Integrating Crop Rotations into High Tunnel Production Systems

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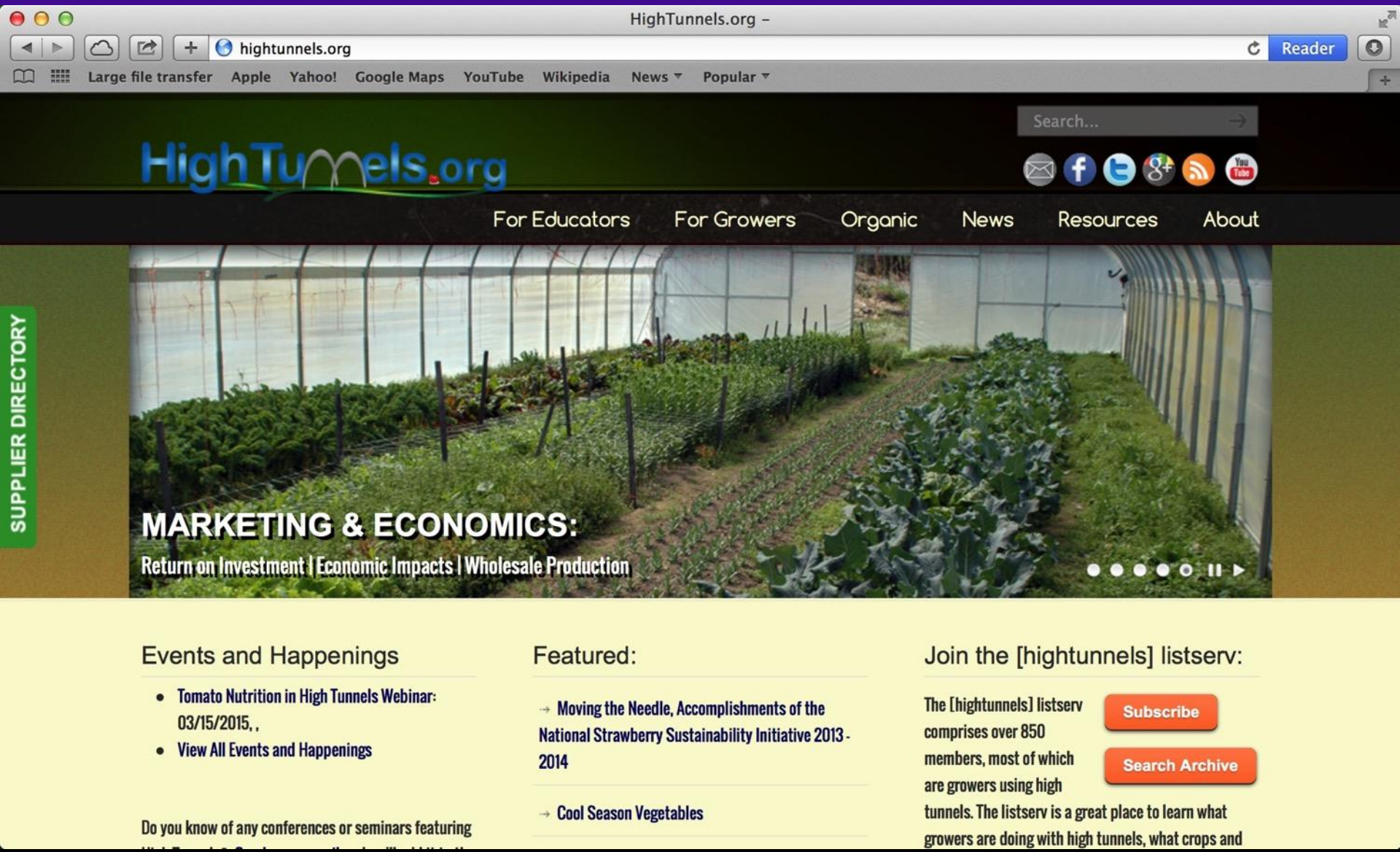
K-STATE Research and Extension

K-STATE Research and Extension | Olathe Horticulture Center

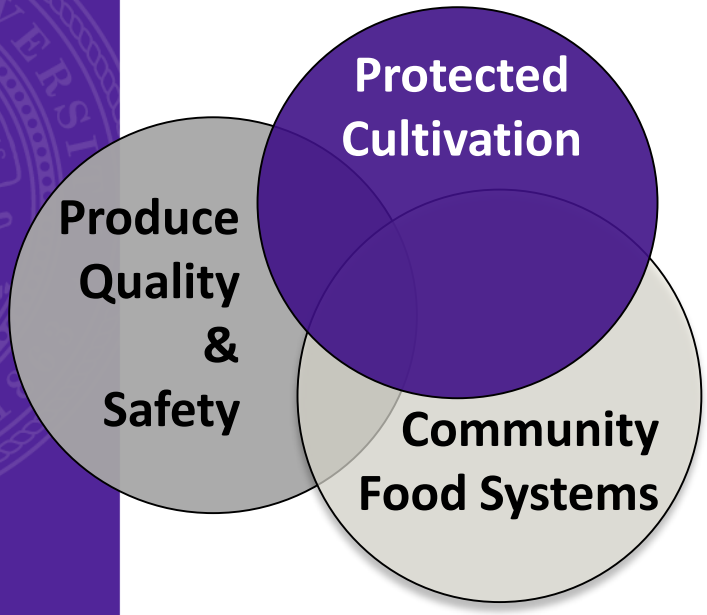
Photo courtesy:
D. Loewen

www.hightunnels.org



High Tunnel Production Systems

HT Research at KSU



Tomato Grafting Program
- SARE, SCRI
- Rootstock
- Propagation
- Transportation

HT Soil Management
- Cover cropping
- USDA OREI

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

NORTH CENTRAL SARE

High Tunnel Variety Trials

Day Neutral Strawberry Production
- Variety and Evaluation
- NSSI / Wal-mart
- Postharvest Quality

National Strawberry Sustainability Initiative

HT Production of Sweetpotato Slips
- 2014 SARE R&E
- Production, Economics

URBAN FOOD SYSTEMS
Kansas State University
www.hfrr.ksu.edu Manhattan | Olathe

Soilborne Disease Management

Integrated Pest Management

An integrative management system for pests and pathogens focused on increased KNOWLEDGE of production systems.

- Crop rotation
- Sanitation
- Raised beds
- Compost
- Soil solarization
- Biofumigation
- Chemical control
- Biological controls
- Plant resistance/tolerance

Get creative with your structure(s)

Crop Rotation in HTs

Benefits of Crop Rotation

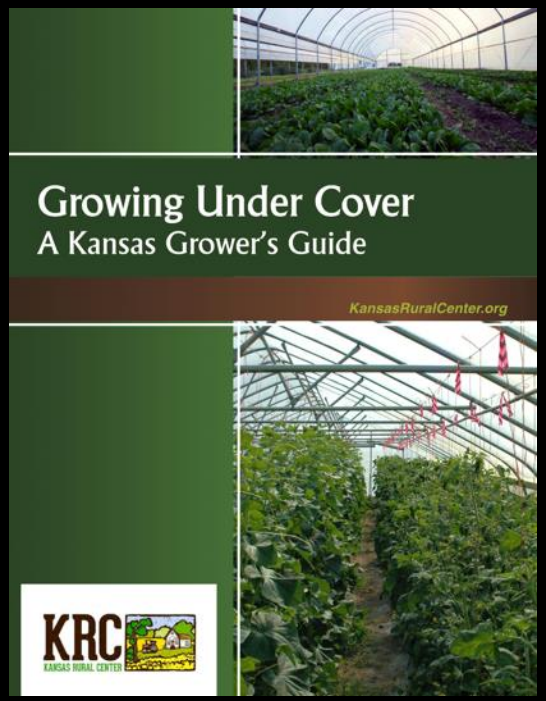
Soilborne Disease

Fertility Management

Crop Rotation 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/ft^2/year fixed costs for structure (KRC, 2017)
- $0.49/ft^2/year fixed costs for structure (NCSU, 2013)
  - 2 years of tomato production ($2.60/lb) paid for structure

(Sydorovych et. al., 2013)

Crop Rotation

Rotate across plant families

Alliaceae	Asteraceae	Brassicaceae	Cucurbitacae	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

What About Cut Flowers?

What About Cover Crops?

What About Cover Crops?

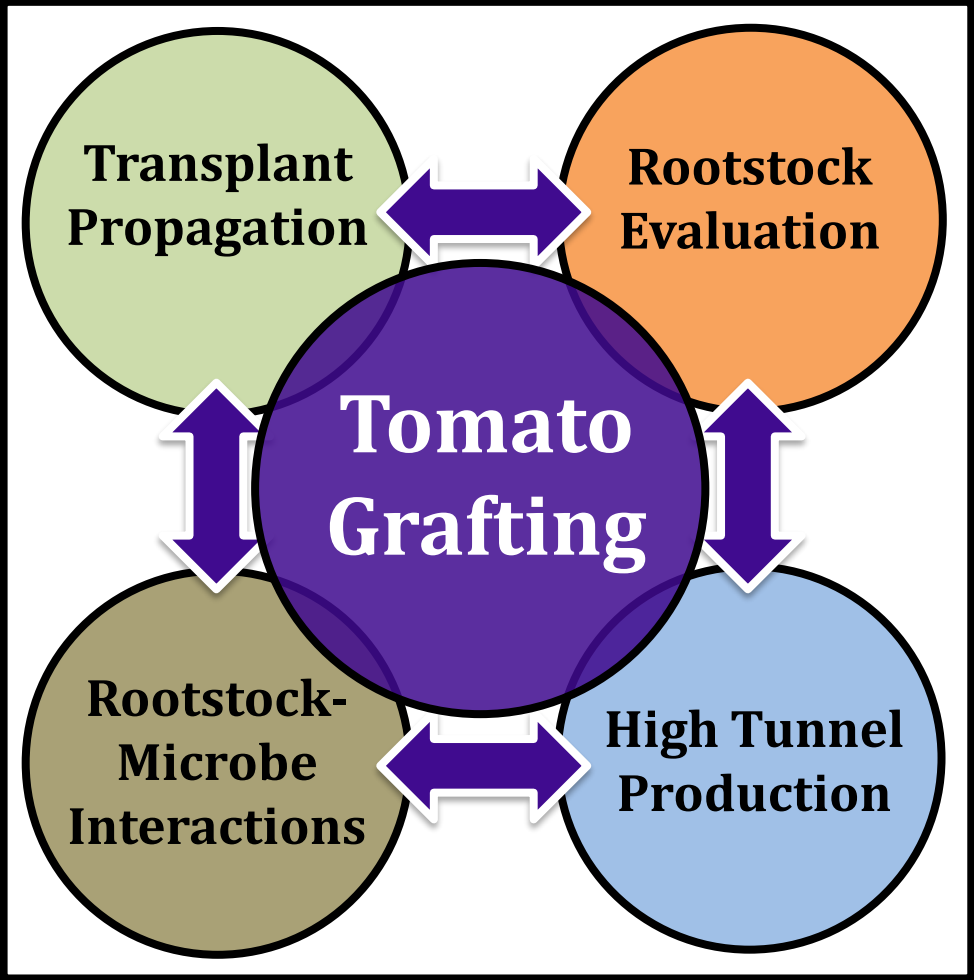
	Biomass (lbs/acre)		C:N	Available N (lbs/acre)
	Rye	Vetch		
High Tunnel	3749.4	329.4	9.8	83.2
Field	721.8	1589.1	8.5	54.2

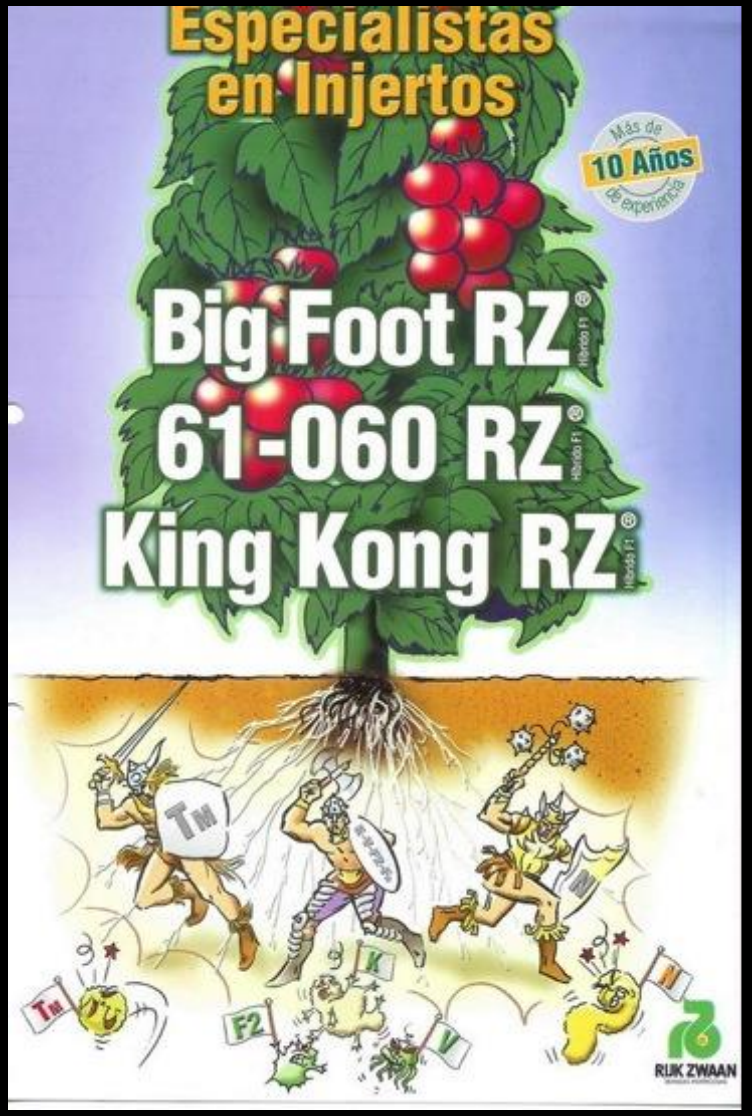
(O'Connell et. al., 2012)

What About Cover Crops?

- OREI Regional Grant
  - UMN, UKY
  - Ashlee Skinner (MS)
- Comparing benefits of CC vs. spinach
  - Economic vs soil-building
- Identifying crops for HT production
  - “Short windows”
  - Summer, fall, over-winter

Diversifying with Rootstocks





Disease Management

Pathogen Eradication with Resistant Rootstocks

Table 1.3. Root-knot nematode soil poulation[u] at Sampson County[y]

	First harvest[w]	Final harvest[x]
Non-grafted	8357 d	1964 b
Self-grafted	8751 d	1228 b
Telone II[y]	379 b	1260 b
Big Power[z]	77 a	40 a
Beaufort[z]	2680 c	2542 b
Maxifort[z]	3091 c	1251 b

= Non-, self-grafted

= Fumigated (Telone II)

= Big Power

= Beaufort, Maxifort

(Rivard et. al., 2010)

Disease Management

Rootstocks	TMV	Corky Root	Fusarium Wilt		Verticillium Wilt (r1)	Root-knot Nematode	Southern Bligh	Plant Vigor
			Race 1	Race 2				
Maxifort *	R	R	R	R	R	MR	HR	+++
Multifort *	R	S	R	R	S	R	HR	+++
Arnold **	R	S	R	R	R	R	MR	++
Estamino ***	R	S	R	R	R	R	NA	+
RST-04-106 ****	R	R	R	R	S	R	MR	+
Emperador *****	R	S	R	R	R	R	NA	+
Big Power *****	R	R	R	R	R	R	HR	++
Colosus RZ *****	R	R	R	R	R	S	NA	+++
Anchor-T ******	R	S	R	R	R	R	NA	NA

R=Resistant , **HR**=Highly Resistant, **MR**=Moderately Resisitant, **S**=Susceptible, **NA** = Not Available

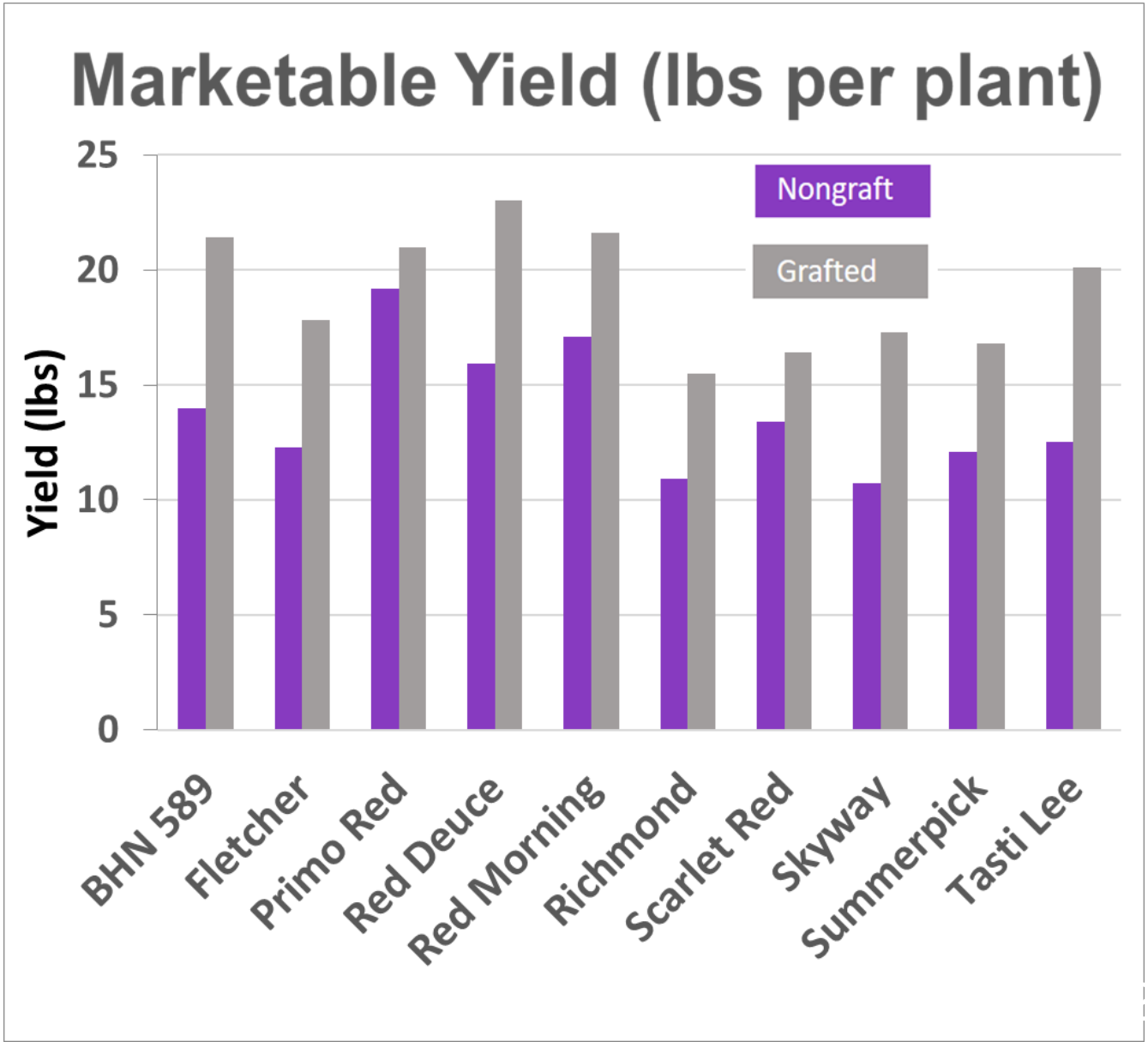
*** = Seminis Seed Co. ** = Syngenta Seeds *** = Enza Zaden**

****** = DP Seeds ***** =Rijk Zwaan ****** = Takii Seed**

Diversifying with Rootstocks

- Rootstocks function as a “rotation” in very few situations.
  - Heirloom or susceptible cultivars
  - High (qualitative) resistance
- They can help with quantitative resistance
- More useful as preventative measure
- Rootstock rotations and polycultures

Diversifying with Rootstocks



Diversifying with Rootstocks

Dan Kuhn, Courtland, KS

2013-18 High Tunnel Bell Pepper Variety Trials

Kansas State University

Horticulture Research and Extension Center

Olathe, Kansas

Paul Andersen, Kimberly Oxley, & Cary Rivard

KANSAS STATE UNIVERSITY

GREEN BELL PEPPERS

530 plants per 4800 ft^2 tunnel @ $1.50/lb
= $2.17 per ft^2

Bayonet (2016)
Declaration (2013-2016)
Intruder (2013-2016)
Red Knight (2013-2016)

Archimedes (2013-2016)
Currier (2014-2016)
Galileo (2016)
Karisma (2013-2016)
Vanguard (2013-2016)

Yield and Quality of Spring-Planted, Day-Neutral Strawberries in a High Tunnel

Kelly Gude, Sara Gragg,
Cary Rivard, Eleni Pliakoni

K-STATE Research and Extension

Kansas State University Horticulture and Natural Resources

The National Strawberry Sustainability Initiative

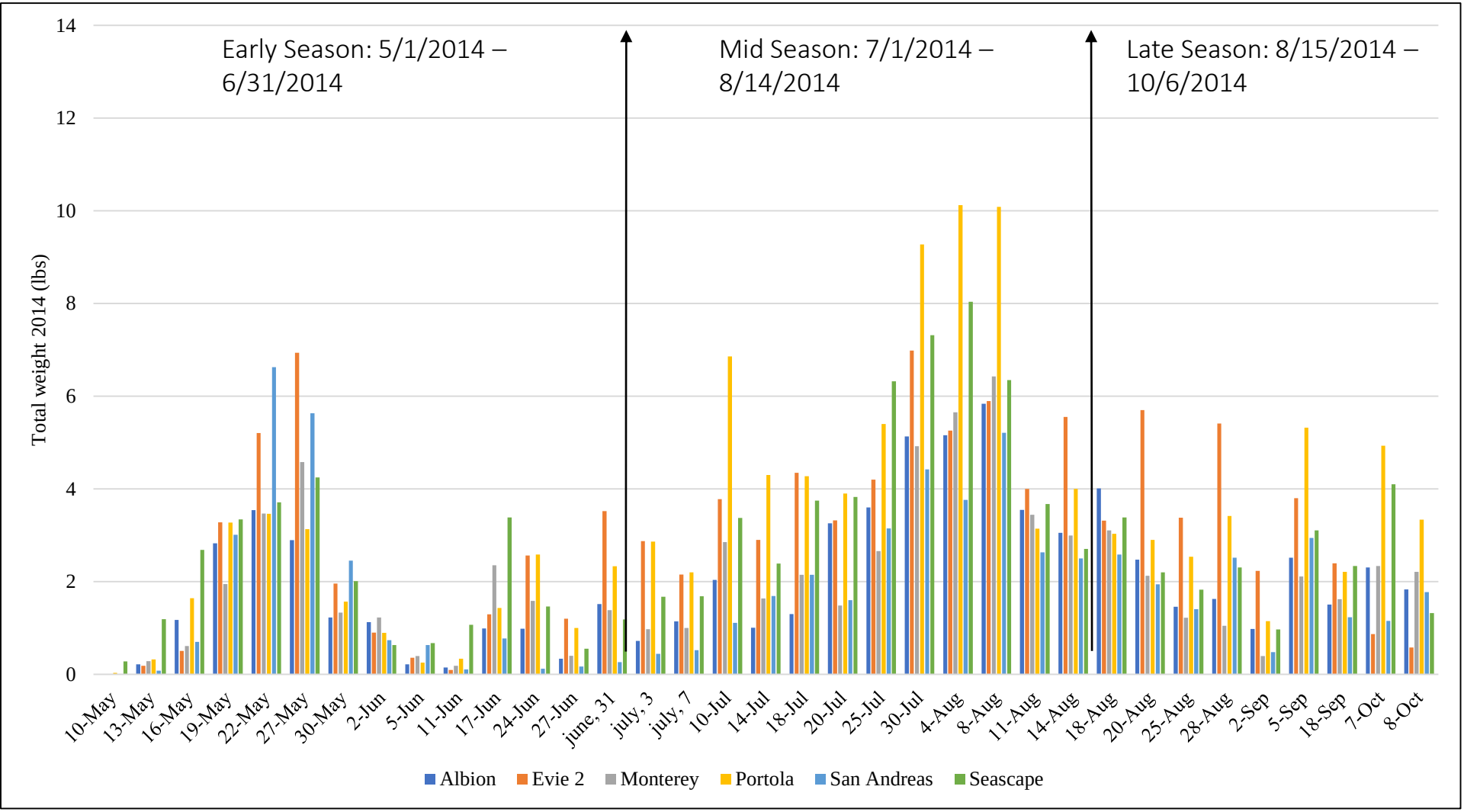
Fall-planted Strawberry Production

Strawberries Grown in High Tunnels

- Growing season extension & enhanced crop productivity
  - Increased yields, size, soluble solids, branch-crown development, vigor
  - Early and late season prices
- High tunnels in Kansas
- Challenges growing in high tunnels
- Solutions
  - Spring-planted day-neutral cultivars
  - Evaporative Cooling

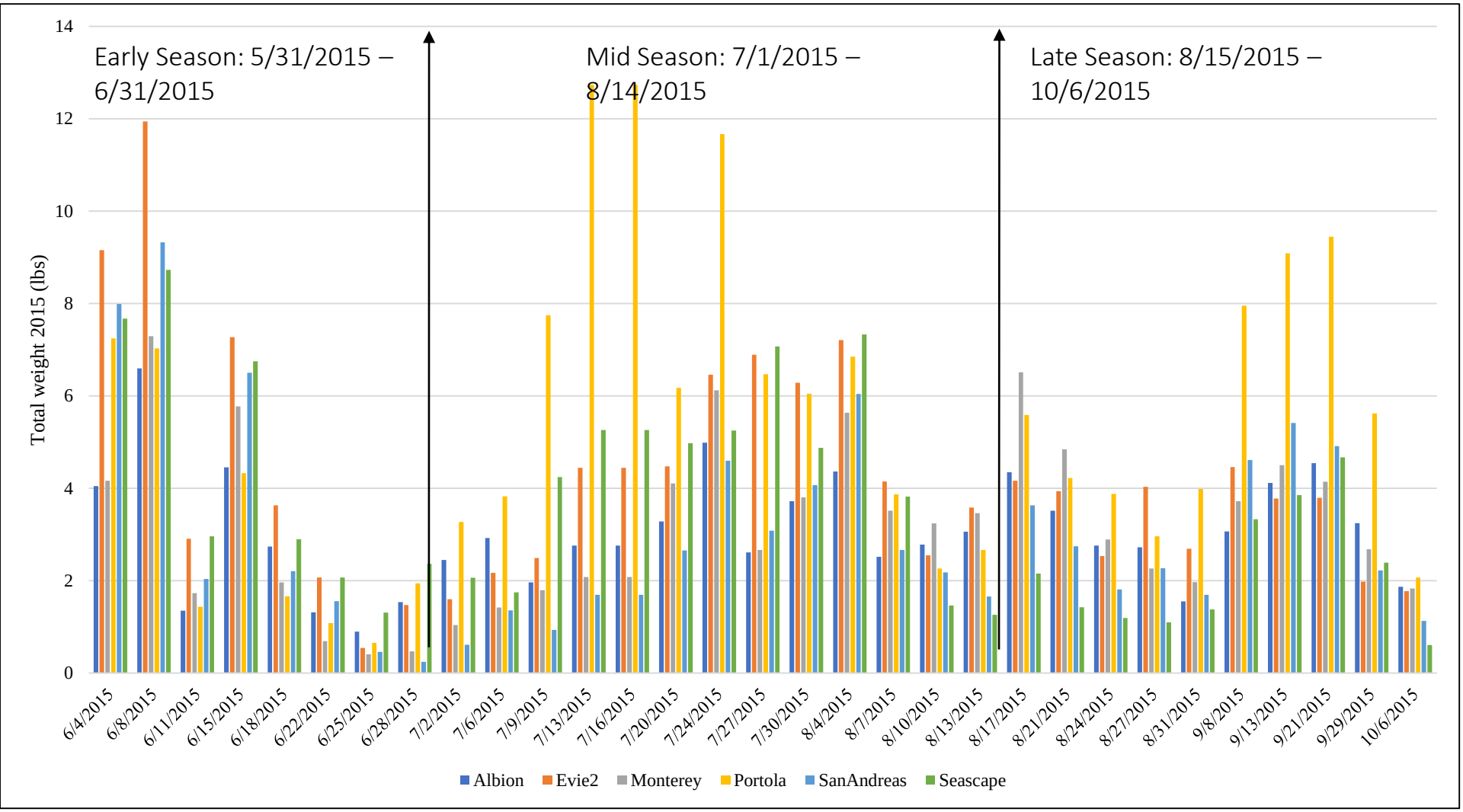
Materials and Methods

Planted April 7



Materials and Methods

Planted April 21



Cultivar	Total fruit yield[w] weight (kg/plant)	Total fruit yield size (g/fruit)	Marketable fruit yield weight (kg/plant)	Marketable fruit yield size (g/fruit)	Marketability weight (%)
2014[xy]					
Albion	0.39 bc[z]	10.49 ab	0.34 bc	11.06 ab	88.6 a
Evie 2	0.53 ab	8.79 cd	0.42 ba	9.36 cd	79.4 b
Monterey	0.40 bc	9.64 bc	0.34 bc	9.92 bc	84.8 ab
Portola	0.60 a	11.06 a	0.51 a	11.90 a	[illegible]
San Andreas	0.33 c	11.06 a	0.27 c	[illegible]	[illegible]
Seascape	0.48 ab	8.22 d	[illegible]	[illegible]	[illegible]
P value	****	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					
Albion	[illegible]	[illegible]	0.24 b	7.80 bc	82.5 ab
Evie 2	[illegible]	7.26 bc	0.28 b	8.13 ab	76.5 b
Monterey	0.30 b	7.44 bc	0.26 b	8.04 b	83.5 a
Portola	0.51 a	8.71 a	0.42 a	9.23 a	82.0 ab
San Andreas	0.28 b	7.97 ab	0.22 b	8.34 ab	78.9 ab
Seascape	0.33 b	6.30 c	0.26 b	6.63 c	79.2 ab
P value	***	****	****	****	*
Season Mean	**0.34**	**7.51**	**0.28**	**8.03**	**80.4**

1600 plants per 4800 ft^2 tunnel @ $4/lb
= $1.76 per ft^2

2017-18 High Tunnel Canteloupe and Watermelon Trials

Kansas State University
Horticulture Research and Extension Center
Olathe, Kansas
Kimberly Oxley, Extension Associate
Paul Andersen, Research Assistant
Cary Rivard, Extension Specialist

Supported by the Kansas Vegetable Growers Association

KANSAS STATE UNIVERSITY

Materials and Methods

Seedless Watermelons

- Promesa
- Extazy
- Sorbet
- Leopard
- Solitaire
- Vanessa
- Pollinator: Accomplice

Materials and Methods

Cantaloupe

- Aphrodite
- Athena
- ME3716
- Goddess
- Grand Slam
- Home Run

Materials and Methods

Cultural Methods

- Planted May 15 (transplants)
- 24” in-row spacing
- 5’ between rows
- Pre-plant and fertigation
- 1 pollinator per 5 plants (watermelon)
- No trellising was used

Cantaloupe

400 plants per 4800 ft^2 tunnel @ $0.54/lb
= $0.90 per ft^2

- Harvested: June 30-August 18
- Total Pounds: 3,279
- Total Num[illegible]
- USDA (2017): $0.54 per pound
- Local Retail June/July: $0.54 per pound
- **Revenue per square feet: $0.90**

Watermelons

- Harvested: July 10-August 18
- Total Pounds: 2,964
- Total Number: 419
- Average lbs per fruit: 7.08
- Pounds
- $0.69 to $0.83 per square foot:
- Local Retail June/July: $0.59 per pound
  - **Revenue per square foot: $0.89**

400 plants per 4800 ft^2 tunnel @ $0.59/lb
= $0.89 per ft^2

High Tunnel Slip Production for Organic Sweetpotato in the Midwest

Zachary Hoppenstedt, Jason Griffin, Eleni Pliakoni, Mykel Taylor, & Cary Rivard,

Kansas Center for Sustainable Agriculture and Alternative Crops

NORTH CENTRAL SARE Sustainable Agriculture Research & Education

KANSAS STATE UNIVERSITY

Propagation Cycle

Sweetpotatoes are bed in early April

Slips emerge and grow until harvest

Slips are cut by hand

Slips are boxed and shipped via UPS to their destination

Planting slips to regenerate seed sweetpotatoes

Crop is maintained until harvest

Sweetpotatoes are harvested and stored over winter

Foundation seed is sourced yearly to maintain healthy stock

Cultivars are propagated vegetatively.

Roots are sprouted, sprouts are cut and transplanted

Propagation Cycle

Materials and Methods

Sweetpotatoes are placed in ground and covered with 2-3” soil and clear plastic. Mid to late Spring.

About 4 weeks later when we see the slips breaking the surface, we remove the plastic.

Start cutting when they reach 8” – 12”

Figure 2. Olathe HT marketable slip yield by planting density, harvest and year

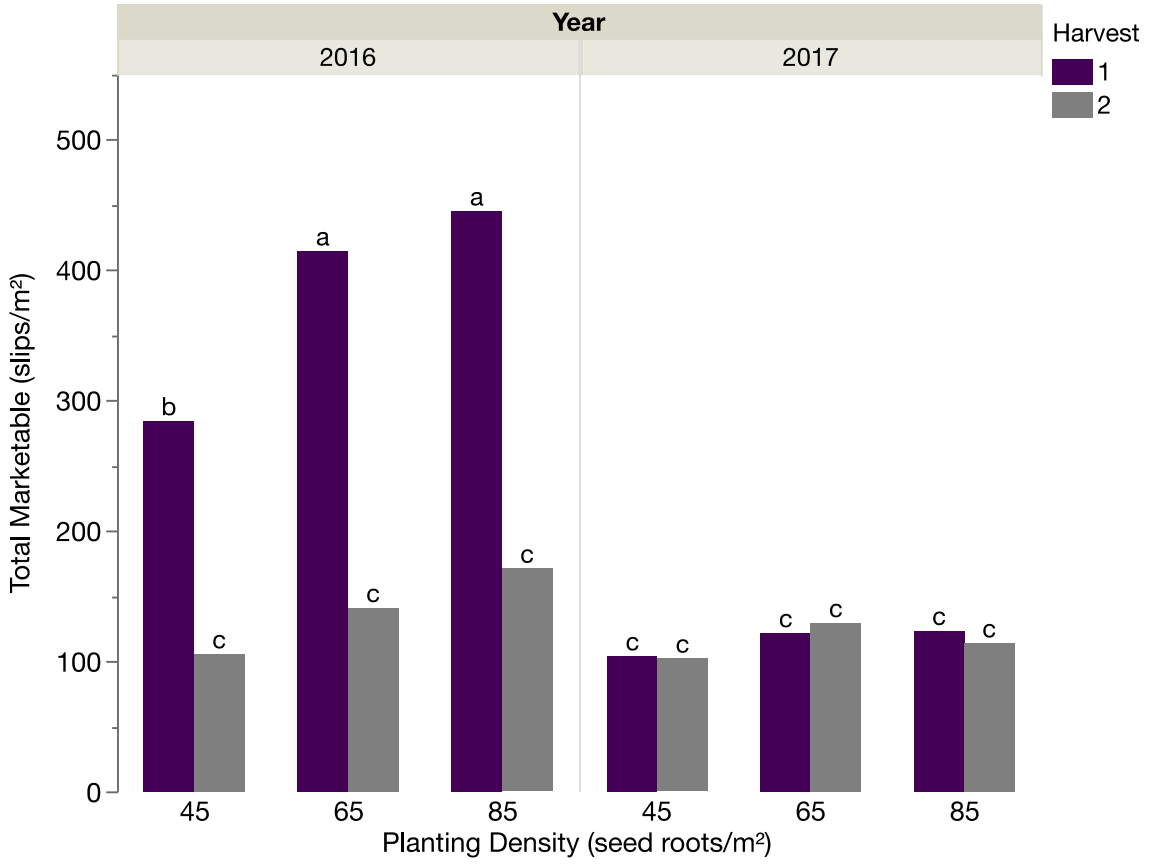
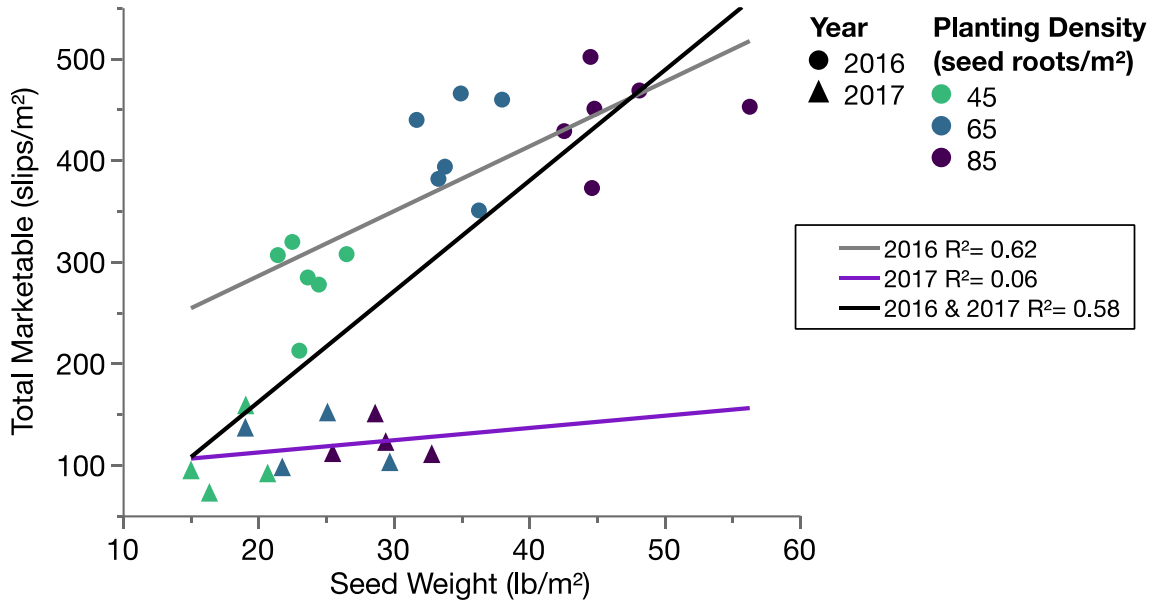


Figure 3. Correlation of HT plot weight and marketable slip yield

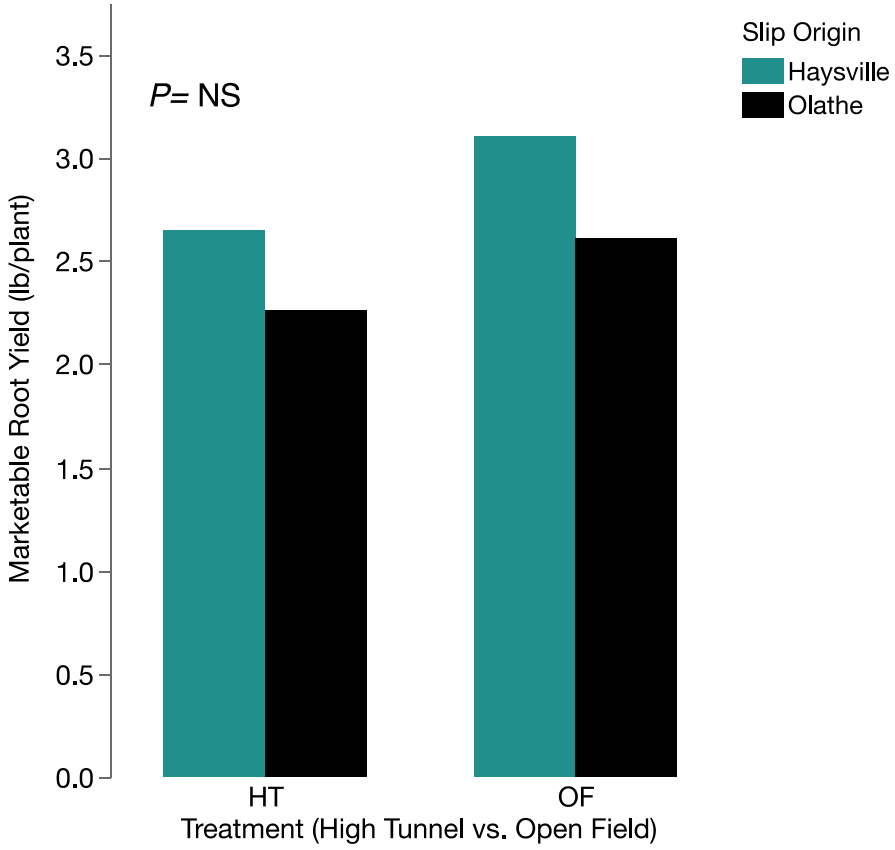


2016 & 2017 Total Marketable = -56.48755 + 10.879733*Seed Weight

Table 1: Slip quality parameters as influenced by slip production system (2016): Combined Sites and Harvests

Treatment	Fresh Weight (g)	Length (cm)	Stem Diameter (mm)	Compactness (mg)	Nodes/Length	Leaf Area/Length (cm^2)
HT	11.71	25.87	3.94	37.07	0.33	5.75
OF	12.78	23.37	3.94	52.38	0.45	7.17
***P* value**	**0.2751**	**0.0619**	**0.9666**	**<.0001**	**<.0001**	**<.0001**

Figure 4. Marketable root yields by slip production system and trial location (2016)



Sweet Potato Slip Research Results

- Data from these trials are being used to [illegible] nd determine the [illegible]
- [illegible] gh t[illegible]
- M[illegible] done looking at G0 vs. G1 vs. G2 planting stock.

65 roots/m^2 and @ $130/1000 slips = $4.30 per ft^2

Crop Type	Production Window	Sale Price	Gross Revenue/ft^2
Organic Slips	**Apr – Jul**	**$130/1000 slips**	**$4.30**
Tomato	**Apr – Oct**	**$2.50/lb**	**$3.66**
Cucumber	**Apr – Aug**	**$1.50/lb**	**$1.62**
Bell Pepper	**Apr – Oct**	**$1.50/lb**	**$2.30**

Revenue based on average trial yields for two harvests and regional price for foundation seed. All other crop values are based on enterprise budgets from Kansas Rural Center's Growing Under Cover v2 Dec. 2016.

KRC KANSAS RURAL CENTER

Putting the Pieces Together

A few scenarios for planning your high tunnel

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

Putting the Pieces Together

A few scenarios for planning your high tunnel

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

Putting the Pieces Together

A few scenarios for planning your high tunnel

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

Putting the Pieces Together

A few scenarios for planning your high tunnel

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

$0.89 – $0.90 per ft^2

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

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

$1.25 per ft^2

Putting the Pieces Together

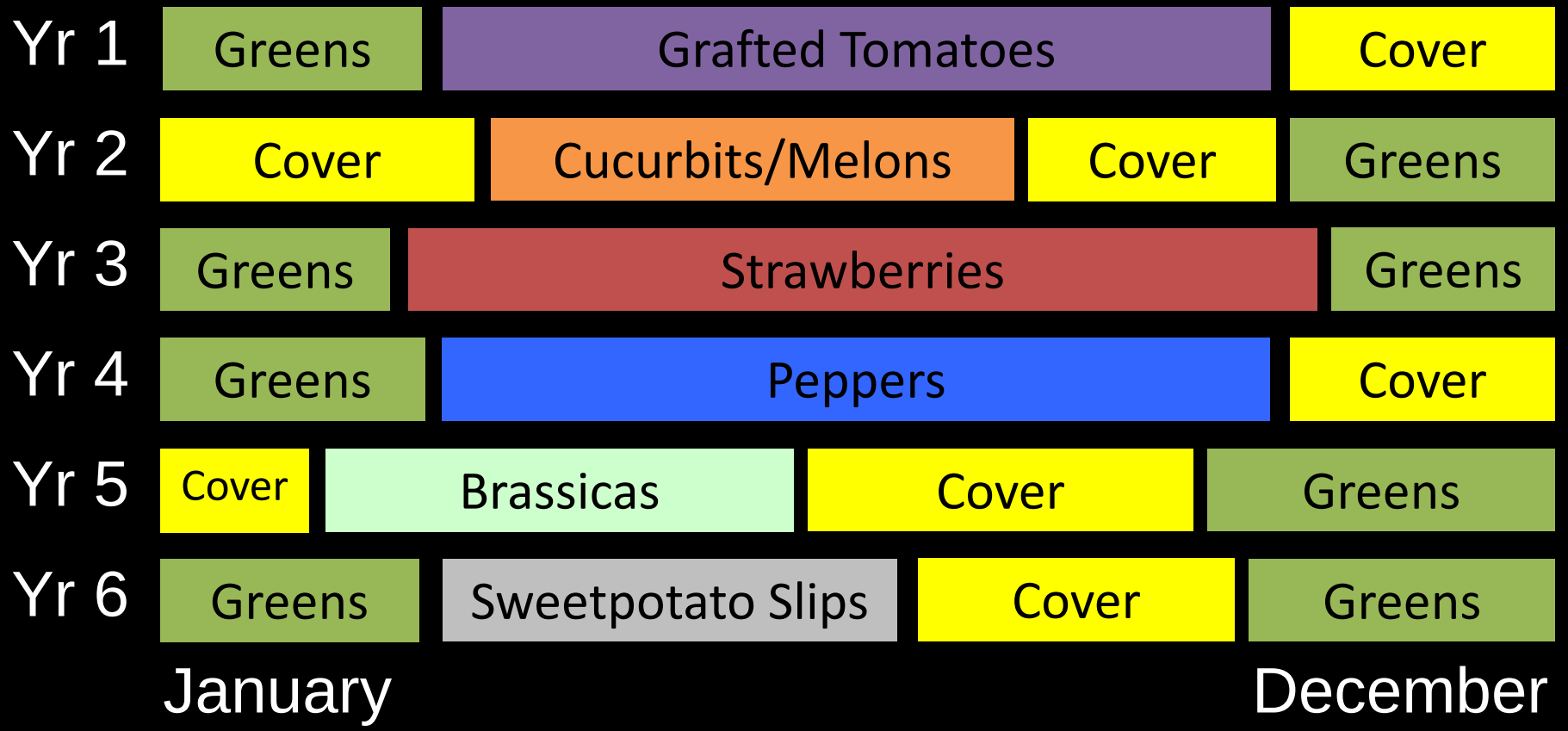
A few scenarios for planning your high tunnel

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

$4.30 per ft^2

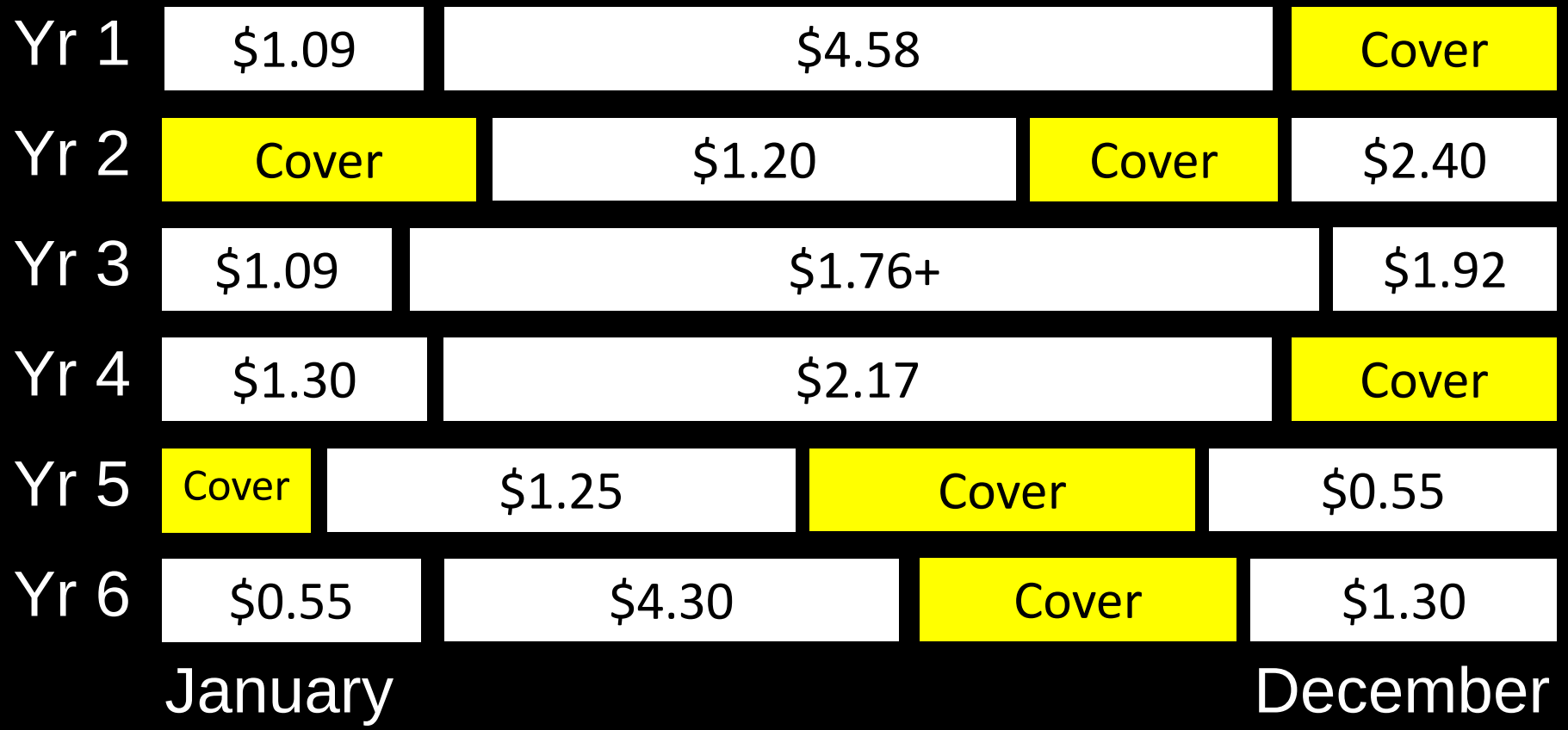
Putting the Pieces Together

A few scenarios for planning your high tunnel



Putting the Pieces Together

Think About Revenue in the Long Term

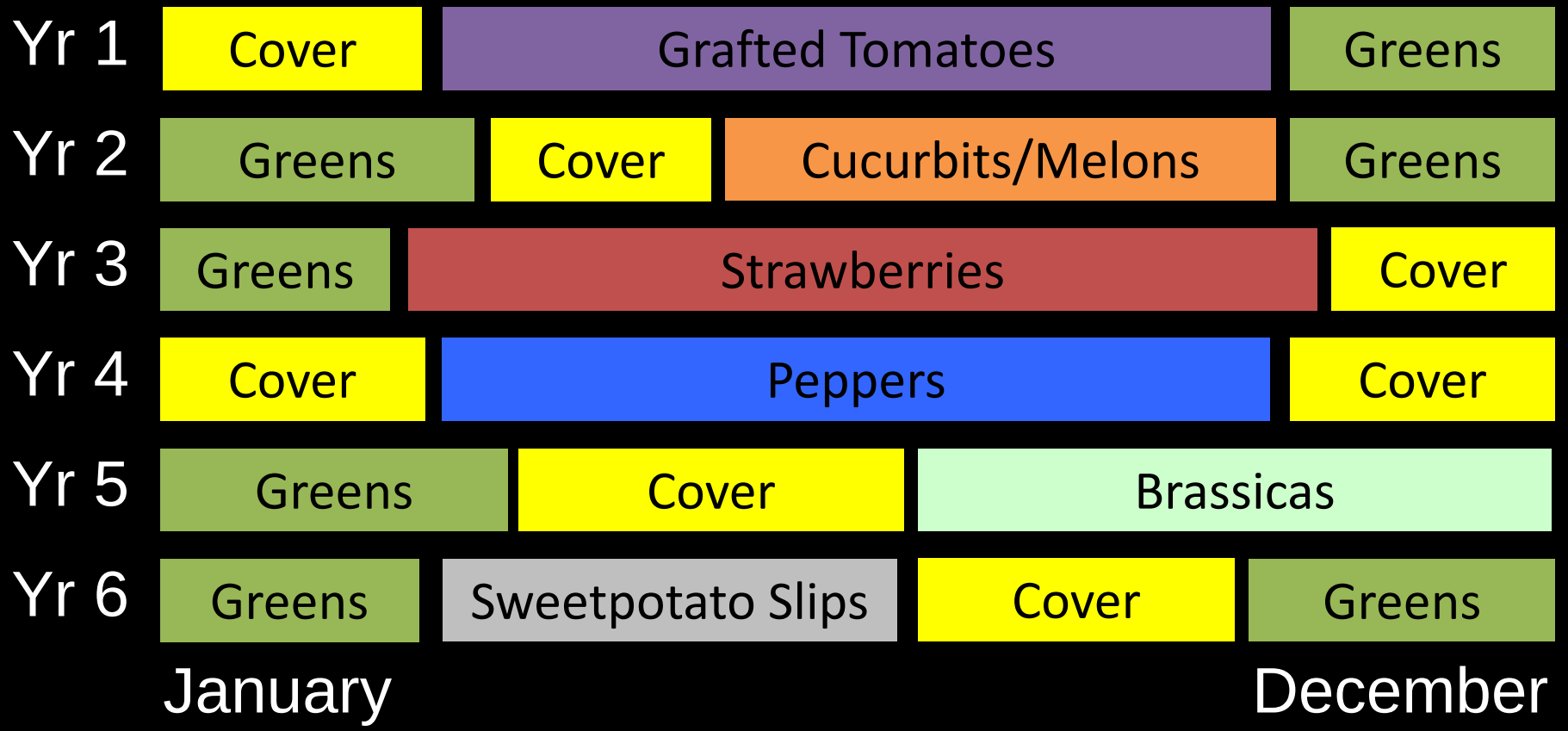


Average Annual GROSS Rev = $4.15 per ft²

Overhead (structure) Costs = 10.6%

Putting the Pieces Together

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



Summary

- Don’t grow tomatoes every year
  - Peppers not a rotation crop
  - Consider inter-specific rootstocks
- Develop new systems
  - Day-neutral strawberries
  - Sweetpotato slips
  - Melons
  - CBD Hemp??
- Recognize the value of crop rotation and soil building
- Find a niche and have fun!


QUESTIONS??