Kowhai (*Sophora* Species) and Other Nitrogen-Fixing Plants of New Zealand©

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INTRODUCTION

New Zealand has a range of trees and shrubs which are able to fix nitrogen from the atmosphere through root nodules. They consist of legumes and some N-fixing non-legumes known as actinorhizal plants. The objective of this paper is to review the species involved (particularly *Sophora* species), and discuss any implications for nursery production.

SOPHORA SPECIES

The genus *Sophora* consists of several flowering leguminous trees and shrubs. They were first called *Edwardsia* and the species and botanical varieties have been reclassified several times; for example Heenan (1998) has revised *Sophora* so that it now includes eight endemic species. Metcalf (2000) reports that seed from the two most common kowhai species were collected by Banks and Solander in 1772 and taken to England where they were probably the first native plants to be cultivated outside New Zealand. The two most widely grown New Zealand species are *S. microphylla* and *S. tetraptera,* and are commonly known as kowhai and are regarded by most New Zealanders as their national flower (Metcalf, 2000). These two tree species are widely distributed in New Zealand but are largely limited to riparian or forest edge sites, and are not pioneer species (Silvester, 1968). Salmon (1997) describes *S. tetraptera* as the North Island kowhai that was found originally growing wild along stream sides and lowland forest margins. Salmon also views *S. tetraptera* as "undoubtedly New Zealand's most beautiful tree".

Sophora chathamica, like the former two species, is quite plentiful and grows on a range of soils in coastal Northland, Wellington, and the Chatham Islands (Heenan et al., 2001). *Sophora microphylla* is the most widespread and is often found on alluvial river terraces while, in contrast, *S. longicarinata* (recently upgraded to species level) comes from a few localised areas around Nelson and Marlborough. Heenan (1998) states that the latter is restricted to calcareous soils and can grow on ledges and in crevices on limestone and marble outcrops. He describes *S. longicarinata* as a calcicole. *Sophora fulvida* and *S. godleyi,* like *S. longicarinata,* are restricted in geographic distribution and soil type with a preference also for base-rich soils of limestone or volcanic origin (Heenan et al., 2001). *Sophora molloyi* and *S. prostrata,* like the former three species, are restricted in where they grow and tend to be found in quite harsh dry habitats where wind and drought minimize the competition from other plants (Heenan et al., 2001). There is, therefore, a contrast between the three more widely distributed species which compete well on more fertile sites and the five species which are quite restricted in habitats — sites that tend to be harsh or specialized through factors such as being rocky, infertile, calcareous, dry, and/or windy.

OTHER WOODY LEGUMES OF NEW ZEALAND

Kaka beaks are in the genus *Clianthus,* which contains two endemic species. *Clianthus* was one of the earliest of the New Zealand plants to be named since it was collected by Banks and Solander in 1769 (Heenan, 2000). They are found in nonforested rocky habitats that are exposed to direct sunlight (Shaw and Burns, 1997). There are only limited populations of *C. maximus* at East Cape and Hawke's Bay and it is classified as vulnerable, while *C. puniceus* is considered to be critically endangered and is only found on an island in Kaipara Harbour (de Lange et al., 1999).

Heenan (1996) described *Carmichaelia* as a legume genus of 17 recognised species. However the genus has been expanded to include a further six species along with the inclusion of three other broom genera of New Zealand (Heenan, 1998; Wagstaff et al., 1999). *Carmichaelia crassicaule,* for example, is a broom, which is endemic to New Zealand and was formerly classified in the genus *Corallospartium*. It is not very abundant and is found in dry and localized areas on the east side of the Southern Alps. It is quite diverse in growth characteristics and can grow to over 6 m or to just a mere few centimetres high. The impressive weeping *Carmichaelia stevensonii* (formerly *Chordospartium*) is endemic to Marlborough province and grows to 8 m (Metcalf, 2000). Finally there are three brooms that were classified as *Notospartium* species and which tend to grow in similar areas to *C. crassicaule* in the South Island. All these broom genera are legumes, which cope with quite dry and often fairly infertile sites but probably have not played a big impact on floral successions because of their limited distribution. This is in contrast to introduced exotic legumes like gorse and broom that are very widely distributed weeds which have been so invasive on many sites in New Zealand. These exotics do, however, contribute to soil N and stabilize slopes against erosion.

ACTINORHIZAL PLANTS OF NEW ZEALAND

Worldwide there are over 190 higher plant species which have actinorhizal associations. These plants have actinorhizal root nodules which make use of a bacterial endophyte, an actinomycete, which is commonly considered to be in the genus *Frankia* (Newcomb and Pankhurst, 1982a). *Coriaria* is an example of an actinorhizal New Zealand native plant, and there are 15 species of which 13 have root nodules. A shrubby form of tutu (*C. sarmentosa*) and the tree tutu (*C. arborea*) occur almost throughout New Zealand (Webb et al., 1990). It is a pioneer species of shrub that grows on a wide range of relatively infertile or dry sites (Newcomb and Pankhurst, 1982a). Salmon (1997) states that *C. arborea* was the first plant to grow on the pumice deposits thrown out from the eruption of Mt. Tarawera. *Coriaria* can have a role in providing fixed N for *Pinus radiata* forests in New Zealand just as it serves to supply N for oaks in Spain (Silvester, 1968).

Discaria toumatou is another example of an actinorhizal New Zealand native plant which makes use of one or more species of *Frankia* (Newcomb and Pankhurst, 1982b). This is a well-known spiny shrub of the tussock lands of New Zealand. It is commonly called wild Irishman or matagouri and is the only endemic species within a genus of 12 Southern Hemisphere spiny shrubs. It is an important associate of short tussock grasslands where it has the unusual distinction of being considered a scrub weed (Keogh and Bannister, 1992). Daly (1969) states that it plays a useful part in forming vegetation on shingle fans, riverbeds, and occasionally on eroded slopes. He points out that it is scattered across large areas and can grow to 6 m.

Pomaderris apetala and *P. hamiltonii* are small shrubs or trees, which like matagouri are in the Rhamnaceae, a family known to include several N-fixing species. The former species is limited to only a few coastal localities, while *P. hamiltonii* is more widespread but is mostly restricted to clay soils (Salmon, 1997).

IMPLICATIONS FOR NURSERIES

Growers of legumes and other New Zealand N-fixing plants in containers do not normally make any special allowance for these plants and they are normally raised in general mixes. It is, however, possible to grow plants with low or nil added N fertiliser if there is sufficient bacteria present to encourage nodulation. This was found by the authors using inoculation of container media for *S. microphylla* (unpublished research). Crushed root nodules were used for inoculant, which promoted more root growth compared to those with no inoculant. Inoculated plants had many more root nodules than non-inoculated ones, especially at low added N levels. Nodulation was also found to require well aerated media while poor aeration at the bottom of the pots inhibited nodule formation. However in other work by the authors (unpublished research) it was found that *S. microphylla* will respond well to added N where no inoculant has been used. It can be concluded that the container production of New Zealand native N fixers should not require any special procedures where plants will go into suburban gardens and parks, i.e., fertile soils.

Legumes and other N fixers will generally tolerate a wide range of sites including ones of low fertility. Many are good colonisers able to cope with quite harsh and infertile sites. However it should be noted that the nursery objective should not be one of trying to produce a starved plant. Nutrient deficient plants would take a very long time to grow in the nursery and establish poorly. The ideal situation would be to produce plants that are not nutrient deficient and have N-fixing nodules. In addition to this, for very infertile sites, inoculation with mycorrhiza would be beneficial, thus producing a plant armed with both bacterial and mycorrhizal symbionts. Matagouri which colonises low-fertility shingle fans has been shown to be very responsive to superphosphate (Scott, 1986) and therefore indicates how an N-fixing plant can benefit from improved phosphorus (P) supply from fertilizers or mycorrhizal P uptake. Inoculation with mycorrhiza (available commercially in New Zealand) would therefore help equip native legumes to assimilate P in rugged terrain. St. John (1994) reviewed the culture of mycorrhizal plants in a commercial nursery for use in habitat restoration.

The need for inoculation of N-fixing plants is seen by the fact that plants like alders (*Alnus*) grow naturally on developed soils but when grown in sterile potting media and on skeletal soils lacking the endophyte, there is no nodulation (Bulloch, 1986). It was found (Danielson and Visser, 1990) that N-fixing shrubs from seven nurseries in British Columbia did not become nodulated in their 1st year on poor soils, with the result that planting stock lacked N-fixing ability.

In conclusion it has been shown that New Zealand has a diversity of N-fixing plants. These plants can be grown for planting in fertile sites or impoverished soils. In the latter case it is suggested that growers consider producing plants in media with low N levels but inoculated to encourage nodulation. Mycorrhizal inoculation should also be considered, coupled with a favourable environment which includes the use of well aerated media (high air-filled porosity for all types of inoculation) and low added P.

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