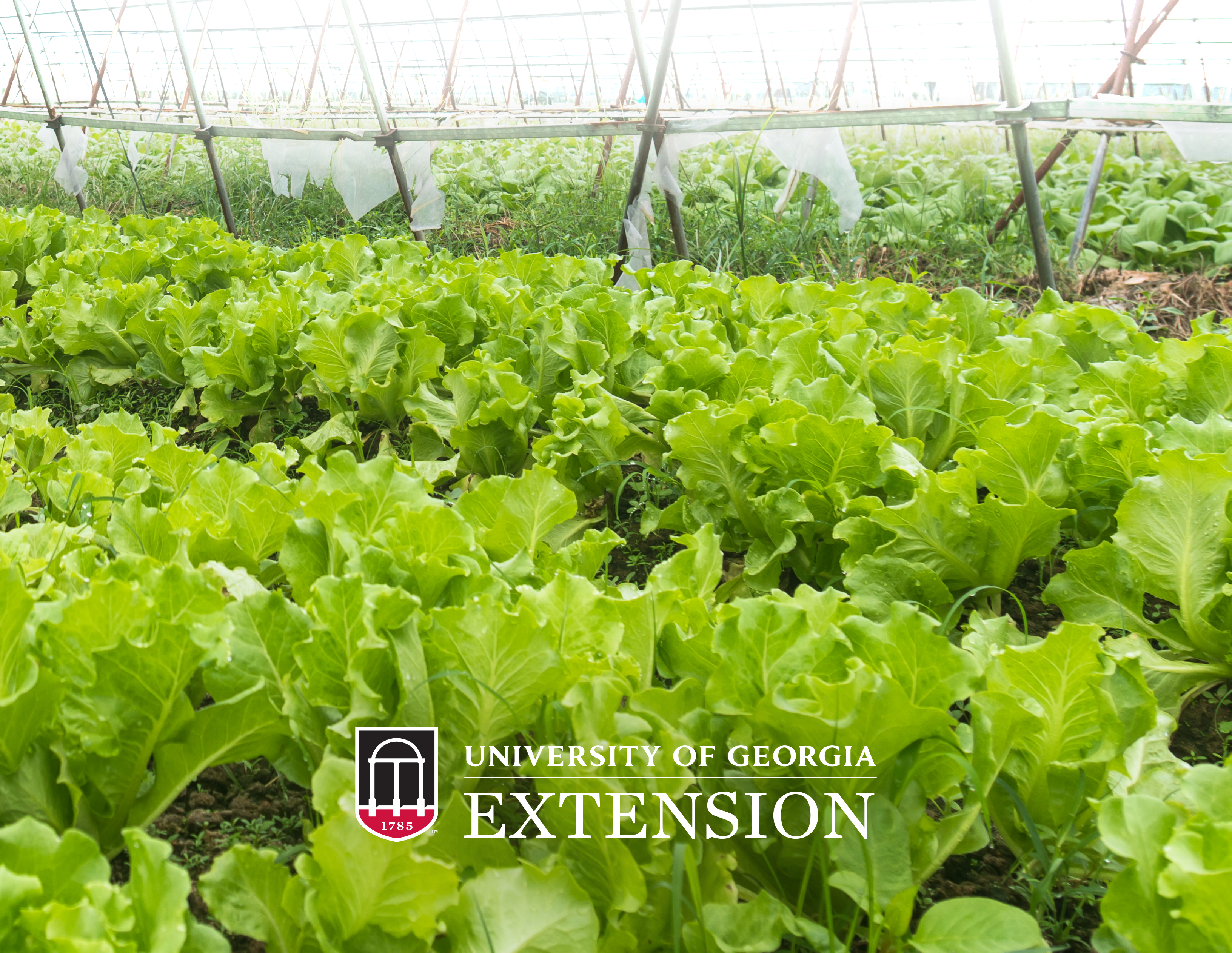
EXTENDING THE GROWING SEASON FOR LETTUCE IN GEORGIA

Using Shade Cloth and High Tunnels

Savanah Laur, North Carolina State University Cooperative Extension
Megan Donovan, University of Florida, School of Natural Resources and Environment
Juan Carlos Diaz-Perez, University of Georgia, Department of Horticulture
Timothy Coolong, University of Georgia, Department of Horticulture



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High tunnels are used by growers to extend the crop production season. They have frames made of wood, pipe, or similar materials covered by single or double layers of greenhouse-grade plastic and often have no electricity or automation (Lamont et al., 2002; Wells, 1996) (Figure 1). Some modifications to the traditional high tunnel can make the system more productive and less labor intensive.

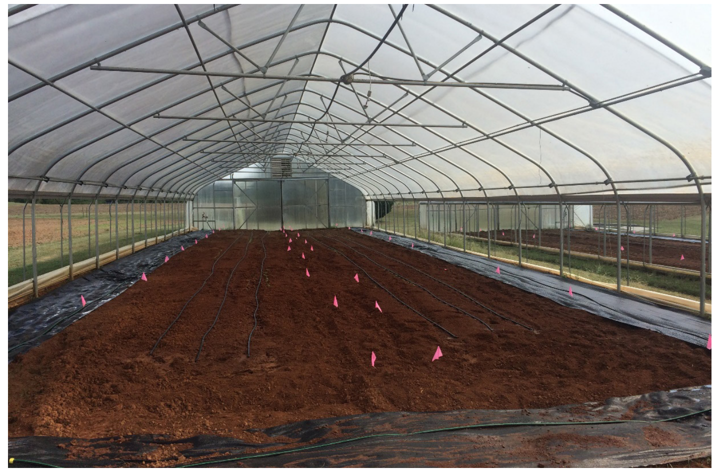

Figure 1. A typical high tunnel with roll-up side walls.

For example, high tunnels may have automated sidewalls that are controlled by air temperature sensors. This can reduce the labor required to open and close the sides of a high tunnel during times of high or low temperatures. High tunnels are able to extend the production season by manipulating the microclimate, allowing growers to sell crops in markets both earlier and later than the typical field season of the crops. This provides opportunities for growers to get better returns from their market. For example, growers can continue to raise crops in high tunnels during extremely cold winter months by adding row covers within tunnels (Figure 2). Conversely, growers can continue to raise crops in high tunnels during extremely hot summer months by increasing shade and ventilation. Many of the modifications made to high tunnels focus on retaining more heat during cold winter months. This is due in part to a higher concentration of high tunnel structures in colder climates compared to warmer climates in the United States (Cary et al., 2009).

Growers using high tunnel systems in the Southeastern United States face unique challenges due to extreme heat. Excessive heat increases plant stress as well as the number of insects and diseases. One way to manage heat stress in high tunnels is by improving ventilation with automated opening sidewalls (Zheng et al., 2019). Growers can also add automated vents to the highest parts of the tunnels to help remove heat. In warmer and more humid climates, such as in Georgia, ventilation alone may not be enough to reduce heat.

Growers can also use shade cloth to manage excess heat (Stamps, 2009). Shade cloth is made from woven polyethylene plastic and comes in different colors. While most shade cloths in the past were black, silver reflective shade cloths are becoming much more common among growers. These reflect more light than shade cloths of other colors and can reduce temperatures in tunnel structures to a greater extent compared to black shade cloths (Hohenstien, 2012). Studies show that shade cloths can be effective at reducing heat stress, which results in improved quality and yields of bell peppers during summer months (Díaz-Pérez, 2013, 2014). The key factors attributed to these results were reduced leaf and root zone temperatures (Díaz-Pérez and St. John, 2019). Additionally, shade cloths are used to grow marketable cool-season crops such as spinach during summer months (Araki et al., 1999). In the South, this can increase profits by allowing growers to offer cool-season crops during warmer spring or summer months. A research study conducted in Kansas showed that producing marketable summer-grown lettuce is possible in a high tunnel with a 39% shade cloth (Zhao and Carey, 2009). A potential disadvantage of shading is the increase of humidity inside the high tunnel. This can lead to more disease-related issues.

To determine the impact of shade cloths on the production of summer lettuce in the deep south, a study was conducted from June to July of 2019 in Watkinsville, Georgia. A 30% black shade cloth was placed over (30 ft by 90 ft) high tunnels with automated, 5-ft-tall sidewalls. The shade cloth came with preinstalled grommets tied tightly to the tunnel

Figure 2. Row covers within a low-cost temporary high tunnel.

with nylon rope. There were 18 varieties of lettuce grouped within 4 types: Mini Romaine, Romaine, Salanova™, and Summer Crisp (Figure 2).
The lettuces were also grown in a nearby field for comparison. All lettuces were grown according to U.S. Department of Agriculture Organic standards, and they were drip irrigated and fertilized using a granular feather meal-based fertilizer.

Although the shade cloth was only 30% shade, the total light intensity within the shaded tunnels was roughly 50% of outdoor conditions. This was likely due to the older plastic that covered the tunnel, which turned translucent over time and provided additional shading. Therefore, growers should consider using a higher shading value than the 30% used in this trial.

Based on this experiment and on grower experiences, shade cloth with a shading value of 30-50% is suitable for producing summer-grown lettuce in north Georgia. Our experience in Watkinsville suggests that shade cloth should be put on the high tunnel in late May and removed by mid- to late September. Leaving shade cloths on a tunnel into early October can result in a reduction in growth due to inadequate light levels. Average air and soil temperatures during the day were slightly lower (2 °F) in the high tunnel compared to the field. It's likely that using a reflective shade cloth instead of black shade cloth would have lowered temperatures even more. The shade cloth increased the amount of lettuce that was marketable. Most lettuce grown in the tunnel was marketable (Figure 3), and almost none of the lettuce grown in the field could have been sold. Yields of all types of lettuce were better in the tunnel compared to the field (Table 1). Some tunnel-grown romaine heads were slightly bitter, but summer crisp types were generally mild.

Figure 3. Organic high tunnel with shade cloth and lettuce growing in July.

Table 1. Effects of growing system (high tunnel or field) on yield and bolting in four types of lettuce grown in summer 2019 in Watkinsville, Georgia. (Adapted from Laur, 2020)

System[z]	Type of Lettuce	Yield/100 row feet[y] (lbs/100 ft.)	Avg. Weight/head[x] (oz/head)
HT	Mini	39.3a[w]	3.1a
FD	Mini	18.7b	1.5b
HT	Romaine	105.7a	12.7a
FD	Romaine	55.9b	6.7b
HT	Salanova	34.8a	4.2a
FD	Salanova	11.1b	1.3b
HT	Summer Cr.	91.7a	11.0a
FD	Summer Cr.	39.9b	4.8b

[z]High tunnel = HT, Field = FD.

[y]Yield based on actual marketable plants harvested estimated per 100 feet using a *single row* of plants spaced approximately 9-10 inches apart. Non-marketable plants (bolting, appearance) were not included in this yield estimate.

[x]Average weight of a marketable head of lettuce.

[w]Means within types of lettuce followed by the same letter are not significantly different according to Tukey's Honest Significant Difference Test ($P<0.05$).

Because of the lower light levels in the high tunnel, some of the red-colored lettuces were not as intense as those grown in the field (Figure 4). The tunnel-grown lettuces had to be harvested within two to three days before it would bolt (flower). Due to the higher temperatures and greater growing degree days in the summer season, there were reductions in the differences between the listed number of days to maturity for the different lettuce varieties. For example, two varieties that were listed to mature in 45 and 57 days, respectively, under typical outdoor conditions in early spring instead matured in 40 and 45 days in the tunnel during summer.

The shade cloth used in this trial cost approximately $600 to cover one tunnel. If removed and stored out of the elements when not in use, this shade cloth could likely be used for at least 10 years (assuming it was used for four months per year). Amortized over a 10-year period, this would cost approximately $60 per season/year. If lettuce was sold in a retail market for $3 per head, 20 heads of lettuce would need to be sold per season to account for the additional cost of the shade cloth.

Adding a shade cloth to a well-ventilated high tunnel resulted in marketable lettuce production during a time of the year when it would otherwise be unavailable. Variety selection was important, and growers are encouraged to try several varieties to find the best one for their system.

Figure 4. High tunnel grown lettuce (left) compared to lettuce grown in the field (right).

Figure 5. Magenta lettuce grown in the shaded tunnel during the summer (left) and typical outdoor grown Magenta lettuce (right). The impact of shade on the color is notable in those varieties that have a red coloration to them.

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