e-GRO Alert

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Will Greenhouse Crops Recover from Chilling or Freezing Injury?

With the recent polar vortex, some growers have seen symptoms of chilling and freezing injury on their greenhouse crops. Other growers are looking ahead to spring and are pondering the idea of finishing some of their crops outdoors to free up greenhouse space. In either of these situations, which crops can tolerate freezing or near freezing temperatures and what can a grower expect from a crop that has been injured from such temperatures?

Whether you are growing annual bedding plants in a greenhouse, high tunnel, cold frame, or outdoors, the potential for chilling and freezing injury exists. Which crops can survive freezing temperatures and how will this affect the crop?

Extreme temperature such as those that were experienced in many parts of the country during the recent polar vortex affected greenhouse crops due to either boiler and heater malfunctions or infiltration of cold air into the greenhouse. For more information on how to mitigate greenhouse heat loss, please refer to Preparing your Greenhouse for the next Cold Spell or Polar Vortex.

Figure 1. Initial wilting or curling of leaves in this sweet potato vine crop are symptoms of freezing injury (left). The desiccated and necrotic leaves are dead (right). Photo credit: Roberto Lopez

What is Freezing Injury?

Freezing injury is damage that occurs to plant tissues when temperatures are below 32 ºF (0 ºC). Pure water freezes at 32 ºF, however, water in plant tissue has dissolved salts (ex. plant sap), which freezes at temperatures a few degrees below 32 ºF. If water freezes in a plant cell, the sharp ice crystals can cut cell membranes, resulting in fluids leaking from the cell, leading to cell and plant death. Freezing injury symptoms include tissue browning, blackening, wilting or curling of leaves and stems. The sweet potato vine, osteospermum, and regal geranium in Figures 1, 2 and 3 are exhibiting symptoms of freezing injury. It is important to remember that younger plant tissue is more vulnerable to freezing than more mature tissue. In addition, plant tolerance to freezing temperatures increases as the plants are acclimated to cold temperatures. In other words, a plant grown in a warm (heated) greenhouse is more susceptible to freezing injury than one that has been in a cold frame, high tunnel, unheated structure or outdoors.

Figure 2. Young osteospermum crop exhibiting symptoms of freezing injury as tissue turns from brown to black. Photo credit: Roberto Lopez

Figure 3. This regal geranium crop was exposed to five nights at temperature below freezing. The plant did recover and was marketable. Photo credit: Madeline Olberg

What is Chilling Injury?

Chilling injury is a form of cold damage (with similar symptoms to freezing injury) that occurs to certain species when exposed to non-freezing temperatures. Chilling injury can occur at temperatures from 32 to 55 ºF (0 to 10 ºC). Plants from tropical origins are often chilling-sensitive, while most temperate zone species are not. For example, basil can show symptoms of chilling injury (Figure 4) when exposed to temperatures below 54 ºF (12 ºC) during production, transport, distribution, storage, and marketing in the retail environment. Therefore, 54 ºF is generally the recommended temperature

Figure 4. This basil crop was grown in a high tunnel were the temperature dropped below 45 ºF. Notice the multiple symptoms of chilling injury including bleached leaves and browning. Photo credit: Madeline Olberg

Figure 5. This poinsettia crop was exposed to temperatures of 40 ºF for several nights. The curled leaves are a result of chilling injury. Photo credit: Kristin Getter

Figure 6. This seed impatiens crop was grown at an average daily temperature of 50 ºF. Chilling injury symptoms progressed from yellowing (chlorosis) to blackening of leaves. Photo credit: Joshua Gerovac

for storage and shipment of most basil cultivars. For more information on chilling injury of basil, refer to Preventing Chilling Injury of Greenhouse and Vertical Farm Grown Basil. In Figures 4 and 5, we can see examples of chilling injury on basil and poinsettia that were exposed to a few hours of temperatures around 50 and 40 ºF (5.5 to 10 ºC), respectively. Notice how plant death did not occur in this case, but the necrotic, yellow, and curled leaves may make them unmarketable. The yellowing (chlorosis) that this seed impatiens crop is exhibiting is another symptoms of persistent chilling injury from being grown in a very cool greenhouse [50 ºF (10 ºC)] (Figure 6).

Crop Cold-tolerance

Temperature influences the rate of development and as a result of lower average daily air temperatures (ADT), flowering is often delayed when plants are grown at cooler temperatures. Over the years, research at Michigan State University has classified crops according to their base-temperature or temperature at which development stops. Can these classifications help determine if a crop will survive a cold temperature event? Tropical and subtropical crops such as ageratum, alternanthera, angelonia, basil, celosia, cleome, coleus, cosmos, lantana, pentas, poinsettia, portulaca, sweet potato vine, vinca, and zinnia are classified as cold-sensitive because their base temperature is 46 ºF or higher. Therefore, these crops will not likely survive if exposed to freezing or near freezing temperatures. Another group of greenhouse crops is classified as cold-intermediate (or cold-temperate) crops as their development stops at moderately low temperatures of 40 to 45 ºF. These crops include calendula, dahlia, geranium, impatiens, lobelia, some petunia cultivars, verbena and wax begonia. Lastly, crops with relatively low base temperature (39 ºF or lower) are classified as cold-tolerant and include dianthus, diascia, heliotrope, American and French marigold, nemesia, osteospermum, some petunia cultivars, snapdragon, stock, and viola.

No matter what the base temperature classification is for a crop, flowering time of all crops decreases as temperature increases.

Acclimating Plants

If you are going to finish some crops outdoors or in an unheated structure, choose from the cold-tolerant and potentially some from the cold-intermediate listed on page 3. Transplant the plugs or rooted cuttings in the greenhouse and grow under normal production protocols until the crop has a well-established root system before you begin acclimating them to cooler temperatures. During acclimatization, lower the greenhouse temperatures to 45 to 55 ºF (7 to 13 ºC) for about a week or more before moving the crop outdoors or into an unheated structure. Only move plants outdoor when the danger of a hard frost [≤28 ºF (-2 ºC)] is minimal in your area. If you have rolling benches, crops can be moved back in to the greenhouse when the potential of a hard frost exist. If you cannot move the crop inside a heated structure, pull a row cover such as reemay cloth over the plants.

Benefits and Risks of Outdoor Growing

Compared to greenhouse production, lower air temperatures, higher light levels, and increased air movement can be expected with outdoor production. Therefore, our group conducted a study to 1) compare the growth and development of 10 annual bedding crop species grown in an unheated high tunnel or unprotected outdoor growing area; 2) evaluate the effect of a one-week initial acclimation period in the high tunnel prior to outdoor production; and 3) quantify the effectiveness of these production methods for producing high-quality bedding plant crops.

Figure 7. Lobelia (top) and regal geranium (bottom) grown in a high tunnel (left), outdoors with a one-week acclimation period in a high-tunnel (center), or outdoors (right). Photo taken five weeks after transplant for lobelia and six weeks for regal geranium. Plants were exposed to 5 nights of temperatures below freezing with a low of 24 ºF. Photo credit: Madeline Olberg

This information gave us some insight into what crops can be produced outdoors and the effects on crop timing and growth; and demonstrates any benefits of an acclimation period prior to outdoor production. We also were able to quantify what would happen to a crop after exposure to freezing temperatures.

The cold-tolerant and -intermediate annual bedding crop species included ‘Aloha Kona Hot Pink’ calibrachoa, ‘Royal Lavender’ regal geranium, ‘Bella Oceano’ lobelia, ‘Antigua Orange’ African marigold, ‘Summertime Pink Charme’ osteospermum, ‘Potunia Plus Red’ petunia, ‘Phloxy Lady Purple’ phlox, ‘Lilac Flame’ primula, Hot Cakes White’ stock, and ‘Empress Purple’ verbena.

Outdoor air temperatures fell below freezing on five nights of our study in April 2015. The entire marigold crop (cold-sensitive species) grown outdoors exhibited symptoms of freezing injury and died after exposure to temperatures of 24 ºF (-4.2 ºC). The regal geranium crop, exhibited signs of chilling injury (Figure 3); and while they were able to recover, this caused a delay in time to flower of 26 days (Figure 7) compared to those grown in the high tunnel. As expected, all species flowered and became marketable sooner in the high tunnel than outdoors. This is likely due to the higher ADT in the high tunnel and thus more rapid development. Primula, calibrachoa, and verbena were delayed by only four to seven days outdoors compared to in the high tunnel; while, lobelia, phlox and petunia were delayed by nine to 11 days (Lobelia, Figure 7). Although, when given an acclimation period of one week in the high tunnel prior to outdoor production, all species, other than regal geranium were delayed by one week or less (two to seven days). Increased light levels outdoors, as well as increased mechanical stress from wind and precipitation, caused reduced stem length and growth for lobelia, osteospermum, stock, and verbena (Figure 7, 8, and 9).

Figure 8. Stock grown in a high tunnel (left), outdoors with a one-week acclimation period in a high-tunnel (center), or outdoors (right). Photo taken six weeks after transplant. Plants were exposed to 5 nights of temperatures below freezing with a low of 24 ºF. Photo credit: Madeline Olberg

Branch number was similar or greater outdoors compared to in the high tunnel for all species. Overall, more compact growth was observed in crops grown outdoors compared to in the high tunnel, though flowering was somewhat delayed for all species. Freezing injury in some instances resulted in a “hard pinch” for some species such as osteospermum (Figure 9).

Issues of crop loss, chilling or freezing injury, flowering delay and weed pressure were apparent in outdoor production, which could be of great concern to growers. Meanwhile, benefits of outdoor production include the low cost of production, compact growth (fewer or no PGRs), increased branching and flower number, and reduced insect pressure.

Figure 9. Osteospermum grown in a high tunnel (left), outdoors with a one-week acclimation period in a high-tunnel (center), or outdoors (right). Photo taken seven weeks after transplant. Plants were exposed to 5 nights of temperatures below freezing with a low of 24 ºF. Photo credit: Madeline Olberg

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