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Faba beans on south-coast sandplain after soil amelioration – a case study

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KEY MESSAGES

- Soil amelioration, particularly liming with incorporation to depth, increases break crop options.
- Faba beans can be successfully grown on light soil types if pH is managed.
- Subsequent nitrogen fertiliser programs should take account of residual N to optimise the benefits of pulse crops.

Background

The need for a range of profitable break crop options has been identified as a regional priority in the Albany Port Zone. In many farming systems, canola is the main crop grown to provide a disease break (from cereals) and offer diversity in weed control options. There are additional benefits to growing legumes as break crops, however barriers to adoption remain. Low grain prices have pushed field peas and lupins out of many systems, however agronomy packages for the less familiar 'high-value' pulses such as faba beans, lentils and chickpeas are improving. These crops are potentially better suited to the high-rainfall zone due to their higher tolerance to waterlogging and cooler conditions. Case studies have been gathered to help us understand and share the experiences of early adopters of high-value pulse crops in the port zone.

The Goads have undertaken an impressive soil amelioration program in recent years to improve the productivity of their sandplain farm near Kojaneerup. By liming, deep ripping and claying they have improved surface and subsoil pH, reduced soil compaction, and increased soil water holding capacity. For the past three seasons the Goads have successfully grown faba beans (*Vicia faba*) on country not typically suited to high-value pulses. Josh says getting the pH right in the root zone is the top amelioration goal for growing faba beans.

Farm snapshot

Growers: Josh, Shannon and Tony Goad
Location: Kojaneerup
Farm size: 1 100 ha
Enterprise mix: 100% cropping, opportunistic stubble grazing.
Soil types: Pale deep sand, deep sandy duplex (sand over gravel, sand over clay)
GSR: 200-350mm (2019: 220mm)
Typical rotation: Canola, barley, faba beans, barley

This case study demonstrates that faba beans can serve as a much needed break crop in the dominant canola-barley rotation in this area. Appropriate soil amelioration, particularly liming with incorporation to depth, is a tactic to broaden profitable break crop options as well as improve long-term productivity in general.

Soil amelioration

Since the Goads destocked their farm nine years ago and legume pastures dropped out of the rotation, no crop legume has consistently stayed in their system. Recently, an intensive soil amelioration program has opened the door for faba beans. Josh prepares paddocks for beans by spreading 2t/ha local lime, deep ripping with inclusion plates to incorporate, and spreading another 2t/ha lime on top. He has also clayed very light areas at 250t/ha, which is a one-off investment with long-term benefits and costs approximately $600/ha upfront.

With this program the soil pH($CaCl_2$) has increased to levels suitable for faba bean production. Surface acidity was measured prior to liming in April 2019, then a few months after at June, pH was assessed at 5cm depth increments down to 30cm. Surface pH increased during this time from between 4.7 and 4.9 to between 5.4 and 6.2. At depth pH was between 5.2 and 6 after liming (Fig. 1). Soil pH measured again in January 2020 and had further increased to between 5.6 and 6.2 (Fig. 1).

The iLime app, developed by DPIRD and the GRDC, was used to assess the rate of soil acidification on these paddocks and therefore the lime required in future to maintain pH level. With customised soil type, rainfall, rotations and yields, the app estimates annual soil acidification at a rate of 100kg/ha/year calcium carbonate equivalent. Under Josh's liming strategy the app suggests the surface pH will hover just under pH 5.5 until year ten when pH starts to decline steadily. As such, we have calculated an annual discounted cost of liming over ten years, and suggest re-liming at ten years.

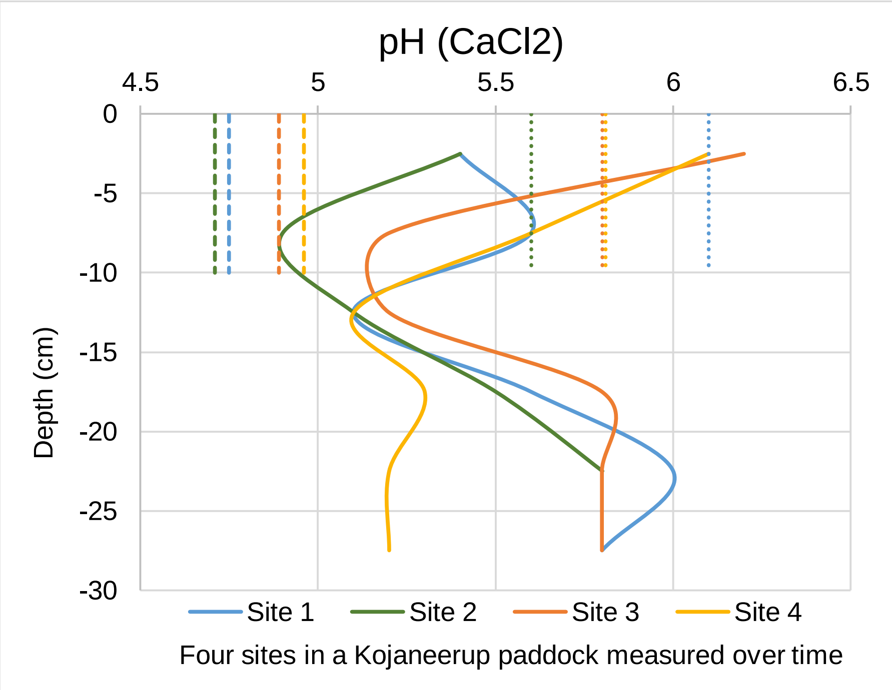

Figure 1. Soil pH($CaCl_2$) measured at four sites in a Kojaneerup paddock before and after liming (4t/ha). Dashed lines show surface pH in April 2019 prior to liming. Solid lines show pH in June after liming and incorporation by deep ripping to 500mm (samples at 5cm depth increments). Dotted lines show surface pH in Jan 2020.

Agronomy

Seeding

In 2019 the Goads trialled two varieties in a 70ha paddock; PBA Samira, and the new higher yielding variety PBA Marne. From previous years' trial and error the Goads decided to use a single chute boot rather than the twin boot that they use for the rest of their program. They have also increased the air hose diameter to 1.25 inches. Beans are inoculated with 10kg/ha Alosca granules and sown 50mm deep at 160kg/ha on 25cm row spacings. They tried peat inoculum in 2017 but found it inefficient and not particularly effective in that season, so opted for the simpler granular option which fits into their dry seeding operation easily. Josh also aims to increase seeding rate to 200kg/ha in future to improve plant establishment.

Nitrogen fixation

Nodulation was scored on multiple plants at four sites in the paddock (Fig. 2) on a scale from 0 (nodules absent) to 8 (extremely abundant). Nodulation ranged from 1 (rare) to 5 (ample), and the average score was 3-4 (moderate to adequate). In terms of nutrition, the paddock received 120kg/ha K Till compound fertiliser drilled in the seed row (approximate 11.5kg/ha N, 11.3kg/ha P, 18kg/ha K, 7.8kg/haS). Soil mineral N levels are shown in Table 1, estimated at between 15 and 24 kg/ha as at January 2020. N mineralisation has been very limited due to no rainfall since November 1, 2019, but mineralisation from crop residues will occur throughout the growing season gradually becoming available to plants.

Figure 2. Nodulation scoring faba beans six weeks after sowing (average growth stage 35).

Table 1. Topsoil nitrogen (N) levels following 2019 faba bean crop, sampled Jan 2020 (low mineralisation)

Paddock location	Ammonium N (mg/kg)	Nitrate N (mg/kg)	Total mineral N*(kg/ha)
Site 1	3	7	15
Site 2	4	9	19.5
Site 3	5	9	21
Site 4	4	12	24

*Estimated Mineral N (kg/ha) = [Ammonium N(mg/kg) + Nitrate N(mg/kg)] x 1.5

Crop protection

A major challenge the Goads have identified is broadleaf weed control, particularly wild radish. Josh notes that there are not many in-season broadleaf control options for beans. They have tried Raptor, and hope crop topping prevents any remaining seed set, however radish was already setting seed before the crop was ready. Next season Josh wants to try Ecopar (pyraflufen-ethyl).

Although disease pressure in 2019 was relatively low, Josh sprayed with Mancozeb and Veritas. He also sprayed twice to keep budworm under control.

Harvest

The 2018 bean crop yielded on average 2t/ha across the paddock, but Josh estimates 200-300kg/ha was left behind in pods that were too low to pick up. The price at that time was very high and Josh sold his for $850/t. Despite the frosts and dry finish in 2019 the beans yielded an impressive 2.4t/ha on average across the paddock. Although prices are more subdued than this time last year Josh managed to sell them at $530/t. Price volatility remains a concern for faba bean growers.

While the Goads have some on-farm storage capacity, maintaining cash flow is a high priority. Due to the lack of a container market at Albany Port, the beans are trucked and exported from Fremantle.

Nitrogen contribution to following crops

Barley (Planet) sown in 2019 on bean stubble was monitored to evaluate N contribution. Canola (Bonito) had been grown adjacent to the beans in 2018, so barley grown into this canola stubble was used as a baseline to compare N contributions. Josh observed that the barley crop following beans grew better biomass earlier in the season compared to barley growing adjacent on canola stubble. Harvest cuts were taken from nine paired sample points by cutting all heads along 1m from four rows. Sampling locations were at least 50m apart, while the paired points (adjacent bean stubble and canola stubble) were approximately 4m apart. Yield estimates were calculated and grain protein was analysed (Table 2). Yield maps were also examined.

With a very dry September and October (except the first weekend) grain fill occurred under frost stress and with terminal drought. With the available data it is difficult to know how the plants partitioned biomass and nitrogen. In future, biomass should be studied prior to anthesis and components of yield need to be analysed, such as harvest index, tiller number, spikelets per head, grains per spikelet, grain weight and screenings. Josh observed that the barley on bean stubble grew more biomass earlier in the season. Early vegetative growth in response to higher N availability would have extracted soil moisture accordingly leading to a soil water deficit earlier in the grain fill period (van Herwaarden et al., 1998). The result of this may have been smaller grain size as well as higher protein concentration, however this is unconfirmed without screenings information. Based on low soil mineral N levels at harvest and the hard finish, it is unlikely that the extra N contribution from faba bean stubble could be translated into more yield in this scenario.

From the harvest cuts the average barley yield following both break crops was 6.33t/ha. Speaking to Josh, the whole paddock average was about 5.5t/ha. Contrary to expectations, barley following canola yielded significantly higher (6.91t/ha) than barley following faba beans (5.81t/ha) (Table 2). However, the difference in overall 'protein yield' (yield x % protein) was not statistically significant.

Most of the paddock met malt grades, and was likely a result of the tight finish which limited grain fill and increased protein concentration in the grain. The areas of the paddock that did not meet malt grades overshot the maximum protein level of 12% and thus were downgraded to feed. These areas were planted to beans in 2018 and protein levels ranged from 11-13.5%, averaging 11.9% (Table 2). Conversely barley following canola had significantly lower average protein levels of 10.8% (Table 2).

Table 2. Planet barley average yield estimates and protein levels from harvest cuts. ANOVA was conducted accounting for sample location. Different letters indicate significance ($\alpha = 0.05$).

Break crop	Barley yield (t/ha)		Barley protein (%)		Protein yield (kg/ha)	
Faba bean	5.81	*a*	11.90	*a*	683	*a*
Canola	6.91	*b*	10.75	*b*	742	*a*
Site average	6.33		11.36		711	
p-value	0.016		0.004		0.130	
LSD	0.827		0.654		81.30	

Select Your Nitrogen model

The Select Your Nitrogen (SYN) model (Diggle et al., 2003) was designed to help growers make N fertiliser decisions by quantifying N availability from legume crops and pastures in previous seasons, soil organic matter, and soil characteristics. SYN estimates the same amount of N fixation from all types of legumes and pastures, accounting for yield and harvest index. However we know that some legumes, like faba beans, fix N more efficiently than others due mainly to their larger biomass.

SYN was developed in 2003 with legume crops like lupins and field peas in mind, as faba beans were not grown widely in WA at the time. With this in mind, a scenario was run in which a legume with a very low harvest index (large biomass) yielded 2.4t/ha grain, leaving behind 114kg/ha of organic nitrogen in crop residue, of which 36%, or 41kg/ha, would be available to a crop in the following growing season under average conditions. Research from NSW DPI (unpublished data of W. Felton, H. Marcellos, D. Herridge, G. Schwenke and M. Peoples) has shown that N fixation in faba bean is closely related to shoot dry matter (DM) whereby for each additional tonne of shoot DM produced, the crop fixes 19.3kg/ha N (r^2 = 0.71). Another study in Victoria developed a similar response curve such that 19.5-20.5 kg/ha N was fixed from each tonne of shoot DM (Denton et al., 2013). Another response curve was developed from a large dataset from around Australia whereby 23kg/ha N was fixed from each tonne of shoot DM (r^2 = 0.67) (Unkovich et al., 2010). These suggest a 7t/ha shoot DM faba bean crop could fix over 140kg/ha N. If SYN estimates 36% of total fixed N is available for the following crop in the first year, this equates to 50kg/ha available N.

Challenges

The main challenge that the Goads are still tweaking in their system is the seeding operation and inoculation process. This season the use of Alosca and single shoot boots improved seeding efficiency, but Josh and Tony acknowledge further refinement is required. Another consideration at seeding is minimising seed damage when transferring seed. For example they favour the use of a grain elevator rather than augers. Josh recalls that the peat inoculation process also caused some seed damage during the mechanical seed coating process, contributing to their decision to use granules.

Other challenges have been broadleaf weed control and crop residue management. Josh and Tony explain that the crop residue left after harvest is quite 'viney'. After the 2018 harvest they decided to do some burning in order to seed barley through it, but this year Josh plans to chop it with a disc implement and reduce the need to burn.

Opportunities

In recent years the Goads have capitalised on upside risk with favourable faba bean prices. Beans supply N to the following crop through the breakdown of nodules and crop residues. In 2019 the amount of N available to barley through bean residues as well as top-up N proved ultimately detrimental. In future, matching fertiliser N inputs to cereal crop requirements following beans will save money and inputs.

The current plan is to grow RR canola on bean stubble in 2020 to clean up the paddock and further assess nitrogen benefits. One reservation about this sequence is that Sclerotinia is common to beans and canola, which increases the risk of Sclerotinia developing in that paddock.

Economic analysis

Gross margins (GM) (Appendix 1 and 2) were constructed from the Goad's variable costs. A standard high rainfall zone (HRZ) (>400mm annual rainfall) OP canola GM was also constructed as a benchmark against the variable costs of faba bean production. For the sake of comparison, all GMs include the cost of liming and deep ripping actualised over ten years (the estimated time frame required before maintenance liming). GMs are summarised in Table 3 by gross income and main variable cost categories.

The faba bean GM (Appendix 1) presents two scenarios; the 2019 paddock actuals, and a generalised HRZ scenario based on data in the 'Farm gross margin and enterprise planning guide' (Rural Solutions SA, 2019). Both are calculated based on 2.4t/ha average yield and FIS price in Fremantle of $530/t. This produces gross income of $1272/ha. The canola GM (Appendix 2) is calculated based on 2t/ha average yield at the same price, $530/t, which generates gross income of $1060/ha. Variable cost breakdowns are summarised in Table 3. Under these scenarios, faba beans have slightly lower variable costs and overall have higher gross margins by $240/ha to $250/ha.

Table 3. Enterprise gross margin summaries for faba bean and canola. Goad 2019 represents farm actuals, while Standard HRZ (high rainfall zone; >400mm annual) represent generalised costs.

		Faba bean		Canola
		Goad 2019	Standard HRZ	Standard HRZ
Yield	t/ha	2.4	2.4	2.0
Price	$/t	$ 530	$ 530	$ 530
Gross income	**$/ha**	**$ 1272**	**$ 1272**	**$ 1060**
Freight and selling	$/ha	$ 130	$ 106	$ 71
Seed and fertiliser	$/ha	$ 222	$ 180	$ 227
Crop protection	$/ha	$ 151	$ 181	$ 170
Soil amelioration annualised cost	$/ha	$ 22	$ 22	$ 22
Operations and insurance	$/ha	$ 83	$ 108	$ 146
Total variable costs	**$/ha**	**$ 608**	**$ 598**	**$ 636**
GROSS MARGIN	**$/ha**	**$ 664**	**$ 674**	**$ 424**

The sensitivity of GM to changes in yield and price is shown in Table 4, based on variable costs being held constant at $608/t. If yields are maintained at just over 2t/ha, the bean price needed to 'break even' is $300/t. Therefore, favourable prices in recent years have made faba beans a very profitable break crop. If the price sits around the median of $500/t, the minimum yield required to cover variable costs (including freight to Fremantle port) is 1.22t/ha.

Table 4. Sensitivity of faba bean gross margin ($/ha) to variations in yield and price, based on a variable cost of $608/ha. Shaded area indicates the location of 2019 actuals.

	Faba bean price ($/t)					
Yield (t/ha)	**$300**	**$400**	**$500**	**$600**	**$700**	**$800**
0.6	-$428	-$368	-$308	-$248	-$188	-$128
0.8	-$368	-$288	-$208	-$128	-$48	$32
1.0	-$308	-$208	-$108	-$8	$92	$192
1.2	-$248	-$128	-$8	$112	$232	$352
1.4	-$188	-$48	$92	$232	$372	$512
1.6	-$128	$32	$192	$352	$512	$672
1.8	-$68	$112	$292	$472	$652	$832
2.0	-$8	$192	$392	$592	$792	$992
2.2	$52	$272	$492	$712	$932	$1,152
2.4	$112	$352	$592	$832	$1,072	$1,312
2.6	$172	$432	$692	$952	$1,212	$1,472
2.8	$232	$512	$792	$1,072	$1,352	$1,632
3.0	$292	$592	$892	$1,192	$1,492	$1,792

Conclusions

Faba beans have been grown successfully on deep sand, country not typically suited to high-value pulses. This case study demonstrates that with appropriate soil amelioration, faba beans can serve as a much needed break crop in the dominant canola-barley rotation in this area. While price volatility remains a concern for pulse growers, gross margin analysis shows that faba beans can be profitable in their own right, as well as increasing the profitability of the rotation.

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