

The Penn State High Tunnel Research and Education Facility

2005 Crop Review



New: The Penn State *Cellar Market*
Mixed Eggplant & Peppers
Specialty & Hot Peppers
Lisianthus
Spring Cut Flowers
Fall Cut Flowers
Sunflowers
Culinary Herbs & Okra
Garlic
Shade Cloth Trial
Other Crops
Weather Review

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Crop	Index	Page
Penn State <i>Cellar Market</i>		2
Mixed Eggplant & Peppers		3
Specialty & Hot Peppers		6
Lisianthus		7
Spring Cut Flowers		9
Fall Cut Flowers		10
Sunflowers		11
Culinary Herbs & Okra		12
Garlic		13
Shade Cloth Trial		15
Other Crops		17
Weather Review		18

Every year, the data collected at the Penn State High Tunnel Research and Education Facility (HTREF) is compiled into the *Annual Crop Review*. This crop review is merely a summery of the ongoing research. Further information may be available on any of the crops listed above, please feel free to contact us with comments or questions. Our *2005 High Tunnel Production Manual* has been updated this year and is also available through the HTREF for \$25.

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The Penn State Cellar Market

Beginning in the summer of 2004 the Penn State Cellar Market opened on the University Park campus under the coordination of Bill Lamont. The long-term goal of the Cellar Market is for an intensive summer course to be built around the many facets of farming and marketing and the integral relationship between the two. This course will prove to be very valuable in our ever increasingly competitive work environment. Students will grow and market the produce as well as calculate the farm and market budget and set produce prices accordingly. As the course is in its development stages, the market has been open for almost two full growing seasons now. We have been able to glean much information about customer preference and quality of the produce in this time. Included in each section below comments about specific varieties will be reported as well as overall trends in customer preference. If you happen to be on the University Park Campus, please feel free to stop by and visit. The Cellar Market is located on Eisenhower Road just beneath the greenhouses of the Tyson Building.

We are excited for the 2006 season as our Cellar Market recently received a bit of a 'face lift'. A new façade was put on the aged vegetable cellar what now has a new life. Our customers prove to be loyal and anxiously await our opening this spring.

A few marketing tips learned from the Cellar Market:

~Know your customer base – On the University Pak campus we are lucky to have a wide diversity of age and ethnicity. However, we are in a transient community, therefore our trends may change from year to year.

~Ask your customers what they would like to buy, grow it if you can – There have been a few crops, like collard greens and okra, that I would not have necessarily grown, but did so at customer request. They have proved to be very successful in the market with a wide variety of our customers.

~Offer tips on how to prepare produce, especially for new or unfamiliar produce. Have recipes for them that might include many other items that you sell. I have found this to result in many sales as well as some great dialog between other customers.

~Learn a few of your regular customer's names. The little things really go a long way in customer retention.

~Label produce clearly – Pretty simple, but I have noticed that if people are confused about the price or are not sure what it costs, they are not likely to buy it.

~ Have fun!



Mixed Peppers and Eggplants

Crops studied: (1) Bell Pepper (2) Eggplant

Study Period: (A) Planted: 14 April 2005 / Final harvest: 31 October 2005

(B) Planted: 17 May 2005 / Final harvest: 31 October 2005

Tunnels: 5A & 5C (mixed crops); both tunnels are 17'x36'.

Study Design: Four rows of raised beds with black plastic mulch, and drip irrigation. Each variety was planted in either a full 30' long row, or a 15' long, half row. Both tunnels were managed with the use of biological controls whereby they receive bio-releases of beneficial insects. Tunnel 5A was planted approximately one month before 5C. Beneficial plants were planted around the inside perimeter of each high tunnel to aid in the retention of released insects as well as the attraction of local beneficial insects.

Spacing: 16", single row

Parameters Evaluated: (1) Yield, (2) Cull (3) Crop-specific weight

Pest Control: Same for both 5A and 5C.

Spray: 27 April - BontaniGard

Spray: 4 May - Pyganic

Release 1: 3 June - *N. cucumeris*

Release 2: 16 June - *N. cucumeris*

Release 3: 17 June - Adult ladybird Beetles

Release 4: 1 July - *N. cucumeris*

Release 5: 7 July - *Encarsia Formosa*, Spider mite Mix.

Fertility: Both tunnels received 4 applications of Liquid Compost Factor (LCF) and one application of 20-10-20.

Quality of Individual Variety: mixed; excellent (*), poor (~)

Seed Sources: Johnny's Selected Seeds for all pepper and eggplant; Territorial Seed for Beneficial Bug Mix



Eggplant

Varieties: (1) Neon (2) Nadia (3) Orient Charm

(1) Yield & (2) Cull

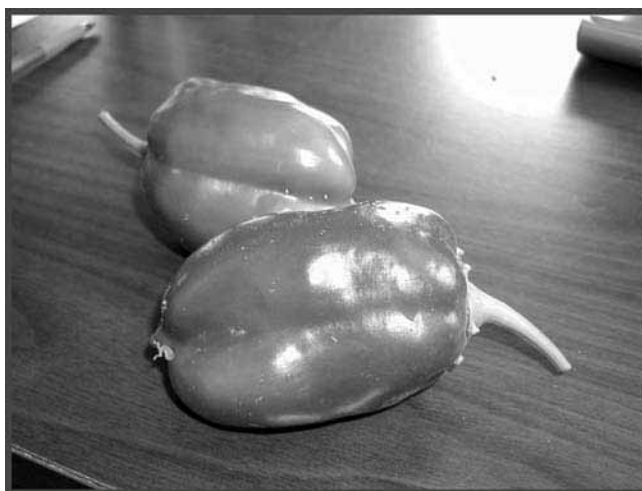
Yields (in lbs.) reflect total quantities from two high tunnels, row length reflects total length of row (in both high tunnels combined).

	<u>Total yield</u>	<u>Total cull</u>	<u>% cull</u>
*Neon [30']	285.8	50	14.9
Nadia [60']	427.8	26.8	5.9
*Orient Charm [30']	429.2	17	3.81

3) Average Eggplant Variety Weight in lbs.

	<u>Average fruit weight</u>
Neon	0.63
Nadia	0.80
Orient Charm	0.32

Notes: All three varieties proved to be very reliable this season. Neon is colorful, has an excellent shelf life and is very productive. Nadia is the traditional dark purple 'Italian' eggplant and Orient Charm is a pink/purple long slender Asian-type eggplant. All three of these varieties sold very well for us at the Cellar Market. All varieties are grow very well in high tunnel production. Pests on these plants included thirps, two spotted spider mites, flea beetles and Colorado Potato beetles (CPB) and where present on all varieties. In high tunnels, manual removal of large beetles such as CPB's is possible, thus managing the population without pesticide use. Beneficial insects where released to manage the other aforementioned pests.



Bell Peppers

Varieties: (1) 3XR Red Knight (large red bell), (2) Sweet Chocolate (brown bell), (3) Gourmet (orange bell), (4) Labrador (yellow bell)

(1) Yield & (2) Cull

Yields reflect total quantities (lbs.) from two high tunnels, row length reflects total length of row (in both high tunnels combined).

	<u>Jumbo</u>	<u>Fancy</u>	<u>Standard</u>	<u>Total Yield</u>	<u>Total Cull</u>	<u>% Cull</u>
*Red Knight [30']	24	61	26.6	111.6	3	2.6
~Sweet Chocolate [30']		7	85.4	92.4	13.3	12.6
Gourmet [30']	7.4	27.2	47.8	82.4	10.9	11.7
Labrador [30']	1.2	45.4	53.6	100.2	12.8	11.3

(3) Average Pepper Variety Weight (lbs).

	<u>Jumbo</u>	<u>Fancy</u>	<u>Standard</u>
Red Knight	0.62	0.47	0.35
Sweet Chocolate		0.21	0.20
Gourmet	0.49	0.47	0.37
Labrador	0.40	0.38	0.34

Variety Notes:

Red Knight: Very large, thick skin and flesh; very flavorful; overall attractive

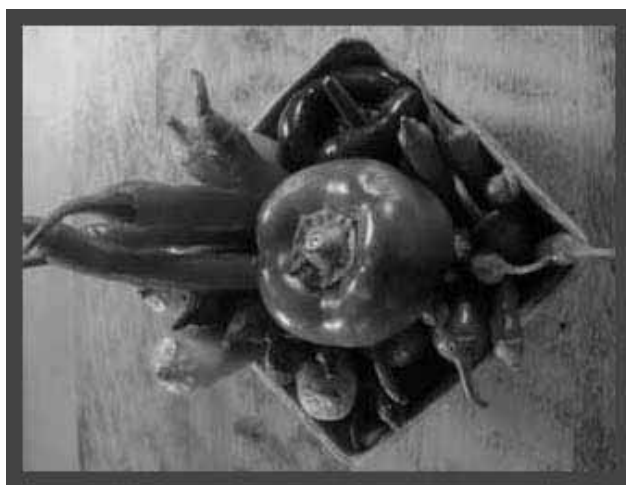
Sweet Chocolate: Small tapered shape; very prolific; nice color, but too small to sell mixed in with other colored bell peppers; will not be growing this again.

Gourmet: good color, mild sweet flavor; reliable orange pepper

Labrador: Reliable yellow pepper; good color and mild flavor

Notes:

All varieties of bell peppers were harvested showing at least 40-50% color. Overall, pest damage was minimal and well controlled by beneficial insects. Labrador and Gourmet are grown every year and we will likely grow 3XR Red Knight again as well.



Specialty & Hot Peppers

Varieties: (1) Super Red Pimento (2) Pepperoncini (3) Cherry Bomb (4) Chilies 'Joe's Long Cayenne' (5) Ancho 'Tiburón' (6) Jalapeno 'Conchos'

Study Period: Planted: 24 May 2005/ Final harvest: 1 November 2005

Tunnel: 4B (17'x36')

Study Design: Raised bed system, black plastic mulch treatment, drip irrigation. Tiburón and Pimento peppers planted in a 30' row, Jalapeno in 15' row and all others in 10' row.

Spacing: 12", single row

Parameters Evaluated: yield

Pest Control:

Release 1: 3 June – *N. cucumeris*

Release 2: 16 June – *N. cucumeris*

Release 3: 17 June – Adult Ladybird beetles

Release 4: 1 July – *N. cucumeris*

Fertility: Two applications of Liquid Compost Factor and one application of 20-10-20

Quality: Exceptional

Seed Source: Heirloom Seed – Pepperoncini; Stoke's Seed – Super Red Pimento; Johnny's Selected Seed – all others.

<i>(1) Yield</i>	<u>Total lbs.</u>
Super Red Pimento	109.8
Pepperoncini	28
Cherry Bomb	36.2
*Joe's Long Cayenne	29.2
*Tiburón	97
Jalapeno	80.4
Total Yield for tunnel:	380.6 lbs.

Notes: Due to the prolific nature of most hot peppers, the plants were not harvested to their fullest, therefore the numbers do not reflect total potential harvest.

I have found the pablano peppers to be among the best selling hot pepper, with cayenne and jalapeno also quite popular. The cherry bombs and pepperoncini (which is not hot) did not sell very well for us. Not sure what to grow? Try the combination of tiburón, cayenne and jalapeno as they offer a nice size, shape, color and heat level options for the customer.



Lisianthus
(2005 & 2004)

2005:

Varieties: Avila Deep Rose, Ventura Peach, Balboa Yellow, Balboa Purple

Study Period: All sown from seed in Hort Farm greenhouse on 31 November 2004

Planted: 13 April 2005 / Final harvest: 8 November 2005

Tunnel: 3C (17'x36')

Study Design: 2 rows of blue plastic mulch, 2 rows of black plastic mulch, all with drip irrigation. Each variety was planted in 2, 15' rows, one row on each color of plastic.

Spacing: 5", single row

Parameters Evaluated: (1) Yield (2) Average Stem Length (3) Effect of plastic colored mulch

Pest Control: None, aphid parasitizers and green lacewings (native and/or via releases in other tunnels in previous years) established and controlled aphid populations by late summer.

Fertility: Two applications of Liquid Compost Factor and one application of 20-10-20

Quality: Excellent

Seed Source: Ball Seed

(1) Yield (2) Average Stem Length & (3) Effect of Colored Mulch

Numbers in bold print are those that performed better on that color plastic.

2005	<u>Blue Mulch</u>		<u>Black Mulch</u>	
	Number of stems	Average stem length	Number of stems	Average stem length
Avila Deep Rose	252	15.2	188	14.9
Ventura Peach	166	15.2	139	14.9
Balboa Yellow	256	18.4	217	17
Balboa Purple	221	19.6	282	20.2

Notes: Avila and Ventura are not recommended for high temperature/high light production but their performance was tested in High Tunnel conditions to see if they would come on earlier than Balboa, which is recommended for high temp/high light environments. Avila and Ventura are recommended for cooler temperatures as well as shorter day length. With an early spring planting in April, the days are still relatively short and the evenings are cool. Indeed, Avila and Ventura were 11 days earlier than both Balboa varieties. Avila and Ventura were also much shorter in stem length than Balboa. This earliness may not be significant enough to warrant growing these varieties in the high tunnel environment, at least not for this climate.

In previous years we have looked at Lisianthus in the field as well as the high tunnel. The quality of the flowers was so inferior to that of which came out of the high tunnel that we stopped growing them in the field. We currently only grow Lisianthus (as well as most other crops) in the protected high tunnel environment.

The Lisianthus crop data from 2004 was not published last year so it will be included here. The previous two years Lisianthus was grown in three high tunnels, and last year, only one. Our market simply does not accommodate three high tunnels worth of Lisianthus. However, this is one of the best crops that we have grown in the high tunnel environment due to its excellent quality in combination with its wholesale and retail value. Because this has the potential to be a key crop for some farmers, this data has been included.

2004:

Varieties: Laguna Peach, Malibu Blue Blush, Catalina Yellow, Balboa Rose

Study Period: All sown from seed in Hort Farm greenhouse on 4 January 2004

Planted: 12 April 2004 / Final harvest: 9 November 2004

Tunnels: 2B, 2C, 2D (17'x36')

Study Design: 2B; 2 rows each of black and white plastic mulch. 2C and 2D; 2 rows each of blue and silver plastic mulch, all with drip irrigation. Each variety was planted in 2, 15' rows, one row on each color of plastic. Sixteen (16) plants were flagged per tunnel and the number of stems harvested off of those plants was recorded over the course of the season.

Spacing: 8", double row

Parameters Evaluated: (1) Yield (2) Average Stem Length (3) Effect of plastic colored mulch (4) Average number of stems per plant.

Seed Source: Ball Seed

(1) Yield (2) Average Stem Length (3) Effect of plastic colored mulch

Note that there were two tunnels with Blue and Silver plastic mulch, and only one tunnel with Black and White plastic mulch.

	<u>Black Mulch</u>		<u>White Mulch</u>		<u>Blue Mulch</u>		<u>Silver Mulch</u>	
	Ave. Stems	Ave. Length (in)	Ave. Stems	Ave. Length (in)	Ave. Stems	Ave. Length (in)	Ave. Stems	Ave. Length (in)
Laguna Peach	162	19.6	164	21	143/113	18/17.4	190 /131	18.3/17.4
Malibu Blue Blush	254	20.4	277	23.3	196/138	18.9/16.9	179/191	17.5/19.5
Catalina Yellow	182	20.1	181	21.9	220 /167	20.5/19.4	139/142	20.1/20.3
Balboa Rose	272	24.9	188	22.7	191/173	21.3/20.6	77/57	19.9/20.4

(4) Average number of stems per plant

	<u>Ave Number stem/plant</u>	<u>Total stems (3 tunnels)</u>	<u>Ave stem length (in)</u>
Laguna Peach	2.8	903	18.6
Malibu Blue Blush	5.8	1235	19.4
Catalina Yellow	3.2	1031	20.4
Balboa Rose	3.5	958	21.6

Notes: All four of these varieties are recommended for high heat, long day-length production as their stem length reflects, they all average approximately 20" stems. There was not a conclusive result to the mulch trial in 2004. Blue and black mulch were chosen for the 2005 trial considering the data presented above as well as observational data throughout the growing season. It has not yet been determined what color plastic will be trailed in 2006.



Spring Cut Flowers

Varieties: Calendula ‘Antares Flashback’, Yarrow ‘Colorado Mix’, Snapdragon ‘Rocket Mix’, Statice ‘Sunset’ and ‘Pacific’ Mixes, Bupleurum, Zinnia ‘Benery’s Giant Mix’, Purple Larkspur

Study Period: Planted: 4 April 2005 / Final harvest: 8 November 2005

Tunnel: 7D (17’x36’)

Study Design: Five (5) permanent raised beds with black plastic mulch, all with drip irrigation. Each variety was planted in 15’ rows; Snapdragon, Zinnia and Statice planted in 2, 15’ rows (totaling 30’ ; data reflects increased number of plants).

Spacing: 6”, single row

Parameters Evaluated: (1) Yield (2) Average Stem Length

Pest Control:

Release 1: 3 June – *N. cucumeris*

Release 2: 16 June – *N. cucumeris*

Release 3: 17 June – Adult Ladybird beetles

Release 4: 1 July – *N. cucumeris*

Release 5: 7 July - *Encarsia Formosa*, Spider mite Mix.

Fertility: Two applications of Liquid Compost Factor and one application of 20-10-20

Quality: Excellent

Seed Source: Ball Seed – Bupleurum, Snapdragons; Self-sown from 2004 – Larkspur; Johnny’s Selected Seeds – all others.

(1) Yield & (2) Average Stem Length

	Total stems harvested	Average stem length (in)	
Calendula	1735	12.5	<i>Notes: Cut flower arrangements sell very well at the Cellar Market. Calendula was very early and productive, but did not sell well. Sold better as an edible flower. Bupleurum is a great cut flower but a little tricky to grow – will definitely try it again in 2006. Snapdragons perform well and sell well in arrangements or as single stem – a must have for cut flower growers! Statice and yarrow make excellent filler and can be dried and sold later if mid-summer harvest is too prolific.</i>
Snaps	4410	22.6	
Zinnia	2390	17.8	
Bupleurum	110	16.5	
Larkspur	2029	21.9	
Statice	1860	21.7	
Yarrow	334	18.2	



Fall Cut Flowers

Varieties: Snapdragon 'Rocket Mix', Statice 'Sunset' and 'Pacific' Mixes, Scabiosa 'Black Knight', Celosia 'Pampas Plume' ('Lime Light Spray' Millet, Salpiglossis 'Painted Tongue')

Study Period: Planted: 11 June 2005 / Final harvest: 8 November 2005

Tunnel: 7B (17'x36')

Study Design: Four (4) raised beds with black plastic mulch, all with drip irrigation. Each variety was planted in 15' rows; Snapdragon and Statice planted in 30' rows (data reflects increased number of plants).

Spacing: 6", single row

Parameters Evaluated: (1) Yield (2) Average Stem Length

Pest Control: None; there was no significant pest population build up that required control.

Fertility: One application each of Liquid Compost Factor (LCF) and 20-10-20

Quality: Excellent / Good

Seed Source: Ball Seed – Snapdragon 'Rocket Mix', Johnny's Selected Seeds – all others

(1) Yield & (2) Average Stem Length

	Total stems harvested	Ave. stem length (in)
Statice	311	22.6
Celosia	422	21.5
Snapdragon	976	17.9
Scabiosa	212	21.13

Notes: There are two varieties mentioned above that do not have corresponding data; these varieties did not establish well due to late planting (or being sown too early). I would like to try them again as I think they would be a nice addition to flower arrangements. The Scabiosa Black Knight is a beautiful deep color and a great addition color-wise, however the stems are on the weak side and the growing habit of the plant is a little weedy. May grow again but will plant further apart. It appears that the Statice and Snapdragons do better when planted earlier in the season (see "Spring Cut Flower" data). The Celosia is a very nice cut flower as well. I will indeed grow this again in the future. It can also be dried and sold at a later date if it is not all needed at time of harvest.



Sunflowers

Varieties: ‘Sunbright Supreme’, ‘Sunrich Gold’, ‘Sunrich Lemon’, ‘Autumn Beauty’

Study Period: Planted: 26 April, 10 May, 23 May, 8 June, 19 July 2005 / Final harvest: 20 October 2005

Tunnel: 4C, 6D (17’x36’)

Study Design: Four (4) raised beds with black plastic mulch, all with drip irrigation. Tunnel 4C had three consecutive plantings and tunnel 6D had two. Approximately 10-15 plants of each variety were planted at one time.

Spacing: 4”, single row

Parameters Evaluated: (1) Yield (2) Average Stem Length

Pest Control: Powdery mildew was noted in each tunnel by the end of the crop cycle.

Spray: 4 May – Pyganic

Release 1: 3 June – *N. cucumeris*

Release 2: 16 June – *N. cucumeris*

Release 3: 17 June – Adult ladybird Beetles

Release 4: 1 July – *N. cucumeris*

Release 5: 7 July - *Encarsia Formosa*, Spider mite Mix.

Fertility: One application each of Liquid Compost Factor (LCF) and 20-10-20

Quality: Excellent / Good

Seed Source: Johnny’s Selected Seeds

(1) Yield & (2) Average Stem Length

	Total number harvested	Average stem length (in)
Sunbright Supreme	81	29.3
Sunrich Gold	90	24.8
Sunrich Lemon	67	24.4
Autumn Beauty	204	25.2

Notes: The key to growing sunflowers for market is to sow the seeds every few weeks. Sunbright Supreme and Sunrich Gold are among the best sunflowers that I have grown. Sunrich Lemon is also a nice sunflower. I have found that the customer likes a choice between yellow or gold petals and dark or light centers. Autumn beauty was chosen because it produces side shoots. It does produce pollen however. The color variation in Autumn Beauty was nice but the plants were oversized in the high tunnel growing well over 7 feet. Its side shoots were a nice addition to the cut flower arrangements.



Culinary Herbs & Okra

Varieties: Basil ‘Genovese’, Cilantro ‘Santo’, Dill ‘Superdukat’, Sweet Marjoram ‘Erfo’, Parsley ‘Italian Dark Green’, Common Mint, Greek Oregano, Rosemary, Summer Thyme, ‘Clemson Spineless’ Okra, ‘Red Burgundy’ Okra

Study Period: Planted: 18 April 2005 Final harvest: 31 October 2005

Tunnel: 7A (17’x36’)

Study Design: Five (5) Permanent raised beds; plastic mulch over all beds, all with drip irrigation. Each variety was planted in 10’ rows, with the exception of cilantro, which occupied 30’.

Spacing: 6” single row, except cilantro and dill, direct seeded multiple times. Okra, 12” single row

Parameters Evaluated: (1) Yield

Pest Control:

Release 1: 3 June – *N. cucumeris*

Release 2: 16 June – *N. cucumeris*

Release 3: 17 June – Adult Ladybird beetles

Release 4: 7 July - *Encarsia Formosa*, Spider mite Mix.

Fertility: Two applications of Liquid Compost Factor and one application of 20-10-20

Quality: Excellent

Seed Source: Johnny’s Selected Seeds – all herbs; Heirloom Seeds – Okra

(1) Yield

	lbs.	
	<u>Harvested</u>	
Parsley	5	<i>Notes: There is great potential for culinary herbs in high tunnels. Our market does not demand large quantities of herbs, therefore our harvests are rather small. The product is quite beautiful however. The quality of the herbs is excellent and they tend to last a week or more post-consumer purchase. Since rain does not damage the leaves of the herbs, they tend to store better after harvest. Marjoram did not sell well and will not be grown again. Cilantro sells very well and needs to be sown every few weeks to maintain a fresh crop due to its tendency to bolt in the heat of the summer. Okra is a new crop for us to grow. It is being grown at the request of a few of our Cellar Market customers. The quantity grown was not sufficient to keep up with the demand. Okra seems to thrive in the high tunnel environment and so demands frequent harvesting.</i>
Mint	5.2	
Oregano	5.9	
Thyme	5.8	
Rosemary	7.1	
Basil	24	
Cilantro	12	
Marjoram	4.9	
Dill	4.2	
Okra	31.2	



Garlic

Varieties: Xian, Medidzhuari, Inchelium Red, German Extra Hardy, German Red, German White

Study Period: Planted: Harvest: 21, 29 June 1, 14, 21, 26 July 2005

Tunnel: 6B, 5D, 6D (17'x36')

Study Design: All: top-dressed with compost with drip irrigation, no plastic mulch.

5D: Five (5) Permanent raised beds (PRB)

6B: Four (4) raised beds – Note; Due to a thrip infestation, the garlic from this tunnel was pulled early and sold as “Baby Garlic”. No seed was saved from this tunnel and the data below will reflect the smaller garlic size.

6D: Nine (9) rows flat culture

Spacing: 6” double row

Parameters Evaluated: (1) Yield (2) Cull (3) Garlic growth in PRB vs. Raised Beds vs. Flat Culture

Pest Control:

Spray: 27 April – BotaniGrad

Spray: 4 May – PyGanic

Spray: 10 June – Spintor

Fertility: Two applications of Liquid Compost Factor and one application of 20-10-20

Quality: Mixed; Excellent, Good, Poor

Seed Source: HTREF Seed stock

(1) Yield (2) Cull

Data represented by X/Y denotes two rows of the same variety in one tunnel.

	<u>6B</u>			<u>5D</u>			<u>6D</u>		
	Num. Heads	Total Lbs.	Cull	Num. Heads	Total Lbs.	Cull	Num. Heads	Total Lbs.	Cull
Xian	139/76	14.5/8	0.75/4	116	20.8	3.4	64/63	7/1.6	3.2/3.8
Medidzhuari	40	3.8	2.8	132	23.6	3.6	21/59	2.8/7.2	10.2/4.4
Inchelium Red	24	0.8	1	120	24.4	4.4	76/66	9.2/9.6	3.8/5.8
German Extra Hardy	28	1.8	3.8				2	0.4	4.8
German Red	16	1.4	0.4						
German White				116	31.4	4.2	69/52	9/5.6	4.6/3.6

(3) Garlic growth in PRB vs. Raised Beds vs. Flat Culture

Due to the pest damage in 6B, the garlic was pulled early, and therefore will not be included in the evaluation of this data set.

The data is evaluating PRB vs. Flat Culture Growth.

There were 5 rows in the PRB tunnel (5D) and 9 in the Flat Culture tunnel (6D). Due to the increased number of rows in 6D, two rows of most varieties were planted. Therefore, two rows of data are represented below for tunnel 6D, where there is only one for tunnel 5D.

Average Bulb Weight (lbs.) and Percent Cull of Garlic between two High Tunnels

	<u>5D</u>		<u>6D</u>			
	Row 1		Row 1		Row 2	
	Ave. bulb Weight	% Cull	Ave. bulb Weight	% Cull	Ave. bulb Weight	% Cull
Xian	0.18	14.0	0.11	31.4	0.03	70.4
Medidzhuari	0.18	13.2	0.13	78.5	0.12	37.9
Inchelium Red	0.20	15.3	0.12	29.2	0.15	37.7
German White	0.27	11.8	0.13	33.8	0.11	39.1

Notes: Percent Cull contributors are size of bulb too small, improper growth or other damage, and human error at time of harvest, all causing the bulb to be unmarketable.

Garlic grown in Permanent Raised Beds proves to be larger than that planted in a Flat Culture for all varieties grown. There is also less of the crop lost to unmarketable bulbs (mostly consisting of bulbs too small for retail sales). Overall, garlic grows extremely well in the high tunnel environment. It is a nice use for the transition from fall to spring to maximize the potential profit of the investment.



Shade Cloth Trial over Lettuce & Greens

Mid-summer production of greens can be difficult in a high tunnel when summer ambient air temperatures reach into the 90's. A 30% shade cloth was hung over a crop of greens to see if we could extend the harvest length (with multiple cuttings from the same plant), with the over-all goal to reduce the air and soil temperature inside the high tunnel. HOBO air and soil data loggers were placed both in the center of the tunnel, under the shade cloth, and in the front of the tunnel, not under the shade cloth. The air temp loggers were situated approximately one foot above the soil level at average plant height.

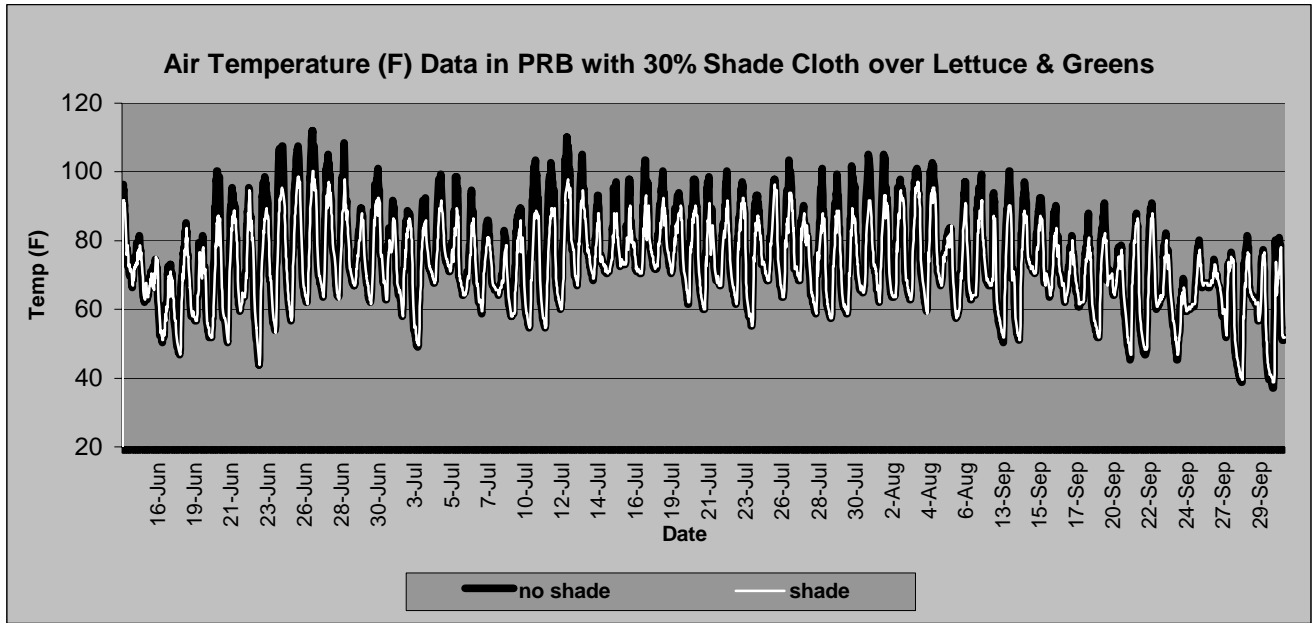
As represented by *Graph 1* below, the maximum air temperatures are consistently lower with the shade cloth than without. The white line represents the air temp under the shade cloth, in the center of the high tunnel (typically the warmest location in a high tunnel as proven by previous air temp studies). The black line represents the air temperature in the front of the tunnel where there was no shade cloth. The air temperature difference between the two locations is not calculated into the graphed representation of the raw data.

While the minimum air temperatures of the shade and non-shade area are not significantly different, the maximum air temperatures are. According to the raw data, the minimum nightly temperatures are the same or less than 1 degree F different. However the maximum daily temperatures can range from 4 degrees to as much as 15 degrees F difference.

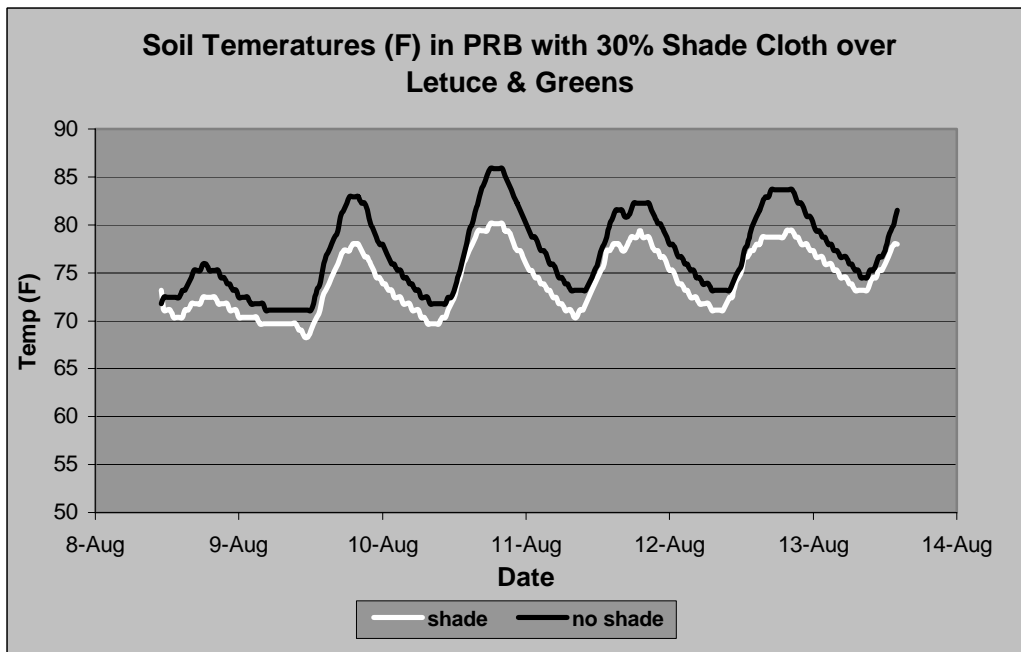
Graph 2 represents the soil logger data. Although the length of time represented is short (due to logger error for the months of June and July), there is a noticeable and consistent degree difference between the soil under the shade cloth and the soil exposed to the full sunlight. Due to the nature of soil, it warms more slowly than air and it also retains its heat better than air. Therefore, at night, the soil not under the shade cloth remains warmer than the soil that is under that shade cloth. On average, there is a 3 to 6 degree difference in the soil temperatures.

The benefits of putting shade cloth allow for greater control of the high tunnel environment and may increase the yield, flavor and vigor of some crops. For some crops, like spinach, this may make a considerable difference, especially if direct seeding it as spinach does not germinate well in high soil temperatures.

Graph 1:



Graph 2:





Other Crops

The cropping potential in high tunnels is relatively limitless. Due to time and labor constraints, not all of the crops grown at the High Tunnel Research and Education Facility have complete data taken for them. However, the crops mentioned below performed very well and should be included as worthwhile for growing in the protected environment of the high tunnel.

Onions: Sweet Spanish onions, namely '*Candy*', have been grown in the fields at the Rock Springs Horticulture Farm over the past few years, however this year, they were tested in the high tunnel environment as well. The onions were grown in a 17' x 96' tunnel on four rows of black plastic mulch with drip tape, . Approximately 1,200 lbs of onions were harvested and then placed on top of the plastic to dry for 5-6 days. The sides of the high tunnels were lowered to about one foot to allow a slight cross breeze and to ensure that the onions were not 'cooked'. The onions were then placed in 30 lb. wooden crates for storage.

Collard Greens: Again, at the request of one specific customer at the Cellar Market, collard greens were grown. Numerous other customers at the market had an interest in them as well and we sold out of greens almost every week. One row of greens was planted and harvested throughout the entire growing season. Approximately 20-30 leaves, measuring 1.5' x 2/2.5' were harvested every week. The greens were planted in a Permanent Raised Bed (PRB) with no mulch. It is not necessary to plant collards in a PRB as they do not need the extra soil warmth. In the future, collards will be planted in a raised bed or flat culture. It is important to try to keep the greens as cool as possible as that is what they prefer. '*Georgia*' collards, an heirloom variety, were grown and performed very well.

Sweet Potatoes: As a crop that grows best in hot dry environments, '*Jewel*' sweet potatoes were grown in a 17' x 36' tunnel on three rows of black plastic mulch, and performed very well in our initial trial. The low canopy of ivy quickly covered the entirety of the tunnel floor. The tubers were dug at the end of the season and placed in a cool dark place to store. Approximately 80 lbs. of sweet potatoes were harvested from the 50 slips initially planted.



Weather Review

The day's weather is recorded manually at the High Tunnel Research and Education Facility. The chart below represents the average ambient temperatures for each month of 2005, as well as the highest and lowest temperature recorded for that month. The rainfall measurements do not include snow or other frozen precipitation.

Temperatures recorded in degrees Fahrenheit

2005	Average Minimum	Average Maximum	Absolute Minimum	Absolute Maximum	Rainfall (mm)	Rainfall (inches)
January	21.6	37.3	-10	64	124	4.9
February	20.7	39.2	2	53	48	1.9
March	24.9	41.1	4	60	31.6	1.2
April	35.4	60.7	23	79	36.6	1.4
May	39.5	65.8	24	82	51.7	2.0
June	57.1	79.5	40	95	46.6	1.8
July	61.3	82.8	48	90	135.2	5.3
August	60.7	83.0	44	92	57.6	2.3
September	51.6	75.9	33	86	69.5	2.7
October	43.4	60.1	26	79	129.6	5.1
November	31.7	53.1	9	70	109.6	4.3
December	16.6	32.5	-10	42		
Total					840	33.1