BIOMASS DISTRIBUTION AND NITROGEN CONTENT OF SELECTED INTRODUCED LEGUMES AT SANTOFT BEACH, MANAWATU

Dr Grant Douglas and Lex Foote
AgResearch Grasslands
Palmerston North

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INTRODUCTION

Yellow tree lupin (*Lupinus arboreus* Sims.) is a perennial, shrubby legume that has been used in New Zealand for several decades to supply biologically fixed nitrogen to marram grass (*Ammophila arenaria*) and other species used in the primary stages of sand dune stabilisation. Since the late 1980s, *L. arboreus* has been attacked by a foliage disease caused by the fungus *Colletotrichum gloeosporioides*. This has resulted in a significant decline in plant populations, and hence biological nitrogen input into fragile sand ecosystems, particularly in the northern North Island.

Part of a collaborative research programme between Forest Research and AgResearch is seeking to identify leguminous species that can fulfil a similar role to *L. arboreus* on sand dunes. Since the early 1990s, a series of spaced-plant and direct seeding trials have been conducted at several locations on the west coast of the North Island and potentially useful species have been identified. As part of the 1998-2000 research contract with the Foundation for Research, Science and Technology, the above- and below-ground biomass and nitrogen content of individual plants of selected legume species were determined in November 1999.

This report documents the findings from this short study and provides background for future detailed studies in the areas of nitrogen transfer between selected legumes and marram grass, and environmental effects and resource requirements of legume species on coastal sand dunes.

MATERIALS AND METHODS

Single plants of five species (*Dorycnium hirsutum*, *Dorycnium pentaphyllum*, *Lotus tenuis*, *Lupinus arboreus*, *Medicago arborea*) were selected for excavation. Plants of all species except *Lupinus arboreus* were growing in the original plots of a spaced-plant trial (FR193/4) conducted at Santoft Beach in the Manawatu from 1993 to 1997. The selected plant of *Lupinus arboreus* was growing within 200 m of the trial. Isolated plants of each species were selected wherever possible to facilitate excavation and reduce the risk of root entanglement with plants of the same species. Plants were of various ages, but were likely aged at least two years. The plant of *Medicago arborea* was originally planted in the FR193/4 trial and was aged almost seven years at time of excavation. This species did not re-establish at any time during the earlier trial.

An attempt was made to excavate a single plant of *Lathyrus latifolius* from a plot in the former FR193/4 trial but this was difficult due mainly to the extensive rhizomatous development between adjacent plants. Consequently above- and below-ground plant material was harvested within a 30 x 30 cm quadrat area centred on an original planting position. All species were sampled between 23 and 26 November, 1999.

Plant material of all species was dissected into foliage/shoots and roots. For all species except *Lathyrus latifolius*, root mass was defined as that being immediately below the lowest branch that produced foliage/shoots. For *Lathyrus latifolius*, root mass was regarded as all material with a coarse, woody exterior. Root mass was dissected on the basis of diameter into classes of less than 3 mm, at least 3 mm and at least 10 mm. All plant material was dried at 80°C for 24 hours. Subsamples of foliage and each root class were then ground to pass through a 1 mm diameter sieve and analysed for total nitrogen in a Carlo Erba (Milan, Italy) autoanalyser.

RESULTS AND DISCUSSION

1. Observations during excavation

Dorycnium hirsutum
Plot in block 1 of FR193/4; selected plant 22 cm high, 45 cm maximum spread, mixture of flowers and immature pods; maximum root diameter about 7 mm (immediately below crown).

First branch from main root axis was 10 mm below crown and had maximum diameter of 3 mm; maximum diameter of any branch root from main root axis was 5 mm and was for a branch root about 40 mm below crown; roots light brown to cream, with latter common for fine roots or root parts.

Nodules – a few e.g. 10-20 were observed – mostly spherical and < 3 mm diameter.

Maximum root length (natural distribution as much as possible) from main root axis was 37 cm – when stretched almost straight, it was 57 cm.

Three roots, two extensions from main root axis ("forked" ending) extended more than 30 cm deep; most roots were in about the top 20 cm of sand.

Lathyrus latifolius
Plot in block 1 of FR193/4; selected area was centred on a well-established sward of the species and it was assumed that all or nearly all root material sampled was of the test species rather than other species e.g. *Acacia sophorae* (growing nearby) and marram grass; plants had light crimson / white flowers.

Numerous nodules, each up to 5 mm long; difficult to declare plant tops (and roots) were from one plant – perhaps several plants; foliage of the test species was up to 110 cm from the edge of the 30 x 30 cm quadrat, perpendicular to the original planting row.

Above ground mass was a mixture of live, chlorotic and dead material; there was a thick mat of dead material in the sampled area, but also some green prostrate stems emanated from the quadrat area; "fleshy" roots (woody exterior, white internally) of 28 mm diameter were excavated at about 35 cm depth; numerous fleshy roots about 30-35 cm depth.

Medicago arborea
Plot in block 3 of FR193/4; whole plant was 150 cm high and 190 cm wide, flowers and immature pods; maximum radial distance of roots was 2.5 m along ground from plant crown – random samples of diameters of root branches at point of attachment to main root axis were 20, 22, 25, 28 and 35 mm.

Most branches from the main root axis were in the top 20 cm of sand and most of these were 2-10 mm diameter; when excavating/pulling out remaining roots, those which broke were 3, 4, 5, 5, 7, 7, 9, and 17 mm diameter at point of break; may have been a few more broken roots but they would have been small e.g. < 5 mm diameter.

No nodules were observed on any root part.

Dorycnium pentaphyllum
Plot in block 6 of FR193/4; maximum spread of foliage was 115 cm; height about 25 cm; flower buds and fully expanded white flowers; numerous nodules 1-2 mm diameter.

Taproot had numerous branches; exterior of main branches and taproot was usually woody and light brown with cream dashes/markings; smaller roots were usually consistently darker brown and roots < 1 mm diameter were usually cream/white.

Maximum diameter of taproot immediately below crown was 17 mm; maximum diameter of any branch root was 5 mm; maximum radial distance of any root tip from taproot was 95 cm; most roots were in the top 30 cm of sand.

Central taproot extended deeper than 48 cm, with negligible branching below 25 cm depth – the root broke at 48 cm (diameter 4 mm), so unknown amount of root missing.

Lotus tenuis
Plot in block 6 of FR193/4; spread 70 cm and height 22 cm; flower buds and fully expanded yellow flowers; healthy; generally very small roots compared to other species excavated.

Taproot with mostly many small (1 mm diameter) roots, except near crown where several branch roots formed which developed aerial parts; one root branch even developed from the main taproot 8 cm below the ground surface and developed to produce aerial growth, possibly because of recent burial.

The deepest root was traced to 68 cm, but a few small diameter roots probably grew deeper; roots were well nodulated.

Lupinus arboreus
Plant height 76 cm and spread 84 cm; flower buds, flowers, immature pods (some fully developed, but still quite green); foliage very healthy – no evidence of disease; after excavation, maximum fully extended root length was 105 cm but in the sand it was probably about 85 cm deep because towards the end of the root, it was approximately horizontal.

Pronounced nodules; maximum size was 15 mm (rectangular shape) but most nodules were more spherical and about 5 mm diameter.

Maximum root diameter was 35 mm immediately below a shoot that produced an aerial part; about 30 cm below the shoot/root transition, the taproot branched into three branches; maximum diameter at branch point for any of the three branches was 15 mm; maximum radial spread in sand from the central shoot/root axis was about 50 cm.

2. Biomass and nitrogen content

The foliage comprised 70-90% of the total plant biomass for each species, except for *Lathyrus latifolius* where about 80% of the biomass was roots (Table 1). This variation in biomass distribution could be because of the different sampling methods used (whole plant vs. area/soil volume basis), although limited experience elsewhere supports the finding that *Lathyrus latifolius* produces significant root mass. In this trial, the roots of *Lathyrus latifolius*

were excavated from a 30 x 30 x 40 cm volume and although the origin of some root branches was uncertain, at least 80% of them were from a single plant. Biomass distribution and the lateral and vertical spread of roots of *Lathyrus latifolius* could be best determined by excavating whole plants grown in isolation

The highest foliage and root biomasses were produced by *Medicago arborea* and values were considerably higher than those for the other species (Table 1). This was probably because of the semi-erect to erect growth habit and relative tallness of the species compared with the more prostrate habit and shortness of most other species. Furthermore, the selected plant of *Medicago arborea* had likely attained its full size in this environment as it was older than the plants of most of the other species.

The canopy of *Medicago arborea* had a high proportion of well-developed woody branches which contributed to its much higher foliage mass. In contrast, the canopies of other species such as *Lotus tenuis* and *Lathyrus latifolius* had negligible woody branches.

The roots of *Dorycnium hirsutum*, *Dorycnium pentaphyllum* and *Lotus tenuis* were all less that 10 mm diameter whereas 60-80% of the root mass of *Lathyrus latifolius*, *Lupinus arboreus* and *Medicago arborea* comprised roots exceeding 10 mm diameter. The biomass of roots of *Medicago arborea* that were at least 10 mm diameter, was over five times that of *Lathyrus latifolius*, which had the second-highest root mass.

Nitrogen (N) content in all species ranged from 1.3 to 2.7% DM (dry matter) in the foliage and 0.9 to 3.2% DM in the roots (Table 1). In *Dorycnium hirsutum*, *Dorycnium pentaphyllum* and *Medicago arborea*, N content in the foliage was similar to that in the roots, whereas content was more variable between plant parts in the other species. For example in *Lupinus arboreus*, the N content of the foliage was 2.5 fold higher than in most of the root material.

Lathyrus latifolius had the highest root N content of all species, regardless of root size. Furthermore, the N content of roots of at least 10 mm diameter was the highest value recorded for any foliage or root sample in the trial. From the data collected, it was estimated that the root mass within the small volume of soil excavated, represented 1,010 kg N/ha to a depth of 40 cm, which is a significant N resource. *Lathyrus latifolius* warrants evaluation as a biological N source in a vegetation system for sustainable management of sand dunes.

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Paul Doyle assisted with the excavation of the large plant of *Medicago arborea*.

Table 1. Mass (g dry matter (DM)/plant) and nitrogen content (% DM) of foliage and roots of various diameter of six legume species at Santoft Beach in November, 1999 (percentage of total plant mass in brackets).

Species	Foliage mass (g)	Root mass (g)				Whole plant (g)
		< 3 mm	≥ 3 mm	≥ 10 mm	Total	
Dorycnium hirsutum	34 (78)	6 (14)	4 (8)		10	44
N (%)	1.5	1.5	1.0			
Dorycnium pentaphyllum	245 (86)	21 (7)	19 (7)		40	285
N (%)	1.8	1.6	1.2			
Lathyrus latifolius[*]	61 (17)	13 (4)	36 (10)	246 (69)	295	356
N (%)	2.1	2.1	2.6	3.2		
Lotus tenuis	39 (68)	9 (16)	9 (16)		18	57
N (%)	2.7	1.9	1.5			
Lupinus arboreus	148 (76)	3 (2)	10 (5)	33 (17)	46	194
N (%)	2.3	1.6	0.9	0.9		
Medicago arborea	15,214 (87)	194 (1)	788 (4)	1389 (8)	2,371	17,585
N (%)	1.3	1.7	1.5	1.2		

[*]foliage harvested from 30 x 30 cm quadrat; root excavated from 30 x 30 x 40 cm soil volume.

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Figure 1a, b. Excavated plant of *Dorycnium hirsutum*; ruler 30 cm long.

Figure 2. Excavated plant of *Dorycnium pentaphyllum*; ruler 30 cm long.

Figure 3. Partially excavated plant of *Lupinus arboreus*; main graduations on staff at 10 cm intervals.

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Figure 4. Excavated plant of *Lotus tenuis*; ruler 30 cm long.

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Figure 5 a, b. Partially excavated plant of *Medicago arborea*; main graduations on staff at 10 cm intervals.