Interseeding covers

Weed management in narrow- and wide- row corn

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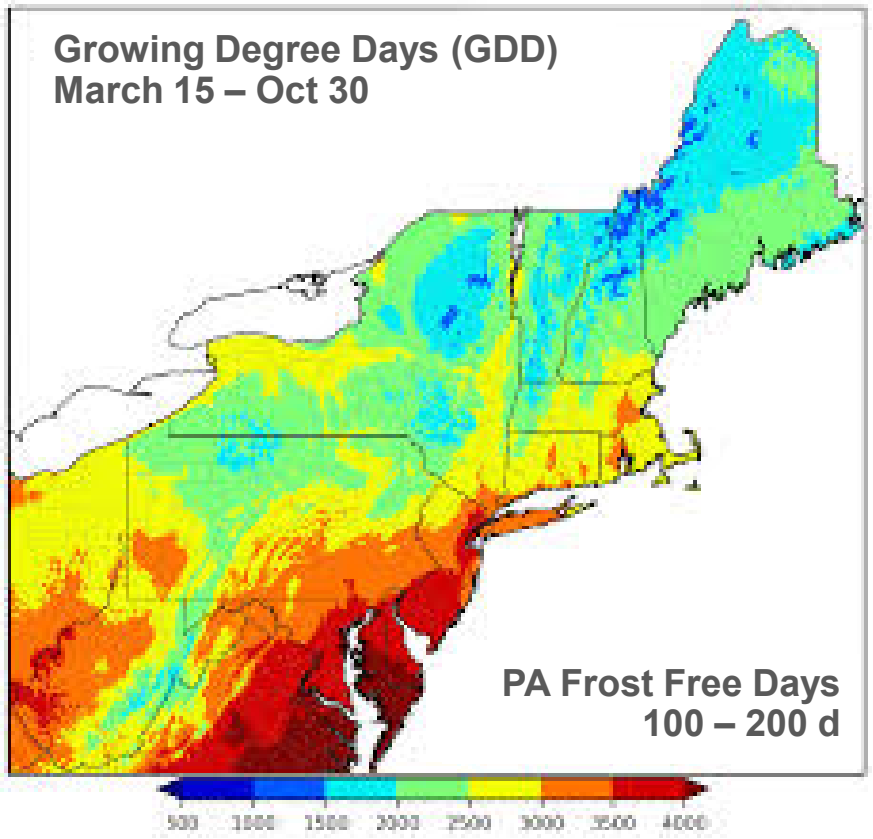
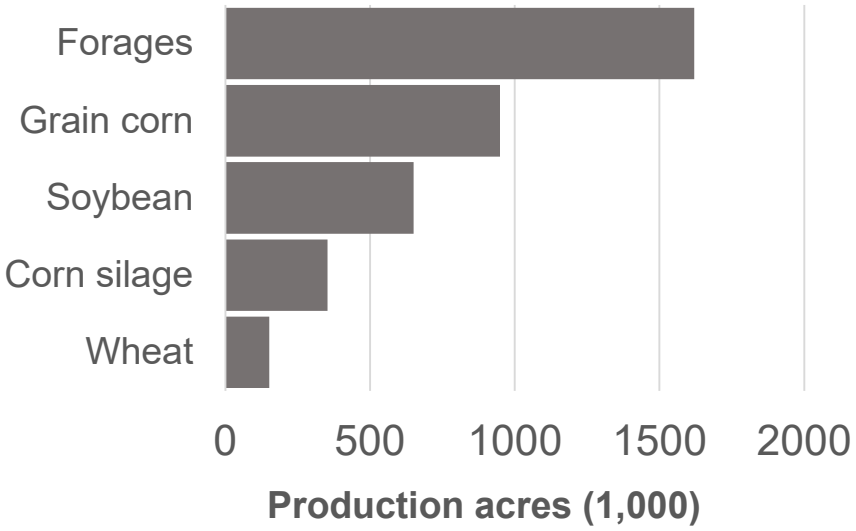
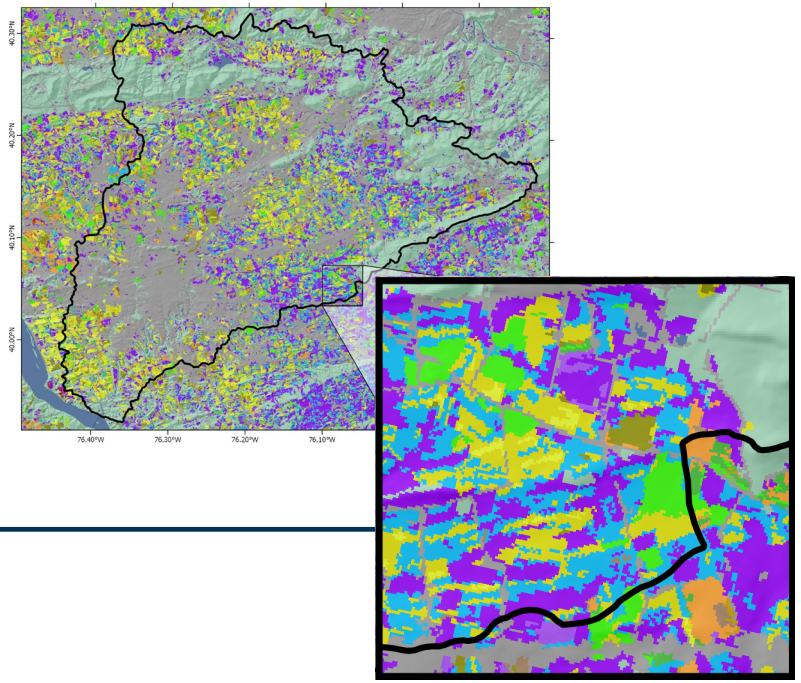
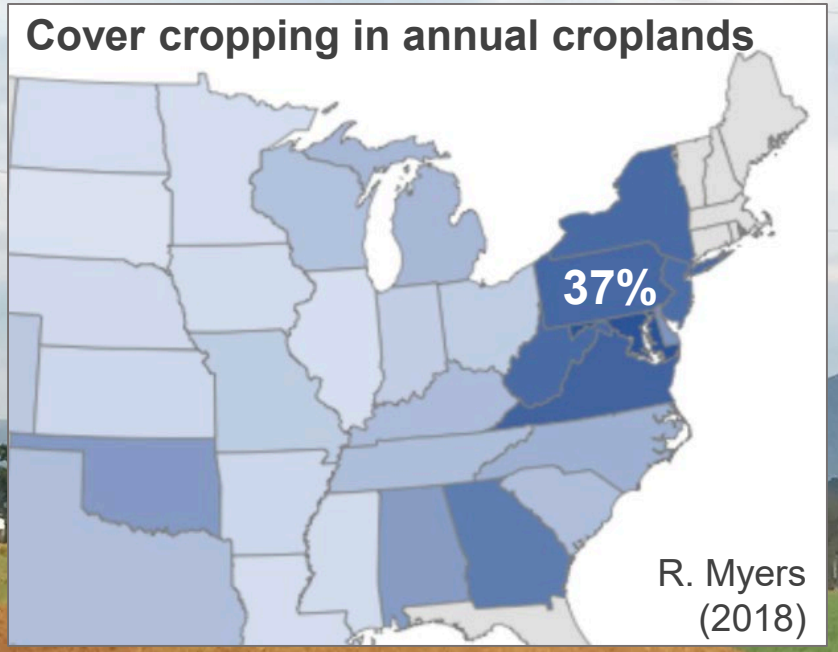






Agronomic fit for cover crop interseeding?



Soil conservation & nutrient management

Interseeding

Crop diversity & soil health

Forage & livestock grazing

Developing BMPs (2010– 2015)

1. **Drill-interseeding in no-till acres to improve establishment**

Developing BMPs (2010– 2015)

1. Drill-interseeding in no-till acres to improve establishment

2. **Interseed shade tolerant cover crop species**

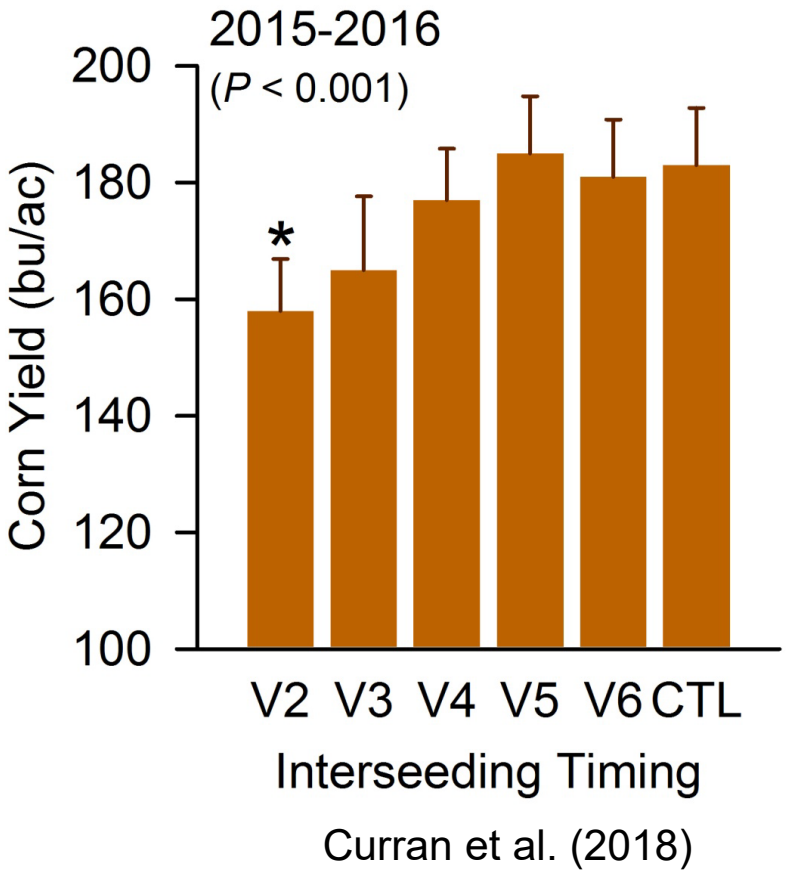
annual ryegrass

Medium red clover

Caswell et al. (2018)

Developing BMPs (2010– 2015)

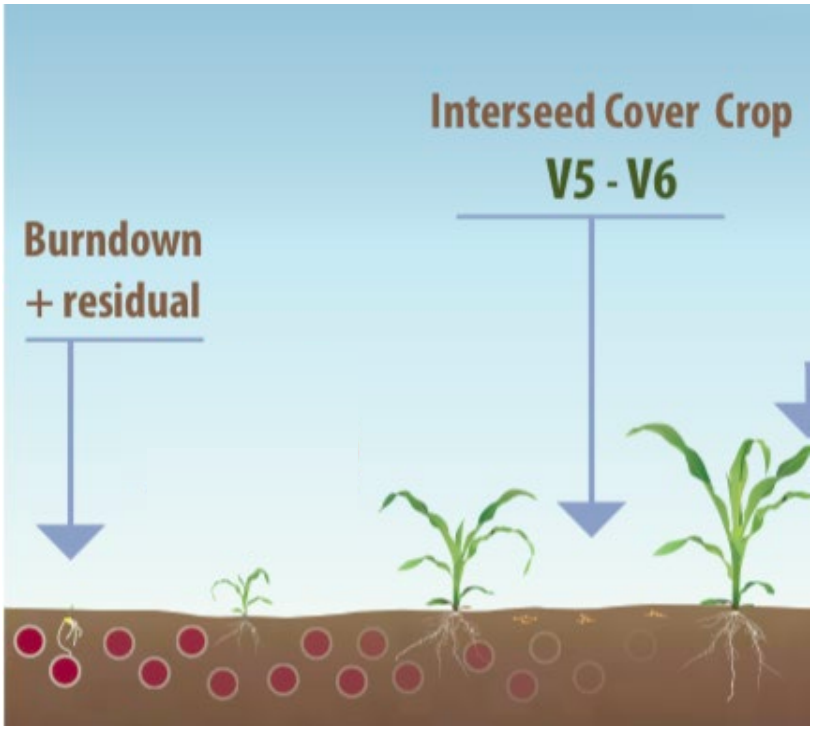
1. Drill-interseeding in no-till acres to improve establishment
2. Interseed shade tolerant cover crop species
3. **Interseed in V4 –V6 growth stage window**



Curran et al. (2018)

Developing BMPs (2010– 2015)

1. Drill-interseeding in no-till acres to improve establishment
2. Interseed shade tolerant cover crop species
3. Interseed in V4 –V6 growth stage window
4. **Use short-lived residual herbicides to setup POST**



Wallace (2018) Farm Journal editorial

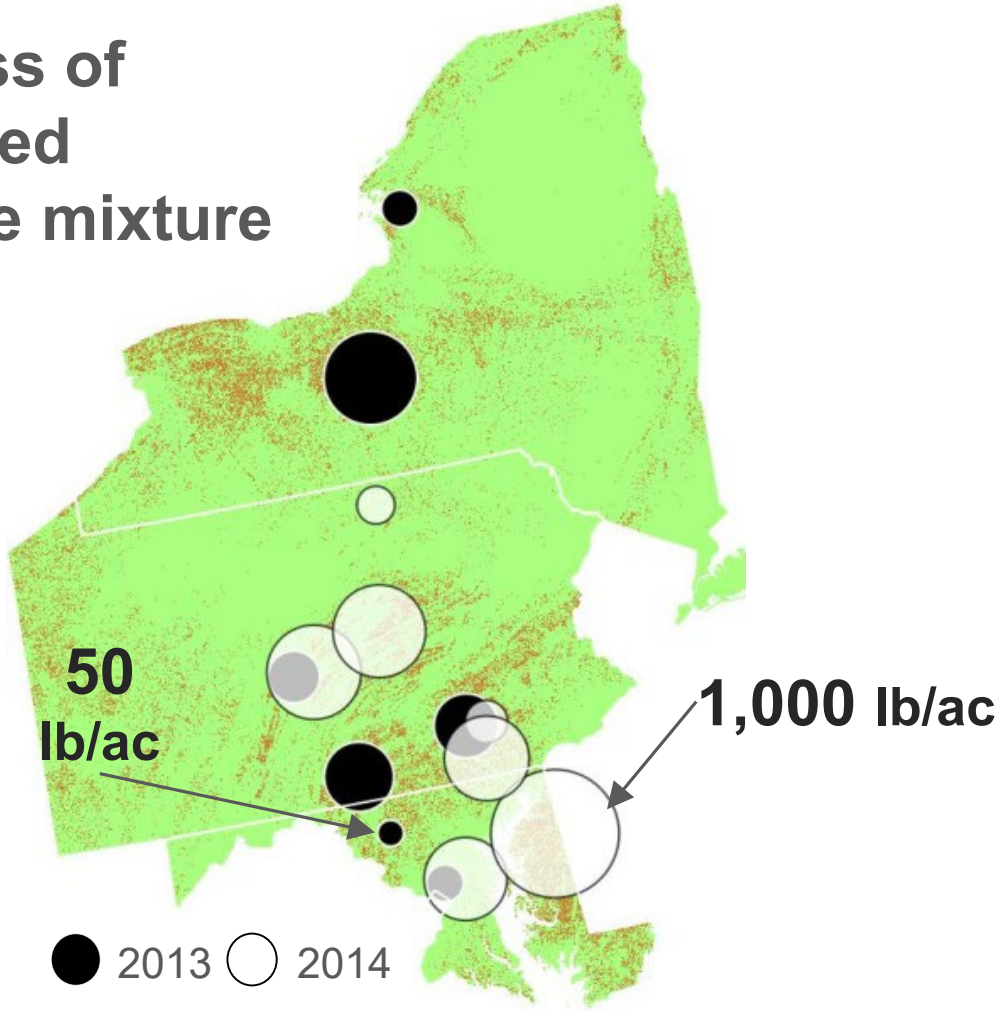
PA set-up programs

Verdict (Outlook + Sharpen)

Outlook/BasisBlend (Matrix/Harmony)

On-Farm Trials (NRCS-CIG; 2013– 2014)

Fall biomass of interseeded ryegrass-legume mixture



Curran et al. 2018

Northern PA (Zone 5)
Interseeded annual ryegrass

Central PA (Zone 6b)
Interseeded annual ryegrass


Central PA (Zone 6b)
Interseeded annual ryegrass in corn (left) vs. fallow (right)


Annual ryegrass, Lancaster Co., 2014
6 weeks after interseeding
(R. Hoover)

Annual ryegrass, Lancaster Co., 2014
14 weeks after interseeding
(R. Hoover)

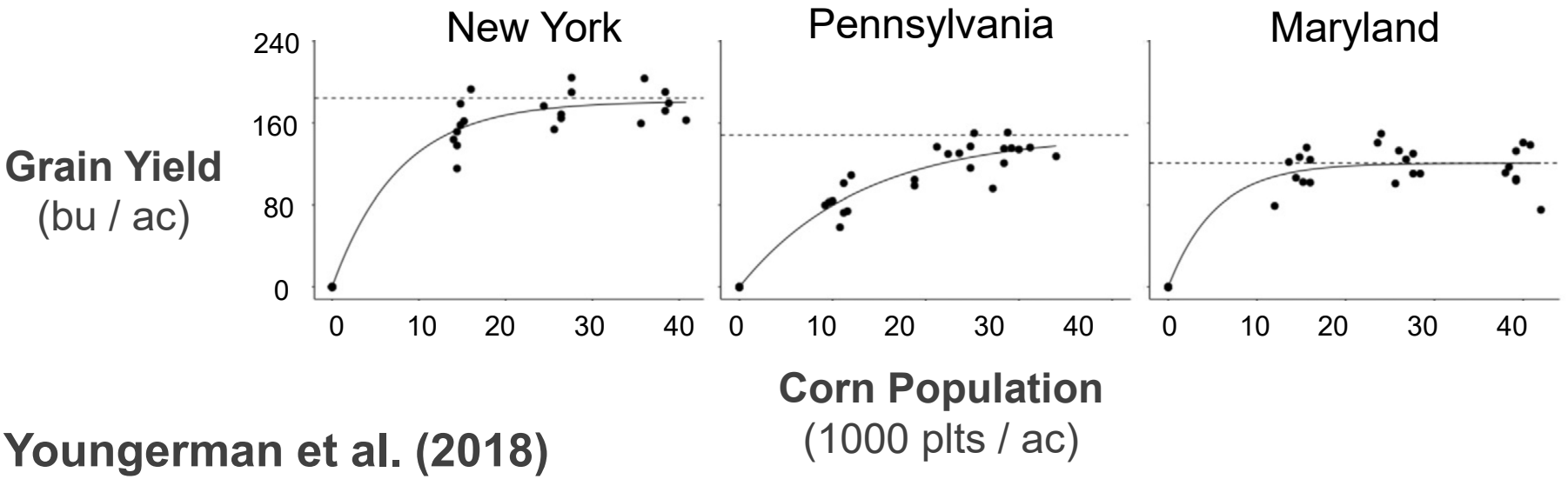
Improving ***persistence*** *of interseeded covers?*

1. Corn populations & hybrid selection
2. Earlier interseeding (V3 window)
3. Row spacing (30" vs. 60")

Management tactics: #1 Seed drop & flex ear hybrids

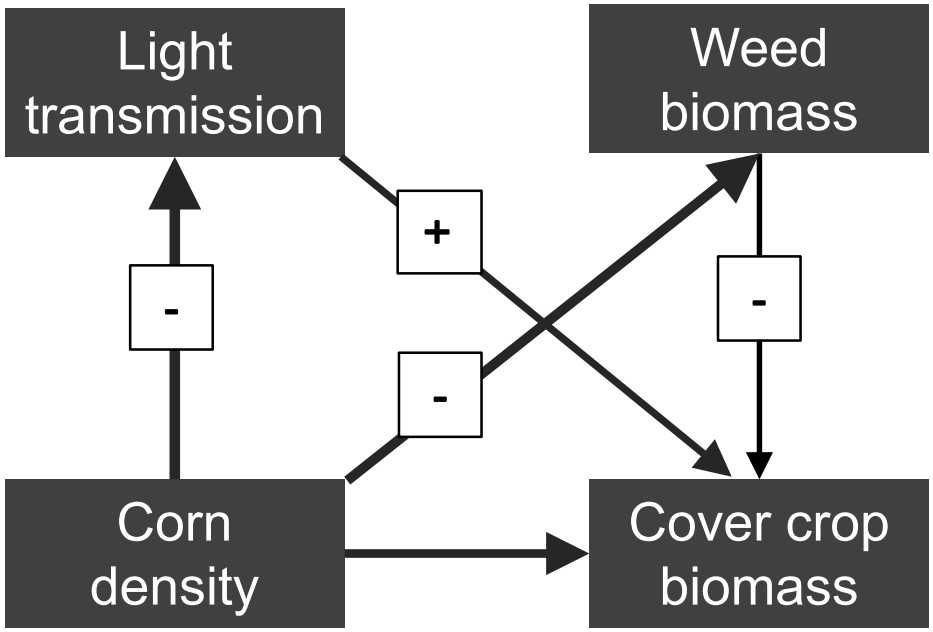
TAKE HOME: Reducing seed drop by 10% (~28K) did not reduce yield of flex-ear hybrids & produceda measurable increase in light transmission in corn canopy.

Viking 69-99' 99 d relative maturity; Flex ear hybrid; Plant Date: May 12 - 26



Youngerman et al. (2018)

Management tactics: #1 Seed drop & flex ear hybrids



Summarized from Youngerman et al. (2018)

Management tactics: #2 Earlier interseeding

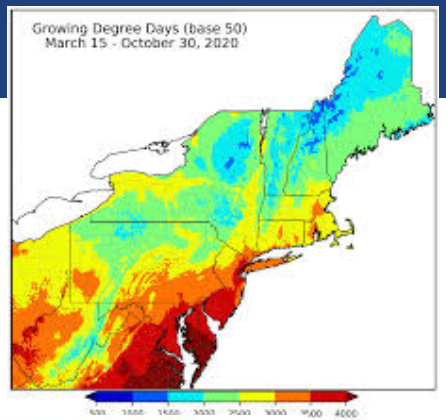
TAKE HOME: Interseeding earlier (V3-V4) increased biomass **production & persistence** in high yielding production regions in southeastern PA.

	Lancaster Co.			York Co.		
Data	ctl	V4	V6	ctl	V3-V4	V6-V7
Corn yield (bu/ac)	155	156	162	253	247	249
Cover crop establishment (%)[1]	-	68	48	-	83	20
Cover crop biomass (lb/ac)[2]	-	**1246**	**969**	-	**327**	**0**

[1]Establishment: whole plot visual evaluation of density and vigor at harvest
[2]Dry matter biomass evaluated in areas of cover crop establishment

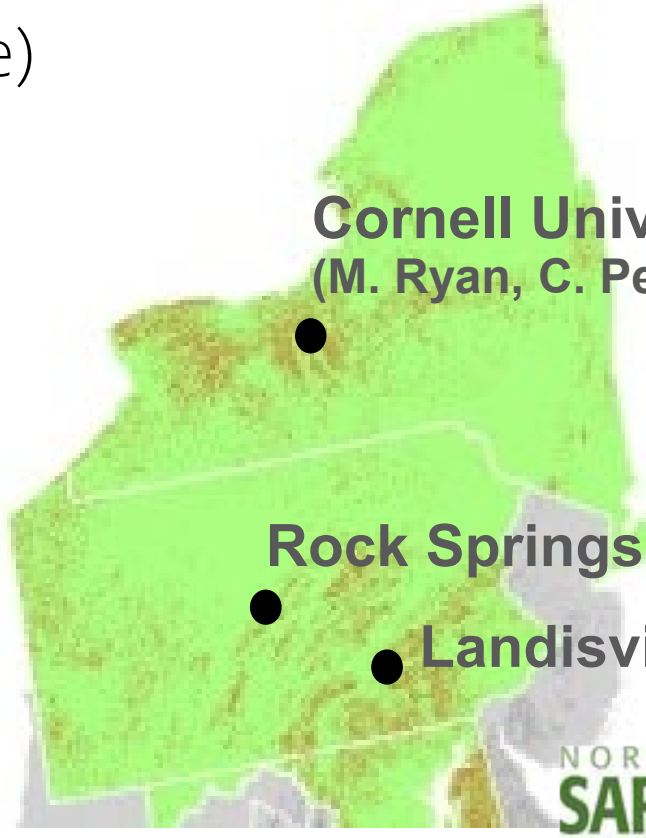
R. Hoover (PSU; unpublished data)

2020 Field Experiment



Improving ***production & persistence*** *of interseeded cover crops?*

1. Hybrids (flex ear vs. determinate)
2. IS timing (V3 vs V6)
3. Row spacing (30" vs. 60")



2020 Field Experiment: Row spacing x hybrid selection

Determinate ear (Local Seeds)
30” row spacing
Seed drop: 32K/ac
Burndown + POST glyphosate
Nitrogen applied at planting

Semi-flex (Local Seeds)
30” row spacing
Seed drop: 32K/ac
Burndown + POST glyphosate
Nitrogen applied at planting

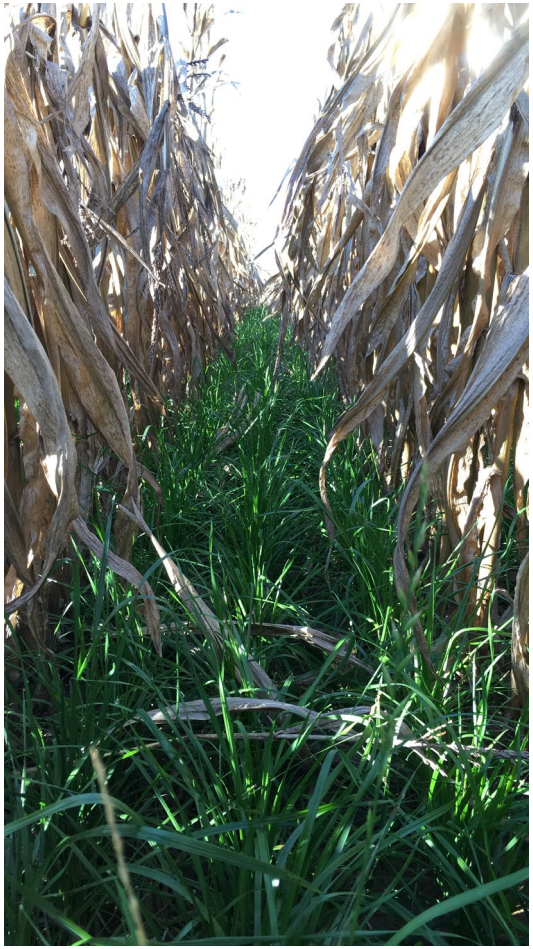
2020 Field Experiment: Row spacing x hybrid selection

Determinate ear (Local Seeds)
60” row spacing
Seed drop: 32K/ac
Burndown + POST glyphosate
Nitrogen applied at planting

Semi-flex (Local Seeds)
60” row spacing
Seed drop: 32K/ac
Burndown + POST glyphosate
Nitrogen applied at planting

2020 Field Experiment: Interseeding timing x species

Annual ryegrass
25 lb/ac
V3 vs. V6



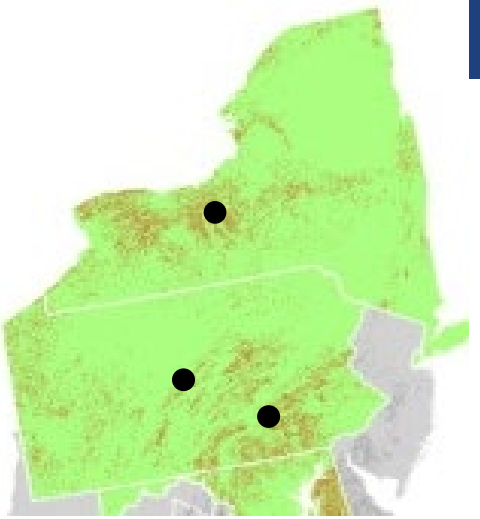
Cereal rye
90 lb/ac
V3 vs. V6

Medium red clover
15 lb/ac
V3 vs. V6

Spacing x hybrid: CC response

TAKE HOME (CC biomass):

- North-south latitudinal gradient
- 2X increase in 60” row spacing
- Determinate > Flex in 30” rows ($p < 0.01$)

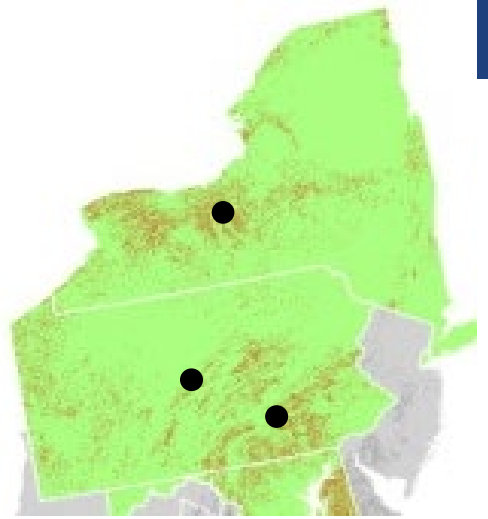


Corn Management		Cover crop biomass (lb/ac) at corn harvest					
Spacing	Hybrid	Aurora NY		Rock Springs PA		Landisville PA	
30”	Flex ear	177	**46%**	94	**11%**	9	**3X**
30”	Determinate	260		105		27	
60”	Flex ear	255	**80%**	170	**-9%**	49	**-9%**
60”	Determinate	460		155		45	

Photosynthetically active radiation (PAR)

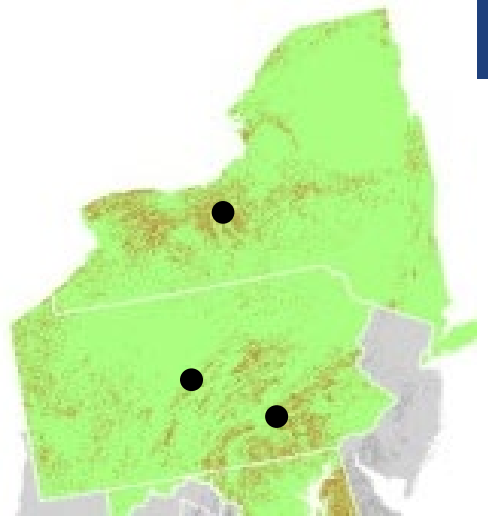
Spacing x IS Timing: CC response

TAKE HOME: Interseeding early(V3) increased CC biomass production in narrow (30”) and wide (60”) rows



Management tactics		Cover crop biomass (lb/ac) at corn harvest					
Corn spacing	CC sow timing	Aurora NY		Rock Springs PA		Landisville PA	
30”	V3	275	+68%	155	+3.5X	30	+5X
30”	V6	163		44		6	
60”	V3	490	+2.3X	213	+86%	61	+2X
60”	V6	211		114		33	

Spacing x hybrid: corn yield



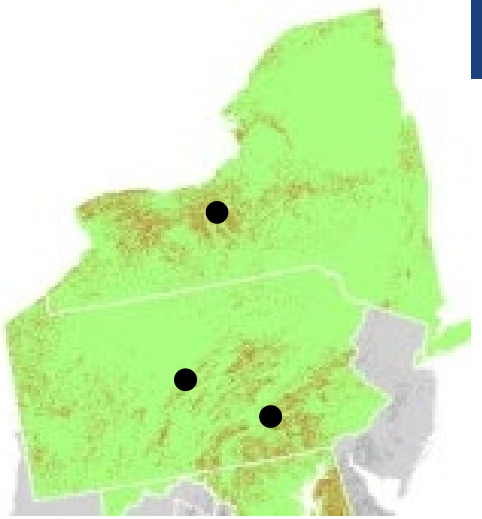
TAKE HOME: Consistent yield decline in 60” rows (16 to 45%)

Determinate > Flex in 30” row spacing
Flex > Determinate in 60” row spacing

Corn Management		Corn yield (bu/ac)					
Spacing	Hybrid	Aurora NY		Rock Springs PA		Landisville PA	
30”	Determinate	157	-45%	100	-27%	196	-30%
60”	Determinate	87		73		136	
30”	Flex ear	158	-35%	90	-16%	179	-22%
60”	Flex ear	103		75		140	

Spacing x hybrid: weed response

TAKE HOME: Use of 60” row spacing increased weed pressure 4X-14X compared to 30” rows ($p < 0.001$)



Corn Management		Weed biomass (lb/ac) at corn harvest					
Spacing	Hybrid	Aurora NY		Rock Springs PA		Landisville PA	
30”	Determinate	274	+4X	17	+14X	100	+12X
60”	Determinate	1090		245		1250	
30”	Flex ear	222	+4X	21	+7X	187	+4X
60”	Flex ear	1050		150		730	

Weed management in wide row corn

- NOTE: If CC will be livestock feed, herbicide options are limited to glyphosate, with few exceptions
- Mixtures of warm season covers will be needed to suppress late emerging weeds (buckwheat, millets, cowpea)
- Some cool season covers may go to seed and become volunteer weed issue
- Problems weeds in 60” corn: Glyphosate-resistant spp., waterhemp, palmer, fall-grasses

Herbicide-resistance management

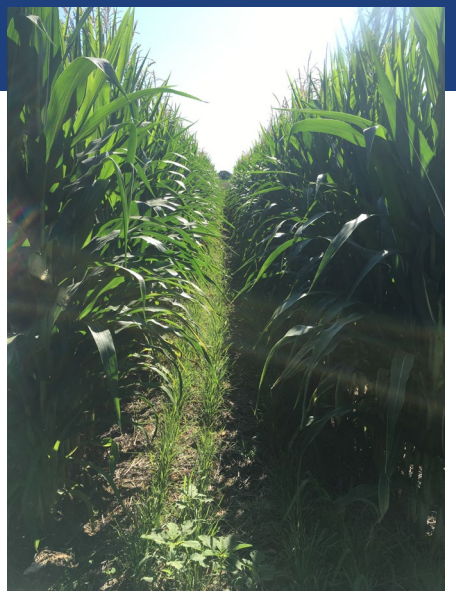
- POST glyphosate program
- Half-rate residuals + POST glyphosate
- Full-rate setup program + POST glyphosate
- Full-rate setup program + multiple MOA POST program
- Overlapping residual programs (PRE fb tolerant CCs fb post-residual)

late-emerging, multiple-resistant, pigweed *spp*

2020 Field Experiment

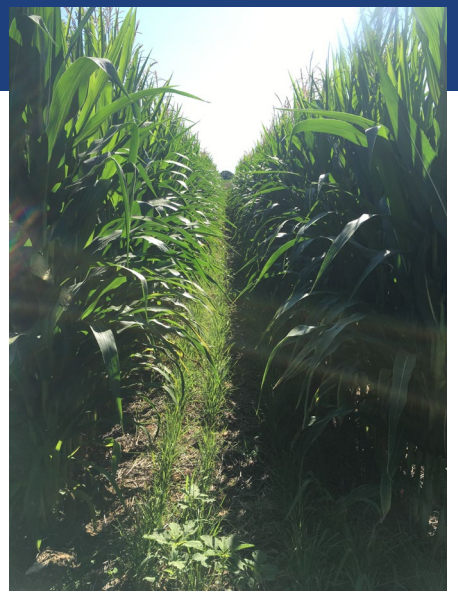
Testing conceptual approaches for:

1. Early interseeding (V3; ~ 28 DAP)
2. Species tolerance (setup vs. Cadillac)
3. Overlapping residuals



PRE	POST fb Interseed	Interseed fb Residual
None	Glyphosate	None
Set-up (Verdict)	Glyphosate	None
Set-up (Verdict)	None	Warrant (acetochlor; 15)
Zidua/Callisto/ATZ	None	None
Zidua/Callisto/ATZ	None	Warrant (acetochlor; 15)

2020 Field Experiment



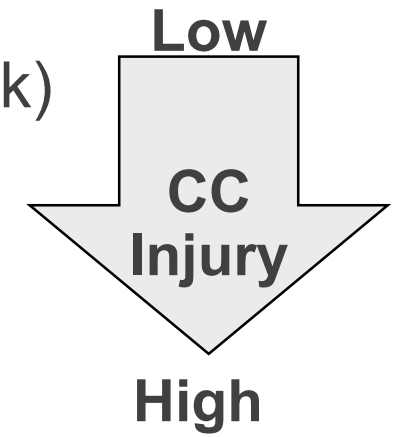
TAKE HOME:

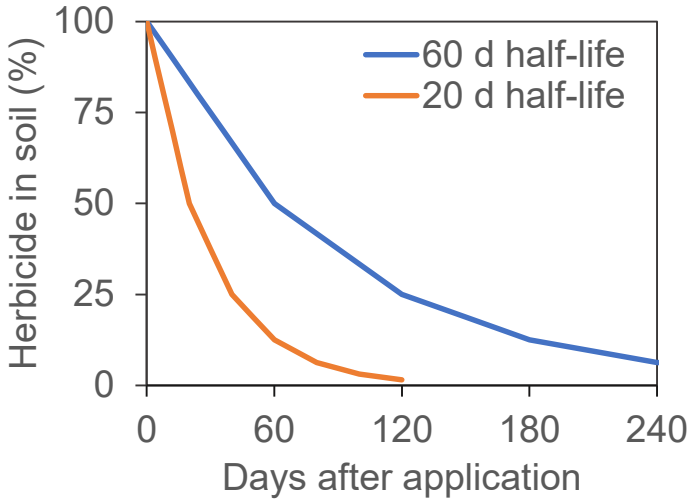
- Set-up programs injures ryegrass at V3 timing
- Cereal rye comes through "Cadillacs"
- Post-interseeding Group 15 residual may improve weed control w/ minimal impact to established cover crops?

		Relative to 1-pass glyphosate		
PRE program at planting	**POST program** days after interseeding	**Weed Control**	**Ryegrass density**	**Cereal rye density**
Verdict	Glyphosate 0 DAI	**+ 50%**	- 70%	+ 100%
Verdict	Warrant 10 DAI	**+ 75%**	- 66%	+ 33%
Zidua/Callisto/ATZ	--	**+ 66%**	- 98%	+ 66%
Zidua/Callisto/ATZ	Warrant 10 DAI	**+ 90%**	- 99%	+ 45%

Persistence in soil

Group 15 herbicides
dimethenamid (Outlook)
acetochlor (Harness)
pendimethalin (Prowl)
S-metolachlor (Dual)
pyroxasulfone (Zidua)





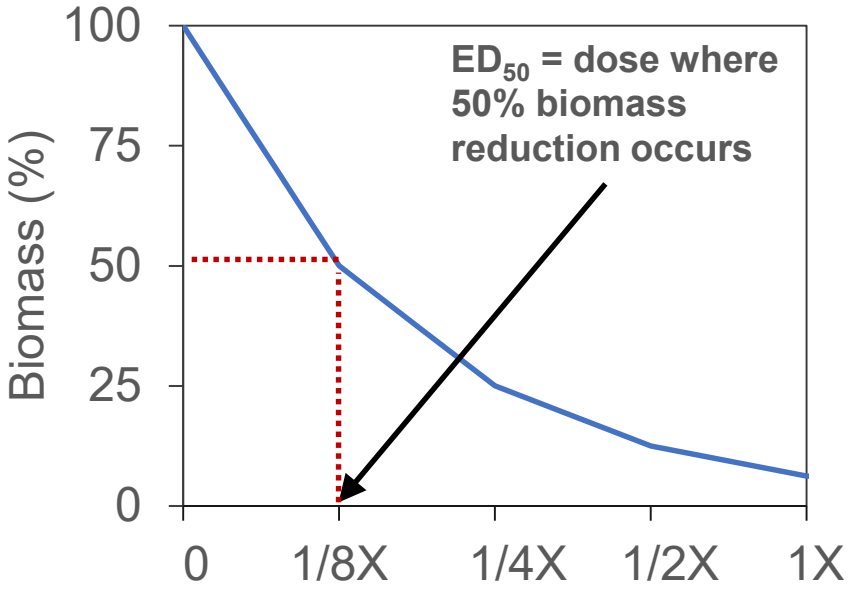
Atrazine
Interseed grass/broadleaves safely at 0.5 – 1 lb ai/ac

HPPDs (Group 27s)
Callisto & Balance will result in significant injury to small seeded broadleafs

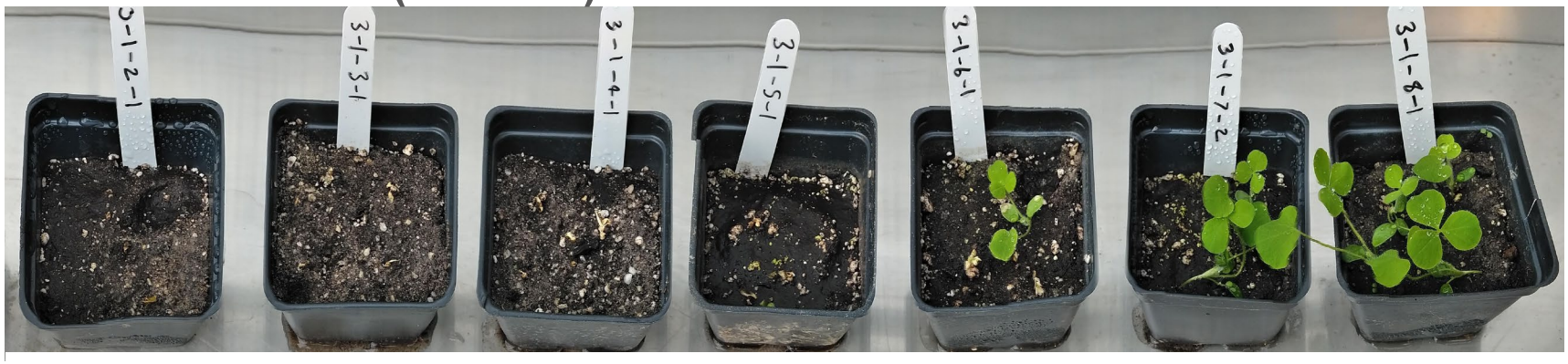
Wallace et al. (2017)

Cover crop sensitivity: Exploiting CC tolerances?

At a given herbicide dose in soil, or # of half-lives, cover crop species should differ in sensitivity.



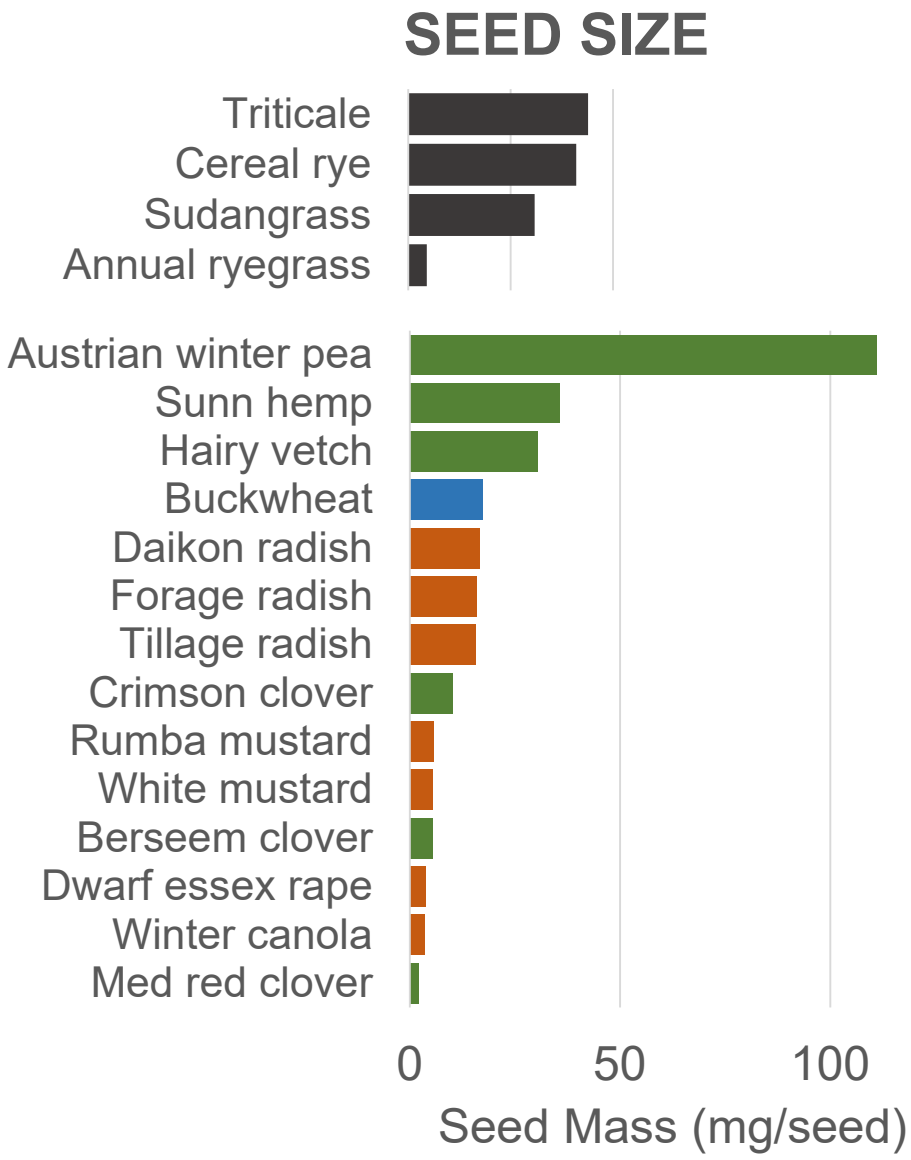
EX: Mesotrione (Callisto): Crimson clover



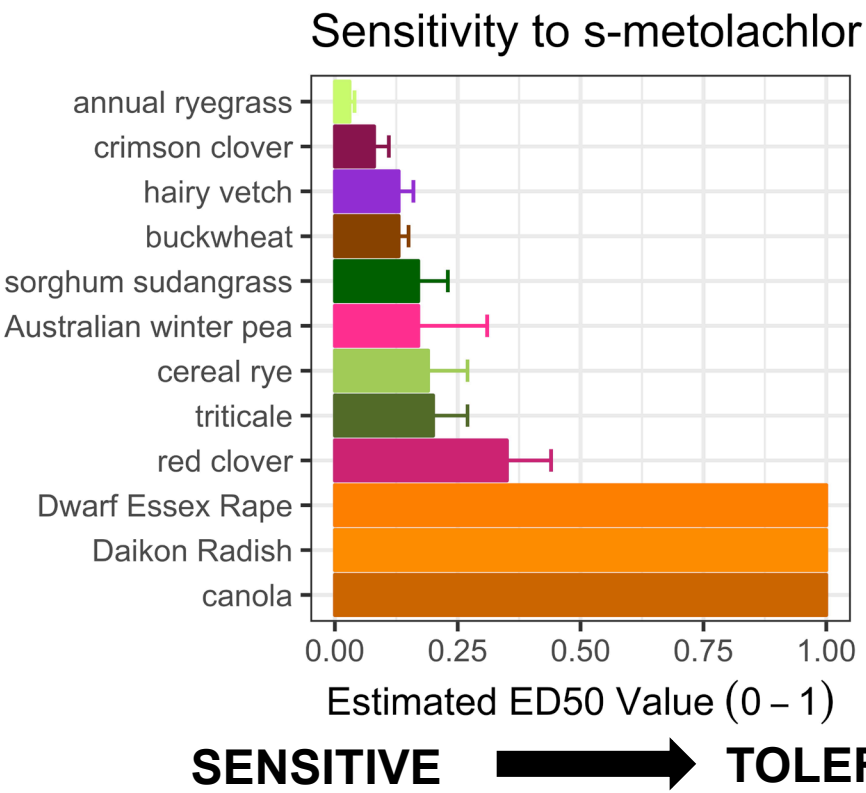
Cover crop sensitivity: Exploiting CC tolerances?

Sources of variation:

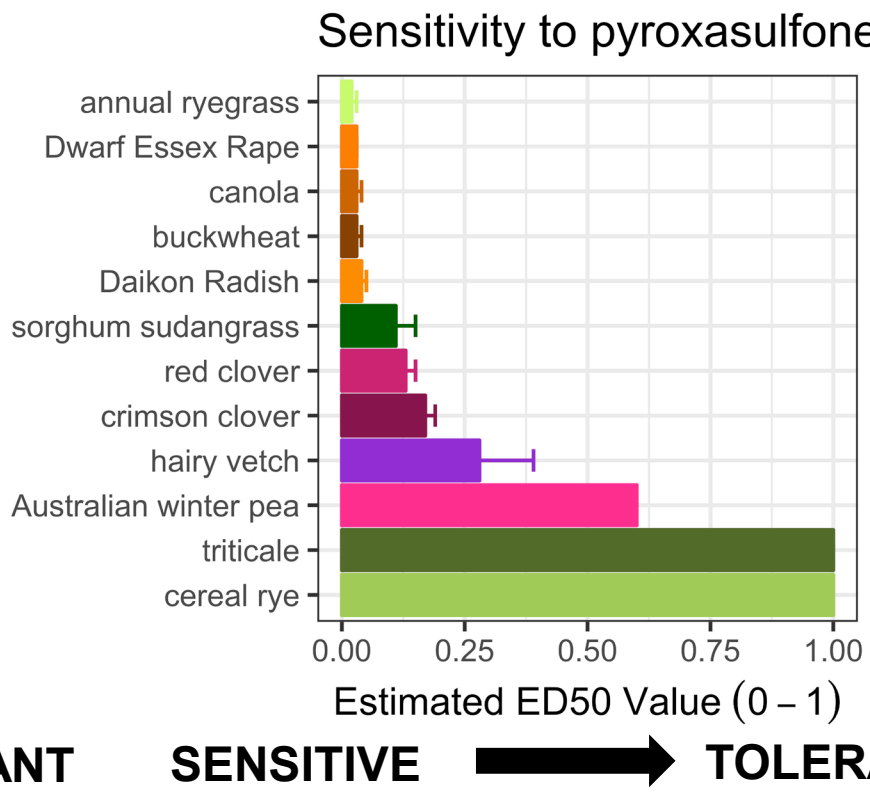
1. Grass, legume, brassicas
2. Seed size



Cover crop sensitivity: Exploiting CC tolerances?



SENSITIVE → **TOLERANT**



SENSITIVE → **TOLERANT**

Wallace and Maloney (in prep)

Relative sensitivity table: forthcoming soon!

	Zidua	Dual	Outlook	Harness	Prowl
Annual ryegrass	5	5	5	5	4
Sorghum sudan	3	3	3	3	3
Cereal rye	T	2	2	3	T
Triticale	T	2	2	4	T
Medium red clover	3	2	5	5	2
Crimson clover	3	4	4	5	2
Hairy vetch	2	3	3	5	2
Austrian winter pea	1	3	2	4	2
Winter canola	5	T	T	3	T
Forage rape	5	T	T	1	T
Daikon radish	4	T	T	2	T
Buckwheat	5	3	5	5	1

SCALE: Estimated ED_{50s} using nearest half-life value; T = tolerant (ED_{50} > 1X rate).

Interseeding & Weed Control Tactics

- Crop diversity & weed seedbanks
  - crop diversity → low weed seedbanks (OR)
  - low weed seedbanks → crop diversity
- NOTE: Integrated livestock systems
  - Necessarily a low herbicide input system
- Proactive herbicide resistance management?
  - Reduce seed rain in the corn phase (waterhemp management)
  - Avoid single MOAs and half-rate herbicide programs
- Making the most of CC mixtures
  - Mixtures limit herbicide options; but we may be able to find CC mixtures that are tolerant to certain programs

Acknowledgments

Past Work

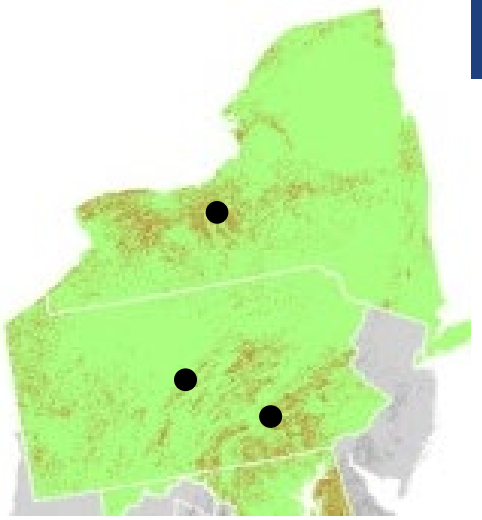
- **Research team:** Bill Curran (Professor emeritus, PSU), Greg Roth (Professor emeritus, PSU), Corey Dillon (Agronomy Farm Manager, PSU), Ron Hoover (On-farm research coordinator, PSU), Chris Houser (PSU), Matt Ryan (Cornell University), Steven Mirsky (USDA Beltsville)
- **Funding sources:** NRCS-CIG, OREI

Current Work (2020 – 2023)

- **Research & extension team:** Tosh Mazzone (Research technologist, PSU), Matt Ryan (Cornell University), Chris Pelzer (Cornell University), Bryan Brown & Jaime Cummings (NY-IPM), Zach Larson, Heidi Reed & Ron Hoover (PSU Extension Agronomy), Jonathan Martin (Finger Lakes Agronomics), Genesee River Watershed Coalition of Conservation Districts, Soil Water Conservation Districts (Niagra Co, NY; Clinton Co, PA)
- **Funding sources:** NESARE

Spacing x CC species: CC response

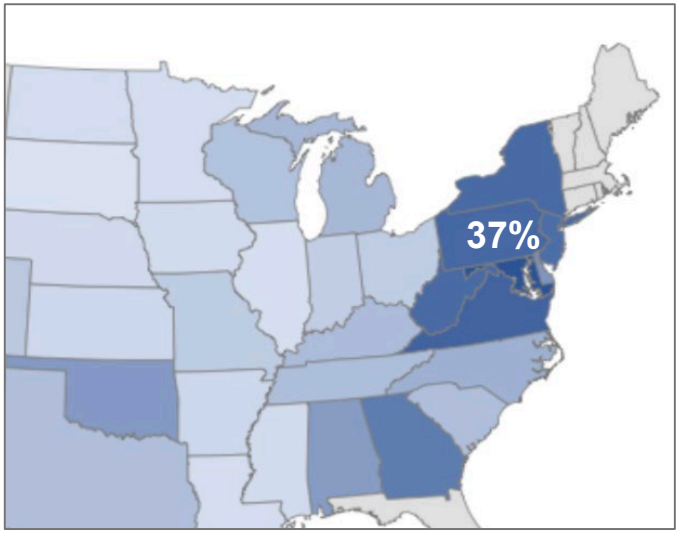
TAKE HOME: Effect of row spacing on biomass of CC species differed by location.



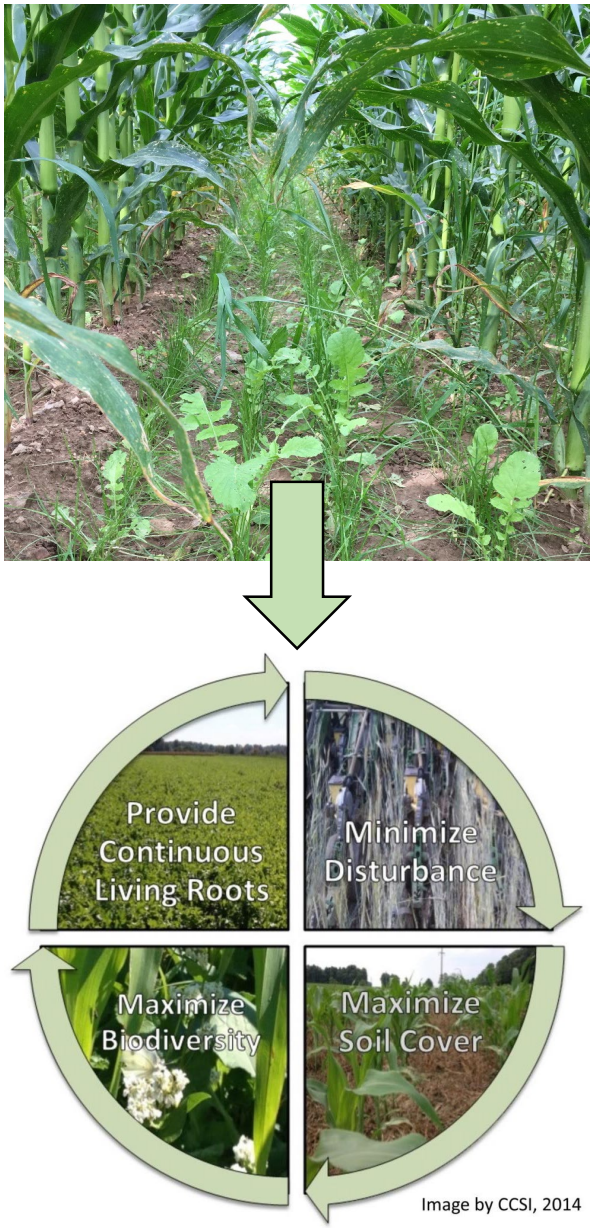
Management tactics		**Cover crop biomass (lb/ac) at corn harvest**					
Corn spacing	**CC species**	**Aurora NY**		**Rock Springs PA**		**Landisville PA**	
30”	ryegrass	274	**73%**	123	**+47%**	14	**+50%**
60”	ryegrass	476		182		21	
30”	cereal rye	213	**76%**	119	**+85%**	7	**+3X**
60”	cereal rye	377		221		22	
30”	red clover	169	**17%**	56	**+50%**	33	**+3X**
60”	red clover	199		84		97	

The Promise and Potential of Interseeding

Cover cropping in grain crop systems



R. Myers (2018)



SPECIES SELECTION

Shade tolerant species

annual ryegrass

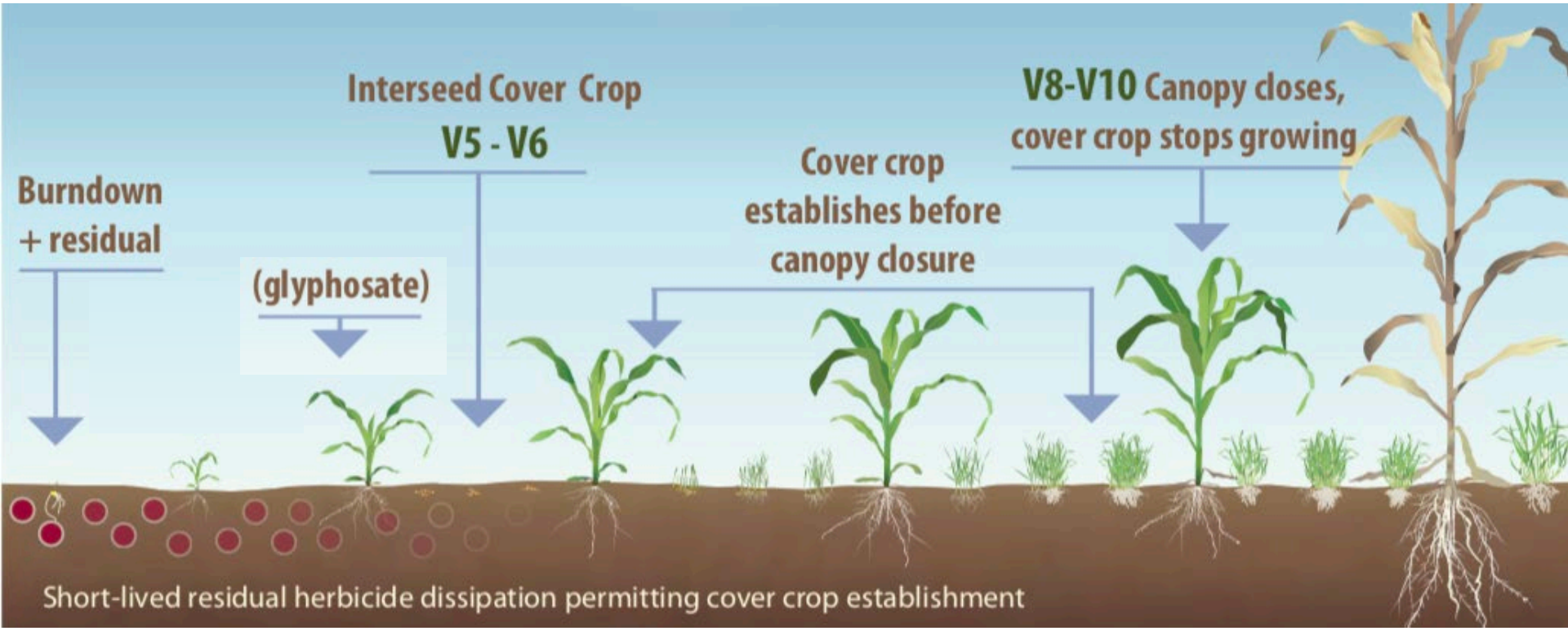
Medium red clover

Daikon radish

Caswell et al. (2018)

SOIL CONSERVATION
on erosion prone lands

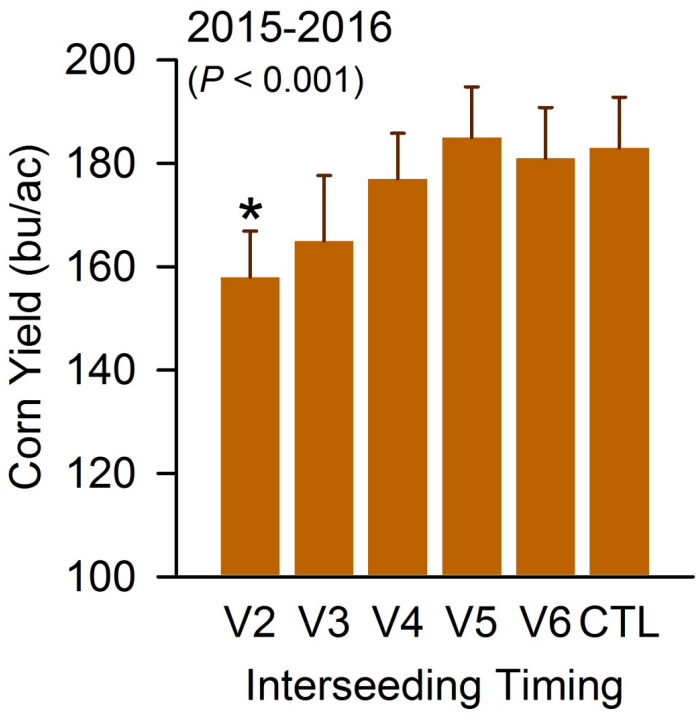
INTERSEEDING BMPs
for no-till corn production

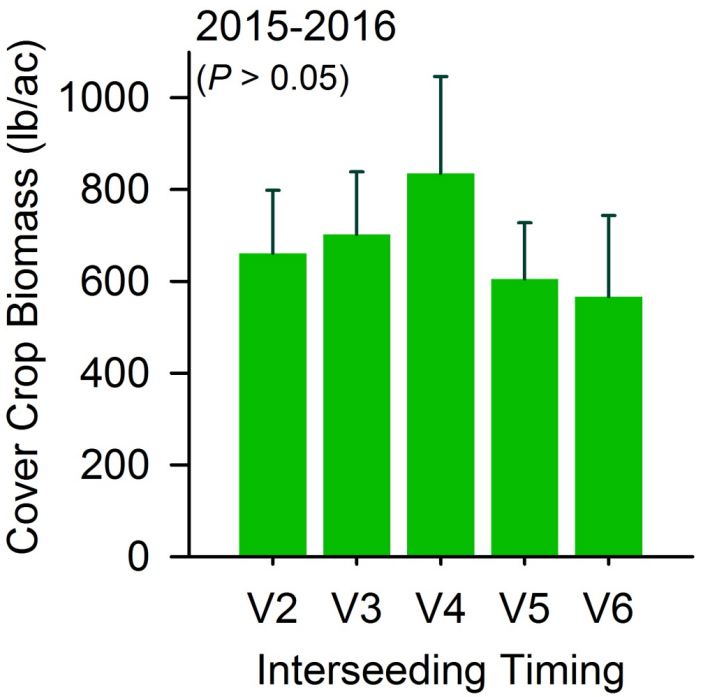


Wallace (2018) Farm Journal editorial

INTERSEEDING TIMING

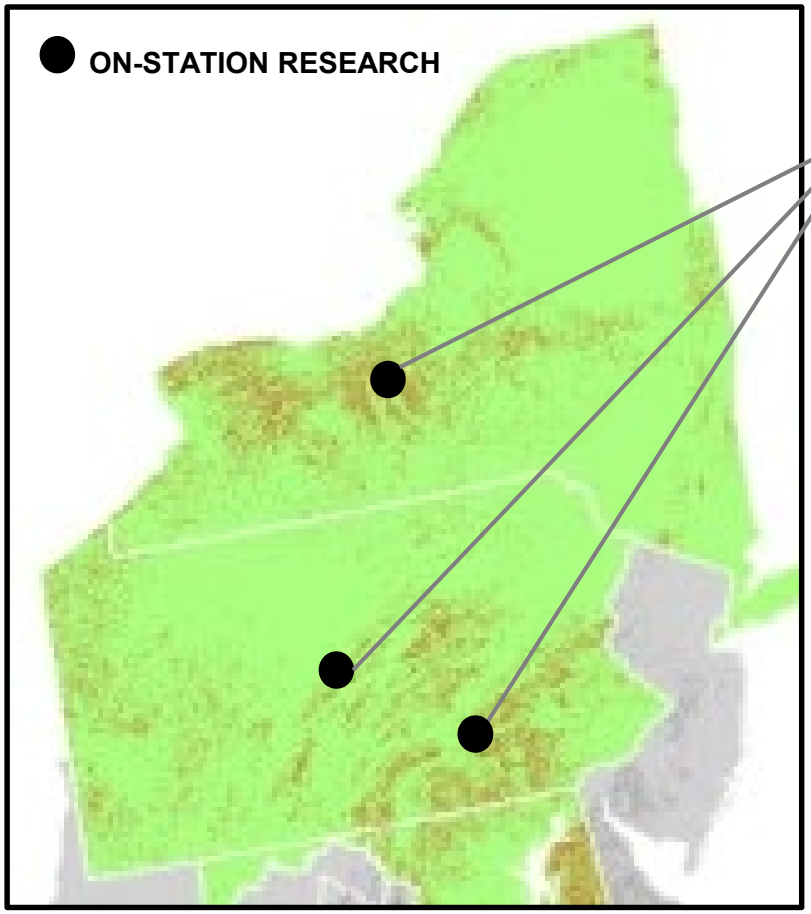
Minimize potential for corn yield drag while maximizing cover crop growing season window



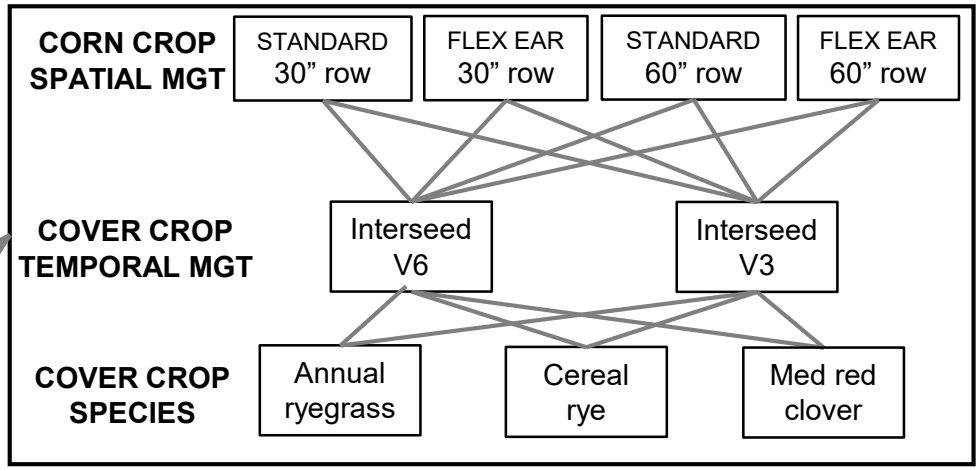


Curran et al. (2018)

ENVIRONMENTAL CONSTRAINTS AND MANAGEMENT RESPONSES FOR INTERSEEDING COVER CROPS



2020 & 2021 EXPERIMENT



NORTHEAST SARE
Sustainable Agriculture Research & Education

2020 Field Experiment

Landisville PA

Determinate ear
30” row spacing; 32K

Semi-flex
30” row spacing; 32K

2020 Field Experiment

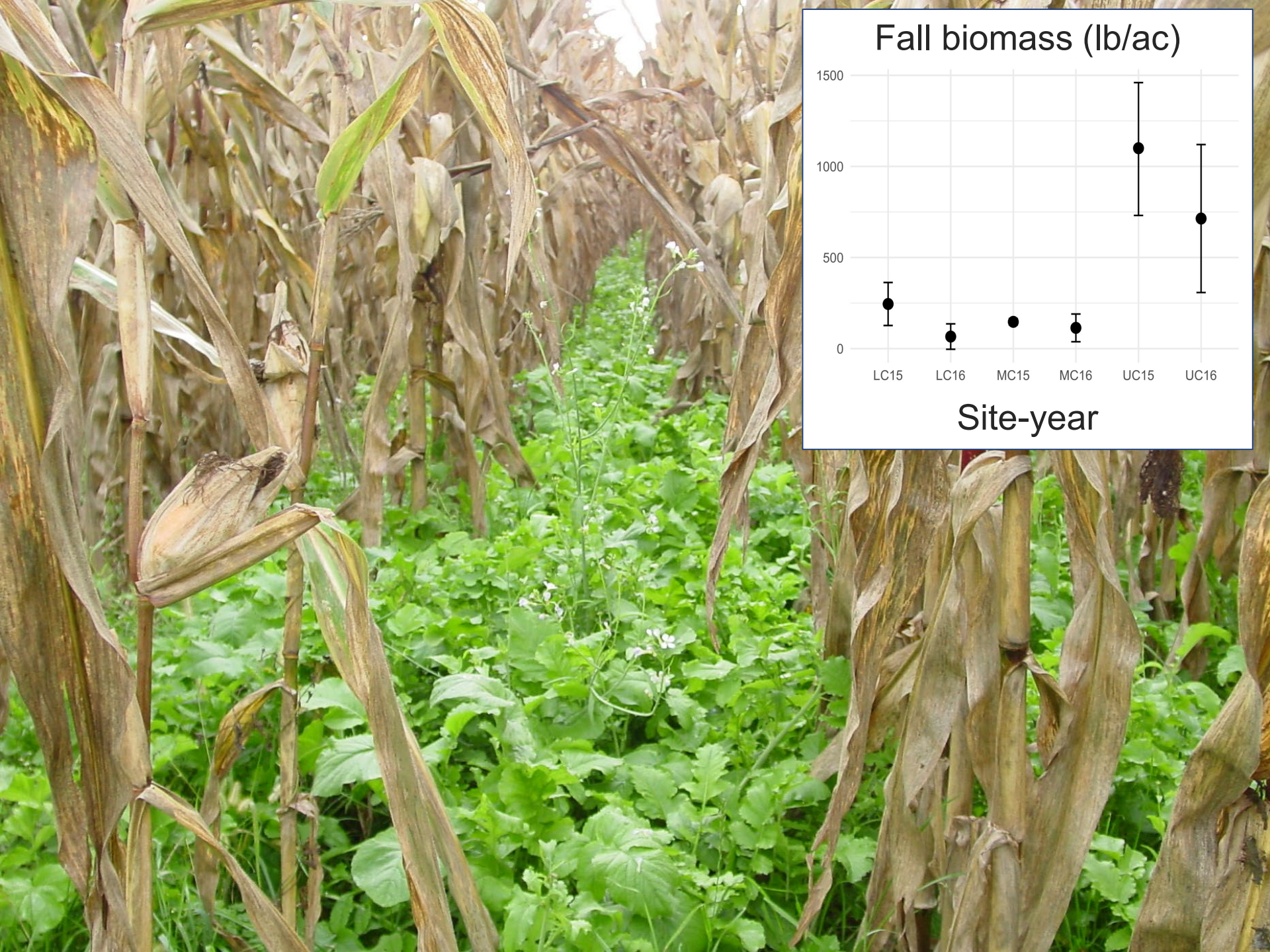
Landisville PA

Determinate ear
60” row spacing; 32K

Semi-flex
60” row spacing; 32K


BRILLION

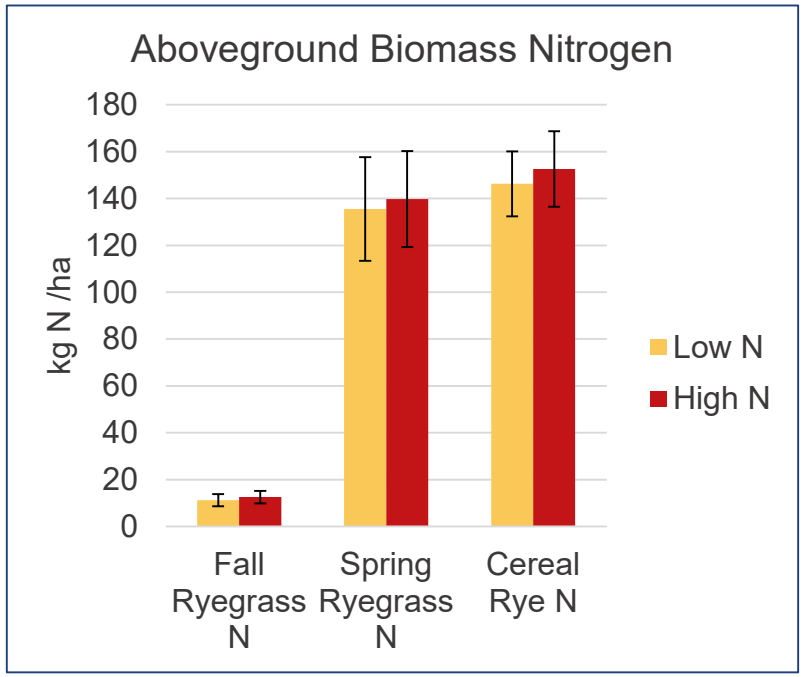
Drill-interseeding marginally improved cover crop establishment compared to **broadcast interseeding** in organic grain corn (Wallace et al. 2019)


Fall biomass (lb/ac)
1500
1000
500
0
LC15
LC16
MC15
MC16
UC15
UC16
Site-year

Nitrogen retention services provided by plant-microbial linkages in organic interseeded cover cropping systems

Sarah Isbell and Jason Kaye, PSU

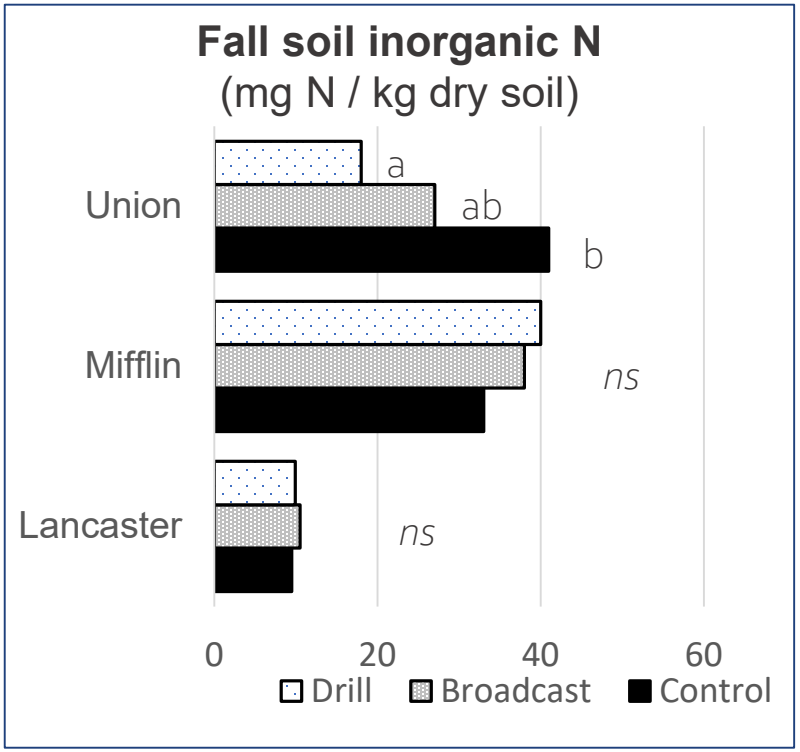
NORTHEAST SARE
Sustainable Agriculture Research & Education
GNE16-122



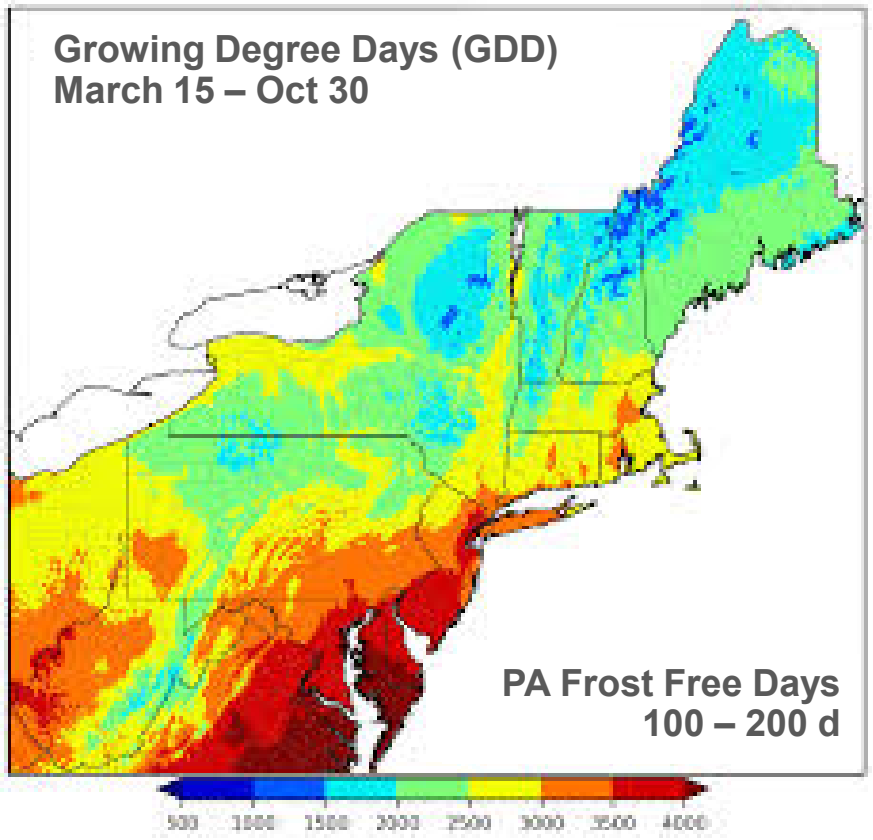
PennState
College of Agricultural Sciences

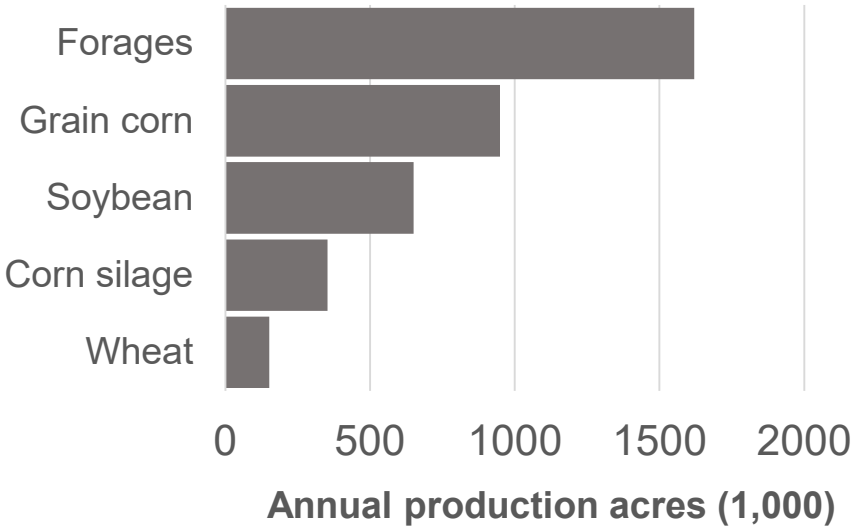
Interseeding

Nitrogen retention on organic grain farms

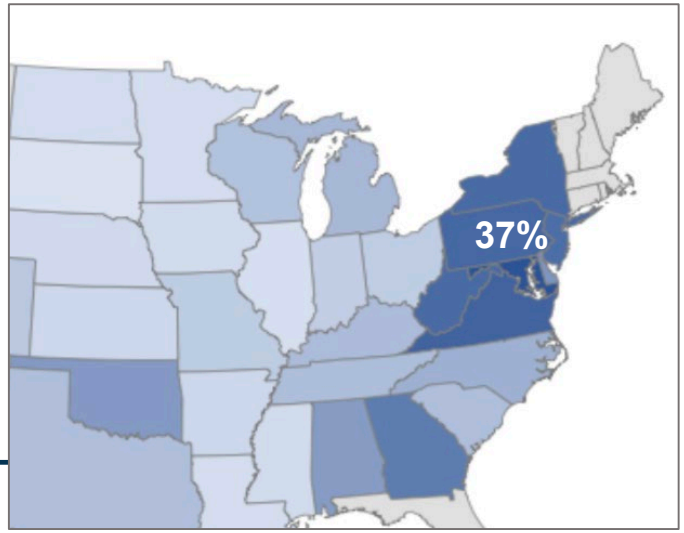


Pennsylvania climate & agriculture





Cover cropping in grain crop systems



R. Myers (2018)

Northeast producer survey (2020)

What factors drive interest in CC interseeding?