

Importance of Treatment Timing in the Control of *Fusarium* Root Rot of Douglas-fir Seedlings

W. J. Bloomberg and W. Lock

Forest Pathologist and Research Technician, Pacific Forest Research Centre, Department of the Environment, Victoria, B.C., Canada.

We thank L. J. Sluggett for assistance in analysis of data.

ABSTRACT

Two soil drenches of captan aqueous suspension to Douglas-fir seedbeds, applied 20 and 40 days after sowing, significantly reduced the number of seedlings killed by root rot caused by *Fusarium oxysporum*, but application of the dry chemical at sowing only, or drenches at 10 and 20 days failed to reduce disease incidence. No increase in control was obtained by increasing the frequency of treatment to every 10 days for up to 40 days after sowing, or by doubling the dosage rate from 0.19 g to 0.38 g/m of row.

Phytopathology 64:1153-1154

Additional key words: nursery, germination, soil fungicide, *Pseudotsuga menziesii*.

Fusarium oxysporum Schlecht. causes root rot of Douglas-fir seedlings during their first year in nursery seedbeds (1). Evidence from pot experiments, using homogeneous gas-sterilized nursery soil artificially infested with a fixed number of fungus propagules, showed clearly that death of a seedling seldom ensued if the root system had not been exposed to infection during the first 10 days after emergence. By contrast, exposure to infection during this period resulted in mortality up to 41% (1). The proportion of root system lesioned by the fungus during a given length of time varied little, regardless of the age at which the seedling had been exposed to infection, which ranged from 5 to 70 days. Apparently, the younger seedlings were killed because the residual root system was insufficient to support life.

To substantiate these results under field conditions, it was necessary to protect seedling roots from infection by

F. oxysporum for various periods after germination, and to record the number of deaths that occurred during the first growing season. Introducing a suitable fungicide into the soil appeared to be the best way of accomplishing this objective. Captan was chosen because it had relatively little phytotoxic effect on most coniferous seedlings, good fungitoxicity to *F. oxysporum*, and a relatively long effective period in soil (2).

METHODS AND MATERIALS.—The experiment was conducted in one nursery in the first year and at another in the second year. The same provenance of Douglas-fir seed was used in both series (germination 80-85%) and had been moist-chilled (stratified) to ensure a rapid uniform germination rate. One hundred seeds, of uniform weight, were evenly spaced along 1.3 m of row, 0.6-cm deep, in a nursery bed and covered with 0.6 cm of coarse sand. In the first year, captan, wettable powder, 50% active ingredient, was applied to the soil according to four different time schedules, using the same dosage rate, 0.375 g per lineal m of row, which is equivalent to 10.8 g per m². This high rate, 8-10 times the manufacturer's (Stauffer Chemical Co.) recommended level for soil treatment, was deemed necessary to offset leaching by irrigation (up to 1.0 cm daily) during the first month after seeds were sown. Experience has shown that emergence is virtually complete within 30 days after sowing.

Treatments were applied according to the following schedules: (i) dry chemical was mixed with the sand used to cover seed immediately after sowing; (ii) an aqueous suspension, 0.275 g per liter, was sprayed onto the surface of the 3.75-cm-wide row 10 and 20 days after sowing; (iii) a suspension, as above, was applied 20 and 40 days after sowing; and (iv) a suspension, as above, was applied 10, 20, 30, and 40 days after sowing. Checks were sprayed with water.

In the second year, captan was applied to rows 10, 20, and 40 days after sowing, using concns 0.375 or 0.190 g per m of row.

The experimental design was the same in both years and consisted of 15 randomized complete blocks sited along the length of a nursery bed 1.1 m wide. Treatments were randomly assigned to 1.2-m lengths of row within each block, each separated by a buffer length of row. Seeds were sown in the latter part of May. Dead seedlings

TABLE 1. Effect of captan soil treatments on the percentage of Douglas-fir seedlings killed by *Fusarium oxysporum*-caused root rot

Year	Dosage (g/m of row)	Form of application	Time of application after sowing (days)	Seedlings killed ^a (%)
1972	0 (check)			5.24
	0.375	Dry powder mixed with cover sand	0 (at sowing)	3.92
	0.375	Suspension	10 and 20	4.17
	0.375	Suspension	20 and 40	2.25
	0.375	Suspension	10,20,30 and 40	2.92
1973	0 (check)			6.45
	0.375	Suspension	10,20 and 40	3.73
	0.190	Suspension	10,20 and 40	3.21

^aValues enclosed by the same bracket do not differ significantly ($P = 0.05$) by the Neuman-Keuls test of multiple means.

were counted frequently and the last count was at the end of October, the seasonal limit for root rot infection (1). Tissue cultures from the margins of root lesions were made to confirm the presence of *F. oxysporum* in dead seedlings.

RESULTS.—During both years in which the experiments were conducted, *Fusarium* root rot levels in all nurseries were lower than in previous years. Consequently, differences between treated and nontreated plots were relatively small. However, in both years, the percentage of seedlings killed by *F. oxysporum* was approximately halved by those treatments that were designed to give the greatest antifungal protection during the critical period for root infection; i.e., up to 10 days after emergence. In 1972, treatment up to 20 days after sowing, i.e., about 10 days before emergence is completed, provided clearly inadequate protection; while treatment up to 40 days after sowing reduced mortality significantly (Table 1). Treatment at 10, 20, 30, and 40 days after sowing produced no further improvement over treatment at 20 and 40 days. In 1973, treatment up to 40

days after sowing produced about the same reductions in disease as in 1972. Furthermore, reducing the dosage rate by 50% did not impair the effectiveness of protection.

None of the treatments had significantly ($P = 0.05$) adverse effects on germination or on shoot length of seedlings.

The results of these field trials confirmed those of the pot experiments, that the critical period for infection of Douglas-fir seedling roots by *F. oxysporum* extends up to 10 days after emergence. Although the field levels of disease were too low for conclusive demonstration, it seems reasonable to suggest that whole-season protection against the disease can be provided by phytoprotective measures applied during the early stages of growth.

LITERATURE CITED

1. BLOOMBERG, W. J. 1973. *Fusarium* root rot of Douglas-fir seedlings. *Phytopathology* 63:337-341.
2. VAARTAJA, O. 1964. Chemical treatment of seedbeds to control nursery diseases. *Bot. Rev.* 30:1-91.