Project Number: 408090

Optimization of subterranean clover for dryland pastures in New Zealand

Sustainable Farming Fund 2015-2016

Progress Report for Milestone M3756

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Lincoln University

June 2016

Introduction

This report outlines the design and establishment of the experiments in the 'Sub 4 Spring' research programme. Farms and research stations in six locations - Mackenzie Basin in Central Otago, South Canterbury, Mid-Canterbury, North Canterbury, Wairarapa and Hawkes Bay (see the progress report for M3755), were selected for the intensive investigation of the use of sub clover for New Zealand conditions

The experiments are a mix of on-farm demonstrations, on-farm experiments, and on-station experiments with the following aims:

1) to define the potential of subterranean clover to provide early lactation feed in New Zealand dryland environments and,

2) to identify solutions to agronomic and edaphic constraints to achieving that potential across different sites in New Zealand.

Eleven experiments have now been established across the six sites. These include a range of experimental treatments to optimise the establishment of subterranean clover, answer local farmer questions and investigate environmental constraints at each location. The different components of the research will provide a comprehensive agronomic package for sub clover use in New Zealand, demonstrate those benefits on farm and outline potential requirements for further research.

This report details evidence that **Milestone 3756** has been completed:

- Pre-treatments confirmed
- Experimental plans
- Post treatments (herbicide, grazing or fences/cages etc.)
- Initial data collected – establishment counts
- Any significant outputs e.g. visits, blog etc.

McKenzie Basin - Omarama

Experiment location and site details

The experimental site is on Omarama Station which is owned and farmed by Richard and Annabelle Subtil.

GPS coordinates of the experimental site are -44.506566, 169.901419, altitude is 477 m a.s.l, and the topography is flat. The area of the site is 0.3 ha (200 m x 15 m).

The Mackenzie soils (Pallic Orthic Brown Soil) are characterised as being shallow and well drained with low plant available water. Analysis of soil samples taken from the experimental site found a low pH of 5.7, medium Olsen P, medium levels of potassium and low levels of calcium, and magnesium in the 0-75 mm depth.

The nearest climate station is at Tara Hills Aws (Tara Hills Aws, agent no. 5212) which is 2.9 km from the site at an altitude of 488 m a.s.l.

Experimental design

Objective 1: To assess the cold tolerance of sub clover cultivars. To do this sub clover survival, dry matter production, reseeding and regrowth will be assessed over two years. The work will be conducted in association with a merino bench marking group and results distributed to them through their facilitator.

Two experiments were sown at Omarama:

- ♣ Experiment 1 – cold tolerance of sub clover cultivars
- ♣ Experiment 2 – effect of interplanting with grass (cocksfoot) on the cold tolerance of sub clover cultivars

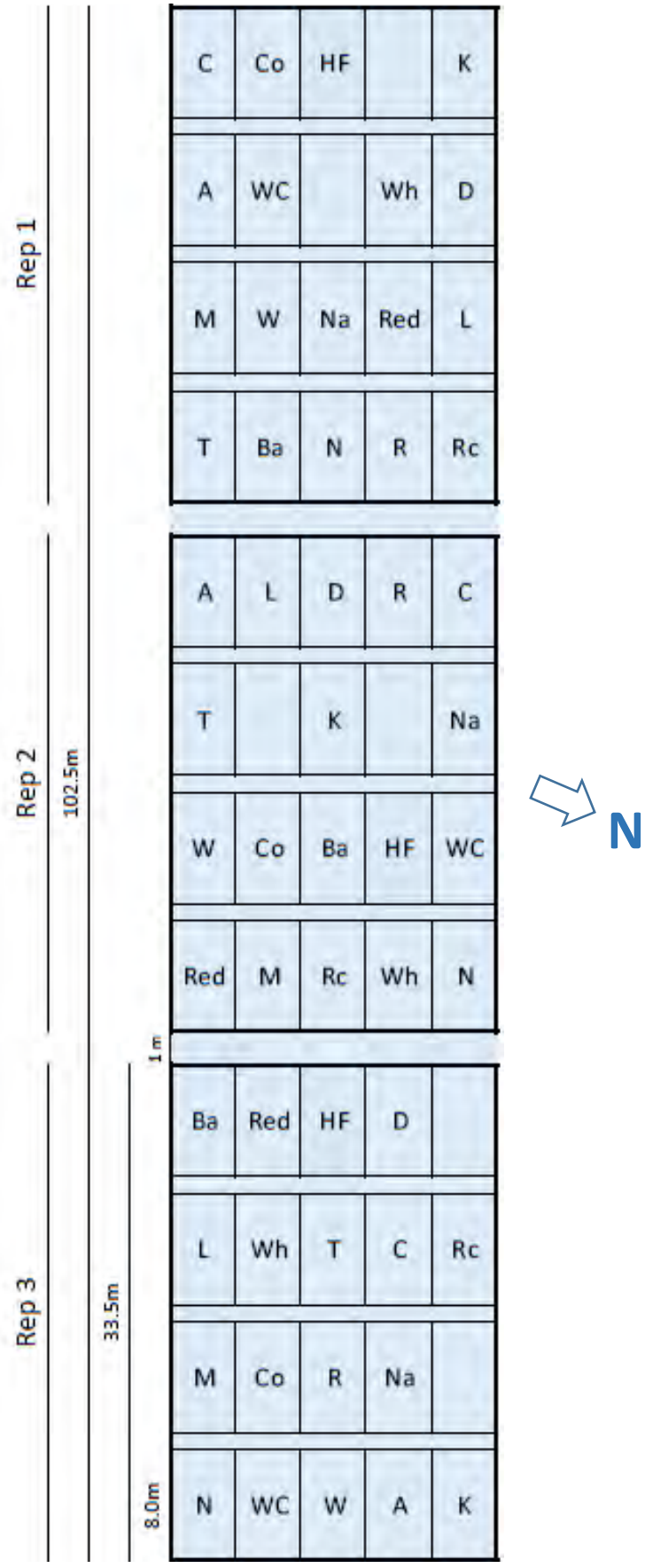
In both experiments the plot size is 8 x 2.1 m.

Experiment 1 – treatments and plot layout

The following sub clover cultivars and control legumes were sown in Experiment 1:

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

Three replicates (blocks) of each sub cover cultivar and control legumes were drilled in a randomised complete block design:



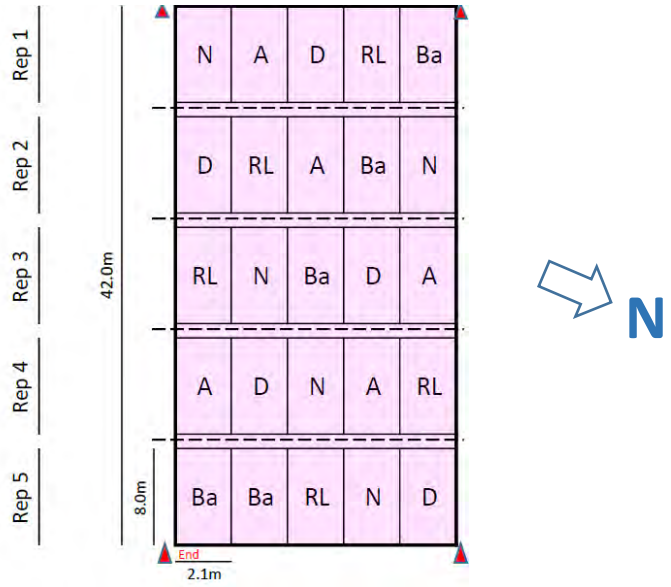
Due to the unavailability of seed for 3 sub clover cultivars there are 3 unplanted plots per rep in Expt 1. One of these plots per rep has been reallocated to monitor the local resident clover Haresfoot trefoil.

Experiment 2 – treatments and plot layout

Three sub clover cultivars and the legumes Russell lupin and 'Bolta' Balansa clover were each sown with "Greenly II" cocksfoot (CF):

Sub clover cultivars Code – name	Sowing rates (kg/ha)	Control legumes	Sowing rates (kg/ha)
A – Antas + CF	20 + 2	Ba - Bolta Balansa clover +CF	10 +2
D – Denmark + CF	20 + 2	RL – Russell lupin + CF	20 + 2
N – Narrikup + CF	20 + 2		

The trial design is a Latin square with 5 replicates of each treatment:



Event log for Omarama

Site preparation

Date	Event (carried out by the farmer and/or staff)
Aug 15	Fertiliser application: Lime at 3 t/ha
11/9/16	Herbicide application: 3.5 L/ha 2,4-D Ester
18/9/16	Herbicide application: 8 L/ha Glyphosate (470 a.i.) with Sharpen
18/9/16	Micronutrients applied: 3.5 L/ha MoBstar + 100 g/L a.i. boron + 35 g/L a.i. molydenum
10/2/16	Herbicide application: 5 L/ha Glyphosate (470 a.i.) with a small amount of oxyflurofen

Trial establishment and post establishment (until 30 June 2016)

Date	Event
18/2/16	DPR team site visit - Experiments 1 and 2 sown with the Lincoln University tractor and research seed drill
23/2/16	Lorsban applied (precaution against clover root weevil): 1.25 L/ha of Lorsban in 200L/ha water (by the farm hand)
31/3/16	DPR team site visit - establishment data collection: seedling counts and photos of all plots in Expts. 1 and 2, soil sampling of 3 reps in Expt. 1, seedling samples from selected sub clover cultivars in Expt. 1 for shoot/root dry weights and assessment of nodulation
26/4/16	DPR staff member passing site visit - site visit to check on progress (observations only)
7/6/16	DPR team site visit - pre-winter data collection from all plots in Expt 1: ground cover assessment and photos, seedling biomass samples for dry weights, scoring of sub clover cultivar cold sensitivity. Exclosure cages placed over 6 sub clover cultivars in replicate 1 of Expt 1. After the visit the site was grazed.

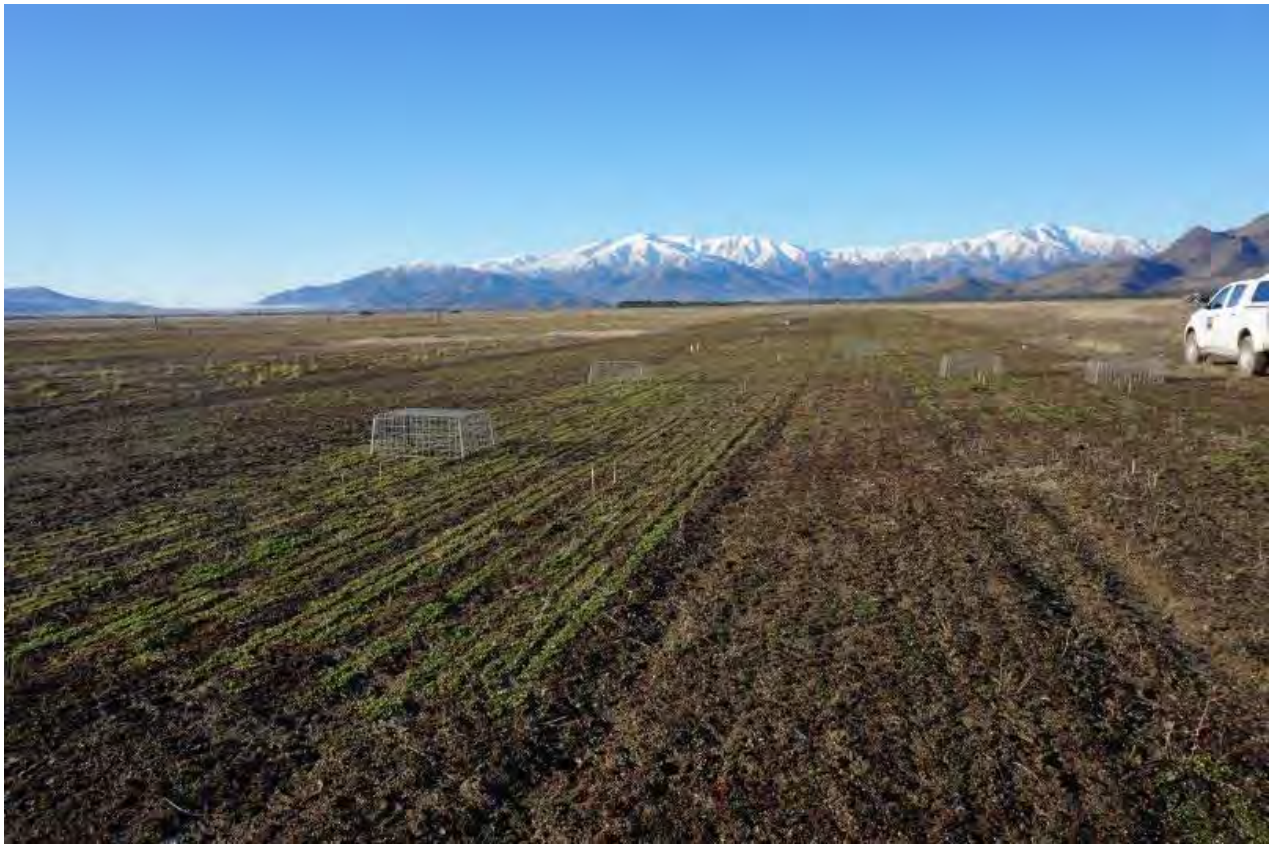
Other events

Date	Event
17/6/16	Facebook post (see www.facebook.com/DrylandPastures) about the 7/6/16 pre-winter visit with photos.

Future events

Spring data collection: the experiment will be left over the winter period and will next be visited in early spring for assessment and data collection.

Photos



Looking north-east across the experimental site. Exclosure cages placed on replicate 1. (Photo: Teresa Lewis, 7/6/2016)

Sub clover leaves go red when exhibiting symptoms of cold sensitivity (Photo: Teresa Lewis, 7/6/2016)

South Canterbury – Cave

Experiment location and site details

The experimental site is on Rock Farm which is owned and farmed by Herstall and Alyson Ulrich.

GPS coordinates of the experimental site are -44.312587, 170.963268, altitude is 160-170 m a.s.l, and the topography is rolling. The experiment is located on an undulating slope that faces west. The experimental area is 0.62 ha (207 m x 30 m) with the experimental plots occupying about 0.36 ha.

The Claremont (Fragic Perch-gley Pallic Soil) and Timaru (Mottled Fragic Pallic Soil) soils are characterised as being moderately deep and poorly drained with moderate plant available water Analysis of soil samples taken from the experimental site found a low pH of 5.5, medium Olsen P, low levels of potassium and high levels of calcium, and magnesium in the 0-75 mm depth. The farmer uses the 'Albrecht' system to monitor and maintain soil nutrients on the farm.

There are no suitable climate stations nearby. The nearest is Timaru Aero Aws (agent no. 5086) which is in a coastal location 20.8 km from the site at an altitude of 26 m a.s.l. The farmer keeps rainfall records.

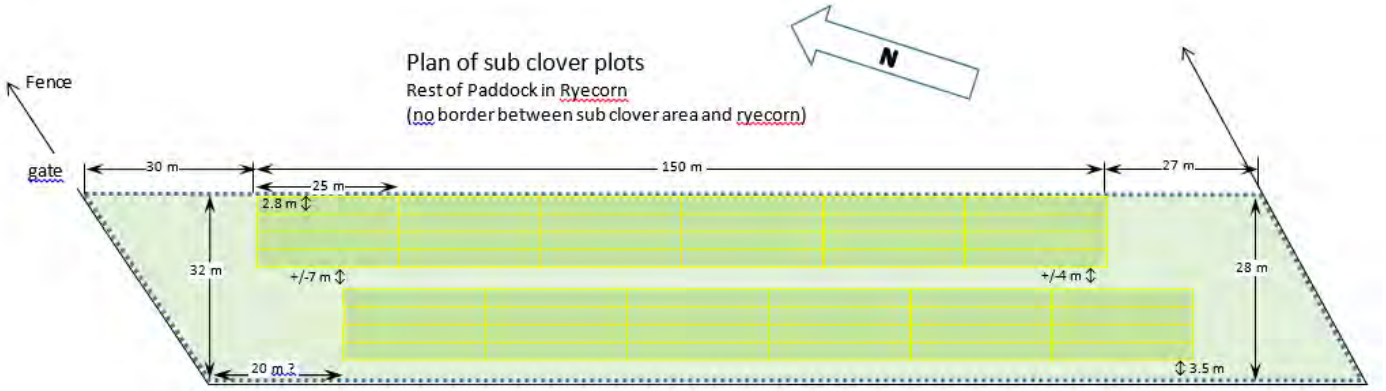
Experimental design

Objective 2: To assess the survival and production of sub clover cultivars on clay soils prone to water logging. To do this the establishment, growth and production of seven sub clover cultivars will be assessed in large plots that cover a range of topography.

Treatments and plot layout

Plot size

Each plot is 2.8 m x 25 m. There are no buffers between plots within a block. There was a drill overlap of up to 5 m at the ends of plots within a row and up to 0.2 m between rows:



Treatments

Seven cultivars of sub clover and a control of Nomad white clover were sown. The sub clover cultivars were Antas, Leura, Denmark, Monti, Napier (only coated seed), Narrikup, and Woogenellup. The seed drilled along the slope using Herstall Ulrich's tractor towing a Teage Series 300 seed drill which was 3 m wide.

Calibration of the seed drill, using the cultivar Narrikup, was done on site to sow 20 kg sub clover/ha and 10 kg white clover/ha in the trial plots. Estimated sowing rates (based on seed remaining) ranged from 18.7 to 22.6 kg/ha for uncoated sub clover cultivars, 28.8 kg/ha for the coated Napier seed and 14.3 kg/ha for the white clover.

Replication

♣ 6 replicates of 8 clovers (7 sub clover + 1 white clover); partial randomization only in two blocks.

♣ 6 plots per row, and a random cultivar pair repeated in an alternating sequence (3 times) within each row. One cultivar drilled in each row in alternate plots, then the second cultivar drilled in a second pass to generate the pattern ababab.

♣ Different pairings of cultivars in top (rows 1-4) and bottom (rows 5-8) blocks as shown in the following diagram:

Row no.	Plot Nos. and Cultivars					
	Rep 1		Rep 2		Rep 3	
1	1. Antas	5. Leura	9. Antas	13. Leura	17. Antas	21. Leura
2	2. Denmark	6. Napier	10. Denmark	14. Napier	18. Denmark	22. Napier
3	3. Woogenellup	7. Monti	11. Woogenellup	15. Monti	19. Woogenellup	23. Monti
4	4. Narrikup	8. Nomad	12. Narrikup	16. Nomad	20. Narrikup	24. Nomad
	Rep 4		Rep 5		Rep 6	
5	25. Nomad	29. Woogenellup	33. Nomad	37. Woogenellup	41. Nomad	45. Woogenellup
6	26. Leura	30. Denmark	34. Leura	38. Denmark	42. Leura	46. Denmark
7	27. Napier	31. Antas	35. Napier	39. Antas	43. Napier	47. Antas
8	28. Monti	32. Narrikup	36. Monti	40. Narrikup	44. Monti	48. Narrikup

Event log

Site preparation

Date	What and rate
9/9/15	Fertiliser*: 200 kg/ha Ammo31 and 2000 kg/ha dolomite
9/11/15	Fertiliser: 190 kg/ha Nprotect
5/1/16	Herbicide: 3 L/ha Glyphosate 360
2/2/16	Herbicide: 2 L/ha Glyphosate 360 plus 40g granstar
12/2/16	Fertiliser: 250 kg/ha Crop20

* Fertiliser applications by farmer made after soil tests were carried out in April 2015.

Trial establishment and post establishment events (until 30 June 2016)

Date	Event
25/2/16	DPR team site visit - initial pegging out of experimental area, drilling requirements assessed, experimental area lightly cultivated with a tractor-drawn Ground Hog soil aerator by farm hand
3/3/16	DPR team site visit - installation of experiment: markers put out to guide seed drilling, experimental plots and headland areas drilled with a Teage Series 300 seed drill behind a tractor, experimental area rolled a Cambridge roller
5/4/16	DPR staff member passing site visit - observations only: photos taken and need for weed control noted
8/4/16	DPR team site visit - data collection: seedling counts (2 50 cm drill row sections per plot), photos and soil samples taken from Block 1. Also plot boundaries were assessed in Block 1 and pegs installed.
19/4/16	Herbicide application (Spinnaker at a rate of 400 ml/ha in 200-300 litres of water) for broadleaves applied by farmer.
3/5/16	DPR team site visit - herbicide application: Gallant Ultra (250 mL/ha in 200 L water with Uptake surfactant at 200ml/200L water/ha) was applied to the experimental plots using a Mule and a 3 m spray boom to control grass species.
8/6/16	DPR team site visit - data collection: ground cover assessment, photos and soil samples taken from Block 1. Seedling samples from all plots in Blocks 1 and 2 for dry weights, scoring of sub clover cultivars cold sensitivity.

Other events

Date	Event
29/4/16	Site visit by a group: Dave Schrader (Farmlands) visited the experiment with 25 people as an introduction to a field day. They spent 20 minutes on site looking at the trial (a treatment map was provided).
17/6/16	Facebook post (see www.facebook.com/DrylandPastures) about the 8/6/16 pre-winter visit with photos.

Future events

♣ PLSC321 (Pasture Agronomy) small group project – this experiment will be offered as a research project for a group of third year undergraduate students to investigate sub clover biomass production over a six week period during July-August.

♣ Grazing of the site will be organised with the farmer.

♣ Spring data collection: the experiment will be left over the winter period and will next be visited in early spring for assessment and data collection.

Photos

DPR team member Malcolm Smith spraying the Cave experimental site (Photo: Dave Jack, 6/4/16)

The Cave experimental site – some sub clover cultivars have grown well (see plots on left edge). There is a strip of sub clover-cocksfoot between the two blocks (Photo: Teresa Lewis, 8/6/16)

Mid-Canterbury

In mid-Canterbury there are two Lincoln University owned farms that are hosting 'Sub 4 Spring' subterranean clover experiments – Iversen Fields on the Lincoln University campus and Ashley Dene Farm which is near Springston.

Experimental site 1: Iversen Fields, Lincoln University campus

Experiment location and site details

Two fields at the Iversen Fields site host subterranean clover cultivar trials. The GPS coordinates of the experimental site are -43.649, 172.468, altitude is 11 m a.s.l, and the topography is flat.

The Wakanui silt loam (Mottled Immature Pallic Soil) is characterised as being deep and imperfectly drained with high plant available water. Analysis of soil samples taken from 0-75 mm depth at the experimental site found a medium pH of 5.8, medium Olsen P, low levels of potassium, medium levels of calcium and magnesium, and low sulphate-S.

The nearest climate station is Lincoln Broadfields (agent no. 17603) which is 2.6 km from the site at an altitude of 18 m a.s.l. There is also a datalogger on site.

Iversen experiment 1: Subterranean Clover phenology – experimental design

This experiment is located in Iversen 2. This experiment is a component of a PhD student's research programme, funded by the project.

Objective 3: To quantify the phenological development of six sub clover cultivars. To do this six cultivars will be assessed across seven sowing dates.

Detailed measurements of vegetative growth and reproductive development will be used to assess how temperature and photoperiod affect plant development. This will allow a matching of cultivar to environment based on the duration of spring moisture supply and temperature regimes prior to summer drought. A validation study has been established at the sixth site in Hawkes Bay.

Treatments and plot layout

The trial design is a split plot factorial randomized complete block design.

Plot size

Each plot is 2 m x 1 m.

Treatments

♣ Six sub clover cultivars: Antas, Denmark, Leura, Monti, Narrikup and Woogenellup. The seed was sown by hand at a rate to achieve 2000 plants per square meter.

♣ Eight sowing dates: 24 June 2015, 28 July 2015, 15 September 2015, 5 November 2015, 15 December 2015, 17 February 2016, 15 March 2016 and 04 May 2016.

Replication

For each sowing date there were 3 replicates of each cultivar.

Map of the trial

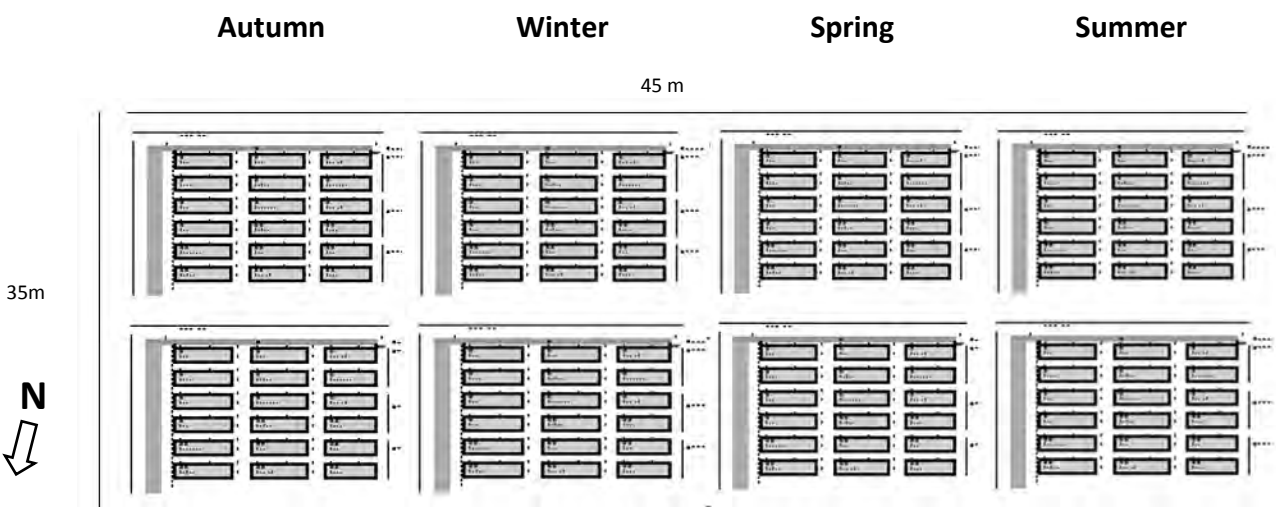


Diagram representing the eight sowing dates complete split plot design: three replicates per cultivar organised on blocks. Total of 144 subplots.

Event log

The site preparation and seed sowing dates were sequential as the subterranean clover cultivars in this experiment were sown in adjacent plots.

Site preparation

Date	Event/task
14/06/15	Fertiliser application: 2500 kg/ha Lime, 500 kg/ha Superphosphate
17/06/15	Herbicide application*: Roundup 630 mL/ha in 100 L water
24/06/15	Seed sowing
21/07/15	Herbicide application: Roundup 630 mL/ha in 100 L water
28/07/15	Seed sowing
08/09/15	Herbicide application: Roundup 630 mL/ha in 100 L water
15/09/15	Seed sowing
27/10/15	Herbicide application: Roundup 630 mL/ha in 100 L water
05/11/15	Seed sowing
08/12/15	Herbicide application: Roundup 630 mL/ha in 100 L water
15/12/15	Seed sowing
10/02/16	Herbicide application: Roundup 630 mL/ha in 100 L water
17/02/16	Seed sowing
08/03/16	Herbicide application: Roundup 630 mL/ha in 100 L water
15/03/16	Seed sowing
27/04/16	Herbicide application: Roundup 630 mL/ha in 100 L water
04/05/16	Seed sowing

* The area of each sowing date was sprayed 5-7 days prior sowing.

Data collection events

♣ For each plot in each sowing date emergence counts were taken every two days for three quadrats (0.01 m^2) from sowing date to final seedling population establishment (~ spade leaf phase).

♣ Phenological data (vegetative and reproductive stages) collected twice a week on selected plants.

♣ Weather data collected daily.

♣ Seed maturity, yield and status (yield/hardness): data are gathered once as plants complete their life cycle (end of growth period).

♣ Seedling regeneration in the subsequent year: data are collected once as seeds produced in the past year start to emerge.

Other comments

Irrigation was needed during the spring and summer periods as rainfall was insufficient to maintain adequate soil moisture levels:

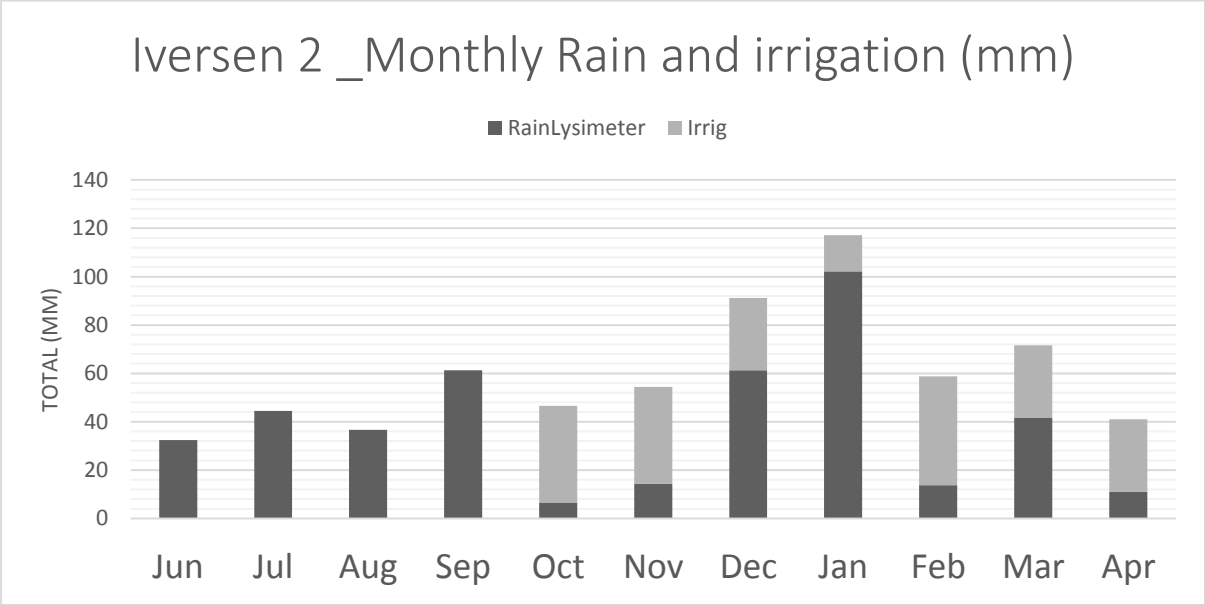


Figure showing water inputs via rainfall and irrigation from June 2015 to April 2016.

Student involvement

♣ International students from ENSAT, Toulouse.

♣ Lincoln University PLSC 321 student projects.

Photos

Iversen 2 experiment: 2015 summer and 2016 autumn sown plots (Photo: Carmen Teixeira).

A French intern assists with experimental maintenance and data collection (Photo: Carmen Teixeira)

Experiment 2: Subterranean clover herbicide tolerance (Iversen 1)

When establishing subterranean clover there is little relevant information on the ability to use chemicals for weed control. This experiment will assess the impact of several common herbicides used to control broadleaf weeds in pastures and is a component of a Masters student's research programme.

Objective 4: To assess the herbicide tolerance of a range of subterranean clover cultivars.

Treatments and plot layout

Plot size was 8 m x 2.1 m.

Sub clover cultivars and control legumes

Code + Cultivar name	Sowing rate(kg/ha)	Controls	Sowing rate (kg/ha)
A - Antas	20	**Control legumes (sown)**	
C - Campeda	20	Ba - Bolta Balansa clover	10
Co - Coolamon	20	Red - "Rossi" Red clover	10
D - Denmark	20	WC– Nomad white clover	10
K - Karridale	20		
L - Leura	20	**Resident clover**	
M - Monti	20	HF - Haresfoot trefoil	N/A
N - Narrikup	20		
Na - Napier (coated)	20		
R - Rosabrook	20		
Rc - Rosabrook (coated)	20		
T - Trikkala	20		
W - Woogenellup	20		
Wh – Whatawhata	20		

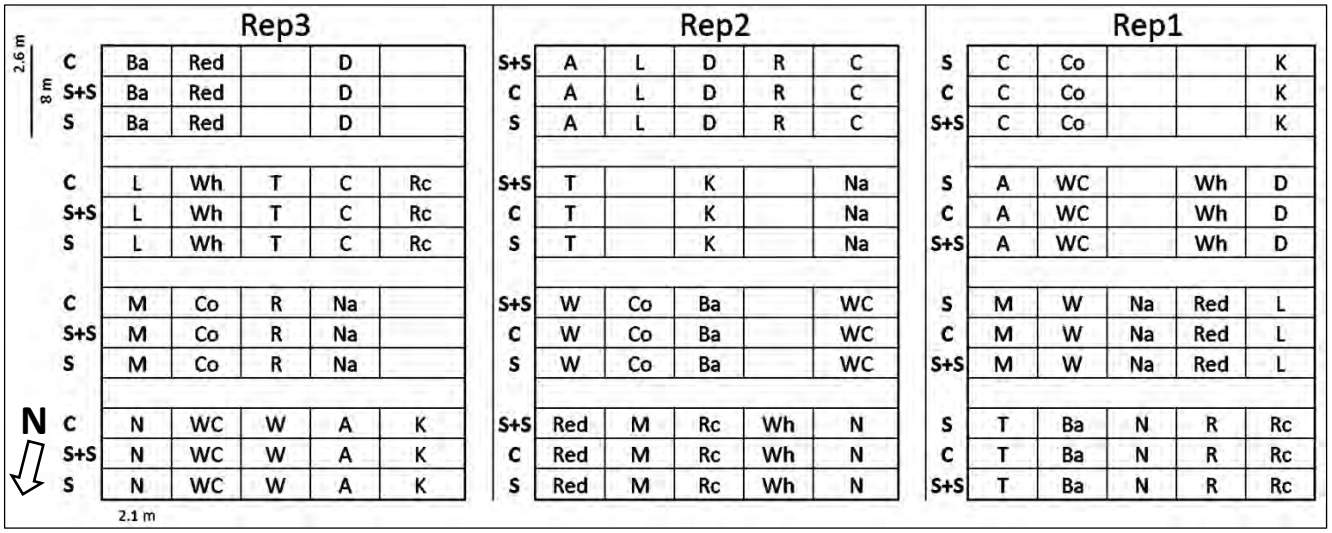
Three replicates (blocks) of each sub clover cultivar and control legumes were drilled in a randomised complete block design. As previously noted, 3 sub clover cultivars were unavailable so these plots were not sown.

Herbicide treatments

There were three herbicide treatments applied: Control (C), Spinnaker (S) and Spinnaker with Sharpen (S+S). Details of the herbicides are:

Herbicide	Active Ingredient	Mode of Action	Rate/ha	Water/ha	Adjuvant
Spinnaker	240 g/L Imazethapyr	ALS inhibition	400 ml	200 L	500 ml Hasten MO 100 L^{-1}
Sharpen	700 g/L Saflufenacil	Increases rate of activity of mixed herbicide	25 g	200 L	500 ml Hasten MO 100 L^{-1}

The herbicides were applied as a strip-plot design across the existing plots:



Each individual plot was 2.6 m x 2.1 m.

Event log

Date	Event
21/01/16	Site prep herbicide application 1: Buster at 5 L/ha in 200 L water
22/02/16	Site prep herbicide application 2: Buster at 5 L/ha in 200 L water
01/03/16	Site prep herbicide application 3: Buster at 5 L/ha in 200 L water
01/03/16	Seed was sown with the Lincoln University tractor and research seed drill
07/04/16	Treatment herbicide applications (as described)
12/05/16	Soil moisture levels very low so irrigation applied ~ 32 mm using a travelling gun irrigator

Methodology for data collection

The following data collection methods are also being used in the Ashley Dene experiments.

Pre-herbicide treatment	1 m length of drill row marked for continued observations Seedling count of 1 m marked drill row
Post-herbicide treatment	Seedling count of 1 m marked drill row on day 3, 5, and 7, then weekly thereafter for a month Whole plot EWRS score on day 3, 5, 7 and weekly thereafter After the first month, five plants will be marked for continued phenological development scoring
Harvest	Single 0.2 m^2 quadrats will be harvested from the center of each plot three times; in August, September, and October
Post-harvest	Fresh weight of samples, before sorting sub-samples for target clover species, broadleaf weeds, grass weeds, and dead matter Samples will be dried and weighed, and dry-matter content, weed content and target species content per plot calculated. Selected samples will be analysed for protein content and quality indices (*in vitro* digestibility, metabolizable energy, etc.) to check for any non-visible effects

Comments

Impact of herbicides

Early observations indicate that Sharpen is an extremely efficient herbicide and controls all broadleaf weeds in treatment area extremely well. However, it has killed sub clover with no surviving plants in treated plots. Red clover is showing some tolerance. The following photos are of the sub clover cultivar Narrikup 7 weeks after treatment (26 May 2016):

Photo 1: Untreated Control (top)
Photo 2: Spinnaker with Sharpen treated, no broadleaf weeds, no clover (middle)
Photo 3: Spinnaker treated, minimal weeds, minimal clover damage (bottom)

Irrigation

♣ As noted for the experiment in Iversen 2, irrigation was required during the summer.

♣ Some plots (16) were noticeably affected by flooding (underwater) in the week of 02/06/16 but to date there has been no noticeable effect.

Experiment site 2: Ashley Dene, Canterbury

Experiment location and site details

Ashley Dene Farm is about 15 kms west of the Lincoln campus in Springston. The GPS coordinates of the experimental site in Paddock C9 are -43.6496, 172.3233, altitude is 11 m a.s.l, and the topography is flat.

The predominant soil is a Lismore silty loam (Pallic Firm Brown Soil) that is characterised as being shallow and well drained with moderate to low plant available water. Analysis of soil samples taken from 0-75 mm depth at the experimental site found a medium pH of 6.0, medium Olsen P, high potassium, medium calcium and magnesium, and high sulphate-S.

The nearest climate station is Lincoln Broadfields Ews (agent no. 17603) which is 12.1 km from the site at an altitude of 18 m a.s.l.

The two experiments at this location are investigating the herbicide tolerance of subterranean clover cultivars at two stages of seedling development and is a component of a Masters student's research programme.

Treatments and plot layout

Plot size was 3 m x 5 m.

Sub clover cultivars and control legume

The following sub clover cultivars were sown: Antas (An), Denmark (De), Monti (Mo), and Narrikup (Na). The control legume was Huia White clover (WC).

Herbicide treatments

There were 10 herbicide treatments applied. Details of the herbicides are:

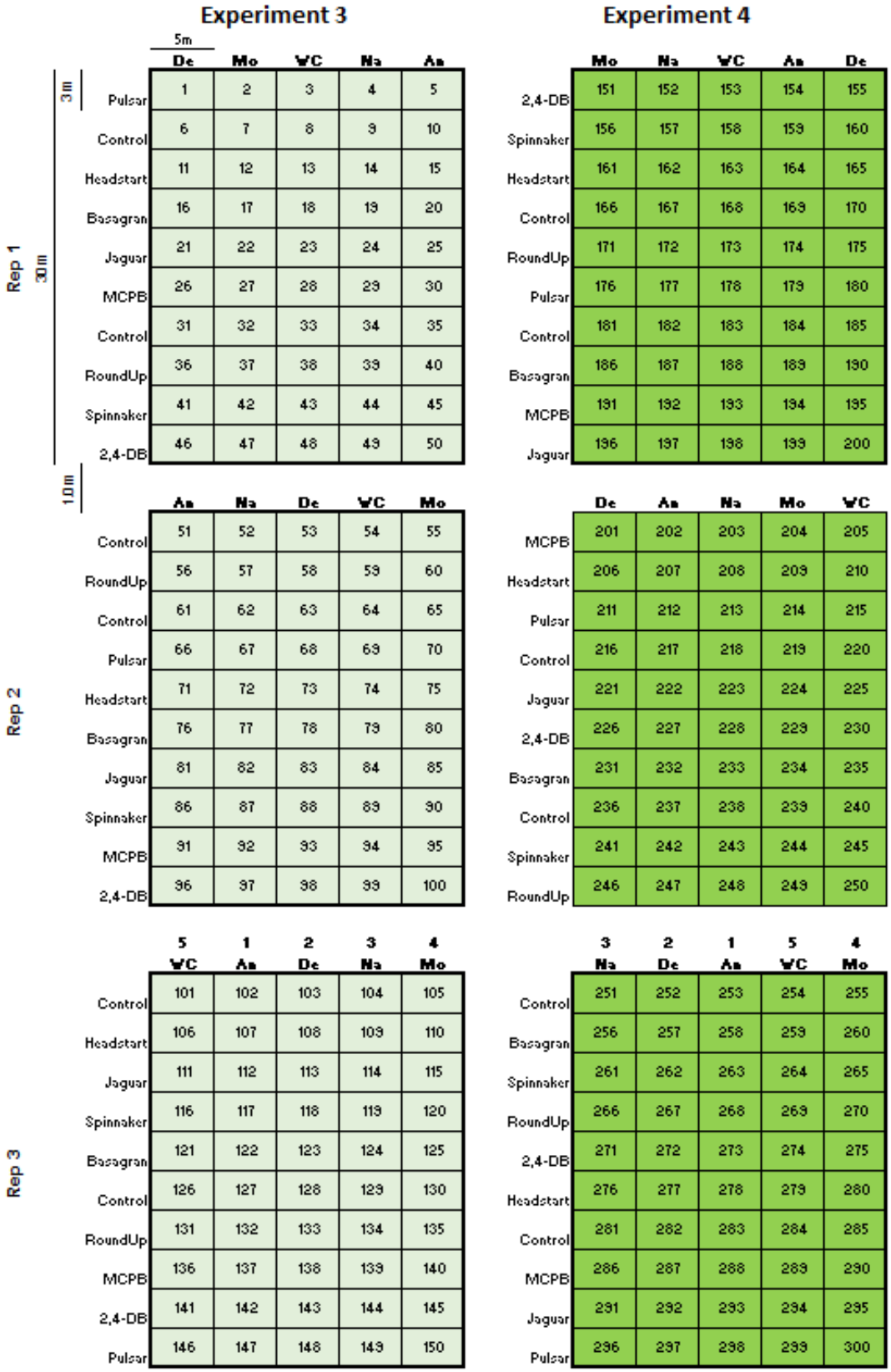
Herbicide	Active Ingredient	Mode of Action	Rate/ha	Water/ha	Adjuvant
Spinnaker	240 g/L Imazethapyr	ALS inhibition	400 ml	200 L	500 ml Hasten MO 100 L^{-1}
Sharpen	700 g/L Saflufenacil	Increases rate of activity of mixed herbicide	25 g	200 L	500 ml Hasten MO 100 L^{-1}
MCPB	385 g/L MCPB	Auxin-type action	7.5 L	300 L	500 ml Hasten MO 100 L^{-1}
Basagran	480 g/L Bentazone	Photosynthesis inhibition	3 L	300 L	500 ml Hasten MO 100 L^{-1}
Pulsar	200 g/L MCPB 200 g/L Bentazone	Auxin-type action + Photosynthesis inhibition	6 L	300 L	500 ml Hasten MO 100 L^{-1}
Headstart	Flumetsulam	ALS inhibition	1.0 L	300 L	DO NOT ADD. Already contains inbuilt surfactant
2,4-DB	400 g/L 2,4-DB	Auxin-type action	8 L	200 L	500 ml Hasten MO 100 L^{-1}
RoundUp	360 g/L Glyphosate	Amino Acid biosynthesis inhibition	1.0 L	200 L	500 ml Hasten MO 100 L^{-1}
Jaguar	250 g/L Bromoxynil + 25 g/L Diflufenican	Photosynthesis inhibition	1.0 L	75 L	500 ml Hasten MO 100 L^{-1}

Stage of herbicide application

Experiment 3: Herbicide treatments will be applied at the 1-2 trifoliate leaf stage.
Experiment 4: Herbicide treatments will be applied at the 3-4 trifoliate leaf stage.

Experimental design

The experiments have a randomised split-plot design.



Event log

Date	Event
22/2/16	Site prep herbicide application 1: Buster 5 L/ha in 200 L water
21/3/16	Site prep herbicide application 2: Buster 5 L/ha in 200 L water
22/3/16	Seed was direct drilled
23/3/16	Experimental area was rolled
14/6/16	Herbicides treatments applied (as described) to Expt 3

Methodology for data collection

The data collection methods and timing are the same as those described for the Iversen 1 experiment.

Future events

- ♣ The herbicide treatment will be applied to Expt 4 in July.
- ♣ Lincoln University PLSC 321 student projects will aid assessment.

Comments

There are a number of resident sub clovers on site. This is a factor for a number of experimental sites in the Sub 4 Spring research programme where known sub clover cultivars are planted on a site where other resident sub clover cultivars are established. This factor emphasises the need for clear guidelines for sub clover identification.

Photo

The Ashley Dene 'Sub 4 Spring' experimental site (Photo: Teresa Lewis, 18/5/16)

North Canterbury – Cheviot

Experiment location and site details

The experimental site is on Koromiko Farm, in the Lowry Hills Range about 15 km west of Cheviot, which is owned and farmed by Hugh Crossley. The GPS coordinates for Experiment 1 are -42.783940, 173.058481. The altitude of the experimental sites is 360-380 m a.s.l. and the topography is predominantly hilly terrain with some river terrace flats.

The predominant soil is a Glenrock silty loam (Typic Immature Pallic Soil) that is characterised as being shallow and well drained with moderate to low plant available water. Analysis of soil samples taken from 0-75 mm depth at the experimental site found a low pH of 5.2, low Olsen P, high potassium, medium calcium, high magnesium and low sulphate-S.

There are a number of climate stations within a 50 km radius although none are in the same geographic environment. The nearest is Culverden Ews (agent no. 376513) which is 13.8 km from the experimental site at an altitude of 181 m a.s.l.

The on-farm experiments at this location are investigating methods for establishing sub clover on uncultivatable hill country.

Objective 5: Identify options for establishment of sub clover through oversowing.

Experiment 1: Subterranean clover oversowing

This experiment is located on uncultivatable hill country that has two 'sites' of interest – 4 ha of sunny face and 8 ha of shady face. Each site has received the herbicide treatments noted below.

Treatment

Pre-sowing herbicides were applied by a helicopter to designated treatment strips across the area. The three herbicides treatments were 6 L/ha Roundup, 3 L/ha Roundup, or Reglone. Each herbicide was applied to the same respective strip on three dates throughout the dry summer period.

The whole site was topdressed with 200 kg sulphur-super-20/ha and then oversown with a 10.9 kg/ha mixture of four subterranean clover cultivars (equal parts Antas, Denmark, Narrikup and Woogenellup) using a helicopter.

Event log

Date	Event
Nov 2015	Treatment herbicide application 1
12/01/16	Treatment herbicide application 2
02/02/16	DPR Team site visit – meet the farmer, make plans for spraying and sowing
22/02/16	Treatment herbicide application 3
18/03/16	DPR Team site visit - assess effectiveness of sprays, check likely locations for experiments, and identify additional site prep required
30/03/16	Basal fertiliser application - 200 kg sulphur-super-20/ha applied by helicopter
30/03/16	Oversowing of sub clover cultivar mixture at 10.9 kg/ha by helicopter
14/06/16	DPR team site visit – seedling counts in areas with varied vegetation/litter/soil disturbance

Experiment 2: Effect of rate of lime application on sub clover establishment

Examine whether additional lime assists the establishment and persistence of sub clover.

Plot size

Each plot is 2 x 5 m (1 m gap between plots in each replicate).

Treatments

There are three treatments in this experiment:

- ♣ Two sites: west facing slope or north-east facing slope (see map below).
- ♣ Two rates of Roundup herbicide: 1 or 6 L/ha.
- ♣ Three rates of lime sulphur application: 0, 1 or 4 tonne/ha

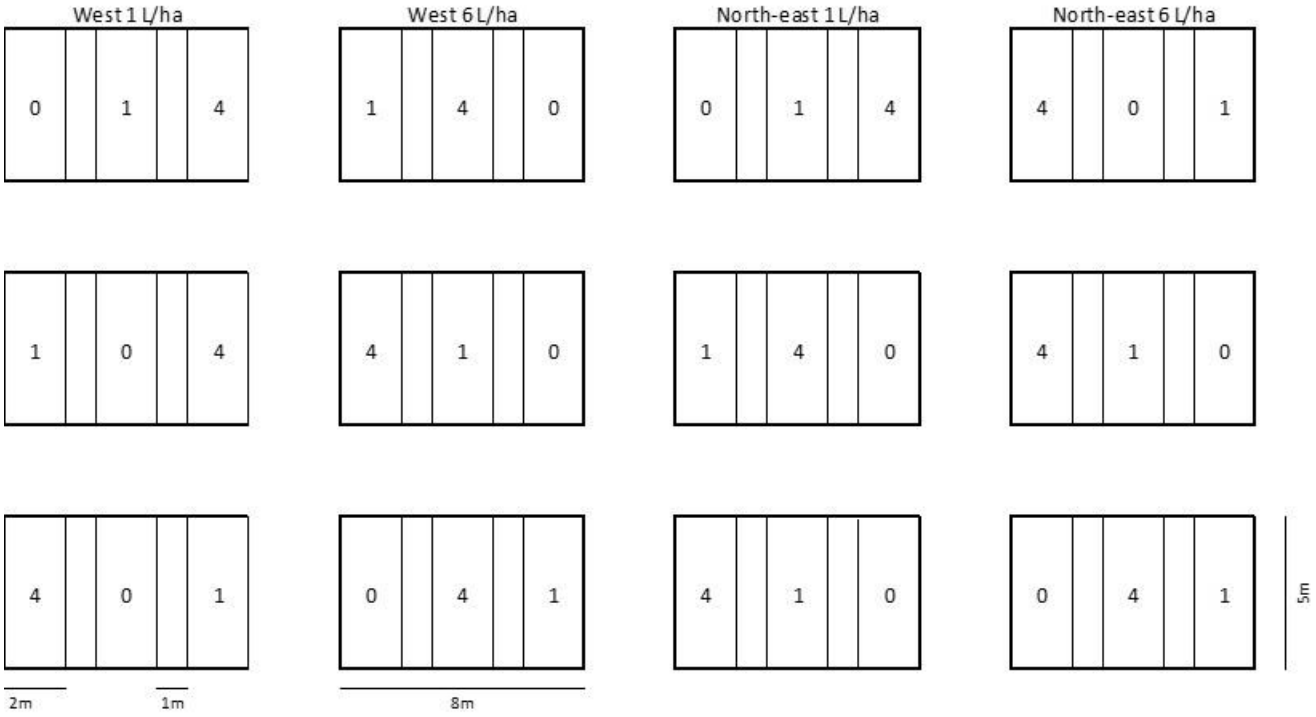
Replication

Three replicates (i.e. 2 sites x 2 spray rates x 3 lime rates x 3 replicates).

Experimental layout

Location of the two sites in Experiment 2:

The following plan details the location and herbicide rate and the rates of lime added to each plot.



Event log

Site preparation

The event log for Expt. 1 applies for this experiment as site preparation.

Data collection

Date	Event
21/4/16	DPR team site visit to install Expt. 2 – pegging plot corners, surface lightly raked to scarify the soil surface and remove surface trash, plots oversown by hand with 20 kg /ha mix of the sub clover cultivars Antas and Denmark (west) or Narrikup (north-east), lime treatments added by hand. Photographs of the experimental plots.
14/6/16	DPR team site visit - soil sampling of each block in Expt. 2

Other events

Date	Event
5/5/16	Cheviot Farm Discussion Group - meeting with DPR Team members Derrick Moot and Dick Lucas at the Koromiko Farm woolshed and a subsequent tour of the farm. Twelve farmers attended and signed up to an email contact list.
19/5/16	Email to the Cheviot Farm Discussion Group to introduce the 'Sub 4 Spring' post-graduate student projects and provide details about the Dryland Pasture online resources (website, blog, and You Tube channel)

Comments

As with many east coast areas of New Zealand the 2016 summer/autumn period was extremely dry. This delayed the sowing of seed at Koromiko Farm and also subsequent germination and establishment.

Photos

DPR team member Russell Croy raking the trash from the surface of a west facing plot in Expt. 2 prior to seed sowing (Photo: Sonya Olykan, 21/4/16)

DPR team member and 'Sub 4 Spring' Master's student Gracie Woolsey applying lime sulphur to an Expt. 2 plot on a west facing plot (Photo: Sonya Olykan, 21/4/16)

Wairarapa

There are a range of on-farm experiments in the Wairarapa based on two farms – one at Ponatahi and the other at Taratahi. The experiments will contribute to Objective 6: Increase sub clover component in mixed swards through grazing management.

Associated farmer group/stakeholders

A Wairarapa 'Sub 4 Spring' discussion group (25 members) was formed after an initial farmer meeting on 3rd September 2015. The target is demonstration of principals in Year 1 and then application on other farms for Year 2 and beyond.

The Taratahi Agricultural Training Centre will use the experimental site on Glenside Farm for practical teaching sessions with the students.

Experiment site 1: Tokaroa Farm, Ponatahi

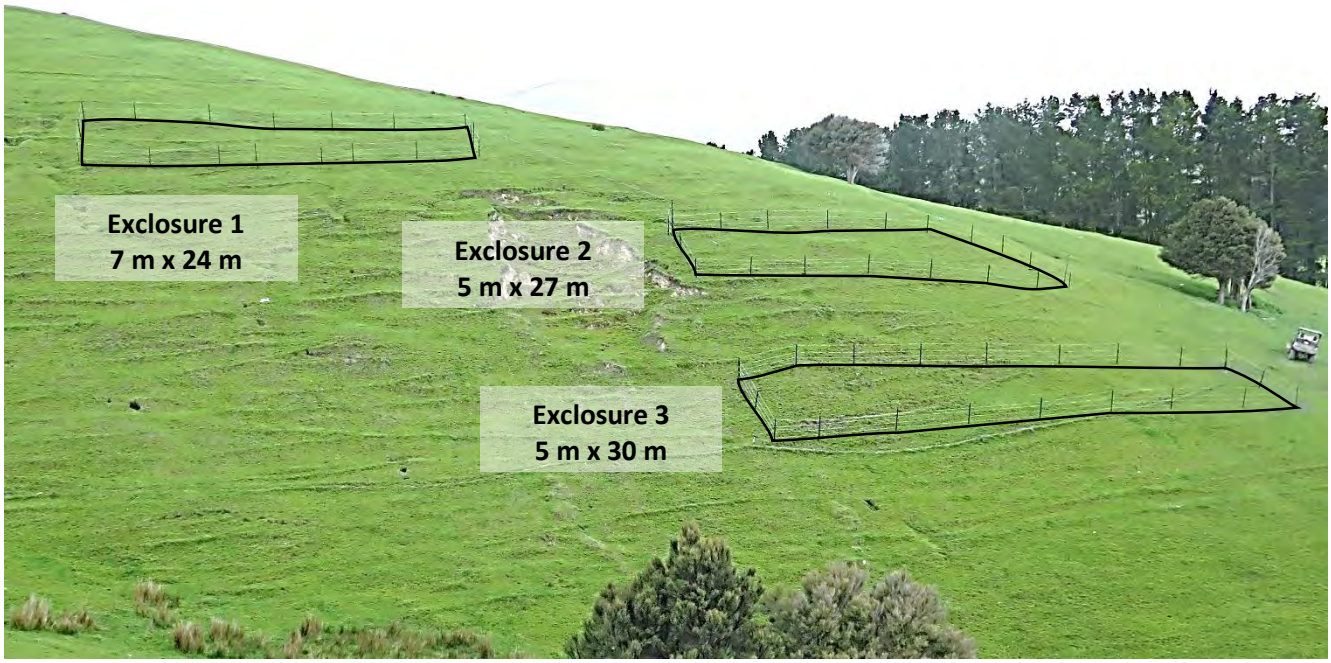
Tokaroa Farm is owned by Dan Nicholson and located at 1106 Ponatahi Road, Carterton 5792. The nearest climate station is Masteron Aero Aws (agent no. 36735) which is 21.7 km from the site at 138 m a.s.l. Soil information for this site is yet to be confirmed.

Experiment 1: Management to increase resident subterranean clover - exclosure demo

This experiment, GPS location -41.157046, 175.543485, is on a slope at an altitude of 140-160 m a.s.l.

Trial details

The experiment consists of three exclosures, as shown in the photo below, built to exclude grazing stock for different lengths of time to investigate the impact of spelling on resident sub clover growth.



Tokaroa Farm – exclosure experiment (Photo: Malcolm Macfarlane)

The exclosures were constructed using waratahs and a 4 wire electric fence powered by a solar unit.

Treatments

The following four closing (spelling) treatments were randomly assigned to the three exclosure areas:

1. Current management (no enclosure)
2. closed for 3 weeks
3. closed for 6 weeks
4. closed for 9 weeks

Stock used: In lamb hoggets plus few young cattle
Stock management: Normal farm management from closing the exclosures until the end of trial.

Event log

Date	Event
26/09/15	Exclosures built 26-27th September 2016 and the trial started
20/10/16	Four herbage cuts (using 0.2 m quadrat) from exclosure 2. Exclosure 2 was then opened up. Five cuts of paddock and 5 cages placed. Photos series of exclosures
07/11/15	Four herbage cuts (using 0.2 m quadrat) from exclosure 3. Exclosure 3 was then opened up. Five herbage cuts of the paddock under the cages Two additional herbage cuts from urine-affected patches Photos series of exclosures
30/11/15	Four herbage cuts (using 0.2 m quadrat) from exclosure 1. Exclosure 1 was then opened up. Five herbage cuts of the paddock under the cages Photos series completed
21/04/16	Site visit by Derrick Moot and Paul Muir. Observes that the site was very dry and there had been no sub clover establishment.
04/06/16	Site visit by Paul Muir and associate. Establishment counts – only subs with true trifoliate leaves counted. Subs still germinating and covers very low because of poor autumn rain. Fences down. Three cages per plot and on controls (12 total).

The herbage (plant material) samples were couriered to Lincoln University for processing. Measurements will seek to determine the total sub clover composition of pastures after three different spring grazing managements.

Future events

♣ The experimental treatments will be repeated in spring 2016.

Experiment 2: Subterranean clover cultivar trial

This experiment will evaluate subterranean clover cultivars that may be suitable for introduction to pastures through direct drilling in this environment. This will assist the completion of Objectives 1, 2 and potentially 3.

Trial details

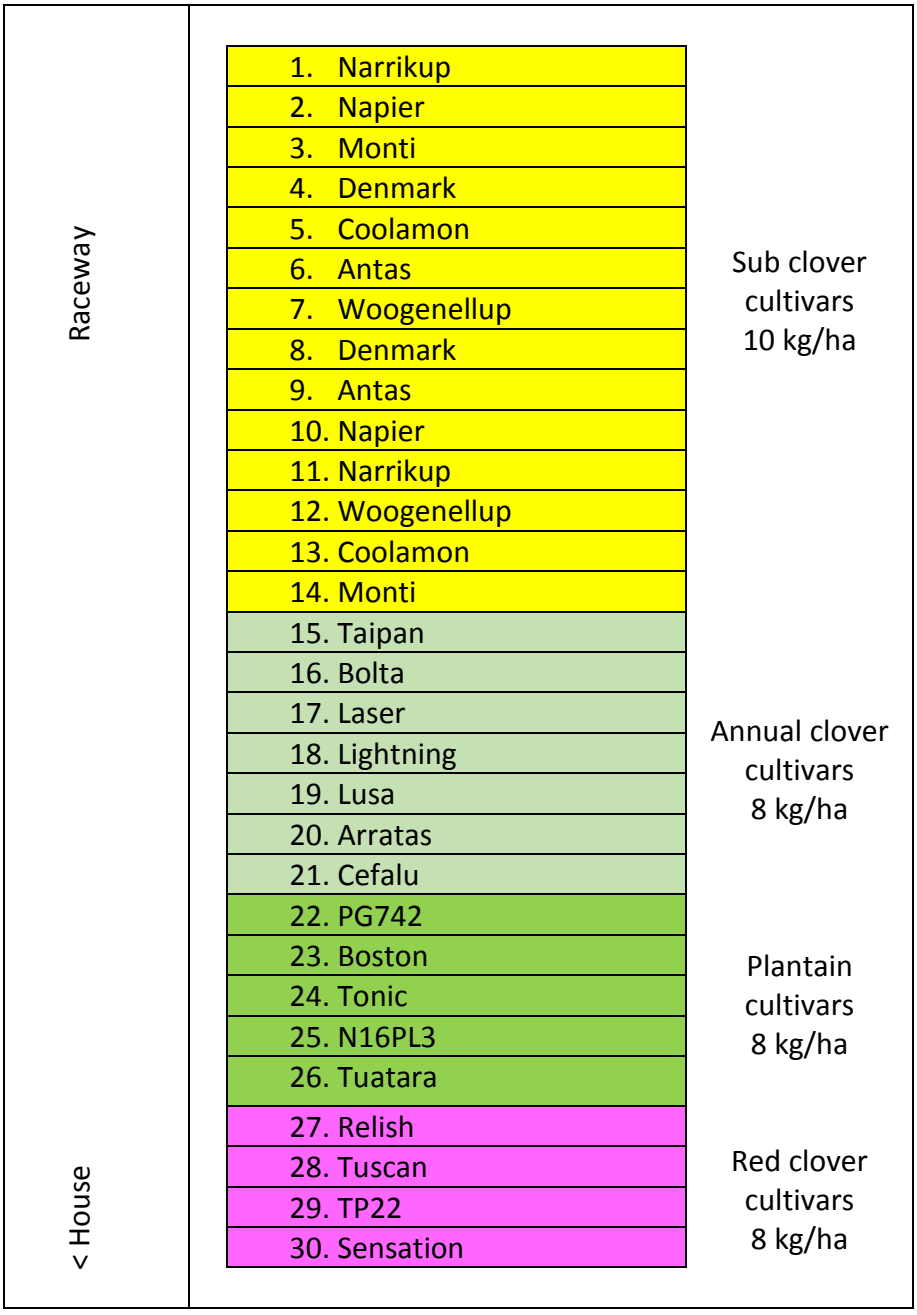
Plot size: 20 x 3 m.

Treatments

Seven sub clover cultivars - Antas, Coolamon, Denmark, Monti, Napier, Narrikup and Woogenellup; were sown by hand at a rate of 10 kg/ha.

Replication

Two replicates of each sub clover cultivar were sown (please note that other legumes and pasture species were also sown in the experimental area):



Event log

Site preparation

Date	What and rate
Nov 2015	3 L Roundup Transorb + 40 g Granstar in 125 L water/ha
Feb 2016	3 L Roundup Transorb + 100 ml Pulse + 40 g Granstar in 125 L water/ha
21/04/16	Seed sown by hand

Data collection

Date	What and rate
4/5/16	Establishment counts – 10 60 x 30 cm quadrats per plot

Comments

- Due to the extremely dry autumn the sowing of this experiment was delayed.
- As at 4th June 2016 an average of 79 sub clover plants per m^2 had established. However it was noted that the sub clover cultivars were still germinating.

Experiment site 2: Glenside Farm at Taratahi

This on-farm experiment is located in 'Holding' paddock of Glenside Farm, which is a Taratahi Agricultural Training Centre training farm on the Martinborough - Masterton Road, Carterton. GPS coordinates are -41.120529, 175.645535. The site is on a steep, uncultivatable northerly-facing slope at an altitude of 210 to 240 m a.s.l. Analysis of soil samples taken from 0-75 mm depth at the experimental site in 2015 found a low pH of 5.6 and medium Olsen P levels.

The results from this experiment will inform Objective 5 – related to options for oversowing.

Trial details

The experimental area is approximately 100 m x 100 m (1 ha).

Plot size

Each plot is 3 m wide and 84 m long. There are 2 m wide buffers between cultivar plots within a block and a 5 m wide buffer between the replicate blocks.

Treatments

Herbicide treatments

There were five herbicide treatments:

- No spray – hard graze only prior to oversowing
- Paraquat autumn - sward suppression only, FLASH® (contains 250 g paraquat/L) added at 0.8 L/ha with low water rate (60 litres/ha), applied just before sowing
- Glyphosate light autumn - sward suppression only, Glyphosate at low rate (0.7 litres Roundup/ha in 100 water litres/ha), applied just before sowing
- Glyphosate full autumn – full pasture kill, Roundup at 3 L/ha plus 40g/ha Hammer in 100 water litres/ha – one application autumn spray only
- Glyphosate full summer fallow - full pasture kill followed by summer fallow, Roundup at 3 L/ha plus 40g/ha Hammer in 100 water litres/ha – spring spray application, summer fallow, then autumn application.

Herbicides were applied up and down the slope by helicopter. Each spray strip, and the buffer strips in-between, are 12 m wide. There are no replicates of the spray treatments:

Glyphosate Full, summer fallow ← 12 m →	Buffer No spray ← 12 m →	Paraquat Autumn ← 12 m →	Buffer No spray ← 12 m →	Glyphosate Full Autumn ← 12 m →	Buffer No spray ← 12 m →	Glyphosate Light Autumn ← 12 m →

Sub clover cultivars

Five sub clover cultivars, Antas, Coolamon, Denmark, Narrikup and Woogenellup, were hand sown at 20 kg /ha. There were three replicates of the cultivars in a randomised block design across the herbicide treatments (i.e. going across the slope):

Upper slope

Replicate	Plot	Cultivar
1	1	Antas
	2	Coolamon
	3	Woogenellup
	4	Narrikup
	5	Denmark

↑ 23 m ↓

5m buffer

2	1	Coolamon
	2	Woogenellup
	3	Narrikup
	4	Antas
	5	Denmark

5m buffer

3	1	Narrikup
	2	Woogenellup
	3	Coolamon
	4	Antas
	5	Denmark

Lower slope

Grazing requirements

- ♣ November 2015 - Pre spraying ensure that paddock residuals are no more than 1000-1200 kg DM/ha
- ♣ Autumn 2016 - Pre spraying ensure that paddock residuals are no more than 1000-1200 kg DM/ha
- ♣ Immediately after oversowing sheep at 200/ha placed into paddock for either 24 hours or moved around slope with dogs for 3 hours.
- ♣ Winter - graze area twice as frequently as would normally happen ensuring that existing sward does not produce completion for establishing plants.
- ♣ Spring- Graze lightly (post field day event) – may be twice
- ♣ Late Spring/Summer - Stay off area to enable reseeding
- ♣ Autumn - Graze to ensure no thatch that can affect seedling reestablishment

Event log

Site preparation, experimental set up and post sowing events

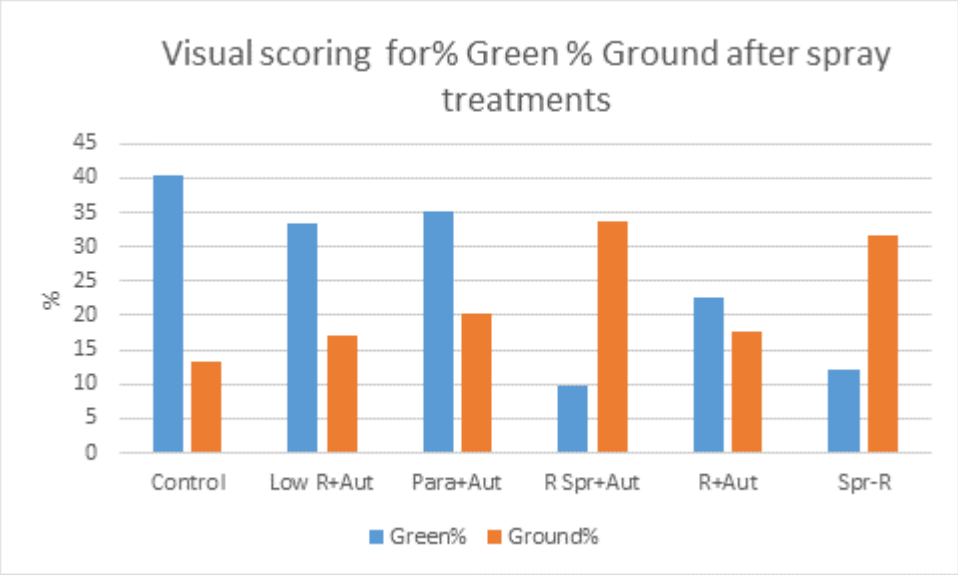
Date	Event
6/11/15	Initial site visit by Derrick Moot (DPR team), Malcolm Macfarlane (On Farm Research) and Annette Litherland (Taratahi Agricultural Training Centre)
26/11/15	Site visit by Malcolm Macfarlane – mark out experimental area and photograph
31/11/15	'Glyphosate full summer fallow' herbicide treatment application - Roundup 3 L/ha in 100 L water
16/12/15	Site visit by Malcolm Macfarlane – assess effect of herbicide applications
11/4/16	Stock grazing of pasture cover down to 1100 kg DM/ha
13/4/15	Annette and Taratahi students – pegged out herbicide strips
19/4/16	Pre-sowing herbicide treatments applied by helicopter
20-21/4/16	Fertiliser was applied to the paddock
23/4/16	Sub clover seed sown by hand using a seed spinner
23/4/16	Seed was treaded in by a flock of 1500 ewes in the 10ha paddock
25/4/16	Ewes removed, pasture cover down to 900 kg DM/ha
27/4/16	Hand spread 10 kg of 'Slugout' across the experimental site

Data collection

Date	Event
8/6/16	Assessment of herbicide impact by Annette Litherland (Taratahi Agricultural Training Centre) - visually scored 10 quadrats for % green, % dead and % open ground
8/6/16	Site visit by Annette Litherland – assess sub clover germination

Comments about site preparation and experimental progress

- Spray drift was noted from some of the herbicide applications.
- An area at the top of the experimental site had a stock camp was heavily infested with thistles. The experiment was moved down the slope to avoid these issues. Also noted that there was significant old pugging damage on the site.
- The dry autumn delayed sub clover seed sowing.
- The effects of the herbicide treatments have been variable:



Future events

- ♣ Established counts will be undertaken in early July.
- ♣ Field days

Other events for the Wairarapa

Date	Event
19/5/16	Email to the Wairarapa Farm Discussion Group (25 members) to introduce the 'Sub 4 Spring' post-graduate student projects and provide details about the Dryland Pasture online resources (website, blog, and You Tube channel)

Photos from Glenside Farm, Taratahi

Close-up of germinating sub clover from the seed sown in the Glenside Farm experiment (Photo: Annette Litherland, 8/6/16)

There is already a well-established population of resident sub clover in the Glenside Farm experiment site that has shown itself after spraying (Photo: Annette Litherland, 8/6/16)

Hawkes Bay

In the Hawkes Bay there are two experiments – a research experiment at Poukawa validating the trial in Iversen 2 at Lincoln University and an on-farm demonstration area at Waiau Station.

Experiment site 1: Poukawa Research Station

Experiment location and site details

The experimental site, GPS coordinates -39.747236, 176.731211, is on Poukawa Research Station, Poukawa. The altitude of the experimental site is 60 m a.s.l. and the topography is flat.

The soil is a Matapiro sandy loam (Calcareous Orthic Melanic Soil) that is characterised as being moderately deep and well drained with moderate to high plant available water. Analysis of soil samples taken from 0-75 mm depth at the experimental site found a low pH of 5.4, high Olsen P, medium potassium, calcium, and magnesium; and high sulphate-S.

The nearest weather station is Maraekakaho Cws (agent no. 40256) which is 12.9 km from the experimental site at an altitude of 150 m a.s.l.

This experiment is similar to the one in Iversen 2 at Lincoln University and will provide validation data for the completion of Objective 3 (sub clover phenology).

Treatments and plot layout

The trial design, plot size and sub clover cultivars are the same as for the experiment in Iversen 2.

Sowing dates

To date there have been three sowing dates: 19/2/16, 30/3/16 and 30/5/16.

Map of the trial

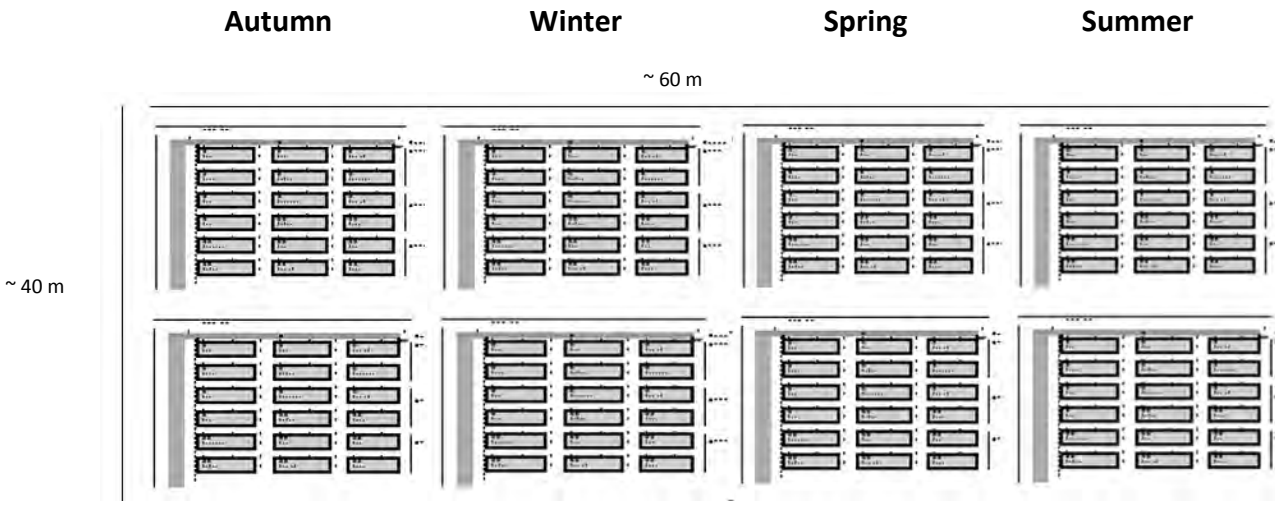


Diagram representing the eight sowing dates complete split plot design: three replicates per cultivar organised on blocks. Total of 144 subplots.

Event log

Site preparation, seed sowing and post establishment treatments

Date	Event/task
12/2/16	Herbicide application: Roundup 630 mL/ha in 100 L water
18/2/16	Site was rotary hoed before seed sowing
19/2/16	Seed sowing – first date
30/3/16	Seed sowing – second date
30/5/16	Seed sowing – third date
30/5/16	Soil samples taken to monitor current area fertility status
30/5/16	Aphids - preventive application. Insecticide (Lorsban 200 mL/ha) applied to plots in sowing dates 1 and 2

Data collection events

The following data collection events started on 21 February, 2016 and are ongoing:

♣ Phenological data (vegetative and reproductive stages): collected twice a week on selected plants.

♣ Visual plot performance: twice when plants had approximately 3-5 trifoliate leaves and then when they have 8-10 trifoliate leaves.

Future events

The next sowing date is scheduled for mid-July.

Photos

Overview of the Poukawa experiment: established plots (February and March) and newly sown area on 30 May 2016 (Photo: Carmen Teixeira, 30/5/16)

On-Farm research assistant Noel Smith assessing the phenological stages of sub clovers. Poukawa experiment site, Hawkes Bay (Photo: Carmen Teixeira, 30/5/16)

Demonstration site 2: Waiau Station, Wairoa

Experiment location and site details

Waiau Station, owned and farmed by Dave Read and Judy Bogaard, is located at 61 Rangiahua Rd, RD3, Waiau 4193 (GPS coordinates of the homestead are -38.949876, 177.335777). Further information regarding the experimental site will be confirmed.

During a field day in November 2015 a suitable paddock called 'Trig' (12.6 ha) was identified for sowing sub clover in the autumn of 2016. This demo site will be used in an advisory capacity for a farmer initiated Wairoa discussion group.

Experimental details

This site is a demonstration area and the details are noted in the following event log.

Event log

Site preparation, seed sowing and post establishment treatments

The following events were carried out and recorded by the farmer, Dave Read.

Date	Event
13/3/16	Started break grazing the paddock with 200 R2 & R3 recently weaned cows
23/3/16	Sowed first half of Trig with a 10 kg/ha mixture of the following sub clover cultivars: Monti, Denmark, Woogenellup, Leura + a dash of Antas
24/3/16	Trampled seed in with a mob of 500 ewe hoggets
25-26/3/16	Two days of steady rain – 60 mm
29/3/16	Sowed second half of Trig
9/4/16	Established sub clovers at first trifoliate stage (15 days since rain)
27/4/16	Plants 5 weeks old and at 4-6 trifoliate leaves
4/5/16	Two very hot dry weeks. Sub clover plants are 6 weeks old but have no new growth
13/5/16	Paddock grazed lightly by 200 weaner heifers for two days
7/6/16	Set stocked small number of light weaners and light ewe hoggets
14/6/16	All hoggets removed, plenty of feed on damper slopes but hoggets grazing sunny slopes

Current status

The site has been severely affected by drought this autumn. Dave Read noted on 14/6/16 “Very depressing, way less sub [clover] than on previous visits. The sunny slopes are still very dry, even the Californian thistles are yellowing off. Since germination we have only had one fall of rain greater than 20mm. There has been a lot of hot weather and wind. In May we have had 40 mm (35% of normal), we are still getting some days into the lower 20 degrees. I hope that, just as after the January rain, there is more sub surviving than it looks, otherwise we try again next year.”