RADIATA MANAGEMENT TECHNICAL NOTE

Site Productivity

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Mycorrhizas and New Species Mixture Trials

Summary

Different tree species form different types of mycorrhizas. Pines and Douglas-fir, for example, form ectomycorrhizas (EM), while cypresses and redwoods form arbuscular mycorrhizas (AM). EM species have a greater ability to use nitrogen and phosphorus from organic sources than AM species, allowing them to grow more readily under the cooler temperatures that occur at higher altitudes and latitudes, or at other sites where nitrogen and phosphorus mineralisation rates are slow. Although AM species may be more responsive to nitrogen and phosphorous, they appear to be better at absorbing cations, especially calcium and magnesium, than EM species, and therefore may be less prone to deficiencies of these nutrients. AM species grown next to EM species have been found to have higher foliar nitrogen and phosphorus concentrations than when grown alone. New trials have been established to determine if there may be nutritional benefits to either EM or AM species when they are grown in mixtures.

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What are mycorrhizas?

A mycorrhiza is an association between certain soil fungal species and plant roots, in which the plant gains the use of the fungal mycelium’s very large surface area and small diameter allowing penetration of much finer soil pores than root hairs, to absorb water and mineral nutrients from the soil. Additionally, mycorrhizal plants are often more resistant to soil-borne pathogens. In return, the fungus benefits from carbon compounds (energy) provided by the plant.

Several different types of mycorrhizas have been recognised, but only two are important for New Zealand exotic plantation tree species, namely ectomycorrhizas (EM) and arbuscular mycorrhizas (AM). Many tree species from the northern hemisphere that have become important forest species in New Zealand, including all pine species, Douglas-fir and larch, form EM. The cypresses (macrocarpa, Mexican, Lawson and Leyland cypress) and redwoods are the important AM species. Many EM fungi produce conspicuous fruiting bodies, some of which are well known (*Amanita, Boletus*), or are truffle-like and fruit beneath the soil surface (*Rhizopogon*). In contrast, AM fungi produce inconspicuous fruiting bodies.

Why redwoods are known as site-demanding Species

Nutrients are found in the soil in simple mineral form (for example as nitrate, phosphate or potassium ions) or in complex organic compounds bound with carbon. Soil bacteria and saprophytic fungi break down some of these organic compounds, releasing nutrients in mineral form which can be absorbed by themselves, or by higher plant species. This process is called mineralisation. It has long been known that mycorrhizas enhance uptake of nutrients in mineral form, especially phosphorus, but research in the last 20-30 years has shown that some ectomycorrhizas can also degrade compounds found in plant litter and obtain nitrogen and phosphorus directly from organic material, thus bypassing the bacterial mineralisation process. This means they are less reliant on soil bacteria and other organisms for breaking down and freeing up nutrients from soil organic compounds. This gives EM species like pines an advantage in environments where nitrogen and phosphorus mineralisation rates are naturally slow, and the availability of these elements is limited. EM species therefore tend to perform better than AM species under the cooler temperatures that occur at higher altitudes and latitudes, or at other sites where nitrogen and phosphorus mineralisation is slow. The important AM species in New Zealand forestry, including redwoods, tend to be restricted to warmer, lower elevation sites and more fertile soils. This is why they are commonly referred to as being ‘site demanding’.

Implications for redwood siting and fertiliser management

The nutritional differences between mycorrhizal types have implications for siting of species at local scales as well as the broad regional, latitudinal and altitudinal scales. Nutrient availability varies across landscapes; for example soils may be deeper and more fertile on lower slopes or in valley bottoms or at flush sites. These sites are where the more site-demanding AM species such as redwoods are likely to be best located. Mycorrhizal differences also have implications for fertiliser management. A Scion study that compared the growth of radiata pine (EM) and *Cupressus lusitanica* (AM) at 35 sites across New Zealand, showed that *C. lusitanica* responded more

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strongly to fertiliser than did radiata pine. The average volume responses of the two species at age four was 54% and 23% respectively. These results indicate that the range of planting sites for AM species such as redwood might be extended by fertiliser application. Similarly, although unknown, weed competition for nutrients may be particularly important for successful establishment of AM species at the nutritional limits of their range, hence attention to very good weed control may be important in extending the range of sites available for redwoods.

“Spring yellows” in coast redwood, growing next to a naturally regenerated radiata pine at Ashley Forest, can be seen in the picture above. The colour difference between the species is thought to be due to their different types of mycorrhizas, with redwood struggling to take up nitrogen in early spring when nitrogen mineralisation rates are low because the soil is still cold. This may also account for differences between green redwood trees on northern faces and yellower trees on southern faces.

While EM species may be better able to access nitrogen and phosphorus than AM species, the opposite seems to be true for the cations calcium and magnesium. In the study mentioned above, while *C. lusitanica* contained lower concentrations of nitrogen and phosphorus than radiata pine in the absence of fertiliser, on average it had much greater concentrations of calcium and magnesium. Magnesium is frequently deficient for radiata pine in New Zealand soils, but magnesium fertiliser application is often ineffective in correcting the deficiency, possibly due to high potassium concentrations which can disrupt magnesium uptake and translocation. There may be situations where EM species are severely magnesium deficient, but where AM species like redwood are capable of satisfactory growth and are unaffected by magnesium deficiency.

Are there nutritional benefits from growing AM and EM species in mixtures?

A possibility that remains to be explored is the potential of growing EM and AM species in mixtures for improving nutrient availability. Improved growth and nitrogen nutrition of AM species of *Araucaria* (in Australia), *Fraxinus* (in North America) and *Chamaecyparis* and *Cupressus* (in New Zealand) has been observed when these species are planted next to pines, indicating EM species may enhance nitrogen uptake in AM species. Results from the Scion nationwide study provided further supporting evidence for this – foliar nitrogen, phosphorus and sulphur concentrations in *C. lusitanica* were enhanced when growing next to radiata pine. No studies have yet shown improved nutrition of an EM species growing in the presence of an AM species. To explore the possibility further, two trials have been set up at Conway Hills (North Canterbury), where plantings of coast redwood and *C. lusitanica*, as AM species, have been interplanted with either radiata pine or Douglas-fir (both EM species). This work is being undertaken in the Scion ‘Protecting and Enhancing the Environment through Forestry’ programme funded by FRST and partly by Future Forest Research.

A new trial at Conway Hills, established to determine if there may be nutritional benefits to either EM or AM species when they are grown in mixtures.