Figure 1. **High tunnel used at Purdue University for bedding plant production.**

High Tunnels: Reduce Heating Costs While Improving Bedding Plant Quality

This is the first article in a two-part series featuring research from Purdue University that focuses on energy-efficient production of cold-tolerant bedding plants.

by **JOSHUA R. GEROVAC** and **ROBERTO G. LOPEZ**

ANNUALS are the bread and butter of the commercial floriculture industry. In fact, they are the most valuable sector and account for 62 percent of the reported wholesale value of $5.9 billion in 2012. However, increasing production costs (energy, labor, etc.) and stagnant wholesale prices have led to thin profit margins. In today's competitive environment, greenhouse growers are constantly searching for ways to reduce production costs.

Energy costs for heating now account for 10 to 30 percent of the total operating costs for commercial greenhouses located in northern latitudes. In an attempt to reduce these costs, some growers have made energy-saving investments, including thermal energy curtains, increasing insulation, switching to alternative fuel sources and purchasing energy-efficient heaters. These costly investments have the potential to significantly reduce heating costs depending on the grower's location, fuel type, boiler, etc. Another option that growers in northern latitudes are experimenting with is growing bedding plants in high tunnels.

High Tunnels Can Help Reduce Heating Costs

High tunnels are structures that typically lack automated ventilation and are heated by solar radiation and cooled through manually operated side- and/or end-wall and gable ventilation (Figure 1). They are primarily used in temperate northern latitudes to extend the growing season and improve the quality of high-value horticultural crops like fruits, vegetables and cut flowers.

Recent research at Purdue and Cornell Universities has shown that growers can utilize high tunnels to reduce or eliminate heating costs associated with finishing bedding plants when compared to a heated greenhouse. While high tunnels have proven to be a cost-effective method of growing, there are associated risks. For example, our research, reported in the July 2012 issue of *Greenhouse Grower*, revealed the risks of growing bedding plants in unheated high tunnels in early spring. Several cold-sensitive species transplanted in a high tunnel during week 15 experienced chilling injury and as a result, several of the crops were lost.

The results of that study led us to conduct a two-year study to determine the effects of transplant date and the use of a row cover on cold-tolerant bedding plants grown in high tunnels. If the effects of low night time temperatures could be mitigated though the use of a row cover, it would prove to be a practice growers could adopt. Therefore, the objectives of our research were to quantify the effects of planting dates and the use of a row

NEXT MONTH
Bench-Top Root Zone Heating

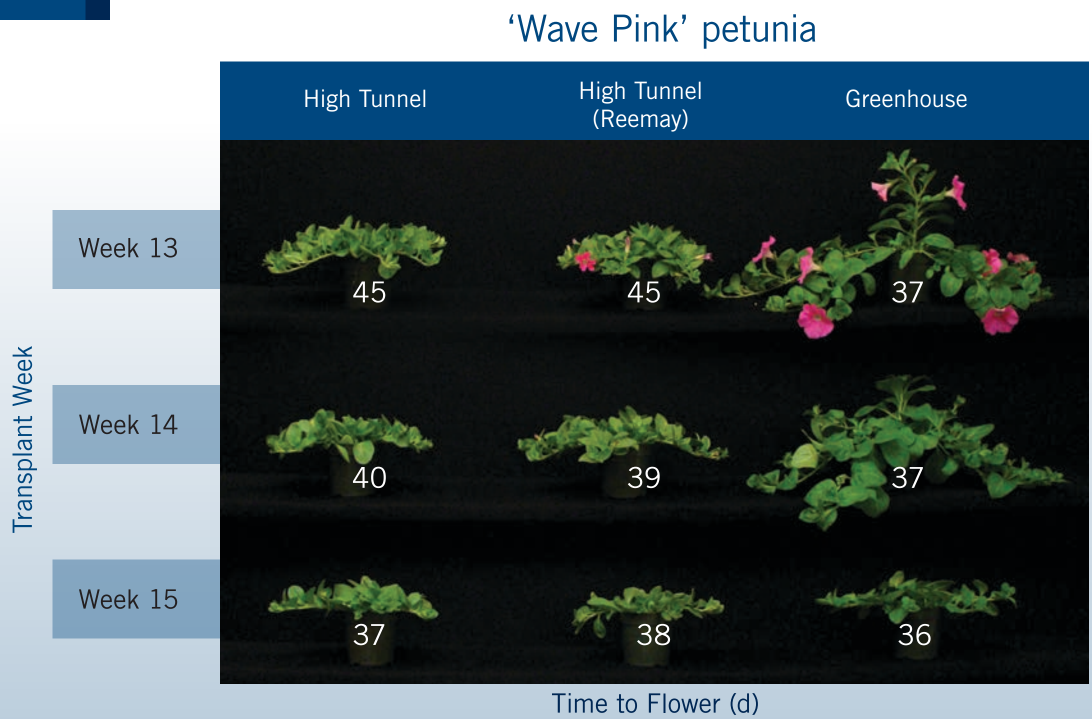

Figure 2. **Time to flower (days) of petunia 'Pink Wave' as influenced by transplant week (week 13, 14 or 15) and production environment (high tunnel, high tunnel plus Reemay or greenhouse). Photos of all plants were taken on week 19.**

cover in a high tunnel, compared to a traditional heated greenhouse, on the growth of several cold-tolerant bedding plant species.

How This Study Was Conducted

Transplant Date. Three transplant dates were evaluated during a two-year study in 2012 and 2013. Plugs of cold-tolerant snapdragon 'Garden Standard Liberty Classic Yellow,' dianthus 'Telstar Crimson' and petunia 'Pink Wave' were received at Purdue University from a commercial greenhouse propagator (C. Raker and Sons, Inc.) during weeks 13, 14 and 15.

Upon arrival, plugs were transplanted into 4.5-inch round containers filled with a commercial substrate comprised of 65 percent Canadian sphagnum peat moss, 20 percent perlite and 15 percent vermiculite. Plants of each species were randomly selected and moved to their respective production environments for each transplant date. Plants were hand-irrigated with acidified clear water supplemented with a water-soluble fertilizer providing 200 ppm nitrogen.

Production Environments. Three different production environments were compared during the two-year study, which included a glass-glazed greenhouse, high tunnel and high tunnel with row cover (Reemay cloth). Reemay is a high-density polyethylene fabric that is used as a row cover to trap warmer air above the crop. Plants in the east-to-west oriented greenhouse were grown under natural photoperiods and a constant day and night temperature of 70°F.

The two main production environments included an east-to-west oriented high tunnel covered with a single layer of 6-mil polyethylene and a glass-glazed greenhouse that was also oriented east-to-west.

Plants in both high tunnel environments were grown under variable day and night temperatures with a natural photoperiod. Ventilation in the high tunnel was provided by manually operated end wall peak vents, end wall doors and roll-up side walls. End wall peak vents were opened when the forecast high was greater than 55°F, end wall vents and doors were opened when the forecast high was greater than 70°F and vents, doors and roll-up side walls were opened when the forecast high was greater than 75°F.

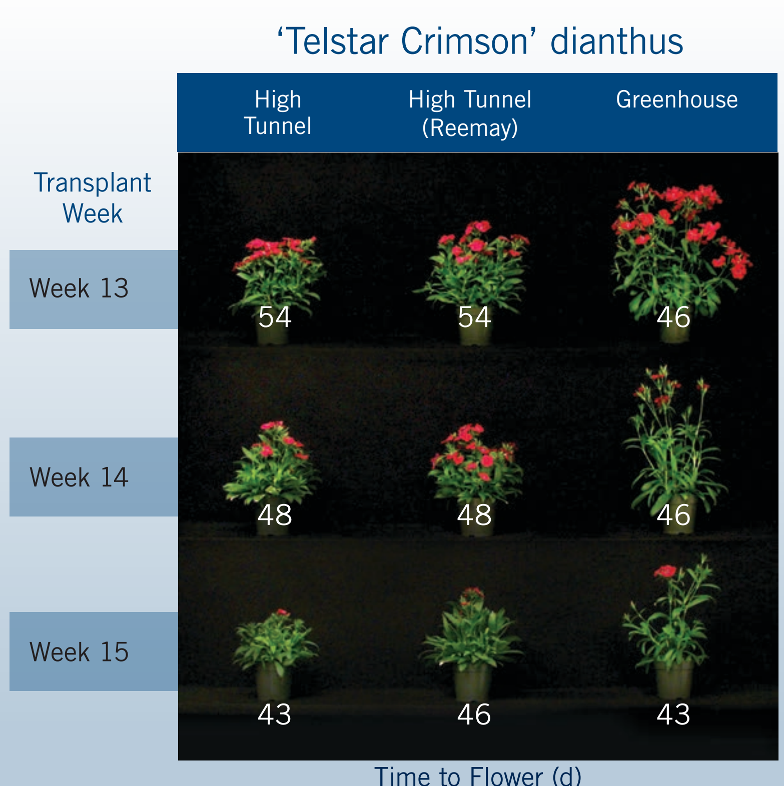

Figure 3. **Time to flower (days) of dianthus 'Telstar Crimson' as influenced by transplant week (week 13, 14 or 15) and production environment (high tunnel, high tunnel plus Reemay or greenhouse). Photos of all plants were taken on week 22.**

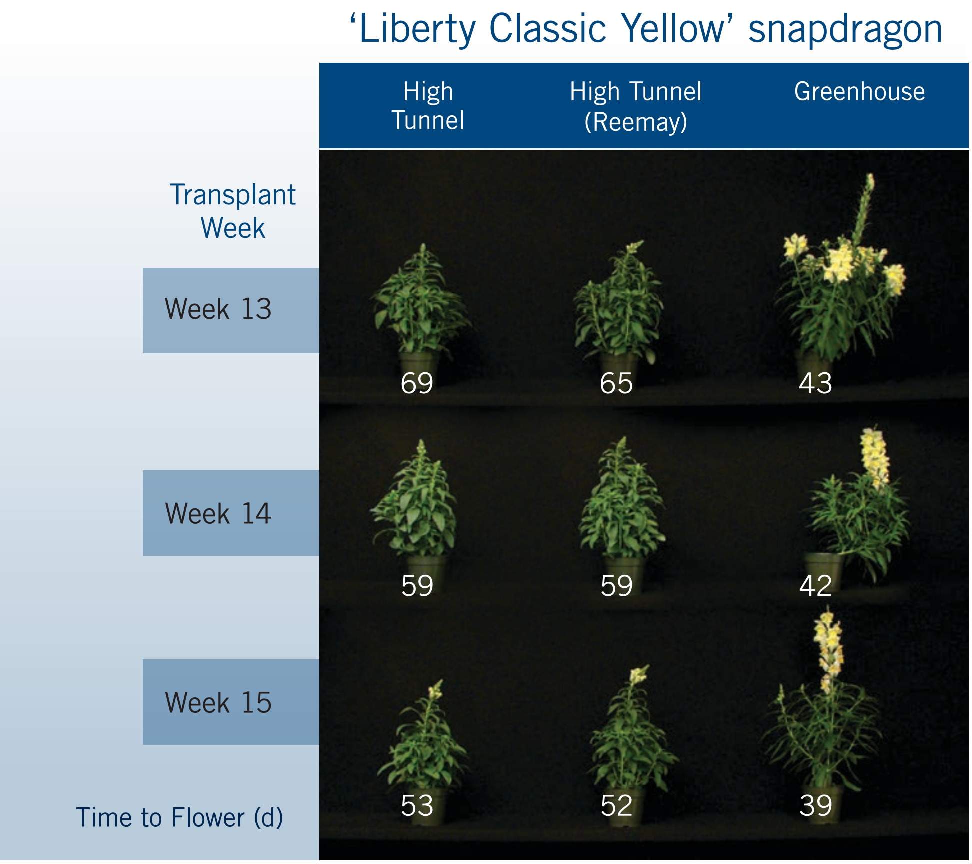

Figure 4. **Time to flower (days) of snapdragon 'Garden Standard Liberty Classic Yellow' as influenced by transplant week (week 13, 14 or 15) and production environment (high tunnel, high tunnel plus Reemay or greenhouse). Photos of all plants were taken on week 22.**

All ventilation was closed as needed during periods of high winds and low temperatures. On nights when the forecast low was less than 34°F, Reemay was pulled over an 18-inch tall frame made of PVC (frame was used to prevent the crop from being damaged by the cloth), with the other half of the plants not being covered with Reemay.

High Tunnel = High Quality Plants

The daily light integral (DLI) received by plants that were grown in the high tunnels was generally double that of the plants in the greenhouse. The increased light levels in the high tunnels were the result of the limited structure needed to support the high tunnel and the single layer of poly. The light levels were further differentiated because greenhouses use shade cloth systems to aid in temperature control, which significantly reduces light levels.

Elevated light levels, coupled with cool morning temperatures (similar to a morning temperature DIP or DROP), significantly improved the quality of the crops grown in the high tunnel. For example, dianthus and petunia that were transplanted in week 13 in both high tunnel production environments were more compact, had more visible buds and increased more in shoot dry mass than the plants grown in the greenhouse (Figures 2 and 3). Snapdragon plants grown in the high tunnel had increased shoot dry mass and visible bud number but were the same height as the plants grown in the greenhouse (Figure 4).

The increase in quality did come at the cost of a longer production time. Times to flower of dianthus and petunia transplanted at week 13 were delayed eight days regardless of the row cover treatment when compared to plants grown in the greenhouse (Figures 2 and 3). This delay could be seen as acceptable by some growers who want to reduce the use of chemical growth regulators and heating costs.

Dianthus and petunia that were transplanted in week 14 and 15 in the high tunnel had little to no delay in time to flower from transplant and were higher quality plants than those grown in the greenhouse (Figures 2 and 3). However, snapdragon was delayed by as much as 26 days when transplanted in week 13, with the row cover reducing the time to flower to 22 days (Figure 4). While snapdragon grown in the high-tunnels were higher quality plants than those grown in the greenhouse, the long production time may make this crop unsuitable for high tunnel production.

Growing In A High-Tunnel Is A Gamble

While the crops being produced in the high tunnel environment were higher quality than those grown in the greenhouse, this production environment can be risky. The coldest night recorded during this two-year study was 32°F. Symptoms of chilling injury were apparent on the dianthus and snapdragon, but they grew out of it relatively quickly.

The Reemay was effective at reducing chilling injury, as symptoms were much less evident on the plants under the row cover. According to our data logger, the air temperature under the Reemay was approximately four degrees warmer than the air temperature in the high tunnel without the cover. This indicates that a row cover is an effective practice that growers could use to mitigate the effects of low night time temperatures.

Additionally, depending on the market you are targeting, a later transplant date can reduce the risk of chilling injury or plant losses, while improving quality. If bedding plant growers are willing to roll the dice and gamble, the elimination of heating and chemical growth regulator costs may pay off by growing in an unheated high tunnel. However, if you are risk averse, we recommend having an emergency heating system on hand for bedding plant high tunnel production. **GG**

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