Dryland Legume Pasture Systems: Quantifying benefits of novel legume pastures to livestock production systems

RESEARCH

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Location
Minnipa Agricultural Centre, paddock S8
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2018 Total: 269 mm
2018 GSR: 208 mm
Paddock History
2017: Scepter wheat
2016: Medic pasture
2015: Mace wheat
Soil Type
Red sandy loam
Soil Test
$pH_{(H20)}$ (0-10 cm) 8.4
Plot Size
6 treatments x 2 ha x 3 reps

Key messages

- **Novel legume species and genotypes have the potential to reduce feed gaps and provide other farming systems and livestock benefits in low to medium rainfall regions of southern Australia.**
- **The five-year large scale grazing systems trial established at Minnipa in 2018 is the main livestock field site for the national Dryland Legume Pasture Systems project. Five annual legume species are being tested.**
- **The priority for this trial in 2018 was to optimise seed set given the poor seasonal conditions, and therefore no grazing was undertaken in the establishment year, but instead will commence with sufficient pasture growth in 2019 to determine the best legume option for livestock production.**

Why do the trial?

In southern Australian mixed farming systems, there are many opportunities for pasture improvement, providing positive impacts to both cropping and livestock systems. Dryland legume pastures are necessary in low to medium rainfall zones to support productive and healthy livestock, along with optimal production in crops following these pastures. The majority of pasture species used in these mixed farming systems are short-lived annuals that complete their lifecycle from winter to early summer, with dry seasonal conditions resulting in a shorter growth window between germination and senescence. This is a major issue for livestock producers in these regions due to unreliable rainfall patterns leading to fluctuating legume growth, and the subsequent impact on feed supply and quality for grazing animals.

Innovative and improved legume species and pasture systems have the potential to fill existing nutrient gaps, thus reducing supplementary feed required for optimum ruminant performance, and maintain or improve livestock productivity through growth rates, fertility or product quality.

The Dryland Legume Pasture Systems (DLPS) project aims to boost profit and reduce risk in medium and low rainfall areas by developing recently discovered pasture legumes together with innovative management techniques that benefit animal and crop production and farm logistics. A theme of the DLPS project involves 'Quantifying the benefits of novel legume pastures to livestock production systems' and aims to maximise the advantages that pastures provide to livestock through increased animal growth and reproduction by extending the period of quality feed and reduced supplementary feeding. The animal systems research within the project will also assess areas of understanding anti-nutritional factors and 'duty of care' for new pasture species, providing opportunities for improved weed management and evaluate the main benefits of novel self-regenerating pasture legumes in crop rotations on animal production, health and welfare.

This theme is a component of a five year Rural R&D for Profit funded project supported by GRDC, MLA and AWI; and involving Murdoch University, CSIRO, SARDI, Department of Primary Industries and Regional Development; Charles Sturt University and grower groups.

A five-year grazing system trial was established at the Minnipa Agricultural Centre (MAC) in 2018 to examine this theme and is the main livestock field site for the DLPS trial in the southern region of Australia.

How was it done?

The large-scale (36 ha) grazing system experiment, measuring pasture production, legume seed bank dynamics and animal benefits from different pasture species was established in paddock South 8 at MAC and fenced in early 2018. The trial, which consists of six treatments arranged in a randomised block design with three replications, with each 'plot' 2 ha in size, was established to allow grazing during pasture phases and on stubbles after harvest in cropping years.

Soil borne disease tests were completed on soils collected on 26 June, with soil sampling for water content, basic nutrition and nitrogen undertaken on 2-3 July. Four permanent sampling points were marked out per treatment area (plot) for future measurements.

The planned rotational sequence for the five-year large-scale grazing trial aims to replicate current low to medium rainfall mixed farming practices, but also give novel pasture legumes the opportunity to successfully establish into the current system. For this reason, 2018 was intended to be the pasture establishment year with the aim to maximise seed set, followed by pasture regeneration in 2019, wheat in 2020, with options of another crop or pasture phase in 2021, depending on seasonal conditions.

Pasture species for the trial were selected after greenhouse tests of their adaptation to Minnipa soil. Twelve different legume species were tested prior to the 2018 growing season. Some clover, biserrula and serradella varieties were excluded from the trial after these experiments due to poor germination and/or growth. Treatments selected for the field trial were a continuous cereal (control 1, Scepter wheat in 2018), naturalised medic (control 2, sown Harbinger strand medic seed sourced locally), vetch (Volga), strand medic (new powdery mildew resistant and SU herbicide tolerant medic PM250), Trigonella balansae (a new aerial-seeded legume with expected good nodulation, closely related to medic) and clover (SARDI Rose, an aerial seeded variety). Table 1 presents the varieties chosen in addition to sowing information.

Table 1 Sowing information for the large-scale grazing trial at MAC in 2018

Species	Germination (%)	Sowing rate (kg/ha)	Fertiliser DAP (kg/ha)	Inoculation*
Wheat	100	75.0	50	Nil
Naturalised medic	58	8.6	50	RRI128 peat @ 250 g/25 kg seed
Vetch	90	44.4	50	WSM1455 peat @ 250 g/100 kg seed
Strand medic	93	5.0	50	RRI128 peat @ 250 g/25 kg seed
Trigonella	90	4.4	50	RRI128 peat @ 250 g/20 kg seed
Clover	77	7.8	50	WSM1325 peat @ 250 g/50 kg seed

**all inoculation treatments were applied with sticker @ 1.5%, lime and fungicide of 350 g/L Metalaxyl-M (ApronXL 350 ES) @ 1 ml/kg seed*

Sowing was delayed due to lack of rainfall, which was required to allow naturalised medic to germinate at the trial site. A pre-emergent herbicide was used two days prior to sowing (2 L/ha Roundup DST + 40 ml/ha Hammer + 118 g/ha Sakura) to eradicate any naturalised medic plants already present, in order to reduce competition with the sown crop and pasture treatments. The 36 ha site was sown between 5 and 7 of July. Wheat and vetch (5 July) were sown first, followed by Harbinger medic (pasture control) and PM250 medic (6 July) and SARDI Rose Clover and Trigonella (7 July) using a disc pasture seeder. Sowing rates were calculated based on recommended rates, % germinable seed and the amount of seed available for each variety, with an insufficient amount of seed available for the PM250 strand medic (sown @ -0.37 kg/ha of the recommended rate).

Plant emergence dates were recorded and counts were taken on 4 September at each permanent sampling point, recording grass and broadleaved weeds and assessing the density of naturalised medic that germinated. Flowering and pest infestation were both monitored during the growing season. Biomass cuts were undertaken on 29 October for later spring (maximum) dry matter production and pasture composition and estimates of the percentage ground cover were also recorded. The herbage was sub-sampled for both nutritive value and N fixation after processing (these samples will also be tested for N-fixation using the ^{15}N natural abundance method), with both of these measures still being analysed. Soil sampling for water content and nitrogen was undertaken after legume senescence on 17 December. At this time, anthesis biomass and pasture composition was measured and samples were collected for pod count, pod weight and seed weight, and are still being processed.

Given the poor start to the season, late sowing time and aim to maximise seed set of the legumes, grazing was not undertaken on the trial in 2018, however baseline livestock measurements have been recorded on animals that will be used for grazing the trial in the 2019 season.

What happened?

Conditions were dry and dusty on the first day of sowing but improved with 4 mm of rainfall on the second and third days. In total, 12 mm of rainfall was received in the week of sowing, with another 5 mm the following week. The wheat (control) emerged 12 days after sowing, the vetch 14 days after sowing, the medics and clover 18 days after sowing and the Trigonella 20 days after sowing. Windy conditions caused some soil to blow into the sowing furrows, which slowed plant emergence and resulted in patchy germination, particularly with some of the smaller seeded species, including the trigonella and medics. A substantial rainfall total of 86 mm over August consolidated the establishment and supported some pasture growth.

Results of the plant emergence counts undertaken in early September are displayed in Table 2. The amount of naturalised medic that germinated in each treatment has also been recorded, with the amount in some treatments observed to affect the establishment and growth of sown legumes due to competition. The vetch had less plants but more early vigour than other legume species, with the smaller seeded species struggling to push through the soil that had covered the furrows after windy conditions. It was difficult to distinguish between the sown Harbinger medic and the naturalised medic regenerating form soil seed reserves.

Table 2 DLPS large-grazing trial sown legume plant counts, plant size, grass weed counts and naturalised regenerated medic plant counts in early September 2018

Species	Plants/m² average (range)	Plant size average (range)	Av. Grass weeds/m²	Av. Regenerated medic/m²
Scepter wheat	154 (142-164)	Z22 (Z16-23)	0	0.5
Harbinger medic	116 (80-144)	5 cm (3-6 cm)	1.5	6.0
Volga vetch	64 (54-80)	10 cm (4-12 cm)	1.8	8.0
PM250 strand medic	105 (82-146)	4 cm (2-6 cm)	1.0	8.7
Trigonella balansae	153 (122-202)	5 cm (2-10 cm)	0.5	14.7
SARDI Rose clover	152 (78-192)	4 cm (2-6 cm)	2.2	7.0

A mixture of Targa Bolt @ 150 ml/ha, Uptake @ 0.35 L/ha and Clethodim @ 450 ml/ha was applied on 27 August to eradicate grasses. Over 80% of plants were flowering in the medic, vetch and trigonella treatments on the 29 September, with the majority of clover flowering on 2 October and most of the wheat was flowering by the 9 October. Aphids were observed on all species apart from the wheat at the end of September and were sprayed on 2 October with 500 g/ha Pirimicarb. All plots were also sprayed with 250 ml/ha Alpha Scud Elite for native budworm on 10 October. These pests did somewhat supress plant growth, however plants recovered quickly after they were eradicated.

September rainfall was close to average with a total of 29 mm, conversely rainfall for October was well below average with only 7.2 mm received for the month (average 34.1 mm). Despite the low rainfall, all of the legume lines achieved satisfactory flowering and seed-set. The main October rainfall event during the middle of the month extended the growing season of some of the legumes and the wheat, however hot weather in the last week of October sped the anthesis process up rapidly. The natural medic began to senesce in early November with all other species growing until later into the month.

Table 3 presents the trial groundcover and peak legume biomass measurements undertaken in late October, and due to the substantial amount of both grass and broadleaved weeds growing within the treatments (many of which could not be controlled due to unavailability of information on the effect of typical chemicals on some of the legume species), the total weed biomass was sampled also. The percentage groundcover across the trial varied from 38-84%, with plots being reasonably patchy due to early season wind (creating sandy areas) and poor germination in some parts of the 2 ha plots.

Biomass for the wheat control varied quite substantially with some areas of the trial having poorer results, with the slightly better yields from replicate 2 (1.5 t/ha) where the plot was located further down a minor slope than the other replicates (1.28 t/ha in both rep 1 and rep 3).

Table 3 DLPS large grazing trial groundcover, peak legume biomass and grass/broadleaved weed biomass measurements in late October 2018

Species	Groundcover (%)	Peak biomass (t/ha)	Weed biomass (t/ha)
Scepter wheat	59 (42-75)	5.7 (4.2-7)	0
Harbinger medic	61 (38-76)	0.8 (0.5-1.1)	0.2 (0.1-0.4)
Volga vetch	70 (52-84)	1.3 (0.7-2.2)	0.2 (0.1-0.2)
PM250 strand medic	63 (46-78)	0.5 (0.1-0.9)	0.4 (0.1-1.6)
Trigonella balansae	59 (41-71)	0.8 (0-1.4)	0.3 (0.1-0.8)
SARDI Rose clover	63 (49-79)	0.5 (0.1-0.9)	0.4 (0.2-0.7)

The sown Harbinger medic biomass again was difficult to separate from the regenerated medic biomass (the same and similar species) and is therefore likely to be an overestimate. The PM250 medic was observed to have a longer growing season, up to a month longer than the Harbinger medic, therefore 'peak' biomass may have increased after sampling in this variety, which may provide some advantage compared to current medic varieties.

As expected, the vetch had the greatest measured biomass, averaging 1.3 t/ha, however was still quite patchy. The trigonella performed reasonably well in a poor season with 0.8 t/ha of biomass, which had the potential to average higher, however had patchy areas within some sampling points where it failed to germinate, most likely due to the windy conditions and being located near a sandhill outside of the trial (where the sand had blown and covered in many furrows after sowing). The SARDI Rose clover had a similar issue in one of the replicates, averaging 0.5 t/ha of biomass. Both the trigonella and clover had a similar growing season length to the PM250 medic.

What does this mean?

Patchy establishment and poor dry matter production of novel pasture legumes in the large grazing trial was predominantly caused by seasonal conditions in 2018, and meant that the potential benefits of these cultivars have not yet been measured or observed in this study. Successful establishment when renovating pastures with new varieties is essential to maximise seed-set and therefore regeneration in the following year(s). Improved pasture establishment methods have considerable potential to reduce costs and labour requirements, and aid farm logistics, which are not being assessed in this trial, but will be evaluated over the next four years through other research and demonstration components of the DLPS project. The project will address key constraints to the adoption of pasture legumes, including concerns over cost effective and efficient establishment methods, through trials examining establishment techniques (such as summer sowing and twin sowing), cultivars with suitable patterns of hard-seededness breakdown and resilience, mixed species feedbases, the ability of new cultivars to produce seed that can be farmer harvested and pasture technologies that are simple and cheap to implement and manage. These improvements may have assisted in a more successful establishment year of the large grazing trial.

It is likely that there are benefits to be had from some of the new legume varieties in terms of filling feed gaps in the low to medium rainfall zones of southern Australia. Improved nutrition and ruminant reproductive benefits are also possible. The later senescence of some of the novel legumes (e.g. PM250 medic and trigonella) may see them maintain higher nutritional value through senescence and reduce the need for supplementary feeding. Their nutritional value is presently being analysed. Farming systems benefits such as using livestock to remove weeds through selective grazing or nutrient cycling are difficult to quantify, and it is hoped that the DLPS project and this large-grazing trial may be able to provide some answers over the five-year period of study.

The priority for this trial in 2018 was to optimise seed set given the poor seasonal conditions, and therefore no grazing was undertaken on the large trial at Minnipa in 2018. Pastures will be allowed to regenerate in 2019 and livestock will be introduced once there is sufficient feed on offer to determine their performance on the different legume pastures. Wheat will be re-sown in the control plots with vetch planned to be re-sown on the same plots it was grown last season. The production of the legume treatments will be measured under grazing in 2019, with pasture regeneration, growth, composition, observed palatability and duty of care (ensuring that the plant type will not be problematic to livestock health, productivity or product quality) assessed in order to determine which legume species provide the best outcomes for livestock production and are able to persist in the farming system.

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