INFORMATION BULLETIN NO 5
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RADIATA PINE DOTHISTROMA RESISTANCE

GF Plus®

RPBC™
Radiata Pine Breeding Co Ltd
BREEDING QUALITY

- **Dothistroma Needle Blight, also referred to as Red Band Needle Blight, is a disease that causes substantial growth losses in forests where severe infection occurs.**
- **Dothistroma Needle Blight is caused by a fungus, *Dothistroma pini*, which grows well only in the proportion of New Zealand's radiata pine forests where the climate is warm and humid.**
- **Genetic selection can significantly decrease disease levels, with increasing GF Plus rating for Dothistroma showing progressive improvement in resistance.**
- **Decreasing disease levels not only reduces growth loss from the disease, but also results in substantial savings in associated disease control costs.**
- **Trial data shows that genetic improvement in disease resistance can be consistently achieved in areas where the disease is serious.**

> TREE BREEDING AND GAIN IN DOTHISTROMA RESISTANCE

Genetic gain in Dothistroma resistance represents the ability to produce a stand of trees with decreased symptoms of Dothistroma Needle Blight, caused by the fungus *Dothistroma pini*. Decreasing symptoms means that growth loss to the disease will be reduced, as well as the annual cost of spraying with copper fungicides. Resistance to Dothistroma Needle Blight is one of the traits currently identified in the ***GF Plus*** scheme (see Information Bulletin No. 1 "Rating the Genetic Quality of Radiata Pine").

Figure 1: Example of impact of varying genetics on Dothistroma resistance

> WHY IS DOTHISTROMA RESISTANCE AN IMPORTANT TRAIT?

Dothistroma Needle Blight causes defoliation, which results in significant growth loss when more than 25% of the needles are infected. Where the disease is a problem, forests are surveyed annually for the severity of symptoms in a nationally coordinated programme. If disease levels are thought to be at the point at which the impact of the disease is considered significant in terms of wood loss, stands are sprayed with copper fungicide in a multi-million dollar programme.

Crown defoliation by *D. pini* can result in severe growth loss. On individual trees with less than 50% of the needles infected, a 1% increase in needles infected has been equated with a 1% loss in volume. Trees with 50% or more infection show proportionately greater loss in volume, and trees with 80% or more infection stop growing completely. Severe levels of disease can lead to tree death.

Figure 2: Typical differences observed between trees in genetic trials (photo courtesy of Scion)

> WHAT CAUSES DOTHISTROMA NEEDLE BLIGHT AND WHAT ARE ITS SYMPTOMS?

Dothistroma Needle Blight is caused by a fungus with a complicated taxonomy that has been renamed a number of times. However, among forest pathologists it is generally known as *Dothistroma pini*, the correct name for the imperfect (or conidial) stage of the needle blight fungus. The sexual stage of the fungus (*Mycosphaerella pini*) is not found in New Zealand.

The disease is characterised by distinct brick-red bands (1-3 mm wide) around the needles, earning it the alternative name of Red Band Needle Blight (Figure 3). The red colour is due to production of a toxin, dothistromin, by the fungus. Black fruiting bodies (stromata) can be seen in the red band in later stages of the disease. Adjacent to the red band are areas of yellow necrotic tissue and flanking this region are sometimes areas of dark green tissue. The

Figure 3: Needles infected with Dothistroma Needle Blight (photo courtesy of Scion)

end of the needle beyond the band dies and eventually the whole needle will drop prematurely. Infection generally starts from the bottom of the canopy and progresses upwards.

> WHERE DOES DOTHISTROMA NEEDLE BLIGHT OCCUR?

The fungus *Dothistroma pini* was first discovered in New Zealand in 1966 near Tokoroa, but has since spread to all parts of the country. Dothistroma Needle Blight is often severe in the central North Island, Waikato, and Taranaki regions and also in the Westland region of the South Island. The fungus can be found in nearly all parts of New Zealand, but is not generally a problem outside these regions except for a few localised areas. However, where it occurs at high levels, it is considered to be a severe problem.

> WHAT FACTORS AFFECT THE SEVERITY OF DOTHISTROMA NEEDLE BLIGHT?

The distribution of the disease can be explained by climate, which has a huge influence on the incidence of this disease. The level of disease is very dependent on summer rainfall and the humidity and temperature in a forest stand. Wet weather, especially over the period between November and February, encourages the release and spread of spores. Infection and growth of the fungus and resultant symptom development require high humidity and warm temperatures. Long dry periods after infection lead to less severe disease. Warm temperatures are less important than humidity, but infection at lower temperature is dependent on an even longer period of extended high humidity. High light intensity can also increase disease severity, so that stands with a northern aspect can sometimes have somewhat higher disease incidence.

The effects of temperature and humidity on the extent of disease also explain the annual differences in disease incidence, which are often large. Similarly, reductions in disease incidence with the silvicultural practices of thinning and pruning are evident. These practices can help reduce disease by removing infected branches, increasing air circulation and decreasing the inoculum in the forest environment.

Figure 4: Dothistroma infection in stand canopy (photo courtesy of Scion)

> HOW DOES DOTHISTROMA RESISTANCE INTERACT WITH OTHER TRAITS?

Selecting for Dothistroma resistance can have an impact on other traits as well. Selection for increased Dothistroma resistance is usually accompanied by a slight improvement in growth rate (measured as diameter at breast height or DBH) and stem straightness, a slight increase in multinodality and a slight decrease in wood density. Where they are undesirable, these associated changes can be minimised by selecting parents that do not show an altered performance for these other traits. However, there is a trade-off in that a decreased Dothistroma resistance must be accepted in order to prevent an accompanying change in these other traits.

Ratings for Dothistroma resistance are directly related to the growth loss that can be expected due to this disease. However, the ***GF Plus*** rating of planting stock for its genetic potential for growth is independent of Dothistroma resistance. (The rating for growth does not include progeny tests that are highly infected with *Dothistroma pini*, where growth performance is related more to the disease than to the stock's innate genetic propensity for growth.) It is therefore usually desirable when selecting for Dothistroma resistance to also take into account the genetic potential for growth rate. Conversely, when selecting planting stock for sites that are not affected by Dothistroma Needle Blight, it is desirable to de-emphasise this trait in order to maximise profitability.

These concepts are illustrated in Figure 5, which shows results of four simulated selections of the best 10 parents for control-pollination:
1) Selection for diameter growth (DBH) only.
2) Selection for Dothistroma resistance only.
3) Selection for both traits together with more emphasis on Dothistroma resistance.
4) Selection for both traits together with more emphasis on diameter growth (DBH).

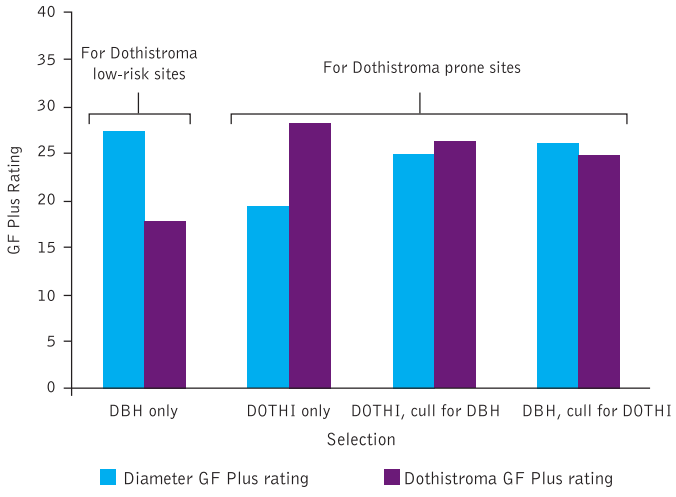

Figure 5. Trade-offs in predicted genetic gain in Dothistroma resistance and diameter growth rate (DBH - diameter at breast height): **GF Plus** values for controlled-pollination of the top 10 parents selected using different selection criteria

Firstly, the maximum possible gain for a trait is achieved when selection is for that one trait only. However, selection for one trait alone also results in the minimum gain in the other trait. In the case of planting sites where Dothistroma Needle Blight is not a problem, forest owners would usually want to aim to maximise growth and sacrificing Dothistroma resistance would not be a problem.

Secondly, substantial gain can be achieved in two traits when both are used as selection criteria. Thus, on Dothistroma prone sites forest owners would likely want to place selection emphasis on both diameter growth and Dothistroma resistance, perhaps with the emphasis placed on each trait dependent on the level of infection expected.

It should also be noted that because of the positive correlation between diameter growth and Dothistroma resistance, selection using any of these strategies will result in genetic gain in both diameter growth and Dothistroma resistance over the population mean.

The old GF rating was based on the expected performance for growth and straightness (form), with diameter growth weighted 2/3 and straightness weighted 1/3. In addition to providing an updated rating for Dothistroma resistance, ***GF Plus*** provides a rating that is not confounded with any other trait, thus providing the transparency required when considering genetic options in view of trade-offs with changes in other traits.

> HOW ARE TRAIT RATINGS DERIVED?

GF Plus Dothistroma resistance trait ratings are derived from Radiata Pine Breeding Company (RPBC) single-tree-plot progeny trials. The trials are on relatively flat sites and infection on each tree is assessed from the same aspect, so that the average level of disease is similar throughout the trial. The amount of infection in a trial does not seem to affect the quality of the assessment for ranking parents; good results (that is, moderately high heritabilities) have been obtained on sites with as little as 15% of the needles infected. Current ratings use data from 10 trial sites measured a total of 18 times at age 2-9 years from planting. Multiple assessments of the same trial can be used in ranking for this disease because they represent independent infection events. An overall performance rating is then calculated (see Information Bulletin No. 1 "Rating the Genetic Quality of Radiata Pine" for more details on rating calculation).

Ratings represent relative predicted performance, and as such, suggest which parents are most likely to have progeny with the highest Dothistroma resistance. Parents predicted to have the highest Dothistroma resistance have corresponded well with actual disease levels in large-plot genetic gain trials.

> WHEN ARE GAINS IN DOTHISTROMA RESISTANCE LIKELY TO APPEAR?

The disease is most severe up to mid-rotation, when trees appear to develop resistance. Reductions in disease symptoms from genetic improvement can be expected from the time of planting. In side-by-side comparisons of different seedlots, genetic differences became visible at about age 2-3 and remained constant as the stand grew. Reductions in Dothistroma Needle Blight symptoms with genetic improvement were also similar in trials in different regions and through time as the stands aged.

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> WHAT GENETIC GAINS CAN BE EXPECTED?

Substantial increases in Dothistroma resistance have been associated with using genetically superior planting stock in genetic trials wherever Dothistroma Needle Blight has been a problem. Correlations of rankings among assessment ages and among sites are similar, which supports other data suggesting that relative genetic resistance remains constant over all areas where Dothistroma is a problem.

The level of reduction in disease symptoms (and thus reduction in growth loss) of genetically improved planting stock is expected to be at a constant level across ages and across sites. That is, if a reduction in disease symptoms is predicted to be 20%, the average number of needles showing disease symptoms would be expected to be reduced from 55% down to 35% in a severely infected stand, or from 25% down to 10% in a less infected stand.

> HOW DOES DOTHISTROMA RESISTANCE AFFECT VALUE?

Dothistroma infection can be successfully controlled using a combination of spraying with copper fungicides and the use of Dothistroma resistant planting stock.

Use of Dothistroma resistant planting stock can be expected to result in substantial savings in annual spraying programmes with copper fungicides. A simulation study done by one of the major forest owners showed that, with a 15% reduction in disease from planting stock with Dothistroma resistance, the company's average spraying costs over a number of years would have been reduced by over 60% and even more in years when disease incidence was high.

Year	Non-resistant breed		Dothistroma resistant breed		Savings		
	Area Sprayed	Cost	Area Sprayed	Cost	Area Sprayed	Cost	% Savings
1983	19	454	15	374	4	80	18%
1984	59	1219	14	327	45	892	73%
1985	32	673	7	195	25	475	71%
1986	58	1209	27	586	31	623	52%
1987	40	563	8	144	32	419	74%
1988	31	477	10	168	21	309	65%
Total	239	4595	81	1794	158	2798	61%
Mean	40	766	13	299	26	467	61%

Figure 6. Simulated study of area sprayed (thousands of ha), costs and savings (thousands of 1988 dollars) of spraying Kinleith Forest with copper fungicide and estimated area and costs required if Dothistroma resistant breed had been planted. (Dick, A. M. P., 1989: Control of Dothistroma Needle Blight in the *Pinus radiata* stands of Kinleith forest. N Z J. For. Sci. 19, 171-179)

In addition, the control of Dothistroma Needle Blight with copper fungicides does not eradicate the disease, and there is often a substantial amount of infection even in stands that are sprayed. Use of resistant planting stock will, therefore, also avoid a substantial amount of the growth losses associated with the needle infection that occurs even with an annual spray programme.

For more information
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