RADIATA MANAGEMENT TECHNICAL NOTE

Site Productivity

Number: RSPTN-011
Date: September 2010

Seedling Performance and Nursery Treatments

Summary

Seedling nurseries apply fertiliser and fungicide as standard practice. However, the potential for these treatments to influence the formation and development of beneficial ectomycorrhizal (ECM) associations is largely unknown. As part of a study into the ongoing effects of nursery management on ECM associations with *Pinus radiata* seedlings, the effects of variations in fungicide and fertiliser applications on root collar diameters of several thousand seedlings were determined. Increasing levels of fungicide application substantially decreased root collar diameters ($P < 0.001$). Root collar diameters tended to increase somewhat with greater levels of fertiliser application but this trend was not consistently statistically significant. Further work is being conducted to determine if the fungicide and fertiliser treatments have altered the diversity and number of ECM associations formed by the seedlings, which may explain the apparent deleterious effect of increased fungicide application on root collar diameter. Measurements on out planted seedlings will continue for at least a further two years to identify any ongoing effects of the nursery treatments on ECM associations and seedling growth.

Authors: Simeon Smaill and Katrin Walbert

Background

Mycorrhizal symbioses are essential to the ability of *Pinus radiata* D. Don (radiata pine) to take up sufficient nutrients and water, and are therefore crucial for seedling growth and establishment (Duñabeitia *et al*. 2004, Ortega *et al*. 2004). Various studies have been conducted to identify beneficial ectomycorrhizal (ECM) species for inoculation in pine tree nurseries, but much less is known regarding the effects of nursery management treatments on mycorrhization and the implications for seedling performance.

This is an important knowledge gap, as it has been confirmed that ECM associations formed with radiata pine seedlings in the nursery can persist for some time after out planting (Walbert 2008). Consequently, it is possible that management practices which affect the development of ECM associations in the nursery can indirectly affect the growth and performance of seedlings for several years following out planting.

To improve understanding of the effects of conventional radiata pine nursery management practices in New Zealand, a trial was established at Te Ngae Nursery, Rotorua (Timberlands Ltd.) to examine the effects of variations in the application rates of fungicides and fertilisers. The seedlings in the trial were subjected to the treatments for approximately five months. Here we report the effects of these treatments on the root collar diameters of the seedlings immediately prior to out-planting, and on the root collar diameters of seedlings approximately one month after out-planting.

Methods

A complete description of the trial layout and dosage regime is presented in the work plan for Task 1.2 (IO1). Briefly, the fungicides and fertilisers used in the trial were selected on the recommendations of the nursery manager. Fungicide selection was based on known problems in the nursery, with particular attention to deleterious fungal species present in the previous year. Soil nutrient analysis determined the fertiliser application regime.

Fungicides:
Ridimol Gold MZ WG (*Phytophthora* root rot),
Sporetak (Terminal crock *Colletotrichum acutatum*),
Shirlan (*Phytophthora* root rot)
Agri-Fos (*Phytophthora* and *Pythium* root rot)

Fertilisers:
Agroblen (NPK)
Nitrophospho Blue (NPK)

Both fungicide and fertiliser treatments were applied at three levels – standard application rates, 25% less than standard and 25% greater than standard.

The fungicide and fertiliser treatments were applied together, making a total of nine treatment combinations. Each treatment combination was replicated 9 times over a total of 81 treatment plots each containing approximately 500 *P. radiata* seedlings. A further 27 plots were established as control plots, receiving no applications of fungicide or fertiliser. The inclusion of these completely untreated control plots allowed the effect of no fungicide and no fertiliser to be compared with fungicide and fertiliser treated plots in a balanced, statistically valid model while also minimising the number of plots required.

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

As all seedlings were subjected to topping and root trimming as part of standard nursery practices the only unbiased measurement available to assess seedling performance was root collar diameter. Root collars were measured on approximately 44 seedlings from each of the 108 plots in the nursery. Prior to lifting, 20 seedlings from each plot were measured, and a further 24 seedlings (approximately) that had already been lifted were measured one month after out planting in Kaingaroa forest. All seedlings used for measurements, ECM analysis and out planting were taken from the centre of each plot.

Results

Root collar diameters across the 2160 seedlings measured in the nursery decreased substantially at the highest rate of fungicide application ($P < 0.001$) relative to the standard and low application rates.

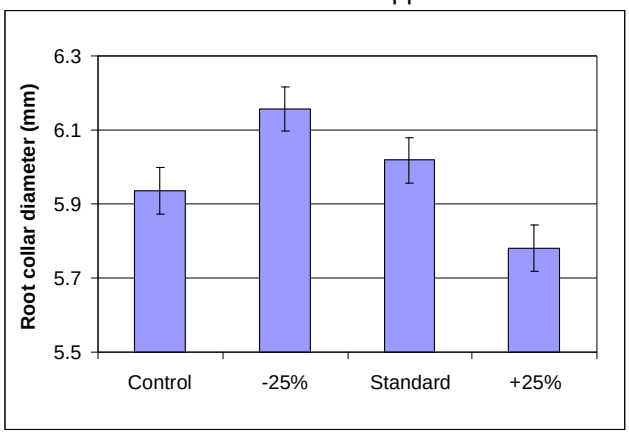

Fig 1. Effects of differences in fungicide application rates on root collar diameter in the nursery seedlings.

The low fertiliser application rate decreased root collar diameters in the nursery seedlings relative to the standard and high application rates ($P < 0.05$).

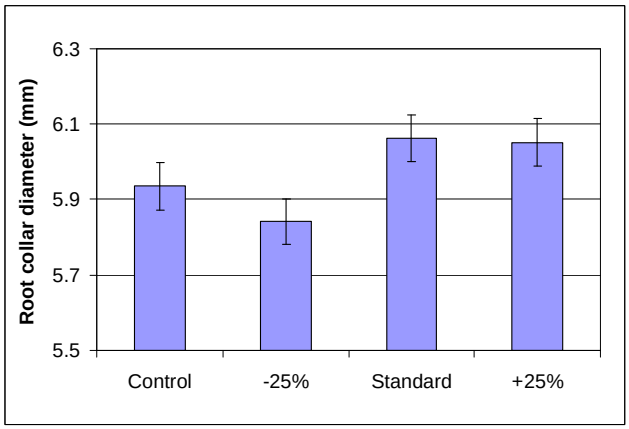

Fig 2. Effects of differences in fertiliser application rates on root collar diameter in the nursery seedlings.

Statistical analysis of the differences between all treatment combinations determined that no combination of fungicide and fertiliser significantly outperformed the control plots in terms of root collar diameter.

The measurements of the out planted seedlings indicated that the negative effect of the high fungicide application rate was still apparent but there was no difference between the low and standard rate. Both low and standard rates also outperformed the control ($P < 0.01$) but there was not difference between the control and high fungicide treatment.

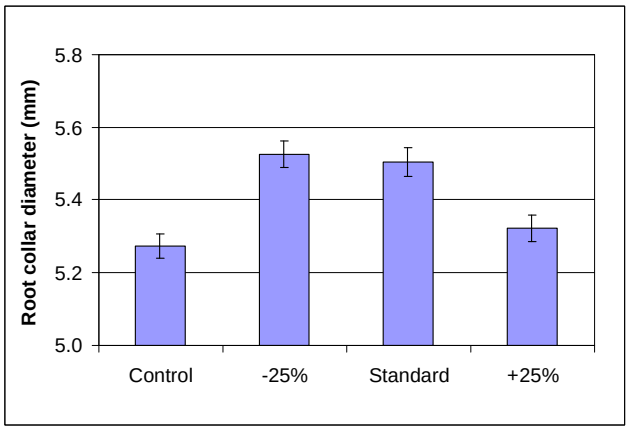

Fig 3. Effects of differences in fungicide application in the nursery on root collar diameter of out planted seedlings.

Any effects of the differences in fertiliser application rates were not evident after one month out of the nursery, although root collar diameters from any plot which received fertiliser at any rate were greater than those from control plots ($P < 0.05$).

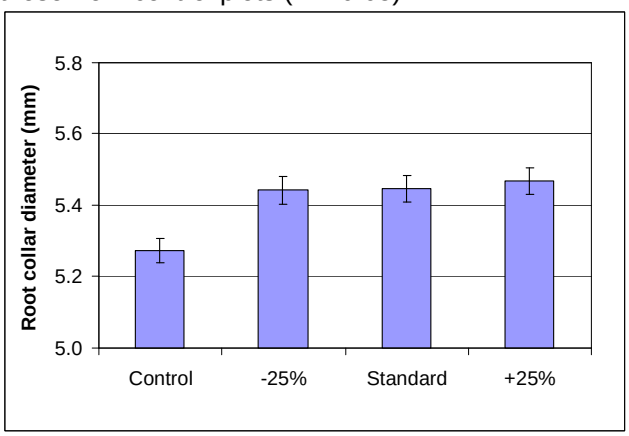

Fig 4. Effects of differences in fertilisation application in the nursery on root collar diameter of out planted seedlings.

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

Interpretation and Ongoing Work

The root collar diameters of the 2596 seedlings measured one month after out planting were smaller (by approximately 10%) than those of the seedlings measured in the nursery. This was probably due to the seedlings being replanted deeper in the ground relative to the seedlings that were measured in the nursery, but may also be an effect of transplant shock (South and Smith 2000)

At this stage the mechanism for the relationship between fungicide application and root collar diameter in the nursery seedlings and out planted seedling cannot be clearly demonstrated. However, given the potential for various fungicides to influence the formation of beneficial mycorrhizal associations (Garbaye *et al*. 1992, O'Neill and Mitchell 2000, Rao *et al*. 2006) it is suspected that the cause may be related to the effects of fungicide on the activity of beneficial mycorrhizal species. This will be investigated by an analysis of root samples taken from 432 seedlings in the nursery. Further sampling will also occur at the out planted site to assess the persistence of any effects of the nursery fungicide treatments on mycorrhizal diversity and development.

Nutrient addition has previously been noted to increase growth rates in seedlings (e.g. Mandre *et al*. 2010). Consequently the observed increases in root collar diameter with greater fertiliser application rates in the nursery seedlings was not unexpected. The results from the out planted seedlings suggest a different finding – that any level of fertiliser application is preferable to none, but the magnitude of the addition is effectively unimportant. This is also borne out in the differences between the control and the low and standard fungicide treatment rates illustrated in Fig 3 but not Fig 1.

Although these preliminary results suggest that decreased fungicide application combined with standard rates of fertiliser addition are most cost-effective in terms of root collar diameters, the relationship between this measurement of tree growth and stand productivity over a longer time frame is not clear. Furthermore, any potential cost and production benefits accruing from reductions to fungicide application rates must be balanced against the need to prevent pathogen outbreaks in the nursery.

Further measurements of the growth of the out planted seedlings, which will be taken over the next few years, are required to better understand the relative benefits of different nursery fungicide and fertiliser application rates.

Fig 5. P. radiata *seedlings at Te Ngae Nursery*

References

Duñabeitia MK, Hormilla S, Garcia-Plazaola JI, Txarterina K, Arteche U and Becerril JM 2004. Differential responses of three fungal species to environmental factors and their role in the mycorrhization of Pinus radiata D. Don. Mycorrhiza 14, 11-18.

Garbaye, J, Churin, J-L. and Duponnois R 1992. Effects of substrate sterilization fungicide treatment, and mycorrhization helper bacteria on ectomycorrhizal formation of pedunculate oak (*Quercus robur*) inoculated with *Laccaria laccata* in two peat bare-root nurseries. Biology and Fertility of Soils 13, 55-57.

Mandre M, Pärn H, Klõšeiko J, Ingerslev M, Stupak I, Kört M and Paasrand K 2010. Use of biofuel ashes for fertilisation of *Betula pendula* seedlings on nutrient-poor peat soil. Biomass and Bioenergy 34, 1384-1392.

O'Neill JJM, and Mitchell DT 2000. Effects of benomyl and captan on growth and mycorrhizal colonization of Sitka-spruce (*Picea sitchensis*) and ash (*Fraxinus excelsior*) in Irish nursery soil. Forest Pathology 30, 165-174.

Ortega U, Duñabeitia M, Menendez S, Conzalea-Murua C and Majada J 2004. Effectiveness of mycorrhizal inoculation in the nursery on growth and water relations of *Pinus radiata* in different water regimes. Tree Physiology 24, 65-73.

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

Rao B, Marx DH and Jeffers B 2006. Response of oaks and elm to soil inoculations with mycorrhizal fungi and rhizobacteria in a nursery. Arboriculture and Urban Forestry 32, 62-66.

South DB and Smith CT 2000. Harvest treatments and fertiliser application affect transplant stress index of *Pinus radiata*. New Zealand Journal of Forestry Science 30, 308-314.

Walbert, K 2008. Ectomycorrhizal communities associated with a Pinus radiata plantation in the North Island, New Zealand. PhD Thesis. Department of Ecology, Lincoln University.