Dicloran Fungicide Causes Stem Injury to Container Spruce Seedlings

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Postsowing applications of the fungicide dicloran (Botran ®) caused stem injury to young blue spruce (Picea pungens Engelm.) seedlings in a Colorado forest nursery greenhouse. Initial symptoms for some of the affected seedlings included stunting, stem swelling, and twisting. Seedlings without conspicuous symptoms appeared to develop normally until later in the growing season, when they fell over or they became brittle and broke when handled during packing and shipping. Tree Planters' Notes 41(1):39-42; 1990.

The Colorado State Forest Service Nursery in Ft. Collins, CO, has grown conifer seedlings in its greenhouses for over 25 years. The nursery produces a wide variety of conifer seedlings in containers, but Colorado blue spruce (*Picea pungens* Engelm.) has continued to be in great demand. Two crops of 1 + 0 container seedlings are produced annually, but spruces are normally grown in the spring crop. Colorado blue spruce is sown in the spring, grows in the greenhouse through the summer, and then is hardened off and over-wintered in shadehouses for sale the following spring.

In the spring of 1985, nursery employees began to notice stunting and abnormal shoot twisting (fig. 1) of blue spruce seedlings a few weeks after the seedlings had begun shoot extension. The affected seedlings failed to develop normally and were soon overtopped by adjacent seedlings. Later in the growing season, other seedlings developed a stem swelling in the area of the hypocotyl above the cotyledon scar (fig. 2); others appeared to develop normal shoots but later fell over.

A closer examination of the lower stem of these seedlings revealed a swollen area in the same region of the stem; the part of the stem below the swelling was very constricted, however, creating a mechanical weakness (fig. 3). Apparently, this physically weakened lower stem was unable to support the heavier shoot, causing the seedling to fall over (fig. 4), or the stem would break at the constriction when the seedling was handled during grading and sorting. By the end of the 1985 growing season, 27% of the blue spruce crop had been damaged and had to be culled.

Figure 1—*Stunting and abnormal shoot twisting of blue spruce seedlings soon after shoot extension has begun.*

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After reviewing the cultural records for the damaged crop and considering the type and development of the stem injury symptoms, two different hypotheses were developed to account for the problem: the growing media could have been contaminated with some phytotoxic chemical, or the seedlings could have been damaged by fungicides applied to control damping-off.

Two different fungicides had been applied to the young spruce crop as postsowing treatments: captan (Captan®) and dicloran (Botran®). Although not specifically registered for control of damping-off, dicloran was applied in rotation with captan in an attempt to provide better fungal control.

Materials and Methods

In the fall of 1985, an operational experiment was designed to try to recreate the conditions that led to the stem swellings. A group of blue spruce seedlings were grown in Colorado Styroblocks, which are Styrofoam block containers composed of 30 individual cells about 492 cm^3 (30 cubic inches) in capacity. The containers were filled with W.R. Grace Forestry Mix, an artificial growing medium composed of 50% peat moss and 50% vermiculite. One Styrofoam block, containing 30 blue spruce seedlings, was sown for each of the five treatments. To facilitate the observation of symptom

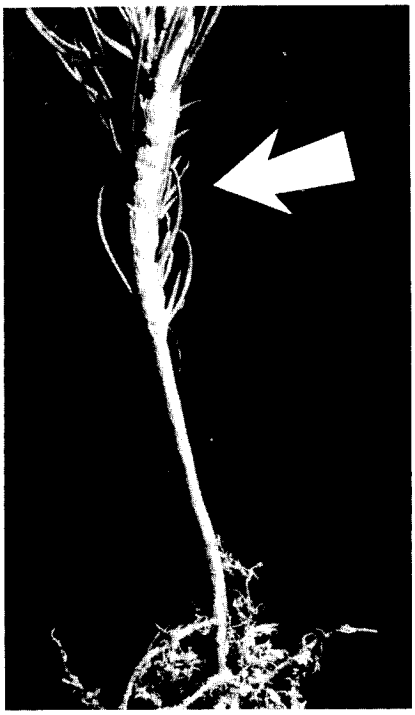

Figure 2—*Stem swelling in the hypocotyl above the cotyledon scar in blue spruce seedlings later in the growing season.*

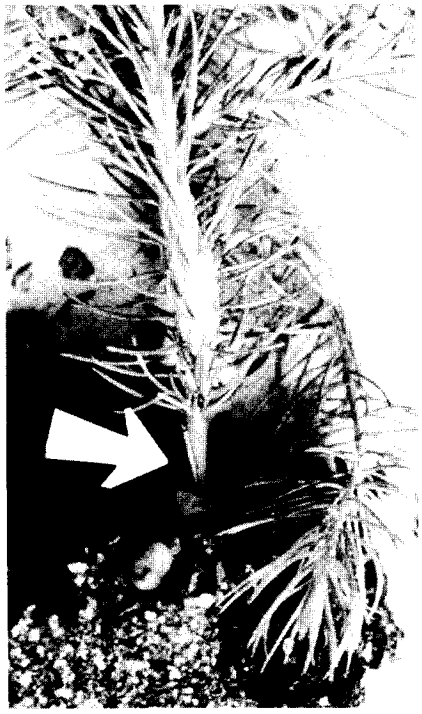

Figure 3—*Blue spruce seedling later in the growing season, showing constriction of the lower stem, which leads to mechanical weakness.*

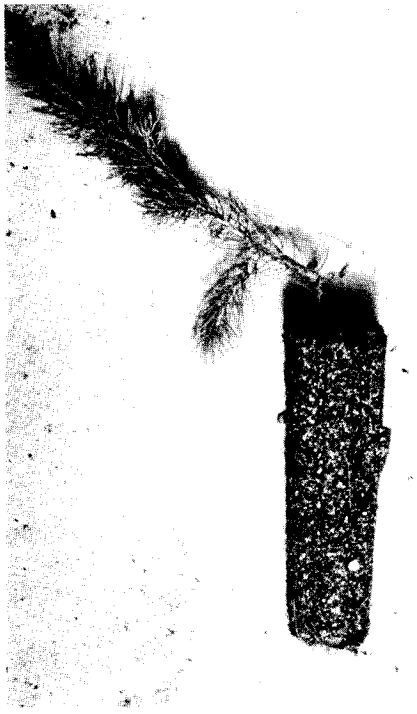

Figure 4—*Blue spruce seedling extracted from its container, with broken stem just below the area of stem swelling.*

development, a range of different sizes and ages was generated by a staggered sowing schedule: 6 different sequential sowing dates at 2-day intervals. This experimental design produced 180 seedlings per treatment (6 blocks of 30 seedlings each), or 900 seedlings for all 5 treatments.

Treatment 1 (control). The blue spruce seedlings were sown normally and grown under standard nursery procedures, but no fungicide was applied.

Treatment 2 (heat pasteurization of the growing medium). The growing medium was heated to 82 °C (180 °F) to volatilize any chemical contamination, and then the seedlings were grown under standard growing procedures with no fungicide applications.

Treatment 3 (captan fungicide). The seedlings were grown normally but were treated with a single application of captan 10 days after the last sowing. The fungicide was applied by portable sprayer at the rate of 1 pound of product per 3,000 square feet of seedlings.

Treatment 4 (dicloran fungicide). The seedlings were grown normally but were treated with a single application of dicloran fungicide 10 days after the last sowing, at the rate of 1 pound of product per 3,000 square feet of seedlings.

Table 1—*Time sequence of stem injury symptom development on blue spruce seedlings in a Colorado container tree nursery*

Observation date (time after sowing)	Symptomatic seedlings/treatment (cumulative %)				
	Control	Heat	Captan	Dicloran	Captan/ dicloran
24 days	0	0	0	0.0	0.0
32 days	0	0	0	14.4	0.0
39 days	0	0	0	24.4	6.1
46 days	0	0	0	27.2	17.8
53 days	0	0	0	31.7	28.3
60 days	0	0	0	33.8	30.0

Treatment 5 (captan and dicloran fungicide). The seedlings were grown normally and both captan and dicloran were applied at the rates stated above. Captan was applied 10 days after the last sowing, and dicloran 17 days after sowing.

Beginning at about 3'/$_2$ weeks after the last sowing, the test seedlings were examined for both damping-off and stem symptom development at approximately weekly intervals. The seedlings were rated as either injured or healthy, and these ratings were recorded for a period of 60 days.

Results and Discussion

The weekly examinations revealed no damping-off, but blue spruce seedlings exhibiting the characteristic stem injury symptoms were first observed in the dicloran treatment about 2 weeks after the fungicide applications (about 1 month after sowing, table 1). Symptomatic seedlings were scattered randomly throughout the Styrofoam blocks, with damaged seedlings recorded in 14.4% of the individual cells.

One week later, during the second examination, symptomatic seedlings had increased to 24.4% of the cells in the dicloran treatment, but were also apparent in 6.1% of the captan/ dicloran treatment (table 1). The number of symptomatic seedlings gradually increased in both the dicloran and captan/dicloran treatments, until around 30 to 34% of the spruce seedlings were affected at 2 months after sowing. None of the seedlings in the control, heat, or captan treatments displayed any damage during the 60-day examination period (table 1).

This operational trial indicates that the dicloran fungicide treatment was phytotoxic to the young blue spruce seedlings when applied after sowing. Dic-

loran is normally used to control grey mold on older seedlings, so this postsowing application does not represent a normal, recommended type of application. Although dicloran injury is not documented in the published literature, this fungicide caused a similar type of stem swelling injury to spruce and hemlock seedlings in another container nursery in Washington.

Although captan apparently did not damage the seedlings in this trial, there have been several reported cases of captan damage in the literature. Captan was found to cause stunting of both roots and shoots of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) seedlings (2). A more recent *in* vitro study reports that captan levels above 500 ppm caused root and shoot stunting of red pine *(Pinus resinosa* Ait.) seedlings, with root injury being the most serious result (3). Carlson and Nairn (1) reported stunting and hypocotyl curling of both red pine and jack pine (*Pinus banksiana* Lamb.) container seedlings. It is unclear why captan was not harmful in these trials.

The fact that the seedlings were injured in the hypocotyl area of the stem may reflect the sensitivity of the young stem before the development of bark tissue. The exact reason for this stem swelling is unknown, but this type of symptom is often the result of girdling. When the photosynthate produced by the shoot is not translocated efficiently down the stem, a swelling develops immediately above the constriction. The stem below the girdle does not develop normally because the cells of the lateral meristem fail to divide at a normal rate. In this case the fungicide apparently damaged sensitive young stem tissues and either killed or damaged the cells of the phloem and lateral meristem, producing a partial girdle of the stem.

Conclusions and Recommendations

The fungicide dicloran can cause stem injury to blue spruce seedlings when applied as a postsowing treatment. Apparently the fungicide damages the meristematic tissue in the hypocotyl area, around the region of the cotyledon scar. A stem swelling develops above the damaged area, creating a mechanically weak area and causing seedlings to fall over or break during handling.

The seedling injury noted in this experiment reinforces a couple of standard rules for applying chemical pesticides. Fungicides or other pesticides should only be used for control of pests listed on the label, and any chemical should first be attempted on a small scale before operational use is considered.

Literature Cited

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