OPEN to the ELEMENTS

Growing Bedding Plants in Unheated High Tunnels

By E. Jay Holcomb and Robert D. Berghage

While many growers are already using high tunnels for cut flower production, the use of high tunnels for container-grown crops is a fairly new practice.

Seasonal bedding plant growers may be less affected by high fuel costs during the winter than a year-round greenhouse production facility — they may not be heating all their greenhouse space during the colder months of the year — but spring heating costs can quickly reduce already thin profit margins. Many bedding plant growers have been examining alternatives to reduce fuel use.

For many years, Penn State researchers have been investigating the practicality of using unheated high tunnels for vegetable and cut flower production and season extension for these crops. The research lessons learned suggest the potential for unheated high tunnels to be used as bedding plant production space to partially or, in some cases, fully replace heated greenhouse space. The objectives of this research:

- To determine which plant taxa were sufficiently cold tolerant to be grown in an unheated high tunnel in the early spring.
- To evaluate relative marketability and cost of production for bedding plants produced in an unheated tunnel compared with those produced in a traditional spring heated greenhouse.

Many growers are already using high tunnels for cut flower product, and high tunnel research has been done for a variety of floral crops, the use of high tunnels hasn't really been explored for container-grown crops.

Preparing Plants

For this project, we used a standalone Quonset-style greenhouse on the Penn State campus as an unheated high tunnel for this project. A section of a computer-controlled greenhouse was set to a traditional temperature with heating setpoints of 60° F day and night temperatures and served as the comparison for this project, with ventilation setpoints of 70° F day and night. Sixteen species of plants, with 50 plants per species for a total of 2,400 plants, were obtained as propagated material grown in 72-cell plug trays, shipped to Penn State on two dates. Liners were transplanted into 4-inch pots; half were placed in the greenhouse and the other half went into the high tunnel.

Plants for the first trial arrived and were planted on March 10. There were several rather cold days during the spring season, but temperatures in the high tunnel did not fall below 32° F. The high tunnel was in a protected location on

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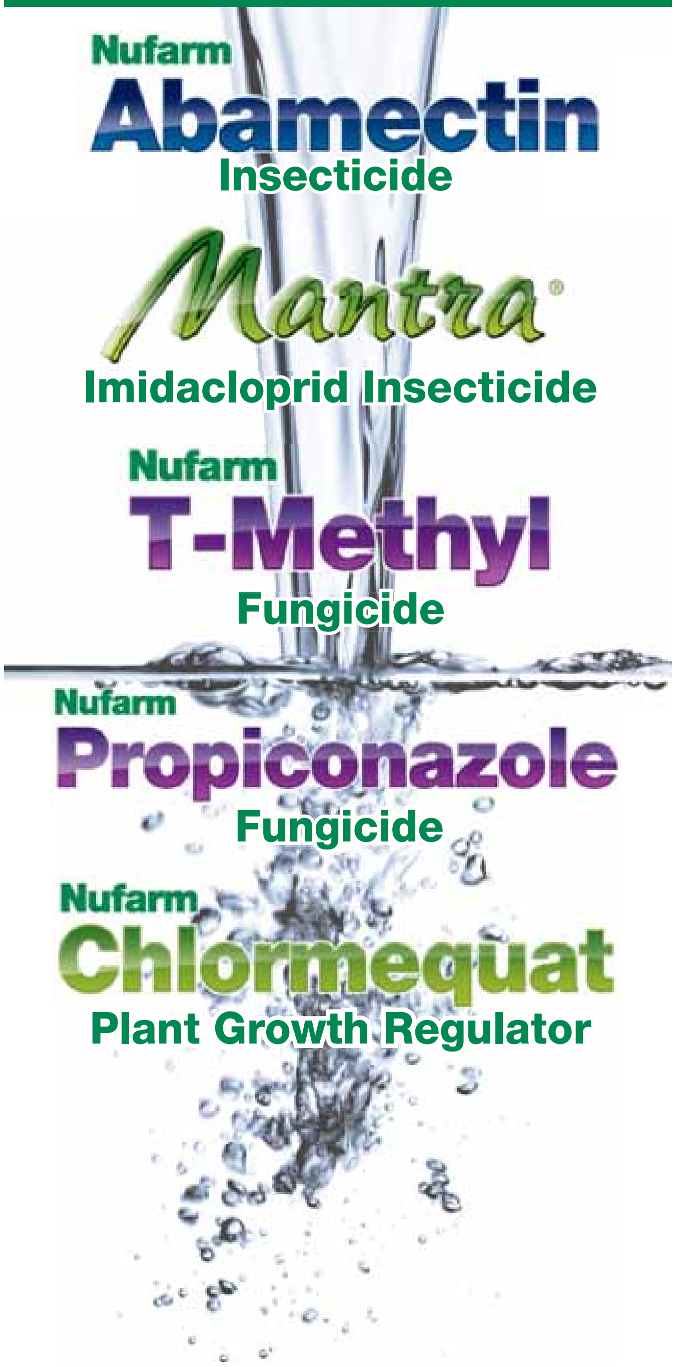

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campus and was covered in double-layer polycarbonate. Even during periods when ambient outdoor air temperatures were below 32° F, there were no visible signs of damage to any of the plants in the tunnel. The plants for the second trial were planted on March 31 and treated like plants in the first trial.

Once plants were placed in their respective growing structures, they received overhead hand watering as needed. Plants in both locations were fertilized at each irrigation; however, because of the warmer temperatures, the plants in the greenhouse were irrigated and, subsequently, fertilized more frequently.

We determined plant diameter or height and an estimate of commercial salability for each crop. In general, the greenhouse plants flowered and reached saleable commercial size first. We measured greenhouse-grown and high-tunnel plants at the same time to get a sense of the difference in size between the plants grown under the two different temperature regimes when the greenhouse plants were at a saleable size.

Visible Results

As expected, the low and variable temperatures in the high tunnel increased crop time to sale for all the crops in the experiment, though the temperature in the high tunnel did not drop below 32° F, and there was no visible freeze damage on any of the plants.

Plants grown in the high tunnel took longer to become saleable than those grown in the greenhouse, but not all plants responded in the same way, so we tried to group plants with growth rates that responded similarly to the different temperature regimes. The first group (Figure 1), which includes plants like pansies, tolerated the colder temperatures in the high tunnel and were only slightly delayed in development compared to the plants in the heated greenhouse, particularly during the second trial. The second group (Figure 2) was cold tolerant but displayed a greater delay for the high tunnel plants to become saleable. An example from this group is snapdragons. The third group (Figure 3), which included plants like verbena, was not very cold tolerant and was delayed substantially by production the high tunnel compared to production in a heated greenhouse.

The amount of delay varied from as little as one to two weeks to as much as three to four weeks. Table 1 provides a summary of the delay for each plant type.

Many of the plants grown in the high tunnel were more compact than those grown in the greenhouse, which might make them more visually appealing to consumers at retail.

Plants Best Suited to High Tunnel Production

It seems the plants in Group 1 would be best suited to grow in an unheated high tunnel. For the first trial, plants in the high tunnel generally required about two more weeks than the greenhouse-grown crops to become saleable. By the second trial, the delay had been decreased by approximately a week.

A Little Background

Scheduling of bedding plants has been well studied and is discussed in numerous articles, but all the scheduling information has assumed that plants would be grown under optimum or near-optimum growing conditions to increase greenhouse profitability by minimizing greenhouse production time and increasing spring product turns through the greenhouse. One researcher concluded that the best way to minimize fuel use for bedding-plant production was to provide environmental conditions that minimize the crop time, that simply reducing temperature reduced leaf unfolding rate and increased total crop time, which generally does not save any fuel. As heating costs continue to increase, we will likely need to reassess this formula for improving profitability.

Another mentioned that valuable greenhouse space could be freed up by moving plants outside, but to date, no one has evaluated the potential for full crop-cycle production and scheduling requirements for bedding plants in an unheated high tunnel. Most of the scheduling work on bedding plants has assumed that the overhead or space costs are constant over time. Within a single greenhouse, it is difficult to calculate the constant or continual change in cost during the season, so assuming a constant cost is a reasonable simplification. But again, with increasing fuel costs, growers may also need to be reevaluated this approach.

It has been suggested that a reasonable value for greenhouse space would be 25 cents per square foot per week. There is much less information available on the space cost for high tunnels, but it could be as little as 5 cents per square foot per week. Based on these estimates, it would be possible to grow a plant in a high tunnel for five weeks for the same cost per square foot as growing it in a traditionally heated greenhouse for one week.

Research from 1992 documented that geraniums respond to environmental conditions where an optimum temperature can provide rapid leaf unfolding and higher or lower temperatures produce less rapid leaf unfolding rates. Later research reported that leaf-unfolding rates of crops differed in their temperature sensitivity. For example, nemesia was delayed nine days, while angelonia was delayed 26 days when temperature was reduced from 68° F to 57° F.

Not all growers know the cold tolerance of bedding plants: One researcher reported that some tropical crops such as lantana, vinca and cleome definitely require warm conditions to maintain growth. Other crops, such as pansy, alyssum and snapdragon, were cool-tolerant annuals that could be finished outdoors.

The size of the plug at transplant can also influence production times. One general rule states that an increase in plug size from 512 to 288, or 288 to 128, would reduce the finish time by one week. To date, the work investigating the influence of plug size on production times has been conducted at standard greenhouse temperatures. It seems likely that larger plugs would perform better in unheated tunnels and be more cold tolerant, but that hypothesis has not been tested.

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Plants in Group 2 generally required more time to become saleable, and as long as that timing could be accommodated, they could be grown in a high tunnel as well. Some flowered a little slowly or grew slowly, but visually they appeared to do well in the high tunnel.

Plants in Group 3 did not grow well in the high tunnel and grew or flowered very slowly until the outdoor ambient air temperature increased. These plants would be best grown in a greenhouse until the temperatures in the high tunnel got warm enough.

It's important to remember, though, that the temperature in the high tunnel did not drop below freezing after the March 10 planting date in these trials, even though outdoor ambient temperature dropped to as low as 26° F. The results might be different if temperatures far below freezing had occurred, and it might be necessary to protect plants in the tunnel with a row cover or thermal blanket in the case of excessively low temperatures.

Cost Savings

An important aspect of using unheated high tunnels is the cost savings over a heated greenhouse. The structure of a high tunnel is also less expensive, as it usually has only a single layer, so perimeter insulating and inflating between the poly layers isn't necessary. The amount of savings would depend on the specific greenhouse or tunnel used, but we have

Figure 1. Pansy 'Majestic Mix' four weeks after planting in the first trial. The plant on the left was grown at 60° F, and the one on the right in the high tunnel.

Group 1: Tolerant Plants

Pansy 'Majestic Mix' was in flower and saleable four weeks after planting in the greenhouse but, like other plants in this group, took an extra one to two weeks to become saleable when grown in the unheated high tunnel for both trials. Pansy in the high tunnel were more compact (4.6 inches tall) than the plants in the greenhouse, which averaged 6 inches tall; like other plants in this group, the pansies still flowered very well in the high tunnel. Figure 1 provides a comparison of the pansies at four weeks after planting. Although the high tunnel plant was not in flower at this time, buds were clearly visible. Plants in the high tunnel were smaller than the greenhouse for the second trial as well.

Group 2: Tolerant but Delayed Plants

Snapdragon 'Floral Showers Mix' tolerated the cool high tunnel but was slower to flower, as shown in Figure 2. As with other plants listed for this group, flowering and attainment of saleable size were delayed at least two to three weeks in the first planting. Delay in the second planting was less and more variable for plants in this response group. When saleable, the high tunnel snapdragons were 10 percent smaller than the plants in the greenhouse.

Figure 2. Snapdragon 'Floral Showers Mix' four weeks after planting in the first trial. The plant on the left was greenhouse grown; the one on the right was grown in the high tunnel.

Figure 3. Verbena 'Lascar Dark Pink with Eyes' seven weeks after planting in the first trial. The plant on the left was grown in the greenhouse; the one on the right was grown in the high tunnel.

Group 3: Intolerant Plants

Verbena 'Lascar Dark Pink with Eyes' grew and flowered very slowly in the unheated high tunnel (Figure 3). Plants grown in the high tunnel were 58 percent smaller than those grown in the greenhouse on April 21, when the greenhouse plants were considered saleable. Plants in the high tunnel had poor leaf expansion, reduced internode elongation and grew more slowly than those in the greenhouse. As normally warm weather arrived, the verbena in the high tunnel did much better. The crop appears to need warm temperatures to grow well. The same trend was evident in the second trial.

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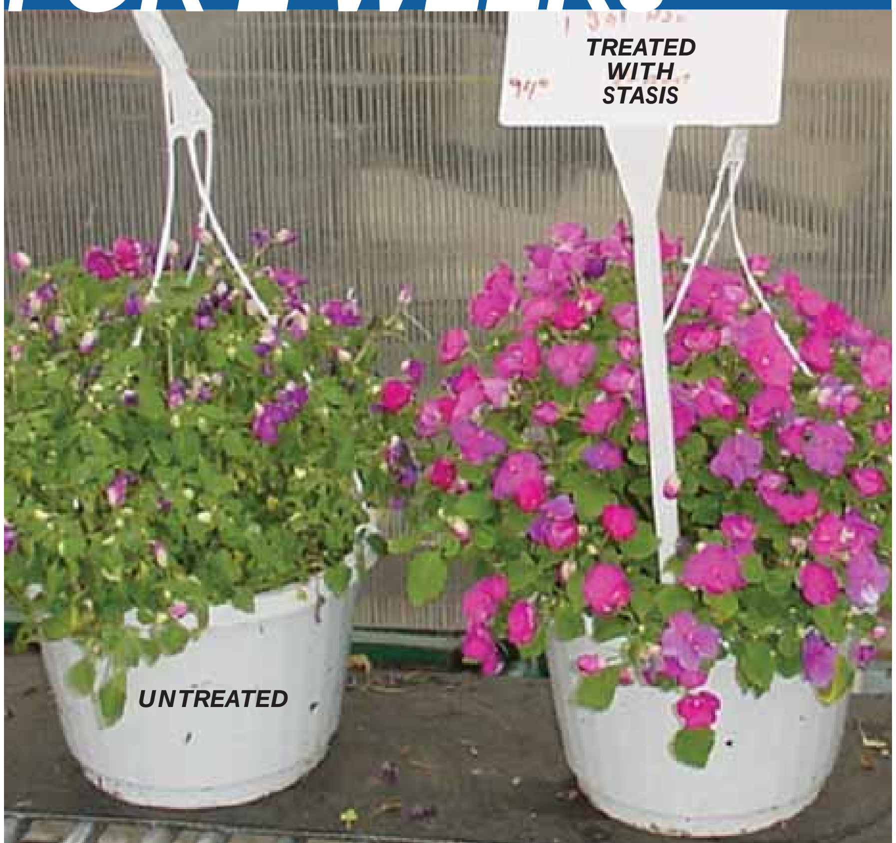

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provided an estimate that we feel will give an idea of the magnitude of the potential savings. For this example, we are assuming a glasshouse heated with natural gas at $8.24 per 1,000,000 BTU. Based on our data, a crop like petunia or lobelia planted on March 15 could finish in a 60° F greenhouse in about four weeks and would reach a saleable size by about April 15. Using a computer program designed to calculate greenhouse heating costs and including heating

Table 1

Plant Taxa	Delay in Salability (weeks)		Reduction in Plant Size compared to HT (percent)	
Response Group	Trial 1	Trial 2	Trial 1	Trial 2
Group 1: Plants that tolerated production in an unheated tunnel				
Dianthus	0.3	1.0	24	-25
Lavender	0	2.7	37.5	23
Linaria	1.0	0.3	-5	8
Lobelia	2.0	0.3	20	15
Pansy	1.0	1.3	23	11
Petunia	1.0	1.3	39	-17
Stock	2.0	0.3	-48	11
Group 2: Plants that tolerated production in an unheated tunnel but suffered greater delay				
Bacopa	2.3	0.3	11	56
Calibrachoa	2.3	2.7	13	0
Dusty Miller	3.0	0.3	20	33
Osteospermum	3.0	---	-69	---
Snapdragon	3.0	3.0	12	4
Thyme	2.7	0	26	35
Group 3 Plants that were intolerant of unheated high tunnel conditions				
Verbena	1.0**	1.0	40	-11
Vinca	3.0	---	38	---
*** This delay of one week indicates that the plants were in flower and might be salable but were small with little leaf expansion and of poor quality*				

Table 1. Summary of the delay in flowering and reduction in plant size for the 3 Groups in the greenhouse compared to the high tunnel

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degree days based on data from State College, Pa., we calculated that it costs 50 cents to heat 1 square foot of greenhouse for the four-week period of March 15 to April 15.

In this example, plants were in 4-inch pots and spaced pot-to-pot; thus, the heating cost for each 4-inch petunia or lobelia would be about 5.7 cents per pot. Similarly, dianthus planted on March 15 to be saleable by the first week of May would have a heating cost of about 7 cents per pot. If planted earlier than March 15 — for the crop to reach a marketable size sooner — the air temperature would need to be increased, and heating costs would be higher.

Let's consider estimated overhead costs separate from heating. An overhead cost of 25 cents per square foot per week in a 60° F greenhouse would mean that a 4-inch lobelia would have an assigned overhead cost of 11 cents. A lobelia grown in a high tunnel for six weeks with an overhead cost of 5 cents per square foot per week would have a per-pot overhead cost of 3.4 cents. Even if overhead cost estimates were doubled in the high tunnel to 10 cents per square foot per week, lobelia in the high tunnel would have an overhead cost of 7 cents, which is still 36 percent less than the overhead in a 60° F greenhouse.

There may be potential to use a high tunnel as a part of the bedding plant production system for some crops in the Northeast and other areas with similar spring climate conditions. GPN

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