Growing pulse crops on sandy soils on lower Eyre Peninsula

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Location
Mount Hope
Billy Pedler
Rainfall
Av. Annual: 420 mm
Av. GSR: 346 mm
2021 Total: 491 mm
2021 GSR: 434 mm
Yield
Grower yield 1.7 t/ha lupin
Paddock history
2020: Wheat
Soil type
Sandy loam
Plot test
0-10 cm pH: 7.12 ($CaCl_2$), P (Colwell) 26 mg/kg, Org. C 0.76 %, Nitrate N 9.4 mg/kg
Paddock scale demonstration
Yield limiting factors
Sowing rate, broadleaf weeds

Location
Yeltukka (NW Cummins)
Michael Treloar
Rainfall
Av. Annual: 396 mm
Av. GSR: 315 mm
2021 Total: 421 mm
2021 GSR: 377 mm
Yield
Potential: Faba beans 6.0 t/ha (Modified French/Schultz, 16 kg/mm)
Actual: 2.0 t/ha
Paddock history
2020: Barley
2019: Wheat
2018: Wheat
Soil type
Sand over clay loam with some calcrete in sub-soil
Plot test
0-10 cm pH: 6.92 ($CaCl_2$), P (Colwell) 23 mg/kg, Org. C 1.42 %, Nitrate N 15 mg/kg
Plot size
10 m x 2 m x 4 reps
Yield limiting factors
Broadleaf weeds

Key messages

- **Soil amelioration has the potential to allow profitable production of high value pulse crops on sandy soils on Lower Eyre Peninsula, however yields may not match lupins.**
- **Using 2021 prices gross margins of crops such as lentils are comparable to canola, however, yields of lentils on sandy soils at the demonstration site and field trials were only around 1 t/ha, much lower than was observed on heavier soils.**

Why do the trial?

This article will report on findings from work conducted at two locations on the lower Eyre Peninsula in 2021 as part of the GRDC's investment "Development and extension to close the economic yield gap and maximise faming systems benefits from grain legume production in South Australia."

Following consultation with the AIR EP Medium Rainfall RD&E Committee, large scale demonstrations and trials in 2021 were designed to answer two questions:

1. Can soils be ameliorated to increase the area that high value pulses are able to be grown on?
2. What is the value of pulse crops, in terms of direct profitability and value to the rotation, compared to other break crops such as canola?

To answer these questions in the 2021 season a demonstration was monitored and and field trials were undertaken.

1. Demonstration Paddock:
Growing high value pulse crops on soil that's been ameliorated.

Background
Around a third of the arable area on the lower Eyre Peninsula consists of acidic sandy - sandy loam topsoils (B. Masters pers. comm.) that have traditionally only been suitable for the production of lupins as a grain legume crop. In recent years pH mapping, coupled with variable rate lime application and an improved understanding of how to implement soil amelioration strategies has sufficiently changed some soils to the point where growing higher value pulses such as lentils and faba beans is now an option (while the latter is not always higher value). However direct yield comparisons of these crops on ameliorated soil have not yet occurred on the lower Eyre Peninsula.

How was it done?

In 2018 a paddock near Mt Hope was mapped for pH and found top-soil pH to vary between 5.2 and 6.5 ($CaCl_2$). In early 2019 the paddock had variable rates of lime applied, depending on the acidity of the soil, which was then was incorporated with delving, and the surface smoothed and then cropped each year.

In 2021 the paddock was planted on 3 June using the grower's air-seeder to sow zones of lupin (cv PBA Barlock), lentil (cv PBA Kelpie) and faba bean (PBA Samira). All crops were treated with high rates of the appropriate inoculant and broadleaf weeds controlled with label rates of herbicide, appropriate for the crop and the soil type.

Table 1. Nodule scores, biomass and grain yield of pulse crops grown at Mt Hope in 2021.

		Plants/m²	Nodule score 3/8	Nodule score 6/9	Biomass (t/ha) 11/10	Biomass maturity (t/ha)	Hand cut grain yield (t/ha)	Harvester yield (t/ha)
Lupin	Ripped	48	5.6	7.2	7.66	8.43	3.29	1.79
	unripped	50			3.92	5.47	2.27	
Faba bean	Ripped	28	7	6.4	4.50	5.10	2.60	2.0
	unripped	30			3.15	4.60	2.20	
Lentil	Ripped	92	4.4	4.8	3.00	3.12	1.07	0.8**
	unripped	96			1.85	2.51	0.75	

**Nodule score 0-8 scale where scores of 4-5 (40-50 small or 4-9 large pink nodules) are considered adequate to ample (Yates* et al*, 2016).*
*** some yield loss experienced due to pod drop prior to harvest.*

Table 2. Pulse crop gross margin x grain price sensitivity ($/ha).

Crop	Grain Price ($/t)									
	300	350	400	450	500	600	700	800	900	1000
Lupin	624	789	953	1118	1282	1611	1940	2269	2598	2927
Faba bean	262	392	522	652	782	1042	1302	1562	1822	2082
Lentil	-176	-123	-69	-16	38	145	252	359	466	573

shaded likely price achieved in 2021.

Table 2a. Grain yields and variable costs used in sensitivity analysis ($/ha).

Crop	Hand cut grain yield* (t/ha)	Variable costs** ($/ha)
Lupins	3.29	363
Faba bean	2.60	518
Lentil	1.07	497

**Yields from hand-cuts collected adjacent to each crop (collected 11 November).*
***variable costs derived from PIRSA Farm Gross Margin Guide 2021*

During the season emergence, nodulation scores, biomass and grain yield data were collected using quadrant cuts at multiple locations in each zone.

What happened?

Soil testing conducted in autumn 2021 found that top-soil pH (0-10 cm) to be 7-7.9, the sub-soil was also near-neutral 7.8 ($CaCl_2$) at 60-100 cm.

Nodule scores conducted twice during the growing season found that all crops were able to produce enough nodules to meet industry standards considered for adequate nodulation, however the beans and lupins did appear to have a higher nodulation rate than lentils.

Pulses grown on the deep ripped/delved soil all yielded higher than where the soil wasn't ripped. A 31% advantage from ripping was recorded in lupins, 15% in faba beans, and 30% in lentils.

Whilst the way the paddock was sown doesn't allow for direct statistical analysis to compare yields of each of the crops against each other, the yields obtained do provide a realistic impression of pulse yields achievable on limed and ameliorated soil in this environment. When these yields were used to extrapolate out to a gross margin it showed that lupins were reasonably profitable in 2021 at the grain yields achieved, but faba bean and lentil have the potential to also be profitable in this environment (Table2).

What does this mean?

While adjusting soil pH and ameliorating soil are important steps in growing high value pulse crops, such as lentils, on acidic sandy soils, returns still may be lower or only match that of a productive crop of lupins.

A range of skills and practices not used in cereal, canola or lupin production are also required when growing high value pulse crops for the first time. These include (but are not limited to) matching broadleaf herbicide performance to soil type and harvesting crops vulnerable to pod drop low to the ground.

2. Field experiments

Background:

Over the last 30 years the lower Eyre Peninsula has grown large areas of canola. This is due to its widespread adaptability to the soils and the lower EP environment as well as the high returns it has provided. Pulse crops have been grown in the region but have, by large, been restricted to heavier alkaline soils or lupins on sandier soils, which generally provide lower returns. Increasing the viability of pulse crops on the lower Eyre Peninsula needs to demonstrate their capacity to produce across a range of soil types found in the region and to compare favourably in terms of profitability to canola. To answer the question of how valuable pulse crops are, trials were established on a sandy soil at Yeltukka, 15 km north-west of Cummins. The paddock where the trials were located had no history of ever growing a pulse crop.

Three trials were established on the site. Two examined rates and types of rhizobia when sown into dry and moist soils on both lentil and faba beans. The third trial examined the performance of a range of pulse crops (lentil, faba bean, lupin, and vetch) relative to canola. All trials will be over-sown with wheat in 2022 to assess the residual value of the pulse crops.

What happened?

Sowing occurred at two dates: 18 May (dry sown) and 29 May (wet sown, rain 26 May). All trials received 100 kg/ha MAP fertiliser at seeding and a foliar trace element spray of 3 L/ha Smart Trace Triple®. Weeds were controlled with 1 L/ha propyzamide and 500 mL/ha clethodim across all treatments, 1.1 kg/ha simazine (applied PSPE) on faba beans and lupins, 400 g/ha simizine + 400 g/ha diuron (applied PSPE) to lentils, 400 g/ha diuron (applied PSPE to vetch) and 500 mL/ha Intervix® applied to canola. 60 mL/ha alpha-cypermethrin was applied during grain fill to control insect damage. No seed dressing fungicides were used at this site. 500 mL/ha carbendazim was applied to lentil and faba beans mid-August. Vetch brown manure plots were sprayed with 2 L/ha glyphosate in early October.

Faba bean (cv Bendoc) was sown at 30 plants/m^2, lentil (cv Hurricane XL) was sown at 120 plants/m^2, lupin (cv Wonga) was sown at 55 plants/m^2, vetch (cv Timok) was sown at 50 plants/m^2 and canola (cv Pioneer 44Y94CL) was sown at 45 plants/m^2.

Despite reasonably effective pre-emergent herbicides being applied, the site had some capeweed emerge in plots which may have influenced yield.

Inoculant trials

Inoculants used were in granular and peat form, both Tag Team® products. They were applied at x1 and x2 label rates. Label instructions for application were adhered to for both products. The peat inoculant was applied to seed day of sowing.

Trials were harvested on 17 November.

Pulse Legacy trial

This trial was sown 29 May, to determine the relative value of growing a range of pulse crops compared to canola. Each crop was managed as per best practice for that crop. All pulse crops were inoculated. Grain yields were collected with hand cuts, due to differences in maturity. This trial will be sown with wheat in 2022 to determine legacy effects.

Table 3. Emergence, nodulation, biomass (NDVI and cut) and grain yield of a granular and peat inoculant applied to Hurricane lentils in 2021.

Inoculant form	Time of sowing (TOS)	Label rate	Emergence 5 June (plants/m^2)	Nodulation 5 June	NDVI 5 June	Nodulation 8 Sept	Biomass 11 Oct (t/ha)	Grain yield (t/ha)
Granular	Dry	x1 rate	117	4.5	0.25	4.4	2.2	1.09
		x2 rate	109	4.4	0.26	4.6	2.85	1.05
	Wet	x1 rate	97	3.9	0.21	5.1	2.7	0.98
		x2 rate	105	4.1	0.21	4.7	2.28	1.14
Peat	Dry	x1 rate	113	3.8	0.25	4.1	1.97	0.66
		x2 rate	112	4.2	0.26	4.0	2.28	0.86
	Wet	x1 rate	116	3.6	0.23	4.2	2.55	0.69
		x2 rate	114	4.1	0.22	4.6	2.74	0.80
LSD (P=0.05)		*Rate*	*ns*	*ns*				*ns*
		Product						*0.22*
		TOS	*ns*					*ns*

Table 4. Emergence, nodulation, biomass (NDVI and cut) and grain yield of a granular and peat inoculant applied to Bendoc Faba Beans in 2021.

Inoculant form	Time of sowing (TOS)	Label rate	Emergence (pl/m²)	Nodulation 5 June	NDVI 5 June	Nodulation 8 Sept	Biomass 11 Oct (t/ha)	Grain yield (t/ha)
Granular	Dry	x1 rate	27	3.4	0.35	7.9	4.1	2.21
		x2 rate	30	3.3	0.32	7.8	4.7	2.01
	Wet	x1 rate	29	3.1	0.37	7.7	3.9	1.77
		x2 rate	34	3.4	0.34	7.7	5.0	1.94
Peat	Dry	x1 rate	28	1.7	0.28	7.0	4.4	1.50
		x2 rate	28	1.6	0.29	7.6	3.6	2.19
	Wet	x1 rate	24	1.0	0.29	7.6	4.8	2.12
		x2 rate	29	2.3	0.29	7.6	4.1	1.84
LSD (P=0.05)		*Rate*	*ns*	*ns*				*ns*
		Product						*ns*
		TOS	*ns*					*ns*

Table 5. rNod soil test of rhizobia numbers following 2021 trials at Yeltukka.

Sample	Rhizobia Group E & F kDNA copies/g sample
Bare soil	0
Bean wet sow	1044
Bean dry sow	82
Lentil wet sow	431
Lentil dry sow	550

**nb levels of around 1000 kDNA copies/g are considered adequate.*

Table 6. Biomass (October and harvest), grain yield and gross margin of the pulse and canola crops grown at Yeltukka in 2021.

Crop	October biomass (t/ha)	Harvest biomass (t/ha)	Grain yield (t/ha)	Variable** cost ($/ha)	Grain price **($/t)	Gross margin ($/ha)
Canola	7.14 cd	6.11 c	1.93 b	756	900	980
Faba Bean	2.41 ab	3.01 abc	1.80 b	504	550	484
Lentil	2.52 ab	2.68 a	1.53 b	461	1000	1073
Lupin	4.10 bc	4.32 abc	2.08 b	379	410	472
Vetch	3.90 ab	2.87 ab	1.24 b	361	700	509
VetchBM*	1.46 a	2.36 a	0.00 a	361	0	-361

**BM = brown manure.*
*** source: 2022 Farm Gross Margin and Enterprise Guide (PIRSA)*

What does this mean?

rNod soil testing of the site (to determine the levels of inoculant present) found no strains of the desired group E&F present (Table 5). Testing at the end of the season only found sufficient levels of inoculant present after growing faba beans sown in wet soil, but all other samples collected were lower than desired levels.

In the lentil inoculant trial, the granular inoculant was able to demonstrate a higher yield. There were no differences in rate applied or sowing time (either wet or dry). Nodulation scores of the lentil trial found nodules at a level considered adequate (but not ample) to meet the plant's needs. There were no differences in grain yield from the faba bean trial. Nodulation scores conducted on the faba bean trial found nodules at abundant levels.

While there was no background of the correct rhizobia strains at this site, both the lentil and faba bean trials were able to show there was no effect from applying higher than label rates and that seeding dry eight days before the break of the season did not affect yield or nodulation.

The legacy trial reinforced findings from the demonstration site that even relatively low lentil yields do have the ability to match canola in terms of gross margin. Raising both lentil yield and yield stability in these soil types, where they haven't been traditionally grown will be explored over the next few years.

Reference

Yates, R.J. Abaodoo, R and Howieson, J. (2016) Field experiments with rhizobia. Pages 145-156 in Working with Rhizobia, J Howieson and M. Dilworth, eds. Australian Centre for International Agricultural Research, Canberra.

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