

# Grower Impressions of Low Tunnel Utility for June-bearing Strawberry Production

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Strawberry growers know that the first berries to market in the spring can be sold for premium prices, drawing in customers to retail operations. With more and more high tunnels being constructed on farms every year, growers are interested in diversifying their crop production in tunnels and including strawberries in addition to tomatoes and other crops. We see a wide variety of strawberry production systems under cover around the Northeast, ranging from sophisticated greenhouses with hydroponic production to high tunnels and smaller caterpillar tunnels. These structures help extend the season for June-bearing (JB) strawberries, hastening maturity in May. They also protect plants from rain and extreme weather events, reducing disease pressure and direct damage to fruit from precipitation. Although larger tunnel structures are a more common sight on New York farms due to federal funding initiatives, we seldom see plastic-covered low tunnels—waist-high structures—on farms. Low tunnels offer some of the same benefits as larger tunnels, but at a lower cost: approximately \$20,000 as a high end estimate for materials to construct one acre of low tunnels.

Plastic tunnel structures offer a variety of benefits for improving crop yield and quality. When grown in low tunnels, day-neutral (DN) strawberries benefit from an extended harvest season and greater yields. Researchers in Maryland reported greater overall yields of strawberries grown in low tunnels compared to open field production (Lewers et al 2017). In a New Hampshire study, strawberry yields were markedly higher during the shoulder seasons under low tunnels, which offers a benefit to producers in the fall when local strawberries are typically less available (Orde and Sideman 2019).

Additionally, tunnels can increase the share of marketable yield and reduce disease occurrence (Conner and Demchak 2018; Demchak 2009; Lewers et al 2017; Orde and Sideman 2019). The plastic covering of tunnels creates a beneficial environment through increased daytime temperatures when sides are rolled down and

protection from precipitation and wind. Keeping rain and hail off fruit decreases disease pressure from *Botrytis* and other pathogens, resulting in a higher percentage of marketable yield. Few studies have been conducted on low tunnels in the Northeast, but Orde and Sideman (2019) measured higher marketable berry yield of DN strawberries grown in low tunnels during the shoulder seasons compared to traditional open field production.

Low tunnels are simple structures that do not require specialized expertise to install and maintain but do require additional materials and labor investment at the start and end of the season. They consist primarily of short hoops, clear plastic film covering, stakes, and bungee cords holding the covering in place. In comparison to larger, more sophisticated structures, they allow for more flexibility for movement from field to field according to crop rotation. Annual strawberry systems with low tunnels are a logistical good fit in vegetable crop rotation schemes. While low tunnels are simple to use, materials can be costly and labor is required to set up and take down the tunnels at the beginning and end of the season (Conner and Demchak 2018). Additionally, tunnels covering rows of strawberries render in-season pesticide application and weed control difficult for some equipment because rows are not easily accessible by tractor-drawn equipment traveling close to the ground. The cost-benefit analyses of low tunnels for individual farms are therefore dependent upon the price received for strawberries and labor availability in-season.

While research has been done on DN strawberries in low tunnels, little is known about whether low tunnels are worthwhile for JB production. Here, we present results from a series of on-farm demonstrations of low tunnels installed over JB strawberries. Results from our demonstrations emphasize grower perspectives on logistic and economic feasibility of low tunnels. We also report data comparing marketable and unmarketable strawberry yield under low tunnels versus open field from two of our farm sites.

Low tunnels offer an economical way for strawberry growers to use protected culture, resulting in higher quality fruit, potential early ripening, and reduced need for fungicides but they may not be appropriate for all operations in the northeastern U.S. Our on-farm studies showed that low tunnels may also increase yield and quality in June-bearing strawberries during wet seasons.



Figure 1. Three low tunnels draped in bird netting at Farm A in April 2021.



Figure 2. Inner tunnel environment at Farm A, with plastic cover draped in bird netting over plasticulture strawberries.

## Materials and Methods

In 2021 and 2022, we installed low tunnels over JB strawberries at two commercial farms in eastern New York (Farms A and B) and one farm in central New Hampshire (Farm C) to gather grower input on whether they impacted maturity, yield, and quality of JB strawberries. One of the farms was certified organic, while the other two were conventional. All farms participating in the low tunnel demonstrations were diversified fruit and vegetable farms that included retail sales of their products. At each site, the grower compared quantity and quality of berries grown under three 30' long low tunnels versus those grown in the open field in adjacent rows. Our low tunnel materials were sourced from Dubois Agrinovation (St-Rémi, QC; Table 1) and were installed by extension staff.

At two of the farms (Farms B and C), marketable and unmarketable strawberry yield was measured during two harvests in 2021. Fruit damaged by pests, disease, or precipitation, and fruit that were undersized were deemed unmarketable. Extension staff collected harvest data at Farm B, while the grower host collected data at Farm C. At Farm B, data from each of the three tunnel and open field replicate beds were analyzed using t-tests performed in JMP statistical software. At Farm C, berries were harvested from only one open field replicate, and no statistical analyses were conducted. No quantitative yield data was collected at Farm A or in 2022 at any of the participating farms. At the end of the strawberry season each year, we recorded our observations and those of the grower hosts. Here, we discuss our findings from the past two qualitative seasons and grower conclusions as to whether low tunnel systems were feasible for JB strawberries on their farms.

## Results

Farm A is a diversified certified organic small fruit and vegetable farm that sells strawberries through farmers markets and community-supported agriculture (CSA) in eastern New York. The growers manage their small-scale production intensively, utilizing multiple high tunnels and row covers for season extension. Grower A was intrigued by the use of low tunnels for earlier harvests of berries to bring to spring markets.

We installed low tunnels over three sections of their rows of 'Chandler' plasticulture strawberries in late April in 2021 and 2022 at first bloom. No drip irrigation was installed in the field, and straw was used between rows for weed management. Due to deer and bird pressure, Farm A used wide-mesh bird netting as a deterrent (Figs. 1 & 2). We draped the bird netting over the tunnels to accommodate the low tunnel system. Unfortunately, due to a freeze later in May 2021 (several hours of temperatures in the 20's F), Farm A lost most of the primary strawberry blossoms. Due to the warming effect of the tunnels, the plants and flowers within the structures were slightly more mature than those in the open field, and therefore tunnel plants may have lost a higher number of primary blossoms than the uncovered plants.

The quality of fruit in low tunnels was good and we observed a reduction in loss from disease compared with open field berries. Remaining low tunnel fruit in 2021 after the early freeze also ripened earlier by a few days which was encouraging for the growers. In 2022 the fruit under the low tunnels were slightly larger and again ripened earlier than the open field strawberries. The growers did report that they found that the low tunnel plants finished quicker than did the field grown berries, resulting in an earlier finish to the season by about 4 days, but this would

be expected if harvests began earlier.

### Lessons learned at Farm A:

- Low tunnel structures do not provide protection from low nighttime temperatures. Additional frost protection (e.g., row cover or micro-irrigation) is still needed to protect flowers from late frosts and freezes. This observation aligns with research conducted at the University of New Hampshire in recent years (Orde and Sideman 2019).
- Bird netting plus the tunnel structures created an overly complex harvesting environment for employees at this farm. Netting had to be removed, and the sides of the tunnels needed to be raised at each harvest.
- Despite yield losses due to the freeze in 2021, Farm A observed improved fruit quality under the low tunnels.
- The seasonality of the fruit is impacted by the low tunnel environment, causing earlier ripening and possibly an earlier end to the season.

Conclusions: Low tunnels were not worth the management effort for Farm A, particularly while using bird netting. Grower A is still interested in protected culture of strawberries given the improved fruit quality but believes that caterpillar or high tunnels would be easier for them to manage.

Farm B is a conventional diversified fruit and vegetable operation in eastern New York offering strawberries at their retail store and for pick-your-own. Grower B was interested in using low tunnels to determine whether the structures would hasten berry harvest; earlier berries in May would draw customers to their farm store.



**Figure 3. Low tunnels installed over matted row strawberries at Farm B in May 2021.**

**Table 1. Materials used for low tunnel demonstrations at commercial farms in New York and New Hampshire during 2021-2022 strawberry seasons**

Material	Size	Notes
Galvanized steel "TunnelFlex" hoops	46" wide x 39.5" tall	Hoops include loops on each side for grounding stakes
Rubber-coated end hoop <sup>1</sup>	~46" wide x 30" tall	Thicker steel end hoop set at 45° angle to taper plastic to anchor stake
Galvanized steel extension posts	2' tall	To anchor ends of tunnel
Galvanized steel anchor stakes	18" tall	Grounding stakes for hoops
Clear perforated plastic film	39.5" wide	1.5 mil thickness with 12" strip of small holes for ventilation on each edge
Bungee cord	1 x ~8' long piece per hoop	Tied in a loop, to hold film tightly on hoops
Ratchet, paracord, and zip-ties	Variable	To tie plastic to anchor posts at ends of tunnel

<sup>1</sup>While shorter end hoops were used in our demonstrations, they are optional. The larger steel TunnelFlex hoops may be used in their place.



On Farm B, we installed the low tunnels over matted row ‘Dickens’ strawberries (Figs. 3 & 4) in 2021 and 2022. We were limited in where we could install the tunnels, because only one field had drip irrigation set up. The grower typically uses overhead irrigation for strawberries and preferred using tunnels only where drip irrigation was available. Shortly after setup in 2021, the farm’s boom sprayer accidentally ripped the plastic because the boom could not clear the tunnels, and it was replaced. The plastic covering on the tunnels was rolled up during sunny days and closed during storms to prevent rain from contacting berries underneath. In addition to the farm workers’ harvests, we harvested some of the berries for comparison between the tunnels and adjacent bare rows in 2021 (Table 2). In 2022, Farm B opened the low tunnels for pick-your-own customers and we did not harvest berries for data collection.

**Lessons learned at Farm B:**

- To reduce risk of crop loss, low tunnels are best used with drip irrigation. Not all growers, however, use drip irrigation.
- Strawberry yield early in the season was numerically higher under the tunnels, but this difference was not statistically significant during our early season harvest ( $P > 0.05$ )
- The strawberry season was very dry in Farm B’s region in 2021, thus there was little disease pressure from *Botrytis* and anthracnose overall. Workers reported firmer, higher quality berries under the tunnels, nevertheless. We measured no significant differences in marketable and unmarketable fruit yield across treatments from our harvests.
- Harvesting under the tunnels was less efficient. While workers typically straddle rows to harvest, one can only harvest one side at a time under a tunnel.
- Pick-your-own customers did not provide negative feedback on their experiences picking strawberries under the low tunnels.
- Spraying with a boom sprayer can be challenging with low tunnels. Tunnel plastic could be rolled up to its highest point on the hoops during spraying, but it can be difficult to navigate the structures in the field, particularly when tunnels are placed over rows with narrow spacing.

**Conclusions:** Low tunnels would be useful for a small proportion of the farm’s early strawberry varieties to achieve earlier harvests. They would be too challenging to implement on a larger scale. Grower B is interested in constructing more low tunnels for early varieties that could boost spring sales in addition to using their high tunnel for strawberry production in the future. No significant differences between strawberry yield under low tunnels versus open field were measured, however, 2021 and 2022 strawberry seasons were abnormally dry with low disease pressure.

**Farm C** is a conventional diversified fruit and vegetable farm located in central New Hampshire. Their strawberries are sold through their CSA program, farm store, and through pick-your-own. Grower C was particularly intrigued by the ability of the tunnels to reduce disease and improve marketable berry yield and was willing to keep the tunnel sides lowered while spraying for a true comparison of disease incidence between the tunnels and adjacent open ground plants.

At Farm C, low tunnels were set up in 2021 over ‘AC Valley Sunset’ berries grown in a traditional matted row system. The rows of berries were quite wide on

this particular farm, and low tunnels were not wide enough to cover the outer edges of the rows of plants (Fig. 5). The strawberries were irrigated using drip tape, which was also used to apply fungicides and fertilizer. Farm C had a very robust spray program for the berries to manage pests and disease. The 2021 berry season was particularly wet, with rain events of up to 7” in June. Workers harvested berries from the tunnels, and grower C provided quantitative data from two strawberry harvests and observations and data on berry quality and disease incidence during the season.

**Lessons learned at Farm C:**

- Although the low tunnels did not eliminate disease, marketable berry yield was higher under the low tunnels versus open field during the rainy 2021 season (Table 2).
- A very minor amount of leaf spot, leaf scorch, and powdery mildew was observed on plants in the low tunnels, but not on other plants in the open field. Heat may have contributed to these symptoms. Overall, the numbers of *Botrytis*-infected berries in the low tunnels were not reduced, but overall incidence at Farm C was very high.
- Workers preferred harvesting berries under the tunnels because it was easier to find marketable fruit. Two workers harvested each row of low tunnel berries, one on each side of the bed. This is already standard practice on the farm because of their unusually wide beds.
- Applying pesticides using a boom sprayer was not a problem; Farm C’s boom sprayer could be raised high enough to clear the tunnels.

**Conclusions:** Data collected at Farm C found the structures demonstrated increased marketable yield compared to the open field plants. Harvesters also preferred picking under the tunnels because of the higher proportion of marketable fruit (it was a wet



**Figure 4. Sides rolled up to allow for air flow and temperature control at Farm B.**

**Table 2. Marketable and unmarketable strawberry yield at Farms B and C in 2021 under low tunnels and in open field plots**

Demonstration site	Harvest date	Mean yield (lbs fruit/30 ft plot)			
		Marketable		Unmarketable	
		Low tunnel	Open field	Low tunnel	Open field
Farm B	11-Jun	2.00	1.69	0.78	0.20
	23-Jun	17.08	21.88	3.22	3.00
Farm C	2-Jul	11.00	6.001	11.5	10.5
	7-Jul	5.00	3.00	9.5	15

<sup>1</sup>Yield in open field treatment at Farm C measured in one 30 ft section only.



**Figure 5. Low tunnels were unable to fully cover wide rows of plants at Farm C. A wider low tunnel system would be needed for this bed setup.**

season with high *Botrytis* rates, however). The farm was willing to try them again and felt wider tunnel hoops would be beneficial given their unique ultra-wide matted row beds.

## Discussion

Low tunnels offer an economical way for growers to use protected culture, resulting in higher quality fruit, potential early ripening, and reduced need for fungicides. Low tunnels are used in Europe and elsewhere across the globe with great success, but they may not be appropriate for all operations in the northeastern U.S. The major challenges observed in our demonstrations on individual farms centered around labor requirements. Low tunnels are a new object in the field and will impact all activities. They require a degree of active management, especially in the shoulder seasons and during precipitation events when plastic sides are lowered and raised. Workers may need to change their harvesting practices to be compatible with the structures, and farms using tractor-drawn boom sprayers need to ensure they have adequate clearance and awareness as they navigate them in the field with equipment. Other considerations include row width, frost protection (as they do not provide low temperature protection), and bird control.

Differing precipitation patterns across the regions allowed us to observe effects of low tunnels in both unusually wet and dry seasons. Most notably, dry conditions at Farm B resulted in little difference between treatments, while abnormally wet weather at Farm C resulted in a measurable increase in fruit yield and quality when comparing harvests from low tunnels to open field. In a changing climate, the Northeast will continue to experience increased incidence of extreme weather events. Low tunnels may be an important tool in mitigating effects of heavy rain, hail, and wind brought by spring and early summer storms, as long as tunnel structures are wide enough to cover rows of plants. While low tunnels have previously been shown to have benefits for DN varieties, these on-farm studies showed that low tunnels may also increase yield and quality in June-bearing strawberries during wet seasons.

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