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Comparison of Disease Management Strategies for Control of Soil-Borne Pathogens in a Forest Tree Nursery

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In a Wisconsin forest tree nursery, pre-emergence mortality of white spruce (Picea glauca (Moench) Voss) was greatest in nontreated plots and least in plots treated with dazomet. Nontreated plots had the most postemergence damping off, and plots treated with silica sand had the least. Seedling mortality was greatest during the first growing season (28% in dazomet-treated plots, 61% in nontreated plots). However, seedling losses were less than 8% in all treatments during the second and third growing seasons. After the first growing season, the incidence of stunting was greatest in plots treated with dazomet and least in plots where seeds were covered with sand. Most of the stunted seedlings recovered during the second and third years of growth. At the end of both the first and third growing seasons, plots treated with dazomet had significantly more seedlings than any other treatment. At the end of the rotation, all treatments had similar numbers of cull seedlings. Tree Planters' Notes 41(1) :29-33; 1990.

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White spruce (*Picea glauca* (Moench) Voss) is an important tree species in Minnesota, Wisconsin, and Michigan forest tree nurseries and accounts for 15% of bareroot seedling production. During the 3-year rotation, production of white spruce seedlings is often reduced due to pre-emergence and postemergence damping-off (1) and root rot caused by *Cylindrocladium* spp. (6).

In the Lake States, nurseries routinely fumigate with methyl bromide or dazomet to reduce populations of soil-borne fungi. However, fumigation also reduces populations of beneficial soil organisms such as mycorrhizal fungi (10). Reduced or delayed mycorrhizal formation may result in stunted, nutrient-deficient seedlings and eventual seedling mortality (3, 7). Roots of stunted white spruce may become mycorrhizal in subsequent years but still do not attain the size of nonstunted white spruce and may be culled (2). Thus, some of the benefits of disease control from soil fumigation may be lost due to detrimental effects on mycorrhizal development.

Alternatives to fumigation, such as chemical seed treatments (5), fungicide drenches (8), and soil solarization (4) have been tested, but have not proved as effective as fumigation. These practices may, however, produce satisfactory disease control while minimizing losses from stunted seedlings.

In this study, we evaluated the relative effectiveness of several disease management strategies-fumigation, seed treatment, soil drenches, and cultural treatment-on growth, incidence of stunting, and survival of white spruce seedlings during a 3-year rotation.

Methods

The experiment was conducted at the Hayward State Nursery, located in Hayward, WI. In early May 1985, the experimental area was sown with a cover crop of buckwheat (*Fagopyrum esculentum* Moench) that was turned under in early July. And in August both peat (800 pounds per acre) and fertilizer (10:20:10, 250 pounds per acre) were incorporated into the soil.

Four chemical treatments were applied to 4 x 40 ft plots:

1. Dazomet, a fumigant, applied at a rate of 125 pounds active ingredient (ai) per acre as a top dressing on August 1, 1985, and then worked into the soil to a depth of 12 inches. The soil was packed with a roller and irrigated with 1 inch of water.

2. Thiram applied as a seed coat with 1.5 ounces ai and 16 ounces of spreader-sticker per pound of white spruce seed.

3. Captan applied as a soil drench at a rate of 5 pounds ai per acre on April 11, 1986, after the soil was free of frost.

4. Captan applied as a soil drench on plots that had been sown with thiram-treated seed.

Nontreated plots served as controls. A completely randomized experimental design was used with three replications of each treatment.

On October 12, 1985, two 4-by 500-foot seed beds were formed, lined with bedboards, and all the plots were sown with seed. The cultural treatment, of No. 40 washed silica sand, was placed directly over hand-sown seed in 2- by 0.5-inch furrows. After the seeds were covered with sand, the plots were packed with a roller to simulate machine sowing. The remaining plots, which had been chemically treated, were then mechanically sown with white spruce seed at a rate of 0.24 ounce per 10.7 square feet. After sowing, seed beds were covered with 50% polypropylene shade cloth and left until spring. Prior to germination, five 4-foot-square randomly located permanent assessment subplots were established in each treated plot to evaluate: pre-emergence mortality, postemergence damping off, incidence of stunting, and seedling stand densities. For convenience, results are presented as seedlings per square foot.

Throughout the experimental period, standard nursery practices were used to maintain seedling growth. This included overhead irrigation applied every other day at the rate of 0.5 inch per day when normal precipitation was inadequate. An N/P/K fertilizer was applied 3 to 4 times per year at 200 to 400 pounds per acre, depending upon soil fertility requirements within the plots.

With each ounce of white spruce seed containing 791 seeds (190 seeds per square foot), and a germination rate of 85%, 161 seedlings were expected to emerge per square foot. Differences between the expected number of seedlings and the actual number of seedlings that emerged were attributed to pre-emergence mortality. Seedlings that had rapidly decaying stems or water-soaked lesions near the ground line were classified as having postemergence damping-off.

During the first growing season seedling stand densities were evaluated on May 18, June 18, July 22, and September 23, 1986, by counting all the living white spruce seedlings within the assessment subplots. The incidence of stunting was determined on September 23, 1986 by counting seedlings that had purple foliage and small stature (2).

First-year seedling yields were calculated by subtracting the number of stunted seedlings in each subplot from the total number of seedlings per subplot. At the end of the third growing season, on September 28, 1988, all seedlings within the assessment subplots were removed from the soil and counted, and their heights were measured to the nearest inch. Final yield of third-year seedlings per treatment was determined by subtracting the number of cull seedlings from the total number of seedlings. Cull seedlings were all seedlings less than 4 inches or greater than 18 inches in height.

Data were analyzed by an analysis of variance. Differences among means were determined with the Student-Newman-Keuls' test. Data presented as percentages are arcsine transformation of means.

Results and Discussion

No single management strategy was found to minimize stunting and provide satisfactory disease control in the first year. Pre-emergence mortality was greatest in nontreated plots (86 seeds per square foot) and least in dazomet-treated plots (72 seeds per square foot) (table 1). Although pre-emergence mortality was lower with dazomet than with captan, thiram, or the captan-thiram treatments, differences among chemical treatments were not significant (table 1). Nontreated plots had significantly more postemergence damping-off (10 seedlings per square foot), whereas plots with silica sand had the least amount of postemergence damping-off (2 seedlings per square foot) when compared with fungicide treatments.

Stand densities of 1 + 0 seedlings were lowest when seeds were covered with silica sand or planted in nontreated soils. Poor initial stand densities in the silica sand plots were due to sand erosion that left seeds exposed on the soil surface rather than to disease. Silica sand may have benefits other than reducing disease. Tinus (9) found that covering seed of ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) with sand instead of soil increased seedling size and stand densities. He attributed this improvement to reduced soil crusting and better water percolation. Germination might have been higher in the silicia sand treatment if the seeds had been sown with a machine drill rather than by hand.

Seedling stand densities declined throughout the first growing season regardless of treatment, with mortality ranging from 28% in the dazomet treatment to 61% in nontreated plots (fig. 1). By the end of the first growing season (September 1986), plots treated with dazomet had significantly higher 1 +0 seedling stand densities than any other treatment group (fig. 1), but almost half the seedlings were stunted (table 1).

Captan, thiram, and the combined captan-thiram treatments produced lower stand densities than dazomet and had almost as many stunted seedlings as the dazomet treatment. In contrast, while producing fewer seedlings, plots treated with silica sand had only 19% stunted seedlings (table 1). However, at the end of the first growing season, plots treated with dazomet, thiram, silica sand, or nontreated plots had similar numbers of healthy, non-stunted seedlings (table 1).

Stunted seedlings survived the rotation, and most eventually attained the height of non-stunted seedlings. These results do not support those of Croghan and LaMadeleine (2), who found that stunted white spruce in a northern Minnesota nursery survived the rotation but never recovered in height and thus were culled because they did

Table 1—*Response of white spruce to disease management strategies at Hayward State Nursery, Grant County, WI, in 1986 (first-year) seedlings and 1988 (second-year) seedlings*

					First year (1 + 0)				Third year (3 + 0)			
	Pre-emergence mortality		Post-emergence damping-off		Stand densities*	Stunted seedlings		Non-stunted seedlings	Stand densities*	Cull seedlings		Acceptable seedlings†
Treatment	No./ft²	(%)	No./ft²	(%)	No./ft²	No./ft²	(%)	No./ft²	No./ft²	No./ft²	(%)	No./ft²
Dazomet	72 a	46	4 ab	4	61 a	30 a	49 a	31 ab	57 a	5 a	8 a	52 a
Captan	80 abc	52	5 ab	8	46 bc	20 b	43 ab	26 b	44 b	5 a	12 a	39 b
Thiram	76 ab	49	8 c	10	47 b	17 b	32 abc	31 ab	43 bc	5 a	11 a	38 bc
Captan/Thiram	82 abc	53	6 a	8	45 bc	20 b	42 abc	25 b	43 bc	6 a	13 a	38 bc
Silica sand	83 bc	54	2 a	3	48 b	9 c	19 d	39 a	48 b	7 a	15 a	41 b
Nontreated	86 c	56	10 d	15	36 c	8 c	26 cd	28 b	36 c	4 a	11 a	32 c

*Stand densities were all seedings within the assement plots.
†Acceptable seedlings were seedlings greater than 4 inches and less than 18 inches.
Values are averages of 3 plots per treatment; values followed by the same letter within a column do not differ significantly at 0.05 according to the Student-Newman-Keuls' test.

not meet the minimum grading specifications.

After the third growing season, plots treated with dazomet had the highest seedling stand densities and, after grading, the greatest number of acceptable seedlings per plot (52 per square foot). Nontreated plots had the lowest number of acceptable seedlings per plot (32 per square foot). All other treatments produced between 41 and 38 acceptable seedlings per square foot. In all treatments, less than 8% of the seedlings died during the second and third growing seasons.

This study demonstrated that most seedling losses occurred in the first growing season. Fumigation with dazomet produced the greatest number of stunted 1 + 0 seedlings but ultimately had no effect on 3 + 0 seedling height. Silica sand and thiram may be alternatives that can be used in some nurseries with success, and these practices could be implemented to produce larger number of non-stunted white spruce seedlings.

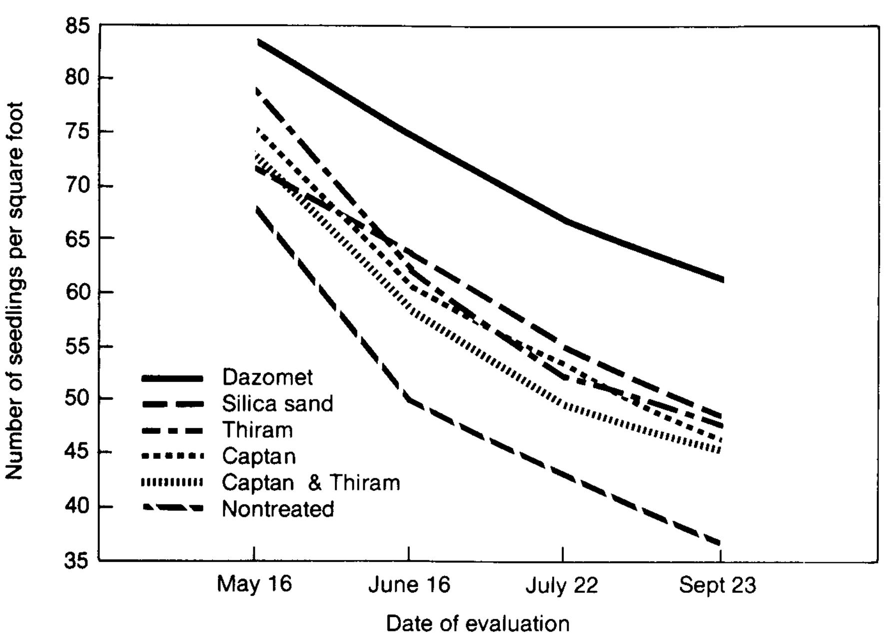

Figure 1—*Decline of seedling stand densities in all treatments at the Hayward State Nursery, Grant County, WI. Values represent the average of five 4-square-foot permanent assessment subplots collected over the first growing season in 1986.*

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