

Rotations and Management Strategies in Organic High Tunnels

December 16, 2020 | NRCS Webinar Series

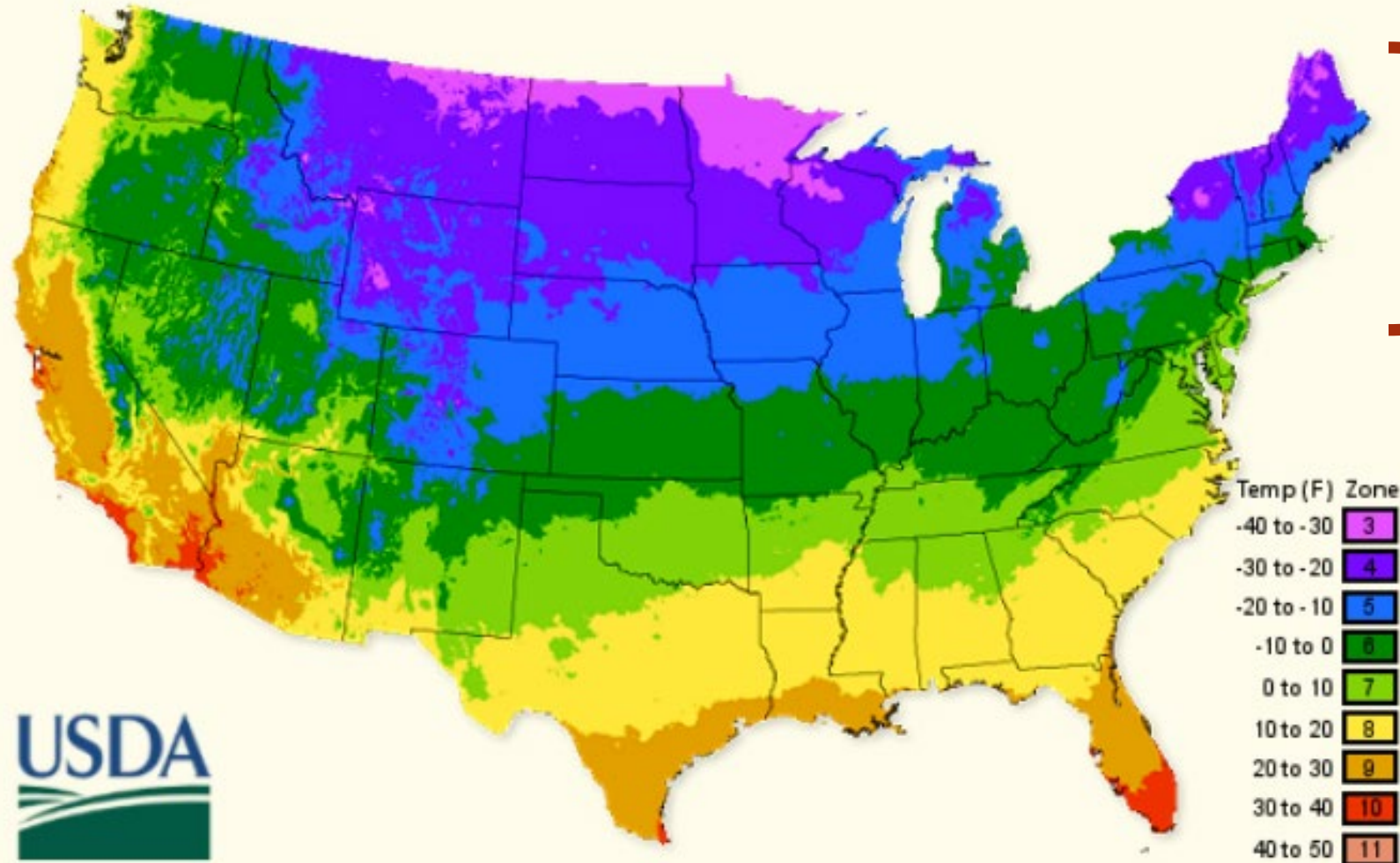
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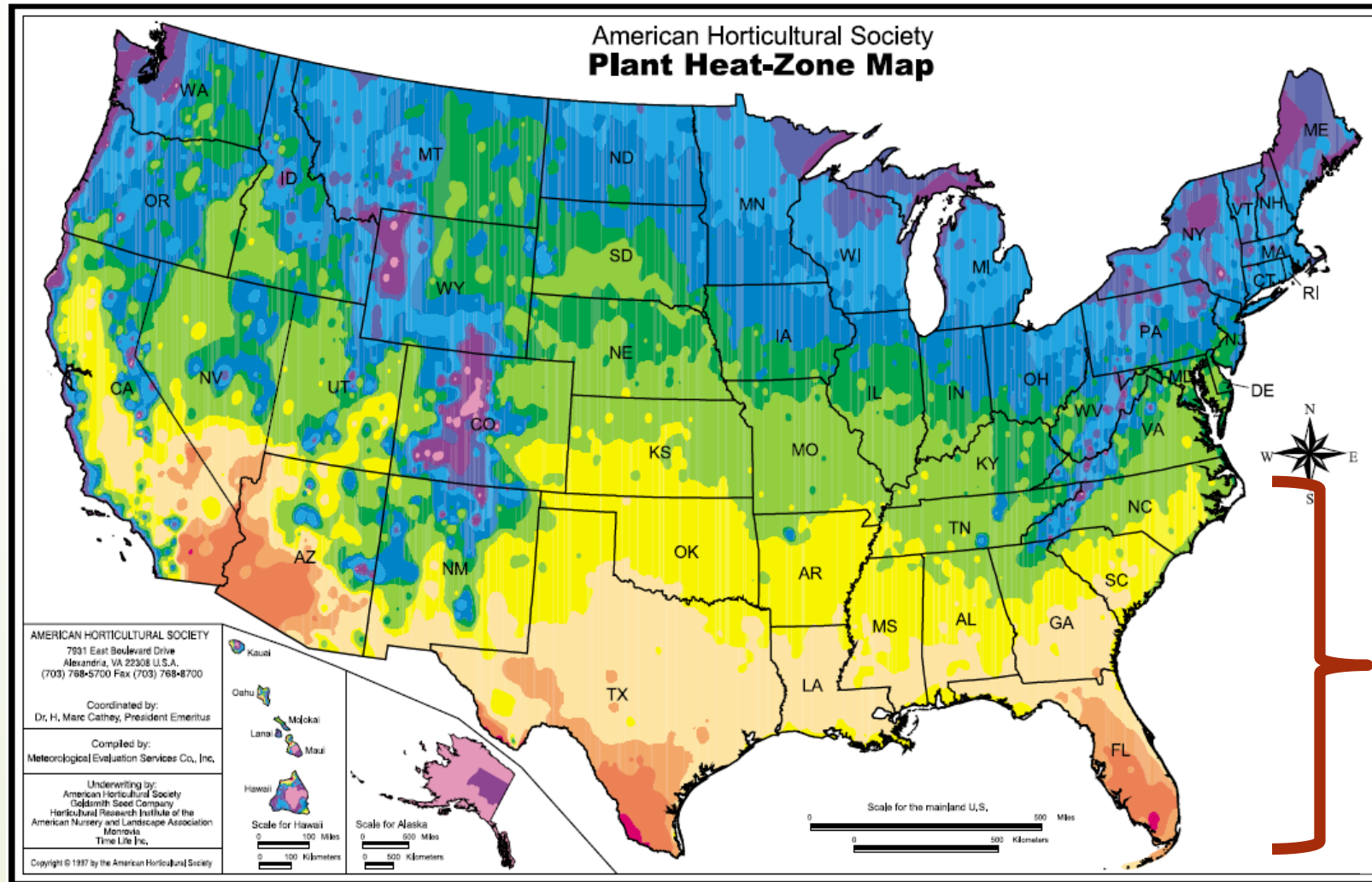


High Tunnel Production Season Extension: Cold Limitation



Crop growth limited by cold during cool seasons in northern latitudes.

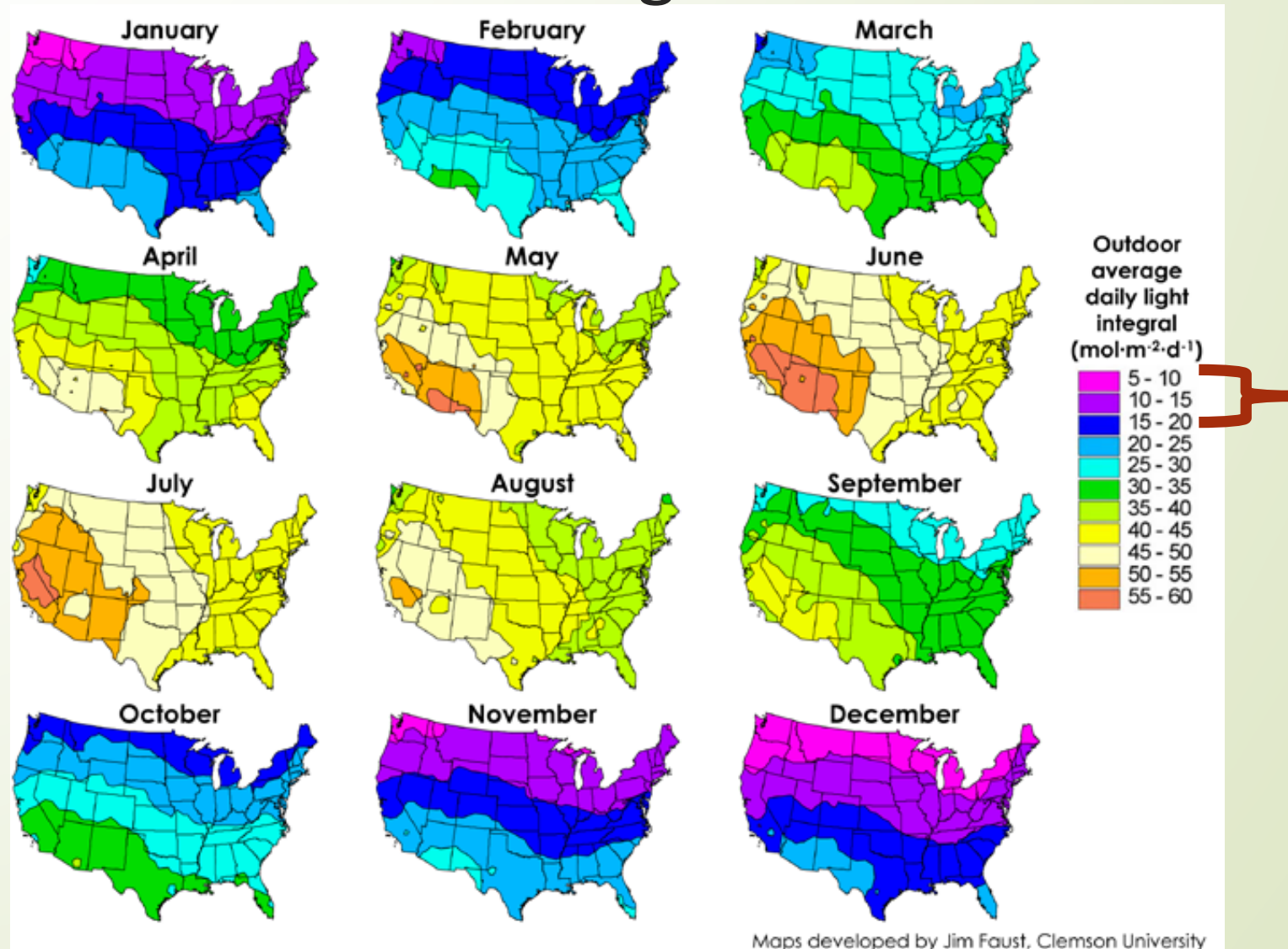
High Tunnel Production Season Extension: Heat Limitation



Average Number of Days per Year Above 86°F (30°C)	Zone
< 1	1
1 to 7	2
> 7 to 14	3
> 14 to 30	4
> 30 to 45	5
> 45 to 60	6
> 60 to 90	7
> 90 to 120	8
> 120 to 150	9
> 150 to 180	10
> 180 to 210	11
> 210	12

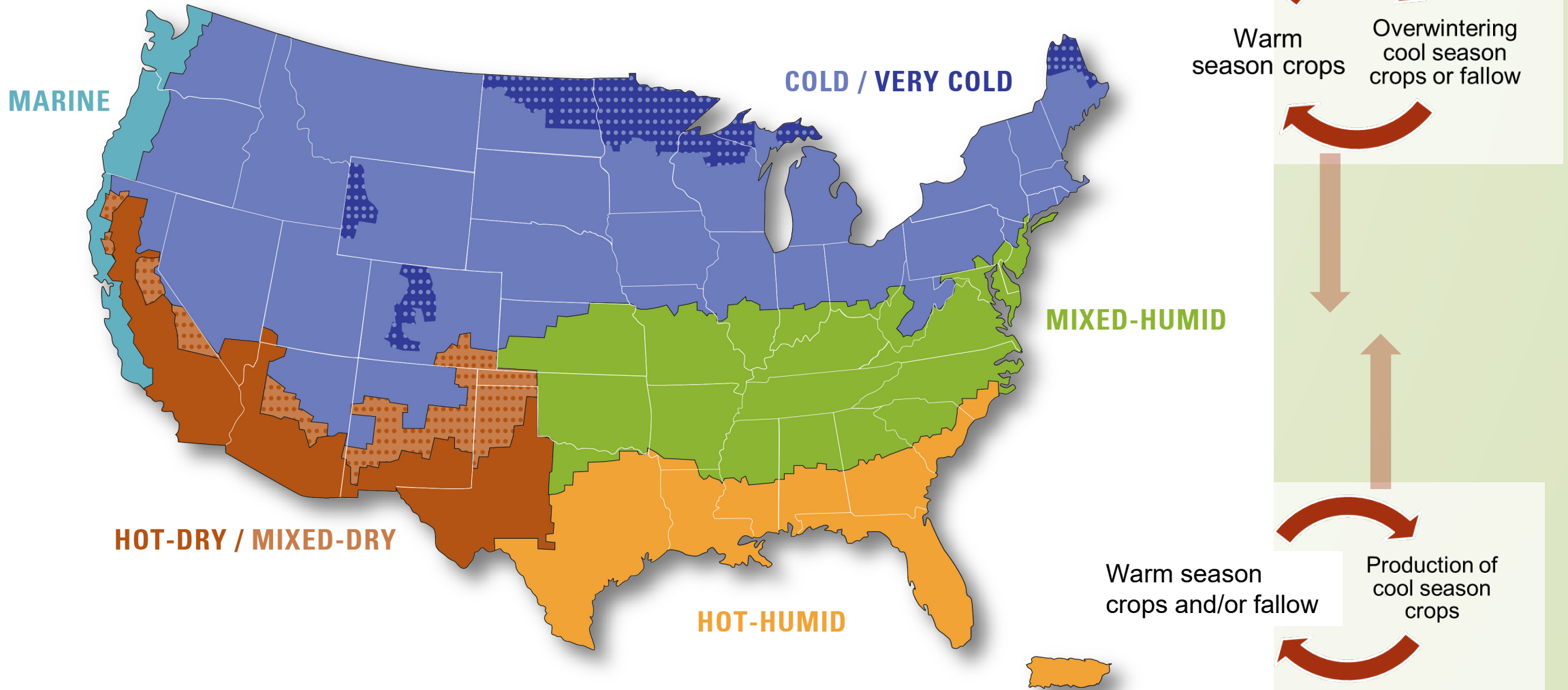
Crop growth limited by heat during warm seasons in southern latitudes.

High Tunnel Production Season Extension: Light Limitation



Crop growth limited by low light conditions during cool seasons in northern latitudes, cloudy regions.

HT Crop Rotations are cold, heat, light and market influenced!



Crop Rotations in HTs

Benefits of Crop Rotation



Soilborne Disease

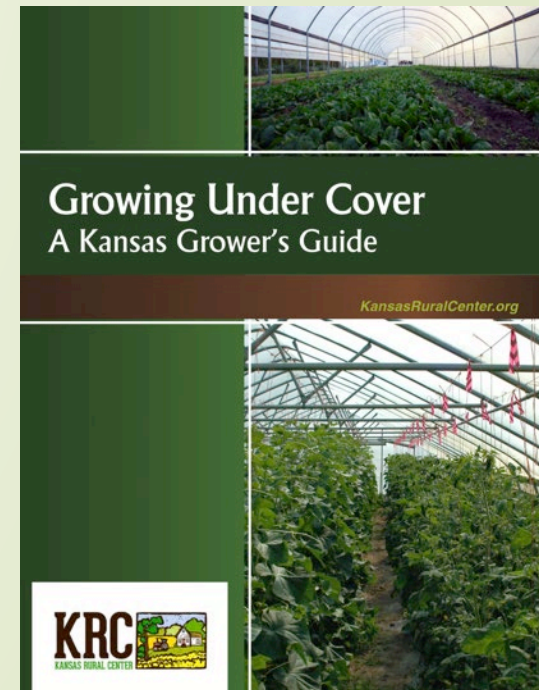


Fertility Management

Crop Rotations in HTs

The Challenge: Generating Per SqFt Revenue

Crop Type	Production Window	Sale Price	Gross Revenue/ft ²	HT Crop
Tomato	Apr – Oct	\$2.50/lb	\$3.66	1
Lettuce	Sept – May	\$2.00/head	\$1.30	2
Spinach	Sept – May	45.50/lb	\$1.09	3
Cucumber	Apr – Aug	\$1.50/lb	\$1.62	4
Bell Pepper	Apr – Oct	\$1.50/lb	\$2.30	5
Salad Mix	Sept – May	\$8.00/lb	\$2.40	6
Beets	Sept – May	\$2.00/lb	\$1.92	



- \$0.44/ft²/year fixed costs for structure (KRC, 2017)
- \$0.49/ft²/year fixed costs for structure (NCSU, 2013)
 - 2 years of tomato production (\$2.60/lb) paid for structure

(Sydorovych et. al., 2013)

Crop Rotations in HTs

Rotate across plant families

Alliaceae	Asteraceae	Brassicaceae	Cucurbitaceae	Fabaceae	Solanaceae
Asparagus Chives Garlic Leeks Onions Shallots	Lettuce Endive Radicchio	Broccoli Brussels sprouts Cabbage Cauliflower Collards Mustard Radish Rutabaga Turnip	Cantaloupe Cucumbers Honeydew Pumpkins Squash Watermelon	All beans English peas Southern peas	Eggplant Peppers Potatoes Tomatoes
Apiaceae	Polygonaceae	Chenopodiaceae	Ipomea	Malvaceae	Poaceae
Carrot	Rhubarb	Spinach Beets	Sweet potato	Okra	Corn



Get creative with your structure(s)

What About Cut Flowers?





Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes	Greens
Yr 2	Greens	Tomatoes	Greens
Yr 3	Greens	Tomatoes	Greens
	January		December



Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes	Cover
Yr 2	Cover	Grafted Tomatoes	Greens
Yr 3	Greens	Tomatoes	Cover
January		December	



Soil health = \$

Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes	Cover
Yr 2	Cover	Strawberries	Greens
Yr 3	Greens	Tomatoes	Cover
January			December



\$1.76 per ft²

Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes	Cover
Yr 2	Cover	Melons	Cover
Yr 3	Greens	Tomatoes	Greens
	January		December



\$0.89 – \$0.90 per ft²

Putting the Pieces Together

Cucurbits Offer a “Short Season” Alternative



Zucchini



Cucumber with gourd rootstock



English Cucumber

Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes	Cover	
Yr 2	Cover	Brassicas	Cover	Greens
Yr 3	Greens	Tomatoes	Greens	

JanuaryDecember



\$1.25 per ft²

Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes		Cover
Yr 2	Cover	Sweetpotato Slips	Cover	Greens
Yr 3	Greens	Tomatoes		Greens
	January	December		



\$4.30 per ft²

Putting the Pieces Together

A few scenarios for planning your high tunnel

Yr 1	Greens	Tomatoes		Cover
Yr 2	Cover	Cucurbits/Melons	Cover	Greens
Yr 3	Greens	Strawberries		Greens
Yr 4	Greens	Peppers		Cover
Yr 5	Cover	Brassicas	Cover	Greens
Yr 6	Greens	Sweetpotato Slips	Cover	Greens
January		December		

Putting the Pieces Together

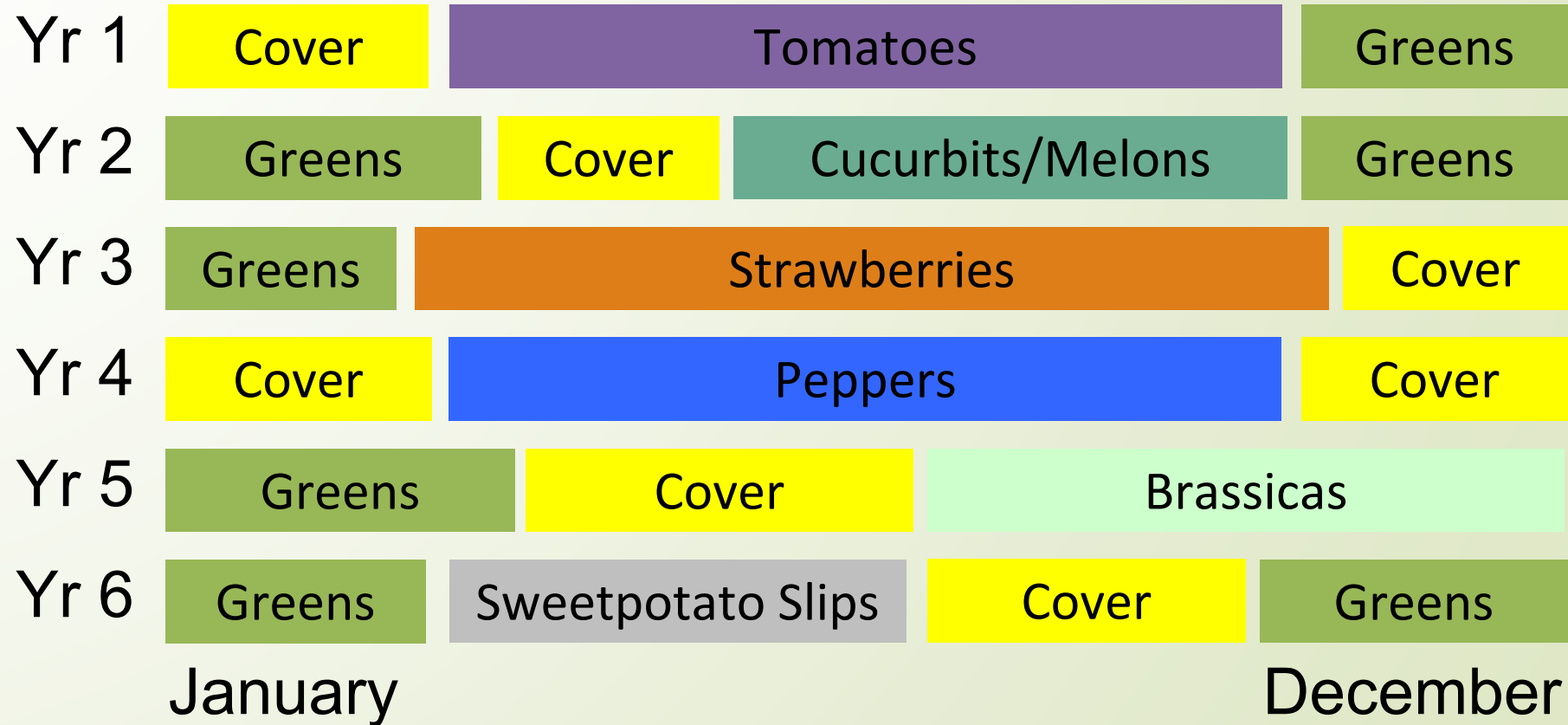
Think About Revenue in the Long Term

Yr 1	\$1.09	\$3.66	Cover
Yr 2	Cover	\$1.20	Cover
Yr 3	\$1.09	\$1.76+	\$1.92
Yr 4	\$1.30	\$2.17	Cover
Yr 5	Cover	\$1.25	Cover
Yr 6	\$0.55	\$4.30	Cover
January		December	

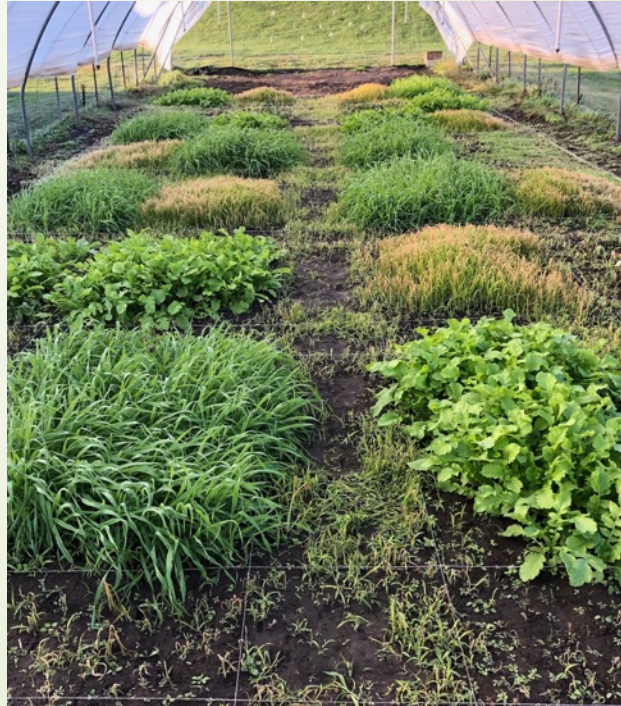
Average Annual GROSS Rev = \$4.09 per ft²
Overhead (structure) Costs = 11%

Putting the Pieces Together

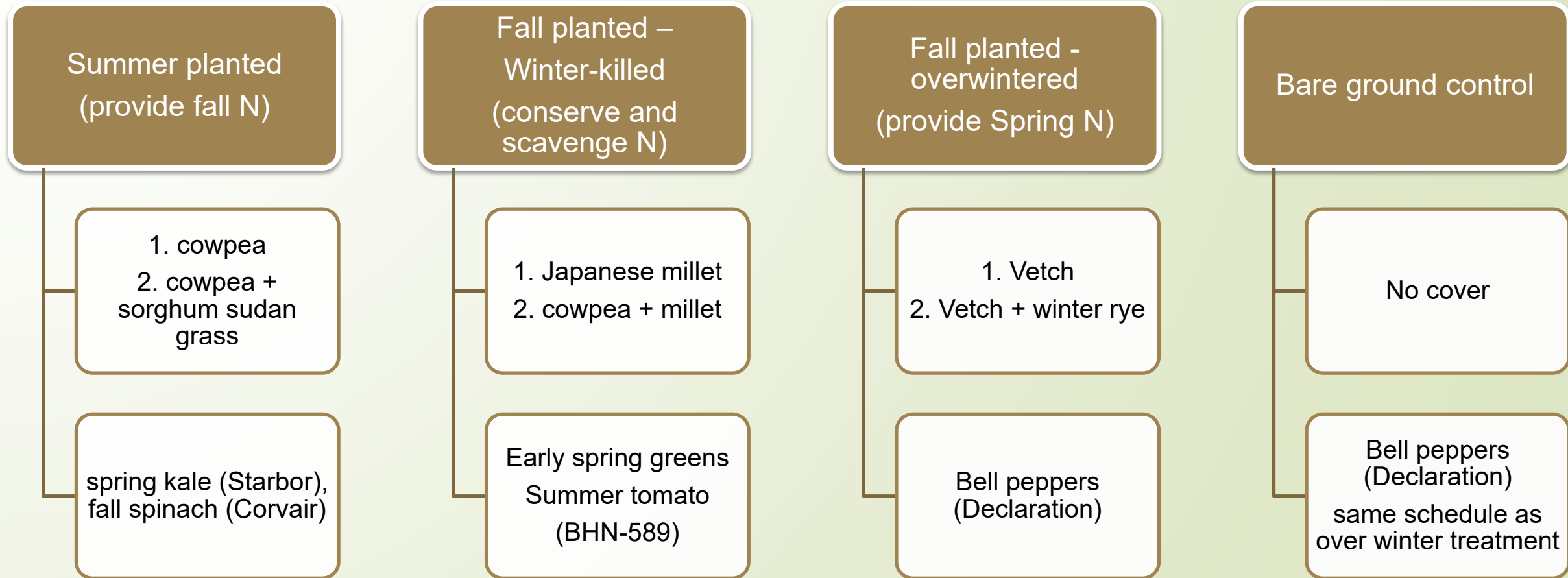
Think About the Timing – Pest Cycles, Labor, etc.



A Multi-Regional Approach for Sustained Soil Health in Organic High Tunnels

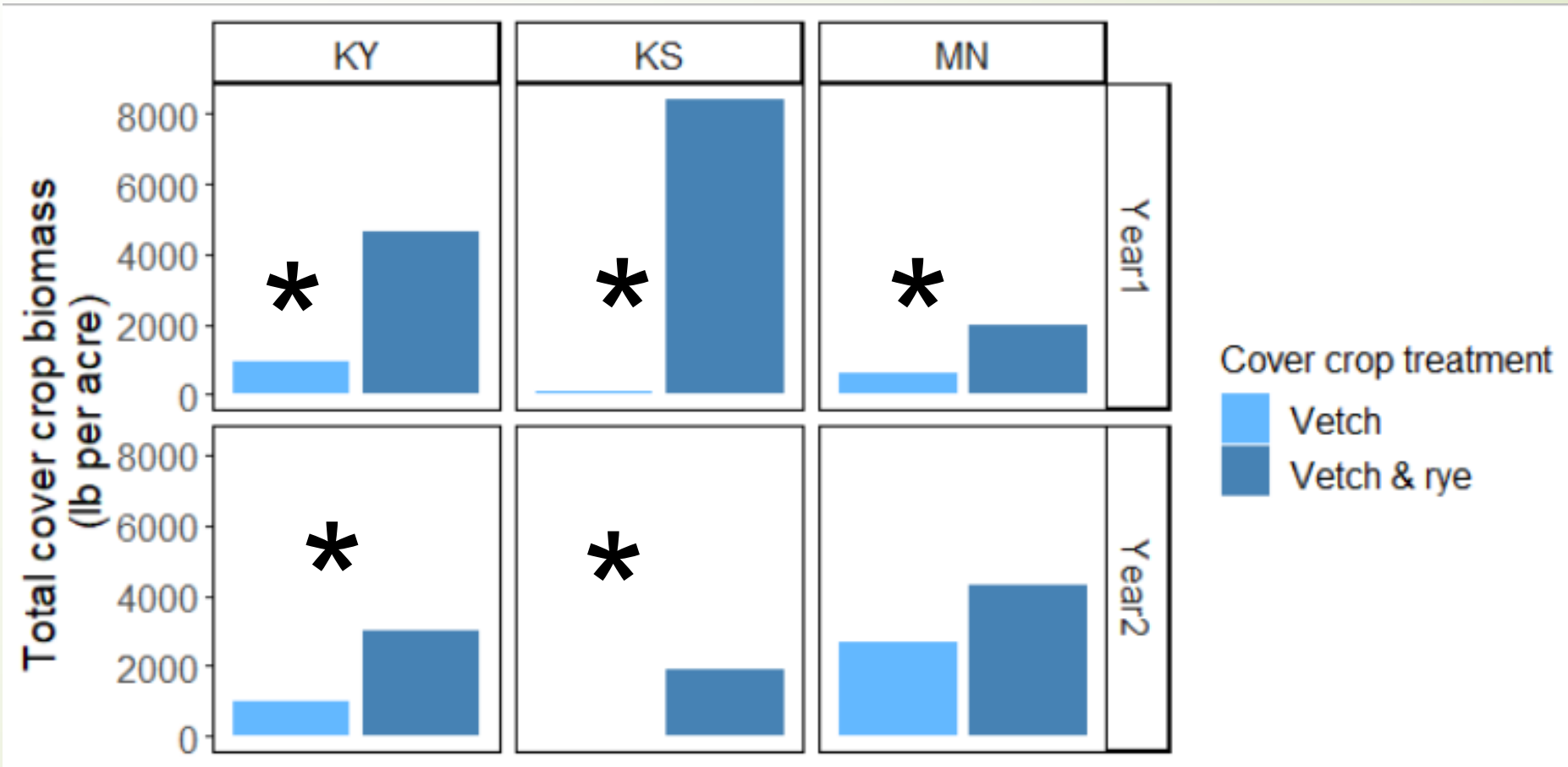


Systems we are evaluating



Overwintering cover crop biomass

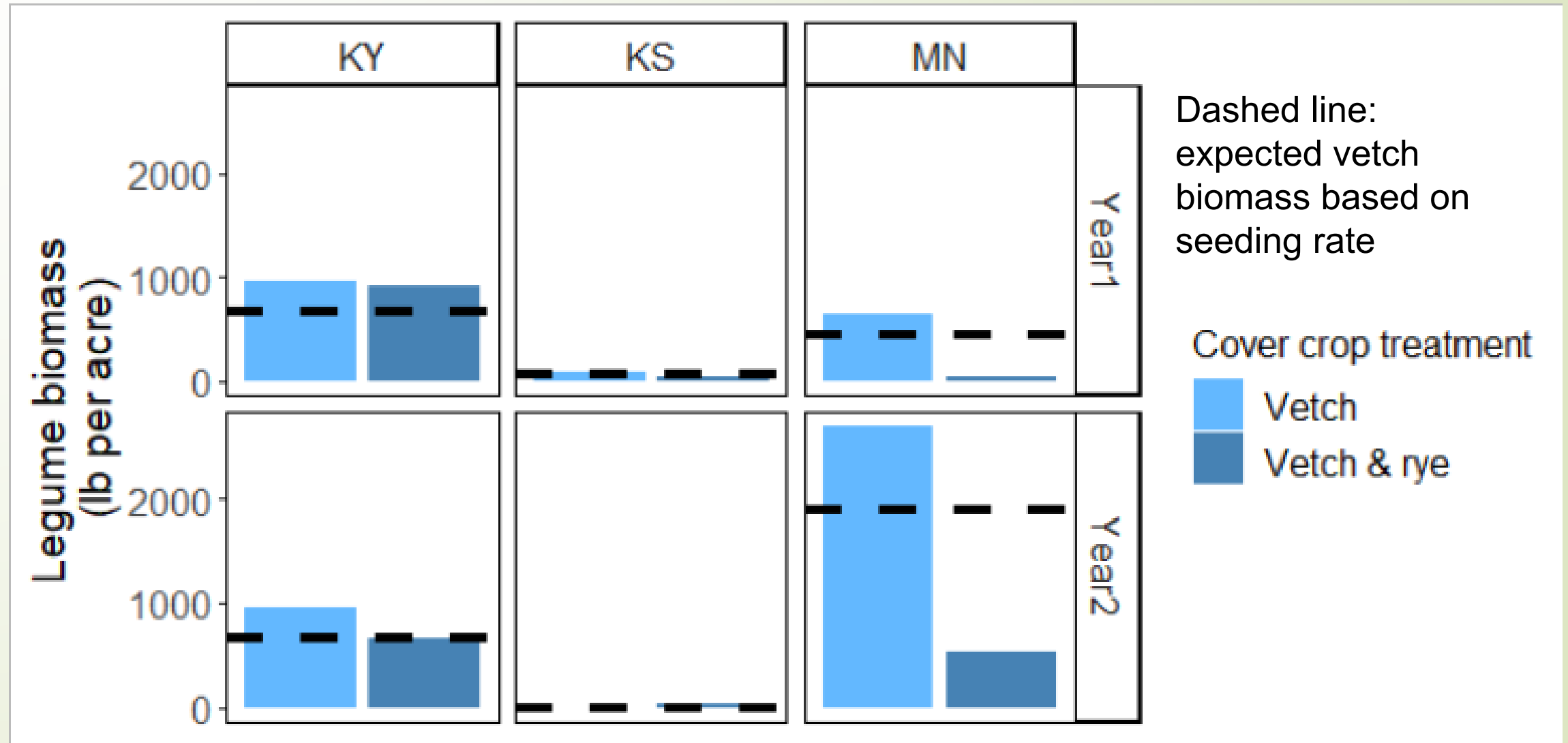
Legume-grass mixtures usually produce more biomass than legume cover crops alone



Hairy vetch and rye mixture in spring

Overwintered legume biomass

In cold climates (MN), legumes struggled when mixed with competitive grasses







In Minnesota, winter annual cover crops were covered with a second layer of row cover; looked pretty good in the dead of winter.





Kansas: A wider variety of cover crops were evaluated in winter

Winter cover crop treatments:

1. Rye
2. Hard red winter wheat
3. Triticale
4. Weed-free bare control plot
5. Hairy vetch
6. Rye and hairy vetch
7. Hard red winter wheat and hairy vetch
8. Triticale and hairy vetch

- The winter cover crops were seeded on 19 October 2017 and 15 October 2018 and terminated on 9 May 2018 and 9 May 2019.



Winter Cover Crop Biomass

Table 2-3: Biomass and plant height of winter cover crops grown alone and in mixtures in a high tunnel in Olathe, KS

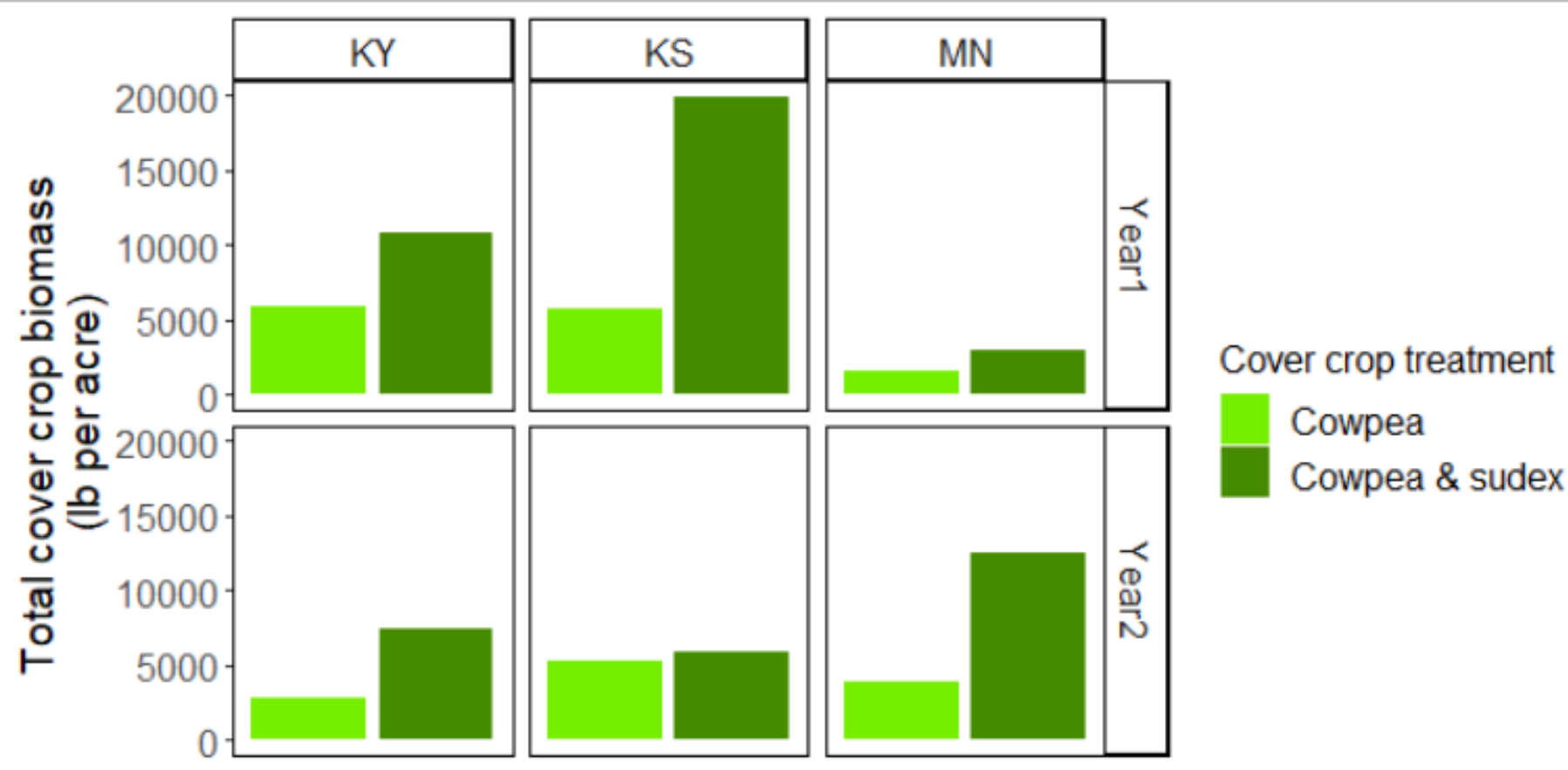
Treatment ^z	2018				2019			
	Biomass ^y (lbs./acre)		Height Measurement ^x (in.)		Biomass (lbs./acre)		Height Measurement (in.)	
Bare Control	0	c ^w	0.00	c ^w	0	c	0	c
Triticale	5481	ab	39	b	89	c	23	ab
Hairy Vetch	92	c	9	c	0	c	11	bc
Wheat	6341	ab	31	b	864	abc	23	ab
Rye	7641	ab	57	a	2187	a	32	a
Triticale and Vetch	8617	a	39	b	0	c	15	abc
Wheat and Vetch	4506	b	32	b	793	bc	26	ab
Rye and Vetch	8756	a	56	a	1965	ab	30	a

^zThe experiment was arranged in a split plot randomized complete block design with the main plot factor as the presence/absence of legumes (hairy vetch) and the subplot factor were the cover crop species/mixtures. There were 4 blocks in the experiment, yielding 4 replications of each treatment. There were differences in cover cropping biomass yields by year ($P=0.0001$).

^y^xCover crops were planted on 19 October 2017 and 15 October 2018 and terminated on 9 May 2018 and 9 May 2019. Cover crops were grown under a quonset high tunnel with average temperatures ranging from 34°F to 60°F. Biomass samples collected using a 0.1 m quadrant for each plot were dried. Oneway analysis of means (ANOVA) was used to evaluate cover crop biomass by treatment for each year. Treatment effects on cover crop biomass yield were significant in both 2018 ($P < 0.0001$) and 2019 ($P < 0.0001$). Cover crop height was measured at cover crop termination.

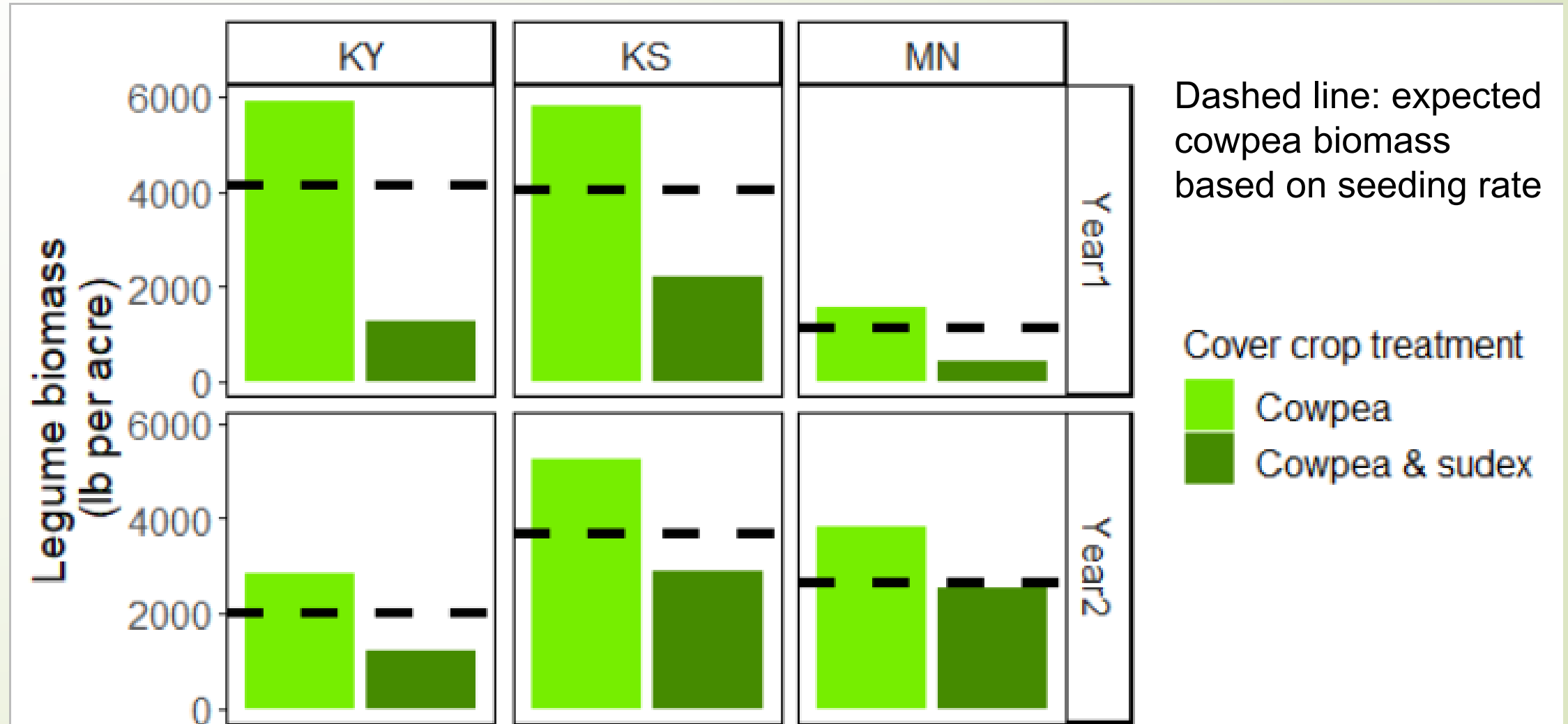
^w Values followed by the same letter in the same column are not significantly different according to a protected Tukey method to compare LSDs with $\alpha=0.05$.

Summer cover crop biomass



Residue remaining following cowpea and sorghum mix mowing was substantial

Summer legume biomass



Kansas: A wider range of summer cover crops were evaluated

Summer cover crop treatments:

1. Buckwheat
 2. Millet
 3. Sorghum-sudangrass
 4. Weed-free bare control plot
 5. Cowpea
 6. Buckwheat and cowpea
 7. Millet and cowpea
 8. Sorghum-sudangrass and cowpea
- In 2018, the summer cover crops were grown from 9 June to termination on 4 September.
 - In the 2019, cover crops were grown from 11 June to 6 August.



Summer Cover Crop Biomass

Table 2-5: Biomass and plant height of summer cover crops grown alone and in mixtures in a high tunnel in Olathe, KS

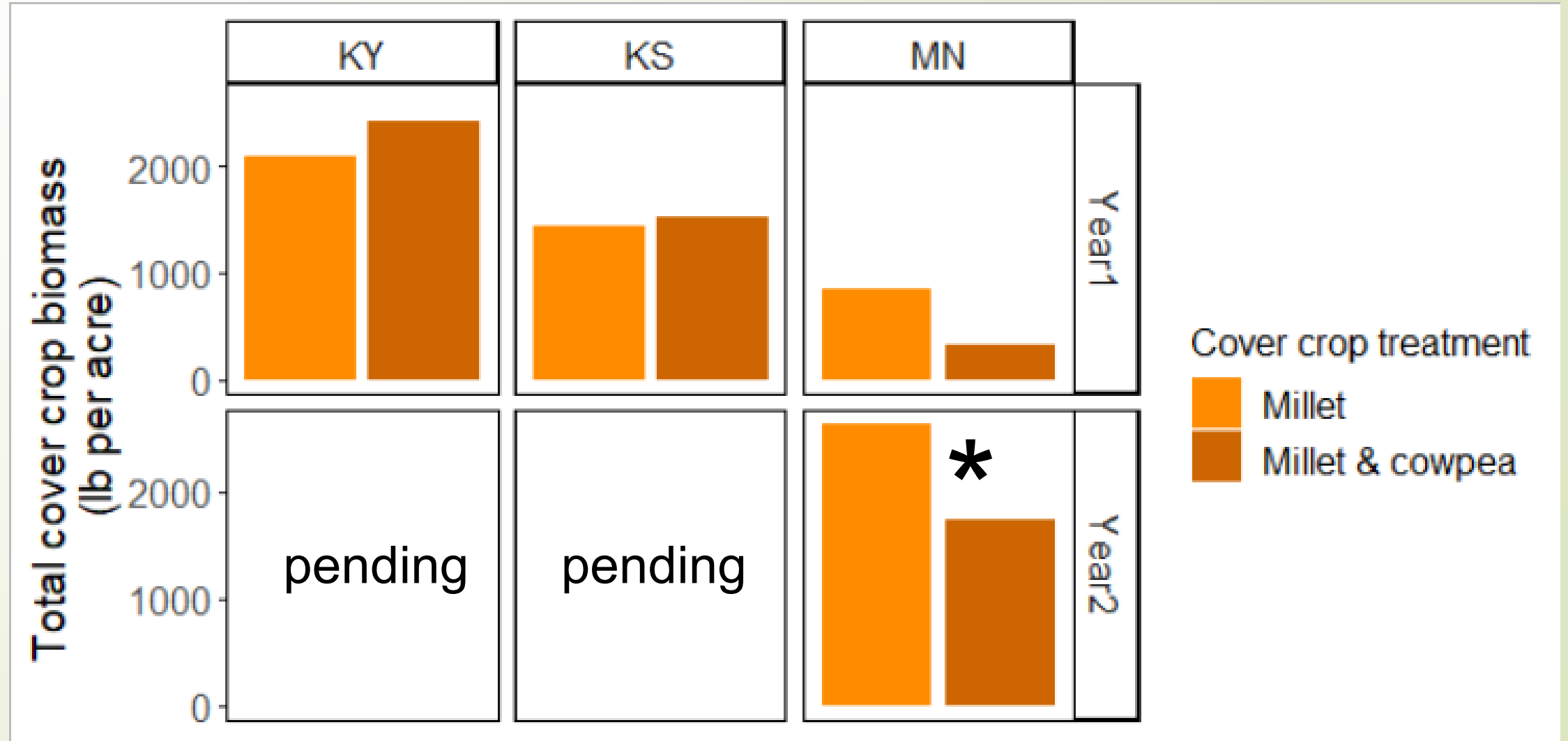
Treatment ^z	2018				2019			
	Biomass ^y (lbs./acre)		Height ^x (in.)		Biomass (lbs./acre)		Height (in.)	
Bare Control	0	c ^w	0	d ^w	0	b	0	c
Buckwheat	1571	c	34	c	3112	b	28	abc
Buckwheat and Cowpea	3796	c	39	c	4993	b	36	abc
Cowpea	6016	bc	38	c	5435	ab	37	abc
Millet	1472	c	32	c	6480	ab	27	bc
Millet and Cowpea	4613	c	39	c	6689	b	35	abc
Sorghum-Sudan	21273	a	78	a	11009	a	63	a
Sorghum-Sudan and Cowpea	20726	ab	54	b	6155	b	53	ab

^zThe experiment was arranged in a split plot randomized complete block design with the main plot factor as the presence/absence of legumes (cowpea) and the subplot factor were the cover crop species/mixtures. There were 4 blocks in the experiment, yielding 4 replications of each treatment. There were differences in cover cropping biomass yields by year ($P < 0.0349$).

^y^xCover crops were planted on 19 June in 2018 and 11 June 11 in 2019 and terminated on 4 Sept 2018 and 6 Aug 2019. Cover crops were grown under a quonset style high tunnel with average temperatures ranging from 76°F to 79°F. Biomass samples were collected using a 0.1 m quadrant for each plot and were dried. Oneway analysis of means (ANOVA) was used to evaluate cover crop biomass by treatment for each year. Treatment effects on cover crop biomass yield were significant in both 2018 ($P < 0.0001$) and 2019 ($P < 0.001$). Cover crop height was measured at cover crop termination.

^w Values followed by the same letter in the same column are not significantly different according to a protected Tukey method to compare LSDs with $\alpha=0.05$

Winterkilled cover crop biomass



Summary of cover crop biomass results

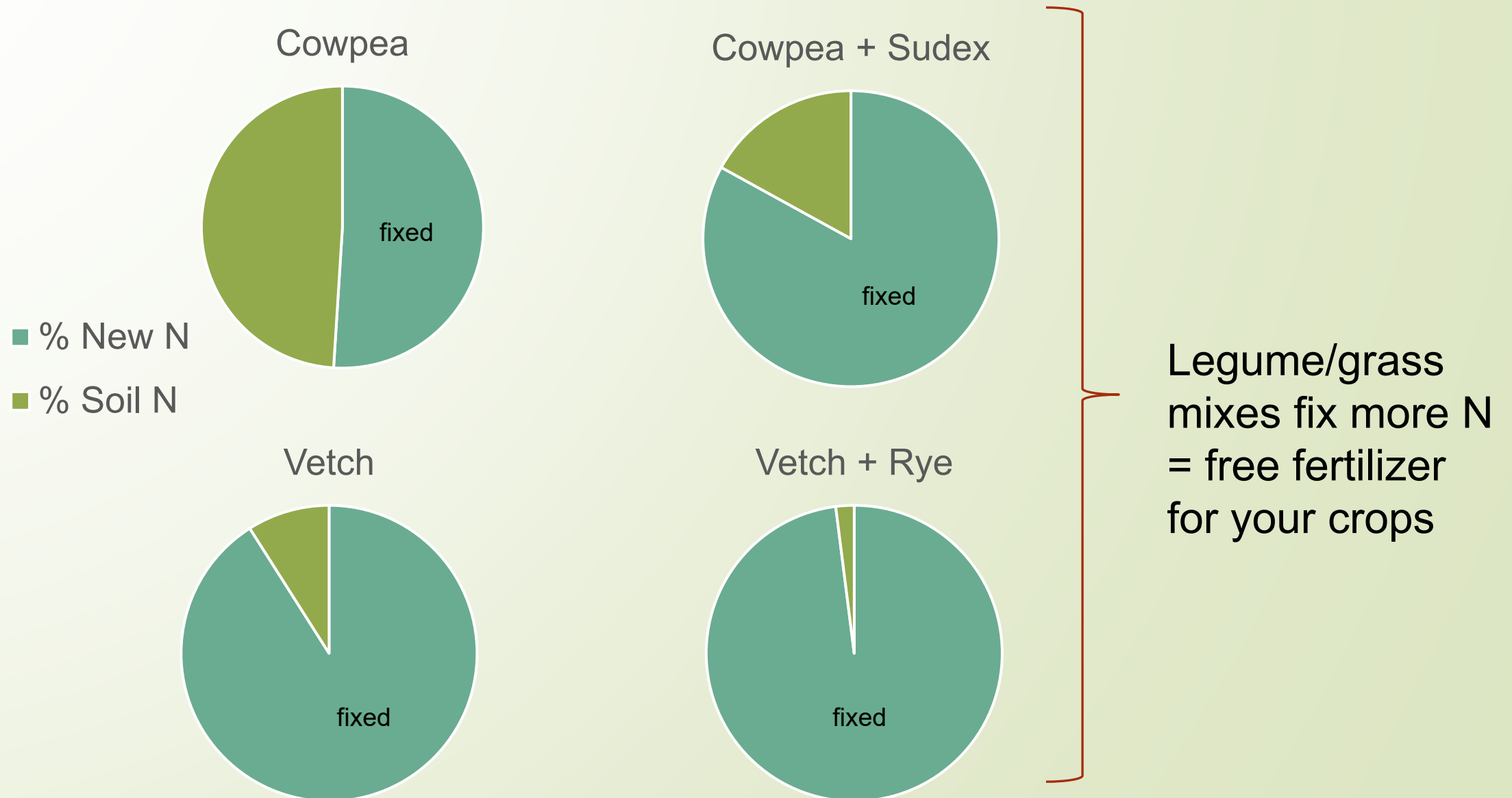
- Cover crops can be grown successfully in high tunnels in all three windows tested in all three states
- Legume-grass mixtures usually produce more biomass than legume cover crops alone
- Mixes often have reduced legume biomass, which may reduce N delivered through nitrogen fixation
- Cowpea does not grow well in fall in MN or KS
- Herbivory is a major problem in winter (deer in KS, rabbits and voles in MN)

Thank you!

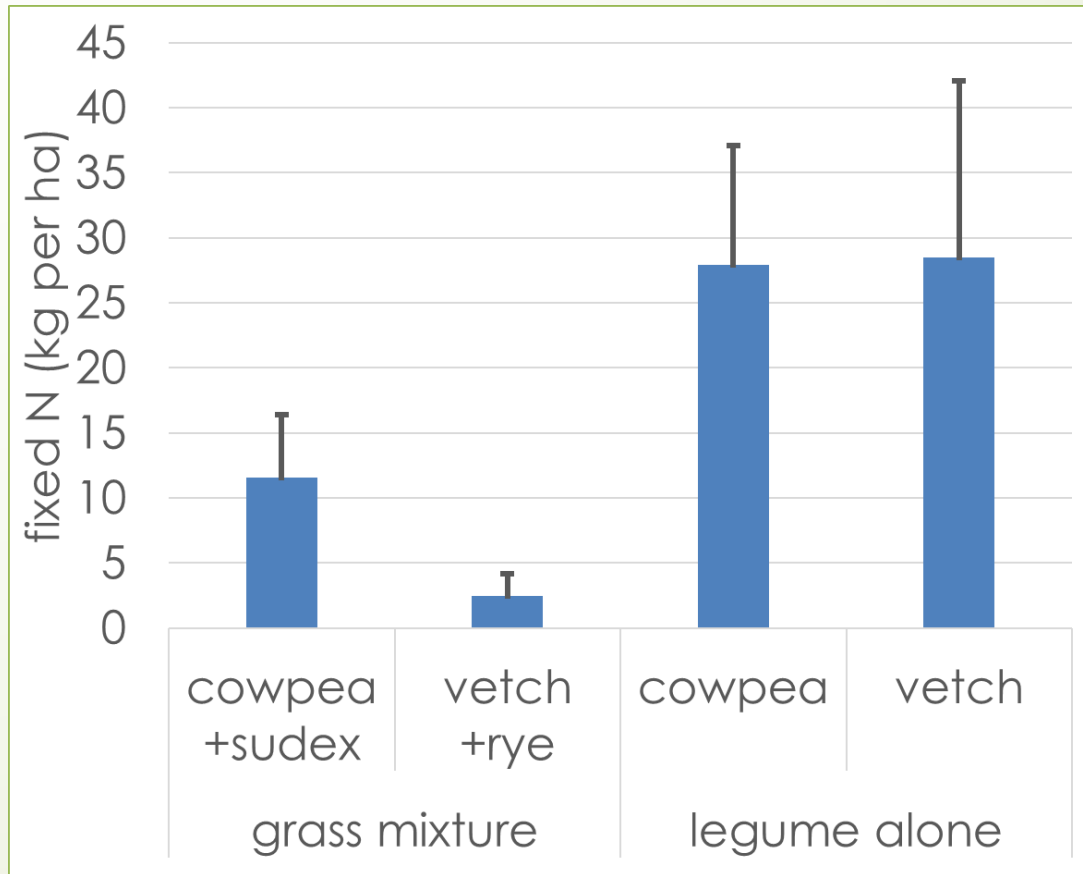


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Driven to DiscoverSM

How much N is 'new' N from nitrogen fixation?



So how much of this new N is provided to the soil?



- When grown with non-legumes, legumes provided less new N due to competition with grasses (There was less legume biomass)
- Legumes grown alone contributed more new (fixed) N from nitrogen fixation, because there was overall more legume biomass
- Cowpea and vetch contributed similar amount of fixed N