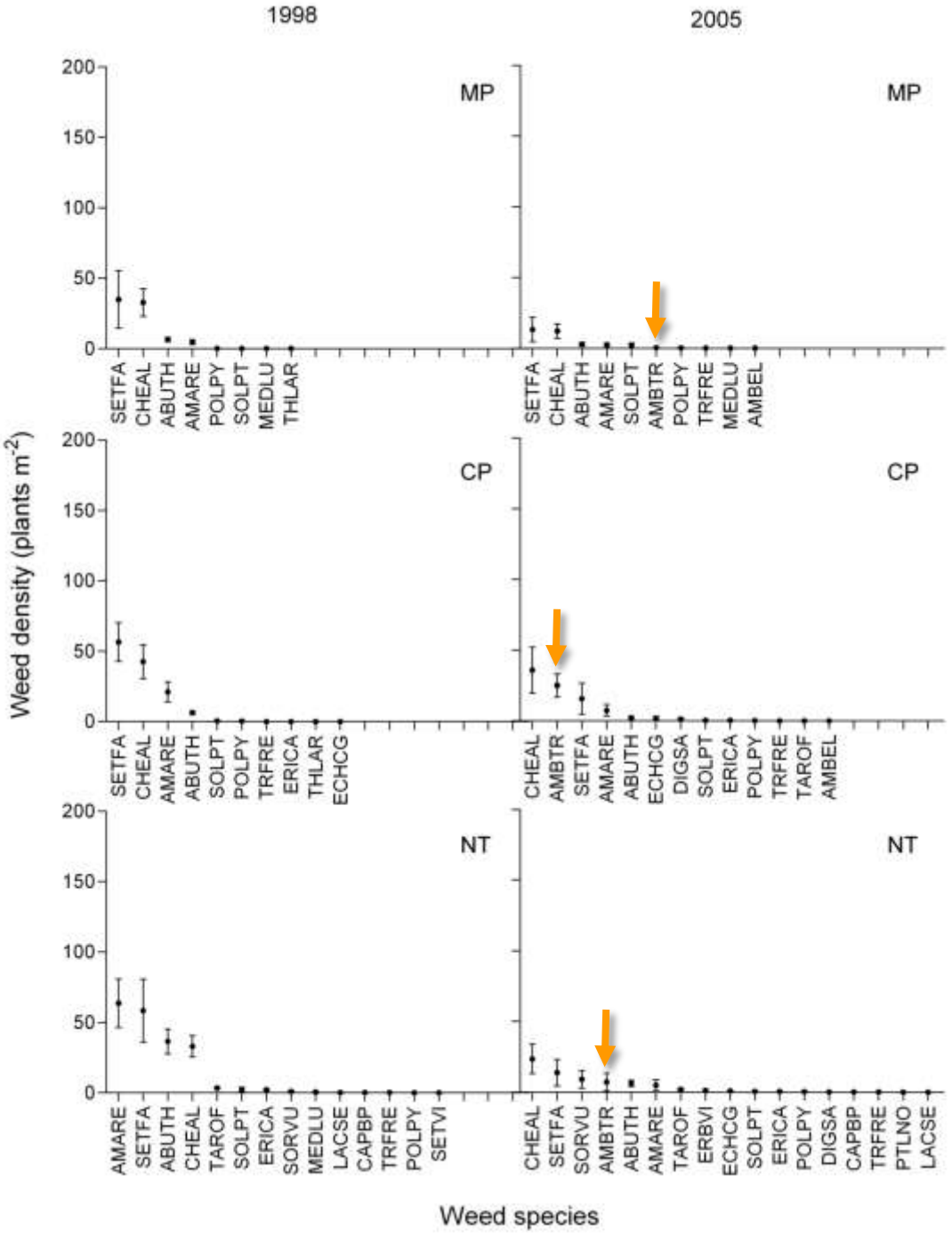
Weed Species Abundance in Continuous Corn (1998-2005)

- Abundance based on early-season weed plant densities
- Weed communities tended to be dominated by a few highly abundant weed species
- Common lambsquarters (CHEAL), giant foxtail (SETFA), and redroot pigweed (AMARE) were abundant across cropping sequence and tillage treatments over 8 yr
- **Giant ragweed (AMBTR) not observed in 1998, but abundant in CP and NT after 8 yr**



Weed Species Abundance in Corn-Soybean Rotation (1998-2005)

- Early-season plant densities typically lower in CS than CC
- Common lambsquarters and giant foxtail were abundant weed species across treatments and time
- **Giant ragweed more abundant in CP than MP or NT after 8 yr**



Late-Season Weed Shoot Mass as Affected by Crop Rotation and Weed Management over 12 Years

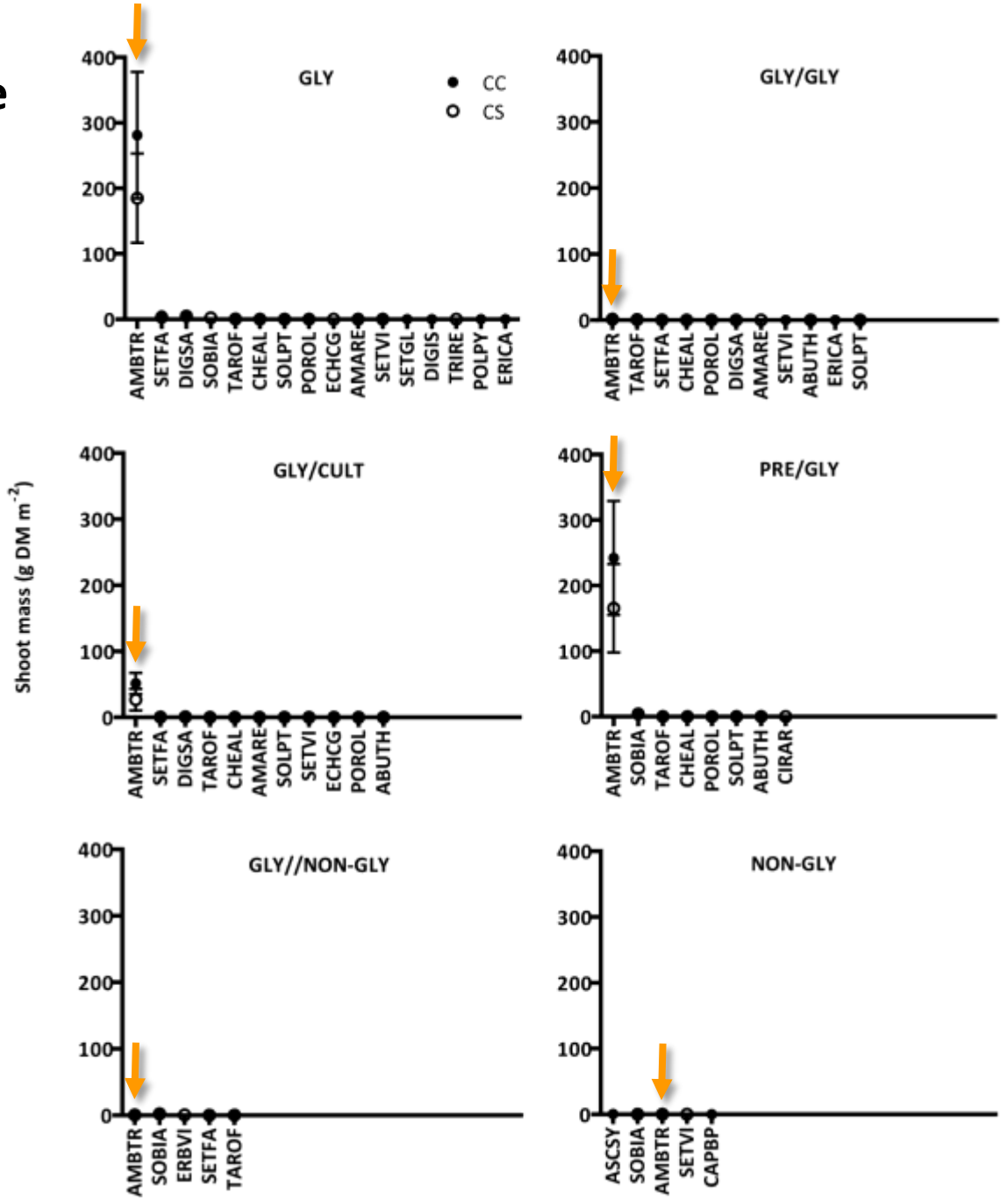
Crop Rotation	Weed Management	Weed shoot mass (g DM m^{-2}) 1998	1999	2000	2001	2002	2003	2004	2005	2009		Linear regression
CC	GLY	7	13	6	34	59	131	54	146	100	A[†]	*[‡]
	GLY/GLY	2	<1	1	2	2	5	1	2	1	E	NS
	GLY/CULT	5	3	8	4	8	36	36	49	22	ABCD	NS
	PRE/GLY	1	3	5	18	21	36	34	74	70	AB	*
	GLY//NON-GLY	4	6	6	30	198	225	129	4	1	E	NS
	NON-GLY	7	8	8	231	132	182	1	<1	<1	E	NS
CS	GLY	2	22	2	15	<1	26	6	34	55	AB	*
	GLY/GLY	2	<1	1	1	2	<1	<1	<1	2	CDE	NS
	GLY/CULT	6	1	1	2	<1	3	1	3	7	BCDE	NS
	PRE/GLY	<1	1	1	4	2	8	6	16	25	ABC	*
	GLY//NON-GLY	5	6	4	20	2	13	4	<1	1	E	NS
	NON-GLY	88	14	3	33	6	43	<1	<1	<1	E	*

[†] Means followed by the same letter do not differ at $P < 0.05$ using Tukey's HSD

[‡] An asterisk indicates regression significant at $P < 0.05$; NS indicates not significant

Weed Species Abundance in Continuous Corn (CC) and Corn-Soybean Rotation (CS) in 2009

- Abundance based on late-season shoot mass
- AMBTR abundance similar between CC and CS
- AMBTR the most abundant species in most weed management treatments
- AMBTR abundance greatest in GLY and PRE/GLY treatments



Late-Season Weed Shoot Mass as Affected by Tillage System and Weed Management over 12 Years

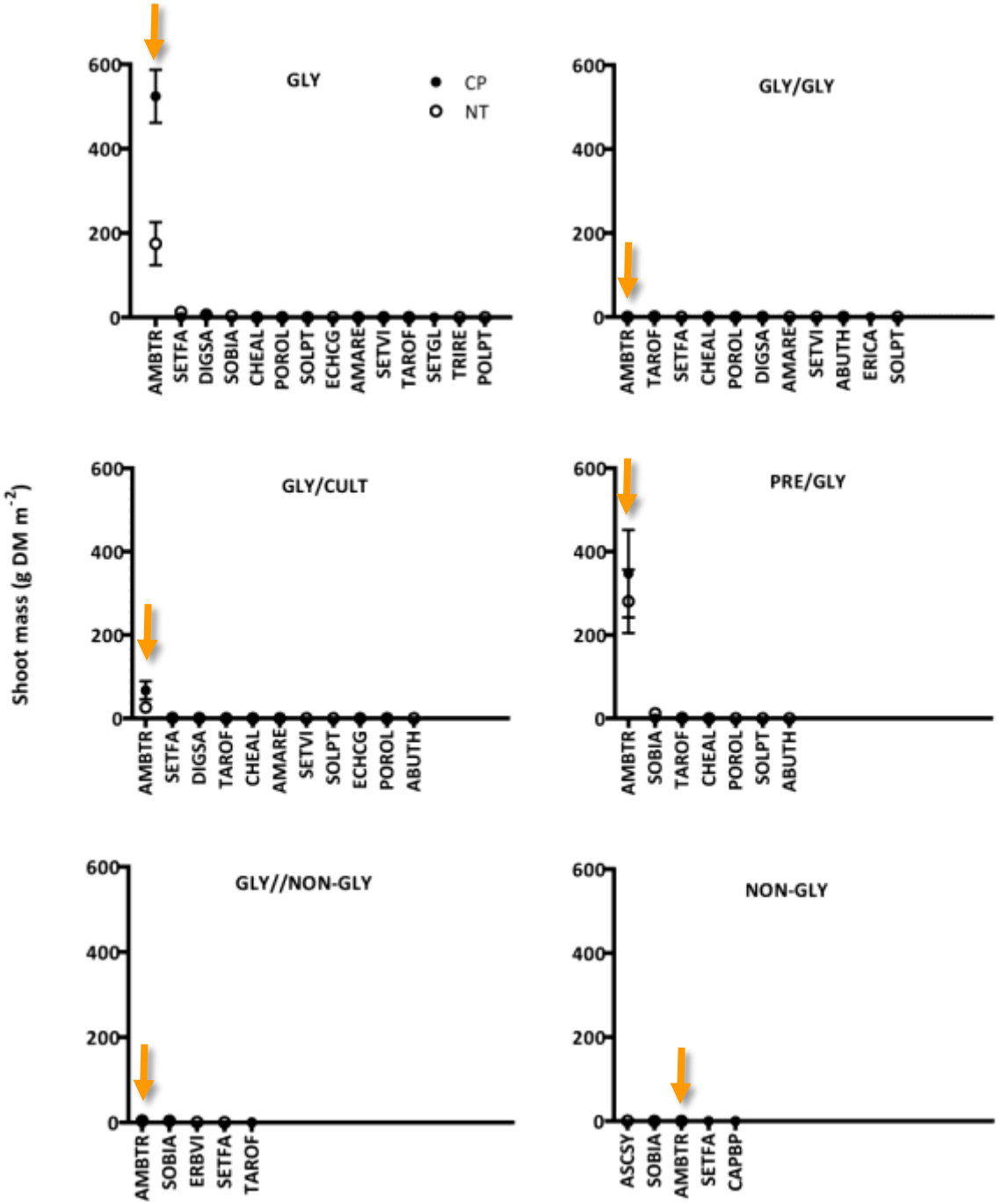
Tillage System	Weed Management	Weed shoot mass (g DM m^{-2}) 1998	1999	2000	2001	2002	2003	2004	2005	2009		Linear regression
MP	GLY	1	10	1	8	2	11	2	12	4	CD[†]	NS[‡]
	GLY/GLY	<1	<1	<1	1	<1	2	<1	<1	<1	D	NS
	GLY/CULT	2	<1	1	1	<1	2	<1	1	2	CD	NS
	PRE/GLY	<1	0	<1	3	1	1	<1	2	1	D	NS
	GLY//NON-GLY	1	1	1	3	4	13	3	<1	<1	D	NS
	NON-GLY	1	1	6	14	6	27	<1	<1	<1	D	NS
CP	GLY	2	15	2	24	7	130	45	132	513	A	*
	GLY/GLY	2	<1	1	2	2	2	<1	2	2	CD	NS
	GLY/CULT	6	2	3	1	2	16	67	36	48	ABC	*
	PRE/GLY	<1	1	1	6	9	41	52	121	157	AB	*
	GLY//NON-GLY	5	2	7	24	48	200	164	2	<1	D	NS
	NON-GLY	60	8	101	175	99	306	<1	<1	<1	D	*
NT	GLY	16	31	11	59	25	137	60	216	180	AB	*
	GLY/GLY	7	1	2	1	6	2	1	2	1	CD	NS
	GLY/CULT	10	6	4	13	8	33	6	27	19	BCD	NS
	PRE/GLY	2	6	12	37	30	96	64	138	261	AB	*
	GLY//NON-GLY	9	76	11	152	63	64	25	3	5	CD	NS
	NON-GLY	126	90	201	266	43	83	1	<1	1	D	*

[†] Means followed by the same letter within year do not differ at $P < 0.05$ using Tukey's HSD

[‡] NS indicates not significant; an asterisk indicates regression parameters significant at $P < 0.05$

Weed Species Abundance in Chisel Plow (CP) and No-Tillage (NT) Systems in 2009

- AMBTR abundance greater in CP than NT for GLY treatment
- AMBTR the most abundant species in most weed management treatments
- AMBTR abundance greatest in GLY and PRE/GLY treatments




Continuous Corn
Chisel Plow
Glyphosate POST
May 25, 2007


Continuous Corn
Chisel Plow
Glyphosate POST fb Glyphosate LPOST
May 25, 2007


Continuous Corn
Chisel Plow
Glyphosate POST
June 13, 2007

Correlation Between Crop Grain Yield and Late-Season Weed Shoot Mass (1998-2005)

Cropping Sequence	Crop phase	Tillage	Late-season weed shoot mass					
			Total weeds	Giant ragweed	Lambs-quarters	Redroot pigweed	Giant foxtail	Shattercane
CC	Corn	MP	-0.41***	-0.36***	-0.24**	-0.04	-0.17*	-0.08
		CP	-0.77***	-0.73***	-0.28***	-0.15	-0.05	-0.24**
		NT	-0.73***	-0.27**	-0.18*	0.06	-0.16	-0.63***
CS	Corn	MP	-0.05	-0.01	-0.14	0.03	-0.04	0.02
		CP	-0.76***	-0.57***	-0.14	0.02	-0.22	-0.50***
		NT	-0.89***	-0.26*	0.08	0.03	-0.12	-0.81***
	Soybean	MP	-0.01	—	-0.04	0.11	0.11	-0.10
		CP	-0.61***	-0.18	-0.07	-0.40***	-0.55***	-0.11
		NT	-0.65***	-0.06	-0.28*	0.13	-0.31**	-0.56***

Asterisks indicate correlation at α = 0.05 (*), α = 0.01 (**), and α = 0.001 (***)

Summary

- Crop rotation, tillage system, and weed management interacted to affect weed communities over time
  - Increased total weed shoot mass over time was largely due to giant ragweed

- Weed abundance was similar between CC and CS after 12 years
  - Abundance increased over time in:
    - Glyphosate POST
    - Metolachlor PRE fb glyphosate POST
  - But fewer instances of high densities and crop yield loss in CS than CC

- Weed abundance was affected greatly by tillage system
  - In MP, weed abundance was very low over time in all weed management treatments
  - In both CP and NT, weed abundance increased over time in:
    - Glyphosate POST
    - Metolachlor PRE fb glyphosate POST
  - Greatest crop yield losses were in continuous corn CP

Conclusions

- Effective long-term weed suppression by glyphosate and other herbicide modes of action was dependent on specific management tactics
  - Tactics that targeted later emerging plants
    - Glyphosate or other herbicide modes of action
    - Inter-row cultivation
  - Resistance management tactics

- Giant ragweed affinity for chisel plow systems may be due to several factors
  - A greater proportion of seeds at optimal soil depths for germination and emergence
  - Longer viability of seeds in the soil
  - Less post-harvest predation of seeds

- Dominance of giant ragweed in weed communities
  - Lower base temperature for germination
  - Lower base temperature for leaf appearance
  - Greater early-season seedling vigor
    - Seed mass
    - Shoot height
    - Leaf area distribution
  - Extended period of germination and emergence