CONTROL OF TERMINAL CROOK DISEASE OF RADIATA PINE SEEDLINGS

A. L. VANNER and J. W. GILMOUR
Forest Research Institute, Rotorua

Summary

Spray trials in nurseries for the control of terminal crook disease of radiata pine (*Pinus radiata* D. Don) seedlings, caused by *Colletotrichum acutatum* Simms. f.sp. *pineae* Dingley and Gilmour, have been carried out over 4 different years. Nineteen fungicide preparations were tested, some in combination, some at varying concentrations, and many with or without an emulsifiable oil. At weekly spray application intervals, captan + phenylmercury chloride and captan + pyridinitril + oil were the most effective. Limited control was also obtained with captan + oil, dichlone + oil, captan + pyridinitril and urbacid with and without oil. At fortnightly spray intervals, only captan + phenylmercury chloride gave effective control. Because of their toxicological properties both phenylmercury chloride and urbacid are undesirable for general nursery use.

INTRODUCTION

Terminal crook disease of radiata pine (*Pinus radiata* D. Don) seedlings is caused by the fungus *Colletotrichum acutatum* Simms. f.sp. *pineae* (Dingley and Gilmour, 1972). Fungal attack is manifested in pine seedlings by the irregular development of the terminal and lateral shoots, the infected shoot tip being killed or becoming inverted in a thickened crozier-shaped malformation. Tissue death is confined to the immature stem and needle tissue in the terminal bud. Subsequent to infection height growth is generally severely restricted for the remainder of the growing season. Eventually growth will occur in the sub-terminal shoots, one of which will normally become dominant. The resultant loss of growth which occurs when the stem terminal becomes infected would make it necessary to retain seedlings in the nursery bed for a second growing season if they are to reach a sufficient size for planting out on the forest site.

Severe infection was first encountered and described in radiata pine seedlings in Woodhill Forest nursery, north of Auckland, in 1963 (Gilmour, 1965). By 1972 the disease had been reported in all but one of the major pine nurseries in the northern half of the North Island.

Nursery spray trials were undertaken at Woodhill State Forest nursery in 1965. With the advent of pine needle blight caused by *Dothistroma pini* Hulbary in many forest nurseries, it was desirable to find a fungicide treatment which would effectively control both diseases. Consequently further nursery spray trials were undertaken at Kaingaroa in 1971 and at the Forest Research Institute (FRI), Rotorua, in 1972 and 1973 to find a dual purpose treatment.

METHODS

Fungicides were selected for field testing against terminal crook disease using four criteria. Fungicides were selected on the basis of their reported effectiveness against *C. acutatum* on other hosts, and against other species of *Colletotrichum*. Fungicides which were very effective against pine needle blight or which had exhibited activity against terminal crook disease in FRI glasshouse screening trials were also included in the 1972 and 1973 trials.

It has been reported (Calpouzos, 1969; Long, 1971; Gilmour and Vanner, 1972) that the degree of control provided by some fungicides is enhanced by the addition of an oil to the fungicide mix. Consequently many of the treatments were tested in 1971, 1972, and 1973 with and without the addition of an emulsifiable oil.

Trials were established in bed sown radiata pine in infected nurseries. Seed was line sown in December and the plots were laid out in a randomised block design, each plot being separated from its neighbour by an isolation strip. Individual spray plots measured 3 m x 1 m in each trial except the 1965 Woodhill nursery trial in which they were 6 m long.

Foliar fungicide spray application commenced within 4 weeks of seed germination and continued until there was a high degree of infection (70 to 100%) in the control plots. Spray application commenced in January and was concluded in May except in the 1973 FRI trial, in which spraying finished in mid March. The fungicides and dosage rates tested are shown in Table 1.

In addition to the foliar spray treatments a partial soil sterilisation treatment was tested in the 1965 Woodhill trial. This was done by replicating the whole trial in two adjacent areas, one of which was treated by machine with a 2:1 mixture of methyl bromide and chloropicrin at the rate of 336 kg/ha before seed sowing, while the other area was left unsterilised.

In order to reduce spray drift and to obtain a more uniform spray application a sprayer, (Fig. 1) was built for use in the 1971, 1972 and 1973 trials. It consisted of a 3 m long by 1 m wide by 1 m high aluminium wind shield built to surround an individual treatment plot. A carriage was constructed to run along the top of the shield, supporting a CO₂ pressurised sprayer and a two-nozzle boom with an adjustment for height.

Because of poor natural infection the 1972 and 1973 trials were artificially inoculated both before and after spray treatments had commenced. The artificial inoculum consisted of sterilised oat grain on which the fungus had been induced to sporulate profusely. The culture medium was broken up and the infected grain was evenly scattered over the trial area at the rate of approximately 3 litres of grain/100 m².

The effect of treatment was estimated by counting the number of infected seedlings in a continuous 50-seedling sample taken from the middle two rows in each plot. In the 1971 and 1973 trials there were three replications, whereas in the 1965 and 1972 trials there were four. Treatment mean percentages of infection were transformed using arcsine transformation and evaluated using Duncan's new multiple range test.

Because of a lack of significant differences between treatments the results of the 1971 trial are not tabulated. Only the treatments which were significantly different from the control have been listed. For comparative purposes in this paper all the mean percentages of infection have been adjusted after statistical analysis, so that the nil treatments (controls) all have the same degree of infection (100% infection).

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TABLE 1:
APPLICATION RATE (kg/ha) OF FUNGICIDE TREATMENTS

	Year of application:			
	1965		1971	
	1972		1973	
	1974		1975	
Nursery:	Woodhill	Kaingaroa	FRI	FRI
Spray volume (litres/ha):	2929	562	1123	1000
Spray interval:	Wkly	2 & 4 Wkly	1 & 2 Wkly	Wkly
aptan+phenylmercury chloride (PMC)	2.9+0.07	1.4+0.05†	3.6+0.06‡	3.2+0.05
bordeaux mixture 4:6:100	4.4*			
opper oxychloride	3.6			
aptan	2.9		1.8‡ 3.6	1.6‡ 3.2‡ 6.4‡
enomyl		0.3† 0.15†	0.6‡ 0.3‡	
nilazine (dyrene)		1.1† 0.6†	2.2 1.1‡	
ianeb		0.9† 0.5†		
aptan+cuprous oxide			3.6+2.2 1.8+1.1‡	
iancozeb			3.6 1.8‡	
lorothalonil			3.4 1.7‡	
entin acetate			2.7	
iophanate-methyl			0.6‡	
iptan+pyridinitril (ciluan)				3.2+1.95‡
uzet				0.8‡
ichlone				0.5‡
rbacid				2.0‡
ram				2.0‡
iram				2.0‡
lpet				2.0‡

*Volck summer oil added to the fungicide mix at the rate of 1.5%.

†Shell Clavas oil added to the fungicide mix at the rate of 2.0% + Triton X-27 emulsifier 0.05%.

‡Shell Universal Orchard oil added to the fungicide mix at the rate of 1%.

+ in 1973 only Triton X-44 wetting agent 0.033%.

N.B. Where a treatment is listed as having been tested with oil it was also tested alone.

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RESULTS AND DISCUSSIONS

Results of 3 years' trials have been tabulated in Tables 2, 3, and 4.

TABLE 2: STATISTICALLY EFFECTIVE TREATMENTS
1965 TRIAL, WOODHILL NURSERY

<i>Treatment</i>	<i>Dosage rate† (kg/ha)</i>	<i>Mean % infection</i>
captan + PMC	2.9+0.07	4.7 a
captan	2.9	31.6 b
Bordeaux	4.4	58.4 c
Bordeaux+oil*	4.4	83.1 d
control		100.0 e

*Volck summer oil applied at the rate of 1.5%.

†Weekly applications.

TABLE 3: STATISTICALLY EFFECTIVE TREATMENTS 1972
TRIAL, FRI NURSERY

<i>Treatment</i>	<i>Dosage rate (kg/ha)</i>	<i>Mean % infection</i>
captan + PMC + oil*	3.6+0.06‡	3.3 a
captan + PMC	3.6+0.06‡	11.3 a
captan + PMC	3.6+0.06†	22.7 ab
captan + oil*	1.8‡	45.3 b
captan + cuprous oxide + oil*	1.8 + 1.1‡	46.0 b
captan + cuprous oxide	3.6 + 2.2‡	49.0 b
benomyl	0.6†	52.0 b
control		100.0 c

*Shell Universal Orchard oil added at the rate of 1.0%.

†Fortnightly applications.

‡Weekly applications.

TABLE 4: STATISTICALLY EFFECTIVE TREATMENTS 1973 TRIAL,
FRI NURSERY

<i>Treatment</i>	<i>Dosage rate† (kg/ha)</i>	<i>Mean % of infection</i>
captan + PMC	3.2+0.05	72.8 a
captan + pyridinitril + oil*	3.2+1.95	73.5 a
urbacid + oil*	2.0	81.1 b
captan + pyridinitril	3.2 + 1.95	85.0 b
urbacid	2.0	88.7 b
dichlone + oil*	0.5	90.8 b
captan + oil*	6.4	90.8 b
captan	6.4	91.5 b
captan + oil*	3.2	92.2 b
control		100.0 c

*Shell Universal Orchard oil applied at the rate of 1.0% + Triton X-44 wetting agent added at the rate of 0.033%.

†Weekly applications.

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At weekly spray intervals captan + phenylmercury chloride (PMC) was significantly more effective than any other treatment in all trials, except for captan + pyridinitril + oil, which was tested in the 1973 trial and found to be equally as effective as captan + PMC. At the dosage rate tested the captan + pyridinitril + oil mixture is too expensive (\$57/ha/application) to be used for routine control.

Of the fortnightly and monthly treatments tested in the 1971 and 1972 trials, only the captan + PMC and the benomyl treatments at the highest dosage rates tested provided any degree of control. In the 1972 trial the captan + PMC treatment, which was applied at more than twice the dosage rate of the 1971 trial, gave almost 80% control, while benomyl at twice the dosage rate of the 1971 trial gave almost 50% control in the 1972 trial. However, the effect of benomyl was anomalous in the 1972 trial, in that the highest dosage rate was more effective at fortnightly intervals than at weekly intervals. This treatment was not significantly better than most of the other benomyl treatments at lower dosage rates both with and without oil, and none of these other benomyl treatments exhibited a statistically significant degree of disease control. Benomyl has also shown anomalous behaviour in 'in vitro' fungicide tests against *C. acutatum* (Bollen, 1972).

The effectiveness of captan at the lowest dosage rate tested in 1972 (1.8 kg/ha) was improved marginally by adding oil at 1 percent to the fungicide mix. The addition of oil increased the effectiveness of captan + pyridinitril in the 1973 trials but only gave a marginal increase with captan (3.2 kg/ha), and with dichlone.

Copper fungicides which are highly effective against pine needle blight did not give control of terminal crook disease, nor did they improve the effectiveness of captan when used in combination with it.

The soil sterilisation treatment applied in the 1965 trial was ineffective.

In the 1965 and 1972 trials the captan + PMC treatment maintained a very high degree of control, but not in the 1973 trial, although it was still the best treatment. This was thought to have been due to 3 days of rain coinciding with artificial inoculation before the succeeding spray application, which provided an unusually high level of inoculum and infection. Probably the heavy rain which followed this spray application would also have reduced the effectiveness of the fungicide deposit.

From the results of these 4 year's trials captan either with oil or at higher dosage rates, dichlone+oil, captan+pyridinitril with or without oil, urbacid with or without oil, and captan + PMC appear to be the most promising of the treatments tested at weekly intervals. Of those treatments tested at fortnightly intervals only captan + PMC was found to provide adequate control. As captan+PMC and urbacid are toxicologically unacceptable for general use, captan+pyridinitril+oil is the most promising treatment tested in controlling terminal crook disease.

Fuller presentation of the results of the 1972 trials are reported by Gilmour and Vanner (1973).

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Fig. 1: Plot sprayer fitted with a two nozzle drop boom, pressurised by CO₂ and mounted on an aluminium wind shield.