Legumes in the High Country

Omarama Station Field Day
15 November 2016

D Moot, RJ Lucas, J Moir, AD Black, KM Pollock, S Olykan, D Hendrie, C Teixeira, R Downward, S Sharifiamina

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Todays Itinerary

12.45 pm  Meet at Omarama Station cook shop, 1st left off Broken Hut Rd, for tea/coffee
1.00 pm  Richard welcomes people and does Health and Safety! Derrick to follow up with an outline of the days proceedings before travelling to the Lysimeter site
1.10 pm  MS Srinivasan, NIWA, outlining the lysimeter work at Omarama Station Travel to the lupin/lucerne plots
1.35 pm  Derrick outlines the principals around legumes water use and some recent results from Lincoln University
1.45 pm  Jim Moir talks about the soil we are standing and the problem of pH and aluminium
2.00 pm  Daniel talks about what he has done and preliminary results – including walking us over one set of treatments so we can see if there are any noticeable visual differences
2.30 pm  Look at the machine (if on site)
2.40 pm  Derrick talks about the trial results from Glenmore
2.50 pm  Will talks about what he is doing now with lupins on the wider property and how they are fitting as feed to his farm system
3.00 pm  Al outlines grazing results from Lincoln
3.10 pm  Sub 4 spring plots – Dick talks us through the different cultivars, what we have done and the frost results etc
4.00 pm  finish and go home for some - visit to the balansa clover paddock for others
5.00 pm  back to the cook shop
Mission statement

“To provide research results that assist dryland pastoral farmers to develop resilient farm systems that are financially, economically, environmentally and socially sustainable.”

The Problems

- Dryland sheep and beef properties usually start the spring season with full soil moisture recharge but run out in summer.
- The amount of water available is dependent on the soil water holding capacity of the soil, the ability of the pasture species to use the water efficiently, and in season rainfall.
- Nitrogen is always deficient in grass dominant dryland pastures and this reduces water use efficiency of the plants.
- The herbage produced must be high quality to maximize liveweight gain during lactation in the reliable spring growth period.
- Lambs born at ~5 kg must grow at least 300 g/hd/d to achieve 35 kg liveweight in 100 days (before soil moisture runs out).
- Lambs still on the farm during the dry summer months compete with ewes for priority forage. This may affect the ewes condition going into mating and subsequently lambing performance the following year.

The Solutions:

- High quality forages that maximize water use efficiency (kg DM/mm/ha) and water extraction (Lucerne).
- Pasture species that fix nitrogen and grow early in spring when soil moisture is available (Annual clovers).
- Grazing management systems that maximize spring liveweight (LWG/ha) gain but enable the high quality forages to survive and thrive.
- Persistent grass species that respond to moisture after summer dry periods (Cocksfoot).
- Appropriate research information to allow farmers to develop management systems that maximize the benefits of dryland pasture species (Field days)!
Website & Social Media

- Website: [www.lincoln.ac.nz/dryland](http://www.lincoln.ac.nz/dryland)

- Blog: [https://blogs.lincoln.ac.nz/dryland/](https://blogs.lincoln.ac.nz/dryland/)

- Facebook: [@DrylandPasturesResearch](https://www.facebook.com/DrylandPastures)

- YouTube: [https://www.youtube.com/DrylandPastures](https://www.youtube.com/DrylandPastures)
Lysimeter site

Rainfall

Cumulative Rainfall November 2015-May 2016

Rainfall at Omarama Station and Tara Hills
August 2016-present
Pasture composition:

- Lucerne monocultures remained >90% pure due to the winter weed control program.
- In the cocksfoot pastures the originally sown grass and companion clover species disappeared from the pasture at about 3% per year (Figure 1).
- Ryegrass and white clover were lost at a rate of 10% per year in these dryland grazed pastures (Figure 2), probably due to grass grub.

Figure 1 Total annual accumulated DM yields of six dryland grazed pastures at the ‘MaxClover’ grazing experiment at Lincoln University over nine years.
Figure 2 Rate of loss of the originally sown pasture components (grass+companion clover) from the five grass based dryland pastures at the ‘MaxClover’ grazing experiment at Lincoln University.
Ovulation rates of ewes following removal from oestrogenic lucerne for different durations

Rachel Fields, Prof Derrick Moot, Ass. Prof Graham Barrell

- Lucerne can contain an oestrogenic compound called coumestrol.
- Coumestrol is produced in response to fungal pathogens. We have found no response to development stage or water stress.
- Coumestrol can lower the fecundity of ewes if they eat lucerne containing high levels during the mating period.
- This results in fewer multiple births and more singles, decreasing lambing rates.

Problem

Suppression of fecundity is temporary and can be mitigated by removing the animals from lucerne. How long before mating should they be removed?

Methods

- 2-tooth Ewes (~18 months)
- 15 ewes per treatment
- Four grazing treatments
- Blocked by liveweight
- Break-fed with back fence
Measuring Ovulation Rate

Ovulation occurs while the ewes are in oestrus (heat). During the autumn, on average ewes will ovulate every 17 days. To measure the ovulation rate the ewes must be synchronised.

- Controlled internal drug release (CIDR) devices were used for 12 days.
- Ovulation occurred 24-48 hours after CIDR removal.
- For each egg that is released from the ovary a corpus luteum develops.
- Corpus lutea were counted by laparoscopy (key hole surgery) a week after ovulation.

Ovulation Rate Results

No effect of grazing treatment on liveweight:
- 5.3 kg gain over six weeks.
- Average weight of 66.3 ± 0.97 kg at ovulation
Removal of ewes from lucerne three weeks prior to ovulation (oestrus) prevented suppressed ovulation rate.

**Solution: Applying to farm systems**

Ewes can be synchronised with teaser rams so that they ovulate at a similar time, and thus the time on lucerne can be maximised.

- Teaser rams cause ovulation and a silent heat within three or four days. This is followed by a cycle every 17 days through the breeding season until pregnancy.
- Remove ewes from lucerne, put with teaser rams for two weeks, and then swap for entire rams.
- This will give ewes approximately three weeks off lucerne before ovulation.

If teasers are not used:
Remove ewes from the lucerne two weeks before the rams are introduced. This will give over half of the ewes at least three weeks off lucerne before they ovulate.

**Disclaimer** - Despite these results, if there is no good alternative to lucerne it is better for the animals to be gaining/maintaining weight on lucerne than losing weight on low quality, dead pasture.
There is a strong, well-documented, relationship between liveweight and ovulation rate.
Yield of four grasses under summer dry conditions

Shirin Sharifamina, Prof. Derrick Moot

**The Problem:** Perennial ryegrass persistence is limited under dryland conditions.

Comparative studies of the effects of nitrogen and severe drought on the production of cocksfoot, tall fescue, brome and perennial ryegrass under summer dry conditions are limited.

**Treatments:**

<table>
<thead>
<tr>
<th>Species</th>
<th>Cultivar</th>
<th>Sowing rate (kg/ha)</th>
<th>Nitrogen</th>
<th>Sowing date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perennial ryegrass</td>
<td><em>Stellar AR1</em></td>
<td>20</td>
<td>Full and 0 N</td>
<td>10/10/2014</td>
</tr>
<tr>
<td>Cocksfoot</td>
<td><em>(SFR36-009)</em></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tall fescue</td>
<td><em>Finesse Q</em></td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brome</td>
<td><em>Bareno</em></td>
<td>35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Two soil types:**

*Ladbooks* (Peaty Orthic Gley soil) and *Ashley Dene* (Lismore Stony silt loam soil) with high and low water holding capacity.

**Measurements:**

- Seedling germination, shoot and root biomass
- Botanical composition
- Dry matter production (DM)
- Soil water extraction
- Light interception
- Canopy temperature
Main results

Establishment year (2014/15):

- Oct 2014 - June 2015, no significant difference in DM at Ashley Dene (1.7-2.7 t/DM/ha) or Ladbrooks (6.8-8.0 t/DM/ha).

Second year (2015/16):

- At Ladbrooks, DM production of all grass species in +N (~20 t DM/ha/yr) was approximately double –N (~10 t DM/ha) (Figure 3).
- N applied at Ashley Dene, did not increase DM yield of tall fescue, brome and perennial ryegrass.
- For cocksfoot +N yield was ~2.5 t DM/ha greater than perennial ryegrass, brome and tall fescue under severe drought conditions.

Figure 3 Accumulated DM production of brome, cocksfoot, perennial ryegrass and tall fescue over time, in 2014-16 at Ladbrooks and Ashley Dene, Canterbury, New Zealand. Treatments are +N and –N. The error bar is the highest SEM when species treatments were different (P≤0.05) on DM production. The arrows indicate a destructive harvest.
Note: nitrogen application in +N treatments occurred after the destructive harvest.

**The Solution:**

- All species were suitable and have produced the same amount of DM when soil moisture was available on a deep peaty soil at Ladbrooks.
- Under severe moisture stress cocksfoot was the most productive and responded quickest to summer rainfall when it had N available.
- Pasture persistence remains to be quantified over the next two years.
Figure 4 The relationships between soil pH and soil exchangeable Al at (a) Site 1 (Mt Pember Station); (b) Site 2 (Glenmore Station); and (c) Site 3 (Glenfoyle Station).
The Lime Blower: a mechanism for deep placement of lime to reduce Aluminium toxicity in SI High Country soils

D Hendrie, J Moir, DJ Moot, J Stevens

The problem: Sites with low soil pH inhibit the ability of our main pastoral legumes, particularly lucerne, to thrive due to toxic levels of soluble aluminium. Surface applied lime takes years to change pH at depth especially in low rainfall environments.

The idea: don’t apply the lime on the soil surface – place it where it’s needed to speed up the process of locking up the aluminium.

The question: how do we place lime at depth in a way that farmers can also implement?

The lime blower was initially tested in an on-farm experiment at Omarama Station on the 27th of February 2014 (Plate 1). The first site was located on a moderately stony river terrace (44°29'10.48"S 169°56'42.27"E, 440 m.a.s.l.). The second site was located on a river outwash flat approximately 3 km south of Site 1 (44°30'3.95"S 169°54'36.88"E. 470 m.a.s.l.). Both sites receive approximately 500 mm of rainfall annually.

Initial Soil pH and Aluminium for this block (2013) is reported in Table 1

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Exch Al (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20 cm</td>
<td>5.7</td>
<td>3.8</td>
</tr>
<tr>
<td>20-40 cm</td>
<td>5.7</td>
<td>2.1</td>
</tr>
<tr>
<td>40-60 cm</td>
<td>5.7</td>
<td>3.5</td>
</tr>
<tr>
<td>60-80 cm</td>
<td>5.8</td>
<td>4.2</td>
</tr>
<tr>
<td>80-100 cm</td>
<td>6.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Site 1 had been sown in ryecorn out of permanent pasture, about 1 week prior to the establishment of the liming experiment. Site 2 had remained in an unimproved state, colonised mainly by hieracium and browntop (*Agrostis capillaris*). Two lime products were applied (agricultural lime and Optimise® pelletised lime) as separate treatments at rates of 0, 0.5, 1.0, 2.0, and 4.0 t/ha. A ripping treatment was also repeated at a rate of 0 t lime/ha. Lime was applied at a depth of 10 cm and 25 cm simultaneously within a single slot.

Throughout the establishment of this initial experiment, it became evident that the venturi-based air system was incapable of handling fertiliser loadings of greater than 800 kg/ha. Also, the pipe lines leading from the distribution head to the coulters were creating too much back pressure at the venturi, which reduced its ability to create a vacuum.

Modifications were made to address these issues and a third experiment was established at Omarama in May 2015. Lime was ripped into the soil at a depth of 5 cm and 20-25 cm at rates of 0, 0.5, 1.0, and 2.0 t/ha using pelletised ultra-fine lime. Lime was also surfaced applied at 1.0 t/ha as a Control. Five replicates of each lime rate were applied. The site was then heavy rolled. The lime was inserted successfully but needs time to react before sowing can occur. Autumn sowing in the high country is impossible due to the onset of winter before seedlings are established.
Following a winter fallow lucerne (14 kg/ha), Russell lupins (12 kg/ha), ryecorn (150 kg/ha) and *Festulolium* (25 kg/ha) were sown into the site at a right angle to the way it was ripped.

The purpose of sowing the ryecorn is to determine its effects on redistributing the applied lime through the soil and because it is common practise for high country farmers to sow it as a ‘break-in’ crop on newly developed land. Extra seed was direct drilled around the perimeter of the trial site.

Photos supplied by John Stevens, Flexiseeder Ltd.
Omarama Station Lime Ripper Trial Design-Year 2

**Lime Treatment**
- Yellow: Ripped, no lime
- Blue: Ripped, 500 kg lime/ha
- Green: Ripped, 1000 kg lime/ha
- Red: Ripped, 2000 kg lime/ha
- Grey: Surface Applied, 1000 kg lime/ha

**Species Treatment**
- 1 yr old Lucerne
- 1 yr old Lupins
- New Lucerne
- New Lupins
- Fest & Serradella

**Fertiliser**
- 1. 100 kg/ha (SS30)
- 4. 400 kg/ha (SS30)
Results 2015/16 – Dry matter yield

Yield results for the 2015/16 growth season are reported in Figure 5.

Figure 5 Total annual dry matter yields (kg/ha) for lucerne and lupin (top) and ryecorn and Festulolium cv ‘Perun’ (bottom) at 0, 500, 1000 or 2000 kg lime/ha. The 0 kg lime/ha treatment was ripped but no lime applied. The 1000 kg/ha SA treatment was 1000 kg/ha of surface applied Optimise pelletised lime.
Figure 6 shows the effects of deep lime placement using the Flexiseeder lime ripper on soil pH at a depth of 15-30 cm. The initial soil pH was 5.1 and exchangeable aluminium was 8 mg/kg. Each point of the graph represents a soil core taken 40 cm apart along a diagonal transect across each lucerne plot in either the 500 kg lime/ha or 2 T lime/ha plots in Blocks 3 and 4 of the trial. Highs in the graph show where soil cores have struck where lime has been placed by the machine, showing the potential for soil pH to be increased at depth by the machine. Soil sampling horizontally across a plot would show extreme peaks and troughs in soil pH and show how well the machine has distributed the lime in the soil profile.

![Omarama Station Soil pH after lime ripping (15-30 cm depth)](image)

**Figure 6** Change in soil pH (H₂O) in the 15-30 cm soil layer at 40 cm intervals along diagonal transects placed across lucerne plots.
Glenmore Results

Prof Derrick Moot, K.M. Pollock

The problem: Lucerne failed to thrive

The solution: Integrate an aluminium tolerant legume – perennial lupin- into the farm system to increase the quality and quantity of feed available for grazing relative to resident pasture

Experimental:
• Two lime rates (0 or 3 t lime/ha)
• Two perennial lupins (Russell and blue)
• 6 sowing rates (2, 4, 8, 12, 16 and 30 kg/ha)
Results – Years 2-4

Figure 7 Total DM yield (t/ha) of 2 yr old blue and Russell lupins sown at 6 rates in Nov 2014.

Figure 8 Lupin plant population (plants/m²) in Oct 2015 (3 yrs after establishment) of Blue and Russell lupin sown at 6 rates at Glenmore Station.
DM yield - Dec 2015

Figure 9 DM yield in Dec 2015 (3 yrs after establishment) at different lime rates (left), for Blue and Russell lupin (centre) and 6 sowing rates (right) at Glenmore Station.

Note: In Yr 4 (2016) the lupins are thriving during the present spring.

Conclusions

• Perennial blue has thrived for 4 years in high aluminium soil when sown at 8 kg/ha.
• Lime aided cocksfoot.
• Regeneration from seed was possible after letting plants flower.
Lupin/cockfoot v lucerne grazing trial at Lincoln University

Dr Alistair Black

Objective: To quantify the feeding value of dryland lupin/cockfoot pasture for sheep.

Method:

• Lupin/cockfoot and lucerne (control) pastures were sown in December 2013 on a Templeton silt loam at Lincoln University.

• Each pasture was rotationally grazed by:
  o Merino ewe lambs 11 Mar to 19 May 2014
  o CPT* ewe hoggets 5 Aug (lupin) or 15 Sep (lucerne) 2014 to 18 Feb 2015
  o CPT ewe lambs 18 Feb to 29 May 2015
  o CPT ewe hoggets 3 Sep 2015 to 14 Mar 2016
  o Coopworth ewe lambs 17 Mar to 20 May 2016
  o Coopworth ewe hoggets 17 Aug 2016 to present

• Soil pH 6.0, Olsen P 17 and no irrigation.

*Beef & Lamb NZ Central Progeny Test sheep were of variable breed percentages incorporating Romney, Coopworth, Perendale, Corriedale, Texel maternal and Growbulk.
Results

Table 2 Sheep liveweight gain (LWG), grazing days (GD), dry matter yield (DMY) and dry matter intake (DMI) for dryland lupin/cocksfoot compared to lucerne. Bold numbers are significantly different.

<table>
<thead>
<tr>
<th>Year</th>
<th>Pasture</th>
<th>LWG (kg/ha)</th>
<th>LWG (g/hd/d)</th>
<th>GD/ha</th>
<th>DMY (kg/ha)</th>
<th>DMI (kg/ha)</th>
<th>DMI (kg/hd/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aut 2014</td>
<td>Lupin/Cf</td>
<td>58</td>
<td>29</td>
<td>1997</td>
<td>4295</td>
<td>1555</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Lucerne</td>
<td>107</td>
<td>60</td>
<td>1790</td>
<td>3519</td>
<td>1832</td>
<td>1.0</td>
</tr>
<tr>
<td>2014/15</td>
<td>Lupin/Cf</td>
<td>768</td>
<td>182</td>
<td>4210</td>
<td>6565</td>
<td>5331</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>Lucerne</td>
<td>1134</td>
<td>250</td>
<td>4528</td>
<td>10229</td>
<td>8528</td>
<td>1.9</td>
</tr>
<tr>
<td>2015/16</td>
<td>Lupin/Cf</td>
<td>674</td>
<td>175</td>
<td>3847</td>
<td>3998</td>
<td>4182</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>Lucerne</td>
<td>1347</td>
<td>264</td>
<td>5101</td>
<td>9773</td>
<td>8291</td>
<td>1.6</td>
</tr>
<tr>
<td>Spr 2016</td>
<td>Lupin/Cf</td>
<td>205</td>
<td>168</td>
<td>1223</td>
<td>1801</td>
<td>1432</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Lucerne</td>
<td>555</td>
<td>235</td>
<td>2364</td>
<td>3730</td>
<td>3466</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 3 Metabolisable energy values (MJ/kg DM) for the lupin/cocksfoot and lucerne pastures.

<table>
<thead>
<tr>
<th>Lupin/Cocksfoot</th>
<th>Lucerne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>12.0</td>
</tr>
<tr>
<td>Petiole</td>
<td>10.6</td>
</tr>
<tr>
<td>Stem</td>
<td>11.3</td>
</tr>
<tr>
<td>Cocksfoot</td>
<td>11.2</td>
</tr>
<tr>
<td>Mix</td>
<td>10.5</td>
</tr>
<tr>
<td>Leaf + Petiole</td>
<td>11.7</td>
</tr>
<tr>
<td>Stem</td>
<td>9.2</td>
</tr>
<tr>
<td>Mix</td>
<td>9.9</td>
</tr>
</tbody>
</table>

Figure 10 Pre-grazing botanical composition of the lupin/cocksfoot and lucerne pastures.
Summary:

- Lupin/cocksfoot was about 50-70% as productive as lucerne (Table 1).
- ME value of lupin leaf was similar to the ME value of lucerne leaf plus petiole (Table 2).
- Lupin content decreased under the lucerne grazing regime at this site (Figure 11). This was possibly due crown and root rot which caused death of lupin plants.
- Lupin herbage was consistently about 80% leaf and 20% petiole with very little stem and flower, whereas lucerne herbage was about 60% leaf plus petiole and 40% stem (Figure 12).
- Overall, the lupin/cocksfoot pasture performed as well as expected for dryland cocksfoot-dominant pastures with traditional legume species.
Weather data summary - Omarama
Climate data was accessed from the Tara Hills Aws weather station, located 2.9 km from the Omarama Station experimental site, using the Cliflo website.

Rainfall
The average annual rainfall in the area is 505 mm. While the total rainfall for 2016 is ‘on target’, with 420 mm by the end of October, the rainfall pattern has seen months of relatively high and low rainfall compared to 30 year long-term averages (Figure 13).

![Figure 12 Monthly amounts of rainfall in 2016 compared to the 30 year average rainfall (Tara Hills Aws).]
The autumn rainfall in March and April was low at 17 and 20 mm respectively. August and September were also dry with only 12 and 13 mm of rainfall. The lack of rainfall, and therefore soil moisture, at key times of the sub clover growing season may have had the following effects:

♣ delayed establishment of sown sub clover populations in autumn, and
♣ reduced dryland pasture growth during September.

Sub clover germination is triggered by a significant rainfall event >20mm during the autumn and this did occur around mid-February when sowing occurred.

**Temperature**

Another key climatic factor affecting sub clover survival and growth is low temperatures. While the ‘traditional’ sub clover cultivar ‘Tallarook’ has been shown to withstand temperatures as low as -6 to -7°C there is little information about the frost-cold tolerance of more recent Australian cultivars. Omarama offers the perfect environment to test the cold tolerance of a range of sub clover cultivars. The 2016 winter mean daily minimum air temperatures were not as cold as the long term averages in June and July (Figure 14).

![Figure 13 Monthly mean daily minimum temperatures in 2016, compared to the 30 year long-term average (1981-2010), and the lowest grass minimum (frost) temperature recorded each month in 2016 (Tara Hills Aws).](image-url)
At Omarama a frost can occur any time of the year. In 2016 the first frost was recorded on 4th January at -2.6°C (Figure 14). The lowest grass minimum temperature recorded in 2016 was -10.4°C on the 2nd July. During June, July and August 2016 the grass minimum temperature went below -7°C on 2, 5 and 3 days respectively (Figure 15). Despite these low temperatures all of the sub clover cultivars have survived and grown at Omarama. Would they have done so in a harsher winter?

Figure 14 Grass minimum temperatures from 1 July - 31 August 2016 (Tara Hills Aws).

![Figure 14 Grass minimum temperatures from 1 July - 31 August 2016 (Tara Hills Aws).](image-url)
Omarama ‘Sub 4 Spring’ experiments

C Teixeira, S Olykan, RJ Lucas, DJ Moot

Location: Omarama Station, Omarama.

Aim: To assess the cold tolerance of sub clover cultivars.

Background
The site is at an altitude of 477 m a.s.l. and this high country environment has a low annual rainfall and cold winter temperatures (as previously described).

Soils
The soil is a Mackenzie loam (Pallic Orthic Brown Soil) characterised as being shallow and well drained with low plant available water and medium phosphorous (P) retention.

Methods
Site preparation

<table>
<thead>
<tr>
<th>Date</th>
<th>Event (carried out by the farmer and/or staff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 15</td>
<td>Lime applied at 3 t/ha</td>
</tr>
<tr>
<td>11/9/15</td>
<td>Herbicide application: 3.5 L/ha 2,4-D Ester</td>
</tr>
<tr>
<td>18/9/15</td>
<td>Herbicide application: 8 L/ha Glyphosate (470 a.i.) with Sharpen</td>
</tr>
<tr>
<td>18/9/15</td>
<td>Micronutrients applied: 3.5 L/ha Mobstar + 100 g/L a.i. boron + 35 g/L a.i. molydenum</td>
</tr>
<tr>
<td>10/2/16</td>
<td>Herbicide application: 5 L/ha Glyphosate (470 a.i.) with a small amount of oxyflurofen</td>
</tr>
</tbody>
</table>
Experimental establishment, maintenance and measurement
The following sub clover cultivars and control legumes were sown in Experiment 1:

<table>
<thead>
<tr>
<th>Code + Cultivar name</th>
<th>Sowing rate (kg/ha)</th>
<th>Controls</th>
<th>Sowing rate (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Antas</td>
<td>20</td>
<td>Control legumes (sown)</td>
<td></td>
</tr>
<tr>
<td>C - Campeda</td>
<td>20</td>
<td>Ba - Bolta Balansa clover</td>
<td>10</td>
</tr>
<tr>
<td>Co - Coolamon</td>
<td>20</td>
<td>Red - Rossi Red clover</td>
<td>10</td>
</tr>
<tr>
<td>D - Denmark</td>
<td>20</td>
<td>RL – Russell lupin</td>
<td>10</td>
</tr>
<tr>
<td>K - Karridale</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L - Leura</td>
<td>20</td>
<td>Resident clover</td>
<td></td>
</tr>
<tr>
<td>M - Monti</td>
<td>20</td>
<td>HF - Haresfoot trefoil</td>
<td>N/A</td>
</tr>
<tr>
<td>N - Narrikup</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na - Napier (coated)</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R - Rosabrook</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rc - Rosabrook (coated)</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T - Trikkala</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W - Woogenellup</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wh – Whatawhata</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Three replicates (blocks) of each sub cover cultivar and control legume were drilled in a randomised complete block design (Figure 17). Each plot is 8 x 2.1 m.

♣ Seed sown on 18/2/16 with the Lincoln University research drill.
♣ Lorsban (at 1.25 L/ha in 200L/ha water) applied as a precaution against clover root weevil on 23/2/16.
♣ At 6 weeks (31/3/16) - established legumes counted
  - soil samples taken from 0-75 and 75-150 mm depths
♣ At 16 weeks (7/6/16) - assessment of % sub clover/legume in a row section
  - legume biomass sample from each plot, including the resident clover Haresfoot
  - scoring of sub clover cultivars for cold sensitivity
  - cages placed on 6 sub clover cultivars in Replicate 1
♣ Experimental area grazed.
♣ At 37 weeks (3/11/16) - 0.2m² quadrat of biomass sampled from each plot
  - Ground cover assessment of each plot (% sub clover, weeds, bare ground).
Figure 15: Sub clover cultivar ‘Narrikup’ in plot 18 at six weeks (top photo, 31/3/16) and at 16 weeks (bottom photo, 7/6/16). (Photos: Teresa Lewis).
Figure 16: Layout of the clover and legume cultivar in Experiment 1 at Omarama Station.
Results

Soils
An analysis of the soil samples (Table 3) found differences in pH, Olsen P and cations between soil depths, i.e. a high pH and more nutrients in the 0-75 mm depth, with high Al at 75-150 mm depth:

Table 4 Soil test results

<table>
<thead>
<tr>
<th></th>
<th>Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-75</td>
</tr>
<tr>
<td>pH</td>
<td>5.7</td>
</tr>
<tr>
<td>Olsen P (mg/L)</td>
<td>24</td>
</tr>
<tr>
<td>Potassium (me/100 g)</td>
<td>0.54</td>
</tr>
<tr>
<td>Calcium (me/100 g)</td>
<td>4.9</td>
</tr>
<tr>
<td>Magnesium (me/100 g)</td>
<td>0.44</td>
</tr>
<tr>
<td>Sodium (me/100 g)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>CEC (me/100 g)</td>
<td>10</td>
</tr>
<tr>
<td>Al (CaCl₂ extractable; mg/kg)</td>
<td>0.6</td>
</tr>
</tbody>
</table>

An analysis of soil samples taken from the 0-75 mm depth in December 2015 found sulphate-sulphur and extractable organic sulphur both at 2 mg/kg.

Establishment

At six weeks there was a cultivar effect (P<0.001) when all legumes were analysed and also when sub clover cultivars were analysed separately (Figure 18).
The differences in the sub clover cultivar plant numbers were a result of 470 plants/m² establishing in the ‘Whatawhata’ plots, which was sown at 100 kg/ha, and 120 plants/m² for ‘Napier’ (coated seed). On average the sub clover cultivars established 230 plants/m² (excluding Whatawhata data). At a sowing rate of 20 kg/ha the amount of seed was 250/m² (uncoated seed) indicating there was a good rate of establishment.

**Early growth**
There was a weak cultivar effect (P=0.028) for all of the legume dry matter production at 16 weeks because of the relatively poor performance of the non-sub clover legumes (Figure 19).
Figure 18 Dry matter production of sub clover cultivars and legumes at 16 weeks (7/6/16) at Omarama Station.

When the sub clover cultivars were analysed separately there was no cultivar effect. Average sub clover dry matter was 633 kg/ha, ranging from 817 kg DM/ha for Leura to 330 kg DM/ha for Napier (coated).

A cage was placed over six sub clover cultivars in replicate 1 and the area was grazed in late July. The herbage under the cages represents the total amount of sub clover growth from the time of establishment (see Figure 20).

Figure 19 Comparison of grazed and ungrazed sub clover ‘Narrikup’ in plot 18 on 3/11/16 (Photo: Bridget Thomas).
Dry matter production in spring

The biomass samples taken at 37 weeks represented about three months of growth from 1/8/16, when grazing was completed. Preliminary results indicate that the sub clover has grown well, compared to the other legumes, with the highest producing sub clover cultivars being ‘Karridale’, ‘Narrikup’ and ‘Campeda’ (Figure 21) which produced over 3300 kg of DM/ha.

Figure 20: Dry matter components of the biomass harvested from sown legumes and Haresfoot at Omarama Station (samples taken 3/11/16).

On average total DM produced in the sub clover plots was 3150 kg/ha. The sown sub clover was 83% of this amount, the resident haresfoot clover was 7%, weeds 8%, grass 1% and dead material 1%.

In plots where no legumes were sown the resident haresfoot clover produced 1710 kg DM/ha and competed well with the weeds. Haresfoot also dominated the Russell lupin plots.
Conclusions

- Site preparation techniques effectively cleared the experimental area of Hieracium.
- Six weeks after sowing the sub clover cultivars had established good populations of around 200 plants/m².
- Despite frosts below -7°C, all of the sub clover cultivars survived their first winter at Omarama, which was milder than average.
- After grazing a number of sub clover cultivars exhibited good regrowth with the best being Karridale, Narrikup and Campeda.
- The resident clover, haresfoot, has also grown well on the experimental site.
- Total sub clover yields of up to 4 t DM/ha/yr will have fixed over 100 kg N/ha in spite of a possible sulphur deficiency.
Why do subterranean clovers have red leaves?

Dick Lucas, Carmen S.P. Teixeira, Gracie Woolsey & Prof Derrick Moot

Background
Subterranean clover (sub clover)
- Autumn/winter legume to complement other legumes.
- High quality feed early in spring and self-reseeding legume with high N contribution.
- Reddening of leaflets of sub clover occurs when plants are under stresses such as low temperatures, which limits growth.

Problem: during winter (June-August) 2015 we observed at Lincoln University experimental areas sub clover plants with red foliage after frost and low temperature exposure. Which cultivars did react readily to cold? Any consequences in the following spring yield?

The experiment
In a randomised complete block field experiment 14 commercial cultivars of subterranean clover were sown (16 April 2015) in four replicates on a Wakanui deep silt loam. The experiment was conducted in the Field Research Centre, at Lincoln University (43°38'57.2730"S, 172°28'04.4341"E; 11 m.a.s.l.). Phosphorus soil level was 13 mg/L (Olsen P) and pH was of 5.4. The area was cultivated prior sowing and bare non-inoculated seeds were broadcasted by hand and lightly raked in plots of 4 m² to ensure plant population between 1000-2000 plants/m².

The non-commercial New Zealand line ‘Whatawhata’ (nucleus seed AK1332) was included based on previous evaluations performed by Widdup & Pennel (2002). Seeds of ‘Whatawhata’ were obtained from Grasslanz, New Zealand. The commercial white clover ‘Nomad’ was included as reference for spring dry matter yield. Sub clover plots were visually assessed in winter 2015 and 2016 to determine the proportion of plants showing red foliage using a scale from 0 to 100 (0 = no red foliage seedlings observed; 100 = 100 % of plants with red foliage). Red foliage is often associated with SCRLV (subterranean clover red leaf virus). Foliage samples were therefore analysed for SCRLV and confirmed that the red foliage was not caused by virus infection (John D Fletcher, Pers. Comm., 11 June, 2015).

Above ground plant biomass measurements were taken from each plot by using a 0.2 m² quadrat, cut to 15-20 mm above ground with electric shears. The herbage sub
samples were sorted into clover, weeds and senesced material, dried at 60 – 70°C to constant weight and the dry weight was quantified.

**Results**

**Visual reddening assessment**

All cultivars showed some degree of reddening in winter (see examples in Figure 23). The percentage of red coloured plants visually scored on the plots ranged from 10 to 60% in 2015 and from 13 to 70 % in 2016 (Table 5).

The *yanninicum* (Y) cultivars showed significantly (P<0.001) more redness (~53%) than the *subterraneum* (S, mean ~23 %) and *brachycalinicum* (B, mean 16%). There was no difference between the *subterraneum* and *brachycalinicum*.

![Figure 21 Close up of ‘Woogenellup’ “red” leaflets in June 2015 (left) and red foliage of ‘Karridale’ plants in July 2015 (right).](image-url)
Table 5 Mean percentage (%) of red seedlings scored in July 2015 and August 2016 (winter) of 15 sub clover cultivars. Subspecies (ssp.) are S= subterraneum, B= brachycalycinum and Y = yanninicum. (SEM = Standard error of mean).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>‘Campeda’</td>
<td>Italy</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>S</td>
<td>‘Coolamon’</td>
<td>Australia</td>
<td>30</td>
<td>23</td>
</tr>
<tr>
<td>S</td>
<td>‘Denmark’</td>
<td>Australia</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>S</td>
<td>‘Karridale’</td>
<td>Australia</td>
<td>58</td>
<td>30</td>
</tr>
<tr>
<td>S</td>
<td>‘Leura’</td>
<td>Australia</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>S</td>
<td>‘Mt Barker’</td>
<td>Australia</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>S</td>
<td>‘Narrikup’</td>
<td>Australia</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>S</td>
<td>‘Rosabrook’</td>
<td>Australia</td>
<td>33</td>
<td>18</td>
</tr>
<tr>
<td>S</td>
<td>‘Seaton Park’</td>
<td>Australia</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>S</td>
<td>‘Whatawhata’</td>
<td>New Zealand</td>
<td>30</td>
<td>41</td>
</tr>
<tr>
<td>S</td>
<td>‘Woogenellup’</td>
<td>Australia</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>‘Antas’</td>
<td>Italy</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>Y</td>
<td>‘Monti’</td>
<td>Australia</td>
<td>60</td>
<td>36</td>
</tr>
<tr>
<td>Y</td>
<td>‘Napier’</td>
<td>Australia</td>
<td>55</td>
<td>69</td>
</tr>
<tr>
<td>Y</td>
<td>‘Trikkala’</td>
<td>Australia</td>
<td>53</td>
<td>47</td>
</tr>
</tbody>
</table>

| SEM  | 6.24      | 3.91       |

**Spring accumulated dry matter (DM kg/ha)**

In 2015 (cuts performed on late September and late October) the sub clover dry matter yield ranged from 10 t/ha (‘Woogenellup’ and ‘Antas’) to ~ 3 t DM/ha (‘Seaton Park’). ‘Nomad’ white clover produced about 1.8 t DM/ha (Figure 24).
We observed that the reddening was stimulated when mean air temperature were ~ 7°C. However, the symptom was temporary and faded with warm spring temperatures (mean air temp. ~12°C) and the plants which had more than 50% of reddening recovered their green coloration again.

- The reddening in this case indicates physiological and biochemical events (e.g. pigment production) to acclimatize and protect vulnerable plants.
- The preliminary results so far indicate no robust relationship with foliage reddening and spring yield reduction ($R^2 = 0.23$).
What happened with sub clovers in Omarama in winter 2016?

Sonya Olykan and Gracie Woolsey

Preliminary Results

Table 5 shows the reddening score of sub clover cultivars and ‘Bolta’ balansa clover from Omarama site. During mid-May and early-June plants were exposed to mean Air temperatures of ~ 5°C (with minimum temperatures ~ -2°C). Plots were visually assessed on June 2016 (data provided by Olykan, S. Pers. Comm., 09 November 2016).

Table 6 Mean percentage (%) of red seedlings found in subterranean and balansa clover plots scored in June 2016 (winter) at the Omarama Station experimental area. Subspecies (ssp.) are S = subterraneum, B = brachycalicinum and Y = yanninicum. (SEM = Standard error of mean).

<table>
<thead>
<tr>
<th>ssp.</th>
<th>Cultivar</th>
<th>Origin</th>
<th>% Red seedlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>‘Campeda’</td>
<td>Italy</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>‘Coolamon’</td>
<td>Australia</td>
<td>38</td>
</tr>
<tr>
<td>S</td>
<td>‘Denmark’</td>
<td>Italy</td>
<td>20</td>
</tr>
<tr>
<td>S</td>
<td>‘Karridale’</td>
<td>Australia</td>
<td>60</td>
</tr>
<tr>
<td>S</td>
<td>‘Leura’</td>
<td>Italy</td>
<td>2</td>
</tr>
<tr>
<td>S</td>
<td>‘Narrikup’</td>
<td>Australia</td>
<td>35</td>
</tr>
<tr>
<td>S</td>
<td>‘Rosabrook’</td>
<td>Australia</td>
<td>55</td>
</tr>
<tr>
<td>S</td>
<td>‘Rosabrook’ (coated)</td>
<td>Australia</td>
<td>22</td>
</tr>
<tr>
<td>S</td>
<td>‘Whatawhata’</td>
<td>New Zealand</td>
<td>21</td>
</tr>
<tr>
<td>S</td>
<td>‘Woogenellup’</td>
<td>Australia</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>‘Antas’</td>
<td>Italy</td>
<td>7</td>
</tr>
<tr>
<td>Y</td>
<td>‘Monti’</td>
<td>Australia</td>
<td>82</td>
</tr>
<tr>
<td>Y</td>
<td>‘Napier’ (coated)</td>
<td>Australia</td>
<td>93</td>
</tr>
<tr>
<td>Y</td>
<td>‘Trikkala’</td>
<td>Australia</td>
<td>77</td>
</tr>
<tr>
<td>T. michelianum</td>
<td>‘Bolta’ balansa</td>
<td>Turkey/Australia</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SEM 13.06</td>
</tr>
</tbody>
</table>
Similarly to observations at Canterbury, the *yanninicum* (Y) cultivars showed significantly (P<0.05) more redness (~ 84 %) than the *subterraneum* (S, mean ~ 35 %) and *brachycalicinum* (B, mean 7%).

Examples of the sub clovers foliage reddening observed in Omarama are presented in Figure 25 (‘Coolamon’ and ‘Trikkala’ ~ 80 % red score) and ‘Campeda’ and Leura’ in Figure 26 (< 3%).

![Figure 23](image1) ‘Coolamon’ (left) and ‘Trikkala’ sub clover plants (right) showing red foliage in winter (June 2016, photos by T. Lewis and S. Olykan).

![Figure 24](image2) ‘Campeda’ (left) and ‘Leura’ sub clover plants (right) showing red foliage in winter (June 2016, photos by T. Lewis and S. Olykan).