

New Zealand Merino Company

Forage establishment and management
in the high country of
New Zealand

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Executive Summary

The series of experiments have provided several key findings that can be drawn from across sites. Focus is on perennial species with a history of success in the region coupled with additional experimental work on new annual clovers.

Lucerne – has been successfully established and is being integrated into a grazing system at Bog Roy. At Glenmore the lucerne establishment was patchy and the reasons why need to be determined. However, our last autumn survey in May showed some development of secondary root penetration through the top soil and a change from the initial horizontal root growth.

Caucasian clover – was swamped by adventive annual clovers and grasses at Simon's Hill and has failed to thrive at Lake Heron. However, plants extracted from Lake Heron and growing at LU have recovered and this may occur in spring 2012 on site. More work on strategic use of autumn and spring herbicide is required to assist establishment.

Annual clovers have been disappointing at all sites. The wet weather and flush of resident annual clovers was unexpected and has resulted in limited annual clover establishment from oversowing. The quantity of seed required to overcome the resident population may make this uneconomic and seed supplies were limited. Alternative strategies of producing seed on site in small paddocks was supported may overcome this problem.

Lupins have proven an acceptable feed source for ewes and lambs for live-weight gain. Further work is warranted to examine the use of these on a wider scale.

The 2011/2012 season was wetter than average during the growing season. This led to considerably more growth and competition from resident species than most farmers considered "normal" which suggests some results may have been unique to the year and need repeating.

A separate proposal has been put to Ballance agrinutrients who have agreed to examine some of the soil x aluminium interactions confronting the widespread adoption of legumes.

A summary of potential areas for further work are outlined for each site. The project has generated a high level of activity with two PhD, one Masters and 3 Honours students now working on related projects to address some of the science questions in more detail.

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Site 1

Lupin grazing trial at Sawdon station (Black + Lucas)

Primary objective

To quantify animal performance and grazing preference on lupins vs control (lucerne and clover) based pastures. Emphasis on documenting nutritional changes in lupins at different phenological stages e.g. vegetative, flowering, green pods, mature plants.

Goals

- Quantify ewe and lamb liveweight gain during lactation.
- Compare the growth rates of weaned lambs grazing either lupins or lucerne.
- Scanning % of ewes flushed on all pastures (1 March – 31 May grazing period).
- Ascertain approximate grazing day data for lupins.
- Determine dry matter production, botanical composition and nutritive value of lupin stands.

Measurement/Observation dates

2011

17 Dec Ewe/lamb liveweight gain trial commenced

2012

12 Jan Herbage samples taken from lupin plots. Samples were ground and analysed for nutritive value.

12 Mar Site visited by Dick Lucas, Keith Pollock, Denis Fastier, Snow Loxton and Travis Ryan-Salter. Lupin physiology, grazing management and fertiliser requirement was then discussed with Dr David Scott.

23 Mar Ewe flushing/liveweight gain experiment commenced. Quadrat cuts were taken from lupin plots to quantify DM production. Soil samples were taken.

19 Apr Both ewe mobs (lupins and control mob) were weighed after 4 weeks of flushing.

29 Apr Herbage samples were taken from lupin plots. Samples were ground and analysed for nutritive value.

18 May Final weighing of ewe's after 8 weeks of flushing. Herbage/whole plant samples were taken. Nodules on lupin roots were taken for rhizobia analysis; results are pending.

Site

Ten ha of Russell lupin subdivided into four 2.5 ha blocks. Prior to the commencement of the ewe grazing trial, plots had been last grazed on February 17th 2012.

Soil

Table 1: Pre-treatment Soil analyses - 23 March 2012

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Lupins	6.0	24	9	4	25	13	5	<0.5

Olsen P, pH and sulphate S are at optimum at this site, and soil Al is low. As a result, maximum growth would be expected at this site, soil moisture permitting.

1. Animal Liveweight Gain

Lamb Grazing

Methods: Lactating ewe's and lambs were divided into two mobs, which grazed either lucerne (control) or lupins. The lupin mob contained 143 2 tooth ewes and 114 lambs whilst the control mob contained 320 2 tooth ewes and 234 lambs. The mobs were weighed after 31 days and 55 days of grazing. The results of the experiment are presented in Table 2.

Table 2: Average weight of lactating ewes and lambs grazing either lupins or lucerne (control) on 17/12/2011, 17/1/2012 and 10/2/2012 at Tekapo, New Zealand.

Ewes	Liveweight (kg)		Lambs	Liveweight (kg)	
	Lupin	Control		Lupin	Control
17/12/2011	56	55	17/12/2011	19	18
17/1/2012	54	56	17/1/2012	23	25
10/02/2012	53	60	10/02/2012	28	31
Average daily weight gain (gms/day)	-55	+ 91	Average daily weight gain (gms/day)	+ 164	+ 218

Ewe Grazing

Methods: Approximately 600 MA ewes were weighed and split into two mobs on 23 March 2012. Ewes grazing lupins were shifted between blocks fortnightly so that each of the four blocks was grazed (8 week grazing trial). The control mob grazed lucerne for 4 weeks (until frosted) and triticale for the remaining 4 weeks.

Table 3: Average weight of ewes grazing Lupins or Lucerne/Triticale over an 8 week autumn grazing trial at Tekapo, New Zealand. Values in parentheses indicate weight range (kg).

		23/3/12 - Start of experiment	19/4/12 - 4 week weighing	18/5/12 - Final weighing
	No. in Mob	Average Weight (kg)		
Lupin Mob	120	54 (51 - 59)	57 (53 - 64)	61 (57 - 68)
Lucerne/Triticale Mob	90	53 (50 - 58)	59 (51 - 65)	62 (56 - 69)

2. Lupin Herbage Quality

Methods: Herbage samples were taken from lupin plots in early January, 23 March and 29 April 2012. The herbage analysis results are presented in Table 4.

Table 4: Metabolisable energy (MJME/kg DM), Crude protein (%) and N % (parenthesis) content of lupin herbage at three observation dates at Tekapo, New Zealand.

	Metabolisable Energy (MJME/kg DM)			Crude Protein (%)		
	January	March	April	January	March	April
Lupin leaf	11.2	11.2	11.1	21.4 (3.4)	18.5 (3.0)	17.0 (2.7)
Reproductive stem	10.8	10.6	-	21.0 (3.4)	18.3 (2.9)	-
Flowers	10.6	10.4	-	21.8 (3.5)	18.4 (2.9)	-
Companion grass	-	10.3	-	-	14.1 (2.3)	-
Yarrow	-	10.7	-	-	18.0 (2.9)	-

On-going measurements for Sawdon 2012/2013

- Assess the results of autumn 2012 flushing on lupins from Sawdon scanning.
- Benchmark lupin herbage nutritive value characteristics so that NRS will be species specific in future.
- Continue to gather information about lupin grazing management, sheep performance and soil fertility at Sawdon Station in Year 2.

Photo 1: A whole Russel lupin plant from Tekapo, New Zealand.



Photo 2: Quantifying the dry matter production of Russel lupin and companion species at Tekapo, New Zealand on 23 March 2012.



Experiment Extension in 2013

The following extension of work on perennial lupins is suggested at different sites, Ashley Dene and at least one Merino High Country farm.

- Measure the response of perennial lupins to various defoliation treatments so that the influence of reproductive development and frequency and intensity of grazing can be defined. An optimum grazing management template for lupin survival, early spring vigour and maximum DM and N yield could then be promulgated.
- Develop rapid indirect methods (height, reproductive stage, photographic standards, stem density other species) to assist grazing managers assess feeding value of lupin dominated pastures prior to grazing. Tannin analyses should also be included in this work.
- Investigate differences between a range of perennial lupins (eg Russell v Blue v low alkaloid selections if available) including productivity (eg N fixation) and animal responses (e.g. grazing preference).
- Define reasons for differences in Merino grazing preference for lupins at different stages of growth and development, soil moisture holding capacity, lupin stand density, sodium content of foliage etc.
- Measure nitrogen relationships in lupin based pastures including the relative importance of dung and urine versus lupin litter and underground N transfer. Further work on Rhizobium strains will indicate the need for inoculation of lupin seed. Measurement of N fixation using the N14 v N15 technique promises to be a superior method to those previously used.
- Investigate the sociability of lupins with a range of pasture species including cocksfoot, clovers and plantain.

Site 2

Legume and coulter type trial at Glenmore Station (Moot + Pollock)

Primary Objective

Investigate the effect of coulter type, lime rate, and pre-sowing treatment (burn/herbicide) on the establishment and production of three legumes in a hill country environment.

Experimental Design

Randomised split plot design containing 3 legume species and 3 replicates. Species form the main plots and drill type the sub-plots (total of 81 plots).

The split plot design allows more variables to be tested within a smaller area whilst also being much more convenient (uninterrupted drill runs). The design is also good for looking at interactions between experimental factors; e.g. Will some legumes have improved establishment under different drill types and/or pre sowing treatment?

Soil

Table 5: Pre-treatment Soil analyses (Mid-December 2011)

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
0 T	5.1	15	23	3	14	8	6	8.9
Pit 0-5 cm	5.1	N/A	N/A	N/A	N/A	N/A	N/A	8.2
Pit 5-10 cm	5.3	N/A	N/A	N/A	N/A	N/A	N/A	4.9
Pit 10-20 cm	5.6	N/A	N/A	N/A	N/A	N/A	N/A	4.1
Pit 20-30 cm	5.5	N/A	N/A	N/A	N/A	N/A	N/A	4.9

Soil pH is very low, especially in the top 10 cm, but increases/improves with depth. Al toxicity is a real and probably dominant issue here (Exch Al values high). P is also likely to be deficient in plants, given that soil P availability will be strongly restricted by low pH.

Table 6: Post-treatment analyses (Mid-December 2011)*

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
0 T	5.1	15	23	3	14	8	6	8.9
3 T	5.6	32	20	5	12	6	5	3.0
5 T	5.8	48	22	7	14	8	6	1.5

* Requires re-testing in Spring 2012.

Soil pH is very low, and exchangeable Al high at this site. Olsen P results are interesting, and unusual. Seems to be a soil pH/P availability interaction occurring, but requires further

investigation. Need to re-sample at high replication in Spring 2012 to confirm this result, and to examine results in more detail. Also need to collect detailed fertiliser history records for this paddock, and the surrounding area. A lime response would be expected at this site.

Table 7: Preliminary Herbage Analyses (Lucerne)

Nutrient	0 T Lime (Reps 1/2/3)	3 T Lime (Rep 1 Wet)	3 T Lime (Rep 2)	3 T Lime (Rep 4 V. Gd)
N % w/w	2.32	1.68	1.49	3.49
P % w/w	0.24	0.30	0.23	0.29
K % w/w	2.1	3.0	2.2	2.1
S % w/w	0.47	0.57	0.42	0.35
Ca % w/w	1.89	2.00	1.58	1.63
Mg % w/w	0.29	0.28	0.24	0.28
Na % w/w	0.01	0.01	<0.005	0.01
Fe (mg/kg)	140	170	130	100
Mn (mg/kg)	97	130	90	49
Cu (mg/kg)	6.5	5.8	5.8	4.5
Zn (mg/kg)	49	59	47	28
B (mg/kg)	54	52	40	27
Mo (mg/kg)	0.37	1.0	0.66	0.16

Yellowing of lucerne confirmed as being an N deficiency. The wetter part of the trial site is N deficient, while the dryer end is not (and is growing well). Could be several causes e.g. anaerobic conditions, soil temp, poor nodulation/N fixation etc. Requires further investigation. Interestingly, S levels are quite high. Other nutrients probably adequate. Mo seems low on 3 T Rep 4.

Investigated Species/Cultivar

- Caucasian clover cv. 'Endura'
- Lucerne cv. 'Force 4'
- Lupin cv. 'Russell'

Treatments

Expmnt 1	Spring herbicide applied in late October 2011, no lime.
Expmnt 2	No herbicide, no lime. In May 2012, remaining tag was sprayed and burnt off. Due to a lack of success in this experiment, this block became a lime rate experiment in May 2012 involving 5 rates of lime (0, 0.5, 1, 2, 4 t/ha).
Expmnt 3 & 4	Autumn herbicide applied in 2011 and dressed with either 3 or 5 tonne/ha of lime, (experiments 3 & 4 respectively). Residual material burnt off in October and a second herbicide application in late October.
Drill types	Taege, Flexi seeder and Duncan triple disc.
Legumes	Caucasian clover, lucerne and russell lupin sown at 8, 7 and 6 kg/ha respectively (only half rates for flexi seeder). All legume seed was inoculated.

Fertiliser In March 2011 500 kg/ha of Super 10 applied. Then at sowing, 15 Nov, 2011, 100 kg/ha of Cropmaster 20 was applied with the drilled seed.

Measurements and Dates

2011

4 Nov Site visited by Derrick Moot, Alistair Black, Keith Pollock, Denis Fastier, John Stevens and Will Murray. Discussed experimental design and experimental detail, took soil samples, measured herbicided areas for plot layouts, treatments etc.

14 Nov Pegged out experimental block and plots, Contractor on site to ring fence the area.

15 Nov Drilled seed of 3 legumes each with 3 different drills according to plot plan. Measured soil moisture and soil temperature.

21 Nov Site was checked for seedling emergence.

6 Dec Counted seedling emergence. Installed temperature and rainfall logger.

8 Dec Photos taken of drill rows to show seedling emergence patterns.

2012

18 Jan Seedlings counted, and seedling distribution and legume vs. resident regrowth assessed. Legume plants taken for lab assessment of inoculation.

22 Feb Visually assessed summer growth and nodulation.

1 Mar DM yield assessed using pasture probe and quadrat cuts. Visually assessed for botanical composition and distribution of sown species. Removed samples for inspection of nodules. Photos taken.

2 Apr Visually inspected following hard grazing.

2 May Pelleted Aglime was applied at nil, 0.5, 1, 2, and 4 t/ha. 410 kg of lime was applied in total. Data logger was offloaded.

3 May Trial area dimension were measured. Sown legume cover-distribution measured using 5 × 0.1 m² quadrats per plot.

17 May Spread 4.5 T of lime on the remaining fenced off area (1.3 ha) (not in plots).

Photo 3: Lucerne roots growing horizontally in response to elevated Al^{3+} levels in the soil at Tekapo, New Zealand on 7 March 2012.



Photo 4: Secondary lucerne roots penetrating the Al^{3+} layer at Tekapo, New Zealand on 7 May 2012.



Seedling emergence and survival (Figures 1&2) were measured relative to the seed rates applied; the latter measured at the time of sowing by weighing the actual seed delivered by each drill for each species and estimating the seeds sown per m of drill row. The yield was measure on 1 March 2012.

Figure 1: Percent emergence on 6 December 2011 at 3 weeks after sowing.

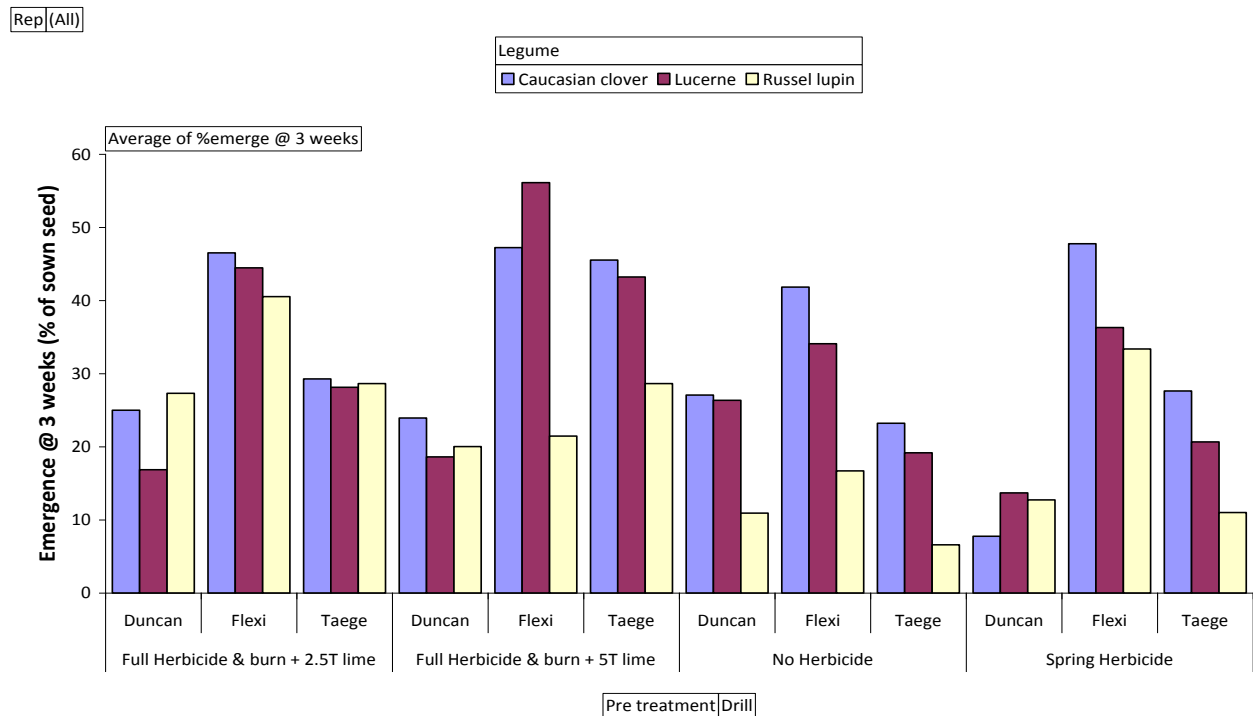


Figure 2: Percent survival of sown seed on 18 January at 9 weeks after sowing.

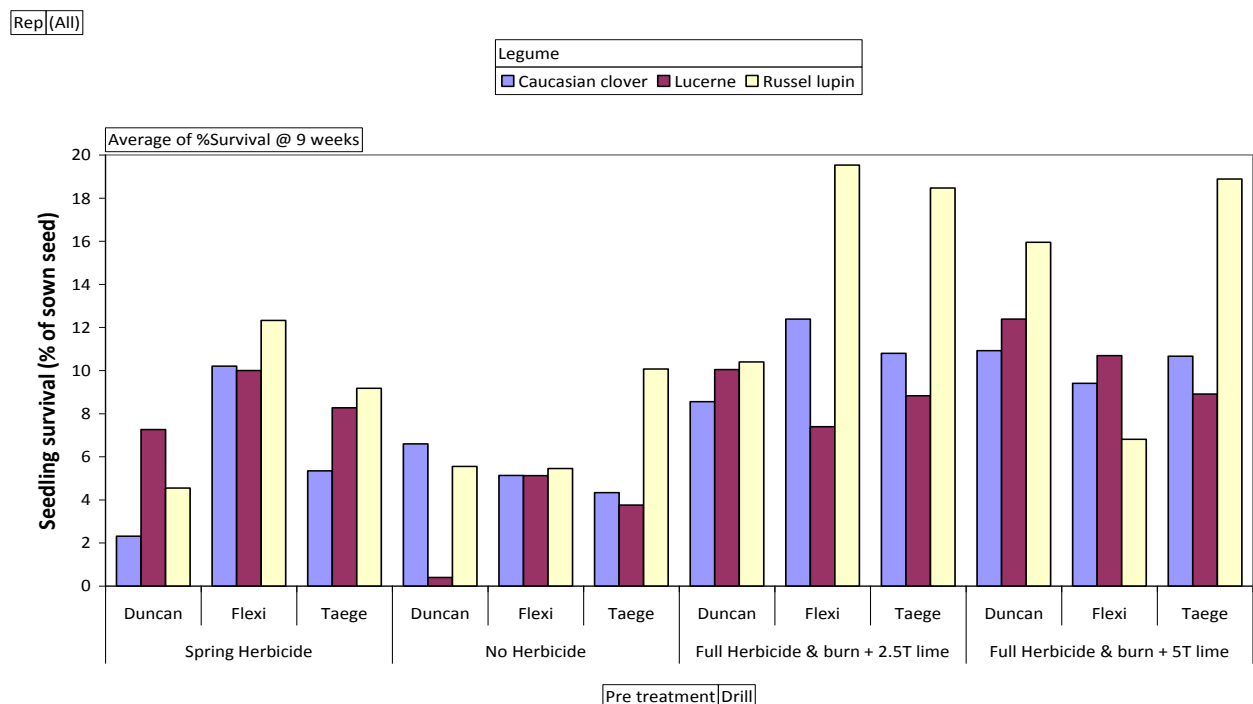
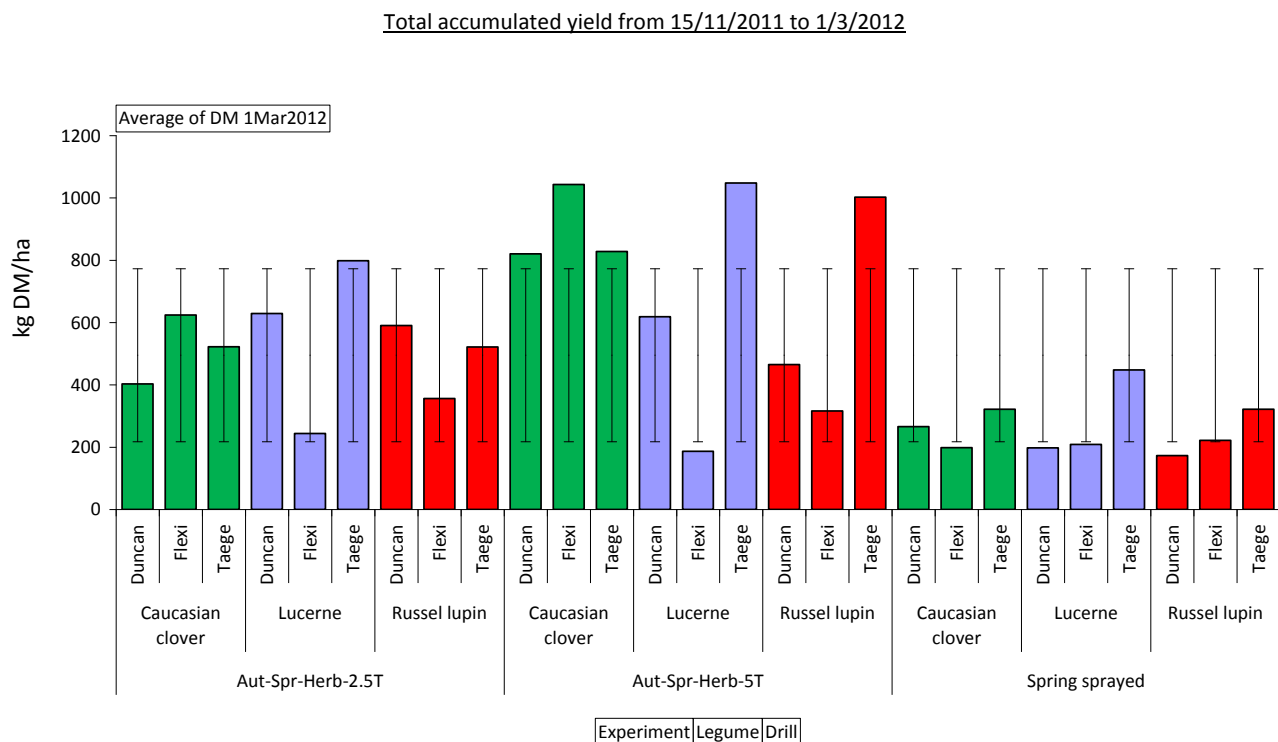


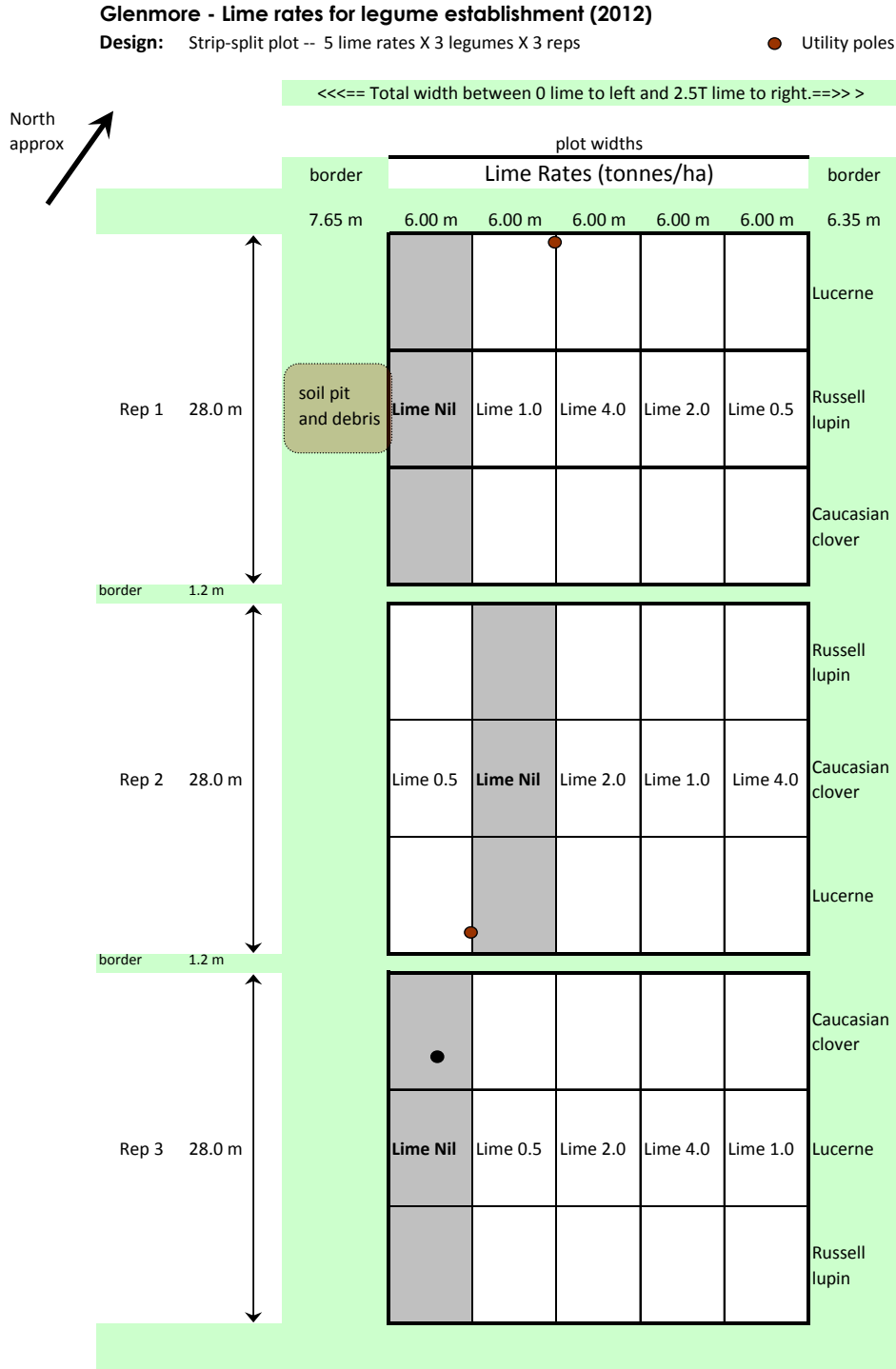
Figure 3: Total accumulated yield from 15/11/2011 to 1/3/2012.



Experiment monitoring and Extension for 2012/13

- Continue with monitoring of experiments 1, 3 + 4.
- Redrill the legumes into established plots in Experiment 3+4.
- In area that was used for Experiment 2 - establish Lime rate (5) X Legume (3) to assess the lime response of acidity tolerance. This will be cross drilled with strips of lucerne, lupin and Caucasian clover in spring 2012. Lime rates were applied in May 2012.

Figure 4: Lime rate × legume establishment (Expt. 3 & 4) experimental design.



- Drill mixture of lucerne, Caucasian clover and lupin with cocksfoot in rest of area outside of established plots. This area has been herbicided, grazed and burnt off in March 2012 and 3.3 t/ha of lime applied in preparation for spring drilling. Aim to let individual legumes dominate on this variable site according to their preferred niches.

Figure 5: Glenmore experimental site layout.

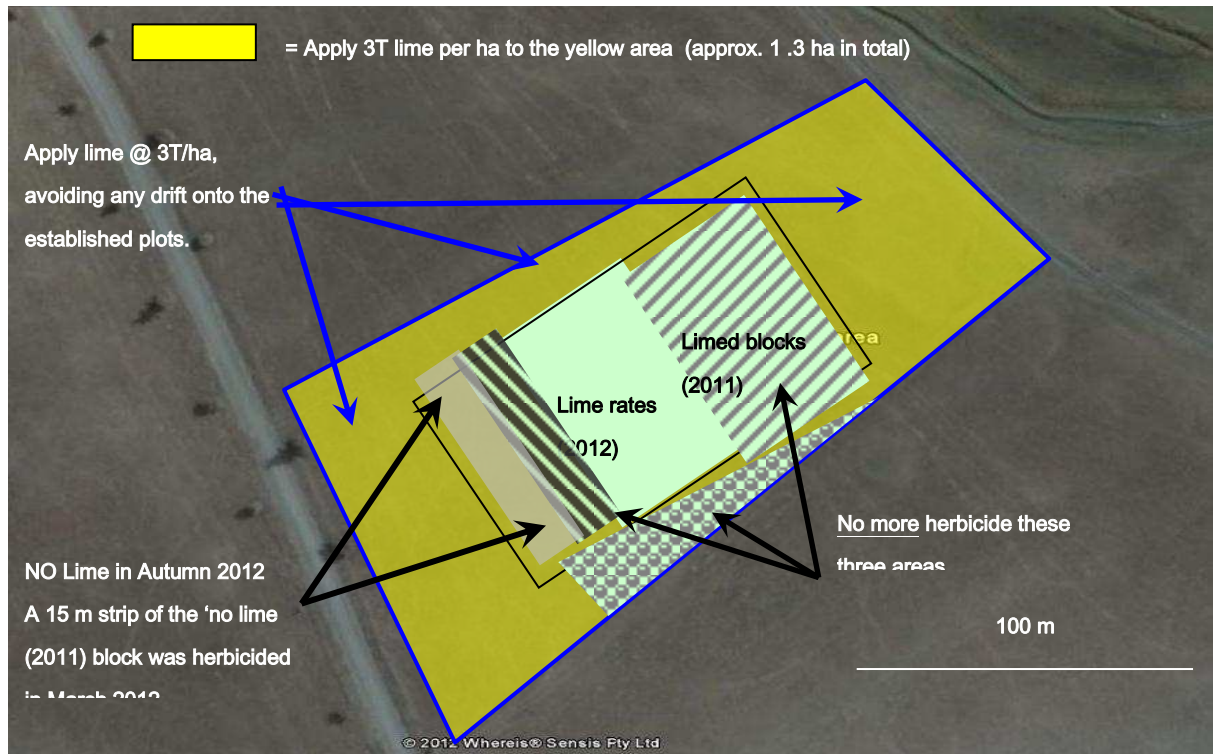


Photo 5: Area of burn-off for experiments 3 & 4.



Site 3

Cocksfoot and Caucasian clover trial at Simon's Hill (Black + Lucas)

Primary Objective

Determine whether fertiliser type and Russell lupin affect the establishment and survival of Caucasian clover and cocksfoot drilled with a unique coulter.

Experimental design

The trial was a 6 x 2 factorial experiment with six fertilisers and \pm Russell lupin as a cover crop. The 12 fertiliser x lupin combinations were drilled with a unique coulter in a randomised block design with four blocks and 3 m \times 10 m plots, repeated on 2 sites of different aspects ('sunny face' and 'dark face') on Simons Hill Station. The fertilisers were:

1. Serpentine Gold (125 kg/ha)
2. Cropzeal 20N (50 kg/ha)
3. PCDAP (x kg/ha) + PC Urea + Tiger 90 (y kg/ha)
4. Crop 20 (x kg/ha) + PCDAP (y kg/ha) PC Urea + Tiger 90 (z kg/ha)
5. Half rate of Serpentine Gold (63 kg/ha)
6. Half rate of Serpentine Gold (63 kg/ha) + Urea (43 kg/ha)

The two sites were grazed hard but not sprayed before sowing. The seed mix was 7 kg/ha 'Endura' Caucasian clover, 2 kg/ha 'Vision' cocksfoot, and zero or 2 kg/ha Russell lupin. Plots were drilled on 23/24 November 2011.

Soils

Table 8: Pre-treatment Soil analyses - 23 November 2011

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Simons Hill	5.6	19	9	8	35	15	4	1.2

Medium-high P and S levels. Soil pH somewhat acid. Exch Al is quite low, and Al toxicity is unlikely likely to be the key factor limiting growth at this site. Soil P and S fertility is medium/high, and probably non-limiting.

Main results

All treatments failed to established due to competition from resident vegetation (mainly hairsfoot trefoil) during a wetter than normal season. While this was disappointing the suggestion that spraying the resident vegetation before sowing could have improved the legume and cocksfoot establishment needed to be explored.

On-going measurements for 2012

No more measurements are anticipated from this trial.

Demonstration established in autumn 2012

To test the impact of herbicides, we advised Denis to 1) establish a herbicide x seed mixture experiment at the 'sunny face' site in February 2012, and 2) spray another area also on the 'sunny face' to have another go at establishing Caucasian clover in spring 2012.

For the herbicide x seed mixture experiment, in February a strip about 15 m wide was sprayed down the hill beside Denis' house and four legume-based seed mixtures were drilled across it, giving two areas drilled without herbicide and one area sprayed and drilled. The four seed mixtures were:

1. Denmark sub clover 10 kg/ha, balansa clover 5 kg/ha, cocksfoot 1 kg/ha and plantain 0.5 kg/ha
2. Campeda sub clover 10 kg/ha, gland clover 5 kg/ha, cocksfoot 1 kg/ha and plantain 0.5 kg/ha
3. Campeda sub clover 10 kg/ha, bladder clover 5 kg/ha, cocksfoot 1 kg/ha and plantain 0.5 kg/ha
4. Lucerne 8 kg/ha, red clover 4 kg/ha, Russell lupin 3 kg/ha, cocksfoot 1 kg/ha and plantain 0.5 kg/ha

On-going measurements for 2012

- Assess the herbicide x seed mixture experiment to determine whether autumn spraying improved species establishment and to determine which species survived the winter.

Outlook for 2013

- Establish a new Caucasian clover experiment, in autumn sprayed areas. We propose to spray the area again in spring and direct drill Caucasian clover with cocksfoot and 100 kg/ha CropMaster 20 as one of four seed mixture treatments in a designed and replicated experiment. The other seed mixtures would include an annual clover mixture (early and late-flowering sub clover cultivars and the early-flowering Frontier balansa clover), lucerne and lotus. The other fertiliser treatments tried in the previous experiment will not be repeated because the Lake Heron results indicated that the CropMaster 20 treatment worked well.

Photo 6: Drilling at the 'sunny face' with a unique coulter at Tekapo, New Zealand on 23 November 2012.



Photo 7: Dominant resident vegetation (*Haresfoot trefoil*) at the 'sunny face' site at Tekapo, New Zealand on 25 January 2012.



Site 4

Lucerne DM production and annual clovers at Bog Roy (Moot + Pollock)

Primary Objective(s)

- *Investigate whether legumes, particularly annual clovers, can successfully establish when oversown on hill country sites which have not received pre-sowing herbicide treatment.*
- *Quantify the seasonal production of lucerne and ryegrass at varying altitudes; in response to temperature, soil type and aspect.*

Goals

- Soil fertility across paddocks and at paired sites.
- Calculate grazing day values in response to dry matter production for different pasture types across the property.
- Dry matter production from cages (improved vs unimproved) across the property every month.
- Evaluate the success of annual clover establishment when oversown without previous herbicide treatment.

Experimental

Lucerne comparative trial

Experiment 1 – Exclusion cages were placed in 8 different paddocks across the property. Each cage measured 0.6 x 0.6 m (0.36 m²) and enclosed a representative sample/area of the paddock. Cages were lifted and herbage samples were cut on a monthly basis. These were then dried and weighed to determine monthly dry matter production.

Annual clover oversowing

Experiment 2 – An experimental area (unimproved browntop dominant pasture) of 0.35 ha was fenced off and grazed by 1400 ewes until resident plants were 2- 3 cm high. Six legume species were arranged in a randomised block design containing six replicates (36 plots). Plots measured 1.5 x 28 m (42 m²).

The randomised block design was chosen to reduce the effect of confounding factors (soil fertility, slope and resident species). Treatments were randomly assigned within each block.

Experiment 3 – Three sites were selected with varying aspect (South, North and West) and elevation (799, 669 and 634 metres above sea level, respectively). At the highest site, 8 quadrats covering 0.5 m² were established, four of which were covered with exclusion cages. Quadrats were established on varying levels of resident vegetation with seed and fertiliser being spread within each quadrat. Four quadrats were established at each of the two lower sites. Exclusion cages were placed over two of the quadrats at each site.

Soil

Table 9: Soil analyses - 22 February 2012

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Reps 1-3	5.9	23	5	8	34	17	2	<0.5
Reps 4-6	6.0	35	3	7	33	25	2	<0.5
Bottom Run	6.0	26	3	9	43	27	2	<0.5

Olsen P high, sulphate S marginal. pH and Al are fine / non-limiting. A high fertility hill site, but with possible S deficiency, and therefore potentially S responsive.

Investigated Species/Cultivar

- Lucerne cv. 'Force 4'
- Subterranean clover cv. 'Trikkala'
- Subterranean clover cv. 'Seaton park'
- Subterranean clover cv. 'Campeda'
- Subterranean clover cv. 'Rosabrook'
- Balansa clover cv. 'Bolta'
- Gland clover cv. 'Prima'
- Lupin cv. 'Russell'

Measurements and Dates

2011

16 Nov First cage cut was taken for improved vs unimproved pasture experiment (experiment 1).

19 Dec Second cage cut taken (experiment 1).

2012

18 Jan Third cage cut taken (experiment 1).

19 Feb Fourth cage cut taken (experiment 1).

22 Feb Pegged out and established annual clover oversowing experiment (Experiment 2) containing three cultivars of subterranean clover, and one each of gland clover, balansa clover and lucerne.

15 Mar Annual clover experiment was visually assessed for seedling establishment. Fifth cage cut taken (experiment 1).

2 Apr Plots were photographed and visually assessed for seedling development and regrowth.

17 Apr Final cage cut was taken for improved vs unimproved pasture experiment (experiment 1).

16 May Three sites were selected with quadrats being laid out at each (Experiment 3). One cultivar of bladder clover, subterranean clover, balansa clover and russell lupin were oversown within each quadrat. Quadrats also recieved a dressing of Sulphur Super 15.

Results

Figure 6: Dry matter production from 16/11/2011 to 15/5/2011 in 8 separate paddocks with either improved or unimproved pasture.

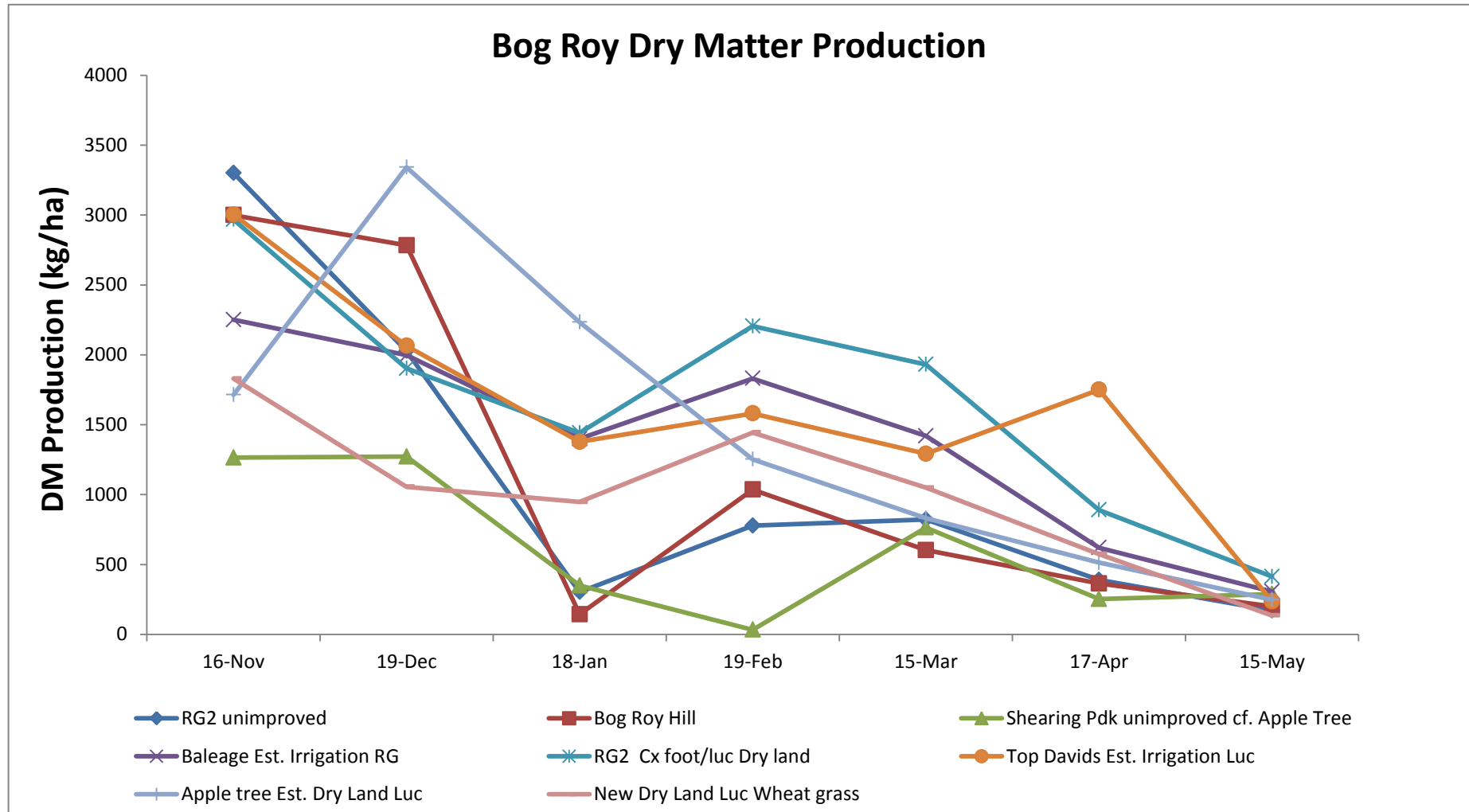


Figure 7: Cumulative dry matter production from 16/11/2011 to 15/5/2011 in 8 separate paddocks with either improved or unimproved pasture.

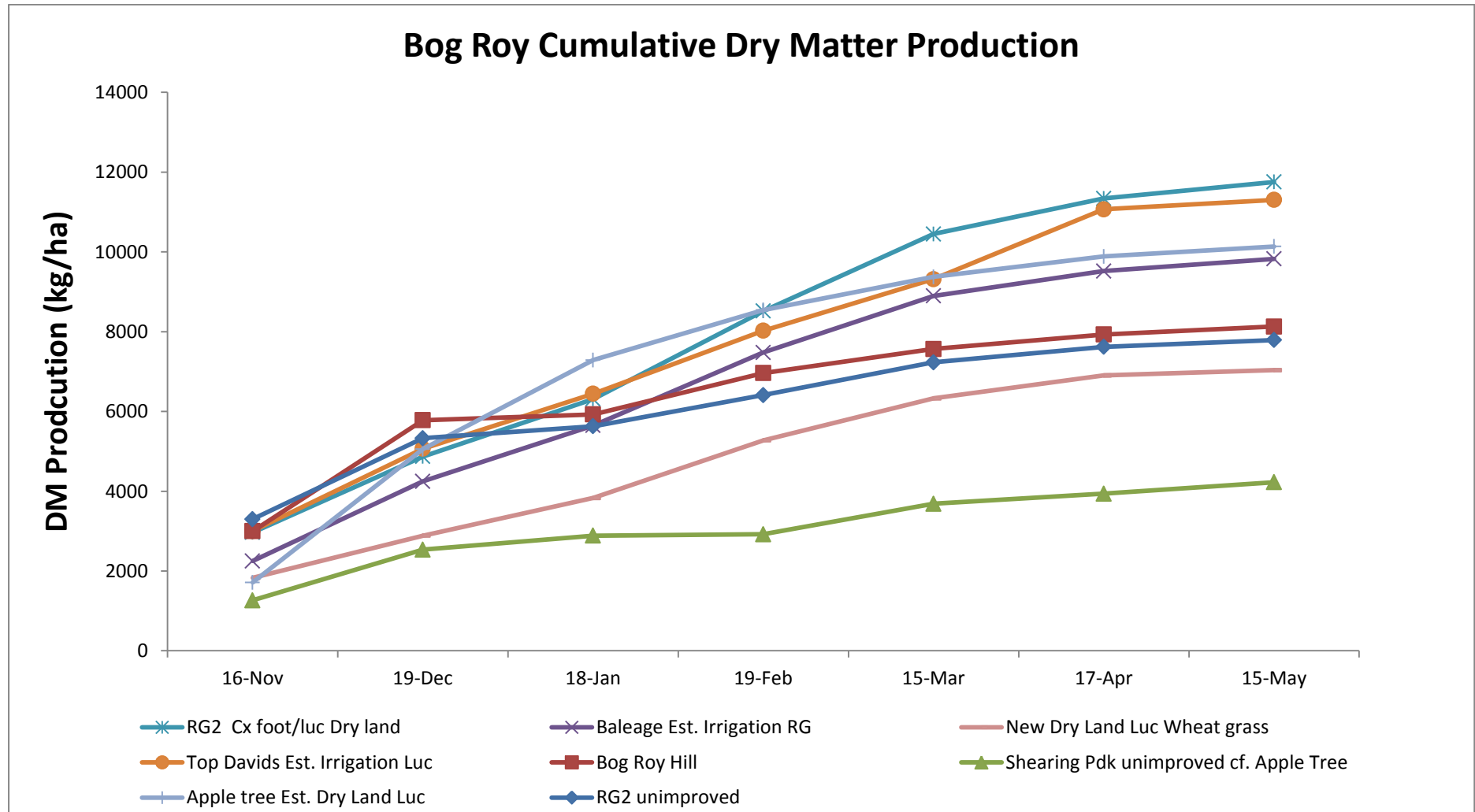


Figure 8: Pre and post grazing DM yield; calculated from pasture height for Mobs 1, 2 & 3.

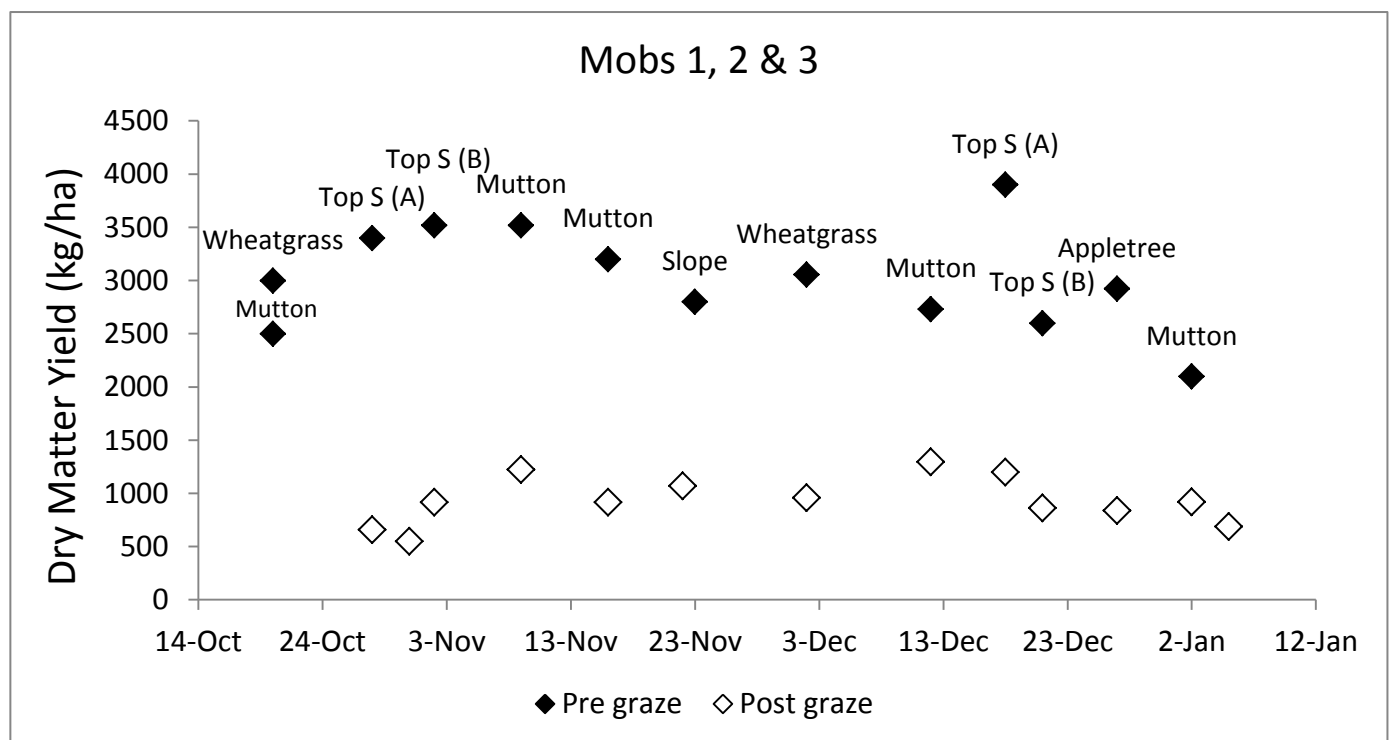


Figure 9: Pre and post grazing DM yield; calculated from pasture height for Mobs 4, 5 & 6.

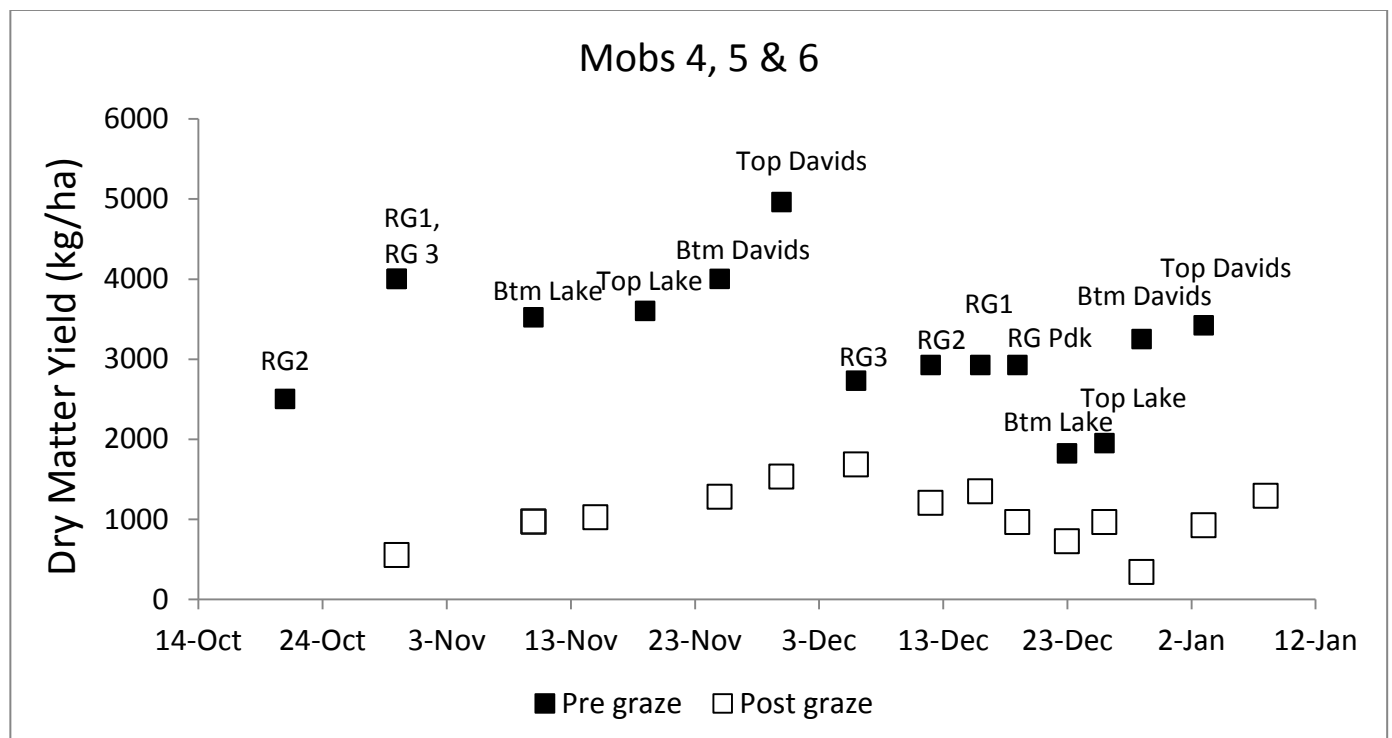


Photo 8: Grazed annual clover experimental site at Bog Roy, New Zealand on 15 March 2012.



Experiment 2 (Photo 8) gave disappointing results in autumn 2012 and very few seedlings were observed in oversown plants and only moderate subterranean clover populations were found in direct drilled areas. Need to re-evaluate in 2012/2013.

On-going measurements for 2012

- Continue to monitor dry matter production for the lucerne comparative trial (Experiment 1).
- Identify annual clover species which have established in Experiments 2 and 3.
- Determine how successfully legumes can establish under heavy competition from resident species.

Outlook for 2013

- Establish a basic pasture production model for improved and unimproved pastures, and how they respond to temperature, aspect and species at varying altitudes.
- Spring sow annual legumes for Experiments 2 + 3.

Site 5

Oversowing of annual clovers at Omarama station (Lucas + Moot)

Primary Objective

To increase the clover content of pasture on sunny and shady slopes by OSTD (oversowing/topdressing).

Goals

- Establish annual clovers through oversowing on faces with contrasting aspects.

Site descriptions

1. The shady face block (approximately 25 ha) generally faces east but folds in the slope create SE and NE faces which appear to influence the soil moisture regime. The slope varies between 15 and 20 degrees. The soil surface is rubbly in places, it is intensively modified by stock tracks and moist bare ground sites where over-sown seed may establish are relatively common. Pasture species present include cocksfoot and perennial ryegrass and a small amount of white clover. Shrubs cover about 20% of the block. Haresfoot clover is the most common legume. There are however large strips on dry mini-ridges where vegetation is less vigorous.
2. The sunny face block (approximately 25 ha) has about 2 ha of stony flat, a 10 to 15 degree north slope plus a west facing rocky slope. The flat area and the north face are dominated by danthonia and rip-gut brome but there are areas where haresfoot clover is common. Briar rose bushes are common on the west face.

Soils

Table 10: Pre-treatment Soil analyses

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Resvr Sunny	6.2	9	3	9	27	5	2	N/A
Resvr Shade	6.3	9	2	9	30	9	2	N/A
Resvr Flats	6.1	11	2	10	30	14	5	N/A

Olsen P low, S very low. S and P will be severely limiting production at this site. pH is at optimum, so Al toxicity will not be an issue. Soil P availability (e.g. following fertiliser application) should be excellent.

Investigated Species

- Subterranean clover cv. 'Seaton Park'
- Balansa clover cv. 'Bolta'
- Balansa clover cv. 'Frontier'
- Cocksfoot cv. 'Greenly'
- *Note- no gland clover available which was our first choice for this site.*

The following seed mixture was flown on to 15 ha of each block on 8 March 2012. Seaton Park sub clover (4 kg/ha), Bolta balansa clover (3 kg/ha), Frontier balansa clover (3 kg/ha), coated Greenly cocksfoot (2 kg/ha, equivalent to 1 kg/ha bare seed). Sulphur super 20 was applied with the seed at 350 kg/ha.

Results

On 17 May 2012 seedlings from over-sown seed were common on the south east facing areas (shady) which had disturbed surfaces. Balansa seedlings in particular had good populations in small patches with up to 50/m². Sub clover plants were less common with only about one per m². Very few seedlings were found on drier sites. This means that only about 30 % of the block is likely to have a balansa plant population large enough to justify closing the block in late October/early November to get maximum reseeding. A light to moderate August/September grazing to control resident grass competition is recommended. An on-site discussion in October to determine flowering and seed production possibilities is anticipated.

On the sunny face; only two balansa and no sub clover seedlings were found after one person hour searching on 17 May 2012. In general the competition from resident grass for water on the north face would have been excessive. However germination may have been delayed and some over-sown seeds may have remained ungerminated on the soil surface. Seed that did germinate may have suffered from light competition as well as for soil water. Hence a false strike may have occurred. Heavy grazing of the area as soon as possible after 17 May was recommended. A subsequent visit in late winter to search for clover seedlings may determine spring grazing management. It is likely that close grazing will be required to control rip gut brome. If there is an unexpected flush of over-sown clovers a part of the block could be spelled so that clover seed production could be assessed.

In the sunny face block on a small NE area where soil surface conditions were suitable, haresfoot clover seedlings were common. There a start was made to develop a 0 to 10 scoring system to describe annual clover populations. A 10 score indicates > 1000 seedlings /m². Photographs were taken to illustrate the scoring system which is required to hasten field observations on all MerinoNZ pasture improvement sites.

On-going measurements for 2012

At least two more visits from the LU team will be made in the late winter/spring of 2012 to discuss grazing management in relation to over-sown species establishment and possible seed production. Cages may be placed to protect plants from grazing; if it is decided that it is not worth closing whole blocks from grazing so that seed may be produced. Alternatively, electric fences across small areas of about half a ha may be considered. Intensive hard grazing on both blocks will be important in the 2012/13 summer to control grass so that competition against both resident and newly introduced annual clovers is minimised after the autumn rains.

Further work on Omarama Station in 2013 to include (1) the establishment of Bolta balansa clover in a four ha flat paddock which is winter wet and summer dry. The paddock cannot be irrigated but if it is chemically fallowed from October 2012 and the balansa sown in the first week of February 2013 a strong stand of clover should establish. A half kg/ha of Kahu timothy and /or a half kg/ha of Tonic plantain may be sown with 5 kg/ha of the Bolta balansa clover. Seed rich hay may be made from this paddock or balansa seed harvested. Cattle may also be used to graze the paddock if seed or hay production is not possible. The cattle may then be moved to start spreading seed to hill areas.

(2) A second four ha paddock which has drier soil conditions could also be used for legume seed production. Part of the current strong cocksfoot stand could be sprayed out in October 2012 for gland clover seed production while (3) the area remaining in cocksfoot could be hard grazed and direct drilled with 10 kg/ha sub clover. Hay made from this mixture could be timed to have a high cocksfoot and / or sub clover seed content. This could be fed out in autumn on to a very hard grazed, sunny face hill block in an attempt to enhance the danthonia dominant grassland. Further work will be done to standardise visual assessment of annual clover populations using photographic reference scales. (See also Mt Grand entry in this report for further comment on methods for increasing seed rates on hill blocks)

Photo 9: Ripgut brome and Haresfoot trefoil on the 'North Face' at Omarama, New Zealand on 8 December 2012.



Photo 10: Quantifying legume content on the 'East slope' at Omarama, New Zealand on 17 May 2012.



Site 6

Large-scale annual clover oversowing at Mt Grand station (Moot + Lucas)

Primary Objective(s)

To introduce more productive annual clover species to sunny face pastures by conventional over-sowing and topdressing.

The dominant legume in lower altitude sunny face pasture on Mt Grand is striated clover. If earlier flowering more productive annual clover species could be introduced the feeding value of pasture on offer to ewes and lambs in spring would be significantly improved. Additionally, if a wider range of clover species can be established they will be able to exploit hill country site variability more efficiently.

Goals

- The use of intensive grazing to improve establishment of sown legumes through the dual-effects of trampling and removal of resident vegetation competition.
- Improve knowledge and management of annual clovers.
- Effect of fertiliser application on resident clovers (e.g. striated).
- Quantify the success of annual clover establishment when oversown/topdressed (OSTD).

Experimental Design

Over the next three years it is proposed that three or four lower altitude, Mt Grand sunny face blocks will be sub-divided and over-sown with annual clovers. One half of each block will be OSTD while the other half will have the same amount of fertiliser applied but without broadcasting clover seed. In some cases the lower altitude area of a block may be OSTD in anticipation of the higher altitude, summer grazing, snow tussock area being fenced off. Assessment of this programme will be difficult to quantify precisely; changes in botanical composition, nitrogen content of grasses, sheep and cattle grazing days and possibly lamb and ewe weaning weights may be measured.

An experiment was established in the lower half of a sunny face in Patterson's on 28 April 2012. Ten 1 m² quadrats were pegged out in areas with varying levels of resident biomass. Four species of annual clover and perennial lupins were oversown in each quadrat.

Investigated Species/Cultivar

- Balansa clover cv. 'Bolta'
- Gland clover cv. 'Prima'
- Subterranean clover cv. 'Campeda'
- Subterranean clover cv. 'Seaton Park'
- Subterranean clover cv. 'Denmark'
- Bladder clover cv. 'Bartolo'
- Lupin cv. 'Russell'

Soils

Table 11: Pre-treatment Soil analyses - 13 September 2011

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Castle Rock	5.2	15	6	5	20	10	1	N/A

pH low, Olsen P and S medium. Site will have Al toxicity problems, and probably associated soil P availability issues. Sulphur levels likely to be limiting pasture growth.

Measurements and dates

2011

8 Apr Pattersons block divided in half with both sides being fertilised with 200 kg/ha Maxi Sulphur Super.

8 Apr Eastern half of Pattersons block oversown with sub clover (6 kg/ha), balansa clover (4 kg/ha), gland clover (4 kg/ha) and plantain (1 kg/ha). Block was intensively grazed before (1400 ewes) and after oversowing (750 ewes).

2012

9 Mar Lower western half of Patterson's was oversown with sub clover (6 kg/ha) and balansa clover (4 kg/ha). The lower altitude zone of the 60 ha Castle Rocks Block was OSTD with sub clover (2 kg/ha), balansa clover (4 kg/ha) and 250 kg/ha sulphur super 30. This was in anticipation of sub-dividing the snow tussock area from the warmer gully which has the potential to produce high quality feed in spring when the tussocks should be spelled for summer grazing.

Pattersons Block was inspected several times by LU staff with the manager, Evan Gibson, over the last 18 months and Evan was in regular contact regarding grazing management decisions in relation to the growth and development of the annual clover species.

As yet no seedlings have been observed from the autumn 2012 oversowing.

Results and Discussion

An average of over 1000/m² seedlings of striated clover established and thrived in Pattersons East in 2011. The striated clover appeared to benefit from the fertiliser application and it dominated the three annual clover species which were over sown. The two top flowering clovers, gland and balansa, grew taller than the 10 to 20 cm high striated clover canopy. The gland and balansa clover plant populations varied widely over the 12 ha block but neither species exceeded an average of 1 flowering plant / m². There were fewer sub clover plants than the smaller seeded top flowering species.

Issues which require further investigation are: timing of seeding, intensity of winter/early spring grazing, the need for Rhizobium inoculation, clover seeding rate and quantification of the production advantages of top flowering annual clovers.

1. Timing: The striated clover germinated before the additional clover seed of was flown on and striated seedlings had about a month's autumn growth advantage. Earlier seeding before the

autumn break should give new clover species an improved chance to compete with resident clovers. Early seeding would be assisted only if suitable rhizobium strains were resident in the soils. Rhizobia on inoculated or coated seed would be unlikely to survive on hot, dry soil surfaces in late summer.

2. Grazing in early spring until the first indications of flower development (stem elongation) would reduce the intensity of resident grass and clover competition.
3. Rhizobia strains from soil and nodules from resident clovers could be isolated and tested on 'improved' clover species to determine the need for clover seed inoculation.
4. Very high seeding rates of more productive species to counter the large resident striated clover population may be successful but would be unacceptably expensive.
5. Comparisons between adventive annual clovers such as striated and haresfoot versus gland, balansa and sub clovers will enable quantification of differences between species at a range of sites.
6. Spring sowing of annual clovers on a large scale.

On-going measurements for 2012

- Decisions about early spring grazing in Castle Rocks lower altitude gulley and Pattersons East and West blocks will be made in August with regard to reducing competition on seedlings established from the autumn over-sowing. In October established plant counts will be recorded and decisions made regarding management to encourage balansa clover seeding.
- In December 2012 another block will be selected for a further attempt to introduce improved clovers on a large scale. Suitable summer grazing management and sub-division plans will then be discussed and implemented.

Outlook for 2013

Further work to develop initial investigations into the possibility of using very high seeding rates on hill blocks from seed produced on farm from cultivated paddocks. Several methods will be compared on different parts of Mt Grand and attempts made to manage adjacent paddocks 'normally' as 'controls' without any heavy rates of seed application.

1. Balansa clover hay was made in the Mt Grand Cottage paddock in late December 2011 (60 x 230 kg square bales from 4 ha). Each bale contained between 6 and 30 kg balansa seed and when bales were rolled down south facing, steep slopes they disintegrated over a swath of up to 60 m x 10 m. Salt spread on the seed rich hay encouraged intensive grazing and under-grazed tall oat grass and cocksfoot 'tussocks' were reduced to short clumps with bare ground between. Very high populations of balansa clover seedlings (>1000/m²) have established in these heavily grazed areas.

Improvements to this technique may be achieved by:-

- Making hay when it is less mature to get higher ME material which is more attractive to sheep.
- Feeding hay to cattle rather than, or as well as, sheep.
- Increasing the area 'hayed' by making round bales, which can be more easily rolled down hill pastures.
- Introducing small amounts of granular salt to hay through an attachment on the baler.

- Increasing the proportion of individual grazing blocks 'hayed' by subdivision (permanent or temporary).
 - Developing one small block each year by grazing intensively with cattle through summer/early autumn to the point where the seed rich hay is up to half the animal intake – this will ensure that seed is spread before the autumn break. Winter hay feeding would result in less desirable spring germination of annual clovers.
2. Harvest seed from paddocks on the flat which are grown specifically for seed production for use on farm for aerial over-sowing (e.g. red and Caucasian perennial clovers; balansa, gland and sub clovers). Note: perennial clovers should be sown in early spring and annuals in autumn.
 3. Grow clover patches for seed on flat to rolling areas of hill blocks or on paddocks adjacent to steep hill blocks. Use electric/temporary fencing where necessary to control cattle grazing when seed crops are mature. Manipulate stock movement on and off seed crops with salt, dogs etc.

Notes: These methods assume suitable Rhizobia are present in the soil where seed is broad-cast or spread in hay or by livestock. This needs to be investigated for a range of sites/soils in the MerinoNZ programme perhaps as part of a PhD programme.

Photo 11: Balansa clover seedlings growing after a seed-rich hay bale was rolled down a steep slope at Hawea, New Zealand on 28 April 2012.



Site 7 – Experiment 1

Establishment of cocksfoot and Caucasian clover in tussock lambing blocks at Lake Heron station (Black+Moir)

Primary Objective(s)

- *Determine whether cocksfoot and Caucasian clover can successfully establish in low lying tussock lambing blocks.*
- *Investigate whether a source of nitrogen at drilling (fertiliser type) improves plant establishment, growth and survival.*

Goals

- Full soil nutrient analysis.
- Gather plant population data at establishment then 6 monthly.
- Determine dry matter production and composition twice in growing seasons.

Experimental

Two trials were established in the 'Clent Hills Native' block.

For Experiment 1, Caucasian clover and cocksfoot were drilled with either 110 kg/ha of superphosphate (0-9-0-12) or 100 kg/ha of Cropmaster 20 (19.5-10-0-12.5) on 20/21 December 2011, in a randomised block design with three replicates and plots 30 m by the length of the paddock (about 400 m). The two fertiliser treatments differed in the amount of N applied (0 and 20 kg/ha respectively), but the amounts of P and S were the same. We chose this design because N fertiliser applied down the spout has been beneficial in other on-farm sowings in the high country.

For Experiment 2, four rates of superphosphate (0, 100, 200 and 400 kg/ha) and two rates of lime (0 and 5 t/ha) were applied after sowing in a randomised block design with four replicates and 12 m x 20 m plots. Two replicates were in an area drilled with super and two replicates were in an area drilled with Cropmaster20. The super was applied on 31 January and the lime on 28 February. We chose these treatments because we suspected the superphosphate response would depend on soil pH.

About 40/m² Caucasian clover plants established in the Clent Hills over-drilled 20 ha paddock. Their leaves indicated possible sulphur and nitrogen deficiency and no nodules were found on roots. To assist with diagnosis of deficiencies in the Caucasian clover soil cores over single plants were collected in May and grown in pots in a LU glasshouse. The plants which had become dormant in the field with the onset of cooler weather and shorter days recovered to some extent in the warm glasshouse.

The randomised block design was chosen to reduce the effect of confounding factors (soil fertility, shade and shelter). Treatments were randomly assigned within each block.

Soil

Table 12: Pre-treatment Soil analyses - 28 February 2012

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Clent Hills	5.5	7	14	5	16	10	3	2.1

Olsen P is very low. Growth will be very P limited at this site, while surprisingly, S is at optimum levels. pH is moderately acid. As a result, soil exch Al is moderate, approaching toxic levels. P, perhaps in combination with some Al issues, are likely limiting growth. We would expect this site to be responsive to P fertiliser applications.

Investigated Species/Cultivar

- Caucasian clover 'Endura'
- Cocksfoot 'Vision'

Measurements and Dates

2011

20 Dec Cocksfoot and Caucasian clover was drilled with respective fertiliser treatment (Trial 1).

2012

31 Jan Superphosphate was applied to Trial 2.

28 Feb Lime was applied to Trial 2. Trial 1 was visually assessed for seedling survival and growth.

7 Mar First counting of Caucasian clover and cocksfoot plants at Clent Hills Native. Samples were taken from each plot for further analysis (shoot and root weight).

15 Apr Clent Hills Native was visually assessed for plant survival and fertiliser response.

9 May Soil cores and individual plants were taken from Clent Hills Native and nitrogen fertiliser was applied to Trial 2.

11 May Soil cores containing individual Caucasian clover plants were placed in the glasshouse at Lincoln University for further assessment.

Main results

- Caucasian clover and cocksfoot populations were not affected by starter N, but plants were bigger after drilling with CropMaster 20 than with super (Table 13).

Table 13: Mean seedling population and size on 7 March 2012 of Caucasian clover and cocksfoot drilled with two starter fertilisers on 20/21 December 2011 at Clent Hills Native, Lake Heron Station.

	Superphosphate	Cropmaster 20	Level of sig.	SED
<u>Caucasian clover</u>				
Plants per 2 m of drill row	12.9	12.2	NS	2.37
Plant dry weight (mg)	12.9	39	***	7.15
<u>Cocksfoot</u>				
Plants per 2 m of drill row	14.3	12.2	NS	4.32
Plant dry weight (mg)	13.7	76.4	***	9.51

NS = not significantly different; *** = significantly different

- In May the Caucasian clover plants were small. Leaves indicated possible nitrogen or sulphur deficiency with no root nodules found. Thus, urea was spread at 100 kg/ha over a 5 m strip in each plot in Experiment 2 to test whether this was due to a lack of N.
- To aid deficiency diagnosis soil cores of single CC plants were collected and grown in pots in a LU glasshouse. The plants had become dormant in the field with the onset of cooler weather and shorter days, but some recover is evident in the glasshouse.
- A 2⁵ factorial experiment was established to investigate possible responses to inoculation with the Caucasian clover super rhizobia bug ICC148, sulphur, phosphorus, nitrogen, and molybdenum plus boron.

On-going measurements expected for 2012

- Continue to assess the \pm drilled nitrogen treatments and super x lime treatments with 6-monthly plant population counts and dry matter production and botanical composition in spring.
- Monitor the glasshouse pot trial over winter to diagnose any deficiencies in rhizobia and minerals.
- Based on the winter pot trial results, any remedial rhizobia or mineral treatments will be applied to the field plots in October/November 2012 as strips within the designed experiments and the response(s) will be assessed over spring.
- Assess the response to the May urea which would indicate nitrogen deficiency.
- Continue plant population counts, dry matter production and botanical composition measurements twice in growing season.

Outlook for 2013

- Examine the effect of sowing time on Caucasian clover establishment and competitiveness.
- Core measurements from the pot trial in the LU glasshouse will be used to diagnose any rhizobia and mineral deficiencies.
- Results from the factorial expt will be used to direct field experiment for remediation of the Cc in 2012/2013.

Photo 12: Shoot and root size of cocksfoot plants sown with either Superphosphate (0-9-0-12) or CropMaster 20 (19-10-0-13) at Lake Heron, New Zealand on 7 March 2012.



Photo 13: Individual Caucasian clover plants from Lake Heron, growing in a temperature-controlled glasshouse at Lincoln, New Zealand on 20 May 2012.



Site 7 – Experiment 2

Fertiliser/lime interactions at an established Caucasian clover stand at Lake Heron station (Black + Moir)

Primary Objective

To determine the superphosphate requirements for a mature stand of Caucasian clover, and whether liming affects these requirements.

Goals

- Full soil nutrient analysis.
- Determine dry matter production and composition twice in growing seasons.

Experimental

The design is the same as the second part of the Caucasian clover establishment trial. Four rates of superphosphate (0, 100, 200 and 400 kg/ha) and two rates of lime (0 and 5 t/ha) were applied after sowing in a randomised block design with four replicates and 12 m x 20 m plots. Two replicates were in an area drilled with super and two replicates were in an area drilled with Cropmaster20. The super was applied on 31 January and the lime on 28 February. We chose these treatments because we suspected the superphosphate response would depend on soil pH.

Soil

Table 14: Pre-treatment Soil analyses - 28 February 2012

Sample	pH	Olsen P (mg/L)	Sulphate S (mg/kg)	Exch Ca (QTU)	Exch Mg (QTU)	Exch K (QTU)	Exch Na (QTU)	Exch Al (mg/kg)
Caucasian	5.5	5	11	7	10	8	3	1.7

Olsen P is very low. Growth will be very P limited at this site, while surprisingly, S is at optimum levels. pH is moderately acid. As a result, soil exch Al is moderate, approaching toxic levels. P, perhaps in combination with some Al issues, are likely limiting growth. We would expect this site to be very responsive to P fertiliser applications.

Investigated Species/Cultivar

- Caucasian clover cv. 'Endura'

Measurements and Dates

2012

31 Jan Superphosphate was applied to plots.

28 Feb Lime was applied to plots.

15 Apr Caucasian paddock, was visually assessed for fertiliser response and botanical composition.

9 May Herbage samples were taken from Caucasian for chemical analysis.

*Note: dry matter yield and botanical composition were not measured in May as originally planned because there were no obvious treatment differences and the herbage had started to die back after recent frosts. Instead it was decided to take samples of leaf plus petiole of Caucasian clover from each plot for mineral analyses as an indicator of any effects of super and lime in the first year.

Main results

- The effects super had on the N, P and S contents in the Caucasian clover leaves are shown in the graphs below. The N, P and S levels increased with increasing rates of super and lime had little or no effect.

Figure 10: Herbage N content of Caucasian clover leaf (lamina + petiole) in response to superphosphate and lime at Lake Heron, New Zealand on 9 May 2012.

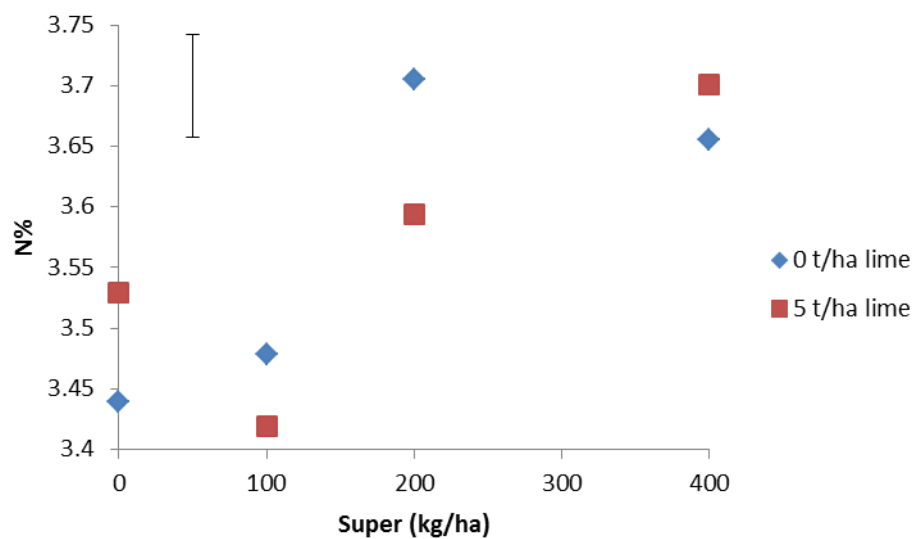


Figure 11:Herbage P content of Caucasian clover leaf (lamina + petiole) in response to superphosphate and lime at Lake Heron, New Zealand on 9 May 2012.

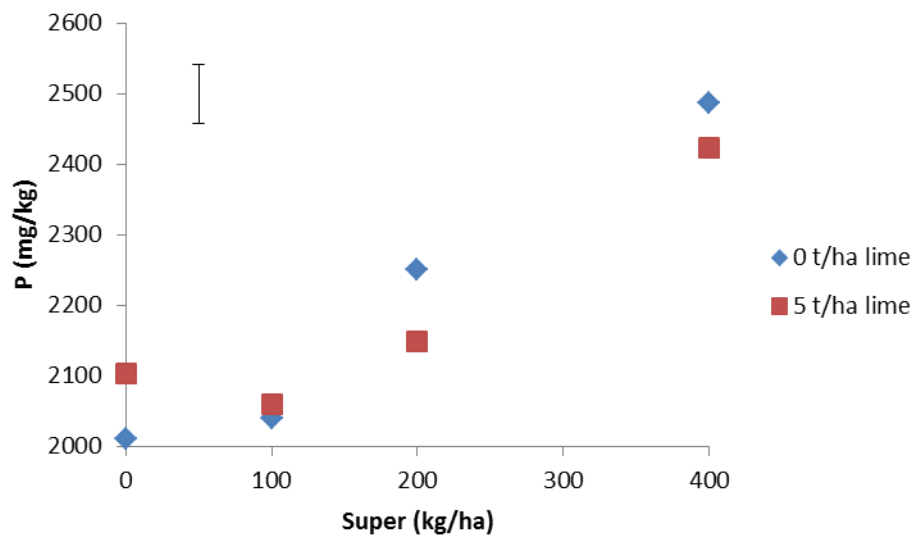
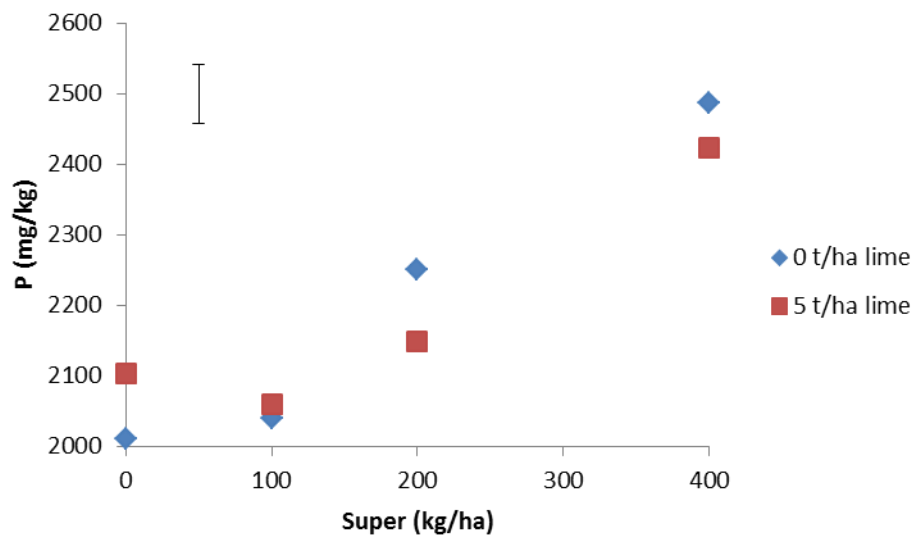


Figure 12:Herbage S content of Caucasian clover leaf (lamina + petiole) in response to superphosphate and lime at Lake Heron, New Zealand on 9 May 2012.



On-going measurements for 2012

- Soil pH, aluminium levels, full nutrient status post treatments
- Plant population counts 6 monthly
- Dry matter production and botanical composition in spring

Outlook for 2013

Continue dry matter production and botanical composition measurements twice in growing season to determine impact of super on DM production.

Photo 14: Caucasian clover and resident weed grasses at Lake Heron, New Zealand on 28 February 2012.



Photo 15: Applying lime to superphosphate \times lime experiment in Caucasian paddock at Lake Heron, New Zealand on 9 May 2012.



Site 8 – Ashley Dene/Lincoln University – Capability development

The need to intensively monitor pasture responses to the environment at more frequent intervals has led to some parallel experiments being using Lincoln University post-graduate students.

Ashley Dene

Lime (3 rates) x species (Lupins, Caucasian clover, Lucerne) experiment on a low pH medium aluminium soil with moderate P levels – Saman Berenji – PhD student.

Annual clover oversowing on different dates – four dates x five species to examine establishment success of species into spring. – Scott Harvey B.Ag.Sci Honours.

Annual clover establishment after direct drilling – four dates x five species to examine establishment success and compare with oversown plots. Lucy Murray B.Ag.Sci Honours

Lupin block – an experiment of perennial blue vs Russell lupins will be established on a 2 ha block at Ashley Dene – could be used for DM calibration, alkaloid analyses or development of grazing experiment.

LU glasshouses

Lupin responses to soil P and Al levels on different high country soils – Isaac Thomas Masters/ Honours.

Rhizobia isolation and reintroduction. Several high country soils have been screened for rhizobia to determine if they contain rhizobia with P solubilising ability- screening is ongoing (advised to balance for potential investment).