Protecting Fraser Fir Seedlings and Transplants from Cold Injury

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The 2002 Freeze, Remembered

The memory of the May 2002 freeze is still painful for many seedling and transplant growers in the mountains of North Carolina. Many lost their seedling crop. Others delayed the harvest of seedlings or transplants for a year or more as they worked to rehabilitate damaged plants. Living in North Carolina, we all know freezes occur and each seedling and transplant grower needs to be prepared to do what they can. A few nursery growers were able to come through the 2002 spring freeze with minimal damage. In some cases, their sites provided for exceptional air drainage allowing temperatures to stay a few degrees warmer. In other cases, the growers applied effective cold protection practices. Irrigation was the most common cold protection practice used, but irrigation only works when certain rules are followed and several growers found that it can fail miserably when they are not. A few growers experimented with freeze protection blankets with mixed results. These practices can make a difference, but only if used properly and only if it doesn't get too cold.

Understanding the Mechanism of Frosts and Freezes

Frosts and freezes can vary tremendously making results obtained from protective measures variable. Duration of cold temperatures, cloud cover, humidity, wind speed, and the extent of low temperature all influence the course of a freeze incident. Heat loss can occur by either convection to surrounding air or radiation to other objects or space. Heat loss by convection comes into play when fronts of cold air move through a region whereas radiation occurs on still clear nights. Frosts occur when air is moisture laden. Freezes occur when ice crystals form in plant tissue with or without a frost.

Frosts are primarily associated with still conditions, radiant heat loss, temperature inversions, and the rapid cooling of warm, moisture-laden air. Frosts occur on clear, still nights when air layers are not mixed by wind and few clouds are present to radiate heat back to the earth. Cooling evening air will not hold as much moisture as it did during the day. Moisture condenses as dew on colder surfaces such as plant leaves that are losing heat by radiation. The dew freezes and forms frost when the surface temperature drops to the freezing point. Plants close to the ground may sustain freeze injury even though the air temperature around the plants is above the freezing point. These "temperature inversions" form a layer of cold air from a few feet to as much as a hundred feet thick.

Many frosts yield little plant damage, because ambient temperatures are still above freezing. The humidity that forms the frost also slows the chilling process and buffers plants against wind desiccation. When frosts are followed by a windy cold front, greater damage can be expected because both radiant and convection heat loss occurs. Convection heat loss increases in windy conditions when greater masses of cold air are moved across a surface.

Freezes occur when cellular water in plant tissue freezes. This can occur with or without the moisture needed to induce a frost. Freezes often occur without frost when the mass of air is already too cold to hold moisture. Thus "black freezes" with no frost are often associated with dry and windy cold fronts. Severe plant injury often occurs under such conditions. If the front remains for more than a few hours, it can deplete reserves of stored heat and overwhelm many freeze protection strategies.

Planning Your Cold Protection Strategy

There are a wide number of cold treatment strategies, but few are universally effective. Certain approaches such as fans, heaters, foggers, or helicopters used by fruit and vegetable growers only work when there is a temperature inversion. Irrigation and row cover blankets can work under a broader set of conditions including cold fronts, but only for a range of temperatures and wind speeds. Severe low temperatures or an extended freeze will overwhelm even the best designed system. Thus, even in the planning stage, it is important to understand the limitations of each strategy. Possible strategies that work for both frosts and freezes include cold frames or poly houses, irrigation, row cover blankets, and experimentally, irrigated and iced shade cloth.

Many ornamental nurseries use irrigated white poly-covered cold frames as a system for protecting both bare root liners and containerized plants. Cold frames trap in heat and moisture and block the wind. Cold frames are very effective but can require daily management to water plants and open and close the ends of the frame for ventilation and temperature control. Cold frames are a fundamentally different production system from raised beds and can unintentionally influence winter hardiness and time of bud break. Cold frames are the winter protection of choice for container grown seedlings but a last resort for bare root plants.

Irrigation is a time-tested strategy that will protect plants if it is properly managed. Irrigation must be started before temperatures at the plant drop to freezing and be kept on until the ice that forms melts off the plant. If fresh water is not added continuously to the iced plants, their temperature will drop from the freezing point, 32 degrees Fahrenheit, to the actual temperature below freezing. Thus, irrigation only works as long as you can keep the sprinklers working. For irrigation to work during an extended freeze, an ample water supply is critical.

Joe Shoupe, Nursery Superintendent at the NC Division of Forest Resources, Edwards Nursery, reported that their alarms go off at the nursery when temperatures drop to 38 degrees. The person on duty watches for frost formation and a further drop in temperature. They begin irrigating when frost begins to form or when temperatures reach 32 degrees. They keep watering until all ice melts off the seedlings the following morning. Joe said they can keep the sprinklers working as long as temperatures are 22 degrees or above. Below that, sprinklers freeze up faster than staff can make the rounds. The nursery uses 5/32 sprinkler heads, but just for freeze protection, a larger spray nozzle would work better.

Row cover blankets have also been used with some success. For ornamental nurseries, spun-bonded polypropylene at 4 oz. per square yard is recommended. Blankets insulate the beds keeping heat and humidity in and protecting plants from wind. However, blankets do have limitations. Once stored heat is depleted, the temperatures under blankets will drop to ambient temperature. Any plant parts that touch the blanket will freeze, so some structure is needed to keep it off the plants. Nurseries have put the 4 oz material over shade cloth supported by frames.

NC Forest Service personnel at Edwards Nursery have tested row cover blankets as well as using irrigation. During the 2002 freeze, about 1/4 acre was covered in 3.5 oz polypropylene. Until the end of February, trial beds were covered with straw and row covers to minimize frost heaving. Beds were uncovered in March to remove the straw and covered back before bud break with shade cloth. During bud break, the blankets were only put on when the threat of frost existed.
The spun-bonded polypropylene blankets tested at Edwards Nursery worked well where there were no holes. Temperatures were maintained about 8 degrees higher under the blankets than outside. Where holes were worn in the row cover, enough cold was allowed under the blankets for the entire bed to be damaged. Joe Shoupe reported going to some length to smooth any rough edges on their row cover frames to protect the blankets. The row cover blankets would work where water was limited.

Some ornamental nurseries have protected beds by making an ice blanket, which apparently, works much like a poly blanket. Growers have irrigated existing shade cloth bed covers until they are sealed with an ice cover. These blankets would need to extend all the way to the ground on all sides and the ends. The shade cloth needs to have weathered several weeks for water to stick to freeze on it. Percent shade and water droplet size also have some effect on how well ice forms on the cloth. An ice blanket would avoid the expense of purchasing polypropylene row covers and would only require enough irrigation to ice the beds. This technique has not been tested on Fraser fir.

Conclusions

If you are growing seedlings or transplants in the mountains, frost and freeze is a common threat if not an annual problem. Effective strategies do exist that can minimize the injury that occurs during moderate freezes down to temperatures in the low 20's. Irrigation and row cover blankets will work if carefully managed. Any strategy must be in place well in advance of bud break. You may have little control of the weather, but you do have control of frost and freeze protection at your nursery.