PROTECTED CULTURE FOR STRAWBERRIES USING LOW TUNNELS

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A major limitation for strawberry growers is the short season when berries are typically available to sell. The first strawberries ripen in mid-June and harvest ends near the 4th of July. Rainy weather during harvest, especially on weekends, can have a significant negative financial impact on growers, particularly if they market through pick-your-own. It would greatly benefit growers if berries could be protected from the weather and produce over a longer season, into the summer and late fall, as this would extend the season and open up new markets.

Many parts of the world are using plastic tunnels to protect berries and extend their season. The newest plastics greatly reduce ultraviolet light that normally would promote fungal spore germination and they reduce infrared light that produces heat. By coupling this plastic technology with varieties that are day length insensitive, one can extend the season both earlier and later than the typical season.

'Albion' strawberries harvested in late fall in Ithaca, NY

With the financial support of the New York Farm Viability Institute, we were able to experiment with these new day neutral strawberry varieties both on research farms

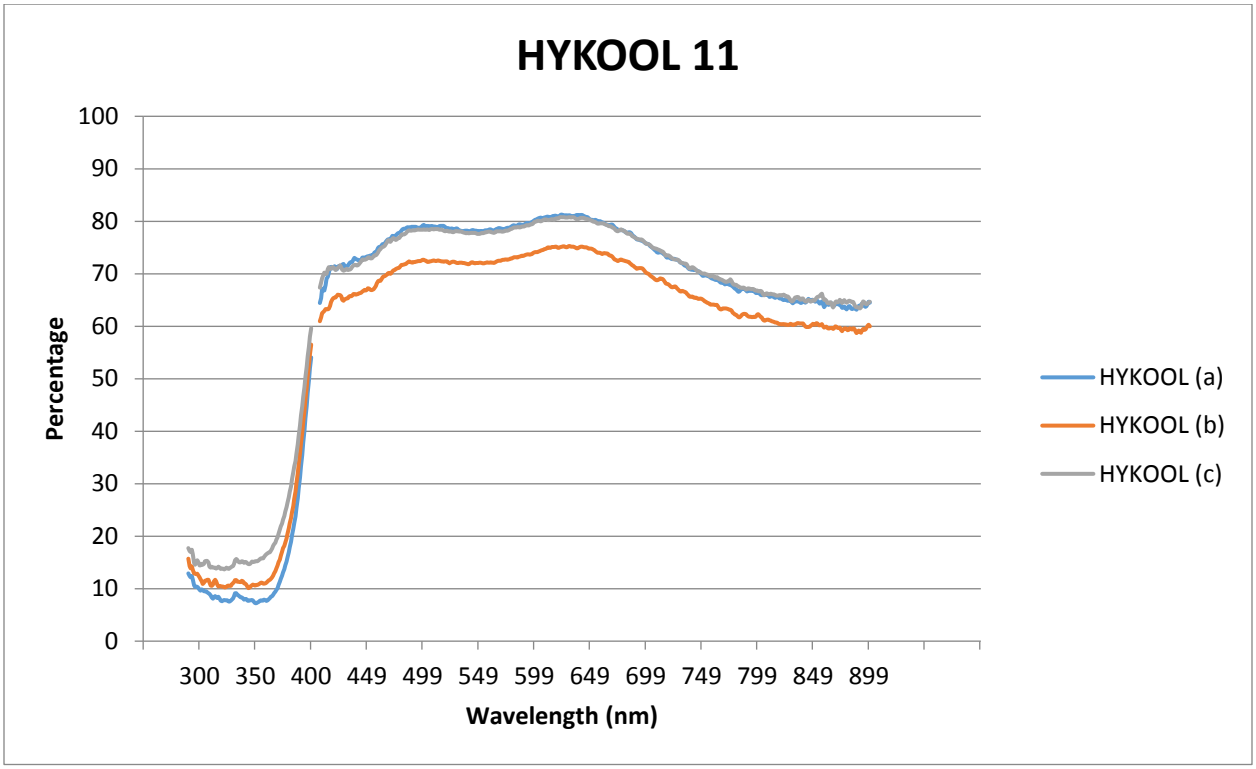
and in grower fields. Given that this is a new concept for New York, we learned some things about what to do to manage these berries, and also a great deal about what not to do. The results of our findings are described in this document. While more research is needed to fine-tune the production system, enough is now known to offer the system to New York growers with the assurance that a reasonably profitable crop can be produced.

Background

In the 1980s, varieties of strawberries (day neutral) with the capacity to produce flowers during all day lengths (spring, summer and fall) were released to the public. While there was initial excitement with these new varieties and their flavor was excellent, grower interest waned because 1) yields were low, 2) fruit size was small, 3) berries were expensive to pick, and 4) tarnished plant bug (TPB) damaged the ripening fruit.

'Tribute' strawberry from the 1980s with outstanding flavor and shape, but small size.

A new generation of day neutral varieties was released in 2004. Although these originated from California, they were relatively well adapted to the Northeast, producing much larger fruits and higher yields than earlier releases. They produce fruit the year of planting and continue fruiting into the fall. After overwintering, they produce another flush of fruit in spring. The fall crop and the second-year spring crop can be protected from rain and cold temperatures by covering rows with plastic on metal hoops – a technology called “low tunnels.” The tunnel plastics not only exclude rain but they can decrease the amount of ultraviolet light and infrared radiation - reducing spore germination and heat load on the plants.



Spectral transmission of a newer plastic. Ultraviolet wavelengths are at the left end of the spectrum, visible light is in the middle and infrared wavelengths are on the right end of the spectrum. The y-axis is percent transmission of light – the higher the value, the more wavelength gets through. This graph shows that the HYKOOL 11 plastic significantly reduces ultraviolet radiation (low end) to less than 20% and decreases the amount of infrared radiation (upper end) by approximately 15% compared to visible light.

The combination of day neutrals and low tunnels has the capacity to extend the strawberry season from 3 weeks to 5 months. A second year planting will produce fruit from June through early-July and the first year planting will produce fruit from late July until early November.

Where do low tunnel strawberries fit into a farm operation?

One of the most important lessons learned from our grower trials is that low tunnel strawberries are not for everyone, even though many growers see the potential benefits. The challenge with these plants is that they need attention from the time they are planted in April through mulching in late November. Planting is at a higher density than standard June-bearing strawberries so is usually done by hand. Fertigation is required weekly, and while not a big time sink, still demands attention even during busy times on the farm. These berries produce fruit for up to five months of the year, so twice-weekly harvesting is required even when other crops must be harvested. Finally, the tunnels may need to be closed and opened during heavy rains or cold periods. The bottom line is that an established farm operation may have trouble "fitting in" a demanding crop like these strawberries. However, a smaller operation that can build around the strawberry crop can have great success as they grow.

Getting started

'Albion' is the variety that has the best flavor, highest sugar content and performs consistently well in our climate. Other varieties (Portola, Monterrey, San Andreas) have larger fruit but less flavor. 'Seascape' has good flavor but smaller fruit. We reason that if we are going to compete with fruit from the West Coast in late summer, then our fruit needs to taste better and be relatively large in size. 'Albion' picked at the peak of

ripeness has flavor that is as good, or better, than most June-bearing varieties and it is reasonably large.

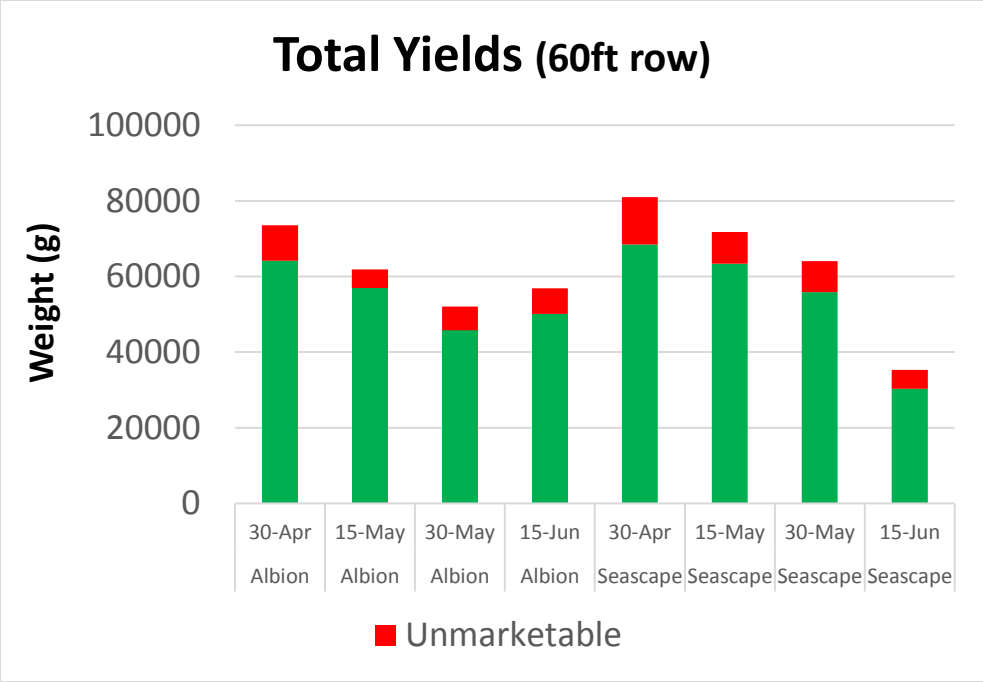
Day neutral strawberry varieties suitable for tunnel production: Albion (upper left), Portola (upper right), Monterrey (lower left) and Seascape (lower right).

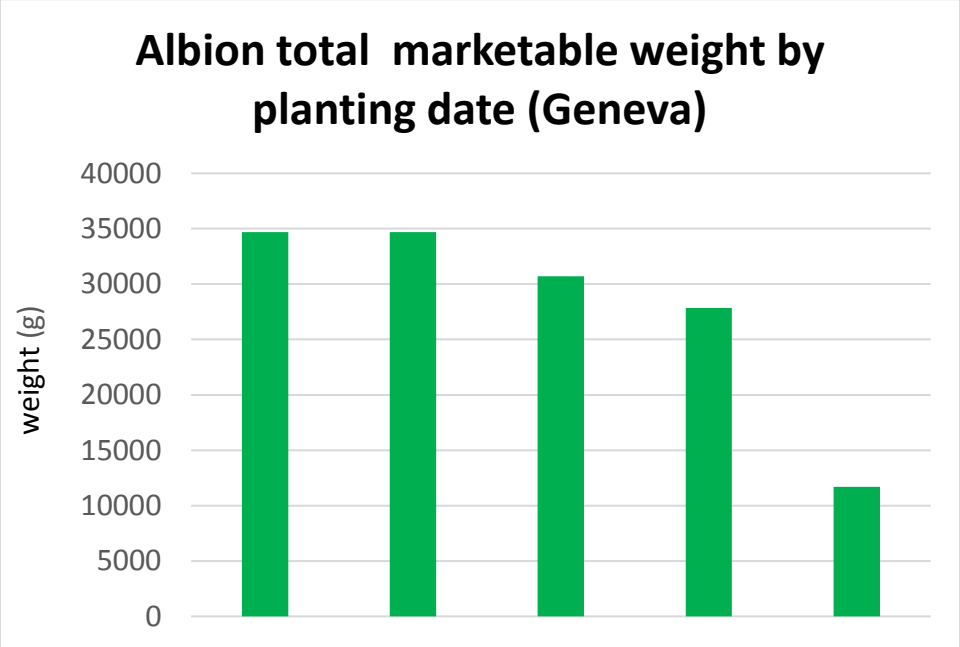
Soil preparation is the same as for other crops. The site should be relatively free of weeds and soil amendments should be incorporated to adjust for nutrient and pH imbalances. Establish raised beds about 18 inches wide, install a drip line attached to a fertilizer injector, and cover the bed with white or black plastic. White plastic works best as it keeps the beds cooler in summer. Each bed should have a trickle irrigation line attached to a fertilizer injection system. One line can service two rows of plants.

Plant in a staggered double row, with plants 9 – 12 inches apart in each row and 12 inches between rows. Use a tool that will insert roots into the bed while disturbing the plastic as little as possible.

Establish raised beds in late fall or early spring so they can be planted as soon as possible in spring. Delaying planting until late May or June will significantly decrease yields. One of our research questions was to determine the effect of planting date on performance. We found that the earlier one can plant in spring, the better. This was clear from experiments at both Geneva and Ithaca. Delaying planting until after May 1 decreased total yields.

Sometimes it is impossible to plant in April because of cold, wet conditions. If this situation is common, preparing beds the fall before can allow planting to occur at the recommended time.





Yields by planting date: April 15, 30, May 15, 30, June 15.

Yields may be enhanced if some granular, slow release fertilizer is incorporated into the bed. Preplant incorporation of fertilizer is practiced in annual systems in California and Florida, so it may be beneficial in New York. We are planning further trials to test this. We will be comparing 60 lb actual N/A of slow release fertilizer to no incorporation this coming field season.

Fertilize the planting with 2 lbs of actual nitrogen per planted acre per week for the first few weeks after planting. Remove the flowers for the first three weeks, or until vigorous new leaves appear from the crown. Plant grass seed between the rows, or lay a landscape fabric or straw mulch to prevent mud from splashing on the berries.

Install tunnels when plants begin to throw new flower trusses. Cover the tunnels with 1 to 2 mil plastic, preferably with a type that excludes ultraviolet light and reduces infrared radiation. Dubois Agrinova (http://www.duboisag.com/) sells kits with plastic that has predrilled holes for ventilation when the plastic is lowered. The cost for the tunnel kits is $450 per 100 foot of row, but less for larger quantities. This cost is recovered in the first year.

We applied straw between the raised beds to suppress weed germination, prevent soil splashing onto the fruit and allow us to harvest after rains.

Managing the tunnels

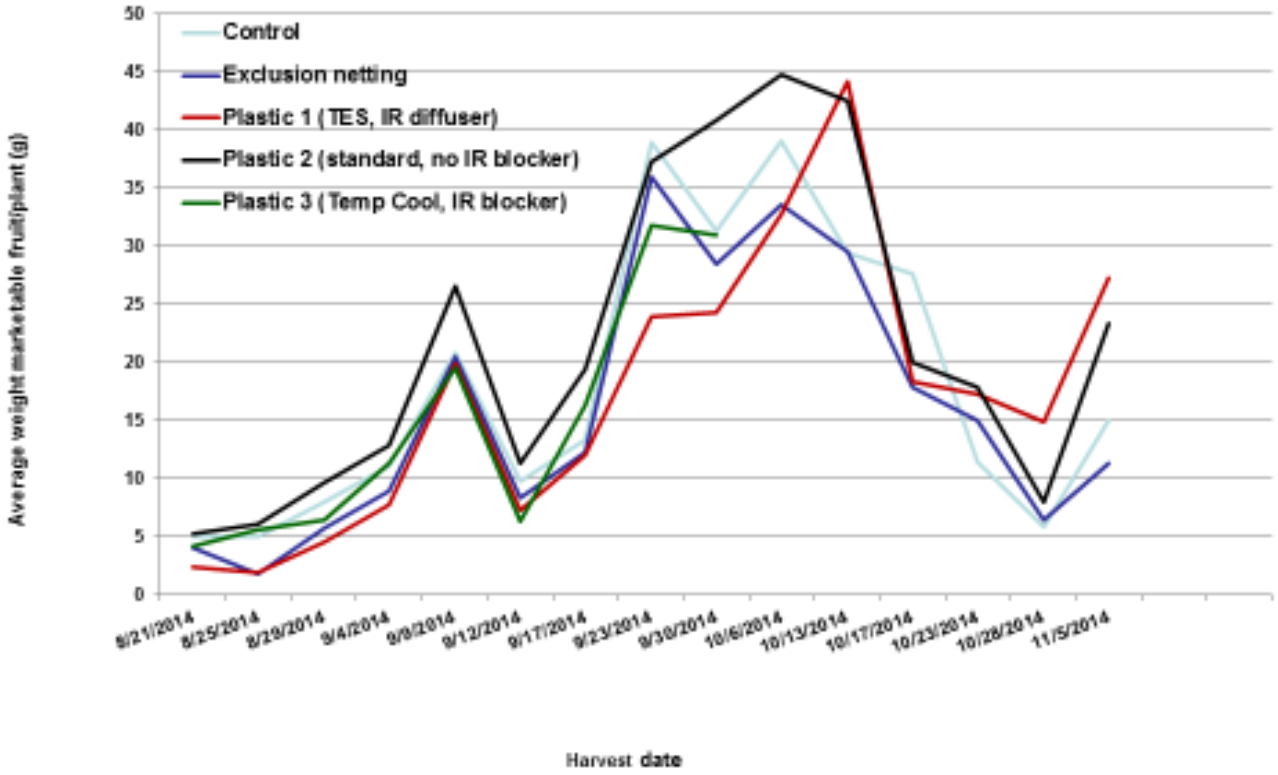
At least one side of the plastic should remain up under normal weather conditions to allow for pollination and to prevent heat build-up. Infrared-inhibiting plastic does provide some shade which is beneficial for the plants, so allow them to be shaded by the plastic if possible. Lower the sides when the weather is cold or stormy. A benefit of the plastic is the near elimination of Botrytis gray mold from water exclusion and inhibition of spore germination from the reduction of UV light. Humidity can build up under the covers if they are in the closed position for an extended time.

Growers find that leaving one side open and the other closed during normal operations can save time when there is a need to close the covers. Leaving the left side on the right hand row open and the right side of the adjacent left hand row open means that someone can close covers quickly by needing to traverse just every other row.

Once plants begin to set fruit, increase the nitrogen to 5 lbs/acre per week. Failure to provide weekly applications of nitrogen was a major reason why our grower-cooperators had lower yields than expected. Runners should be removed periodically.

Harvest the fruit at least twice a week. Peak yields will occur in late August-early September, with production occurring through October.

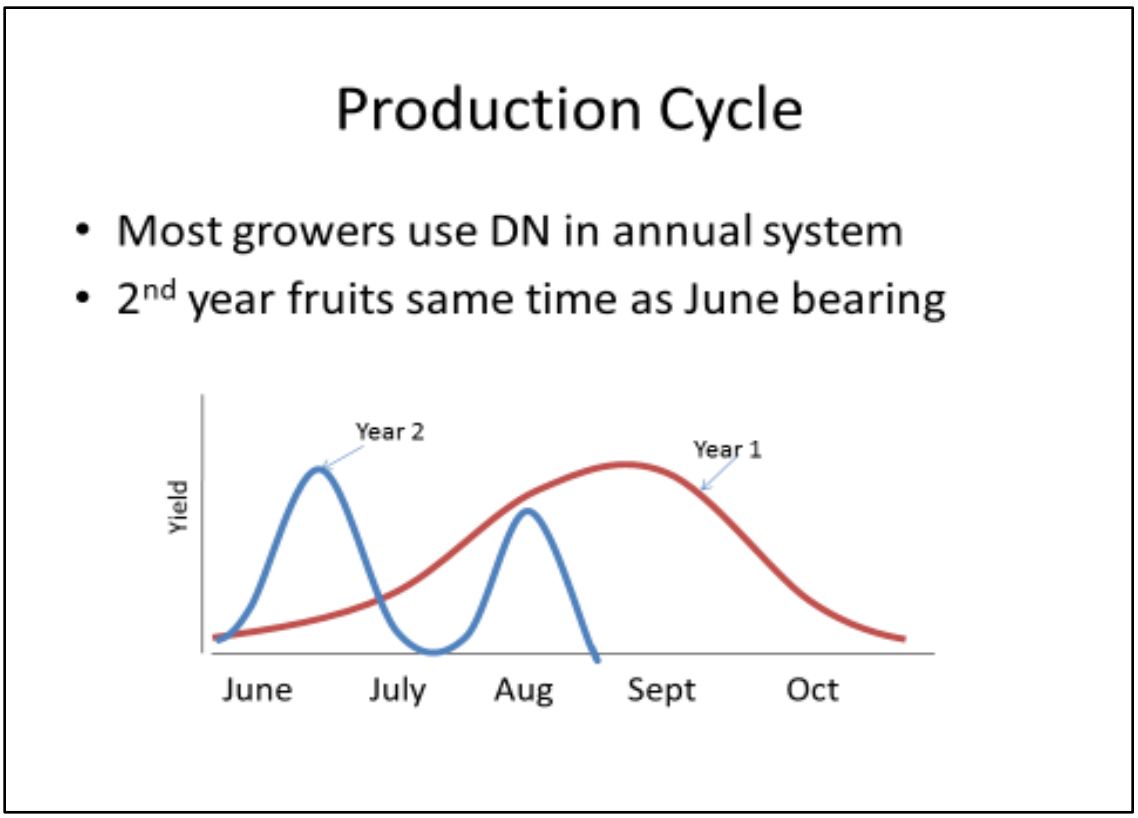
Figure 1: Albion harvest dates and marketable fruit



Once the temperature falls below 40F, lower the tunnels. If the temperature falls below 30F in mid-October, cover the entire field with row cover for the night to continue fruiting. This will extend the harvest season should the weather warm again. It is also possible to apply overhead irrigation with the covers closed to provide additional protection from cold. A closed bed can be 15 – 20 degrees warmer than ambient when the sun is shining so care must be taken to ensure that the cover is in the correct position when the ambient temperature is 70F or above (open) and 40F or below (closed).

Once harvest is over, lower the plastic to one side or remove the plastic and cover the beds with straw. ‘Albion’ does not overwinter well in cold weather so we have additional studies planned to see how we can improve winter survival. This might involve a different approach to mulching or not allowing plants to fruit at the end of the year so they can build up carbohydrates for the winter.

Remove the straw in late March/early April and allow these plants to fruit again. The tunnel can be used to protect from late spring frost. Plastic can be reused for at least one more year and possibly two.



Pests

In general, pest pressure (gray mold and powdery mildew) is low under tunnels. Spotted winged drosophila (SWD) damage has been minimal in our trials provided that fruit is harvested regularly and not left rotting in the field. In one trial we used netting in place of plastic to determine how it would perform when the sides were down continuously throughout the fall to exclude SWD. Surprisingly, the netting had many of the benefits of the plastic. Sufficient air movement occurred so that flowers were pollinated without bees. Enough moisture was excluded so that fruit rot was low, and enough heat was retained on cold nights to prevent early frosts and extend the season. There was no SWD damage on those fruit, but damage levels were low throughout the planting.

Some growers experience tarnished plant bug damage (TPB) later in the season. This pest is managed by ensuring that the surrounding area is not hosting TPB (e.g. alfalfa) or by treating with an insecticide in the late evening with a backpack sprayer after bees have gone to their hive. It is possible to exclude TPB with netting as well.

Twospotted spider mites can become a problem under low tunnels. These mites prefer hot and dry conditions which the low tunnel environment creates. Exposing plants to cool, damp weather by fully pulling the cover to one side can help to reduce populations, although extended exposure to damp weather can promote gray mold. Predatory mites should work well in low tunnels because they are protected from weather extremes. Miticides should be a last resort.

Tarnished plant bug damage to strawberries

Gray mold (left) and powdery mildew (right) damage to strawberries

Tunnels or Not?

We compared the performance of strawberries under tunnels to those not tunneled at both the research farms and in grower fields. In two of the grower fields, yields were not different. In one grower plot, yields were substantially higher under the tunnel – 9,497 vs. 5,202 lb/A. In our research plots, we had 27% higher yields and 15% higher marketable fruit under tunnels averaged across five varieties. In a cold spring yields were 239% higher with 37% higher marketable fruit due to the frost protection provided by the plastic cover. Similarly, in a study in Maryland, season length was extended to 9 months with low tunnels. Total yield and marketable yield under low tunnels were 188% greater and 313% greater, respectively, compared with open beds. With no fumigation or fungicides, losses to fruit rots under low tunnels were 12% less than in open beds. The cost of materials to construct low tunnels was determined to be recoverable from the increased yield. In this study, impact sprinklers were used with tunnels closed to prevent cold temperature injury under the covers in late fall, allowing harvest to extend into December.

(http://www.tandfonline.com/doi/full/10.1080/15538362.2017.1305941).

Grower trial comparing tunneled to open field production.

Production and Economics

Over the course of the first year with an April planting date, we harvested 20,000 lb/acre, which is as much as a good June-bearing cultivar will produce in one season. Average berry size of 'Albion' was 15 grams, which is the size of a medium king fruit on a June-bearer. Flavor was excellent. Production peaked in early September with two quarts (four pints) of berries per 10 feet of row every week, but in October plants consistently produced about a quart of berries every 10 feet of row per week until a hard frost.

In spring of the second year, a large flush of fruit is produced about the same time as that of early June-bearers. Tunnels can be used to accelerate flowering if desired. Spring yields can be almost as much as the previous year's yield so growers should plan to have fruit from both day neutral and June-bearing plants at the same time. We have not found it to be economical to hold over day neutral plants into a second summer and fall. Rather, we grow them for about 15 months and then remove them. Hot summers, in particular, are not conducive for strawberry production.

We found that, while attractive, growers may not be able to "fit" such a crop into their farm operation since day neutrals require constant attention. Plastic has to be raised and lowered, plants have to be fertilized weekly, and once harvest begins, it lasts for months. However, the rewards can be great. Growers have reported gross sales of $50,000 - $80,000 per acre from 'Albion' in New York State, although $40,000 is more

typical. Given that the cost of materials for an acre is about $40,000, sales can pay for the materials in the first year. In the second year, costs include plants, fertilizer, labor and harvest, but not hoops and plastic as these can be reused. Conservatively, these second-year costs can be $20,000, but with sales approaching $30,000 or more, the margins are quite good.

Economics (first year)

• Income	
– 20,000 lbs/A X $4.00/lb =	$80,000
• Expense	
– Tunnel materials	39,200
– Mulch/irrigate beds	2,000
– Plants	2,420
– Fertilizer/Pesticides	180
– Labor (30 wk X 15 hr/wk X 15/hr)	6,750
– Harvest ($0.50/pint)	13,300
– Containers	3,650
Net revenue	$12,500

In the second year, the tunnel materials, mulch and plants are already in place, and there is no need for fertilizer since plants will be removed after the flush of fruiting.

Economics (second year)

• Income	
– 15,000 lbs/A X $2.50/lb =	$37,500
• Expense	
– Tunnel materials	
– Mulch/irrigate beds	
– Plants	
– Fertilizer/Pesticide	
– Labor (10 wk X 10 hr/wk X 15/hr)	1,500
– Harvest ($0.50/pint)	10,000
Net revenue	$26,000

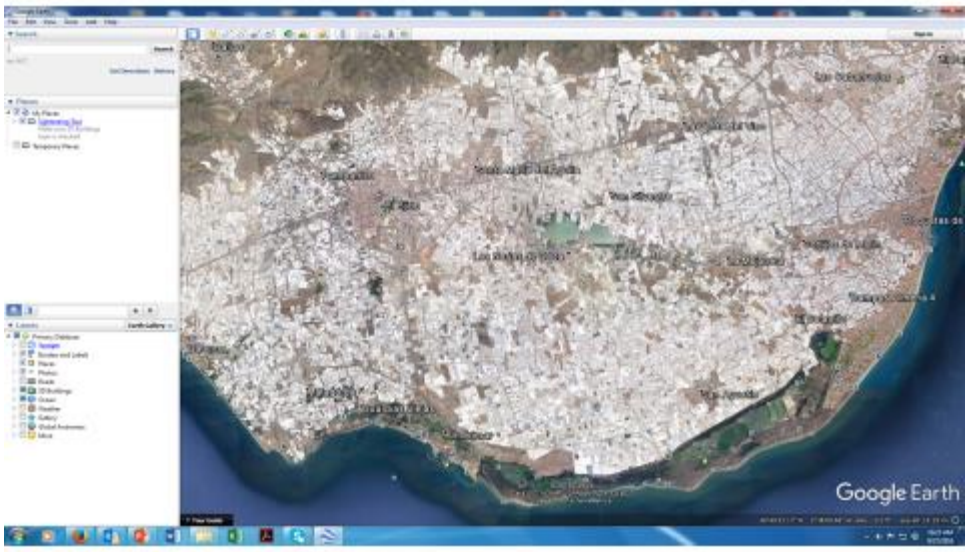
Economics (first year with tunnel purchased)

• Income	
– 20,000 lbs/A X $4.00/lb =	$80,000
• Expense	
– Tunnel plastic replacement	1,000
– Mulch/irrigate beds	2,000
– Plants	2,420
– Fertilizer	180
– Labor (30 wk X 15 hr/wk X 15/hr)	6,750
– Harvest ($0.50/pint)	13,300
– Containers	3,650
Net revenue	$50,700

This system pencils out as profitable with what we believe are reasonable assumptions. A similar economic analysis can be found here (http://fruit.cfans.umn.edu/files/2016/01/Low_Tunnel_MFVGA_2016_FINAL.pdf) and here (http://fruit.cfans.umn.edu/2016-strawberry-economics/). The first site also contains photos of the production system being installed.

If a grower can devote time every week to managing these strawberries, then potential profits are definitely there. Some education may be required to convince consumers that October strawberries are locally grown, but the appearance and flavor of these berries will impress even the pickiest connoisseur.

Much of the world is now producing berries under tunnels. The Northeast is one of the last regions to move in this direction. China has been producing strawberries in plastic houses for decades. Most of Spain's strawberry production in is tunnels. Northern Europe and now much of California's raspberry production is under tunnels. Quebec and Ontario are also moving quickly to tunnel cultivation as is South Africa. The Northeast stands to benefit more than these other regions from protected culture because of the triple threats of rain, wind and cold and the benefit of large number of consumers at our doorstep, allowing us to profitably produce better quality fruit than what is shipped in from distant locations.



Satellite image of southern Spain where large strawberry production areas are covered with low and high tunnels.

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Special thanks to:

Kaspar Kuehn
Richard Gaisser
David Zakalik
Cathy Heidenreich
Courtney Weber
Colin Day
Deborah Breth
Barb Neal
Teri Bishop
Jeremy Wolf
Tim Stanton