

2005 Frost Protection Research Results

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In the spring of 2004, *Limbs & Needles* published my article on frost protection practices that are available to nurserymen to protect seedlings and transplants. In the article, I reviewed current frost irrigation practices, the use of frost protection blankets, and specific frost protection practices used on Fraser fir seedlings at the Division of Forest Resources Nursery in Crossnore, NC.

In this follow-up article, I will present the results from frost protection research conducted in the spring of 2005 with the help of Jeff Vance, Della Riley, and Bryan Davis. This data was presented at the 2005 NCCTA summer meeting farm tour. Both the successes and failures associated with this work have practical implications for effective frost protection in the nursery.

The 2005 research was conducted at three nurseries. Wayne Ayers (Mitchell County), Steve Stanley (Watauga County), and Glenn Sullivan (Ashe County) were each kind enough to provide beds of transplants for the study. The three study sites were established during the first and second weeks of April. Temperatures were monitored at five-minute intervals from April 7 until May 5, 2005 using Hobo field data recorders. Daily minimum temperatures were compared among treatments for the frost events that occurred on April 16, 17, and 24 and on May 3, 2005.

All four frosts monitored in 2005 were radiational frosts that occurred in conjunction with a temperature inversion. There was little or no wind and clear skies each night. The frosts were of fairly short duration with temperatures dropping below freezing around midnight and warming after sunrise. The coldest temperature layers during an inversion were close to the ground as heat was radiated away from soil and plant surfaces into the atmosphere (see Figure 1). For example, the minimum air temperature measured at waist height at the Ayers nursery on April 24 was 29 degrees, but the minimum temperature recorded at the level of the seedlings was 23 degrees.



Figure 2. Nursery bed treatments from left to right: Shade cloth ice blankets, 1.5 oz. Poly-spun fabric, Tufbell row cover fabric, and an uncovered check.

The study involved four treatments covering 50 feet of nursery bed that were repeated in irrigated and non-irrigated zones. The four treatments included a check, a white 1.5 ounce poly-spun frost blanket, a black 50% shade cloth, and Tufbell, a clear reflective mesh row cover (see Figure 2). The white poly-spun blanket was intended to be a dry frost blanket treatment, but the shade cloth and Tufbell products were both selected as foundations over which irrigation water would form an ice blanket. At each nursery, irrigated and non-irrigated zones were situated close enough to compare the same seedling source, but far enough for the irrigation to not influence the dry treatments.

The treatments in this study represented different types of frost protection. Conventional irrigation warms plant material with the heat released during ice formation and works only as long as additional water is applied to the ice. Frost blankets, on the other hand, provide a physical barrier to radiational heat loss. Theoretically, ice blankets trap radiant heat just like the poly-spun blankets once ice seals the mesh surface. Once the ice blanket is formed, irrigation is discontinued. With conventional irrigation, application must continue until temperatures warm above freezing.

The three materials were stretched over PVC hoops and secured using six-inch landscape staples. The hoops were tall enough to minimize direct contact of the blankets with foliage and the risk of frost injury. The PVC hoops were

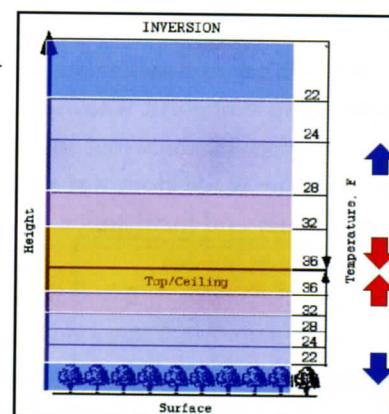


Figure 1. Temperature inversion with a layer of warmer air above the coldest air on the ground and plant surfaces.

anchored with 20 inch pieces of rebar. A single wire was used to stabilize the hoops and reduce sagging between hoops. We tried to close any gaps between fabric and soil to minimize heat loss during a frost. In the same way, any tears in the fabric were patched since even small holes result in significant heat loss during a frost event.

Frame construction is visible in Figure 3.



Figure 3. Close-up of frame construction: 1/2 inch PVC hoop, stabilizing wire, stake, and stapled fabric.

Irrigation was used intermittently at the three sites for the different frost events. Problems occurred with irrigation pumps and with the data recorder at one site and with set-up at another site. The only irrigation data available was from the Stanley site on April 16, shown

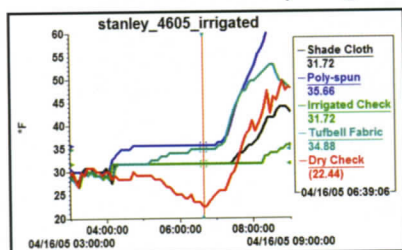


Figure 4. Irrigated treatment versus the dry check treatment at the Stanley site on April 16.

in Figure 4. All four irrigated plots exhibited a rapid increase in temperature after the irrigation was turned on, rising from 28° to just under 32° in less than 10 minutes. The dry check (shown in red) continued to drop in temperature reaching a minimum of 22° F. Irrigation alone maintained seedling temperatures ten degrees higher than no irrigation. As ice blankets formed on the fabrics, temperatures increased to almost 35° F under Tufbell and almost 36° F under the poly-spun fabric. These temperatures represent 12° and 13° increases over the dry check and 3° and 4° increases over the irrigated check. Temperatures under shade cloth did not increase above 32° F until after sunrise and only slightly ahead of the dry check plot.

When an ice blanket was formed on the open mesh Tufbell fabric, the heat gain was as good as that observed on the tight poly-spun fabric. The failure of the black shade cloth to form an ice blanket or increase temperature may have had more to do with the weave of the material than anything else. Tufbell was a very fine woven mesh on which water beaded, whereas the shade cloth was a coarse, flat weave that did not hold water as well. A heavier, knitted shade cloth might hold water better and form an ice blanket more readily than the material used for this study.

Treatment differences were also observed among dry treatments. Figure 5 shows average minimum temperatures for dry treatments at all three nurseries for the April 16 frost event. Similar patterns were observed for the other frost events



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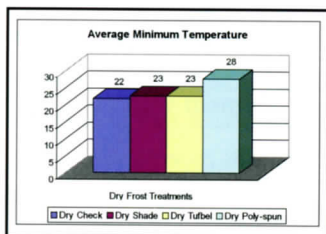


Figure 5. Average minimum temperatures on April 16 across three nurseries.

where frost blankets were closed up before the cold. Temperatures under the poly-spun fabric were an average of 6 degrees higher than the check plots. At one nursery, there was a nine-degree increase. Without irrigation to form ice, neither the Tufbell or shade cloth significantly altered temperature.

While the dry poly-spun fabric did not raise the temperature above freezing, temperatures moved from the level at which serious damage would occur to one at which little or no damage might be expected.

Higher temperatures are desirable during a frost event, but they can be devastating during sunny spring days. Figure 6 shows the maximum daytime temperatures observed in the seedling canopy on April 11 averaged across the three sites. Only the four cover types are shown since irrigation was not applied on a daily basis. The highest temperature, 121° F, was measured under the poly-spun fabric.

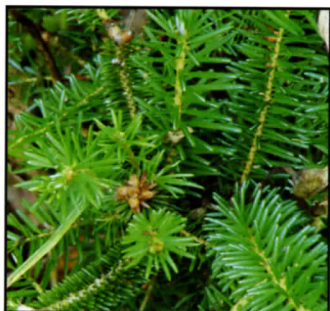


Figure 7. Terminal dieback resulting from excessive heat under poly-spun fabric.

Terminal dieback was observed early in the course of this study at two of the three nursery sites primarily under poly-spun fabric treatments. Injury symptoms are shown in Figure 7. The percent of seedlings injured by heat at each nursery is displayed in Figure 8. Damage occurred at the two nurseries where the ends of the poly-spun row covers were initially kept closed. Little damage occurred at the third site where the ends were kept open until there was a threat of frost. Damage occurred under the irrigated poly-spun cover at one site, but under the dry poly-spun cover at the other site. Seedling injury was probably a function of how tight the cover was closed during the day, not the presence or absence of irrigation during a frost.

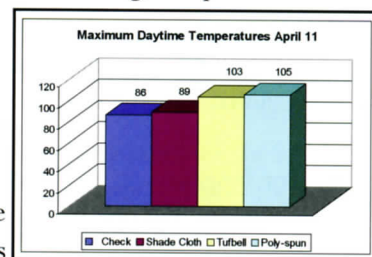


Figure 6. Maximum daytime temperatures on April 11 across three nurseries

In springtime applications, the poly-spun row covers should be open-ended or be pulled off the beds except for the afternoon before a frost or freeze is predicted. Management made a difference in the amount of injury. The ice blanket treatments did not incur the damage observed with the under-managed poly-spun fabric. The open weave may have allowed enough air movement to avoid damaging temperature spikes. As a result the ice blankets would involve a labor trade-off of less daily management but would require irrigation at the onset of freezing temperatures for every frost and freeze.

The measured frosts in 2005 were of short duration and fairly mild. Where extended cold fronts with freezing temperatures and winds occur, these strategies may not last long enough. Irrigation nozzles can freeze at lower temperatures or over time. Frost blankets only work as long as the earth under the cold frame is warm enough to heat the plants and air trapped inside.

Yet in May when tender growth is out, night-time frosts and freezes associated with inversions are the norm. Usually, days will warm above freezing. For a majority of after-bud-break freezes, these treatments could make the difference between widespread injury and little or no damage.

Cost of the different materials is an important consideration. For a complete accounting, the cost of irrigation and row cover construction should be considered. However, if one assumes that irrigation is a necessary cost of growing seedlings, the simple comparison between treatments is the cost of the different fabrics. The 1.5 oz. Poly-spun fabric (Remay or Agrifabric) costs between 4 and 5 cents per square foot or \$40 per 100 foot bed. The 47% woven shade cloth used in this study cost 12.5 cents per square foot or \$100 per 100 foot bed. The Tufbell fabric cost about 31 cents per square foot or \$248 for an equivalent sized bed. None of the materials were in good enough shape to effectively use a second year. One could spend several hours opening and closing the ends of beds before and after a frost to save the \$210 additional cost of Tufbell over the poly-spun material. We knew it was expensive when we included it in the study, but it

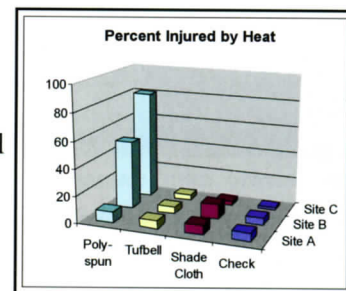


Figure 8. Percent of transplants injured by excessive heat by treatment and nursery site.

offered new technology, was worth a try, and did work without injuring seedlings.

As you consider the type of frost protection to rely on next year, weigh the strengths of the treatment with your resources and comfort as a risk-taker:

- Do you have an adequate temperature monitoring system to turn irrigation on soon enough? Do you know when your seedling beds approach 32 degrees F, or do you rely on the TV weatherman or Ray's Weather predictions of regional freezing temperatures?
- For irrigation to be effective, it must be turned on before temperatures drop below freezing and be kept on until the ice melts. Do you have enough water to maintain coverage all night, several nights in a row?
- Is Phytophthora root rot a real concern in your nursery beds such that additional water from irrigation in late spring is problematic?
- Do you have the time, labor, and ability to be on-site frequently enough to open and close poly-spun fabric covers daily?
- Are you willing to risk a relatively new and risky treatment such as ice blankets?
Can you afford to grow seedlings or transplants without some form of frost protection?



Part 2: Troubles with Twig Aphids

Precision Twig Aphid Control

By Jill R. Sidebottom and Doug Hundley

In the first article on the 2005 balsam twig aphid control season, Doug Hundley and I discussed causes for the severe twig aphid damage experienced by many growers this past spring. The cool spring weather slowed bud break and shoot elongation, allowing the new growth to be vulnerable to aphid feeding longer. Twig aphid treatments that would have usually been judged as successful ended up failing. Unfortunately this year many growers were experimenting with new methods of controlling twig aphids.

So what are the best ways to control twig aphids? In this article, Doug and I will be reviewing the three main methods of twig aphid control— spraying with a high-pressure sprayer, spraying with a mistblower, and using granular Di-Syston. In the year 2000 according to the 2001 Pest Management Survey, 16% of growers reported controlling twig aphids with a high-pressure sprayer, 8% with a mistblower, and 67% with Di-Syston.

No matter what method of control you are using, you should check for rust mites and spider mites before treating. That might change the materials you use. Also, if there are a lot of cones in the trees, remove them before treatment. Twig aphids hide in cones and are shielded from pesticide applications.

High-pressure sprayers. As we stated last time, spraying with a high-pressure sprayer is the surest way to guarantee twig aphid control. It is also the most labor intensive and therefore costly. If you need to treat for balsam woolly adelgid also, then using the high-pressure sprayer is truly justified. Wait until March or early April and you will control both adelgids and aphids. Remember, if you are looking at treating for both twig aphids and woollies using the synthetic pyrethroids Asana, Astro and Talstar, that is a good choice as they are effective, BUT they may also create problems with hemlock rust mites the following spring. A treatment with Thionex controls both pests and has lead to far fewer problems with rust mites. This is however, a more toxic product and should be used with care. Remember you cannot apply Thionex within 300 feet of water.