SUSCEPTIBILITY OF PINUS RADIATA SEEDLINGS TO INFECTION BY DIPLODIA PINEA AS AFFECTED BY PRE-INOCULATION CONDITIONS

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ABSTRACT

Pinus radiata D. Don seedlings in a high state of susceptibility to infection by **Diplodia pinea** (Desm.) Kickx during summer were altered to a state of high resistance through "winter" preconditioning in growth cabinets. Conversely, seedlings in a high state of resistance during winter became much less so after "summer" preconditioning. Preconditioning effects were related to temperature and photoperiod differences. The data support observations that susceptibility of **P. radiata** seedlings to inoculation with **D. pinea** fluctuates with season, being high in spring–summer but low in autumn–winter.

INTRODUCTION

Previous studies have established that shoot dieback in *Pinus radiata* caused by *Diplodia pinea* is mainly a disease of young green stems (Chou 1976a). Stem tissue past a certain stage of development is resistant to infection, as shown by the fact that lesion extension generally stops at the junction of current and previous season's growth. Also, artificial inoculation of the fungus into the stem region where the epidermal tissue has started to lose its greenness or shows signs of suberization, has not been successful (Chou 1976b). In nature, although infection can occur all the year round, there is a distinct peak which coincides with the time of spring–summer flush (Chou 1976a).

Because seedlings less than a year old do not have a well-defined seasonal growth pattern, they were expected to be susceptible to *D. pinea* infection throughout the year. However, inoculation trials carried out at different times of the year had shown wide variations in inoculation results which could not be explained satisfactorily by differences in post-inoculation conditions (Chou unpubl. data). Success was high in spring–summer and low in autumn and winter, suggesting seasonal changes in host susceptibility.

This paper reports results of several experiments designed to determine whether seedling susceptibility to *D. pinea* infection can be affected by simulated "winter" or "summer" preconditioning in growth cabinets.

MATERIAL AND METHODS

Potted seedlings were preconditioned for 1 month in growth cabinets set to simulate "winter" or "summer" conditions as outlined in Table 1. Three experiments were carried out, one in November–December when seedling susceptibility was expected to be naturally high, one in May–June when seedling susceptibility was expected to be low, and one in February–March when inoculation results have been erratic – presumably because host susceptibility is in a state of transition. Controls in Experiment 1 were seedlings left in a thermostatically controlled glasshouse at 20°/15°C day/night, and in Experiment 2 potted plants placed in the nursery for a month served as controls.

TABLE 1—Effect of pre-inoculation conditions on **D. pinea** infection of **P. radiata** seedlings (results 4 weeks after inoculation)

Expt. No.	Date of Expt.	Pre-inoculation conditioning			Seedlings inoculated	No. with DT	No. with RSL
		Season	Photoperiod (h)	Temperature regime day/night (°C)			
1	Nov–Dec	Summer	12*	24/10	19	11	8
		Winter	8†	12/10	20	1	14
		Control (glasshouse)			20	7	12
2	May–June	Summer 1	16*	20/10	20	3	12
		Summer 2	16*	25/15	19	7	6
		Winter	8*	20/10	20	0	3
		Control (nursery)			18	0	1
3	Feb–Mar	Summer	14*	24/10	20	18	1
		Winter	9*	12/10	24	10	8

* Full light = 140 W/m²
† Full light = 80 W/m²
DT = dead top
RSL = restricted stem lesion

The seedlings used were at least 6 months old and less than 12 months, and within each experiment all seedlings were the same age.

The preconditioned seedlings and the controls were inoculated by brushing a spore suspension on to the topmost part of the shoot as previously described (Chou 1976b, 1977, 1982). After inoculation all plants were kept in a misting chamber at 25°C for 48 h in Experiments 1 and 2 and for 64 h in Experiment 3. After misting all plants were transferred to the glasshouse at 20°/15°C as stated above. Infection was assessed 1 month after inoculation and scored as dead top (DT) or restricted stem lesion (RSL) (Chou 1982). Plants showing no stem symptom were considered to have "no infection". Seedling heights were measured to the nearest millimetre at the beginning and end of each experiment.

RESULTS

"Summer" and "winter" treated seedlings differed markedly in their response to infection (Table 1). Out of a total of 98 "summer" preconditioned seedlings inoculated in the three experiments, 46 developed dead top and 39 had restricted stem lesions – a total of 87% with infection; among the 82 "winter" treated seedlings inoculated, only 11 developed dead top and 26 had restricted stem lesions – a total of 45% with infection. The proportion of both dead tops and infection total differed significantly in summer and winter treatments (chi-squares of 21.8 and 23.6 respectively, $p = 0.01$).

The controls in Experiments 1 and 2, representing seedlings in natural winter and summer conditions, showed marked differences in infection response, suggesting seasonal changes in host susceptibility.

In Experiment 2 the control seedlings were clearly at a very low level of susceptibility. The two "summer" treatments both had the effect of increasing host susceptibility, and the higher temperature "summer" treatment seemed to have a greater effect than the lower temperature one. Average height increments of seedlings during the experiment were 1.8 cm (summer 1), 1.5 cm (summer 2), 1.0 cm (winter), and 0.8 cm (control) showing that height growth continued, though at a slower rate, in both artificial and natural winter conditions. Since the "winter" treatment in this experiment differed from "summer (1)" only in photoperiod but not in temperature level, it is apparent that photoperiod alone can affect host growth and susceptibility.

In Experiment 1, which was carried out in early summer, untreated host plants showed high susceptibility but this was greatly reduced by "winter" treatment. The increased resistance in "wintered" seedlings was apparently expressed largely in restriction of lesions rather than in prevention of the initial stages of infection involving spore germination and host penetration. This was evident in the marked reduction in the level of dead top but not in infection total. A similar effect was demonstrated in Experiment 3.

CONCLUSIONS AND DISCUSSION

The data suggest that seedling susceptibility to *D. pinea* infection can be altered by pre-inoculation conditions, and hence support previous observations that susceptibility undergoes seasonal changes. This is an example of "predisposition" which Yarwood (1959) defined as environmentally conditioned susceptibility or, more fully, the tendency of non-genetic conditions, acting before infection, to affect the susceptibility of plants to disease. Other comparable terms are preconditioning, disease proneness (Gaumann 1951), and disease potential.

Seasonal predisposition is therefore an important factor to bear in mind in planning inoculation trials whether for pathogenicity tests, screening for disease resistance, or any other purposes.

The wider role of predisposition in the epidemiology of shoot dieback, as well as the anatomical, physiological, and biochemical changes accompanying preconditioning, and their causes, are unknown and merit further study.

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REFERENCES

CHOU, C. K. S. 1976a: A shoot dieback in **Pinus radiata** caused by **Diplodia pinea**. I. Symptoms, disease development, and isolation of pathogen. **New Zealand Journal of Forestry Science 6:** 72–5.

——— 1976b: A shoot dieback in **Pinus radiata** caused by **Diplodia pinea**. II. Inoculation studies. **New Zealand Journal of Forestry Science 6:** 409–19.

——— 1977: Effect of tree age on **Diplodia** infection of **Pinus radiata**. **Plant Disease Reporter 61:** 101–3.

——— 1982: **Diplodia pinea** infection of **Pinus radiata** seedlings: Effect of temperature and shoot wetness duration. **New Zealand Journal of Forestry Science 12:** 425–37.

GAUMANN, E. 1951: Pflanzliche Infektion-slehre. Verlag Birkhauser, Basel. 681 p.

YARWOOD, C. E. 1959: Predisposition. Pp. 521–62 **in** Horsfall, J. G.; Dimond, A. E. (Eds) "Plant Pathology — An Advanced Treatise", Vol. 1: Academic Press, New York.