FUTURE FORESTS RESEARCH

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number: RSPTN-036
Date: September 2013

Altering Nursery Management Improves Field Performance

Summary

This technical note describes the main findings of the research undertaken in the FFR IO1 "Influence of Nursery and Forest Management Practice on Plant Growth" project, which examined the potential for changes in nursery fertiliser and fungicide use to improve *Pinus radiata* seedling performance.

Ectomycorrhizal (ECM) fungi in the nursery soil responded to fertiliser and fungicide use, the ECM species most beneficial to the seedlings being strongly negatively affected. Seedling growth in the nursery was reduced by increased fungicide use, while increasing fertiliser use beyond standard rates provided no benefits. The fungicide treatments produced significant legacy effects in seedlings after two years in the field.

Seedling survival rates, diameter and height increments were greater in seedlings that were exposed to less fungicide in the nursery. Further research is required to generalise these results, but it is apparent that a change in nursery management towards less fungicide use may be cost effective, producing seedlings that are better adapted to the locations in which they are planted.

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Background

Fertiliser and fungicides are routinely used in radiata pine nurseries to improve seedling growth and provide protection from pathogens[1]. However, both treatments can have affects on the colonisation of seedlings by ectomycorrhizal (ECM) fungi [2,3], which may negatively affect survival and growth once the seedlings are transplanted to the field[4,5].

The FFR IO1 project "Influence of Nursery and Forest Management Practice on Plant Growth" was established to determine if it was possible to improve early seedling performance by altering chemical use in a *P. radiata* nursery to make better use of ECM fungi present in the soil. The principal results of this project are reported here.

Nursery Trial

The nursery trial was established at Te Ngae Nursery, Rotorua (Timberlands Ltd.). The trial consisted of 108 plots, each containing approximately 500 *P. radiata* seedlings, treated with various application rates of fertiliser and fungicide products in different combinations over five months.

The rates used were:

- none,
- 25% less than standard,
- standard,
- 25% more than standard.

Further details on the trial are presented in Smaill and Walbert (2010)[6].

After five months had elapsed, the seedlings were ready for lifting and transplantation to the field. Root collar diameters on at least 44 seedlings per plot were measured and analysed prior to outplanting. These data determined that the growth of the seedlings while in the nursery was significantly affected by the variations in chemical use (Figure 1).

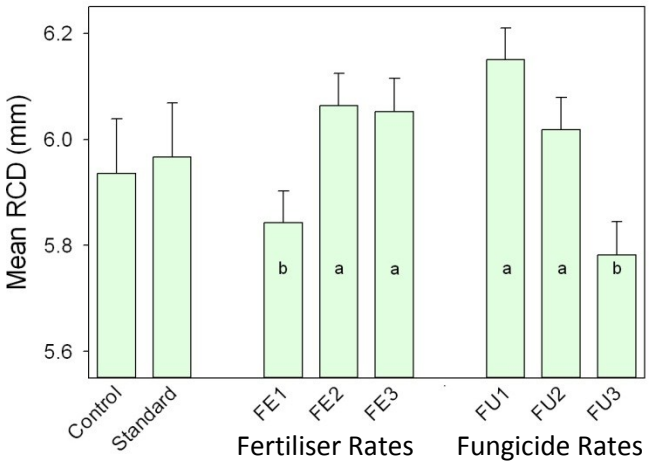

Fig 1. The lowest fertiliser application rate (FE1) significantly decreased seedling root collar diameter growth (RCD) compared to the standard (FE2), and increased (FE3) rates. The greatest fungicide application rate (FU3) significantly decreased seedlings' growth compared to the lowest (FU1) and standard (FU2) rates. Seedlings receiving no fertiliser and no fungicide (Control) performed just as well as seedlings receiving the standard treatment (FE2 and FU2 in combination).

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To assess how the fertiliser and fungicide treatments had affected ECM development, four seedlings from each of the 108 plots were collected, and the root tips colonised by ECM fungi on three randomly selected lateral root branches were counted and identified. Approximately 150,000 root tips were identified as being infected with an ECM species. *Rhizopogon rubescens* was the most frequently observed ECM species (57% of all observations), followed by *Wilcoxinia mikolae*, *Hebeloma* sp., *Tuber* sp. and *Thelephoraterrestris* in decreasing order of incidence. These five species accounted for 99.94% of all colonised root tips[7].

Increasing fertiliser and fungicide application both significantly decreased the relative proportion of *R. rubescens* present on the seedlings. It was thought that this may have implications for seedling nutrition, as *R. rubescens* is considered a particularly beneficial ECM species, able to increase nutrient uptake in seedlings of coniferous species [8]. This was confirmed by nutrient analysis of the seedlings, which showed that the presence of *R. rubescens* was positively associated with a greater content of nitrogen, sulphur, magnesium and manganese, whereas all other ECM species had either no or a negative effect[9].

Field Trial

Despite the significant findings, all results generated within the nursery were purely academic unless they produced some measurable effect when the seedlings were planted out in the field. This was investigated by taking approximately 2600 seedlings from the nursery trial and planting them in Kaingaroa Forest (Figure 2).

Figure 2. Trial area in compartment 1172/5 of Kaingaroa Forest.

The seedlings were planted at the site in July 2010. Full details of the trial (design, plot layout, measurement periods) are given in Smaill (2012) [10].

Measurements of seedling performance showed that there were significant legacy effects of the nursery treatments on seedlings performance in the field site after two years, despite no further fertiliser or fungicide treatments being applied. Seedling mortality after two years in the field was 4% for seedlings that received no fertiliser or fungicide, whereas mortality was 8% for seedlings that received the standard dose of both fertiliser and fungicide.

Seedling growth was significantly affected by fungicide applications, with both root collar diameter (Figure 3) and height increments (Figure 4) indicating that greater fungicide use resulted in less growth.

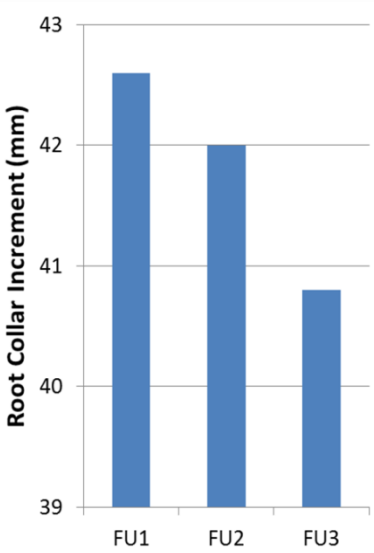

Figure 3. Increased fungicide use in the nursery significantly (P > 0.001) decreased root collar growth after two years.

Differences in fertiliser use in the nursery did not affect growth increments after two years in the field. There was also no difference between seedlings that received the control treatment and the standard treatment in terms of growth, despite the significant difference in survival rates.

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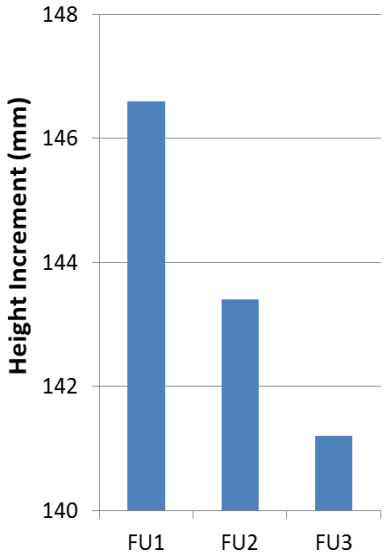

Figure 4. Increased fungicide use in the nursery significantly (P > 0.001) decreased height growth after two years.

Examination of the ECM species associated with the seedlings after two years in the field showed that several substantial changes had occurred. Across all treatments, *W. mikolae* replaced *R. rubescens* as the dominant ECM species, and a number of ECM species present at the field site were starting to colonise the seedlings (Figure 5).

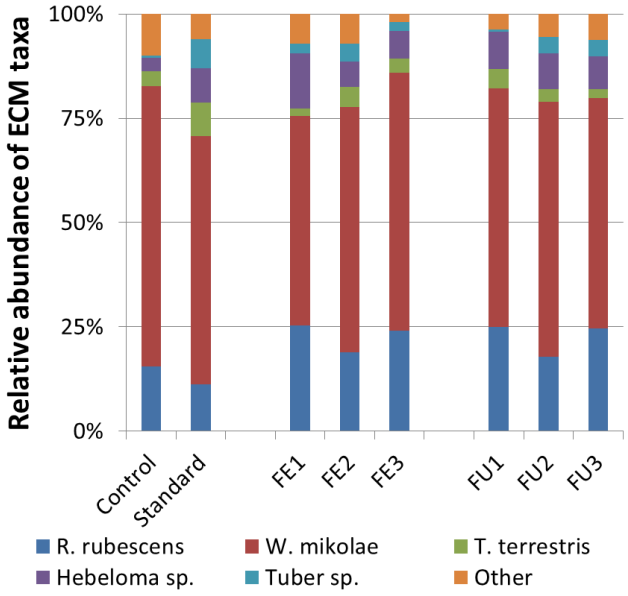

Figure 5. Relative proportions of different ECM fungi associated with the seedlings after two years.

Analysis of these data showed that, in terms of ECM associations, there were no longer any meaningful differences due to the nursery treatments.

Conclusions

The extent of this project is unmatched by any previous attempts to relate nursery management to seedling ECM associations and field performance in New Zealand or elsewhere. The large numbers of seedlings examined in the nursery and field provide confidence in the validity of the results, as does the vast number of ECM root tips examined.

The results of the field trial show that gains can be made in terms of seedling survival rates by altering nursery practice, specifically by reducing the use of fungicide. Given that seedling growth was examined for only two years, it is unknown if the observed differences in diameter and height growth related to nursery fungicide application rates will persist, or be lost over time.

If the variations in growth increment were driven by the differences in the ECM species associated with the seedlings, then it is likely that this effect will not be meaningful over time, as the ECM species present on the seedlings is no longer different (Figure 5). However, if the observed variation in growth rates was the product of differences in how well the seedlings were adapted to conditions at the field site (based on both ECM species and the responses to treatment in the nursery), then it is likely that these differences will persist. This can only be resolved through further measurements at the field site.

Future Research and Opportunities

This project is based entirely on one crop of seedlings from one nursery, planted out at a single field site. It is probable that other crops at other nurseries would yield different results, so this must be investigated. For example, at Te Ngae nursery reductions in the use of fungicide did not result in any increase in fungal pathogens in the seedling crop, but this may not be observed in other nurseries, or in other years. Furthermore, all field observations are based on two years' growth, and it is not possible to reliably extrapolate these results across a longer time frame.

Regardless of these caveats, these results have shown there is an opportunity to produce better quality seedlings in the nursery by making relatively small changes to nursery practice – in this case, by spending less money on chemical products. There

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are many other options for altering nursery practice, such as decreasing stocking rates, which has already shown potential for substantial gains in terms of field survival rates [11].

Extending this research has the real possibility of developing nursery management practices that are able to produce seedlings tailored to the sites they are going to, rather than the current one-size-fits-all approach. This could produce great benefits, but will only be achieved through research and cooperation between nursery growers and forestry companies to provide appropriate recompense for seedlings that may be more difficult to produce, but are of higher quality.

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