Northern NY Agricultural Development Program
2008-2009 Project Report

Project Title: Extending the Growing Season for Horticulture Production in NNY

Project Leader(s): H.C. Wien, Department of Horticulture, Cornell University; Amy Ivy, Cornell Cooperative Extension, Clinton County; and Mike Davis, E.V. Baker Farm, Willsboro, NY

Collaborator(s): Sue Gwise - CCE Jefferson County; Richard Gast - CCE Franklin County; Anne Lenox Barlow - CCE Clinton County; Emily Selleck - CCE Essex County; Judson Reid, Regional Vegetable Specialist - Yates County, Elizabeth Buck – Cornell University Summer Intern

Cooperating Producers: Jefferson County – Almeda Grandjean; St. Lawrence County – Dan Kent; Franklin County – Roseanne Gallagher; Clinton County – Lou Lesniak, Ken Campbell, Beth Spaugh; Essex County – Adam Hainer, Rob Hastings

Background: Protecting horticultural crops grown in Northern NY from the extremes of weather continues to be a high priority among growers in this region. There is great interest in the use of high tunnels and other protective structures for production of a range of crops, as evidenced by attendance and participation in an April 2008 grower workshop held in Saranac Lake and at open house demonstrations held throughout the region during the summer of 2008. That high level of interest continues: see attendance figures in this year's events and activities. Growers are also looking for low cost ways to extend their growing season. Our project focused on crops that could be grown in the fall to provide an additional source of income as the summer crops wind down.

Methods: (What you did--very brief description with emphasis on information that would be important to farmers. Do not provide detailed descriptions of laboratory methodology etc. that would have meaning only to other scientists.)

Two Conferences

Feb 26-27 in Saranac Lake provided a total of 12 hours of instruction and discussion for 41 attendees. Program featured several experienced growers as speakers as well as Chris Wien, Jud Reid, Laura McDermott and Chuck Bornt. Some breakout sessions for experienced and beginning growers and demonstrations on bottom heat, irrigation and trellising.

Dec 12 – in Watertown provided 4 hours of instruction and discussion for 27 attendees, featuring Jud Reid and 3 experienced growers. Focus on new growers.

Grower Trials

8 Cooperating Growers grew a fall crop of their choosing and recorded their progress and results.

Two Field Trips – focus on fall greens production
Oct 28 to Ithaca – Chris Wien and Judson Reid were our guides. Saw research high tunnels in Freeville and on campus and a large CSA with 3 high tunnels in Trumansburg. 9 growers and 2 CCE staff attended.

Nov 2 to Washington County – Laura McDermott was our guide. Visited 3 successful operations. 11 growers and 4 CCE staff attended.

Four Field Meetings
8/25 at Ken Campbell' in Clinton Co. with Chris Wien, Jud Reid and Nelson Hoover. 10 attended.
9/29 at Dan Kent's in St. Lawrence Co with Chris Wien. 8 attended.
12/5 at Roseanne Gallagher's in Franklin Co, 6 attended
12/6 at Beth Spaugh's in Clinton Co, 11 attended.

Results: (Include data in tables, charts and/or graphic format as appendices. Format. Please use subheadings to distinguish different sections if appropriate.)

Yield and Gross Sales Data
3 participating growers gathered yield data from for the following summary. Note: This study was on crops grown from late Aug-early September through late November-early December. Most tunnels will have spring and summer crops as well. Production costs are low - a few dollars for seed, some labor to pull covers on and off and harvest:

Grower A (120 sq ft area, both inside and outside the tunnel)
Harvested 2 successive crops from the study bed from 9/7 to 11/18.
Gross yield was $1.67/sq ft (lettuce, arugula, mizuna)
Compared to 1 month of growth outside for gross yield of $.42/sq ft
All sold at $6/lb wholesale

Grower B (360 sq ft area, inside the tunnel)
Arugula and Mizuna Mix produced well, more than this grower could sell.
Gross yield was $.85/sq ft (potential for $1.15/sq ft if all was sold)
All sold at $6/lb wholesale

Grower C (480 sq ft area, inside the tunnel)
Arugula and lettuce grown separately then combined into a mix for sales.
Gross yield was $2.43/sq ft
Based on average sale price of $9/lb (half sold at wholesale $6, half sold at retail $12/lb)

These numbers can be compared with a study done in 2007-08 on summer crops of cucumbers and tomatoes. These crops have much higher costs of production because they need regular trellising and pruning and they take longer to bear a marketable crop. The gross yield for cucumbers was **$1.49/sq ft** (with production costs of $1.71). For tomatoes, the wholesale grower had a gross of **$2.60/sq ft** with costs of $1.70/sq ft) and the retail grower had a gross of **$4.66/sq ft** (but with high overhead costs of $2.34/sq ft).

HIGH TUNNEL RESEARCH AT THE WILLSBORO FARM:
As part of the high tunnel research and extension program, several trials were conducted at the E.V. Baker Farm at Willsboro, where raspberries, strawberries and tomatoes were grown in 2009. The results of this work are found in Appendix A.

Conclusions/Outcomes/Impacts: (Recommendations, guidelines, application[s] to NNY agriculture etc, including **negative results**. Production guidelines/suggested management practices etc. that flow from the research. If farmers are involved in the research or demonstration, provide information on their impressions on the importance of the work its usefulness at the farm level and benefits they are seeing.)

What our growers learned/observed regarding fall tunnel crop production:

- It's easier to grow each type of green separately (arugula, mustards, lettuce, spinach, etc) for management purposes (different growth rates, disease susceptibility) and then mix them together during washing.
- By blending the different types you increase your average yield and profit per total square feet of production.
- Unheated greenhouses warm up nicely on frigid, sunny days. It's the cloudy, cold days that stop the growth. And rowcover further blocks the light on those cloudy days.
- Arugula and mustards are easy to grow and vigorous but they are not as popular with the customers. Spinach is a little harder and lettuce is the most difficult to manage when temperatures drop below freezing outside.
- Customers mostly want lettuce and spinach. Arugula and young mustard can be mixed in. Big interest in salad mix all year round.
- The going rate in NNY for salad mix is $6/lb wholesale, $12/lb retail
- The growers' gross from tunnel greens ran between $0.87 to $1.20 up to $2 and $2.58 per square foot.
- There are many variations on timing, spacing, varieties, harvesting, etc. Each producer needs to try different methods to see which works best for their operation and market.
- Start spinach no later than Aug 15-20 for a fall/winter crop. Later plantings go dormant during Dec-Jan and growth resumes in February

Other fall crops to consider
Swiss chard – good potential for young leaves used in salad mixes or as a braising mix
Braising mixes – let the mustards and chard grow a bit longer but they'll need cooking before eating
Broccoli – don't bother in high tunnel. Our local grower's experience mirrored western NY growers' experiences in the past.

Observations on other aspects of high tunnel use:

- Tomatoes are a lucrative and popular crop among high tunnel growers, but fertility management, particularly supplying sufficient potassium during the long fruiting period, is a major constraint.

- Late blight disease affected field-grown tomatoes severely, and in most cases, destroyed the plants; in high tunnels, plants survived with minimal control measures in spite of pressure from this disease (see Willsboro report, attached)
- Trellising techniques for the tomato crop that require less labor need to be identified and publicized

Outreach: (Indicate what you have done to inform farmers of this project, its progress, findings and how farmers can apply the results to their farming operations. Attach copies of articles, slides or how these can be obtained including www site links etc. Include information on whether or not farmers are using the information, how they are using it and the benefits they see if possible.)

We will use the summary results in spring newsletters and at future field meetings and high tunnel conferences.

Next steps if results suggest continued work is needed in the areas of research, demonstration and/or education. Based on feedback from participating growers, more opportunities to learn from other growers' experiences would be very helpful. The road trips exposed growers to very different production methods and approaches and spurred discussion back home. There are many approaches growers can take getting the most production from their tunnels. Growers need to see and hear about various crops and methods and trial them in their own tunnels in order to determine what works best for them.

Across the region we observed problems relating to poor nutrition in the summer tomato crops. Several growers experienced blossom drop by late July which reduced their late season production. Foliar analyses revealed the deficiencies which were then corrected and the problem resolved.
Growers' experiences in 2009 also suggest that additional demonstrations are needed to improve fertility management of tomatoes, to counteract the tendency of the plants to stop fruit production late in the season.

Based on the results obtained in the Willsboro high tunnel, the conduct of a tomato grafting workshop in mid-winter to encourage use of this technique in growers' tunnels to boost yield and fruit quality is advisable.

Acknowledgments: This project was funded by the NY Farm Viability Institute.

Person(s) to contact for more information (including farmers who have participated:

Ken Campbell, Campbell's Greenhouses
PO Box 339
Dannemora, NY 12929
518-293-7972

Rob Hastings, Rivermede Farm
49 Beede Lane
Keene Valley, NY 12943
518-576-4686

APPENDIX A.

2009 High Tunnel Project
Cornell Willsboro Farm

Tomatoes

Objectives

1. To compare the performance of two tomato varieties grown both inside and outside the high tunnel.
2. To test the effect of grafting tomato seedlings onto disease resistant rootstock on fruit yields inside and outside the tunnel.
3. To examine the influence of two potting mixes on seedling vigor and transplant productivity.

Methods

Two tomato varieties, *Geronimo* and *Buffalo*, were selected for the 2009 study. These varieties were selected because they were reported to be resistant to leaf mold and suitable for growing in a greenhouse environment. *Maxifort* was chosen as the rootstock variety for the grafting trials. Seeds of each variety were started in April in a heated greenhouse using two different potting mixes: a custom made experimental mix (A) and a commercial 'Fort V' mix from Vermont Compost Co. Half the seedlings were grafted when stem diameters reached 2mm to 6mm. Top grafts were used for seedlings at the 2mm – 4mm stage, while an apical (v-notch) graft was used with seedling stems 4mm – 6mm in diameter. In June, seedlings were transplanted into the same beds that tomatoes were grown in the previous year, both inside and outside the tunnel. All plants were pruned to two leaders and string trellised to an overhead wire. Water and nutrients were provided through a drip irrigation system.

Four plants from each of the treatment combinations were planted in the beds inside and outside the high tunnel. The six treatment combinations included:

- Geronimo V (Geronimo, non-grafted, fortV potting mix)
- Ger x Maxi V (Gernonimo, grafted to Maxifort rootstock, fortV potting mix)
- Buff x Maxi V (Buffalo, grafted to Maxifort rootstock, fortV potting mix)
- Buffalo V (Buffalo, non-grafted, fortV potting mix)
- Buffalo A (Buffalo, no-grafted, experimental potting mix)
- Buff x Maxi A (Buffalo, grafted to Maxifort rootstock, fortV potting mix)

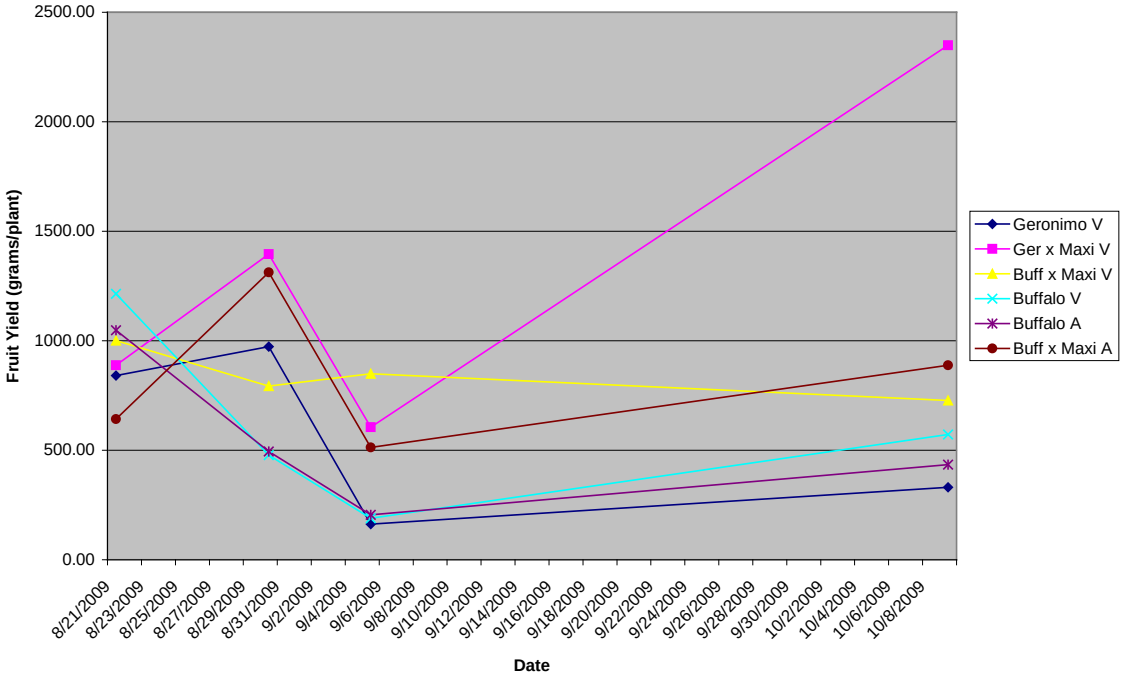
Results and Discussion

High Tunnel Effect:
Late Blight destroyed tomato plantings across the northeastern U.S. during the 2009 field season, and all the tomatoes in our outside planting were lost to the fungal disease. In contrast, the tomatoes growing in the high tunnel were not affected until very late in the season, even though

they were growing only 30ft from the outside plants and were presumably exposed to *Late Blight* inoculum when the high tunnel sides were rolled up. The absence of late blight on the tunnel grown tomatoes illustrates how high tunnel growing conditions that result in minimal leaf wetting can inhibit the establishment of some fungal pathogens.

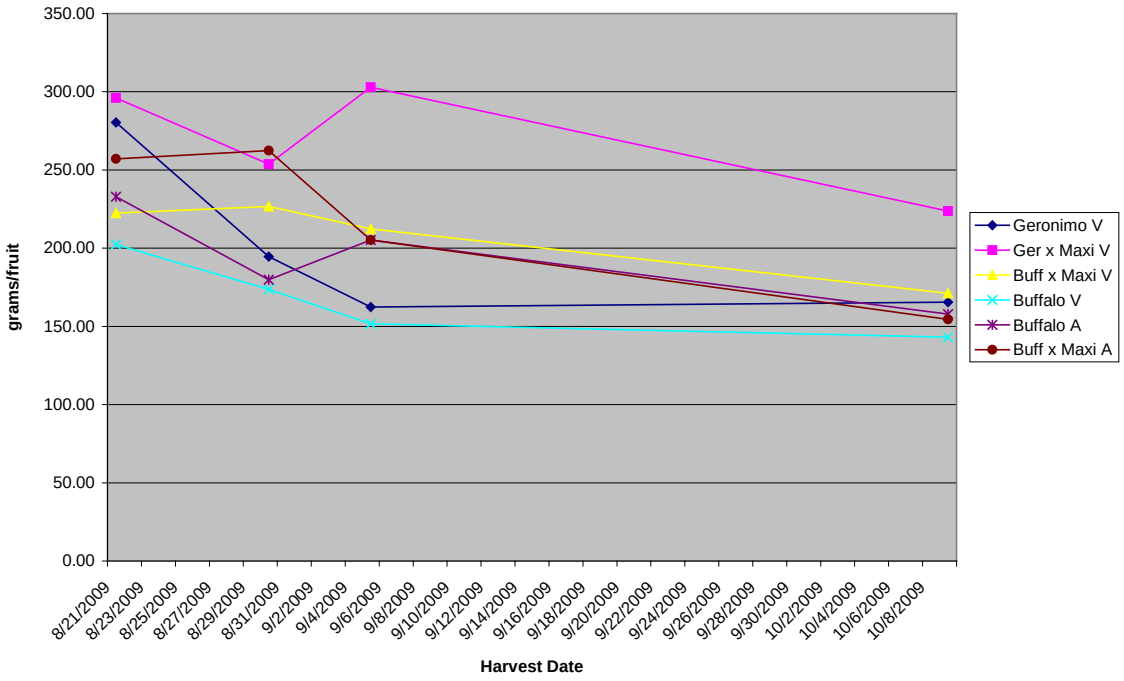
Fruit yields:
Fruit yields at the first harvest were clustered and showed no pattern with respect to variety, grafting, or seedling potting mix (Figure 1). In later harvests there was a marked trend toward higher yields with the grafted plants compared to the non-grafted plants of both varieties, indicating that the vigor and disease resistance associated with the Maxifort rootstock was translating into increased yields.

Figure 1. Fruit Yields



Fruit Size:
There was a general trend toward decreasing fruit size as the season progressed (Figure 2). As with the overall fruit yield, average fruit size tended to be larger with the grafted plants. At the first full harvest the average fruit sizes for the two *Geronimo* treatments (both grafted and non-grafted plants) were greater than average fruit sizes for any of the *Buffalo* treatments. In subsequent harvests the *Geronimo* plants that were grafted to *Maxifort* rootstock continued to produce large fruits, while fruits in the non-grafted plants were markedly smaller. *Buffalo* exhibited a similar trend with grafted plants producing larger fruits than non-grafted plants at the later harvests.

Figure 2. Average Fruit Size



Potting mixes:
Seedlings of all three tomato varieties grew much faster in the 'Fort V' than the experimental mix (Photo 1). Five weeks after seeding, the shoots of plants growing in 'Fort V' were twice the size (shoot fresh weights averaged 13.2 grams/plant) of those growing in the experimental mix (shoot fresh weights averaged 6.5 grams/plant). While seedlings grown in the experimental media were much smaller, they appeared healthy and had a very dark green color. Slower seedling growth in the experimental mix resulted in delayed first fruit set and harvest, but did not appear to influence total fruit production.

Photo 1. *Buffalo* tomato plants growing in Fort V (left) and an experimental potting mix (right) five weeks after seeding.

Photo 2. 2009 High Tunnel tomato bed.

Strawberries

Background

One ever-bearing (*Everest*) and three June-bearing (*Earliglo*, *Evangeline*, and *Jewel*) strawberry varieties were planted in beds inside and outside a 30' x 96' high tunnel on the Cornell Willsboro Research Farm in 2007. Strawberry plants were transplanted into 32" wide beds on June 9, and each bed was equipped with two drip irrigation lines. The high tunnel was not covered during the 2007 field season, so all plants experienced identical growing conditions during the establishment year. A single layer of plastic greenhouse cover was installed on the tunnel in November, 2007.

Results and Discussion

Berry Quality
2009 strawberry results were consistent with 2008 observations. For the second year in a row the weather conditions were very wet during strawberry season, and the berries growing in the high tunnel produced higher quality berries that were cleaner, had fewer blemishes, and much less mold than berries produced outside.

Earliness
The high tunnel environment accelerated berry ripening as all four varieties produced marketable fruit inside the tunnel over a week before any fruit was harvested from the outside plantings (Figures 3&4). Protection from the wet early summer weather conditions also served to extend the picking season inside the tunnel.

The sequence of fruit ripening for the three June-bearing varieties differed slightly from 2008 as *Evangeline* matured more fruit earlier in the season than *Earliglo*. *Jewel* fruit ripening was later than that of *Earliglo* and *Evangeline* in both 2008 and 2009.

Yields
All four strawberry varieties produced much higher fruit yields inside the high tunnel compared to outside (Figure 5). Of the June-bearing varieties, overall fruit yield was highest in *Jewel*, followed by *Earliglo* and then *Evangeline*. This sequence was consistent with the 2008 results.

The higher yields of nicer quality fruit that ripens earlier and continues to ripen for a longer time period highlight the advantages of producing strawberries in a high tunnel environment. Additional advantages include the ability to easily harvest fruit in rainy weather, and the potential for longer lived strawberry stands. After three years the outside plantings of *Everest*, *Evangeline*, and *Jewel* all looked much less vigorous than those in the high tunnel. While the unusually wet weather that occurred during the past two strawberry seasons in Willsboro may have magnified the advantages of growing strawberries in high tunnels, it is clear that strawberries are well suited to high tunnel production.

Figure 3. High Tunnel Strawberry Harvests

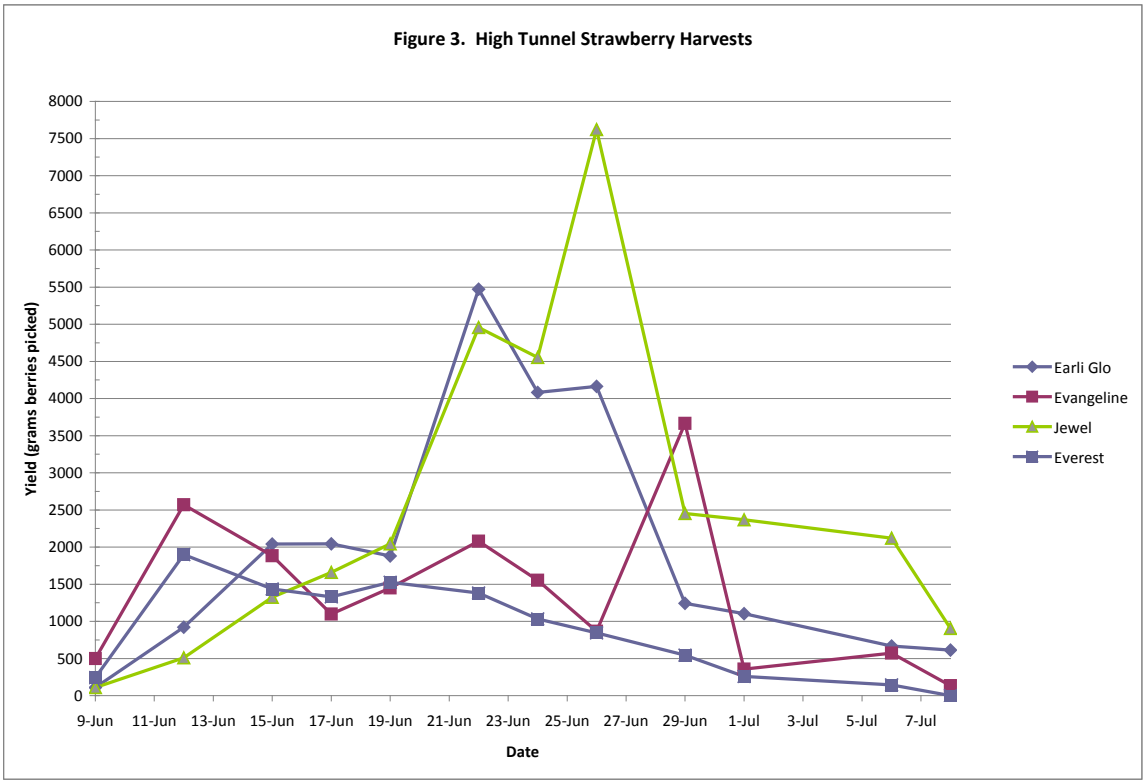
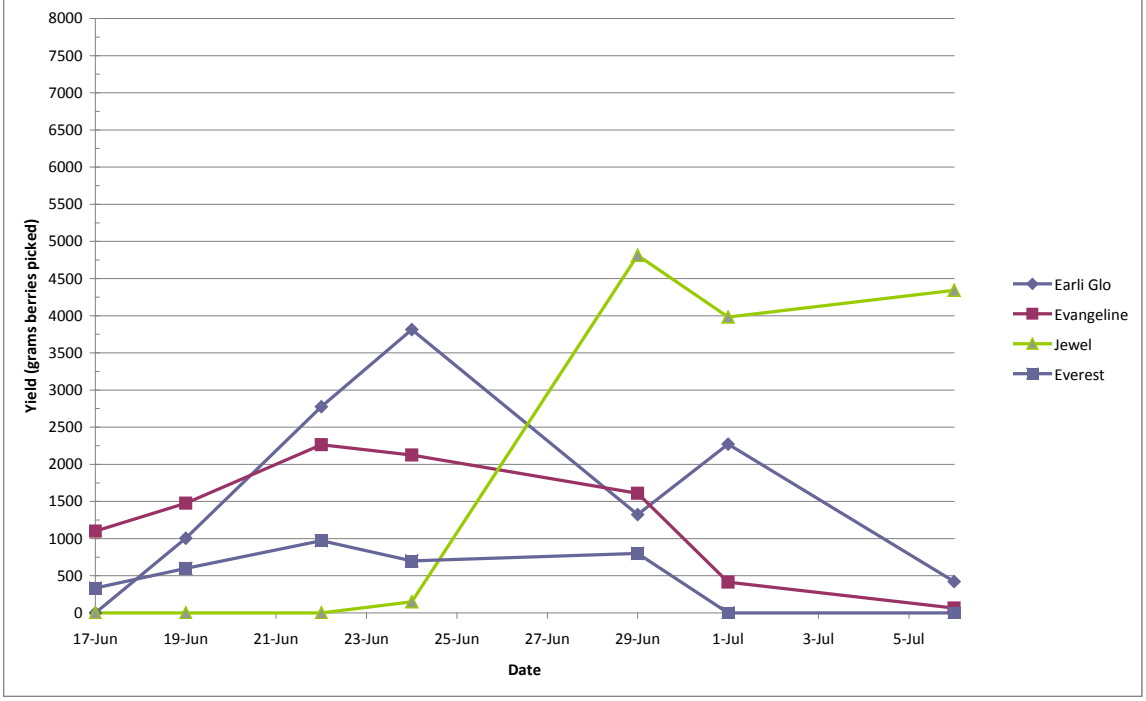


Figure 4. Outside Strawberry Harvests



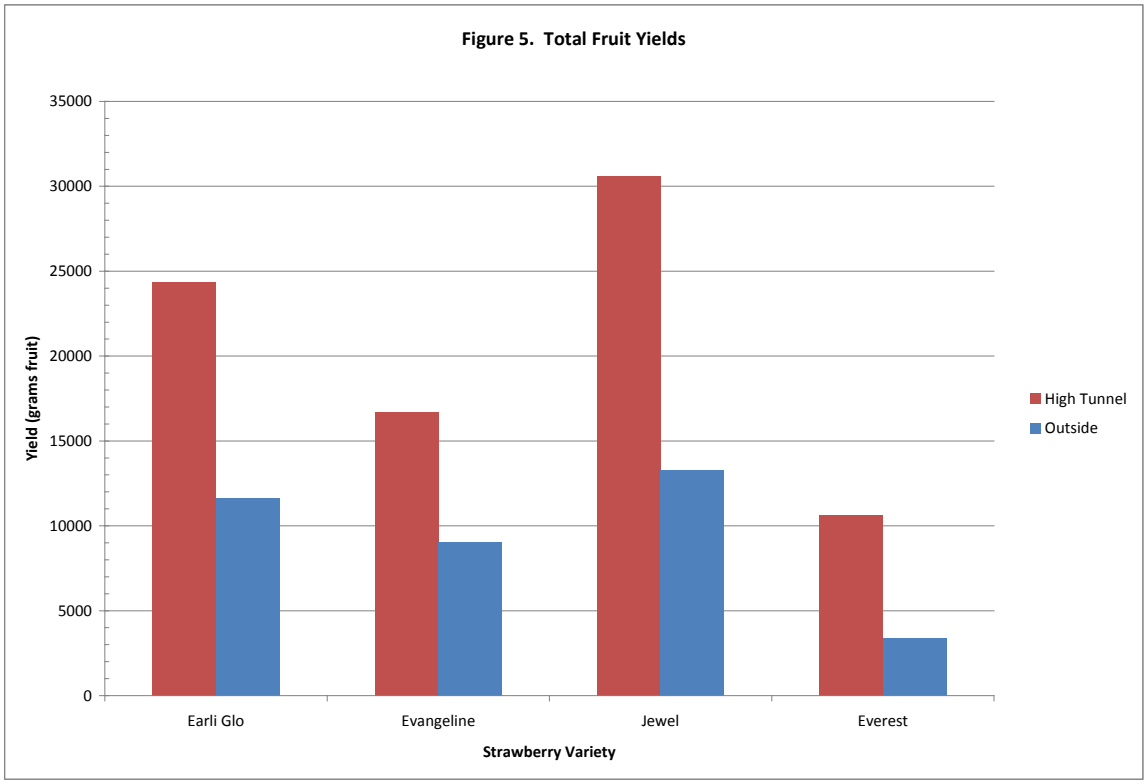


Photo 3. Everbearing *Everest* strawberries harvested from the Willsboro Farm high tunnel in 2009.

Raspberries and Blackberries

Background

Raspberry and blackberry plants were transplanted into two 90' long beds inside the high tunnel on the Cornell Willsboro Research Farm on June 9, 2007. On the same date, an identical berry planting was established on two 90' long beds located adjacent to (outside) the high tunnel so that the performance of plantings inside and outside the high tunnel could be compared. Varieties included *Encore* (red raspberry), *Jewel* (black raspberry), *Kiwigold* (yellow raspberry), *Heritage* (red raspberry), *Prelude* (red raspberry), and *PrimeJan* (blackberry). Each bed was equipped with two drip irrigation lines to provide water and fertilizer.

Results and Discussion

2008, 2009 comparisons
2009 raspberry yields were much higher than 2008 yields both inside and outside the high tunnel (Table 1). 2009 was the third year (second year of production) for the raspberry plantings and higher yields in 2009 may have been largely a function of stand maturation.

Yields
Brambles growing in the high tunnel exhibited continued vigorous growth in 2009 (Photo 4), and fruit yields were exceptional. While raspberry production in the outside beds was significantly higher than in 2008, it was still only a fraction of the production inside the tunnel (Figure 6). *Jewel* was the highest yielding main season raspberry variety both inside and outside the high tunnel (Figure 6). The particularly high yield from *Jewel* inside the tunnel reflected the remarkable response of the variety to the tunnel environment. *Jewel* shoots grew to the top of the tunnel and required considerable pruning. *Encore* and *Prelude* also performed well inside the tunnel, but did not need to be topped.

For the second season in a row the *Prime Jan* blackberries failed to produce much fruit inside or outside the tunnel. While *Prime Jan* growth inside the tunnel was more vigorous than outside, the outside plants grew well and appeared healthy. Lack of *Prime Jan* fruit production after three years suggests that either a different management strategy is required, or the blackberries are not well suited to this region.

Table 1.

	INSIDE		**OUTSIDE**	
Raspberry Variety	2008 Yield (lbs of fruit)	2009 Yield (lbs of fruit)	2008 Yield (lbs of fruit)	2009 Yield (lbs of fruit)
Prelude	8.7	47.7	1.5	16.9
Jewel	8.5	82.7	1.2	18.1
Encore	2.2	43.2	0.9	8.1
Heritage	21.5	58.5	3.8	NA

Figure 6. Yield Comparison of HT and Outdoor Raspberries, 2009

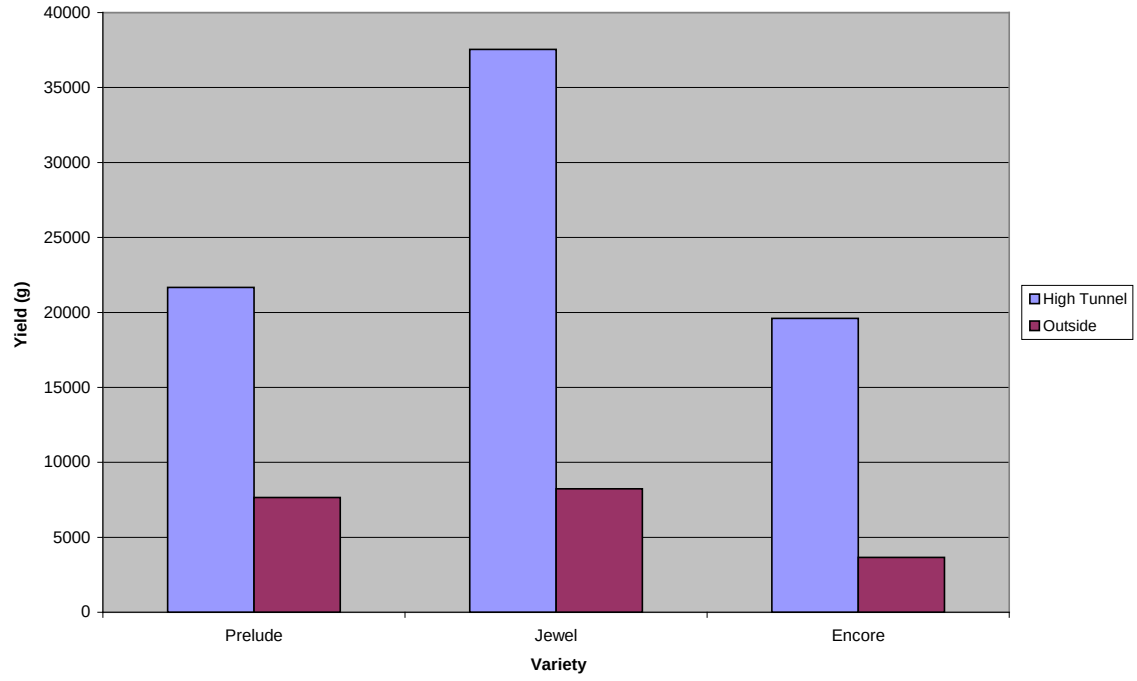


Photo 4. Raspberries growing in the Willsboro Farm High Tunnel in 2009.

Movable High Tunnel

Movable high tunnels offer several potential benefits to diversified growers:

1. Can provide a covered environment for crops during critical times of the year or periods of the crops life cycle.
2. Can provide frost protection for selected crops in the spring and fall, and enhance the growing environment for heat loving crops during the summer.
3. When used for multiple crops in a given growing season, farmers can maximize the return on the tunnel investment.
4. Mobility allows growers to avoid salt and soil-borne disease problems that can occur when crops are continually grown in permanent greenhouse beds.

In 2009, two 20' x 24' metal frame hoophouses were purchased and erected on the Cornell Willsboro Farm. Frames were custom made from bent square tubing. We bolted the two 20' x 24' sections together to make one large 20' x 48' house. The metal tubing along the base of the tunnel sides was set in metal u-channel that was laid on the ground to function as a track. When the tunnel is being moved, the tunnel base slides over the u-channel track to the new location. To allow the tunnel to be moved over established plantings, such as fall-bearing raspberries, we designed and constructed metal end walls that could be completely disassembled and separated from the rest of the tunnel structure. Once the high tunnel is in its new location, ground anchors and tie down strapping are used to lock the structure in place.

Photos

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Fig. 1. Michael Kilpatrick explains the pro's and con's of the different types of tunnels he uses to protect his crops on our November road trip to Washington County (*Amy Ivy, CCE Clinton Co*)

Fig. 2. Judson Reid and Chris Wien explain the timing of their fall greens trial at the Freeville research high tunnel on our October road trip to Ithaca (*Amy Ivy, CCE Clinton Co*)

Fig. 3. Ken Campbell demonstrates his adjustable trellis system for tomatoes at his August field meeting in August (*Amy Ivy, CCE Clinton Co*)

Fig. 4. Research assistant Nelson Hoover, summer intern Elizabeth Buck, Judson Reid and Dan Kent, inspecting tomato plants for late blight in Kent's high tunnel

Fig. 5. Amy Ivy, Mike Davis, Elizabeth Buck, Nelson Hoover and Judson Reid discussing the assembly of the moveable high tunnel at the Willsboro Farm

Fig. 6. Amy Ivy and Mike Davis examining tomato plants in Adam Hamer's high tunnel

Fig. 7. Nelson Hoover inspecting high tunnel greens at Rob Hastings Rivermede Farm