Dry matter yield and botanical composition of the ‘MaxClover’ grazing experiment at Lincoln University, Canterbury, New Zealand

PHOTO DIARY - 2002/03 to 2010/11

Prepared by: DJ Moot; A Mills; RJ Lucas; KM Pollock; M Smith
Lincoln University Dryland Pastures Research Team

Funded by:
The ‘MaxClover’ Grazing Experiment was established at Lincoln University, Canterbury in Feb 2002. There were six paddocks of each of the six pasture types. This gave 36 individual plots of 0.05 ha each.


No nitrogen fertiliser or irrigation was applied to any pasture over the nine years. Other nutrients (S, P) and lime were applied in response to annual soil tests.

Annual soil test results can be found on the ‘MaxClover’ page at [www.lincoln.ac.nz/dryland](http://www.lincoln.ac.nz/dryland)

No irrigation was applied. Annual rainfall ranged from 490 to 770 mm and the mean is about 630 mm/yr at this location.

Rainfall is variable and unpredictable, particularly from September to March when potential evapotranspiration exceeds rainfall leading to the development of soil moisture deficits.
<table>
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<th>Plot No.</th>
<th>Reps 1</th>
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<th>Reps 4</th>
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**Notes:**
Plot numbers (1-36) are indicated for each plot.

The plan (not to scale) has been rotated so it has the same orientation as the aerial photo on the next page.

**Dryland**
4 clovers + cocksfoot
v R/W v Luc
(Reps 1 - 4 sown Feb, 2002)
(Reps 5 & 6 sown autumn, 2003)

- **B** Bolta balansa clover (3.5 kg/ha)
- **C** Vision cocksfoot (4kg/ha, reps 1-4)
- **Cc** Endura caucasian clover (5.9 kg/ha)
- **Luc** Kaituna lucerne (5.7 kg/ha)
- **R** Aries AR1 ryegrass (10 kg/ha)
- **S** Denmark sub clover (10 kg/ha)
- **W** Demand white clover (3 kg/ha)

**Plot sizes**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Area</th>
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<td>22 x 23m</td>
<td>0.05 ha</td>
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The ‘MaxClover’ Grazing experiment in paddock H19 at Lincoln University
Grazing management

Lucerne was always rotationally grazed.

Grass-based pastures underwent a period of set stocking, short (2-paddock) or intermediate (3-paddock) rotational grazing in early spring before being rotationally grazed in a six paddock rotation until insufficient feed supply led to destocking of the pastures (drought or low winter temperatures).

Pastures were generally destocked in winter when there was insufficient feed. This simulated a commercial farm system when sheep would be removed to graze winter forage crops or a smaller area of the farm set aside for winter grazing.

For pastures with annual clovers (sub or balansa) stock were removed to allow re-seeding. The timing differed as pastures were closed sequentially as the rotation progressed.

When necessary, ewes were used to hard graze annual clover pastures in early autumn to open the sward in preparation for the germination of annual clover seedlings after autumn rains.
Total annual LW production (kg/ha)

(a) CF/Sub
(b) CF/Bal
(c) CF/Wc
(d) CF/Cc
(e) RG/Wc
(f) Luc

Spring, Summer, Autumn

Not determined

Mills et al. 2014b
Total spring LWt production

![Graph showing spring LWt production from 2002/03 to 2010/11 for different treatments: CF/Sub, CF/Bal, CF/Wc, CF/Cc, RG/Wc, and Luc. The y-axis represents Spring LWt (kg/ha) ranging from 0 to 1000 kg/ha, and the x-axis represents years from 2002/03 to 2010/11. Not determined is indicated by a bar with an equals sign.](image-url)

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Mills et al. 2014b
Total summer LWt production

Summer LWt (kg/ha)

- CF/Sub
- CF/Bal
- CF/Wc
- CF/Cc
- RG/Wc
- Luc

Not determined

04/05 05/06 06/07 07/08 08/09 09/10 10/11

02/03 03/04 04/05 05/06 06/07 07/08 08/09 09/10 10/11

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Mills et al. 2014b
Total autumn LWt production

Autumn LWt (kg/ha)

Year: 02/03, 03/04, 04/05, 05/06, 06/07, 07/08, 08/09, 09/10, 10/11

- CF/Sub
- CF/Bal
- CF/Wc
- CF/Cc
- RG/Wc
- Luc

Mills et al. 2014b
Yield and composition of six dryland pastures over nine growth seasons

- Lucerne produced more DM than all grass based pastures in most years.
- Its tap-root enabled access to water from lower soil layers but it also used water more efficiently than the grass based pastures - especially in spring.
- CF/Sub clover was the highest yielding grass based pastures in Years 6-9.
- Yields of all pastures declined over time.
Figure 1. Total annual accumulated dry matter production

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Summary of yields in Figure 1

- RG/Wc yield declined from 10.5 to 6.6 t/ha in Year 9.
- Lucerne yield was over 17 t/ha in 3 years and 12.9 t/ha in Year 9.
- CF/Sub yield declined from 12 t/ha to 8.7 t/ha in Year 9.
- CF/Wc, CF/Cc, CF/Bal yields were lower than CF/Sub in most years.
All the cocksfoot pastures lost sown components at about 3% per annum.

The perennial ryegrass/white clover pasture lost RG+Wc at about 10% per annum.

Figure 2. Change in the proportion of originally sown pasture components (grass + clover) over time.
Summary of Figure 2

- After 9 years about 10% of the RG/Wc pasture was from originally sown species compared with about 60% in the cocksfoot based pastures. Lucerne (not shown) was about 85% pure due to winter weed control.

- In Years 1-3 the RG/Wc pastures maintained a high proportion of ryegrass and white clover. Most experiments only run for 3 years – this long-term experiment shows how this pasture deteriorated from Year 4 to Year 9.

- By Year 5-6 only about half the yield in RG/Wc pastures is from the sown species. Ideally pasture renewal would be recommended at this point.

- By Year 9 only about 10% of the 6.6 t DM/ha that was produced was from RG or Wc.

- For cocksfoot, sown pasture species decreased by about 3% per year. This meant after 9 years about 60% of the total yield produced by the four cocksfoot based pastures was from the originally sown pasture species.

- Cocksfoot was persistent but pasture vigour had declined. These pastures did not require renovation but had the potential for increased production. We recommend overdrilling in autumn with 10 kg/ha sub clover plus 1 kg/ha white clover to increase clover content and nitrogen fertility which would stimulate production from the existing cocksfoot component.
Unsown species <5% in Year 1 .......>45% in Year 6

RG/Wc pastures
Spring WUE

![Graph showing water use efficiency (WUE) for different crops. The graph plots accumulated dry matter (DM) (t/ha) against water use (mm).

- Lucerne:
  - 28 kg DM/ha/mm
- Grass/clover:
  - 20 kg DM/ha/mm
- Grass only:
  - 13 kg DM/ha/mm

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Moot et al. 2008
Lucerne Objectives

• Describe management to maximise production, quality and persistence

• Describe key establishment issues

• Examples of lucerne on farm.
Growth:
is dry matter accumulation as a result of light interception and photosynthesis

Development:
is the ‘age’ or maturity of the regrowth crop e.g. leaf appearance, flowering

Growth and development are both influenced by environmental signals
The canopy: the energy capture device
Vegetative growth

Growth rate (kg DM/ha/d)

Mean temperature (°C)

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Moot et al. 2003
Experiment 2
flexible grazing

- 25 days resting
- 3 days grazing
- 38 days resting
- 4 days grazing
What’s going on down there?
Partitioning to roots

Tap root dry weight (t/ha)

Month

- 42-day
- 28-day

Moot et al. 2003
Spring

• 1\textsuperscript{st} rotation aided by root reserves to produce high quality vegetative forage.

• can graze before flowers appear (~1500 kg DM/ha) ideally ewes and lambs but

Growing point at the top of the plant
Rotation 1 Pre-graze
Plot 1 (21/9/07)
2.3 t DM/ha
20-25 cm tall
MaxClover – 38-42 day rotation

DM Yield (t/ha)

Monthly rainfall (mm)

MaxClover – 38-42 day rotation

Moot & Smith 2011

Practical Lucerne Management Guide
Rotation 2 Pre-graze
Plot 1 (2/11/07, 38 d)
2.9 t DM/ha
35-40 cm tall
Stocking rates in New Zealand

- Spring 14 ewes plus twins/ha
- Summer 70 lambs/ha
- Ideally 7-14 days maximum on any one paddock
- Less intensive systems – don’t open the canopy
Spring grazing
Seasonal grazing management

**Spring/summer (Nov-Jan)**

- Priority is stock production (lamb/beef/deer)
- Graze 6-8 weeks solely on lucerne
- 5-6 paddock rotation stocked with one class of stock (7-10 days on)
- Allowance 2.5-4 kg DM/hd/d – increase later in season
14 ewes + twins/ha
High numbers for 7-10 days
Fibre and salt
Maximize reliable spring growth – high priority stock
Seasonal grazing management

*Early autumn (Feb-April)*

- terminal drought ⇒ graze standing herbage
- allow 50% flowering
- long rotation (42 days) somewhere between Jan and end of May.

⇒ build-up root reserves for spring growth and increase stand persistence
Autumn = flowering plants
But don’t flush on this!
Metabolisable energy of lucerne

Metabolisable energy of lucerne.

Brown & Moot 2004
Animal health

- **Clostridial bacteria**: vaccinate
- **Cobalt**: vitamin B12 injection
- **Worm haven**: Camping on small area – river edge?
- **Avoid flushing if**: leaf spots or flowering lucerne
  - new regrowth or tops only are O.K.
Animal health

- **Redgut**: problem on high quality feeds – fibre
- **Bloat**: cattle more than sheep – capsules
- **Na def.** (0.03%): salt licks/fence-line weeds/pasture
- Require 0.11% Na - sheep/beef/dairy
Cemetery Block 103.93ha

Main Block

Total experimental area 2013/14 = 30.0 ha

Home Block 47.88ha

H7 Spring grazing management of lucerne

C6/7 Legume/grass mixes
   A) Lucerne/grass

C9 (North)
   New Legume/grass mixes
   B) Clover/grass

C9 (South)
   Old - terminated Mar 2013
   B) Clover/grass
Lucerne/grass mixes

Tracks for stock movement
Early spring
## Total Accumulated LWt production

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<td>Jul</td>
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<td>Nov</td>
<td>800</td>
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<td>Mar</td>
<td>1000</td>
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- **Luc**
- **Luc/Brome**
- **Luc/CF**

### Graph

**New Zealand’s specialist land-based university**
DM Yield

- Luc(-)
- Luc/Brome
- Luc/CF

Date:
- Jul12
- Sep12
- Nov12
- Jan13
- Mar13
- May13
- Jul13
- Sep13
- Nov13
- Jan14
- Mar14
- May14
- Jul14

Total accumulated yield (kg DM/ha):
- 0
- 2000
- 4000
- 6000
- 8000
- 10000
- 12000
- 14000
- 16000
Lucerne/cocksfoot mix – Sept 2013
Establishment

**Soils**
- deepest free draining soils
- pH 6.0
- RG/Wc fertility

**Sowing**
- 8-10 kg/ha
- 10-25 mm
- peat inoculated 8-10 kg/ha
- *spring or autumn*
- cultivated/direct drilled (DAP)
What a root nodule looks like

Engine room for N-fixation
Lucerne root
~8 months after sowing
> 1.5 m length
Autumn Spraying

Timing is Critical
Most important tool
Glyphosate, granstar, penetrant

Key Results
Conserve soil moisture
Kill mass root systems

Kearney et al. 2010
Drilling seed with fertiliser
Direct drilling = seed + fertiliser
Hills Creek Station

Sown 4/11/2008
Photo taken 5/11/2010
Over 60,000 ha sown and doubling of lucerne seed sales over 10 years

“35% Rate of return on investment”
Sowing rate and date

Established 2007 LU – Templeton silt loam

Coated ‘Grasslands Kaituna’ lucerne.

Four sowing dates

• 21 February,
• 2 March,
• 16 March and
• 30 March

Four sowing rates

• Equivalent to bare seed @ 7, 10, 13 and 16 kg/ha
Sown seed & plant population over time

Seed or plants/m²

Sowing rate of coated seed (kg/ha)
- 7
- 10
- 13
- 16

Seed or plants/m²

- Seed: Feb-Mar 2007
- Emerge: Autumn 2007
- Sep'07: Year 1
- Aug'08: Year 2
- Aug'09: Year 3
- Aug'10: Year 4
- Aug'11: Year 5
- Aug'12: Year 6

Moot et al. 2012
Seedling lucerne yield to early June

Coated seed rate: kg/ha

- 7
- 10
- 13
- 16

DM yield (kg/ha)

Sowing date (2007)

21 February

02 March

16 March

30 March

LSD

Moot et al. 2012
Weeds present @ 09 October 2007 (Year 1)

Sown 21 Feb 2007    Sown 30 Mar 2007
Annual yield in relation to sowing date

Sowing date (2007)
- 21 Feb
- 02 Mar
- 16 Mar
- 30 Mar

Annual DM yield (t/ha)

Stand age
- Year 1
- Year 2
- Year 3
- Year 4
- Year 5

SEM

Moot et al. 2012
Annual yield in relation to sowing rate

Lucerne seed rate: kg/ha
- Orange: 7 kg/ha
- Black: 10 kg/ha
- Green: 13 kg/ha
- Blue: 16 kg/ha

SEM

Stand age:
- Year 1
- Year 2
- Year 3
- Year 4
- Year 5

Moot et al. 2012
Regrowth (year 2)

Seedling

Ashley Dene, January 2012
1) Lismore stony silt loam

Volumetric water content (mm$^3$/mm$^3$)

Drained upper limit
Lower limit

~115 mm
2) Wakanui silt loam

Volumetric water content (mm$^3$/mm$^3$)

- Depth (m)
- ~325 mm

DUL
- LL; lucerne

Sim 2014
Sowing date

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<thead>
<tr>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
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Total annual yield (t DM/ha)

0 5 10 15 20 25

Establishment

Year Two

Ashley Dene

17 kg DM/day
$R^2 = 0.88$

Iversen Field

80 kg DM/day
$R^2 = 0.98$

13 kg DM/day
$R^2 = 0.60$

50 kg DM/day
$R^2 = 0.95$

Delayed sowing cost yield
Taproot mass

Sown: February ~ October

Sampled: June
Conclusions from establishment

• Spring sow - October

• Yield in year one is lower due to partitioning

• Plant population self thins over time

• Sow on deep soils
Irrigation

• Before sowing to encourage root growth

• When the canopy is closed to reduce soil evaporation and weed growth

• Large amounts (50 mm) infrequently rather than small (15 mm) amounts frequently

• Fallow – dry soil vs wet soil
Fertilizer

- Higher requirement from cutting than grazing
  - 2% K = 20 kg/ha/t DM removed

Or

- 50% K super = 80 kg/ha/t DM removed

- KCL = 40 kg/ha/t DM removed + P and S from super
Case study – Bonavaree farm, Marlborough
Over grazed – high erosion risk

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Annual rainfall at ‘Bonavaree’

![Graph showing annual rainfall from 1970 to 2010 with long-term average indicated.](image)

New Zealand’s specialist land-based university
Salt bush
Young lucerne
Chemically fallowed land
### ‘Bonavaree’ production change over 10 years

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<th>2012</th>
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<td>1100</td>
<td>1800</td>
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<tr>
<td>Sheep numbers</td>
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<td>4158</td>
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<td>Lambing (%)</td>
<td>117</td>
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<td>Lamb weights (kg)</td>
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<td>19</td>
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<td>Lamb sold (kg)</td>
<td>38324</td>
<td>74460</td>
<td>↑94%</td>
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<tr>
<td>Wool (kg)</td>
<td>18317</td>
<td>20869</td>
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<tr>
<td>Sheep:cattle</td>
<td>70:30</td>
<td>50:50</td>
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<tr>
<td>Gross trading profit (ha)</td>
<td>$317</td>
<td>$792</td>
<td>↑149%</td>
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The website...

Info on:
• Current projects
• Field day presentations
• Scientific publications
• FAQs
• Postgraduate study

www.lincoln.ac.nz/dryland
Conclusions

• Lucerne growth rate is seasonal based on storage and remobilization of reserves

• Lucerne can be grazed or cut and carried based on yield – not time of flowering

• Replace nutrients removed through cut and carry (K)

• Minimize soil evaporation by timing of irrigation
Set stocking lucerne in early spring – the stuff you need to know

Posted on 31/10/2014 by Anna Mills

Posted on behalf of Prof. Derrick Moot

This grazing management is based on new research out of Lincoln University. It is recommended ONLY for farmers with a large proportion (>40%) of their properties in lucerne who require greater areas to lamb on in early spring and who already follow the optimum rotational grazing management system advocated by Prof. Moot and Lincoln University’s Dryland Pastures Research Team.

After 15 years telling people never to set stock on lucerne Prof. Moot has mellowed (...slightly). The rules for set stocking lucerne outlined below must be followed. Failure of farmers/managers to follow these guidelines may result in killing your lucerne stand within 2 years. Deviations from the guidelines are at your own risk.

Planning for spring set stocking happens in early autumn

Dryland Pastures Blog:
http://www.lincoln.ac.nz/conversation/drylandpastures/
References & Links

Dryland pastures website: http://www.lincoln.ac.nz/dryland
Dryland Pastures blog: http://www.lincoln.ac.nz/conversation/drylandpastures/
MaxClover photo diary (PDF 18.7 MB)


Mills, A., Lucas, R. J. and Moot, D. J. 2014b. ‘MaxClover’ Grazing Experiment. II. Sheep liveweight production from six grazed dryland pastures over eight years. *New Zealand Journal of Agricultural Research, XX, XXX-XXX (In Press).*


