FUNGICIDE TRIALS TO CONTROL DAMPING-OFF OF CONIFERS

by

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FUNGICIDE TRIALS TO CONTROL DAMPING-OFF OF CONIFERS[1]

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Summary

No single fungicide gave consistently good damping-off control for pine and spruce in slightly alkaline, loamy seedbeds in a Saskatchewan nursery. Increased seedling stands were obtained by certain seed pelletings and by repeated soil applications with captan, Dexon, Dyrene, thiram, or zineb. The inconsistency was explained by the unpredictable nature of the biological control probably taking place in the treated soil.

INTRODUCTION

Prolonged susceptibility (19) makes damping-off a difficult problem in densely sown conifer seedbeds. Protection by seed treatments with fungicides is usually, but not always (14), of too short duration. Protection can be extended by increasing the amount of fungicide adhering to seed by means of stickers. Successful control of conifer damping-off has been reported from pelleting the seed with methyl cellulose stickers together with captan, thiram, or zineb (1, 2, 5, 20, 21). Another approach is by repeated applications of nonphytotoxic fungicides into soil (5, 9, 14). To reduce phytotoxicity, small amounts of thiram were applied every week after a heavier initial application, which successfully controlled damping-off in a greenhouse trial (4).

To find fungicides low in phytotoxicity, screening tests were made with germinating pine seeds (16, 17). Wide margins between the phytotoxic and protective limits were found for rimocidin, captan, thiram, Dexon (especially with Pythium), Dyrene (especially with Rhizoctonia), and omadines. Many others, including zineb, passed the tests with narrower margins. The tolerances of different fungal pathogens to various fungicides vary greatly (6, 7, 8, 16, 17, 18). Therefore certain pathogenic strains may be controlled by certain fungicides but others only by other fungicides (11, 13). This suggests control by mixtures of fungicides. The following describes trials with these fungicides and approaches in a nursery where damping-off is usually severe.

MATERIALS AND METHODS

The trials were performed in 1955 to 1960, at the Forest Nursery Station, Indian Head, Saskatchewan, in an old seedbed area with loamy, slight alkaline soil. Scots pine (Pinus sylvestris) in 1955 and 1956 and Colorado spruce (Picea pungens) in 1957-60 were used as hosts.

The common pathogens, judged from incidences of organisms isolated each summer from seedlings in the experimental and nearby seedbeds, were Pythium ultimum Trow and P. debaryanum Hesse. Especially in 1955 and 1956, some isolations of Rhizoctonia praticola Saksena & Vaartaja and a few of Phytophthora cactorum (Leb. & Cohn) Schroet. were also made. Fusarium spp. and, in 1955-1957, Alternaria spp. were isolated frequently but the pathogenic importance of these is doubtful. Damping-off incidence in untreated plots varied as follows: 1955 high (75%), 1956 fair (32%), 1957 low (20%), 1958 low (18%), 1959 fair (64%) and 1960 high (78%). Little conclusion could be drawn on the potential control by fungicides in 1956-58.

Results will be reported for: 1) p-dimethylaminobenzenediazo sodium sulfonate (Dexon (Bayer 22555)), 2) 2,4-dichloro-6-(o-chloroanilino)-s-triazine (Dyrene), 3) 1,2-dichloro-1 (methyl sulfonyl) ethylene (Chemagro D-113), 4) 3,5-dimethyl-tetrahydro-1,3,5,2H-thiadiazine-2-thione (Mylone), 5) captan (Orthocide), 6) thiram (Tersan), 7) pentachloronitrobenzene (PCNB (Terraclor)), and 8) zineb. Several other fungicides were included but with inconclusive results not reported here.

The fungicides were applied with methyl cellulose (pelleting) on the seed (20), or spread on soil surface with plenty of water but avoiding run-off. The rates applied are given in Table 1. Each experimental plot was usually 3.5 x 2.5 feet. The designs were randomized blocks (three to five), or, when soil sterilizers were tested, split blocks.

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Table 1. The main results of fungicide trials in 1955-1960[a] in conifer seedbeds at Indian Head, Saskatchewan.

Fungicide	Year	Rate (lb/acre)[b]	Seedling stand, % of untreated
Zineb 65W	1955	63 (in pellets)[c]	158*
Zineb 65W	1960	40 + 5x13	200**
Dexon 50W	1959	26 + 4x6	140**
Dexon 50W	1960	20 + 5x6	140
Dyrene 50W	1959	67 + 4x13	94
Dyrene 50W	1960	130 + 5x13	173**
Captan 75W	1955	63 (in pellets)[c]	133
Captan 50W	1959	30 + 4x6	121
Captan 50W	1960	53 + 5x13	145
Thiram 75W	1955	63 (in pellets)[c]	112
Thiram 75W	1960	53 + 5x13	137
PCNB 75W	1959	26 + 4x6	76
Dexon + Dyrene	1959	26 + 5x6 and 67 + 4x13	118
Dexon + Dyrene	1960	26 + 5x16 and 130 + 5x13	166**
Dexon + thiram	1960	26 + 5x6 and 53 + 5x13	147*
Dexon + captan	1960	26 + 5x6 and 53 + 5x13	140
Dexon + PCNB	1959	26 + 4x6 and 26 + 4x6	83
Thiram + thiram	1955	63[c] + 10x25[d]	101

*Significantly different from untreated controls at the 5% level.
**Significantly different from untreated controls at the 1% level.
[a]Results in 1956-1958 negative or not significant.
[b]Amount in first application + number and amount of supplement.
[c]Seed pelleting: 2.5% methyl cellulose in water at 10% + the fungicide at 20% seed weight.
[d]Pelleting with thiram supplemented with 10 soil treatments, each with thiram at 25 lb/acre.

RESULTS

Success in Damping-off Control: With few exceptions, only results with fungicides that at least once gave significantly increased seedling stands are given in Table 1. Results in 1956 (little damping-off) were not statistically significant with small increases in seedling stands, for example, by 13% with captan and by 17% with zineb. In 1957 and 1958 (hardly any damping-off) results were negative or not significant. In such years of low damping-off incidence, fungicidal applications appear a useless expense. However, this argument against fungicides is usually of less importance than obtaining all possible control whenever damping-off is severe. Outstanding improvements were obtained with zineb, Dexon, and Dyrene but not consistently. Captan and thiram, commonly used in the prairie nurseries, failed to give outstanding control in any year but gave considerable control in most of these trials as well as in other nurseries in trials not considered here. The results will be discussed as the basis for a working hypothesis.

Hypothesis of Biological Control: Many soil fungicides may exert a double action: (a) directly against the pathogen; (b) biologically through changes in antagonistic soil flora. Under certain conditions (a) may give insufficient control and (b) sometimes but not always sufficient additional control; this variation is assumed to be due to the complex and dynamic character of soil flora.

In 1959 Dexon gave significant damping-off control when alone, but failed when mixed with PCNB (seedling stand only 83%). No phytotoxicity was detected and chemical interaction seemed unlikely because these two materials are commonly mixed. Interference with the normal biological control appeared probable considering the highly selective action of PCNB (6, 10, 16, 18). In 1959, mixing Dexon with Dyrene decreased the control from a significant level to a nonsignificant level, although the reverse occurred in 1960. It is again hard to suggest plausible explanations other than differences in microbiological control.

Mixing Fungicides: Mixtures of fungicides were tried in 1957, 1959, and 1960. Several mixtures in 1957 gave nonsignificant decreases in seedling stand. Only the mixture thiram + Dexon, in 1960, increased the stand (to 147%) slightly over that with the better one of the two alone (Dexon, 140%). The opposite was true in four other mixtures in 1959 and 1960 and the differences were much larger. These results were explained in two ways: (a) only one type of pathogen was common (Pythium ultimum and P. debaryanum), (b) mixing two fungicides can be expected to cancel a part of the favorable selective action which each would exert alone.

Better results with fungicidal mixtures might be obtained whenever pathogens of different genera are common. To prevent the possible evolution of tolerance, alternations of the fungicides are needed. Alternation from year to year might achieve this without cancelling the selective action and biological control.

Soil Sterilization: The data for 1959 and 1960 in Table 1 are combined results in both sterilized and unsterilized soils. Sterilization did not result in statistically significant control. The sterilization was done with Mylone 85W at 200 lb/acre in 1959 and with Mylone 50D at 510 lb/acre in 1960. With such heavy rates even though by surface applications only, one would expect reduction in diseases caused by fungi acting mainly in a thin layer of surface soil. Reinfestation either from outside the plots or from deeper nonaffected soil layers obviously provided enough inoculum to frustrate any disease control. No phytotoxicity was detected; nor was this suggested by the seedling stands that, in the best fungicidal treatment, were equally high in both sterilized and unsterilized soils.

Although mostly lacking statistical significance, the following data may be worth consideration. The low average stand with Dexon + PCNB, assumed to result from insufficient biological control, was not as low in unsterilized as in sterilized soils. The same was true in the low stands for captan in 1959 and 1960, for Dexon in 1960, and for all except the best one of mixed treatments. The stands with D-113 (tested in 1960, excluded from Table 1) were as follows: unsterilized soil - 155%; sterilized soil - 75%. These results can be explained by reduced antagonism after the saprophytes had been killed by Mylone which is nonselectively toxic to fungi in soil (3).

CONCLUSIONS

The results were viewed on the basis of biological control. Unfortunately, full benefit from this hypothesis is obtained only with laborious analysis of soil flora. Nevertheless, further investigations are helped by a hypothesis which explains the common inconsistencies in the present and numerous other studies and would take into account the selective effects on antagonists. Many such effects have recently been found for the common soil fungicides thiram and captan (4, 5, 7, 8, 10, 12, 15, 17, 18). Domsch (7) realized that captan exerted damping-off control at a concentration that was not fungicidal in soil, and explained this mainly as biological control. With several materials the fungicidal concentration (in soil) would have been phytotoxic; yet they had useful control. Most saprophytic soil fungi tolerated fungicides better than pathogens (7). Various fungi known as producers of antibiotics were especially tolerant of captan and thiram. Many of our results were consistent with the hypothesis of biological control, namely: 1) a failure, similar to that reported by Gibson, et al. (10), with PCNB; 2) reversal of good control when PCNB was used as a mixture; 3) generally poor control with fungicidal mixtures; 4) apparently reduced control with fungicides if the soil was sterilized; 5) great variation from year to year.

The antagonistic relations of soil fungi are inconsistent and complex (8). This was also found when fungi largely obtained from the seedbeds of the above experiments were paired in over 1000 combinations in agar cultures. Although many of the saprophytes and mycorrhizal fungi were antagonistic to Pythium, they were also antagonistic to each other and their net effects remained obscure. Until soil microbiology is more advanced one must accept a certain degree of unpredictability even with the best soil fungicides.

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