Using Root-Zone Heating for Energy-Efficient Petunia Production

A new study shows that you can grow your petunias in a cooler greenhouse to save money and still produce a high-quality crop.

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Potted petunias continue to be one of the most popular bedding plant crops produced by greenhouse growers. In 2014, more than 25 million plants valued at over $262 million were sold in the U.S. (USDA, 2015). Although petunias are considered a cold-tolerant species, greenhouse production of this crop in northern latitudes often incurs significant heating costs. In an effort to reduce heating costs, greenhouse air temperature set points are often lowered. As average daily temperatures (ADT) are lowered, plants develop progressively slower, which can cause delayed flowering and, subsequently, missed market dates.

At some species-specific temperature, development stops. This is referred to as the base temperature (T_b). The T_b of petunia is between ≈37 and 45F (2 to 7C) depending on the cultivar, which means that at or below this temperature, the crop will stop growing. They also have a reported optimum temperature for development of ≈77F (25C), where flowering is most rapid. However, while growing at the optimum temperature produces a flowering crop most rapidly, a reduced crop quality is often observed.

Recent studies on the effects of reduced air temperatures in greenhouses and high tunnels indicate that flowering of cold-tolerant crops, such as petunia, can be delayed by up to 16 days when air temperature set points are lowered by just 5F. Root-zone heating (RZH) has previously been found to be an efficient method of increasing the rate of development for a variety of crops, including verbena, poinsettia, chrysanthemum, tomato and snapdragon.

Our objective was, therefore, to evaluate development, growth and quality of four petunia cultivars when greenhouse air temperature was reduced from a constant 70 to 59F (21 to 15C) and bench-top RZH of 70 (21), 75 (23) or 80F (26C) was utilized. Commercially available, vegetatively propagated petunia cultivars were selected based on breeder input for cold-tolerance and growth habit. ▶

Figure 1. Flowering of petunia Sun Spun Lavender Star, Potunia Plus Purple and Sanguna Patio Red seven weeks after transplant, grown at a mean daily temperature (MDT) of 59F without root-zone heating (RZH) or with a RZH set point of average daily temperature (ADT) 70, 75 or 80F, or at a ADT of 70F as per commercial practice (Comm.).

How we conducted the study

Plant material and culture. Rooted cuttings of Petunia Sun Spun Lavender Star, Potunia Plus Purple, Supertunia Bordeaux and Sanguna Patio Red were received by week 3 (January 20). All plants then received a soft-pinch and were sprayed with 400 ppm ethephon (Florel) to abort and abscise all premature flowers and flower buds. All plants were transplanted on January 22 into 4.5-in. containers filled with soilless substrate consisting of (by volume) 65% peat, 20% perlite and 15% vermiculite.

Greenhouse environment and temperature treatments. Plants were grown in two separate glass-glazed greenhouses under a 16-hour photoperiod consisting of natural daylengths with day-extension and supplemental lighting provided by high-pressure sodium (HPS) lamps to achieve a daily light integral (DLI) of ≈10 to 12 mol•m^{-2}•d^{-1}.

One greenhouse had a constant air temperature set point of 59F and plants were placed onto benches without RZH or with a RZH set point of 70, 75 or 80F (Figure 2). Root-zone temperatures were achieved by circulating hot water (120F/49C) though rubber tubing on the benches, individually controlled by root-zone temperature probes

Figure 2. Experimental set-up of petunias growing on benches with or without root-zone heating (RZH) with a mean daily temperature (MDT) of 59F average daily temperature (ADT).

Figure 3. Petunias growing on bench-top root-zone heating.

inserted horizontally at the center of the substrate. Pots were placed into shuttle trays, which sat directly on the rubber tubing (Figure 3). A separate greenhouse served as a commercial control with a constant air temperature set point of 70F and no RZH.

Effect of RZH on time to flower

Time to flower (TTF) decreased with increasing RZH for all cultivars grown under a reduced air temperature (Figure 1). For example, TTF of Supertunia Bordeaux was 49, 43, 41 or 39 days for plants grown at an air temperature of 59F without RZH or with RZH set points of 70, 75 or 80F, respectively.

With the exception of Sanguna Patio Red, all plants grown at an air tempera- ▶

ture of 59F with a RZH set point of 80F had similar or reduced TTF compared to plants grown at an air temperature of 70F (commercial control).

Time to flower of Sun Spun Lavender Star was reduced by four days for plants grown on a RZH set point of 80F and at an air temperature of 59F, compared to the commercial control. On average, flowering of all cultivars was delayed by nine days when grown under reduced air temperatures without RZH, compared to those in the commercial control.

Rate of development is directly influenced by plant temperature and increased plant tissue temperature was measured with increased RZH. For example, plant tissue temperature was an average of 59, 60, 61 and 65F for plants grown at an air temperature of 59F without RZH or with a RZH set point of 70, 75 or 80F, respectively. Plant tissue temperature was an average of 62F for petunias grown in the commercial control at an air temperature of 70F. This rise in plant temperature with increasing RZH set points likely reduced time to flower.

Comparison of growth and quality

Generally, plant growth decreased with increasing RZH for all cultivars. For example, stem length of Supertunia Bordeaux was reduced by 1.5 in. when grown on a RZH set point of 80F compared to without RZH. Shoot dry mass (SDM) at flowering of Supertunia Bordeaux, Potunia Plus Purple and Sun Spun Lavender Star plants grown at an air temperature of 59F with a RZH set point of 75 or 80F was similar to those grown at an air temperature of 70F. This decrease in stem length and SDM with increasing RZH is likely due to a decreased TTF and, consequently, a shorter time period for vegetative growth prior to flowering. More compact growth is generally considered beneficial and can allow for decreased need for application of chemical plant growth regulators (PGRs).

Grower recommendations

The reduction in production time that results from a decreased TTF can directly relate to increased savings. Reduced plant size, in terms of decreased stem length and SDM, was also observed for plants grown at a reduced air temperature with RZH. These effects are beneficial to growers, as reduced plant size allows for fewer PGR applications, occupies less greenhouse bench space for production and allows for an increased number of plants per cart for shipping.

Given cultivar specificity and variation, careful crop selection for vigorous and cold-tolerant cultivars may be of great importance for production under this heating regime. Overall, our data suggest that high-quality, compact petunias can be produced without delay at a greenhouse air temperature of 59F in combination with a RZH set point of 75 to 80F. GT

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