INFLUENCE OF TIME OF APPLICATION OF CUPROUS OXIDE ON CONTROL OF *DOTHISTROMA* NEEDLE BLIGHT

J. W. GILMOUR and A. NOORDERHAVEN*
Forest Research Institute, New Zealand Forest Service, Rotorua

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ABSTRACT

The degree of control of **Dothistroma pini** Hulbary was determined for 16 different monthly spray schedules of high volume applications of cuprous oxide at 0.2% active ingredient copper. **Pinus radiata** D. Don. seedlings exposed to heavy natural infection for one year were hand sprayed and the differences in the degree of defoliation with treatment were compared. For a single spray schedule it was found that the most effective time of application was November, and December was almost as effective. Applications in either August, September, or October were too early and those in January, February, or March were too late to be effective.

Only those two-spray schedules which included a November or December application provided effective control and the best of these was the October + December schedule. The combination of an October spray with the December application improved its effectiveness but the combination with a February spray did not enhance the effect of the December application. Similarly the September + November schedule was more effective than the single November application while the combination with a January application had little effect. This increase in effectiveness of the two-spray schedules as against the single sprays was due to a more gradual build-up in initial defoliation levels rather than to a large difference in the final levels reached.

INTRODUCTION

The optimum timing schedules for copper-based fungicides to control *Dothistroma* needle blight have been determined for a number of pine species in various parts of the world. In hand spray trials two applications, 3 to 5 weeks apart have been found to provide very good protection for one growth season on *Pinus nigra* (Arnold) in USA (Thomas and Lindberg 1954); on *P. nigra* and *P. ponderosa* Laws. in Nebraska, USA (Peterson 1967); on *P. nigra* in Iowa, USA (Epstein 1970); and on *P. pityusa* Steven in Georgia, USSR (Schischkina and Tzanava 1966). Hocking (1967) showed that, in Tanzania on *P. radiata,* a 4-month interval between sprays was more effective than a

* Present address: Department of Primary Industries, Brisbane, Australia.

6-week interval in a two-spray schedule. He also found that this schedule was effective for 2 years. In a number of low-volume aerial spray trials Gibson (1965) and, Gibson *et al.* (1966), have shown that a two-spray schedule, with an interval of 6 weeks, provided good control of this disease in lightly infected stands in Kenya. The timing of the first annual spray application in relation to the growth of the current year's foliage, and the phenology of infection were studied by Peterson (1967). He found that a single application 7 weeks after needle emergence provided 100% protection of the current year's needles, but the single application was less effective if it was applied when the needles were just emerging. Epstein's (1970) first application was made when the new season's needles had emerged $\frac{1}{8}$in.

In a climate with a marked bimodal rainfall pattern and no dormant season for tree growth Gibson *et al* (1966) and Hocking (1967) found that the most effective time for spray application was at the onset of the rainy periods.

This paper describes the effect on *Dothistroma* disease development on *P. radiata* seedlings of a copper-based fungicide when applied to run-off in an annual one-spray and an annual two-spray schedule (with an 8-week interval). Applications were made at eight different times of the year.

METHOD

In July 1967, six-tree, trial spray plots were established in a 5yr-old *P. radiata* stand thinned to about 600 stems per acre (s.p.a.), which was moderately to heavily infected with *Dothistroma pini* (40% to 50% mean infection). Uninfected 9-month seedlings of *P. radiata* were planted at 1ft intervals within experimental plots and the plots were positioned so that they were not directly under the crowns of the infected stand but were within 2ft-3ft of infected foliage. The plots were at least 8ft apart and were separated from each other by a row of infected trees.

The following spray schedules were tested by applying cuprous oxide* at 0.2% active ingredient (a.i.) Cu to run-off, with a knapsack sprayer:

1. A once-yearly application schedule applied in the middle of each month from August 1967 to March 1968 inclusive. This provided a total of eight individual treatments.
2. A twice-yearly application schedule with an 8-week interval and commencing in the middle of each month from August 1967 to March 1968 inclusive. This also provided a total of eight individual treatments.

Each of the 16 spray treatments and an unsprayed control (Table 2) were replicated four times in a randomised block design.

Disease assessments were made at monthly intervals from August 1967 to June 1968.

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* IW-D Cupoxide, 50% weight for weight copper, formulated as a wettable powder by Ivon Watkins-Dow Ltd, New Zealand.

A visual scoring method was adopted using the grades of infection shown in Table 1. These were based on a 1½ logarithmic scale after Horsfall (1945).

TABLE 1—Grades of infection

Grade	Percentage of normal crown depth defoliated or severely infected by **D. pini** Mean	Range
1	2.5	Trace to 5
2	15.0	6 to 25
3	37.5	26 to 50
4	62.5	51 to 75
5	84.5	76 to 95
6	97.5	96 to 100
7	100.0 and dead	

This scoring method estimates the result of the interaction between decrease in foliage due to disease and the increase in foliage due to growth.

RESULTS AND DISCUSSION

The development of the disease on the treated and untreated seedlings is expressed by the changes in the mean percent defoliation over the period of the experiment (Table 2).

TABLE 2—The effect of time of application of cuprous oxide on disease development of **Dothistroma pini** on **P. radiata** seedlings

Time of application	Mean % defoliation as at: 2.11.67	6.12.67	10.1.68	20.2.68	15.3.68	23.4.68	4.6.68
			Single treatments				
Aug	T*	T	7	58	63	84	92
Sep	T	T	5	74	74	88	92
Oct	7	21	28	55	63	80	91
Nov	3	33	35	35	30	38	40
Dec	10	35	52	58	50	48	44
Jan	15	46	81	85	81	81	80
Feb	14	33	66	85	74	82	74
Mar	14	35	63	90	78	90	88
			Two treatments, 8 weeks apart				
Aug & Oct	T	T	T	43	37	81	81
Sept & Nov	T	T	T	24	26	42	47
Oct & Dec	6	17	15	28	26	34	33
Nov & Jan	15	40	46	37	30	24	29
Dec & Feb	15	40	72	63	48	42	42
Jan & Mar	19	46	72	85	76	80	67
Feb & Apr	12	33	58	86	86	88	84
Mar & May	6	28	61	81	80	85	89
			No treatment				
Untreated	12	31	66	90	82	93	96

* T = trace (less than 1% of needles infected).

Note. Defoliation levels were negligible up to November and have been omitted from the table.

The progress of defoliation levels with treatment and time, is illustrated in Fig. 1, and the effect of treatments on defoliation levels 12 months after the seedlings were exposed to infection are compared in Fig. 2. These figures show that:

1. Unsprayed seedlings showed little infection up to October 1967, 3½ months after exposure to infection. From October onward, defoliation rapidly increased at an

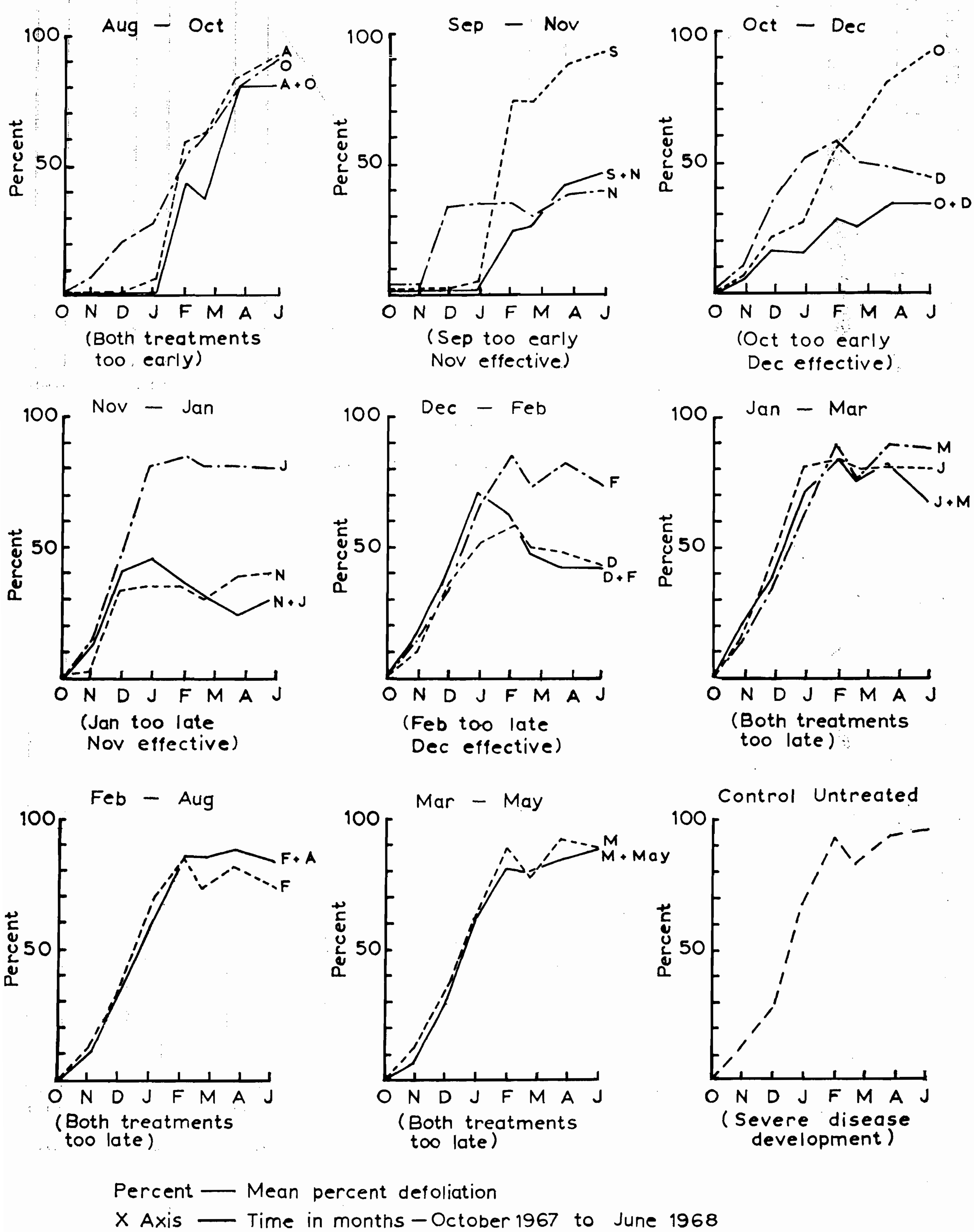
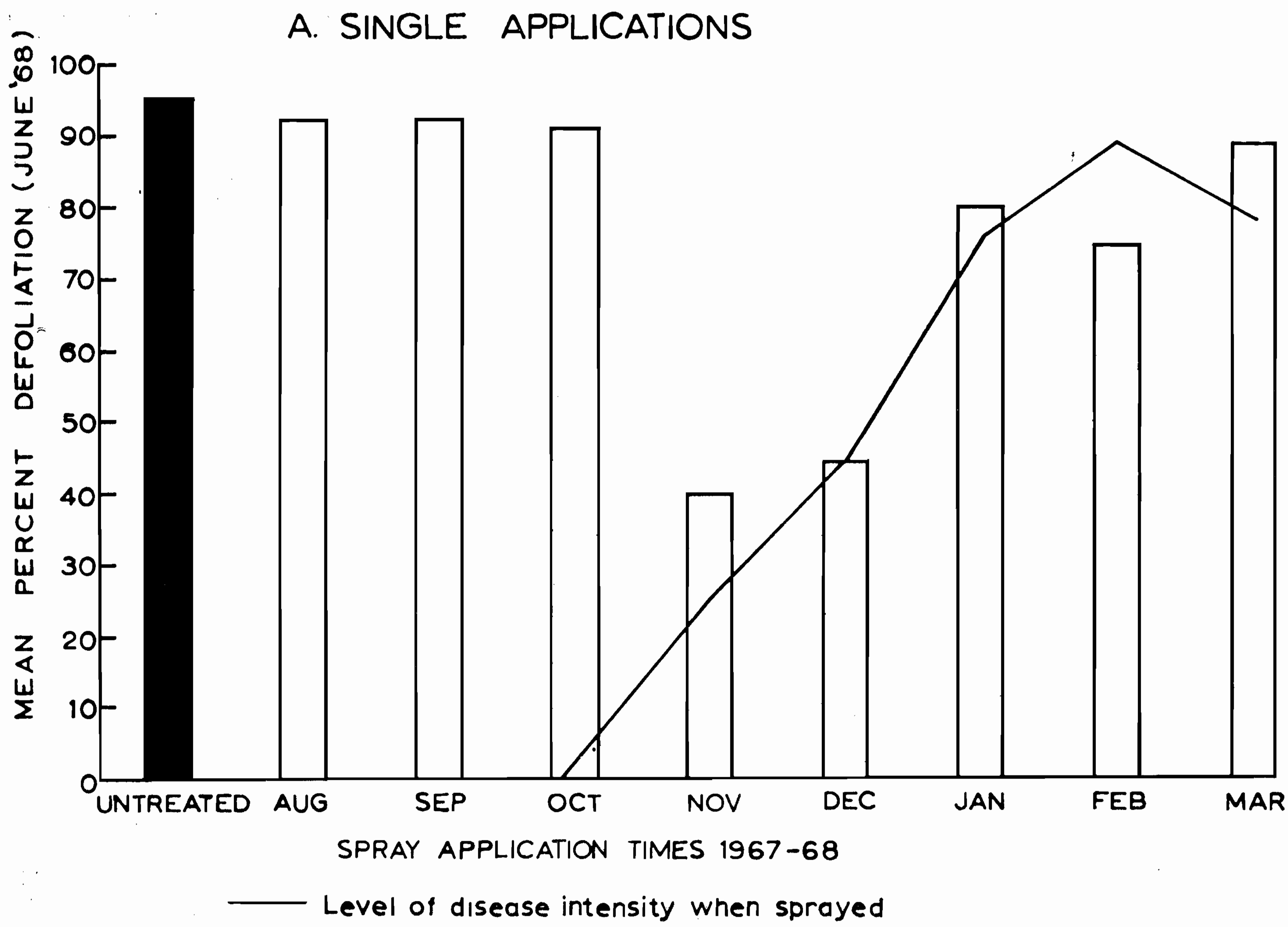


FIG. 1—The influence of the number and time of copper fungicide applications on the progress of defoliation by **D. pini.** October 1967-June 1968.



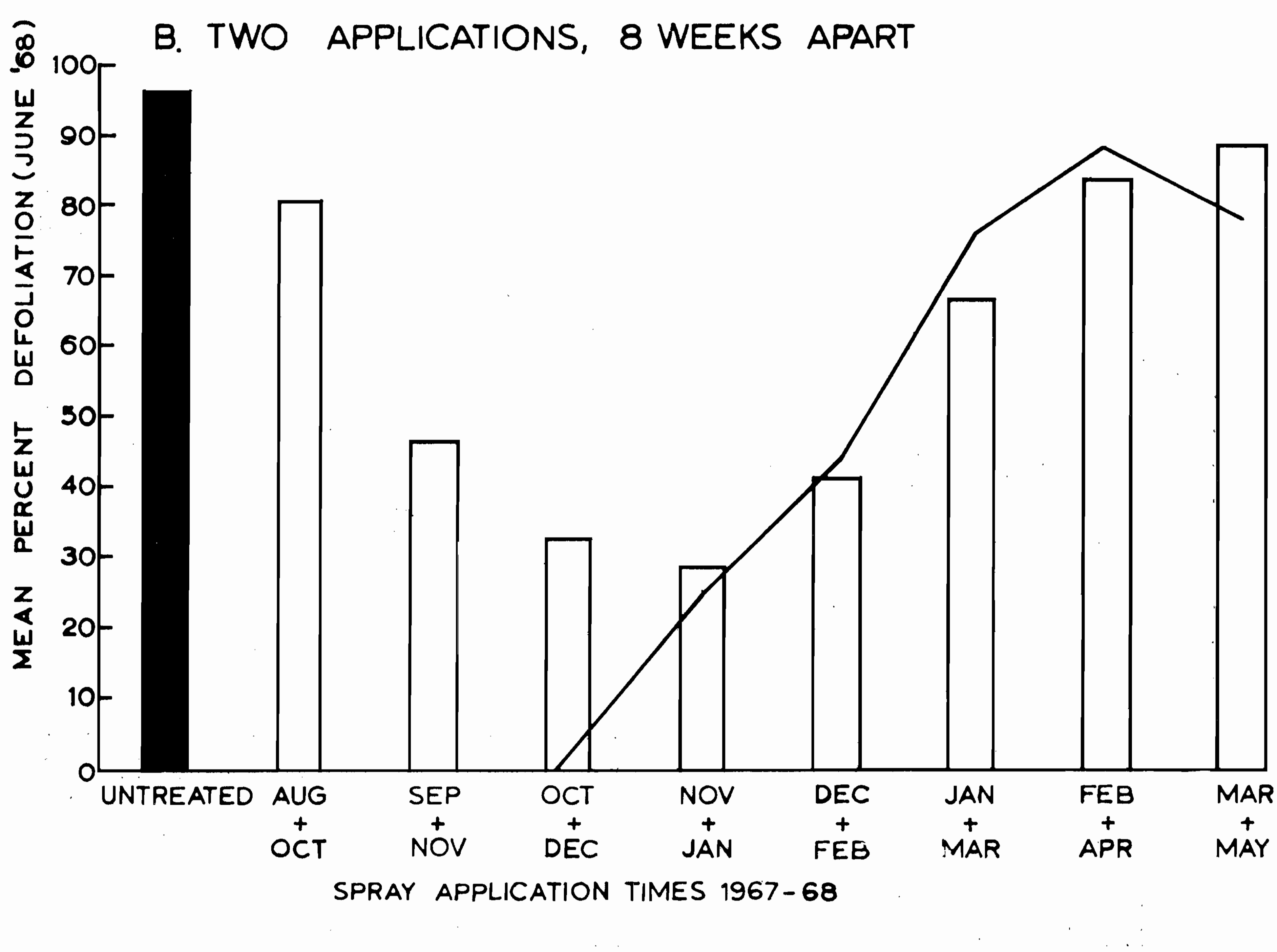


FIG 2—Fungicide schedule trial, 1967-68; final assessment, June 1968.

average rate of about 20% per month to reach about 90% in February. In March the defoliation level dropped slightly and then increased to a peak of 96% by June 1968.

2. The single application in August or September delayed the onset of defoliation by 3 to 4 months but had little effect thereafter; in both cases the defoliation increased rapidly to over 90% by June 1968.
3. The single October application again had no effect on the final June defoliation levels but did reduce the average rate of increase of defoliation to about 10% per month over the whole 8-month period.
4. Of the single applications after October only those in November and December had any appreciable effect on the subsequent progress of defoliation or the final levels attained. The single November application caused an almost immediate halt in the rapidly rising defoliation levels which had already reached 35% at the time of spraying. Defoliation levelled off at this point until February-March when there was a small decrease, and then an increase to 40% by June.

   The effect of the December application was delayed by a few weeks and initially was not quite as marked as that of the November application, but once the peak of 58% mean defoliation was passed in February, levels steadily declined to a June figure of 44%.
5. The single applications in January, February, or March all had a small depressing effect on the final (June) defoliation levels, but they were inadequate because the levels had already exceeded 80% before these treatments had any effect.
6. In common with the single spray schedules, those double-spray schedules which included either a November or a December application showed the lower infection levels at the final assessment. These schedules were the September + November, October + December, November + January, and the December + February schedules. They all reduced final defoliation levels by half or more (to *ca.* 47, 33, 29, and 42 mean percent defoliation respectively).

   Although the greatest reductions in defoliation levels were provided by the November + January schedule and the December + February schedule both these treatments allowed initial defoliation to rise to high levels before the treatment had any effect. By January the mean defoliations were 45% and 70% respectively. In contrast the September + November and the October + December schedules prevented this initial rapid build-up in disease, defoliation levels rose more gradually, and did not reach their peak (47% and 33% respectively) until the end of the trial period in June 1968.

CONCLUSIONS

November was the most effective time to apply a single spray of cuprous oxide to control *Dothistroma* needle blight of *P. radiata* while an October + December application was the most effective double spray schedule in the 1967-68 growth year on one site in Kaingaroa State Forest. The double spray schedule was a little more effective than the single spray schedule. These findings confirm the indication obtained in aerial spray trials in which low volume application of copper-based fungicides were used to control this disease in a 5-7yr *P. radiata* stand. The indications were that a double application (December + February) was comparable to a single application in December, while the single February application was very much less effective. (Gilmour and Noorderhaven, in prep.)

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