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2019
Annual Results Report
"Legumes for Profitability in the Esperance Port Zone"

Project code:	9176167
Prepared by:	Michelle Handley (Researcher) michelle@sepwa.org.au South East Premium Wheat Growers Association Michelle Handley (Administrator) michelle@sepwa.org.au
Date submitted to GRDC:	7th May 2019

REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	NO	
Results are incomplete	YES (in that this is year 1 of a 3 year project)	
Commercial/IP concerns	NO	
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KEY MESSAGES

- While growing season conditions were dry and grain yields were low and therefore not profitable, both Bolt lentils and Gunyah field peas yielded highest of the 5 break crop species grown at the Salmon Gums demonstration site. Soil boron levels were relatively high at this site.
- Following waterlogged conditions in August, Bonito canola out yielded the 4 four legume break crop species grown at the Gibson demonstration site, with Samira faba beans a close second.
- The addition of an extra 72 Units of nitrogen (171L Flexi-N delivered in 3 incremental applications) to the 5 break crops at the Gibson demonstration site resulted in significant increases in yield and earnings before tax profit in both Bonito canola and Samira faba beans but made little difference to the performance of PBA Strikers chickpeas, Morava vetch and Jurien lupins. The addition of extra nitrogen to Faba beans lifted yield by an average of 0.763t/ha taking it to 2.473t/ha which was close to the average yield of un-topped-up canola (2.169t/ha).
- In terms of earnings before tax, the faba bean crop was the most profitable of the 5 break crops grown at Gibson. It is important to note though that the $800/tonne price seen for faba beans in February 2018 was well above both the five and ten year average for this crop.

SUMMARY

This project set out to contribute to an understanding of legume agronomic and financial management in the Esperance Port Zone in an effort to support the decision-making process undertaken by growers in deciding the best crop sequence for their farms, including which break crop best suits their needs.

The project established 3 demonstration sites at locations that experience different soil and climatic conditions, one at Ravensthorpe, one at Salmon Gums and another at Gibson. Agronomic management and associated costings were tracked for a range of legume species and canola at each site through the growing season to harvest.

The crops at the Ravensthorpe location failed due to insufficient rain. At Salmon Gums, while conditions were dry and grain yields were low and therefore not profitable, both Bolt lentils and Gunyah field peas yielded highest of the 5 break crop species grown. Following waterlogged conditions in August, Bonito canola outyielded the 4 four legume break crop species grown at the Gibson demonstration site, with Samira faba beans a close second.

The addition of an extra 72 Units of nitrogen (170L Flexi-N delivered in 3 incremental applications) to the 5 break crops at the Gibson demonstration site resulted in significant increases in yield and earnings before tax profit in both Bonito canola and Samira faba beans but made little difference to the performance of PBA Strikers chickpeas, Morava vetch and Jurien lupins, which were heavily impacted by waterlogging. The addition of extra nitrogen to Faba beans lifted yield by an average of 0.763t/ha taking it to 2.473t/ha which was close to the average yield of un-topped-up canola (2.169t/ha).

In terms of earnings before tax the faba bean crop was the most profitable of the 5 break crops grown at Gibson. It is important to note though that the $800/tonne price seen for faba beans in February 2018 was well above both the five and ten year average for this crop. It is more realistic to work on a faba bean price in the $320-$380/tonne and to remember the price has been lower still at times.

1.0 BACKGROUND

The benefits of break crops to the following year's cereal or canola crops have been studied and reviewed extensively since the 1990's. Results from GRDC's Crop Sequence project demonstrated that canola and legume break crops can frequently be as profitable, and in some instances more profitable, than wheat. Canola was consistently the most profitable break crop in this project, but the role of legumes in providing rotational benefits for subsequent crops by increasing soil N supply was also evident.

Break crops form an important part of cropping systems in the Esperance Port Zone (EPZ). Many growers include canola in their crop sequence and renewed interest has been shown in legumes to complement canola and cereals in the rotation. There have been a range of reasons for this interest.

For example, the latest lentil varieties appear to provide good yield potential and high prices seen in the lentil market and successes experienced in South Australia have caught the attention of local growers. There are however, a number of lentil agronomy questions that require attention as experience in growing, harvesting and storing them in the EPZ is not extensive.

Faba beans are another legume option for the EPZ, one that has consistently produced good yields in the region for a number of years. Further, currently available varieties have useful levels of disease resistance. An increase in the uptake of faba beans is reliant, though, on early sowing opportunities, improved price signals and increased seed availability in WA.

Nonetheless, there are still areas of the EPZ which are searching for a profitable legume for their farming system and there is also a need for better pulse market development in the EPZ. It can be difficult to sell legumes and transport costs can take the shine off their higher commodity prices and soil health benefits.

With further breeding, agronomic research and extension to spread the learnings on how to maximise production there is the opportunity for more legumes to be grown in the region. With increased production comes the potential for more marketing power.

2.0 OBJECTIVES

This project aims to:

1. Contribute to the agronomic understanding of best practice pulse agronomy in the EPZ.

2. Contribute to the financial decision-making process undertaken by growers in deciding the best crop sequence for their farms, including which break crop is the best option to suit their needs.

3.0 METHODS

Three demonstration sites were established in autumn 2018 in the Esperance Port Zone on varying soil types and in varying rainfall zones. Four randomised replicates of 5 break crop species treatment plots (canola, vetch, chickpeas, faba beans and lupins), 6m in width and 240m long, were sown at the Gibson demonstration site. Three randomised replicates of 5 break crop treatment plots (canola, vetch, lentils, field peas and faba beans), 36m in width and 275m long, were sown at the Salmon Gums site. At the Ravensthorpe site 3 replicates of 4 break crop treatment plots (faba beans, field

peas, lentils and canola), 36m in width and 120m long, were sown. In the second year a cereal crop will be grown at each demonstration site, in each of the treatment plots.

Prior to seeding soil coring was undertaken at each site, to 1m depth. Subsamples were taken and comprehensively analysed from 0-10cm and subsequent depth increments determined by soil horizon changes.

In crop agronomic management was implemented by the site host, at their expense, in accordance with their usual farm practice under the advice of their agronomist. Knock-down weed control was implemented prior to seeding. Subsequent herbicide treatments were applied depending on the weed burden present during the growing season and the likely return on investment. Fertiliser was applied at seeding with top-ups applied as required and if the host grower determined it was cost effective to do so. An N rich treatment (N+) was applied to treatment plots at the Gibson demonstration site which resulted in the addition of an extra 171L/ha of Flexi-N being applied to these areas in 3 cumulative applications.

At harvest, grain yield was measured using a weigh trailer.

The costs associated with production of each crop at each site and financial return were incorporated into an analysis of the economic profitability of each species undertaken by Farmanco.

Learning from each site was extended to all growers in the Esperance Port Zone and each site involved collaboration with host growers and a range of project partners including RAIN, North Mallee Farm Improvement Group, Farm and General, Landmark, DPIRD and Farmanco. Communication and extension actions undertaken by the project are listed in Appendix 1.

4.0 LOCATION

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1 - Gibson	-33.60324	121.79034
Nearest Town	Gibson	
Trial Site #2 – Salmon Gums	-33.81125	121.59662
Nearest Town	Salmon Gums	
Trial Site #3 - Ravensthorpe	-33.633023°	120.287159°
Nearest Town	Ravensthorpe	

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or GRDC Agro-Ecological Zone/s please indicate which in the table below:

Research	Benefiting GRDC Region (can select up to three regions)	Benefiting GRDC Agro-Ecological Zone (see link: http://www.grdc.com.au/About-Us/GRDC-Agroecological-Zones) for guidance about AE-Zone locations	
Experiment Title	Western Region	☐ Qld Central	☐ NSW Central

	Choose an item. Choose an item.	☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☐ WA Eastern ☒ WA Mallee	☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☒ WA Sandplain

5.0 RESULTS

5.1 Ravensthorpe Demonstration Site

5.1.1 Soil Type

Figure 1: Red loam over clay soils prevail at the Ravensthorpe demonstration site.

Soil at this demonstration site was alkaline throughout the depth profile and conductivity, boron and exchangeable sodium percentage increased with depth (Table 1). These values indicate that soil at this site below the surface 40cm is within the range research suggests may be unsuitable for legume crops.

Table 1: Pre-crop soil analysis at the Ravensthorpe demonstration site.

Parameter	Unit	Depth		
		0-10cm	10-40cm	40-80cm
Colour		GRBR	BRWH	BRWH
Gravel	%	0	0	0
Texture		3	3	3
Ammonium Nitrogen	mg/kg	<1	<1	<1
Nitrate Nitrogen	mg/kg	14	3	1
Phosphorus Colwell	mg/kg	27	4	<2
Potassium Colwell	mg/kg	662	293	346
Sulfur	mg/kg	4	7.3	34.7
Organic Carbon	%	1.52	0.4	0.26
Conductivity	dS/m	0.178	0.392	0.55
pH Level (CaCl2)		7.8	8.6	8.9
pH Level (H2O)		8.7	9.9	10.1
DTPA Copper	mg/kg	1.63	2.89	1.47
DTPA Iron	mg/kg	20.72	15.65	12.84

DTPA Manganese	mg/kg	3.35	1.29	0.54
DTPA Zinc	mg/kg	0.66	0.13	0.12
Exc. Aluminium	meq/100g	0.029	0.027	0.027
Exc. Calcium	meq/100g	20.1	6.93	2.1
Exc. Magnesium	meq/100g	9.7	8.24	8.05
Exc. Potassium	meq/100g	2.08	0.92	0.99
Exc. Sodium	meq/100g	1.4	5.77	9.09
Aluminium CaCl2	mg/kg	<0.20	N/A	N/A
Boron Hot CaCl2	mg/kg	3.69	17.18	27.78

5.1.2 Seasonal Conditions

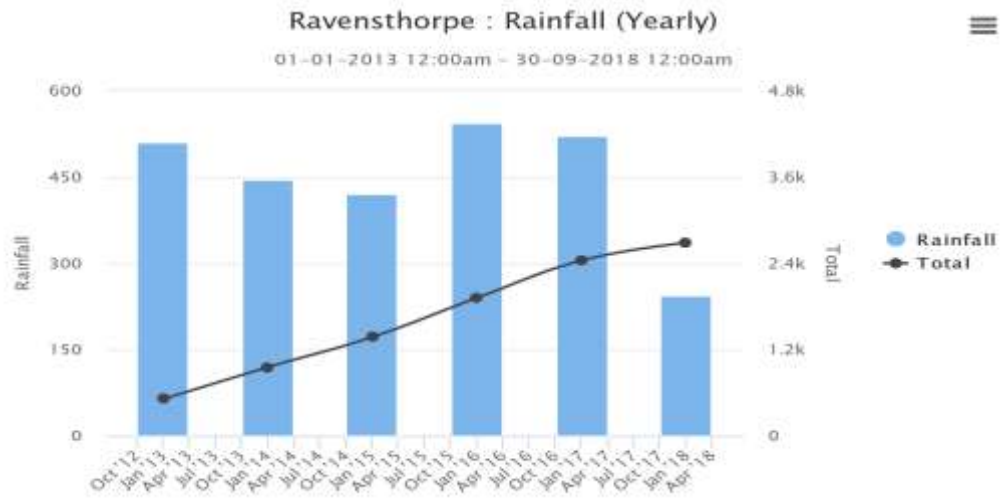

Figure 2: Monthly rainfall for Ravensthorpe, January 2013 to September 2018.

Growing season rainfall received in Ravensthorpe for the April to September period in 2018 was 120.6mm compared to 180mm in 2017 (Figure 2). In addition to receiving less rain during the growing season, 2018 also saw less summer rain received than in 2017 resulting in less subsurface moisture available prior to seeding. Rainfall for the January to September period in 2018 was 197.2mm compared to 471.8mm in 2017.

5.1.3 Growing Season Data

Due to the below average rainfall received in 2018 in the Ravensthorpe area the legume crops, seeded on 24th April 2018, at this demonstration site failed. Germination was not sufficient to make any of the legume species or canola plots feasible to harvest (see Figure 3).

Figure 3: Ravensthorpe Legume Demonstration site, 21/8/18.

5.2 Salmon Gums Demonstration Site

5.2.1 Soil Type

Figure 4: Neutral to alkaline loamy clay over clay soils prevail at the Salmon Gums site.

Soil at this demonstration site was similar to that found at the Ravensthorpe demonstration site in terms of its chemistry. The soil was alkaline throughout the depth profile and conductivity, boron and exchangeable sodium percentage increased with depth (Table 2).

The increase in boron from 5mg/kg at the surface to 48mg/kg at 30cm depth suggests that boron would be likely to restrict root growth of all crop types below 30cm. The conductivity, boron and exchangeable sodium percentage values recorded below 30cm depth indicate that soil at this site is within the range research suggests may be unsuitable for legume crops. Research also suggests this soil type is likely to be responsive to the application of gypsum although it may be difficult to incorporate the ameliorant to the required depth.

Table 2: Pre-crop soil analysis at the Salmon Gums demonstration site.

Parameter	Unit	Depth		
		0-10cm	10-30cm	30-70cm
Gravel	%	0	0	0
Texture		3	1	3
Ammonium Nitrogen	mg/kg	<1	<1	<1
Nitrate Nitrogen	mg/kg	14	2	<1
Phosphorus Colwell	mg/kg	41	5	2
Potassium Colwell	mg/kg	556	359	500
Sulfur	mg/kg	4.2	3.9	25.6
Organic Carbon	%	1.16	0.45	0.28
Conductivity	dS/m	0.152	0.249	0.505
pH Level (CaCl2)		7.7	8.1	8.5
pH Level (H2O)		8.6	9.3	9.7
DTPA Copper	mg/kg	0.9	2.59	3.11
DTPA Iron	mg/kg	14.66	26.04	14.09
DTPA Manganese	mg/kg	1.74	2.39	1.22
DTPA Zinc	mg/kg	0.89	0.14	0.22
Exc. Aluminium	meq/100g	0.063	0.082	0.064
Exc. Calcium	meq/100g	14.96	12.43	7.55
Exc. Magnesium	meq/100g	5.36	9.92	8.42
Exc. Potassium	meq/100g	1.59	1.12	1.41
Exc. Sodium	meq/100g	1.42	4.16	8.38
Aluminium CaCl2	mg/kg	<0.2	N/A	N/A
Boron Hot CaCl2	mg/kg	4.85	15.97	47.65

5.2.2 Seasonal Conditions

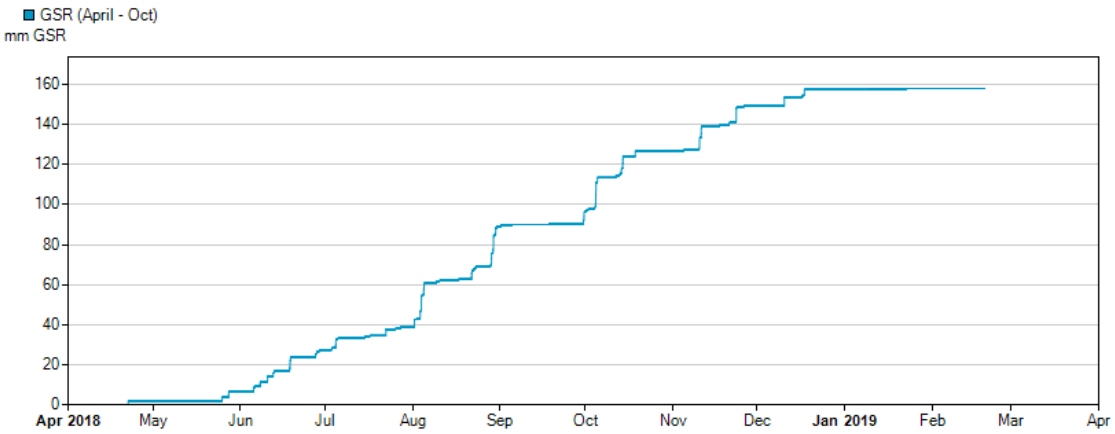

Figure 5: CSIRO Northern Mallee Rainfall, April 2018 – March 2019.

Growing season conditions at the Salmon Gums demonstration site were not ideal. Rainfall between seeding on the 8th May and early September was 90mm which is likely to have affected flowering (Figure 5). Another 25mm fell in October which resulted in re-flowering of the legume species, especially the Faba beans. Two frost events were experienced in August when the crops were at early flowering and 4 frost events occurred in September during pod set.

5.2.3 Growing Season Data

While the crops were seeded on 8th May 2018 they geminated following a 6mm rain event in June, effectively giving a growing window of 4.5 months and growing season rainfall of 115mm.

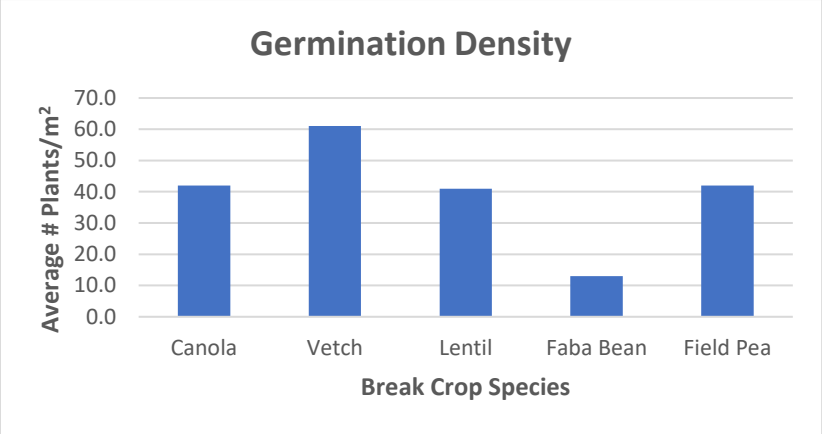

Figure 6: Break crop species germination density, Salmon Gums,11/7/18.

Germination was satisfactory given the dry conditions present at seeding. Vetch numbers were higher than ideal given the seeding rate targeted was 25kg/ha (Figure 6). This was also the case in the canola treatment strips, 20-25 plants per m^2 would have been ideal. The germination density achieved by 11th July for the lentils, field peas and faba beans were appropriate to Salmon Gums' low rainfall environment.

The presence and percentage cover of broadleaf weeds was low in all break crop species strips at this demonstration site throughout the growing season. The data presented in Figure 7 illustrates the total weed burden before harvest. Numbers of weeds were low and the small size of plants present indicate they had germinated following 25mm rainfall in October. The canola strips were the most weed free.

While average broadleaf weed numbers are presented in Figure 7 it was notable that one replicate of the three faba bean replicates included in the demonstration had higher weed numbers than the other two. It is possible that the boomspray ran out of Terbyne® herbicide on the last pass of the paddock and hence this strip missed application as good weed control was achieved in all other strips.

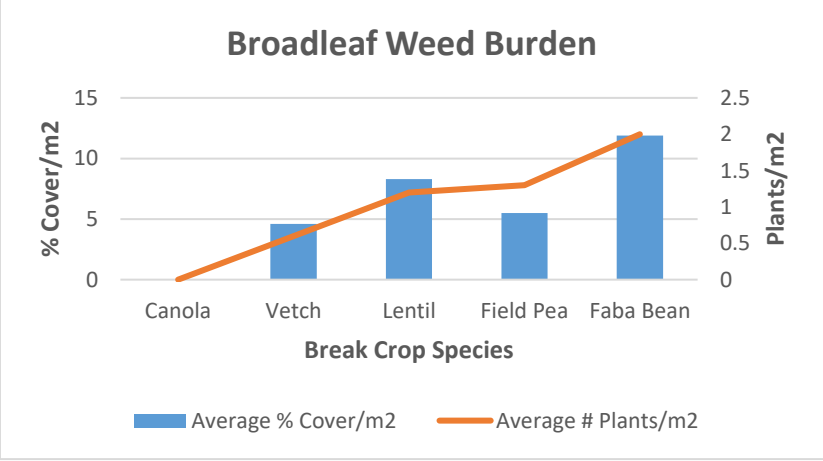

Figure 7: Broadleaf weed burden per break crop species, Salmon Gums, 5/11/18.

5.2.4 Harvest Yield

The average field pea yield was the highest of the 5 break crop species grown at the Salmon Gums demonstration site but this was not significantly different from the average lentil yield achieved (Figure 8). Bonito canola, Barloo vetch and Samira faba bean yields were almost half that of the Gunyah field peas and Bolt lentils and they were not significantly different from each other (Table 3). The maximum yield achieved was 0.287t/ha in one of the field pea replicates while the lowest yield achieved was 0.079t/ha in one of the canola replicates.

Table 3: 2018 break crop species average harvest yields, Salmon Gums.

Species	Av. Yield (t/ha)	% of Field Pea
Canola	0.098	39%
Vetch	0.127	50%
Faba Bean	0.133	52%
Lentil	0.237	93%
Field Pea	**0.254**	**100%**

All of the legume species were hard to harvest. Plant height was short making it difficult for the harvester cutter bar to get under pods that were set low on the plants. Vetch was the most problematic, followed by lentils, then beans and lastly field peas. Estimates made during harvest put yield left behind in the lentils at approximately 25%.

While yields were low following relatively dry growing conditions the results recorded at this demonstration site indicate that, of the break crop species grown, both lentils and field peas may offer a break crop option of merit for this area. It would be beneficial to see if the soil boron and exchangeable sodium levels below 30cm soil depth impede yield in another season when rainfall was sufficient to support more vigorous crop growth. Past experience indicates that an additional 30mm of rainfall during June to October could increase yield considerably as well as making the crops taller and therefore easier to harvest.

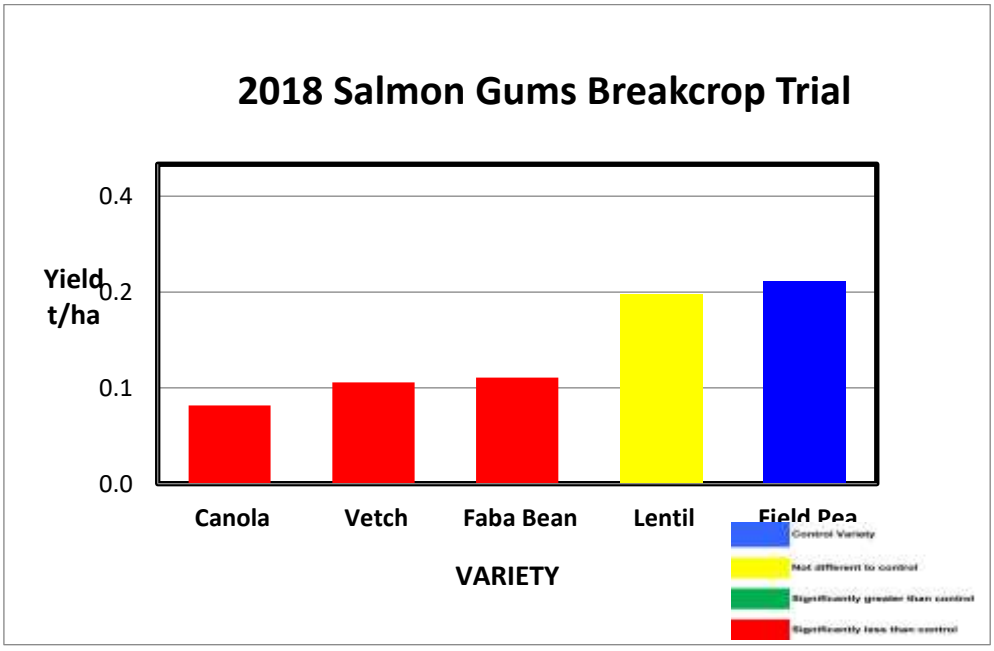

Figure 8: Relative average break crop species 2018 grain yields, Salmon Gums. Least significant difference (5%) = 0.06212 t/ha, p <0.001.

5.2.5 Economic Analysis

None of the break crop species grown at the Salmon Gums demonstration site were profitable (Table 4). The Lentil and field pea crops, which yielded highest at the site, incurred the lowest per hectare losses (-$187 and -$183 respectively) followed by vetch (-$230), then faba beans (-$244) then canola (-$326).

Table 4: Salmon Gums Demonstration Site Earnings Before Tax (EBT) Analysis following 2018 winter cropping season (prepared by Farmanco).

Crop Enterprise		Lentil	Canola	Field Peas	Faba	Vetch
Yield	t/ha	0.24	0.10	0.25	0.13	0.13
Average Grain Price (FIS)	$/t	$500	$592	$600	$800	$500
Total Income	$	$119	$58	$152	$106	$64
Income	**$/ha**	**$119**	**$58**	**$152**	**$106**	**$64**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$26	$1	$55	$73	$16
Grain Freight (Up Country)		$2	$1	$3	$1	$1
Grain Handling Charges		$3	$1	$3	$2	$2
Crop Contract		$21	$21	$21	$21	$21
Other Crop Costs & Crop Ins		$15	$15	$15	$15	$15
Wages Gross		$15	$15	$15	$15	$15
R&M Mach./Plant/Vehicle		$32	$32	$32	$32	$32
Fuel & Oil		$22	$22	$22	$22	$22
Fertiliser, Lime & Gypsum		$0	$77	$0	$0	$0
Pesticide		$73	$101	$73	$73	$73
Variable Operating Costs	$	$209	$287	$238	$254	$196
Variable Operating Costs	**$/ha**	**$209**	**$287**	**$238**	**$254**	**$196**
Operating Gross Margin	$	($90)	($229)	($86)	($147)	($133)
Operating Gross Margin	**$/ha**	**($90)**	**($229)**	**($86)**	**($147)**	**($133)**
Fixed Operating Costs	$	$73	$73	$73	$73	$73
Fixed Operating Costs	**$/ha**	**$73**	**$73**	**$73**	**$73**	**$73**
Total Operating Costs	$	$282	$360	$311	$327	$269
Total Operating Costs	**$/ha**	**$282**	**$360**	**$311**	**$327**	**$269**
Operating Profit (BIT)	$	($163)	($302)	($159)	($220)	($206)
Operating Profit (BIT)	**$/ha**	**($163)**	**($302)**	**($159)**	**($220)**	**($206)**
Finance Costs	$	$24	$24	$24	$24	$24
Earnings Before Tax (EBT)	**$**	**($187)**	**($326)**	**($183)**	**($244)**	**($230)**
Earnings Before Tax (EBT)	**$/ha**	**($187)**	**($326)**	**($183)**	**($244)**	**($230)**

5.3 Esperance Downs Research Station (EDRS) Demonstration Site

5.3.1 Soil Type

Figure 9: Acidic sand over gravelly sand soils prevail at the Gibson demonstration site.

Soil at the Gibson demonstration site was acidic (4.6-5.5) at 0 to 30cm depth indicating that acidity may constrain legume crop growth and nodulation at this site. From 30cm depth pH was close to neutral to 1m depth (Table 5).

Cation exchange capacity, which influences nutrient and water holding capacity, was low in the top 30cm soil layer meaning nutrients are more likely to leach down the profile. Potassium levels were relatively low in the 10-30cm layer.

Table 5: Pre-crop soil analysis at the Gibson demonstration site.

Parameter	Unit	Depth			
		0-10cm	10-30cm	30-70cm	70-100cm
Colour		GR	LTGR	LTGR	BRYW
Gravel	%	0	5	0	0
Texture		1	1	3	3
Ammonium Nitrogen	mg/kg	1	<1	<1	<1
Nitrate Nitrogen	mg/kg	31	2	4	5
Phosphorus Colwell	mg/kg	30	27	<2	<2
Potassium Colwell	mg/kg	72	40	223	248
Sulfur	mg/kg	4.6	4	58.3	82.3
Organic Carbon	%	1.14	0.42	0.23	0.12
Conductivity	dS/m	0.1	0.061	0.23	0.277
pH Level (CaCl2)		4.6	5.5	6.3	6.6
pH Level (H2O)		5.4	6.3	7.1	7.4
DTPA Copper	mg/kg	0.52	0.26	0.09	0.12
DTPA Iron	mg/kg	81.11	40.77	14.13	17.61
DTPA Manganese	mg/kg	1	0.28	0.38	0.7
DTPA Zinc	mg/kg	1.11	0.21	0.07	0.09
Exc. Aluminium	meq/100g	0.117	0.08	0.18	0.238
Exc. Calcium	meq/100g	2.48	0.9	1.93	2.49
Exc. Magnesium	meq/100g	0.42	0.32	2.52	2.87
Exc. Potassium	meq/100g	0.15	0.11	0.51	0.65
Exc. Sodium	meq/100g	0.11	0.21	1.45	2.12
Aluminium CaCl2	mg/kg	2.95	0.6	N/A	N/A
Boron Hot CaCl2	mg/kg	0.4	0.31	1.97	2.5

5.3.2 Seasonal Conditions

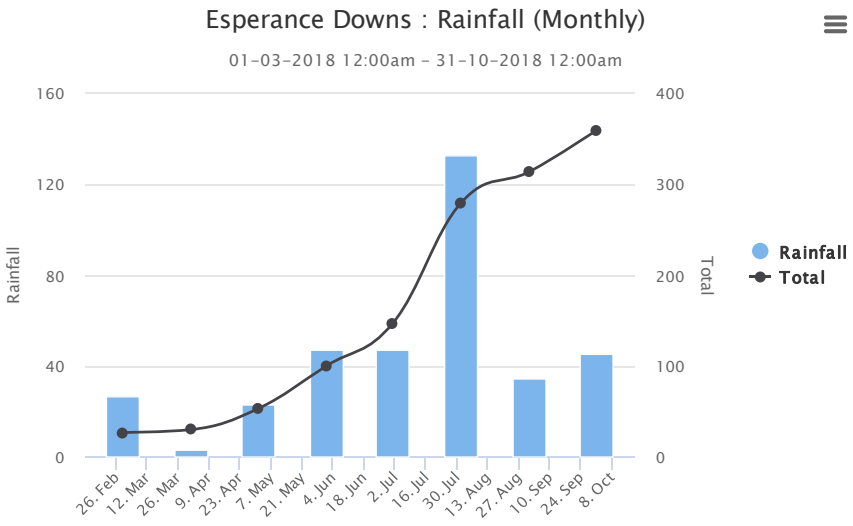

Figure 10: Monthly rainfall totals for Gibson demonstration site (EDRS), February to October 2018.

Rainfall was ideal from sowing on 11th May 2018 through until late July but high rainfall in early August resulted in waterlogging through lower lying areas of the site (Figure 10). There were no frosts at this site.

5.3.3 Growing Season Data

Given the rainfall conditions and soil type present, the plant densities recorded on 26th June 2018, were good to ideal across each of the 5 break crop species (Figure 11).

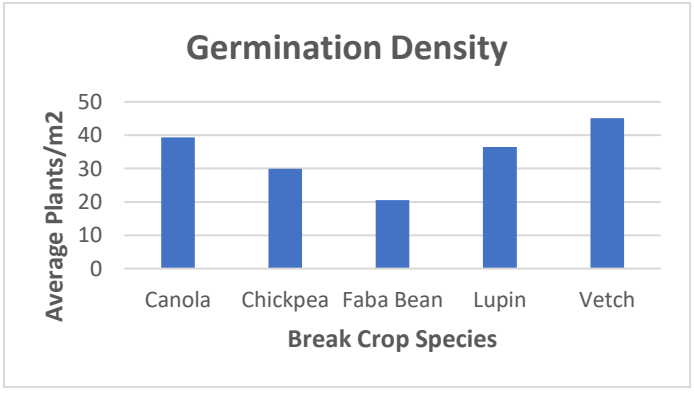

Figure 11: Break crop species germination density, Gibson, 26/6/18.

The high broadleaf weed burden recorded in November in the legume plots compared to the canola plots reflects the current lack of in-crop herbicide options for late application (Figure 12). There was a significant late germination of weeds at the Gibson site following wet conditions in August.

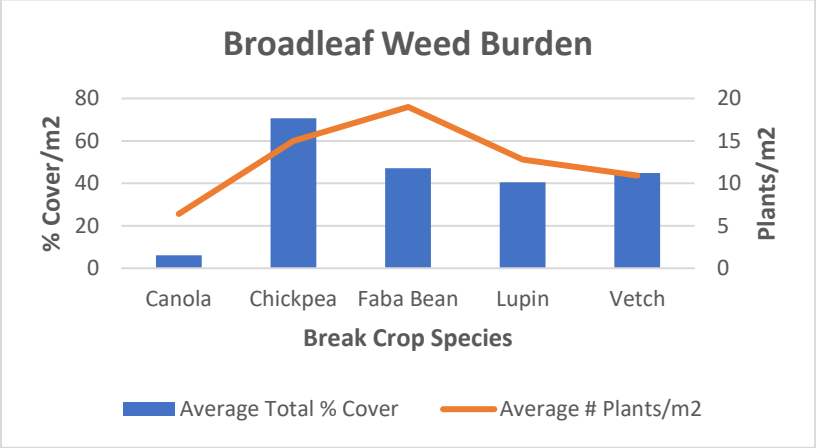

Figure 12: Broadleaf weed burden present in each Gibson break crop species strip, 14/11/8.

The addition of trifluralin in pre-sowing herbicide application may have reduced wireweed establishment in the legume plots. The in-crop application of atrazine applied to the canola plots resulted in good broadleaf weed control in these plots.

5.3.4 Harvest Results

Table 6: 2018 break crop species average harvest yields with and without the addition of an extra 171L/ha Flexi-N during the growing season, Gibson.

Break Crop Species	Plus Extra Nitrogen (N+)	No Extra N (N-)	N Effect
Canola	3232	2169	+1063
Chickpeas	593	425	+168
Faba Beans	2473	1710	+763
Lupins	1304	1066	+238
Vetch	505	330	+175

Of the 5 break crop species included at the Gibson demonstration site Bonito canola yielded the highest followed by Samira faba beans, then Jurien lupins, then PBA Strikers chickpeas and lastly Morava vetch. (Table 6 and Figure 13).

The addition of an extra 72 units of nitrogen did not significantly change the yields achieved by the vetch, chickpeas or lupin crops but it did significantly improve performance of both the faba bean and canola crops (Figure 13). Average yield increases were 0.763t/ha and 1.063t/ha respectively. The addition of extra nitrogen significantly increased the performance of the faba bean crop taking average yield close to that of the un-topped up canola replicates.

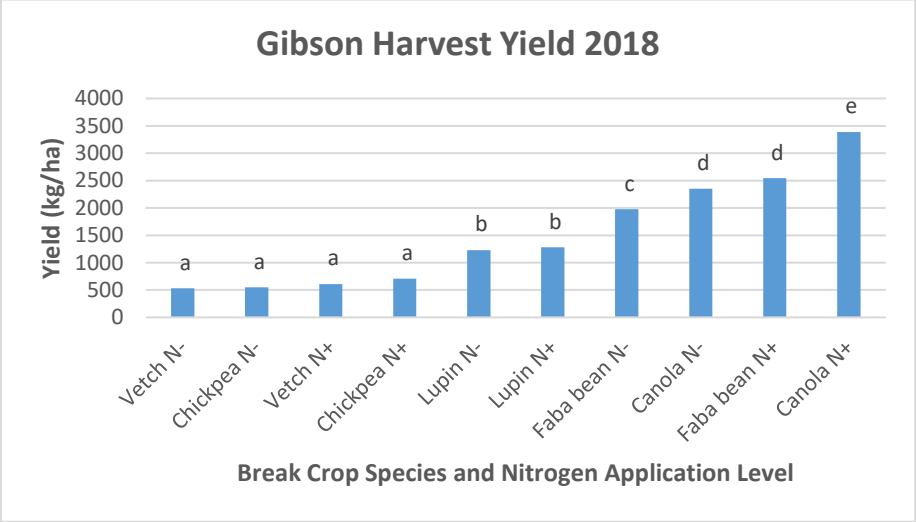

Figure 13: Average break crop species grain yields per nitrogen application level, Gibson ($p < 0.001$).

The relatively poor yields achieved by the vetch and chickpea crops most likely reflects the effect of waterlogging exposure in August. All of the legume species were more affected by the site's waterlogged conditions than the canola strips. To the eye, the chickpea replicates appeared to be most affected and the faba beans the least. The lupin yields recorded are below average for the area and are likely to reflect waterlogging exposure. The un-topped up faba bean yield (N-) was average for the area and indicates their better waterlogging tolerance than the other legumes grown.

5.3.5 Economic Analysis

While canola yield outperformed the other 4 break crop species grown, in terms of earnings before tax faba beans were the most profitable of the 5 crops grown (Table 7). Neither the lupin, chickpea or vetch crops grown were profitable, all resulting in earnings before tax losses. This was the case regardless of whether additional nitrogen was applied or not (Tables 8 & 9). The addition of an extra 72 units of nitrogen resulted in a large increase in earnings before tax in both the canola and faba beans, with an increase of $521/ha and $509 respectively.

Table 7: Gibson Demonstration Site Earnings Before Tax (EBT) Analysis following 2018 winter cropping season. Data from both the Nitrogen top up plots and the Non-topped-up plots have been combined to assess total profitability per break crop (prepared by Farmanco).

Crop Enterprise		Lupin	Canola	Chickpea	Faba	Vetch
Yield	t/ha	1.19	2.70	0.51	2.09	0.51
Average Grain Price (FIS)	$/t	$370	$592	$600	$800	$500
Income	**$/ha**	**$438**	**$1,599**	**$305**	**$1,673**	**$253**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$44	$2	$54	$120	$20
Grain Freight (Up Country)		$1	$3	$1	$2	$1
Grain Handling Charges		$10	$42	$6	$26	$6
Crop Contract		$51	$51	$51	$51	$51
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$47	$47	$47	$47	$47
Fuel & Oil		$30	$30	$30	$30	$30
Fertiliser, Lime & Gypsum		$102	$204	$102	$102	$102
Pesticide		$127	$140	$136	$162	$124

Variable Operating Costs	$	$483	$590	$497	$611	$452
Variable Operating Costs	**$/ha**	**$483**	**$590**	**$497**	**$611**	**$452**
Operating Gross Margin	$	($45)	$1,009	($192)	$1,063	($199)
Operating Gross Margin	**$/ha**	**($45)**	**$1,009**	**($192)**	**$1,063**	**($199)**
Fixed Operating Costs	$	$170	$170	$170	$170	$170
Fixed Operating Costs	**$/ha**	**$170**	**$170**	**$170**	**$170**	**$170**
Total Operating Costs	$	$653	$760	$667	$781	$622
Total Operating Costs	**$/ha**	**$653**	**$760**	**$667**	**$781**	**$622**
Operating Profit (BIT)	$	($215)	$839	($362)	$893	($369)
Operating Profit (BIT)	**$/ha**	**($215)**	**$839**	**($362)**	**$893**	**($369)**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$**	**($271)**	**$783**	**($418)**	**$837**	**($425)**
Earnings Before Tax (EBT)	**$/ha**	**($271)**	**$783**	**($418)**	**$837**	**($425)**

It's important to note when considering these results that the faba bean price used to calculate the earnings before tax profit outcome for this crop in February 2018 was $800/tonne. The price has since increased further to almost $1200/tonne in April 2018. Rabo Bank's Senior Grains and Oilseed Analyst, Dr Cheryl Kalisch Gordon has indicated that this price is well above long term average prices and the cost of production due to 2 main factors. Firstly, supply shortages in all major production regions of the world in 2018 and secondly, locally a tight east coast grain complex.

The profitability scenario would be somewhat different if earnings before tax had been calculated using the 5 year or 10 year average faba bean price (Figure 14). Dr Kalish Gordon suggests it would be more realistic to work on a price in the $320-$380/tonne range.

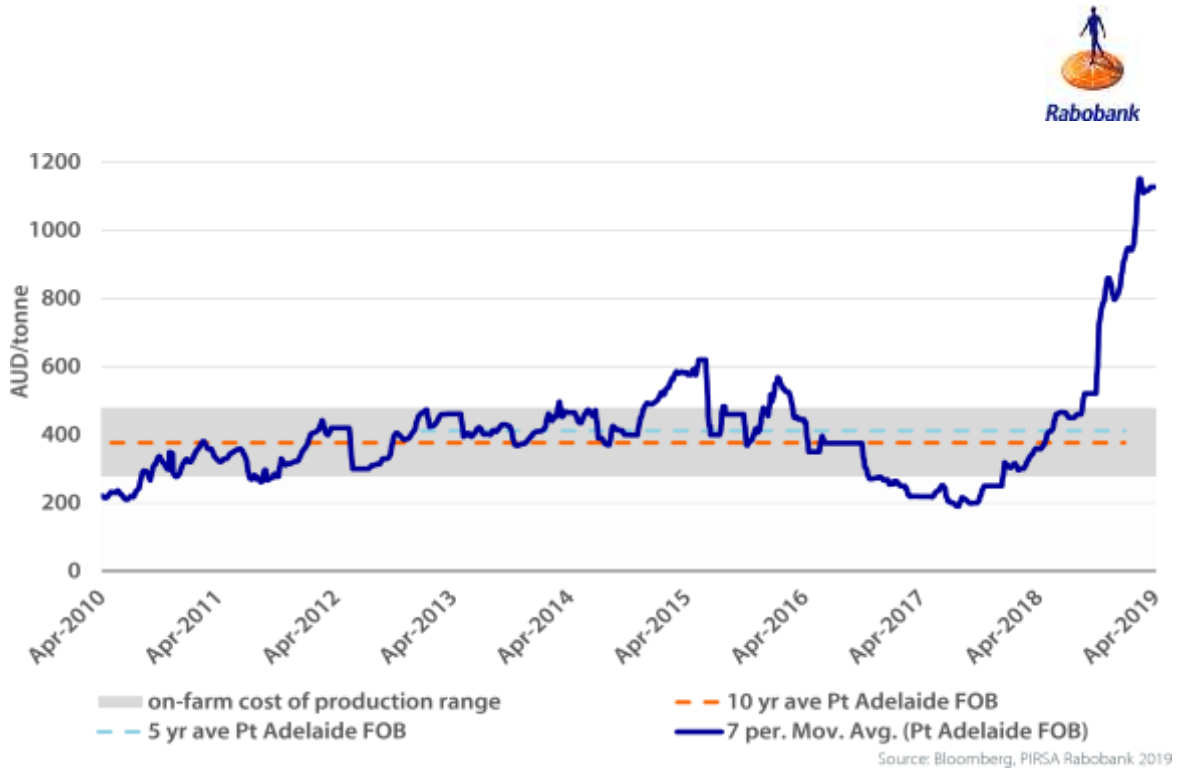

Figure 14: Faba Bean pricing and production costs from April 2010 to April 2019. The figures presented are based on SA pricing and costs because that is where the market is most liquid but with the market being export dominated, SA pricing can be considered reflective of the prices for WA.

Table 8: Gibson Demonstration Site Earnings Before Tax (EBT) Analysis following 2018 winter cropping season in plots to which no extra nitrogen was applied (prepared by Farmanco).

Crop Enterprise		Lupin	Canola	Chickpea	Faba	Vetch
Yield	t/ha	1.07	2.17	0.43	1.71	0.51
Average Grain Price (FIS)	$/t	$370	$592	$600	$800	$500
Income	**$/ha**	**$394**	**$1,284**	**$255**	**$1,368**	**$253**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$44	$2	$54	$120	$20
Grain Freight (Up Country)		$1	$2	$0	$2	$1
Grain Handling Charges		$9	$33	$5	$21	$6
Crop Contract		$51	$51	$51	$51	$51
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$47	$47	$47	$47	$47
Fuel & Oil		$30	$30	$30	$30	$30
Fertiliser, Lime & Gypsum		$57	$158	$57	$57	$57
Pesticide		$127	$140	$136	$162	$124
Variable Operating Costs	$	$437	$534	$450	$560	$406
Variable Operating Costs	**$/ha**	**$437**	**$534**	**$450**	**$560**	**$406**
Operating Gross Margin	$	($42)	$750	($195)	$808	($154)
Operating Gross Margin	**$/ha**	**($42)**	**$750**	**($195)**	**$808**	**($154)**
Fixed Operating Costs	$	$170	$170	$170	$170	$170
Fixed Operating Costs	**$/ha**	**$170**	**$170**	**$170**	**$170**	**$170**
Total Operating Costs	$	$607	$704	$620	$730	$576
Total Operating Costs	**$/ha**	**$607**	**$704**	**$620**	**$730**	**$576**
Operating Profit (BIT)	$	($212)	$580	($365)	$638	($324)
Operating Profit (BIT)	**$/ha**	**($212)**	**$580**	**($365)**	**$638**	**($324)**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$**	**($268)**	**$524**	**($421)**	**$582**	**($380)**
Earnings Before Tax (EBT)	**$/ha**	**($268)**	**$524**	**($421)**	**$582**	**($380)**

Table 9: Gibson Demonstration Site Earnings Before Tax (EBT) Analysis following 2018 winter cropping season in plots to which an additional 72 units of nitrogen (ie 171L Flexi -N) was applied (prepared by Farmanco).

Crop Enterprise		Lupin	Canola	Chickpea	Faba	Vetch
Yield	t/ha	1.30	3.23	0.59	2.47	0.51
Average Grain Price (FIS)	$/t	$370	$592	$600	$800	$500
Income	**$/ha**	**$482**	**$1,913**	**$356**	**$1,978**	**$253**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$44	$2	$54	$120	$20
Grain Freight (Up Country)		$1	$4	$1	$3	$1
Grain Handling Charges		$11	$49	$7	$31	$6
Crop Contract		$51	$51	$51	$51	$51

Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$47	$47	$47	$47	$47
Fuel & Oil		$30	$30	$30	$30	$30
Fertiliser, Lime & Gypsum		$148	$249	$148	$148	$148
Pesticide		$127	$140	$136	$162	$124
Variable Operating Costs	$	$530	$642	$544	$661	$497
Variable Operating Costs	**$/ha**	**$530**	**$642**	**$544**	**$661**	**$497**
Operating Gross Margin	$	($48)	$1,271	($188)	$1,317	($245)
Operating Gross Margin	**$/ha**	**($48)**	**$1,271**	**($188)**	**$1,317**	**($245)**
Fixed Operating Costs	$	$170	$170	$170	$170	$170
Fixed Operating Costs	**$/ha**	**$170**	**$170**	**$170**	**$170**	**$170**
Total Operating Costs	$	$700	$812	$714	$831	$667
Total Operating Costs	**$/ha**	**$700**	**$812**	**$714**	**$831**	**$667**
Operating Profit (BIT)	$	($218)	$1,101	($358)	$1,147	($415)
Operating Profit (BIT)	**$/ha**	**($218)**	**$1,101**	**($358)**	**$1,147**	**($415)**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$**	**($274)**	**$1,045**	**($414)**	**$1,091**	**($471)**
Earnings Before Tax (EBT)	**$/ha**	**($274)**	**$1,045**	**($414)**	**$1,091**	**($471)**

6.0 CONCLUSIONS

The results from the Gibson demonstration site generally supports previous experience in the Esperance Port Zone with growing the selected break crops. The results from the Ravensthorpe and Salmon Gums sites should be considered in light of the season in which the trials were conducted. Conditions in Ravensthorpe were so dry this trial will be recommenced in 2019 at this location.

While growing season conditions were dry and grain yields were low at Salmon Gums, both Bolt lentils and Gunyah field peas achieved the highest yields of the break crops grown. While none of the break crop species grown were profitable, this result is of interest given the high boron levels found at this location.

Previous research indicates that field peas are considered moderately tolerant to boron and that lentils are very sensitive. The lentil variety included in the trial was Bolt which has shown signs of moderate intolerance to boron in the Victorian mallee region rather than the very sensitive level of tolerance shown by other lentil varieties. The results of this trial appear to support the Victorian experience.

Boron at this site started at 4.85mg/kg at the surface, rose to 15.97mg/kg at 10 to 30cm depth and increased further to 47.65mg/kg at 30 to 70cm depth. For most crops, 1-4 mg-B/kg soil is sufficient to prevent nutrient deficiencies while levels in the range of 12 mg-B/kg soil and beyond may take the crops into the Boron toxicity range. However, critical levels at which boron begins to reduce the growth of pulses are yet to be well established. Plants cope with boron toxicity by excluding boron from the roots and different plants vary in their ability to exclude boron but as a general rule, pulses are more sensitive to boron toxicity than cereals. Boron toxicity is exacerbated by low rainfall.

All of the legume species were hard to harvest and some of the legume crop was left in the paddock, especially in the case of the vetch and lentils. Plant height was short due to low rainfall which made it difficult for the harvester cutter bar to get under pods that were set low on the plants. Past experience

suggests that an additional 30mm of rainfall during June to October could increase yield considerably as well as making the crops taller and easier to harvest.

Following waterlogged conditions in August, Bonito canola out yielded the other break crop species at the Gibson demonstration site, with Samira faba beans yielding next highest. The addition of an extra 72 Units of nitrogen (171L Flexi-N delivered in 3 incremental applications) resulted in significant yield and earnings before tax profit increases in both canola and faba beans but made little difference to the yields achieved by PBA Strikers chickpeas, Morava vetch and Jurien lupins.

In terms of earnings before tax the faba bean crop was the most profitable of the 5 break crops grown at Gibson. It is important to note though that the $800/tonne price seen for faba beans in February 2018 was well above both the five and ten year average for this crop. It is more realistic to work on a faba bean price in the $320-$380/tonne and to remember the price has been lower still at times.

It's likely the relatively poor, unprofitable yields achieved by the lupins, vetch and chickpea crops were a result of waterlogging exposure in August. Pulses are known to generally not be suited to waterlogged soils and all of the legume species at this site were more affected by the site's waterlogged conditions than the canola strips. To the eye, the chickpea replicates appeared to be most affected and the faba beans the least. The lupin yields recorded are below average for the area and are likely to reflect waterlogging exposure. The un-topped up faba bean yield (N-) was average for the area and indicates their better waterlogging tolerance than the other legumes included. Faba bean is known to be the most tolerant of the pulses to waterlogging.

Broadleaf weed control was an issue at Gibson, the high broadleaf weed burden recorded late in the season in the legume plots compared to the canola plots reflects the current lack of in-crop herbicide options for late application. There was a significant late germination of weeds at the Gibson site following wet conditions in August. The in-crop application of atrazine applied to the canola plots resulted in good broadleaf weed control in these plots. The addition of trifluralin in pre-sowing herbicide application may have reduced wireweed establishment in the legume plots.

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REFERENCES & USEFUL LINKS

List of key publication references and web links relevant to the project and for further exploration of the topic.

Appendix 1 – Communication Activities

1. Communication and Extension Plan – completed 30/5/18

2. SEPWA Newsletter Articles

a) April '18 Edition – "GRDC Projects on the Move"

b) June '18 Edition – "Is your Break Crop Helping or Costing You?"

c) August '!8 Edition – "Legume Fungicide Management Important Despite Dry Conditions"

d) October '18 Edition – "EDRS Field Day Trial Site Key Learnings"

e) October '18 Edition – "Are Herbicide Residues Holding Back Your Pulse Crop?"

f) December '18 Edition – "Finding the Break Crop that Fits Your Rotation"

g) December '18 Edition – "Improving production of saline waterlogged soils using Neptune™ messina"

h) April '19 Edition – "Lentil Workshops Highlight How Things are Done in the Wimmera"

i) April '19 Edition – "Break Crop Trial – Year 1 Results are in"

3. Demonstration Site Visits

a) 20/7/18 – EDRS Demo Site Tour (10 attendees)
The EDRS Legume Profitability Site was visited during site tour with Lawson Grains Property Managers, their State Manager and Operations Manager.

b) 15/8/19 – Grass Patch Field Day (45 attendees). Lentils, Peas and Vetch were viewed on a property at Grass Patch. Discussion at this site centred on the varieties sown and seeding timing and depth. DPIRD's Mark Seymour spoke at this site.

c) 12/9/18 – EDRS Field Day (100 attendees)
The EDRS Legume Profitability Demonstration Site was visited during this field walk. Discussion centred on the vulnerability of chickpeas, lentils and lupins to waterlogging as this was evident at this site following a period of waterlogging in August, as was the tolerance of faba beans. This year's dry start meant canola at the site escaped the early waterlogging conditions that can occur at Gibson and as such showed the good potential of canola in these conditions. The site highlighted the need to select the right break crop for likely growing conditions. For the Gibson area, it is common to face waterlogging during the growing season. Farm and General's Agronomy Manager, Greg Warren, spoke at the site as did DPIRD's Mark Seymour.

d) 19/9/18 - North Mallee Field Day (35 attendees)
The Salmon Gums Legume Profitability Site was visited during this field walk as was a DPRID research site also located in Salmon Gums. Discussion at the Legume Profitability site centred on the performance of the varieties grown in the 65mm growing season rainfall received to date and possible soil types worth trying lupins on. Farm and General's Greg Warren spoke at the site as did DPIRD's Mark Seymour.

4. Speaking Events

a) 21/9/18 – PASE AGM Question and Answer Panel Session (with Jason Vermeersch (PASE President), DPIRD's Mark Seymour and a grain marketer) (25 attendees). During this hour long session growers asked a wide range of legume variety, agronomy, harvest, storage and marketing questions.

b) 15/2/19 – Harvest Review (110 attendees) – Legume Profitability site data was presented.

c) 22/2/19 – Lentil Agronomy Workshops featuring Jason Brand and Mark Seymour (9 Local agronomists attended agronomist session, 21 attended the grower session). The agronomist session was a Q&A style in which agronomists asked questions that were on their mind and Jason and Mark answered based on their research experience. Topics covered went systematically through lentil agronomics from soils, seeding, in crop management through to harvest issues. The grower session that followed was a seminar style in which Mark and Jason presented their research key messages.

d) 20/3/19 – North Mallee Updates (35 attendees) – Legume Profitability demonstration site yield data was presented.

e) 25/3/19 – Farmanco Crop Sequencing Workshop (18 attendees), Ravensthorpe.

5. Surveys

a) Survey Monkey Questionnaire regarding grower attitudes to legumes, November '18. Results supplied to Liebe Group.