"It was broadleaf that saw me right" – in praise of *Griselinia littoralis*

By Geoff Baylis

The University of Otago was founded before the University of New Zealand so it kept its name when it merged with colleges in Auckland, Wellington and Christchurch to form that federation. It was the UNZ that set the syllabus (in detail right down to *Pinus* and *Mucor*), did the examining using professors overseas, and awarded the degrees. When I sat my MSc the examiner was in Dublin, the exam papers had not been proof-read and not all the questions made sense, but this was trivial – one year all the scripts were lost at sea! An attempt was made to establish a PhD in the 1920's, but there were not enough good researchers willing to be supervisors so the degree was abandoned until 1947. So in the 1930's we went abroad to get a PhD. I chose London and made a bad start, losing confidence in the project and the supervisor. It was the shrewd and kind Professor William Brown FRS who helped me produce an acceptable thesis in the remaining eighteen months of my scholarship. Has this any bearing on broadleaf? A little because years later when I told Brown that I was beginning work on mycorrhizas he sighed and said, "More reputations have been lost than made in that field". It was broadleaf that saw me right.

I was trying to find a better root for teaching anatomy when I sectioned broadleaf. It clearly hadn't a clue about classic root structure but I was fascinated by a fungus filling the cells of its wide cortex. For the first time I was confronted by *Rhizophagus* discovered some fifty years before, found in almost everything everywhere since and dismissed as a harmless symbiont. If it was more than this broadleaf would tell me. A critical experiment would stick as close to nature as possible, but I would have to steam the soil to run some non-mycorrhizal controls. The mycorrhizal plants would be best inoculated with their normal rhizosphere by growing them briefly in unsteamed soil. Then they

would be returned to the steamed Ross Creek soil in which they had been raised and a comparison run with seedlings that had been in this soil all the time. Broadleaf grows slowly in our hillside soils and the experiment ran for a year. Differences then were dramatic: plants with *Rhizophagus* were growing, those without it had stalled completely and as the inoculation period had been brief they included a few identical in history with the mycorrhizal plants. Arthur Campbell's Microanalytical Laboratory could quantify low levels of phosphorus and his analyses showed that a higher phosphorus content differentiated the M from NM plants. Mr J.L. Grigg and Invermay reported that the soil had only a quarter of the agricultural minimum of available phosphorus and it proved possible to match the growth of M and NM just by giving the NM plants phosphate.

Barbara Mosse at East Malling Research Station in Kent was actually the first to persuade the reputable journal, *Nature,* to publish a claim to have demonstrated a growth increase attributable to *Endogone* to which genus *Rhizophagus* was now assigned. She worked with apple, but failed to discover the significance of phosphorus uptake because there was no Arthur Campbell at East Malling. *Griselinia littoralis* being a "Who he?" it was after 1964, when Jim Gerdemann confirmed our results at Illinois using maize, that research on what by now was called VA mycorrhizas began to produce hundreds of papers per year, as it still does.

Broadleaf clearly was an extreme example of what today is called mycorrhizal dependency – MD. Maize and apple did not stop growing completely without mycorrhizas and ferns and liverworts grew as volunteers in our steamed soil, so a team of PhD students investigated the basis of mycorrhizal dependency (MD). Karen Cooper studied ferns, Conway Powell rushes and sedges, Jim Crush grasses, Ian Hall rata and kamahi, and Peter Johnson aspects of infection. We concluded that length and abundance of root hairs determined a plant's capacity for non-mycotrophic

uptake of phosphorus. It is pretty obvious why this should be. In a poor soil the phosphorus becomes immobile and to reach it the root system must closely pervade the soil. Only root hairs and fungal hyphae, both being extensions of single cells, do this economically. Even lengthening the hair-like rootlet of a heath involves extending some fifty cells.

We now accept that in mature soils phosphorus is the limiting nutrient and that its extraction is the primary function of mycorrhizas, the great majority being VA. The non-mycorrhizal families, rushes, sedges and crucifers being the most important, have copious root hairs. *Rhizophagus* has become a whole Order of fungi, the Glomales. Some species give more rapid growth response in their hosts than others and are available commercially as inoculum (irrelevant for cruciferous crops), but the resident VA fungi form as it were a powerful union that soon suppresses an alien. Inoculum at a low price could be profitable after crucifer crops or a long bare fallow have depleted the soil's inoculum.

Professor Philipson took a close look at the morphology and anatomy of *Griselinia* and decided it had little in common with the Cornaceae or with any other family but he rejected a Griseliniaceae as a defeatist option and hoped more research would give it a place somewhere. Maybe it is time taxonomists paid attention to roots. Our flora is small enough to make a good starting point. There is a British ecological flora that does consistently describe root systems but never mentions their most significant feature – root hairs. A mistake to avoid!

Griselinia littoralis reached Britain in 1872. It must have travelled in a pot because each seed ripens in a small succulent fruit and is killed by drying. In the UK it is recommended only for mild districts. But provenance is important and I felt sure that seed from the top of Mt Cargill would provide my friends in Shetland with a hardy evergreen and that airmail would get it there alive. This has all come true.