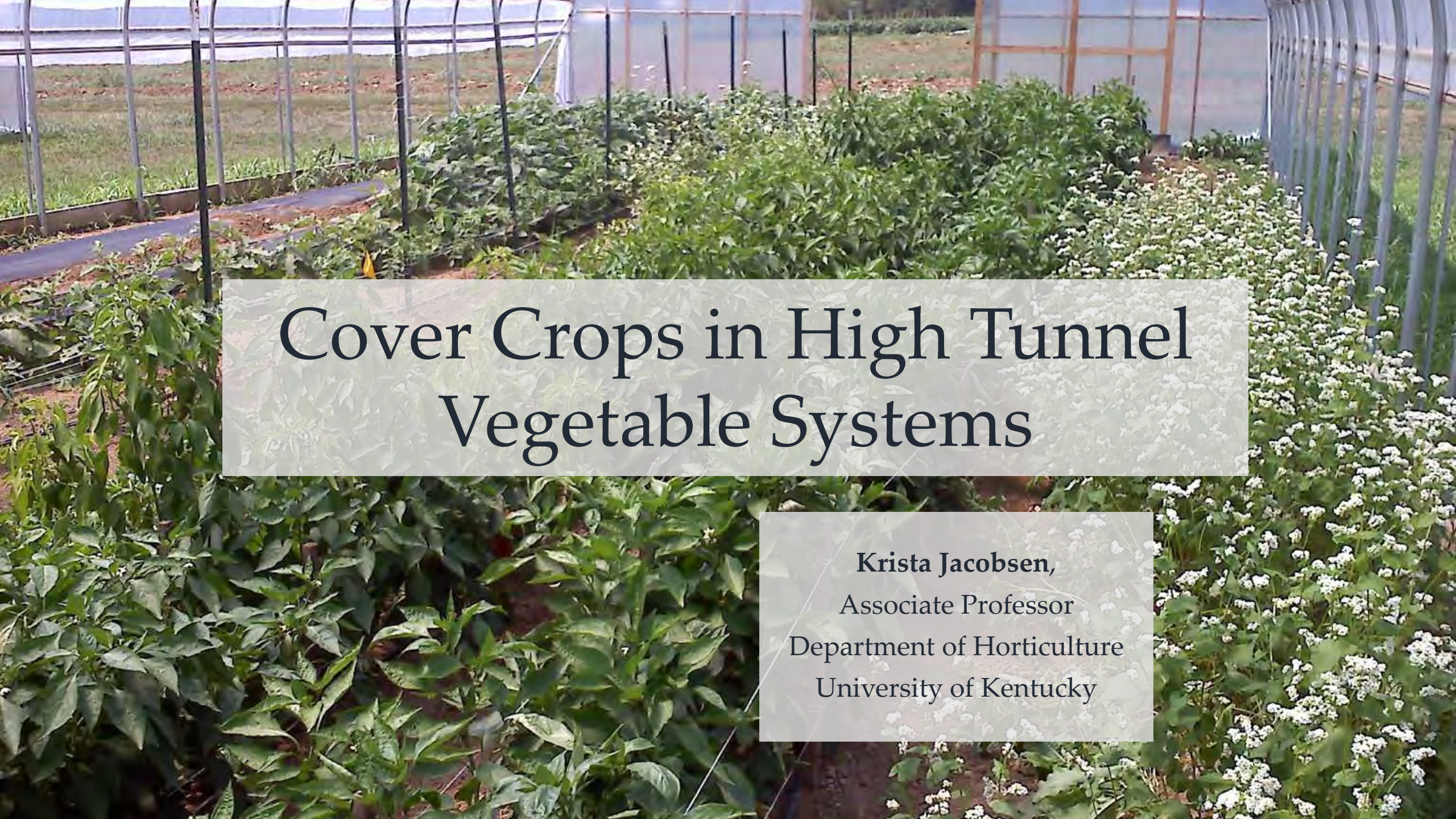


Cover Crops in High Tunnel Vegetable Systems

Krista Jacobsen,
Associate Professor
Department of Horticulture
University of Kentucky

What is a high tunnel?
Why is it so different than the open field?

- (Usually) unheated greenhouse structures
- (Usually) passively heated and ventilated
- Allow for season extension and year-round specialty crop production
- Small scale, high intensity production
  - 30-50% higher yields
  - 30’ x 72-96’ is relatively standard
  - Multi-bay systems can put a lot of acreage under plastic


High tunnels and suburban housing north of Kunming in Yunnan Province, China.
And we thought tunnels were big in the US!
National Geographic Magazine, February 2018

High Tunnels: Intensively Cropped, Irrigated Deserts

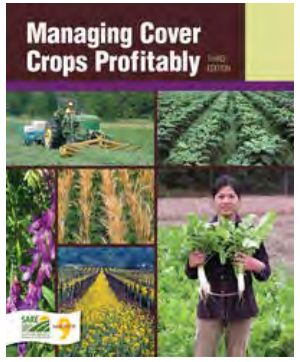
- Generally warmer, but more temperature variability than open field
- Do not experience leaching rains, so salts (and nutrients) remain
- Irrigation required for both crop production and decomposition
- Warmer environment increases soil organic matter breakdown and nutrient mineralization
- Faster growth rates can make nutrient deficiencies worse

The High Tunnel "Cover Crop Niche"

Rotation

Tomatoes Fallow

Tomatoes Lettuces or Greens



"Niche"

Temporal window

Pests

Nutrients

Management factors

Water

Biomass

Decomp factors

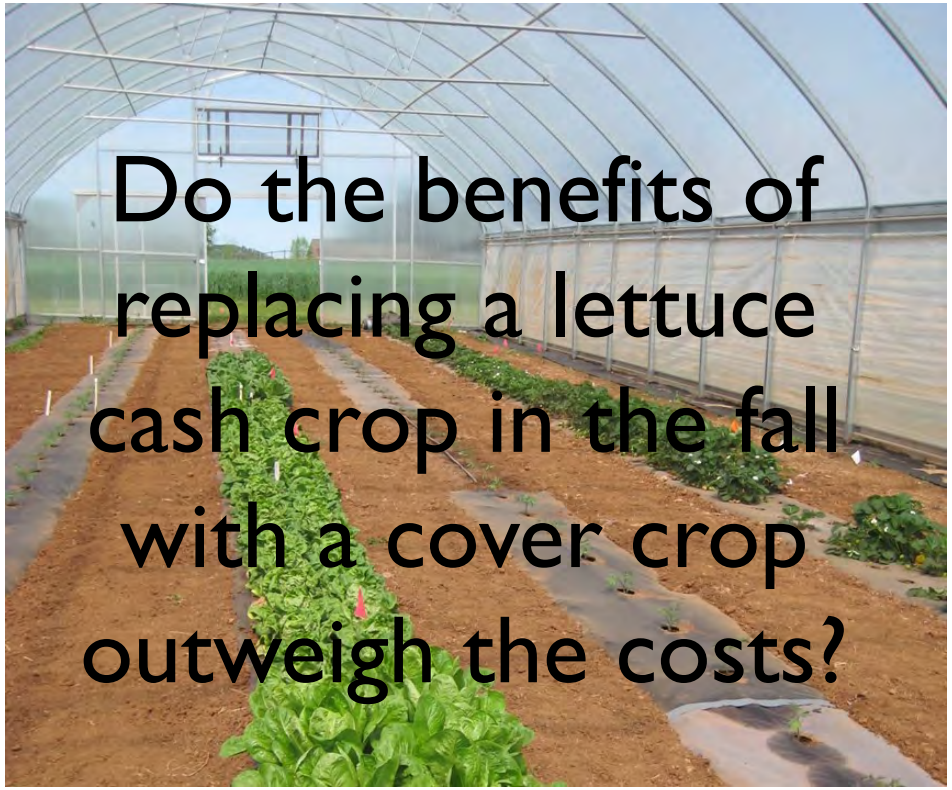
Nematodes, varmints

N, but also P, SOM & salts

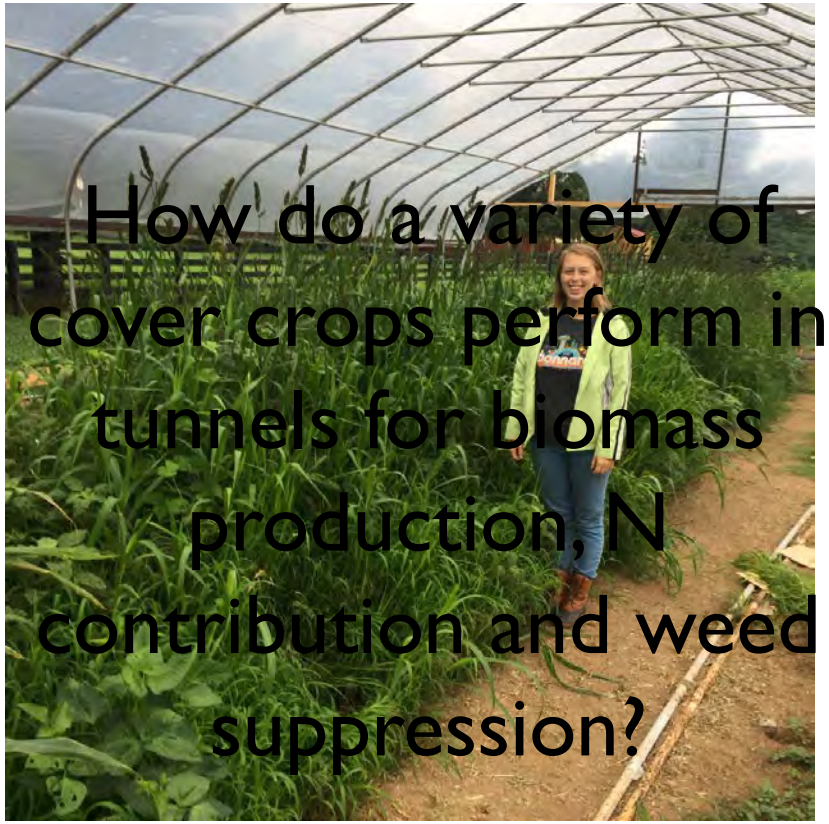
Termination timing, technique

Covers Crops Under Cover

I. Evaluating ecosystem services of cool season cover crops in high tunnel veg systems



II. Novel cover crops for high tunnel “niches”

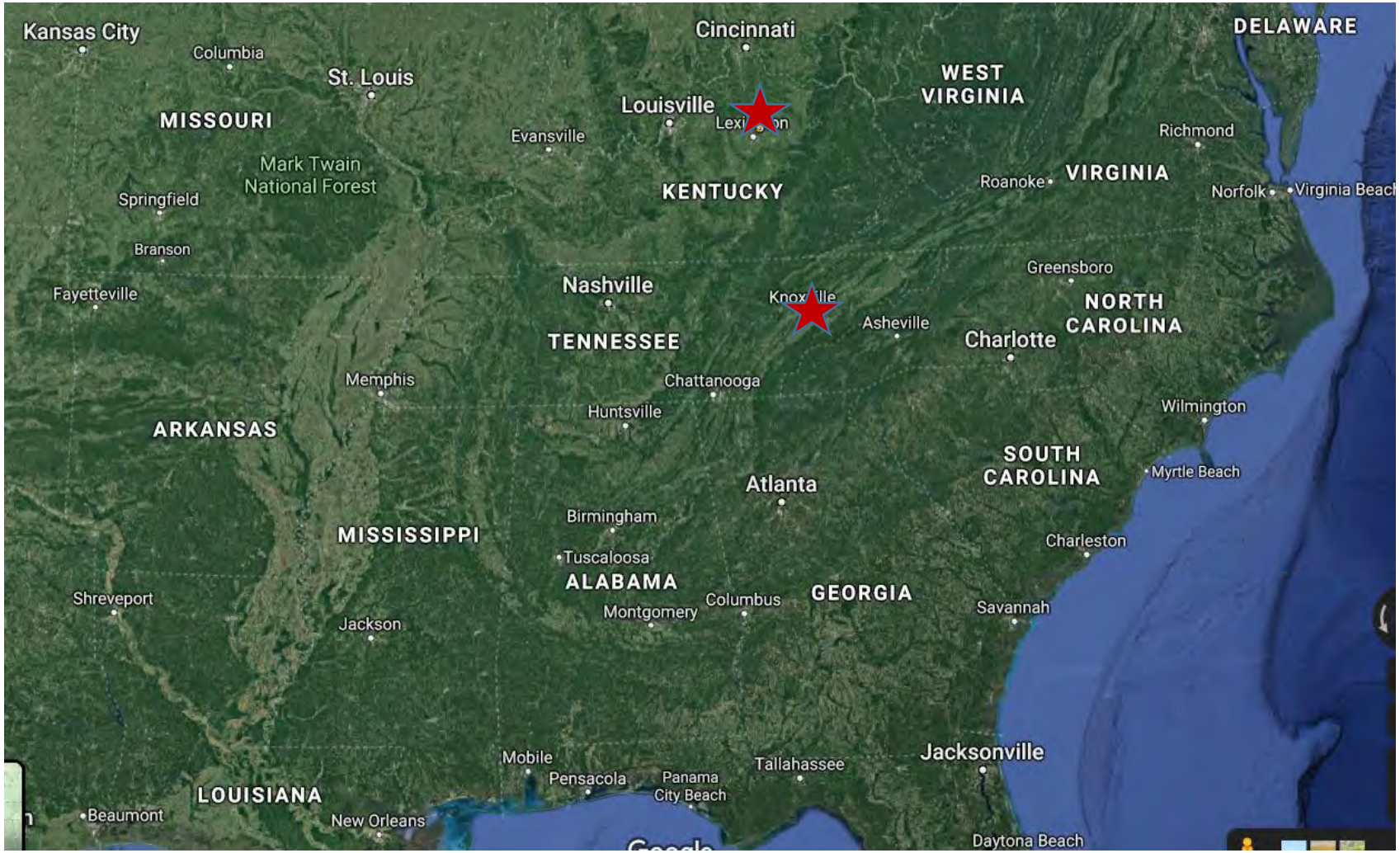


Southern SARE R&E award LS16-272, and a Southern SARE YSE grant

Ecosystem Services Experimental Design

Two years, two sites

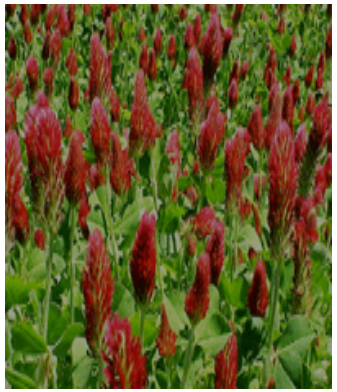
- Univ. of KY
  Lexington, KY
- Univ. of TN
  Knoxville, TN
- Fall 2016-Fall 2018



Ecosystem Services Experimental Design

4 fall-winter treatments:

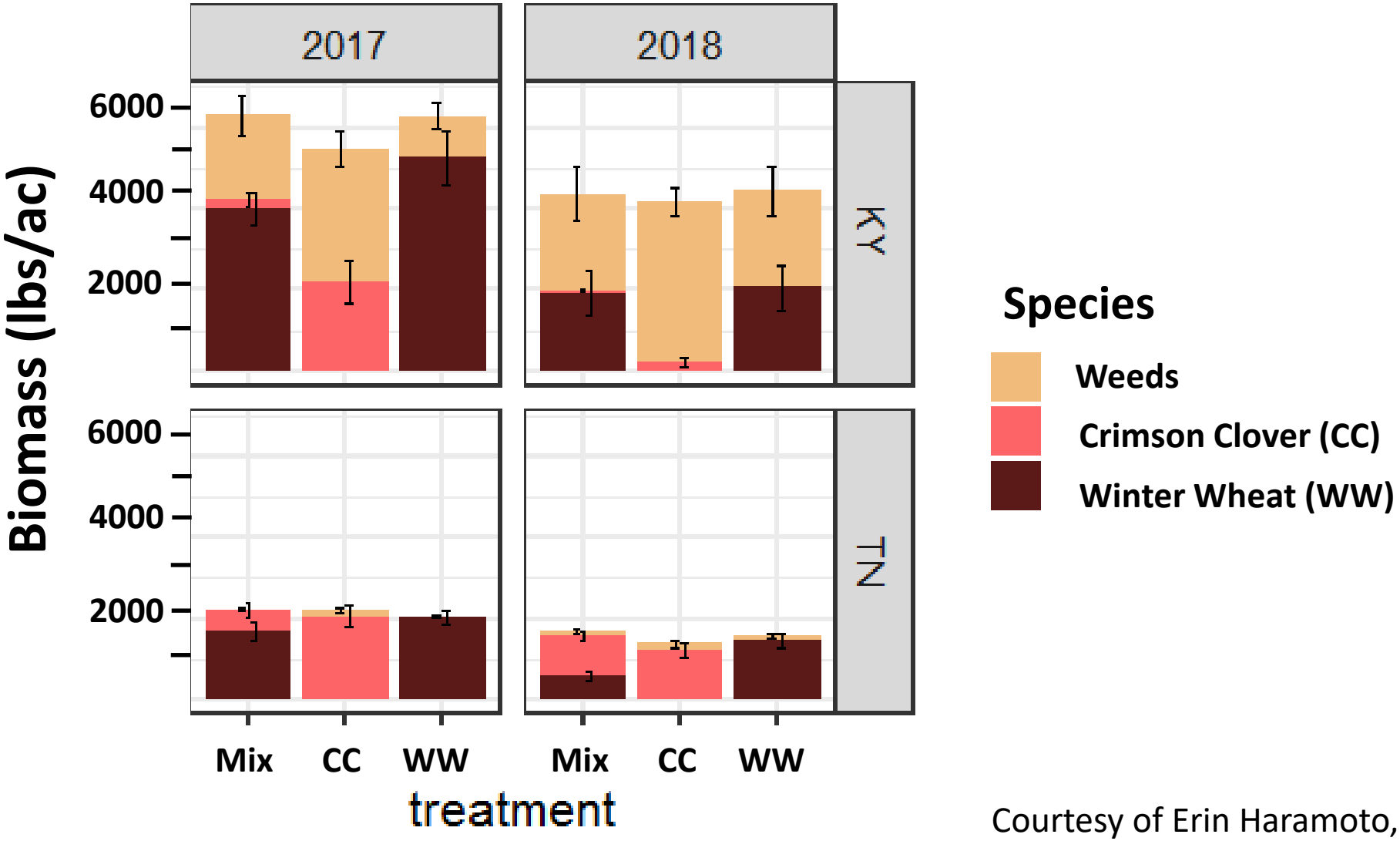
- Winter wheat cover crop (125 lbs/acre)
- Crimson clover cover crop (30 lbs/acre)
- Wheat/clover mix cover crop (15 lbs/acre clover, 60 lbs/acre wheat)
- Lettuce cash crop (‘Winter Density’ and ‘Kalura’ romaine)




Ecosystem Services Experimental Design

- Plots were 30 ft beds per high tunnel (6 reps in KY, 8 reps in TN)
- Cover crops sown and lettuce planted Oct. 2016 and 2017
- Cover crops mowed early March 2017 and 2018, tilled in 5 days after mowing
- NatureSafe 8-5-5 spread about 2 weeks later and tilled in
- Fertilizer amount based on N credit from cover crop biomass (clover plots had less added fertilizer)
- Cover crop calculator to determine N from biomass:
  - http://www.extension.uidaho.edu/nutrient/CC_Calculator/Cover_Crop_Main_page.htm
- Tomatoes ('Early Girl') planted in all treatment beds in late March 2017 and 2018, 14 plants per plot

Cover Crop and Weed Biomass



Courtesy of Erin Haramoto, UKY

Subjective Plant Health Ratings: UT

Treatment	Rating
Clover cover	7.7 a
Lettuce cash crop	6.8 ab
Wheat cover	5.7 b
Wheat/Clover bi-culture	7.2 ab

Ratings: 1 = least healthy to 10 = most healthy

Courtesy of Annette Wszelacki, UT

Total Yield Data

No cover crop treatment effects, except in wheat in TN 2017.

Treatment	Marketable and Total harvest by weight- season total fruit (lbs/plot)							
	Kentucky				Tennessee			
	2017		2018		2017		2018	
	Mkt	Total	Mkt	Total	Mkt	Total	Mkt	Total
Cash crop	84.8	120.5	26.6	45.6	56.3	136.7 a	9.0	52.5
Clover	88.7	122.9	31.7	53.8	63.7	144.9 a	12.6	61.0
Mixture	86.7	117.2	26.2	50.4	57.8	136.7 a	15.2	55.6
Wheat	91.4	120.6	37.2	60.4	46.8	109.3 b	14.7	53.0
P-value	0.9455	0.9637	0.1303	0.6876	0.1051	0.0094	0.0762	0.8431

Courtesy of Jenny Moore, UT

Effects on soil properties, Kentucky

No substantial cover crop treatment effects.

Effect	PMN	POXC	P (lb/ac)	K (lb/ac)	pH	Ca (lb/ac)	Mg (lb/ac)	Zn (lb/ac)	Total_ N (%)	Soluble_Salts (mmhos/cm)	Total_C (%)
Treatment	0.1326	0.5210	0.3988	0.2554	0.2840	0.9133	0.5747	0.4540	0.7304	0.9971	0.8889
Depth	<.0001	0.0003	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Treatment * Depth	0.4263	0.7758	0.9288	0.0923	0.0979	0.0397	0.0905	0.3593	0.4555	0.8876	0.3914
Date	<.0001	0.0230	0.1072	<.0001	0.0028	<.0001	0.0010	0.6525	0.0100	<.0001	0.0042
Treatment * Date	0.1862	0.0230	0.6124	0.5065	0.6123	0.9400	0.4141	0.5764	0.9675	0.7929	0.9294
Date * Depth	0.8273	0.2943	0.0250	0.3370	0.3575	0.2366	0.1668	0.0396	0.0015	0.0206	0.0082
Treatment * Depth * Date	0.5769	0.8831	0.7744	0.8317	0.8346	0.1374	0.5429	0.8885	0.3363	0.4481	0.5218

Proc Mixed, date*rep as random variables. P-values considered significant if $p \leq 0.05$.

Effects on soil properties, Kentucky site

Main effect		P (lb/ac)	K (lb/ac)	pH	Ca (lb/ac)	Mg (lb/ac)	Total N (%)	Total C (%)	Soluble Salts (mmhos/cm)	Season	PMN (lbs/ac)	POXC (lbs/ac)
Date	**2016**	NS	304a	6.48a	5695a	572a	0.15ab	1.54a	0.42a	Fall	11.6ab	275ab
										Spring	13.7ac	383a
	2017	NS	245b	6.67b	5662a	747b	0.16a	1.76b	0.41a	Fall	15.3c	208b
										Spring	8.8b	496a
	2018	NS	181c	6.37ab	4433b	623a	0.14b	1.47a	0.23b	Fall	10.0b	358a
Depth	**0-6”**	203a	296a	6.69a	5838a	789a	0.17a	1.82a	0.25a		13.6a	405a
	6-12”	272b	213b	6.33b	4689b	526b	0.13b	1.38b	0.48b		10.2b	273b

Effects on soil properties, Tennessee

Date and depth trends similar to KY, but some treatment effects in TN.

Effect	PMN	POXC	P (lb/ac)	K (lb/ac)	pH	Ca (lb/ac)	Mg (lb/ac)	Zn (lb/ac)	Total_N (%)	Soluble_Salts (mmhos/cm)	Total_C (%)
Treatment	0.6680	0.9391	0.0058	0.3252	0.0148	0.1609	0.0539	0.2723	0.1160	0.0189	0.2707
Depth	0.8747	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0001	<.0001	<.0001	<.0001
Treatment * Depth	0.5910	0.0564	0.7248	0.5798	0.8635	0.7321	0.3816	0.1608	0.9758	0.4567	0.2946
Date	0.0003	<.0001	0.1327	<.0001	0.3086	0.0047	<.0001	<.0001	0.0439	0.0082	0.1113
Treatment * Date	0.0904	0.2692	0.1135	0.0221	0.0674	0.2925	0.0084	0.0267	0.0467	0.2957	0.3077
Date * Depth	0.1935	0.4588	0.0176	0.4100	0.0005	0.0174	<.0001	<.0001	0.3295	0.0108	0.0331
Treatment * Depth * Date	0.7067	0.0696	0.3600	0.8533	0.6517	0.7690	0.6062	0.7293	0.0930	0.2354	0.0674

Effects on soil properties, Tennessee

Some indication that cover crops may help reduce P contributions in organic systems.

Main effects		P (lb/ac)	K (lb/ac)	pH	Ca (lb/ac)	Mg (lb/ac)	Total N (%)	Total C (%)	Soluble_Salts (mmhos/cm)	Season	POXC (lbs/ac)	PMN (lbs/ac)
Date	2016		280a		2911a	676a	0.0838a		0.23ab	Fall	203a	6.8a
										Spring	428b	9.0a
	2017		228b		3052a	695a	0.0821ab		0.27b	Fall	446b	15.9b
										Spring	259a	ND
	2018		153c		2468b	497b	0.0763b		0.16b	Fall	393b	6.8a
Depth	0-6”	100a	301a	5.76a	3269a	670a	0.0991a	1.15a	0.37a		426a	
	6-12”	25b	156b	5.41b	2352b	576b	0.6656b	0.83b	0.13b		258b	
Treatment	Continuous Crop	62a		5.58ab					0.20a			
	Grass Cover	49b		5.65a					0.21ab			
	Grass + Legume Cover	53ab		5.57ab					0.21ab			
	Legume Cover	49b		5.55b					0.25b			

Summary

- The positive effects of cover crops can take several years to become apparent
- Cover crop treatments have complex effects on ecosystem properties, and cost/benefit varies by site/management goals
  - Cover crop treatments with legumes had yields comparable to lettuce plots with less fertilizer cost
  - Wheat was best at outcompeting weeds, but may have tied up N during tomato growing season
- High percentage of unmarketable fruit primarily due to YSD- worse in 2018

Novel Covers Experimental Design

Cool Season	Warm Season
Balansa clover ‘Fixation’	Sunn hemp
Crimson clover ‘Dixie’	Sunn hemp ‘AU golden’
Arrowleaf clover	Chinese red pea
Berseem clover	Florida broadleaf mustard
Persian clover ‘Mihi’	German millet
Alsike clover	Japanese millet
Festulolium ‘1015FL’	Iron and clay pea
Triticale	Red hemp
Annual ryegrass ‘Nelson’	Sesame
Oats ‘Bob’	Sodbuster radish
Timothy ‘KYPP9801	Teosinte

- Screening study in Lexington
  - 11 warm-season and 11 cool-season cover crops outside of the “traditional” crops used in the SE
- Focus on crops for rapid biomass production, weed suppression, and other desirable traits identified by participating farmers
- Participating growers in each project state: GA, KY and TN

Novel Covers Experimental Design

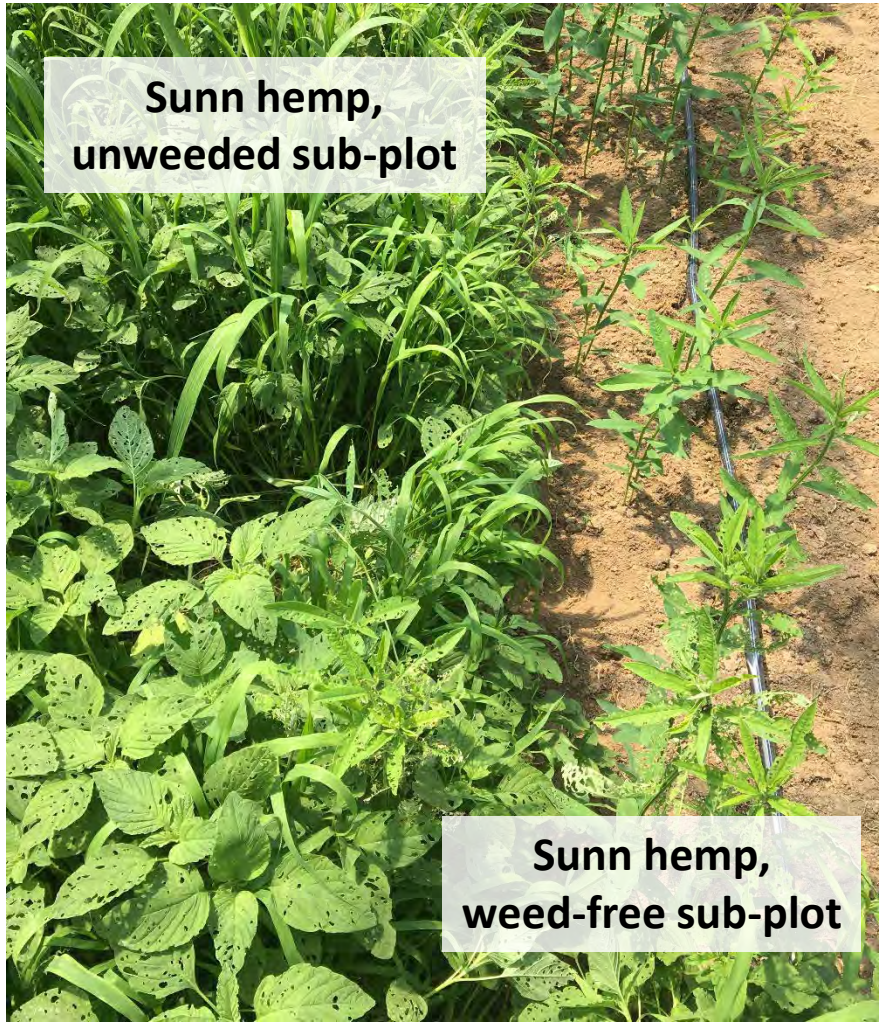
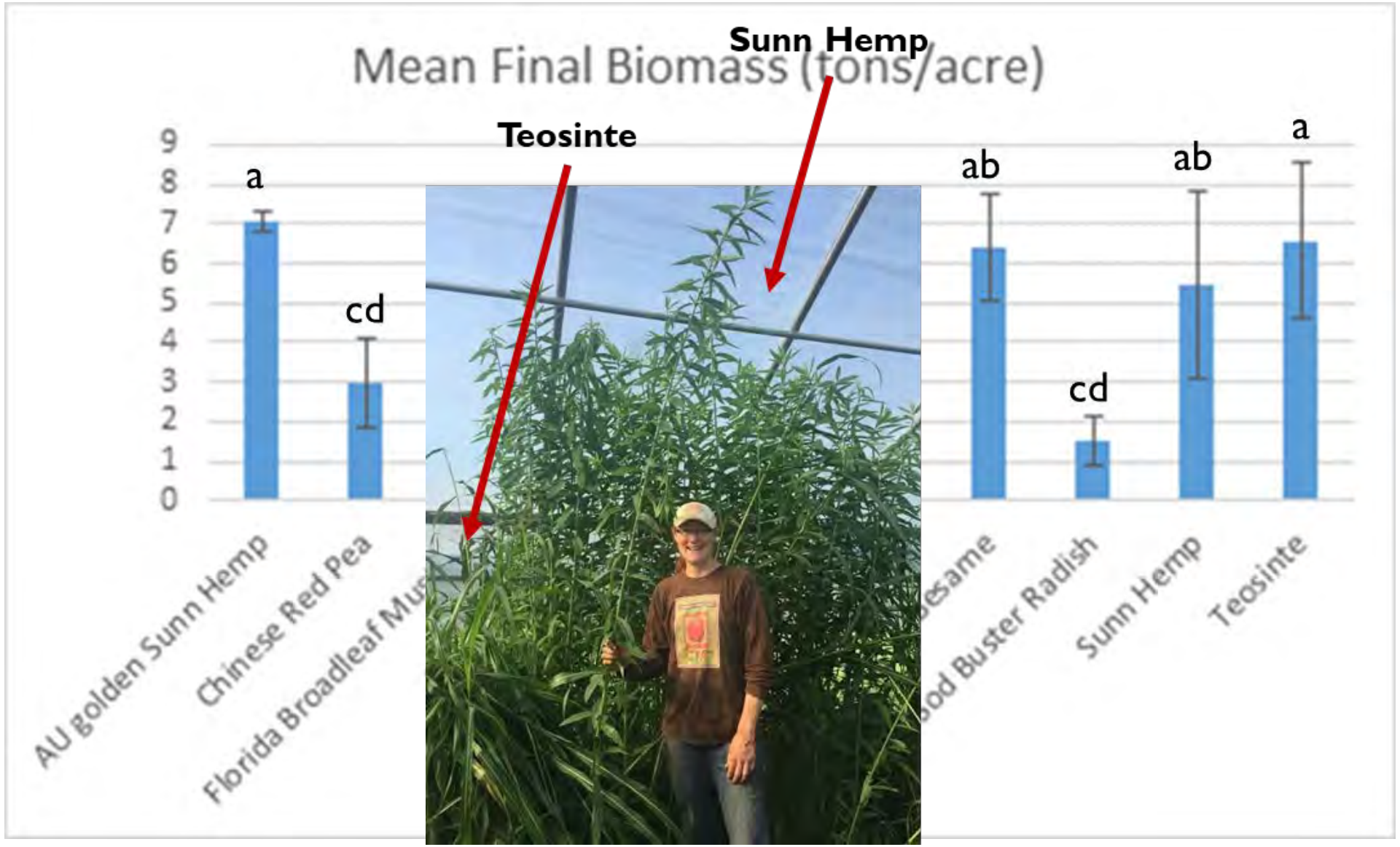


Photo take July 9, 2018 (24 days after seeding).
Photo courtesy of Dr. Erin Haramoto.

- Plots 5’ x 10’
- 3 replications (1 per tunnel)
- Two years
- Unweeded and weed-free subplots
- Regular biomass samples in each subplot
  - Monthly for cool season
  - Bi-monthly for warm season

Final warm season biomass, 2017

- Represents weed-free biomass at maturity
- Some promising new candidates for later-maturing pea and millets
- Too hot for the brassicas
- Too much biomass?



Participating Growers, GA 2018

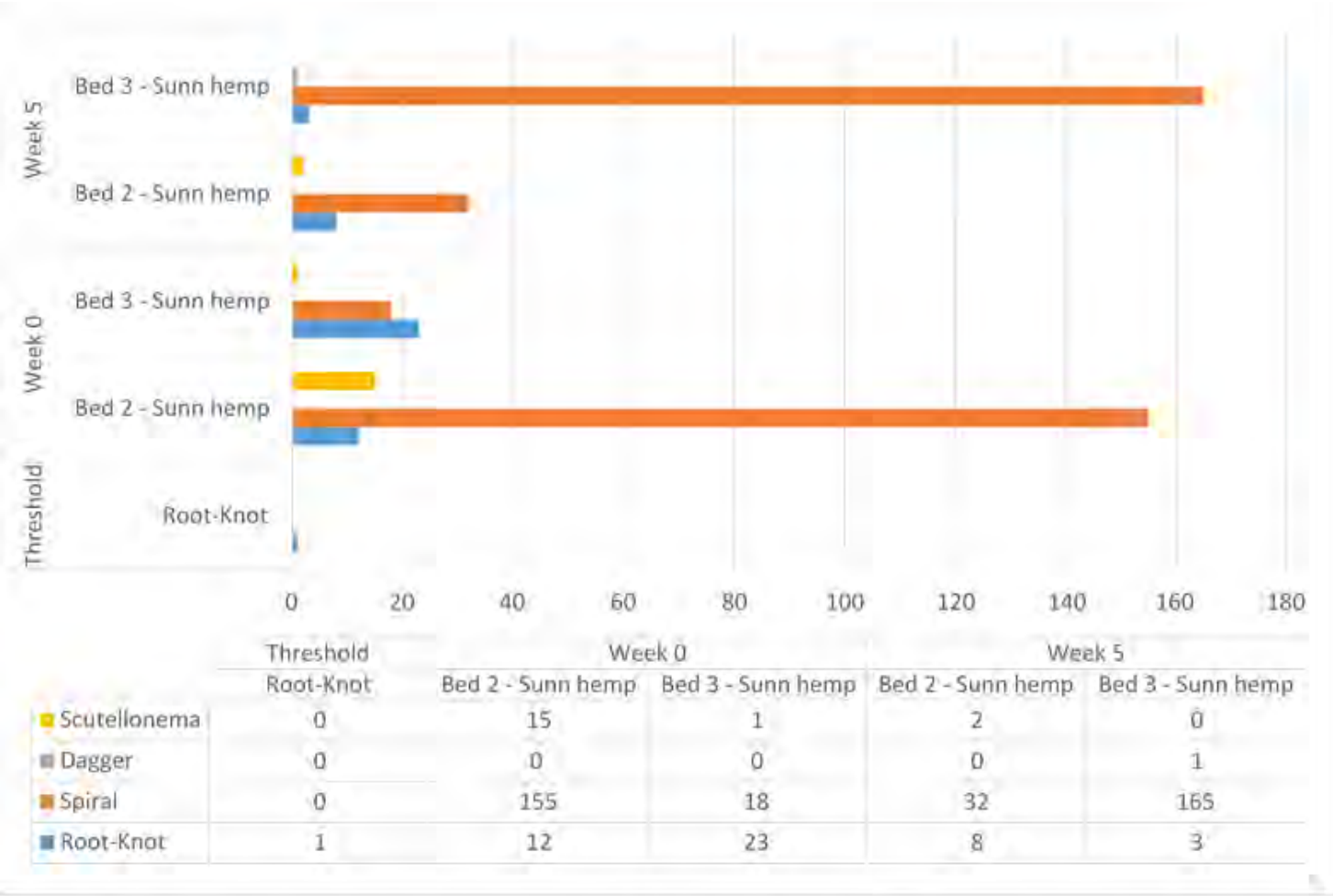
Sunn hemp, ~25 days after planting

Celia Barss, Woodland Gardens, Winterville, GA

Sunn hemp (left) and cowpea (right), ~55 days after planting

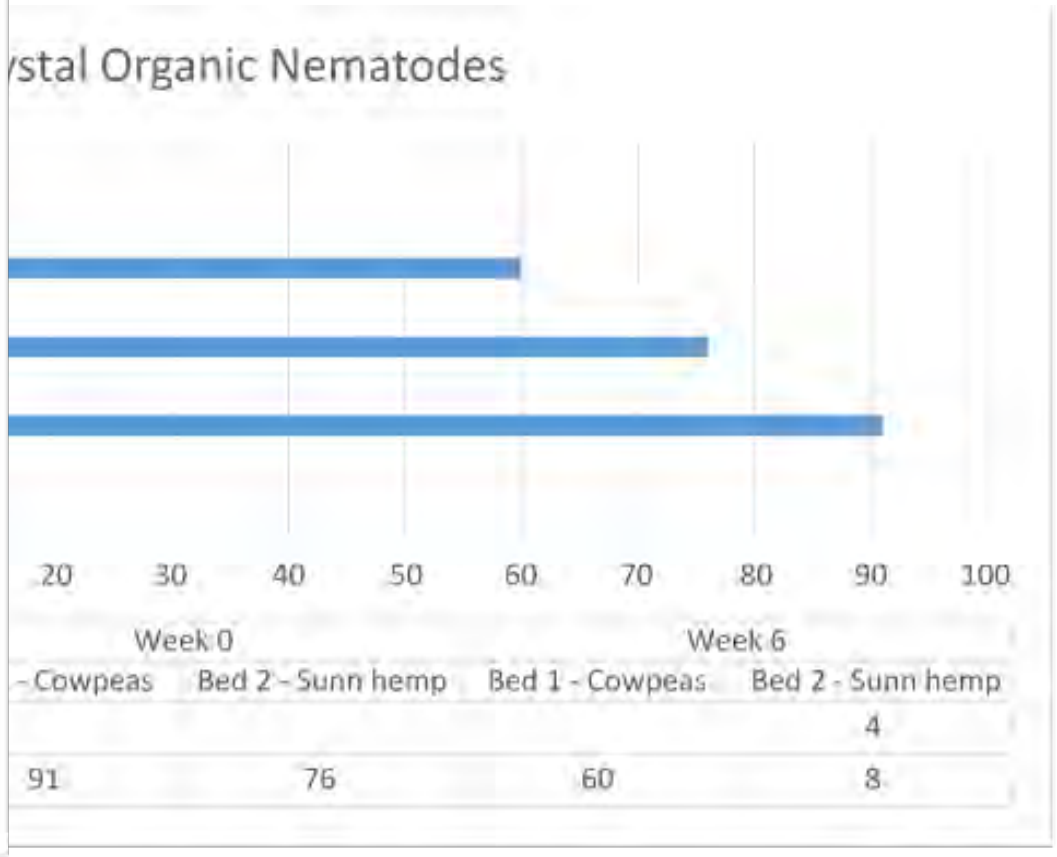
Nicolas Donck, Crystal Organic Farm, Newborn, GA

Participating Growers, GA 2018



	Threshold	Week 0		Week 5	
	Root-Knot	Bed 2 - Sunn hemp	Bed 3 - Sunn hemp	Bed 2 - Sunn hemp	Bed 3 - Sunn hemp
Scutellonema	0	15	1	2	0
Dagger	0	0	0	0	1
Spiral	0	155	18	32	165
Root-Knot	1	12	23	8	3

Figure 5. Nematode counts on Week 0 and Week 5 at Woodland Gardens Farm in Winterville, GA. 2018



: 0 and Week 6 at Crystal Organic Farm in Newborn, GA. 2018

Thank you!

Acknowledgements

Participating farmers

- Celia Barss, Woodland Gardens, GA
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- John Ledbetter, Hines Valley Farm, TN

Co-Investigators and project staff

- Julia Gaskin (UGA), Annette Wszlacki (UT), Jenny Moore (UT), Erin Haramoto (UK), Tim Phillips (UK), Tim Woods (UK), Brett Wolff (UK), Jennifer Taylor (UK), Debendra Shrestha (UK), Alex Tracy (UK) and many more students, etc.

Southern SARE

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