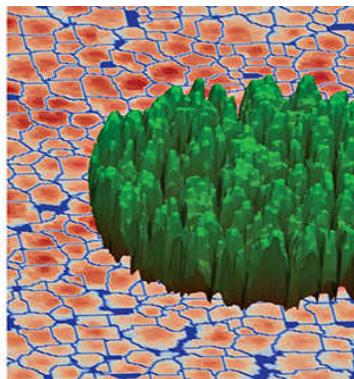
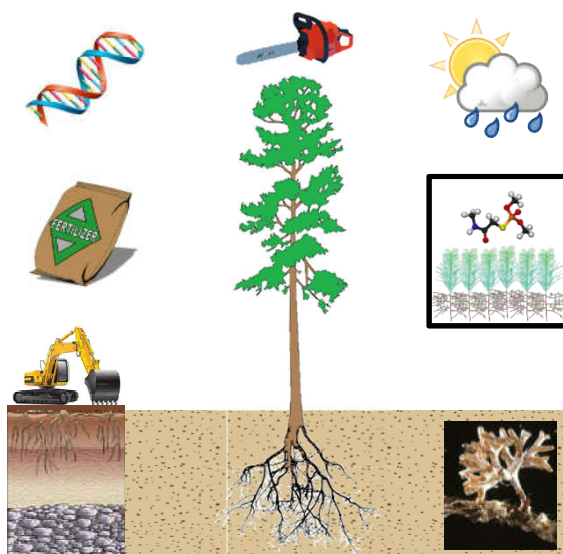


## Nursery and Seedling Optimisation

Simeon Smaill and Patrick Murray



## The impact of nursery management



Nursery management and handling practices affect the status of seedlings leaving the nursery gate

This has important implications for performance in the plantation

- Initial survival rates
- Initial growth rates
- New ground syndrome

## What nursery research has already accomplished

Past studies have made a huge difference

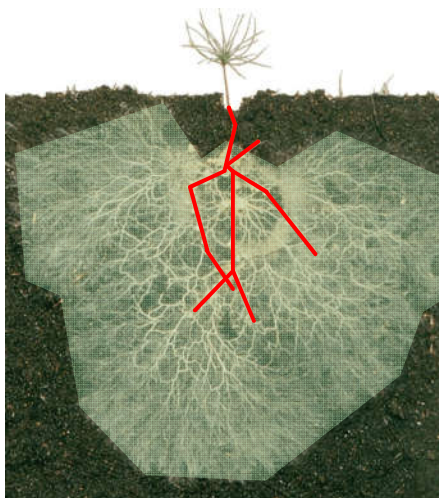
- Undercutting and wrenching
- Topping
- Target stock root collar values
- Fertiliser use
- Fungicide use
- Plastic bags to retain moisture
- White planting boxes and pods
- Planter boxholders and bags



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## What nursery research has already accomplished

Some of the first nursery work Scion did was mycorrhizal in nature



- Ectomycorrhizal (ECM) fungi are key to the ability for conifers to acquire nutrients and water
- The soil volume that the seedling alone can access is insignificant...
- compared to what the ECM can access and deliver to the plant

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## What nursery research has already accomplished

Major problems with chlorosis for new Douglas fir plantations in Nelson region in 1930's – mortality, poor growth and the resulting stocking effects devalued the remaining trees

- R E Lawrence believed it was due to a lack of mycorrhizal fungi on the seedlings
- Tested effects of spreading litter from a successful plantation in Hanmer
- Had positive results – prevention of chlorosis in new seedlings, recovery in affected trees... but not recorded at the time



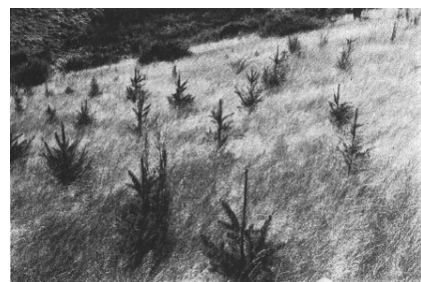
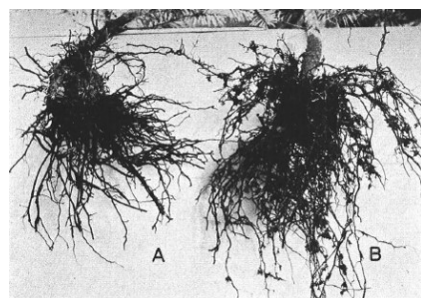
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## What nursery research has already accomplished

Happened again in the 1950's in Otago – extensive study undertaken this time

- Traced to lack of mycorrhizal inoculation in major nursery in Milton
- Remedied problem by adding forest litter to the nursery and the plantations
- Documented this time!  
Gilmour, J.W. (1958) New Zealand Journal of Forestry 7: 94–106

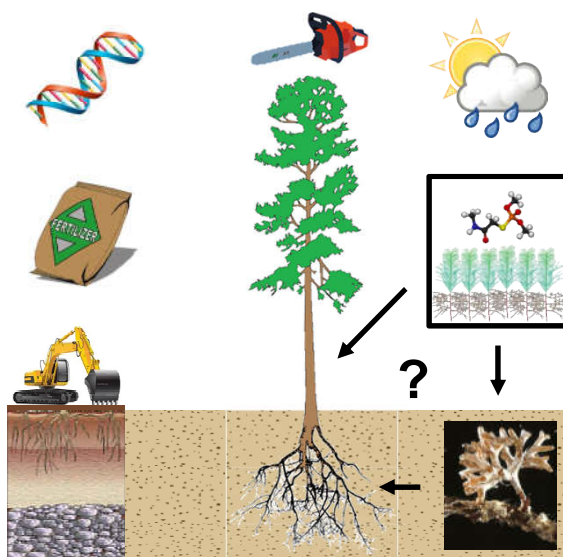




## Murray Davis and friends



## The impact of nursery management



All of this work made NZ a world leader in nursery research and nursery practice by the mid 1980's

So, of course, government funding stopped – no significant research for 30 years

Outcome? Intensification of chemical use

Recently, able to do some new research under the FFR programme

- What are the chemicals doing to the ECM?

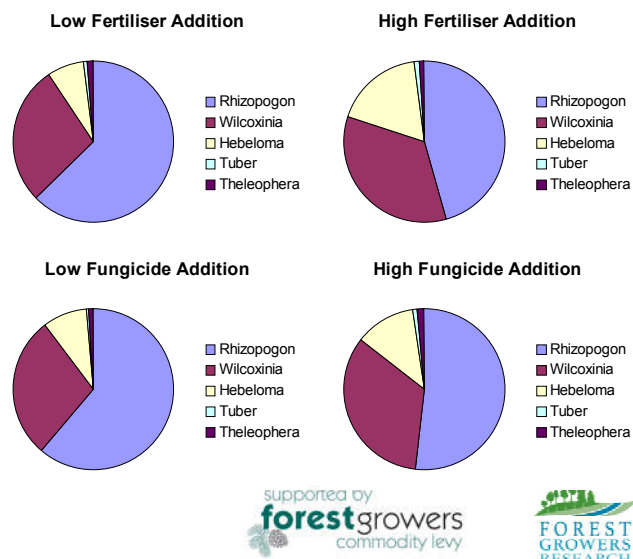
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## ECM and nursery chemicals at Te Ngae

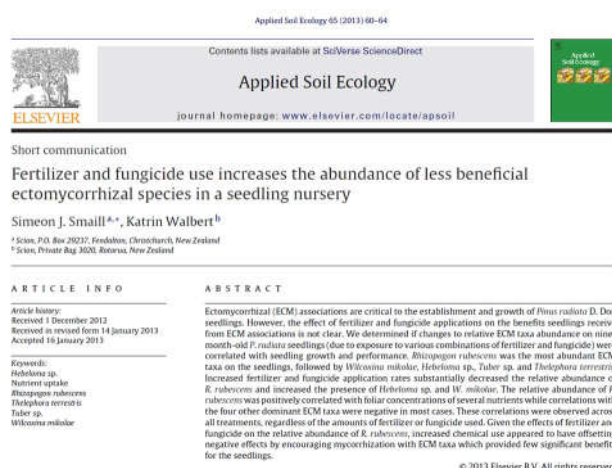
Found that the chemicals were significantly altering ECM populations on seedlings leaving the nursery gate

- Less fertiliser and fungicide increased *Rhizopogon* in particular
- Reducing fungicide had no effect on health – actually resulted in greater root collar diameters



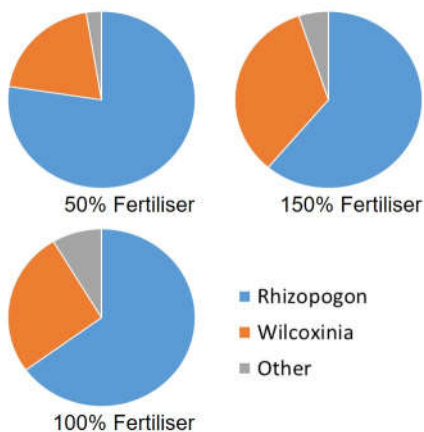
## ECM and nursery chemicals at Te Ngae

- Proportion of *Rhizopogon* on roots positively correlated with foliar N, Mg, S and Mn nutrition
- All other mycorrhiza were essentially unrelated to nutrition, or had negative correlations
- Smaill and Walbert (2013) *Applied Soil Ecology* 65: 60-64



## Further ECM and chemical testing

The Te Ngae trial provided useful data, but was limited – only one nursery and a single cohort of seedlings – so another trial was established at the Scion nursery



Same trends as the earlier Te Ngae trial

- Greater chemical use reduced the presence of the most beneficial mycorrhiza
- No productivity losses with reduced chemical use
- No impact on disease rates and seedling health with reduced fungicide

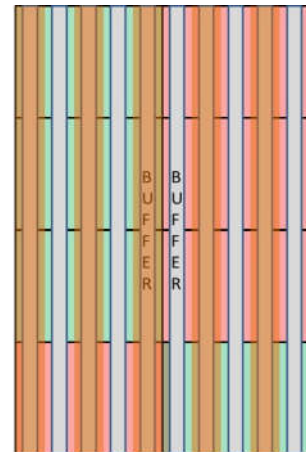
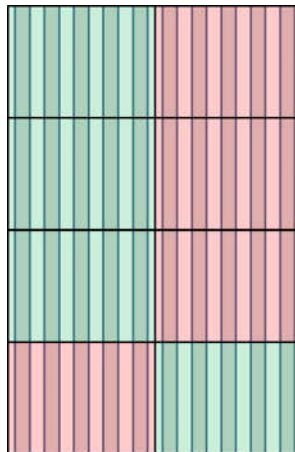
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## Taking the research into practice

Discussions with ArborGen led to the establishment of new trials over 2.4 km of seed bed in 2015

- Can we replicate the maintenance of seedling growth with fewer nutrients?
- Can we replicate the maintenance of seedling health with fungicide reductions?

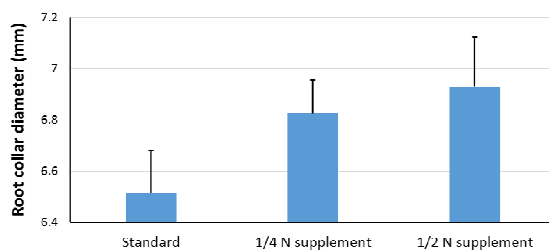


## Maintained seedling health



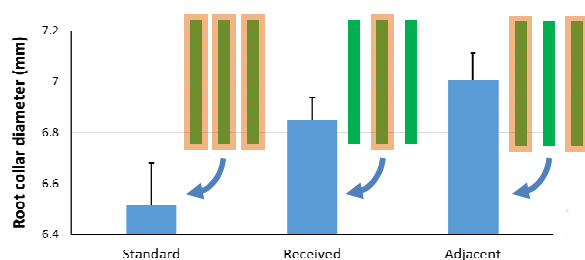
## With better growth

Successful transition from experimental to operational scale

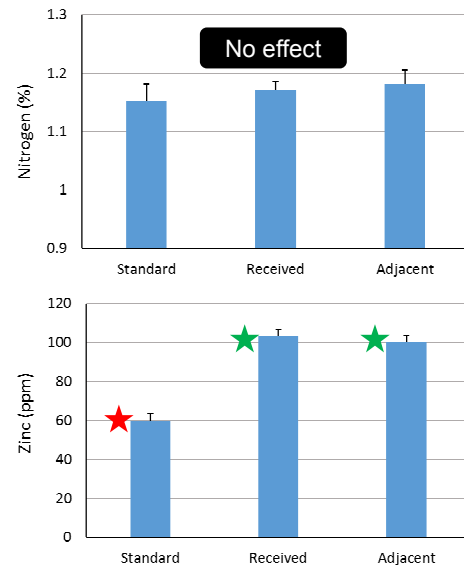
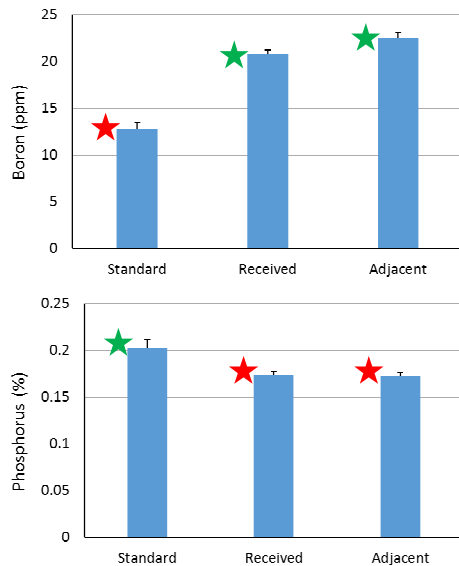


- Gains in seedling growth rates with less N added
- Increased root collar diameters by 4.8% and 6.3% with only a quarter and a half the dose of N

- Gains in seedling growth rates with less fungicide
- Increased root collar diameters by 5.1% and 7.5% by reducing exposure



## Fungicide reductions and seedling nutrition



## Further operational scale work



6.3 km of seed bed in another section of Tokoroa ArborGen

- Tested reductions in Prochloraz fungicide – protection from Terminal Crook
- Combined with biuret as N source at 40% rate of urea
- Found that seedling growth was not affected – can reduce both fungicide and N additions
- Still waiting on nutritional and ECM data



## Patrick Murray

Operates Murray's Nurseries in Woodville

- Five million seedlings per year
- Has explored various methods to reduce inputs and maintain or improve seedling quality
- Active in research with University of Canterbury and the NZDFI
- Highly involved in the FFA and NZPPI



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## Topping Residues and Botrytis



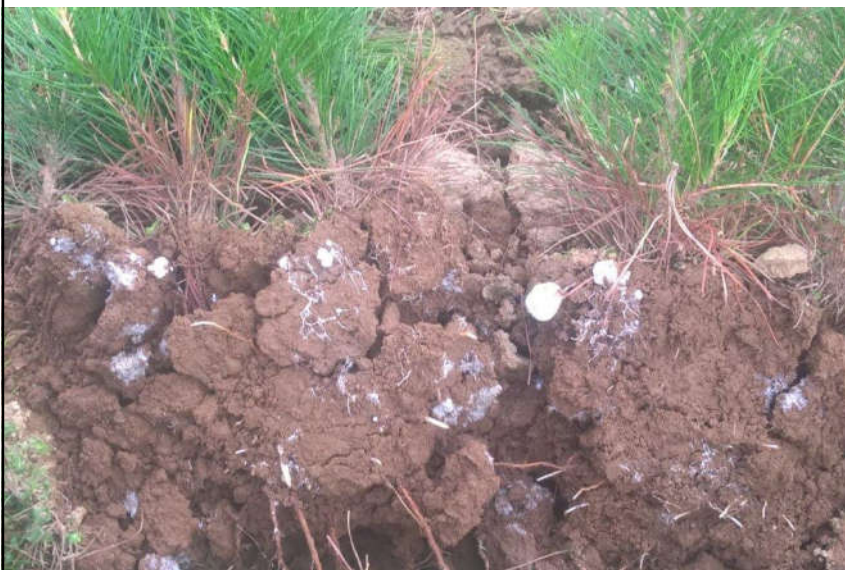
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## Mycorrhizal development



## Cuttings





## 10 row seed sower

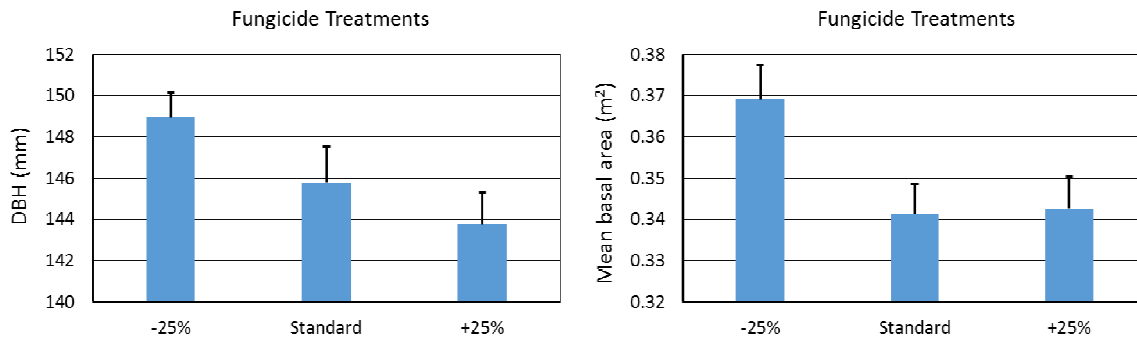


## Impacts on plantation performance – legacy effects?

- Took 2600 seedlings from within the first nursery trial at Te Ngae and planted them at a moderate field site
- Site mycorrhizae taking over from around year 2, but legacy effect of nursery treatment persists
- After 6 years, better survival and growth with less fungicide in nursery, no gains from more fertiliser use in nursery



## Extent of nursery fungicide legacy effect



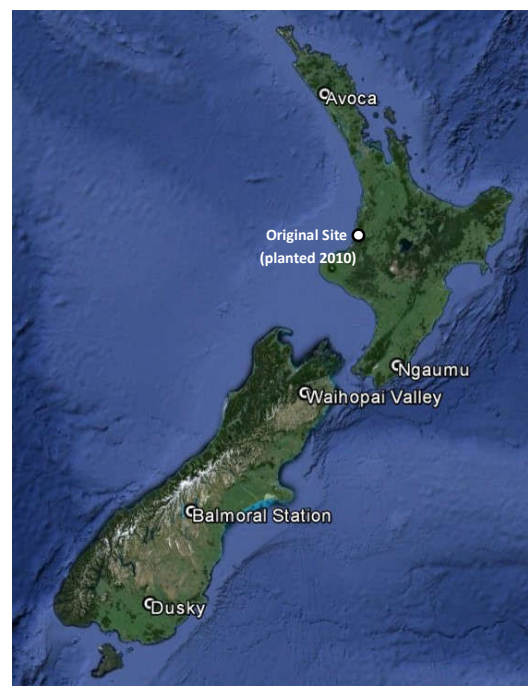
Based on the information we have on these seedling when planted, it appears that this effect is driven by the differences in the ECM community leaving the nursery gate – the more *Rhizopogon*, the better the performance

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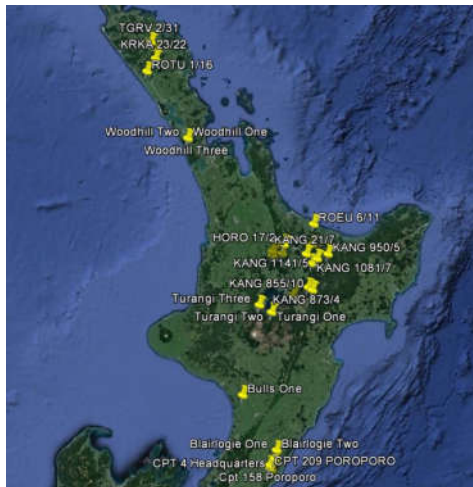
## More outplanting trials

- The Te Ngae seedlings were planted out to only one site... maybe we were lucky?
- To assess this, planted seedlings from the 2015 Scion trial at five new locations
- To date, these seedlings are following the same trajectory as those planted out from the original Te Ngae trial – less fungicide, better mycorrhiza, better performance in the plantation





## Even more outplanting trials



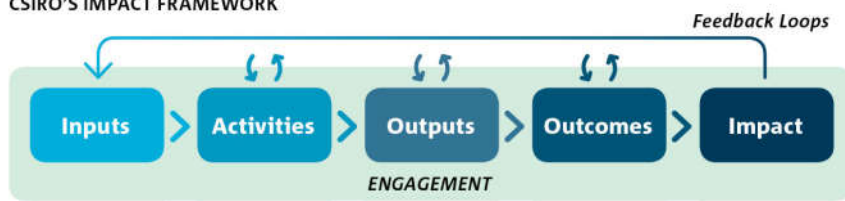
From the 2016 Tokoroa ArborGen trial, seedlings have been planted at 46 trials sites – where do the mycorrhizal differences matter most?

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## Making a difference to forestry with nursery research

CSIRO'S IMPACT FRAMEWORK



Hypotheses, trials and papers

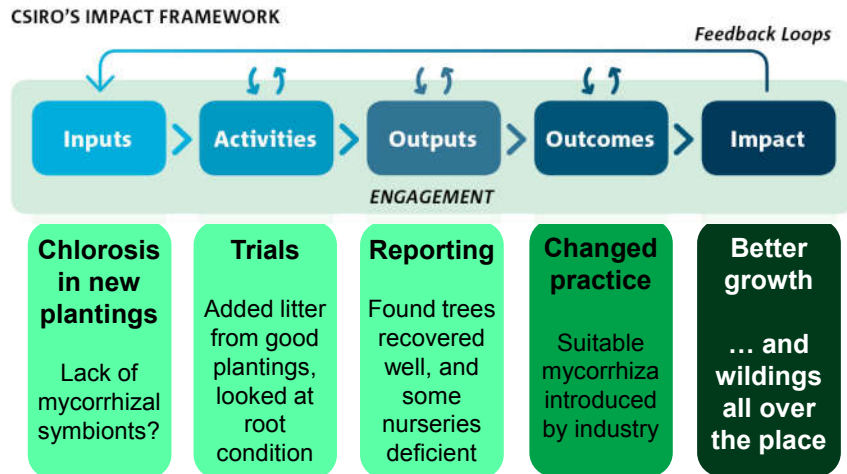
Changes in practice

Improved systems

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## Consider the initial Douglas fir chlorosis problem



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## A cautionary tale

- Trials done with mycorrhiza introduced into sterilized hill country soil in the mid 1970's (NZ J Agric Res 20)
- Amazing results – after 10 weeks, clover dry matter growth was increased by 130% to 3700% compared to controls
- These outputs were heavily promoted and reported widely throughout NZ media – promised a new revolution in farming, driven by these mycorrhizal species

*N.Z. Journal of Agricultural Research 20: 59–62*

59

### Mycorrhizas in hill-country soils

#### II. Effect of several mycorrhizal fungi on clover growth in sterilised soils

C. L.L. POWELL

Ruakura Agricultural Research Centre, Ministry of Agriculture and Fisheries,  
P.B., Hamilton, New Zealand

White clover seedlings were inoculated with the indigenous and five introduced strains of mycorrhizal fungi and were planted out into four sterilised hill-country soils. After 10 weeks' growth, infection with the indigenous mycorrhizal fungi had caused increases in shoot DM over non-mycorrhizal plants ranging from 130% in Waingaro steeppland soil (south aspect) to 3700% in Te Kuiti silt loam. It was more efficient than the indigenous fungi at increasing P uptake and plant growth in Te Kuiti and Mahoeu silt loams. The indigenous fungi in both Waingaro steeppland soils were more efficient than all five introduced fungi at stimulating plant growth. The relative efficiencies of the five introduced mycorrhizal fungi were different in each soil. There was no correlation in any soil between the P uptake efficiency of mycorrhizal fungi and the frequency of their hyphal connections between the soil and the root system.

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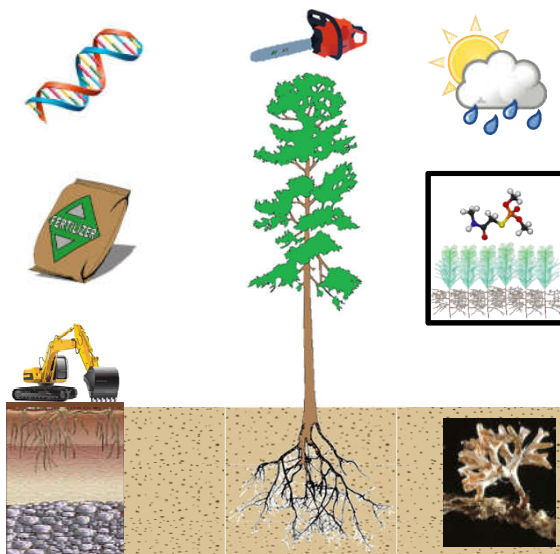
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## Outcomes for the agricultural sector...

- Nothing – operational trials trying to introduce these mycorrhizal species did not show anything of note, after a lot of money and resources had gone into them... stalled at output phase
- Effects spilled out to mycorrhizal research in other sectors, regardless of involvement – funding cuts and decreased interest
- Huge dent to mycorrhizal research as an area of relevance and value to the primary sectors in NZ – which contributed to the 30 year gap in seedling nursery research in NZ



## The place of nursery management in forestry



Part of the overall system – nursery and the associated ECM work is not the end all, be all – just another set of options to get more growth in the forest

In terms of science, in the last 7 years we've made up a lot of ground that we lost during the funding gap, but still need to get the benefits out into practice

Next step is to go beyond catching up – new science, new opportunities to make nursery systems even better



## Future projects

- Scion has consulted with several nursery leaders and we have identified the following as priorities for current and future bids:
  - Incorporation of endohyphal bacteria to provide direct benefits to plants (e.g. N fixation, stress tolerance) – funded by MBIE
  - Automated tissue culture production, including reliable integration of beneficial microbes
  - Automation of physical processes in nursery settings – chemical handling, inventory, lifting and grading
- Additional FGLT funding to extend research further
  - Potential to use new N supplements for weed control
  - Test specific fungicides against beneficial mycorrhiza
- Work on closer nursery / forestry linkages



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18 October 2017

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