SESSION 2: Chairman: Mr. P. F. Jenkins

Climate and Soil Type in Relation to *Phytophthora* Attack on Pine Trees

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In 1953 and 1954 in the Auckland district and in 1956 throughout the North Island, *Pinus radiata* on farms and urban properties suffered from a spectacular disease causing death or defoliation. Symptoms were caused by a group of soil fungi belonging to the genus *Phytophthora.*

Species of *Phytophthora* are amongst the most serious soil-borne parasites of plants. Infection is normally associated with asexual reproduction and liberation of motile zoospores from sporangia occurs only in actual moisture. This dependence on water is characteristic of diseases caused by *Phytophthora* spp. It explains why they are commonly associated with poorly drained situations, with irrigation or with wet seasons.

P. cinnamomi is the species most commonly found in association with the disease of *P. radiata.* This fungus is associated with a disease of *Pinus echinata* in south-eastern U.S.A., pineapples in Hawaii, tea and rubber in Indonesia and Malaya, and is also a major pest on over 200 host species. Like most *Phytophthora* spp. it is almost cosmopolitan.

In the case of cosmopolitan fungi with air-borne spores it is easy to understand how they came to be distributed in high altitude winds. However, even if the sexual or resting spore stage of *Phytophthora* spp. became air-borne in dust, it is doubtful if they would withstand the consequent desiccation. Introduction to new areas can often be traced to soil on roots of imported plants, e.g., infected soil brought on to cotton plantations with rhododendrons is thought to be the source of *P. cinnamomi* causing disease in the now regenerated forest areas in south-eastern U.S.A.

Distribution is very widespread in New Zealand. In the case of plantation trees, of course, it is possible that infection could have come from nurseries. However, *Phytophthora* spp. are also present in indigenous plant communities. The search has so far been limited but results are interesting. In the Cornwallis area I have isolated *P. cinnamomi* from a high proportion of soil samples in *Leptospermum* scrub, kauri ricker stands and a very advanced *Coprosma arborea*—nikau association. In the Waitakeres it was a common constituent in soil from below mature kauri trees. The same fungus was present under 9 out of 10 mature kauri trees investigated over 1000 feet up on the southern slopes of Little Barrier Island. If it was unwittingly introduced from the mainland by Maoris last century and spread during the relatively short period that stock roamed on parts of those slopes, it certainly became remarkably well dispersed and well established.

Several species of *Phytophthora* are involved in the disease of pines. While there is some evidence of gradual spread of infection within stands, in many or most cases the fungi have probably been present in the soil throughout the time that the trees have been growing. They probably cause rootlet injury in all seasons but in most years rootlet regeneration is sufficient to balance rootlet loss, with the result that trees are able to make normal spring growth. In the epidemic years, however, autumn and winter rainfall was unusually heavy and it would

seem that the balance was not restored in time. Trees suffered from physiological drought at their period of greatest water demand.

An analysis of rainfall data over the last 15 years indicated that it was the occurrence of abnormally heavy autumn rainfall in the epidemic years which was the critical factor (Newhook 1959). In most years soils such as the heavy clays of North Auckland become baked hard in summer and in consequence are slow to rewet in the autumn. Most rainfall is lost as surface run-off and it is not until June or July or even later (August in 1958) that the main body of soil becomes wet. In the epidemic years abnormally heavy and prolonged autumn rainfall would have more than doubled the period during which rootlet infection by *Phytophthora* could occur. There would thus have been greater opportunity for wholesale rootlet death.

A most important aspect of the autumn rewetting of the soil is that soil temperatures are then much nearer to the optimum for fungus activity. Autumn soil temperatures range from 11-16°C., while winter temperatures drop to 9 or 10°C. Temperature is known to be a very important factor governing geographical distribution of fungi and it is quite likely to be, similarly, an important seasonal factor governing infection. In this instance the coincidence of suitable moisture and suitable temperature conditions is necessary for epidemic infection.

In March 1957, following the 1956 epidemic, a survey was made with C. F. Sutherland of New Zealand Soil Bureau and J. Levy of New Zealand Forest Service (Sutherland, Newhook and Levy, 1959) to relate mortality and neeedle casting of conifers to soil type—in particular to soil drainage. Data from 1570 *P. radiata* and 863 *Cupressus macrocarpa* stands led to the following conclusions:—

(1) From the point of view of total disease symptoms, the 1956 rainfall almost neutralised differences in soil drainage. These latter, however, did influence the amount of death or recovery after the wet season finished.

(2) Although *P. radiata* is initially more susceptible to the disease, it showed a much higher recovery rate on all soil types than *C. macrocarpa*.

(3) Susceptibility of *P. radiata* increased and likewise the recovery rate of trees which had developed symptoms decreased, with increasingly poorer soil drainage. Susceptibility of *C. macrocarpa* on the other hand, was greatest at both extremes of soil drainage, while the recovery rate amongst affected stands was uniformly fairly low.

The differences in behaviour between *P. radiata* and *C. macrocarpa* are interesting and may be explained, at least in part, by (a) differences in ability to regenerate a new rootlet system after attack by *Phytophthora* and (b) differences in rate of shedding of needle fascicles or branchlets in response to onset of physiological drought. *C. macrocarpa* appears to be slower than *P. radiata* in both these functions. Thus, in contrast to *P. radiata* which responds rapidly to a departure from field capacity moisture (and this is soonest with better drained soils), *C. macrocarpa* may not be able to regenerate an adequate root system before the well drained soils dry out in summer. With slower abscission, *C. macrocarpa* may appear outwardly to be less susceptible; in actual fact water reserves would be more seriously depleted than in *P. radiata* where there is a more rapid restoration of balance between transpiring area and reduced rootlet surface; this would affect the ability of *C. macrocarpa* to recover.

In conclusion it must be stressed that the presence of a fungus such as *Phytophthora* in the soil constitutes an environmental factor that must be considered as of equal importance with other factors such as soil physical properties, climate, aspect, etc., with which it interacts. As part of this environmental complex, it must have an influence on other diseases such as *Diplodia* dieback, *Lophodermium* and other needle-cast diseases, and perhaps on pests such as *Sirex* attacking pines in plantations, all of which troubles are most serious on weakened trees.

REFERENCES

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