Foliar Diseases of Pine – The New Zealand Experience

Lindsay S. Bulman

Introduction

The great majority of New Zealand plantation forest area, over 90% of the total 1.7 million ha, is comprised of *Pinus radiata*. This species is relatively healthy and does not suffer many of the serious root rots, rusts, and insect pests that are problematic in other parts of the world. Radiata pine suffers from three significant foliar diseases – Dothistroma needle blight, Cyclaneusma needle cast and physiological needle blight (PNB). This article summarizes work done in New Zealand on these three diseases.

Dothistroma Needle Blight

Dothistroma needle blight was first discovered in New Zealand in the early 1960s, and was formally identified as *Dothistroma pini* Hulbary in 1964. The sexual stage of the fungus (*Mycosphaerella pini* Rostrup ex Monk) is not found in New Zealand. Immediately, a research programme was started to examine:

- Infection process
- Infection period, effect of light and weather
- Optimal spray regimes
- Host susceptibility and response

Gadgil (1967, 1974, and 1977) found that prolonged needle wetness is needed to initiate and continue infection – continuous wetness at 20°C/12°C day/night temperature resulted in appearance of stromata after 14 days. After conidia germinate, hyphae grow haphazardly, penetrate stomata, and advance only in disrupted mesophyll. Bassett (1970) showed that dothistromin is present. Infection period is summer, when temperatures are over 16°C. Infection can occur at 7°C but wet conditions and many spores (i.e. >6 million per seedling induced 15% disease at warmer temperatures) are needed.

The role of dothistromin is uncertain. A relationship between pathogenicity or virulence in the field has never been established. Production of dothistromin in culture is extremely variable (Bradshaw and others 2000). Franich and others (1986) proposed that lesion development is caused by benzoic acid production in response to dothistromin. Significant differences between lesion length induced by doses of dothistromin on resistant and susceptible trees were found, but such relationships were weak.

Environment plays a critical role in disease development. A combination of consecutive wet summers, trees growing closely together, and no aerial application of fungicide has resulted in tree mortality in New Zealand. In one experiment mortality reached 12% but effects of Dothistroma needle blight were confounded with Armillaria root rot (Woollens and Hayward 1984). New Zealand does not have the variety of damaging bark beetles and root diseases that can attack and kill trees weakened by Dothistroma needle blight. There is a strong relationship between summer rainfall and disease. Temperatures in spring and summer in New Zealand are high enough to promote infection and are not limiting. Figure 1 shows the relationship using data gathered from a large forest growing in the central North Island of New Zealand.

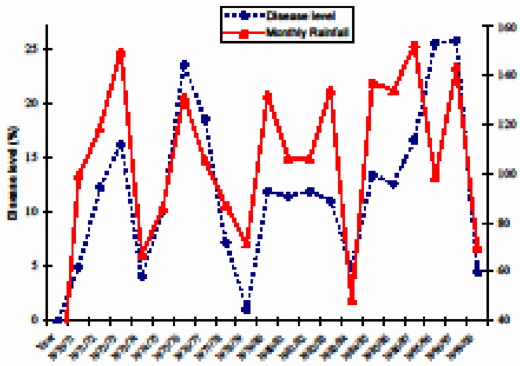

Figure 1—Relationship between summer rainfall and disease.

In: Jackson, M. B. comp. 2007. Proceedings of the 54th Annual Western International Forest Disease Work Conference; 2006 October 2—6; Smithers, BC. Missoula, MT: US Department of Agriculture, Forest Service, Forest Health Protection.

Lindsay Bulman is a Forest Pathologist at Ensis Forest Biosecurity and Protection, Rotorua, New Zealand.

From October 2003 to August 2005 lesion and stromatal development was monitored monthly on radiata pine trees at three locations. The monitoring proved to be problematic because the work was tedious and counting individual stromata on individual needles was difficult. Not only that, as disease developed on one cohort of needles those needles fell off and had to be replaced by healthier ones. This disrupted monitoring the progress of numbers of stromata and lesions significantly. However, preliminary results indicate that the primary infection period is in late spring, followed by another in late summer or early autumn. This late infection period was unexpected. Models based on our knowledge of disease development and the empirical data gathered in the monitoring experiment are now being developed.

Dothistroma needle blight causes significant economic loss in New Zealand (*see* figure 2). Volume growth loss is proportional to average disease level (Van der Pas 1981) and annual loss is in the order of $NZ24 million per year.

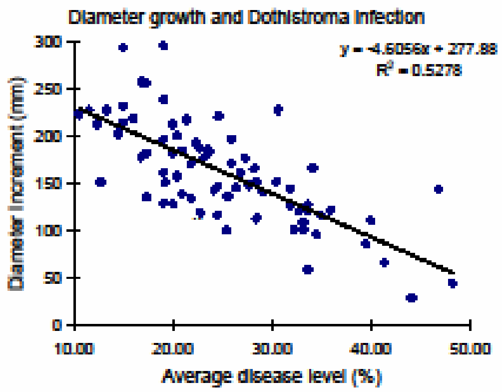

Figure 2—Relationship between diameter growth and Dothistroma disease level.

However, aerial spraying copper fungicide provides effective control. The fungicide kills conidia-bearing stromata and thus reduces inoculum. It also protects foliage from fresh infection. It is the only example in the world of successful control of a forest pathogen by aerial application of fungicide. Control has also been achieved by the development of resistant breeds where gains of 10 to 12% have been reported experimentally (Carson 1989).

Dothistroma needle blight can be controlled by cultural techniques. Stands grown on pulpwood regimes (660 to 1630 stems per ha) were sprayed on average 5.5 times during the period when they were susceptible to the disease (when trees were aged between 1- to 15 years-old). In contrast, stands managed on a clearwood regime (lower branches pruned and stocked at 300 to 350 stems per ha) were sprayed far less frequently. About 75% of these stands in a forest growing in similar conditions to the forest managed on pulpwood regimes were sprayed zero to 2 times during the susceptible period.

A great deal of research has been carried out on Dothistroma needle blight but there are still things to learn. For instance, the relationship between dothistromin production and virulence or pathogenicity in the field is unknown. Dothistroma should be treated as a biosecurity risk even though the fungus already exists in New Zealand. Like all forest pathogens, we need to maintain a watch for all new subspecies, races, formae speciales, even if the species is already present (Gadgil and others 2002). The factors that induce hyphae to penetrate stomata are unknown. We have good data on performance of resistant breed in field trials but performance when planted in large contiguous areas has not been monitored.

Cyclaneusma Needle Cast

Cyclaneusma needle cast, caused by *Cyclaneusma minus* (Butin) DiCosmo *et al.*, affects susceptible radiata pine individuals scattered among non-susceptible individuals. The same individuals are affected year after year, where one-year-old needles turn yellow in spring and are readily cast. A less severe needle cast often occurs in autumn. The main infection period is autumn and early winter and infected needles are cast about six months afterward. Cyclaneusma colonises needles first, followed by many fungi such as *Lophodermium* spp (along with *Cyclaneusma* the most common species) and *Strasseria*, *Hendersonia*, *Cladosporium*, and others.

There are at least two types of *Cyclaneusma minus* in New Zealand, based on morphological characteristics. One type is more common than the other, but no association between type and pathogenicity has been seen. Disease incidence and severity is worse on moist sites (gullies or high altitude sites prone to mist). Disease is most severe in trees ages between 6 and 15 years old, with trees younger than 5 years and older than 20 years very rarely affected.

Cyclaneusma causes significant growth loss where an average disease severity of 80% will result in a volume increment loss of 60%. Control methods include breeding. This should offer a good opportunity because disease occurs on the same individuals year after year. The breeding programme has selected for good needle retention so by default over the years has selected against Cyclaneusma needle cast. The other control method available is to selectively remove susceptible individuals during thinning operations. However, this method has some operational difficulties because the disease is only apparent over a short time of year and doesn't show until age 6, by which time the first thinning and pruning operations have usually taken place.

Research priorities include identification of high risk sites so control measures can be carried out, determining the fungal genetic population variation, and determining what induces Cyclaneusma to move from an endophyte to a pathogen in some individuals. The fungus can be readily isolated from needles of susceptible and resistant trees during the peak disease expression period.

Research on Cyclaneusma needle cast in New Zealand is summarised in Bulman and Gadgil 2001.

Physiological Needle Blight

A disorder, now named Physiological needle blight (PNB) has been recorded in New Zealand since the early 1980s. Over the last 10 years, sporadic outbreaks have been recorded in certain regions every 2 to 3 years. Almost exclusively trees older than 14 years are affected. Distribution is patchy within a stand and defoliation is usually severe (Figure 3). Often 80% of the crown will be affected.

Needles droop and wilt, but remain firmly attached to the branch. Many fungal isolations from affected needles were carried out and only non-pathogenic fungi were obtained. Similar symptoms were induced in glasshouse studies where foliage of age cuttings was kept continuously moist for over 8 weeks. Applications of broad-spectrum fungicide reduced the incidence of needle death. Fungi colonising the needles were also reduced but were not eliminated. It is probable that the natural saprophytic fungal colonisers accelerate death of needles in a severely stressed state. An association between reports of outbreaks and above average rainfall and raindays in June and July was found after extracting forest health reports. This finding was supported by results of aerial surveys undertaken in 2002 and 2003. Thus, experimental work has indicated that the disorder is physiological in origin although the physiological nature of the needle breakdown is not fully understood

Figure 3—Physiological needle blight in a 17-year-old stand.

Research in progress involves pre-dawn water potential measurements to determine root function. Results were not conclusive, but may have indicated that root waterlogging may be contributing to the disease. The age effect may be due to increased resistance and decreased water conductance with tree age.

Work on PNB is ongoing.

References

Bassett, Colin; Buchanan, M.; Gallagher, R. T.; Hodges, R. L., 1970. A toxic difuroanthraquinone from *Dothistroma pini*. Chemistry and Industry No 52: 1659-1660.

Bradshaw, Rosie E.; Ganley, Rebecca J.; Jones, W. T.; Dyer, P. S. 2000. High levels of dothistromin toxin produced by the forest pathogen *Dothistroma pini*. Mycological research 104(3) 325-332

Bulman, Lindsay S.; Gadgil, Peter D.2001. Cyclaneusma needle-cast in New. Zealand. Forest Research Bulletin No. 222. Editors: L. S. Bulman & P. D. Gadgil. 75 p. http://www.ensisjv.com/Portals/0/FRBulletin222.pdf

Carson, Susan D., 1989: Selecting *Pinus radiata* for resistance to Dothistroma needle blight. NZ Journal of Forestry Science 19, 3–21.

Gadgil, Peter, D. 1967. Infection of *Pinus radiata* needles by *Dothistroma pini*. NZ Journal of Botany 5: 498-503.

Gadgil, Peter D. 1974. Effect of temperature and leaf wetness period on infection of Pinus radiata by Dothistroma pini. NZ Journal of Forestry Science 4:495-501.

Gadgil, Peter D. 1977. Duration of leaf wetness periods and infection of Pinus radiata by

Dothistroma pini. NZ Journal of Forestry Science 7:83-90.
Gadgil, Peter D.; Bulman, Lindsay S.; Glassey, Ken L. 2002. Quarantine risk associated with air cargo containers. New Zealand Journal of Forestry Science 32(1): 28-47.
van der Pas, J. Bou. 1981. Reduced early growth rates of *Pinus radiata* caused by *Dothistroma*. NZ Journal of Forestry Science 11: 210-220
Franich, Robert A.; Carson, Michael, J.; Carson, Susan D. 1986. Synthesis and accumulation of benzoic acid in *Pinus radiata* needles in response to tissue injury by dothistromin, and correlation with resistance of *P. radiata* families to *Dothistroma pini*. Physiological Plant Pathology 28: 267-286.
Woollons, Richard C.; Hayward. W. J. 1984. Growth losses in *Pinus radiata* stands unsprayed for *Dothistroma pini*. NZ Journal of Forestry Science 14(1): 14-22.