Development of new pasture systems in NW Victoria

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Abstract
This project aimed to identify resilient, low-cost novel pasture legumes and appropriate management packages adapted to the Mallee region of south-east Australia.The study commenced with the sowing of seven novel pasture legume species, listed in Table 1, at three times: June 2018, February 2019 and May 2019. It measured similar 2019 establishment and production results from Bladder clover (*Trifolium spumosum)*, Rose clover (*Trifolium hirtum)*, annual medic (*Medicago littoralis)* and serradella (*Ornithopus sativus*) following the first two sowings compared to the sowings in May 2019. In 2020, the site was sown to wheat, and grain yield and quality were similar following all seven pasture entries plus vetch *(Vicia sativa)*. A continuous cereal treatment included in the trial found wheat following barley had 1 t/ha less grain and almost 2% less grain protein relative to wheat following all the legumes. A further trial site was established in 2020 to compare pasture productivity and seed harvestability. Serradella had higher biomass production than alternative pasture species but similar to vetch on a neutral to mildly alkaline deep Mallee sand. Serradella was successfully machine harvested in a season with above the average 300 mm rainfall.

Keywords
Pasture establishment, novel pasture species, pasture wheat rotation.

Introduction
This article introduces the south-east Australian project "Dryland Legume Pasture Systems" (DLPS). The Victorian Mallee component of the project has specifically looked at:

1. Alternative pasture establishment systems aimed to reduce the cost of pasture establishment.
2. Legume pasture species/cultivars that have not traditionally been grown in the target region. Each species may provide benefits such as increased production on certain soil types; the ability for seed to be machine harvested and retained; hard seed characteristics that provide a viable pasture after a cropping phase.

Methods
The major trial site, commenced in 2018, was at Piangil in the Victorian north-eastern Mallee on a red loamy sand, pH ($CaCl_2$) 7.4 at 0-10 cm and 8.4 at 70-100 cm depth, respectively. An associated 2020 trial, at Speed in the central Victorian Mallee was located on a deep sand over a sandy clay loam at 60-70 cm, and soil pH (CaCl2) were 6.4 (0-10 cm) and 8.2 **(**70-100 cm), respectively.

The Piangil trial commenced with three establishment methods; Twin sowing (28 June 2018) with a companion crop of barley (cv Compass), summer sowing (7 February 2019) as monocultures and autumn sowing (13 May 2019) as monocultures of seven legume pasture species (3 main plots x 7 sub plots x 4 replicates). The seeding rates of the legume pastures (Table 1) were calculated on the basis of providing each species and time of sowing with adequate numbers of germinable seeds (~100 m^2) in autumn 2019. The specie specific planned germinable seed numbers were based on pre-sowing germination studies. Any 2018 legume germination from the twin sown treatment was chemically removed.

In 2020 the trial was sown to wheat (cv Catapault) on 28 April by direct drilling into the existing pasture plots. Basal fertiliser was applied as 62.5 kg/ha of DAP S Z with 43 kg/ha urea topdressed on all plots on the 19th of June

Table 1. Alternative pasture legumes common names, species, cultivars and seed (kg/ha) sown at the twin, summer and autumn time of sowing. Vetch and barley were sown at the autumn sowing.

	Treatment	Cultivar	Twin	Summer	Autumn
			Sowing rate (kg/ha)		
Biserrula	(*Biserrula pelecinus*)	Casbah	5.7	5.7	4.5
Bladder clover	(*Trifolium spumosum)*	Bartolo	14.7	14.7	6.8
Gland clover	(*Trifolium glanduliferum)*	Prima	5.3	5.3	4.6
Annual medic	(*Medicago littoralis)*	PM 250	7.2	7.2	6.8
Rose clover	(*Trifolium hirtum)*	SARDI	9.8	12.5	6.8
Serradella	(*Ornithopus sativus*)	Margurita	7.4	7.4	6.8
Trigonella	(*Trigonella balansae)*	5045	4.9	4.9	4.5

Comparative plant measurements of the three times of sowing for seven pasture legumes in 2019 included: emergence on 5 June from 8 by 0.1m^2 quadrants; pasture biomass on 17 September and seed yield on 5 December both from 5 by 0.1m^2 quadrants. The comparative subsequent 2020 wheat grain yields and quality from the times of sowing and pasture legumes interactions were also collected by machine harvesting and testing of sub-sampled seeds.

More extensive measurements were collected from the autumn time of sowing treatments. This included a 2019 autumn sown vetch (*Vicia sativa* cv Studenica), sown at 25 kg/ha, and the Catapault wheat, that followed 2018 wheat and 2019 barley. Measurements included: 2019 biomass (tDM/ha) and related nitrogen (N) fixation (kgN/t of dry shoots) from all legumes; 2020 pre-seeding total soil N (0–100 cm) and water content (mm H_2O, 0–100 cm) following all legumes and wheat; 2020 wheat plant establishment (plants/m^2); root disease (visual assessment ratings 0 to 5); pre-harvest crop biomass (t/ha) and harvest index (% grain to biomass); grain yield (t/ha) and grain protein content (%), and post-harvest soil water content (mm H_2O, at 0– 00 cm depth).

The associated 2020 sown trial at Speed (4 entries x 3 replicates) was sown with both commercial seed and unprocessed seed pods that were machine harvested and/or hand collected in the field. Seeding rates were based on germination tests and seed size. The aim was to achieve similar kg of emerging drymatter/ha of all entries. All legume seeds and seed pods were inoculated with their specific rhizobia group in both 2019 and 2020.

The trial had comparative establishment (plants/m^2), productivity (tDM/ha), harvested seed yields (plot header) and seed left behind post-harvest (t/ha) of four forage species. The trial entries are presented in Table 3.

Measurements were analysed using ANOVA in Genstat 5.

Results

Total rainfall at Piangil was 142 mm in 2019, 75 mm April to July, 25 mm August to October. Total rainfall in 2020 was 235 mm with 187 mm growing season rainfall. The associated trial at Speed in the central Victorian Mallee had above average 276 mm growing season and 416 mm total annual rainfall in 2020.

Twin sowing established less plants (34 versus 58 plants/m^2) than the autumn sowing, summer sown populations were similar to the twin and autumn treatments (48 plants/m^2) This was approximately 50% of the planned 100 plants/m^2. All 3 treatments had similar biomass (~1.0 tDM/ha) on 17 September and seed yields (~200 kg/ha) on 5 December. Of the 7 species the Biserrula established lower plant populations from the twin and summer sowing, the trigonella from the twin sowing and the gland clover from the summer sowing compared to their autumn sown treatments. The result was ongoing comparatively lower biomass and seed yield from those species, Biserrula, trigonella and Gland clover, following the twin and/or summer sowing times compared to the autumn sowing.

Wheat yields in 2020 were similar between the 3 pasture times of sowing and pasture species except the annual medic treatment (2.5 t/ha) was less than the gland clover (2.9 t/ha). Grain protein content following the Biserrula treatment (11.8%) were lower than the mean (12.4%) of combined treatments.

More intensive comparative measurements were collected from the autumn sown seven pastures, vetch and continuous cereal treatments.

Table 2. 2019 biomass production (tDM/ha) and N fixation (kgN/tonne of plant shoot), 2020 pre-sowing soil N (kgN/ha, 0-1m) and soil water (mm H_2O, 0-1m) wheat grain yield (t/ha) and protein content (%) in response to seven pasture legumes, vetch and wheat sown in autumn 2019 at Piangil

	2019		2020			
	Biomass (tDM/ha)	Plant shoot (kgN/tDM)	Soil N (kgN/ha 0-1m)	Soil H_2O (mm/0-1m)	Grain yield (t/ha)	Grain protein (%)
Biserrula	0.85bc	7.4cd	110a	135ab	2.8ab	11.9b
Bladder clover	1.37ab	18b	116a	135ab	2.7ab	12.4ab
Gland clover	0.55c	5.7cd	115a	150a	2.9a	12.3ab
Annual medic	1.6a	23.4a	102a	121b	2.5b	12.3ab
Rose clover	1.6a	15.2bc	119a	127b	2.7ab	12.4ab
Serradella	1.03b	11.7c	111a	131b	2.7ab	12.4ab
Trigonella	0.65c	12.3c	107a	144a	2.7ab	12.3ab
Vetch	1.5*	25	102a	128b	2.6ab	12.7a
Continuous cereal	na	na	22b	120b	1.8c	10.7c

Letters in table following figures refer to significance at P=0.05 within that column

- Green manured in August 2019

The annual medic and vetch treatments were calculated to have fixed the most N but with no measured benefits in pre-seeding total soil N (Table 2). The annual medic had a lower grain yield than the Gland clover. This was possibly associated with reduced available soil water. The wheat (continuous cereal) treatment produced lower grain yield and quality.

Following the 2019 treatments the 2020 seminal wheat root disease scores (0-5) for cereals averaged 1 and were similar for all treatments. The mean wheat biomass at flowering was 6 tDM/ha, however the continuous cereal was less at 4 tDM/ha. All treatments had a 44% harvest index (grain yield/biomass). Post-harvest soil water content was an average of 5 mm less than pre-harvest with the Gland clover/wheat treatment having the highest (17 mm) decline.

Table 3. Establishment numbers (plants/m^2) total biomass (tDM/ha) machine harvested and post-harvest plot retained seed (kg/ha) of 4 pasture legumes sown on a deep sand in 2020 at Speed

Entries	Variety	(plants/m^2) 4 May	(tDM/ha) 16 October	Seed yield (t/ha) Harvest	Retained
Vetch	Volga	45	7.1a	2200	820
Strand medic	PM 250 seed	165	4b	0	1500
Strand medic	PM 250 pod	77	4.9b	0	1690
Serradella	Margurita seed	199	7.5a	1030	800
Serradella	Margurita and Eliza pod	154	7.6a	990	800
Clover	Sardi Rose seed	193	3.5b	0	600
Clover	Sardi Rose pod	83	3.1b	0	700

The PM250 and Rose clover sown as unprocessed seed/seedpods established less plants than the processed seed, however there was no subsequent production loss in the season of above average rainfall. Serradella produced more biomass than the annual medic or Rose clover and had similar biomass to the vetch. More than 50% of the serradella seed was collected by the harvester versus more than 70% of the vetch. The Sardi Rose clover seed heads were collected by the harvester but not retained within the machine, the strand medic pods were not available for collection being detached from their vine and on the ground.

Conclusion

The benefits of legumes in the low rainfall mixed farming regions are well documented. Moodie et al. (2017) reported that legumes grown in sequence with cereals increased wheat yields by 0.5 – 1.5 t/ha and improved annual profits by up to $100/ha. This study supported that outcome with wheat following a legume pasture yielding 50% more and with a 20% higher grain protein compared to a wheat in a continuous cereal rotation.

Vetch is the dominant legume break crop grown throughout the Mallee region. Identifying alternative legume pasture options with potential systems benefits to vetch the project found:

- Bladder clover, annual medic, Rose clover and serradella can be successfully sown in the season and/or summer preceding the pasture phase as opposed to vetch with soft seed characteristics that requires an autumn seeding. This supports the study of Latta and Moodie (2017) who reported the successful twin sowing of serradella and annual medic in comparison with vetch. The practise would reduce the cost of establishment through using on farm produced seed pods that soften in the field over the summer and autumn to support an autumn germination. Autumn sowing requires processed commercial seed to ensure a germination.
- Productively, there were no measured benefits in subsequent wheat production from the novel pasture species compared to vetch. Serradella achieved similar biomass production to vetch on a deep sandy soil but Rose clover and annual medic produced less. Serradella and vetch both achieved a commercial level of seed harvest in an above average rainfall season.
- Issues yet to be determined in relation to the novel pasture species are their comparative hard seed characteristics that may support a self-regenerating pasture following the cropping phase and also their grazing sustainability as a legume monoculture.

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