Dryland Legume Pasture Systems: Legume adaptation

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RESEARCH

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
5 m x 1.5 m x 4 reps

Key messages

- **This is a component of a new five year Rural Research and Development 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.**
- **This trial aims to assess a diverse range of annual pasture legumes in order to determine whether there are more productive and persistent options for the drier areas (<400 mm) of the mixed farming zone of southern Australia.**
- **Several new legume species established well under very difficult conditions, but in general were not as productive as the medics or vetch.**
- **In the 2018 growing season, Caliph barrel medic was the best adapted pasture legume species to the conditions at Minnipa.**
- **Astragalus was the best adapted alternative legume species, although it was poorly nodulated.**
- **Zulu arrowleaf clover also performed well, however its peak dry matter production and flowering time may be too late for SA conditions.**

Why do the trial?

Legume pastures have been pivotal to sustainable agricultural development in southern Australia. They provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens, and improve fertility through nitrogen (N) fixation. Despite these benefits pasture renovation rates remain low and there is opportunity to improve the quality of the pasture base on many low to medium rainfall mixed farms across southern Australia. A diverse range of pasture legume cultivars are currently available to growers and new material is being developed. Some of these legumes, such as the annual medics, are well adapted to alkaline soils and have high levels of hard seed, which allow them to self-regenerate from soil seed reserves after cropping (ley farming system). Other legume cultivars and species are available and being developed that offer improved seed harvestability, are claimed to be better suited to establishment when dry sown and/or provide better nutrition for livestock. Regional evaluation is needed to determine if they are productive and able to persist in drier areas (<400 mm annual rainfall) and on Mallee soil types common to the mixed farming zone of southern Australia.

The Dryland Legume Pasture Systems project will both develop and evaluate a range of pasture legumes together with innovative establishment techniques, measure their downstream benefits to animal and crop production and promote their adoption on mixed farms.

How was it done?

The trial at Minnipa in paddock S8 was arranged in a fully randomised block design, with four replications. Similar trials have been established at Loxton (SA), Piangal (Vic), Kikoira (NSW) and Condobolin (NSW). Data was analysed using Analysis of Variance in GENSTAT version 19. The least significant differences were based on F probability=0.05.

Thirty different pasture legume species (Table 1) were sown to provide a broad range of legume species and attributes. The chosen species are a mixture of old varieties, new varieties, pre-releases, legumes with new traits, and pasture gene-bank selections based on their likely adaptation to rainfall and soil type. Some legume cultivars developed in Western Australia have also been included. These have performed well in WA and more recently in NSW, on their acid-dominant soils, but have had limited evaluation in South Australia where neutral to alkaline soils prevail.

The trial was sown on 27 June under relatively dry conditions, having received 22 mm of rain in the three weeks prior to seeding. All seed was inoculated with the best available strain of rhizobia and lime pelleted before sowing.

Prior to sowing, plots were sampled at 0-10 cm to provide basic soil chemistry and a soil disease profile. The trial site was sprayed before sowing with 1.5 L/ha Weedmaster (Glyphosate) + 80 ml/ha Nail and 300 ml/100 L of LI 700, to kill any naturalized medic plants that had germinated.

The plots were scored for coverage and vigour of growth on 19 September and measured to assess ground cover (using Green Seeker) on 21 September 2018. Plants requiring specific rhizobia: *Astragalus hamosus, Lotus ornithopodiodies* and *Lotus arenarius*; plus the WA cultivars: Margurita French serradella, Casbah biserrula and Bartolo bladder clover, were sampled on 25 September 2018 for measurement of nodulation. Seventeen of the most promising pasture lines were sampled on 26 September 2018 for spring dry matter (DM) production.

Once dried and weighed, the DM samples were sent to Adelaide to be assessed for their nutritive value, however the results are not yet available. Plots were sampled to estimate seed production for all entries on 3 December 2018.

Table 1 Annual pasture legume species sown in the legume adaptation trial at Minnipa in 2018

Pasture species	Notes
Harbinger Strand medic	Old cultivar; West Coast ecotype
Herald Strand medic	Old cultivar; aphid resistant
Jaguar Strand medic	Pod and leaf holding medic from Pristine Forage Technologies
PM250 Strand medic	Powdery mildew resistant; tolerant of sulfonylurea (SU) herbicide residues; specifically developed for SA dryland Mallee farming systems
Pildappa Strand medic	West Coast ecotype, previously considered for release
Caliph Barrel medic	Old cultivar
Cheetah Barrel medic	Pod-holding medic from Pristine Forage Technologies
Sultan SU Barrel medic	Tolerant of SU residues; Boron tolerant; good aphid resistance
Boron Burr medic	Boron tolerant; spineless
Scimitar Burr medic	Old cultivar; spineless
Toreador Disc medic	Developed for sandy soils
Minima medic	Widely naturalised in dry areas; spineless
SARDI Rose Clover	Developed in upper mid-north; not widely sown in Mallee but reports of good performance
Rose Clover Early 35623	Experimental; early flowering and aerial seeded
Bartolo Bladder Clover	WA cultivar; aerial seeded, limited testing in the southern region
Prima Gland Clover	WA cultivar
Zulu Arrowleaf Clover	WA cultivar; earliest flowering line
Tammin Subterranean Clover	New cultivar; high level of hard-seed and tolerant of Red-legged Earth Mite
Balansa Clover X nigrescens clover	Experimental; an aerial seeded hybrid
Volga Common Vetch	Old cultivar
Studenica Common Vetch	New vetch specifically developed for drier areas
Capello Woolly Pod Vetch	Old cultivar
Casbah Biserrula	WA cultivar; with limited testing in the southern region
Margurita French Serradella	WA cultivar suited to acid soils
Santorini Yellow Serradella	WA cultivar; hard-seeded suited to acid soils with limited testing in the southern region
Trigonella balansae 5045	New species, aerial seeded
Trigonella balansae Early 37928	New species, early line; aerial seeded
Astragalus	Experimental Australian Pasture Genebank selection; new rhizobia
Lotus arenarius	Experimental Australian Pasture Genebank selection
Lotus ornithopodiodies	Experimental Australian Pasture Genebank selection

What happened?

Plant establishment and production

Dry (July receiving only 25 mm of rain) and windy conditions delayed plant emergence for approximately one month after sowing. Plant density counts were completed on 7 August (Table 2). Although still small, seedlings of all lines had emerged after 39 mm of rain in first week of August. However, there were differences between the lines for both vigour and number. Many smaller seeded lines such as the Casbah biserrula, Minima medic, Prima gland clover and the hybrid clover (balansa X nigrescens), were less vigorous. Others, including the two lines with the highest plant density counts, Toreador disc medic (177 plants/m^2) and Zulu arrowleaf clover (176 plants/m^2), were very small but healthy, with some seedlings at the one leaf stage. Trigonella 5045 (86 plants/m^2) and the earlier maturing line, Trigonella 37928 (81 plants/m^2) had relatively low plant density counts and were showing signs of moisture stress. Tammin subterranean clover had a very poor emergence with only 42 plants/m^2. This line continued to perform poorly. Caliph barrel medic, the best performing line in the trial, showed early promise with a plant density count of 147 plants/m^2 and healthy looking plots with seedlings at the 1-2 leaf stage.

Following more favourable conditions (38 mm late August) plots were scored (x/100) for coverage and vigour of growth on 19 September. Studenica common vetch had the best score of 90, followed by Caliph barrel medic with 84, with Capello woolly pod vetch, Cheetah barrel medic, Volga common vetch, Sultan barrel Medic, Scimitar burr medic and Toreador disc medic all scoring above 50. PM250 strand medic was just lower with a score of 49. The poorest plots (Margurita French serradella and Tammin subterranean clover) scored less than 10.

Table 2 Plant density (plants/m^2) and growth stage at Minnipa 7 August 2018

Pasture species	Plant density (plants/m^2)	Observation of early growth
Santorini Yellow Serradella	123	Plants small but healthy. Some at 1 leaf.
PM250 Strand Medic	112	Plants fairly small but healthy. Some at 1 leaf.
Studenica Common Vetch	50	Plants vigorous and healthy.
Toreador Disc Medic	177	Plants small but healthy. Some at 1 leaf.
Bartolo Bladder Clover	151	Plants small but OK. Some 1 leaf.
Trigonella 5045	86	Plants still very small. Signs of moisture stress.
Herald Strand Medic	149	Still small but mostly 1 leaf.
Casbah Biserrula	62	Plants still very small. Some 1 leaf.
Pildappa Strand Medic	140	Plants very small but OK. Mostly 1 leaf.
Astragalus Early	112	Small but look healthy. At 1 leaf stage.
Minima Medic	87	Sparse and tiny.
Trigonella Early 37928	81	Very small but some at 1 leaf. Struggling a bit.
Margurita French Serradella	99	Very small but OK. Most at 1 leaf.
Capello Woolly Pod Vetch	59	Recovered really well after rain. Now healthy.
Scimitar Burr Medic	124	Small but vigorous. At 1 leaf stage.
Boron Burr Medic	138	Small but vigorous. At 1 leaf stage.
Lotus ornithopodiodies	138	Very small but looking OK. Some at 1 leaf.
EP Harbinger Strand Medic	131	Uneven in places but doing OK. At 1 leaf.
Tammin Subterranean Clover	42	Struggling. Plants up are OK and at 1 leaf.
Prima Gland Clover	90	Very tiny.
Lotus arenarius	86	Tiny but some starting to show first leaf.
Rose Clover Early 35623	91	Not a lot of plants but doing OK. Mostly 1 leaf.
SARDI Rose Clover	133	A bit uneven in places but doing OK and 1 leaf.
Volga Common Vetch	42	Not a lot of plants but very healthy.
Cheetah Barrel Medic	101	Plots looking healthy. One leaf stage.
Balansa Clover x nigrescens	139	A lot of plants but VERY tiny!
Caliph Barrel Medic	147	Plots looking healthy and at 1-2 leaf stage.
Zulu Arrowleaf Clover	176	Plants very small but OK. Some 1 leaf stage.
Sultan Barrel Medic	146	Plants small but healthy. At 1-2 leaf stage.
Jaguar Strand Medic	99	Plants small but OK. At 1-2 leaf stage.

Plots were measured to assess ground cover using a Green Seeker on 21 September. As no lines apart from the Woolly pod vetch had achieved 100% plot coverage, these readings were fairly low. Capello woolly pod vetch, Caliph barrel medic, Studenica common vetch, Cheetah barrel medic and Astragalus had the highest readings.

DM cuts were performed on the seventeen most promising pasture lines (Table 3). Caliph barrel medic and Studenica vetch, produced the highest DM. Caliph barrel medic produced 1.30 t/ha of DM, which was double that of the site mean of 0.65 t/ha. Studenica common vetch produced nearly double the DM of the commonly grown Volga vetch. These results were consistent with earlier observations of ground cover and vigour.

The trial suffered two pest attacks. Firstly by Cowpea aphids which appeared on all lines but at higher density on the vetches, and then by Native Budworm. Fortunately both of these pests were brought under control and did not appear to have caused any lasting damage.

The spring DM cut provided a reasonable assessment of the maximum production of most legumes in the trial, especially the medics; however will have underestimated the production of some species that responded to late rains. The serradellas, biserrula, astragalus, lotus and some clovers, were observed to continue growing after the DM assessment. Most notable, was the growth of Zulu arrowleaf clover which continued throughout November and had not fully senesced at the time of seed production measurements in early December. It would have been interesting to have taken late DM cuts on these later maturing lines, especially on the Zulu arrowleaf clover, although whether the extra production provided by these later flowering and possibly deeper rooted legume species occurs in seasons that lack late rains, needs to be clarified.

Of the medics, the barrel species were the first to senesce, whilst PM250 lasted the longest. In late October it was still reasonably green with lots of flowers.

After sampling for DM, it was decided to remove Capello woolly pod vetch from the trial, as there were concerns that it could become an established weed. It was sprayed out with Weedmaster (glyphosate), and hence does not appear as an entry in Table 4.

Seed production was measured on 3 December (Table 4). All lines flowered, with most considered to have set enough seed to enable regeneration next year. Zulu arrowleaf clover had the highest seed production with 44,253 seeds/m^2. Bartolo bladder clover (24,032 seeds/m^2), Casbah biserrula (17,599 seeds/m^2), Prima gland clover (16,182 seeds/m^2), Lotus arenarius (13,219 seeds/m^2) and Astragalus (12,643 seeds/m^2) were also prolific seed producers. The two Vetch lines produced the lowest amount of seed. Regeneration in 2019 will be strongly influenced by the breakdown of hardseed, which varies between legumes and is modified by environmental conditions. Regeneration will be measured as an important aspect of adaptation.

Pasture legume nodulation

Legume species that were likely to be responsive to inoculation, in the absence of any naturalised soil rhizobia, were assessed (six plants per plot) for nodulation (Table 5). Biserrula and the two species of Lotus were found to be adequately nodulated, with these species averaging more than five nodules per plant and not exhibiting any symptoms of nitrogen deficiency. Bladder clover and French serradella were less well nodulated, with individual plants found not to have any nodules. In the case of French serradella, nodulation was similarly erratic at other sites and would probably benefit from an increased rate of inoculation.

Table 3 Dry matter (t/ha) measurements at Minnipa 26 September 2018

Pasture species	Dry matter (t/ha)
Caliph Barrel Medic	1.30 a
Studenica Common Vetch	1.20 a
Cheetah Barrel Medic	1.02 b
EP Harbinger Strand Medic	0.93 bc
Toreador Disc Medic	0.88 bcd
Capello Woolly Pod Vetch	0.78 cde
PM250 Strand Medic	0.72 de
Pildappa Strand Medic	0.71 e
Scimitar Burr Medic	0.68 e
Volga Common Vetch	0.68 e
Jaguar Strand Medic	0.65 ef
Astragalus Early	0.50 f
Trigonella 5045	0.30 g
SARDI Rose Clover	0.24 gh
Bartolo Bladder Clover	0.18 gh
Casbah Biserrula	0.12 h
Margurita French Serradella	0.08 h
LSD (P=0.05)	*0.16*

The fact that bladder clover was better nodulated at other field sites might be explained by the root disease damage observed on the plants from Minnipa, which may have contributed to the decreased nodulation at this site. Astragalus failed to nodulate, but still managed to grow reasonably well. Further work to overcome the nodulation issue will be needed to enable a valid evaluation of this legume.

What does this mean?

Despite a challenging start with the dry and windy weather, all of the legume lines established, flowered and set some seed; and have therefore provided some indication of their potential in a challenging season.

The ranked performance of the most promising legume species at the Minnipa trial site is shown in Table 6. This was determined by averaging the ranking of each legume for seeding emergence, green seeker, plot vigour, DM and seed production.

Caliph barrel medic has so far proved to be the best adapted cultivar to the conditions on Minnipa Agricultural Centre, producing the most DM, along with Studenica common vetch. It also performed well in terms of plant establishment, plot coverage, vigour and seed production. Studenica common vetch, whilst producing the same amount of DM as Caliph, fell down the rankings for its poor plant establishment and seed production.

Annual medic species occupied the top five positions in the ranking table. These initial rankings may change in the longer term due to factors such as seed set, hard-seeded breakdown and seasonal variations, but nonetheless highlight that the medics performed well under very low rainfall conditions. Several cohorts of improved medic material will be developed further, based on these findings.

Astragalus was one of the better performing alternative legumes, despite issues of poor nodulation. Zulu arrowleaf clover was an excellent performer in terms of plant establishment and seed set, however its peak DM production was in late spring and its flowering time may be too late for low rainfall SA conditions. Bartolo bladder clover had good plant establishment and excellent seed production, however its DM production was very poor. Trigonella was slow to establish and had below average DM production, however it continued to grow vigorously into late spring and produced a large amount of seed.

The potential benefit offered by some of the legume species, including improved ease of seed harvest, improved nutritive value and N-fixation may come at the expense of DM production.

This trial will be allowed to regenerate in 2019. The growth of pasture lines that successfully regenerate will be monitored to determine how their performance differs from the establishment year.

Table 4 Seed assessment measurements at Minnipa 3 December 2018

Pasture species	Average No. of seed pods/m²	Average No. of seeds/ pod	Average No. of seeds/m²
Santorini Yellow Serradella	691	5	3,404
PM250 Strand Medic	1,344	5	6,181
Studenica Common Vetch	41	4	147
Toreador Disc Medic	1,480	4	5,994
Bartolo Bladder Clover	740	32	24,032
Trigonella 5045	3,254	4	11,795
Herald Strand Medic	1,215	3	3,827
Casbah Biserrula	1,220	14	17,599
Pildappa Strand Medic	1,466	5	7,075
Astragalus Early	617	20	12,643
Minima Medic	2,154	4	7,915
Trigonella Early 37928	2,535	4	9,253
Margurita French Serradella	575	4	2,573
Scimitar Burr Medic	2,001	5	10,106
Boron Burr Medic	1,708	5	8,324
Lotus ornithopodiodies	2,425	4	10,246
EP Harbinger Strand Medic	1,256	5	5,873
Tammin Subterranean Clover	325	2	691
Prima Gland Clover	1,240	13	16,182
Lotus arenarius	1,241	11	13,219
Rose Clover Early 35623	474	9	4,465
SARDI Rose Clover	758	12	9,317
Volga Common Vetch	55	4	227
Cheetah Barrel Medic	1,053	6	6,526
Balansa Clover X nigrescens	643	6	3,935
Caliph Barrel Medic	1,229	6	6,850
Zulu Arrowleaf Clover	495	89	44,253
Sultan Barrel Medic	1,023	6	5,803
Jaguar Strand Medic	910	3	3,003

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Commercial annual legume cultivars are produced by a range of companies and we appreciate them making their cultivars available for this work.

Table 5 Summary of nodulation at Minnipa in 2018

Pasture species	Summary of observations
Bartolo Bladder Clover	Nodulation low, possibly limiting (only at MAC)
Margurita French Serradella	Low nodule number, possibly limiting
Casbah Biserrula	Nodulation satisfactory and not limiting
Lotus ornithopodiodies	Nodulation satisfactory and not limiting
Lotus arenarius	Nodulation satisfactory (but erratic at Lameroo)
Astragalus Early	Nodulation failure, but no signs of N deficiency

Table 6 Ranked performance of legume pasture species at Minnipa (seeding emergence, green seeker, plot vigour, dry matter and seed production)

Rank	Pasture species
1	Caliph Barrel Medic
2	Toreador Disc Medic
2	Scimitar Burr Medic
2	Cheetah Barrel Medic
5	EP Harbinger Strand Medic
6	Astragalus Early
7	Pildappa Strand Medic
8	PM250 Strand Medic
9	Zulu Arrowleaf Clover
10	Bartolo Bladder Clover
11	Studenica Common Vetch
12	SARDI Rose Clover
13	Trigonella 5045
14	Jaguar Strand Medic
14	Volga Common Vetch
16	Casbah Biserrula
17	Margurita French Serradella