RESEARCH ANNUAL

2020 Results

Southern Dirt

Contents

Investment in WA-Focused Linseed Agronomy 4
KEY MESSAGES 4
SUMMARY 4
BACKGROUND 5
OBJECTIVES 5
Methodology 6
LOCATION 9
RESULTS 10
CONCLUSIONS 15
Cost benefit analysis: 16
Red Wheat Trials 18
KEY MESSAGES 18
SUMMARY 18
BACKGROUND 18
OBJECTIVES 19
METHODS 19
LOCATION 20
RESULTS 20
CONCLUSIONS 25
Ripper Gauge demonstration sites Albany Port Zone 26
KEY MESSAGES 26
SUMMARY 26
BACKGROUND 26
OBJECTIVES 27
METHODS 27
Trial 28
LOCATION 28
RESULTS 29
CONCLUSIONS 34
Appendix: 35
REFERENCES & USEFUL LINKS 37
'Demonstrations of legume crops for reliable profitability in the Albany Port Zone' 38
Abstract 38

Executive Summary 38
Background 40
Project objectives 42
Methodology 43
Location 45
Results 46
Discussion of Results 55
Conclusion 58
Implications 58
Recommendations 59
Appendix A. 60
Appendix Title 62
Non-Wetting Management Options for Growers in the Albany Port Zone 63
KEY MESSAGES 63
SUMMARY 63
BACKGROUND 63
OBJECTIVES 64
METHODS 64
LOCATION 65
RESULTS 66
CONCLUSIONS 70
Increasing Profits with Dual Purpose Crops 71
Abstract 71
Project objectives 71
MER Report 72
Data Results Collated and Analysed 73
Site 3-Kojonup District High School methodology 73
Site 3-Kojonup District High School results 74
Site 3-Kojonup District High School discussion and conclusions 77
..... 78
Alternative Fodder Crops for Turning Off Weaner Lambs/Hoggets 80
Executive Summary 80
Project Background 80
Project Purpose 81

Project Objectives 81
2 Methodology 82
3 Results 84
Conclusions/Recommendation 92
6 References 92
7 Appendix 93
Controlling red legged earth mites using intensive spring grazing 95
Key words 95
Key messages 95
Aims 95
To demonstrate if short periods of intensive grazing in spring will control red legged earth mites (RLEM) effectively without the use of insecticides. 95
Introduction 95
Method 95
Results and Discussion 96
Conclusion 99
Acknowledgments 99
Contact details 99

Investment in WA-Focused Linseed Agronomy

Author: Dan Hester
Project Lead: Southern Dirt
Investment Partners: GRDC

KEY MESSAGES

- Linseed can be successfully grown within the rotation in the Great Southern of WA.
- Agronomic strategies and guidelines were successfully implemented across the board from managing weeds to harvesting.
- Linseed was shown to yield 76% of Canola.
- Current pricing of Linseed shows the returns to be higher than Canola, which was over limited tonnes.
- PredictaB results highlighted that Linseed crops in the rotation are a real option for managing nematodes with nematode disease risk considerably lower in testing after the Linseed crop than before
- Further work is required to better understand the benefit of Linseed on managing Nematodes, broad leaf weed control options and required fertiliser regimes.
- Below average rainfall in 2020 impacted yield and future demonstrations are required to better determine yield potential.

SUMMARY

Linseed (flax) is a niche product with the potential as an alternative break crop to aide in disease and alternative weed management strategies. It was grown in the Boyup Brook (Great Southern) region from the 1940's to the 1960's. Market demand in recent years has evolved from a fibre product into a health food product.

The objective of this project is to support the introduction and scale up of commercial cultivation of Linseed in the Great Southern region of Western Australia, and will support a larger initiative developed by Southern Dirt to develop a localised Linseed supply chain to take the crop from paddock to consumer on the back of renewed demand for Linseed's omega 3 oil composition and capturing additional value for local growers.

The demonstration examined the production potential and agronomic package development of 2 Linseed varieties, Bilton and Croxton, against canola over 4 sites within the Great Southern. Linseed integrated into the machinery being used by all four growers without any investment into additional machinery or changes required. The agronomic package was successful across the board and importantly enabled successful weed control,

The project demonstrated Linseed can successfully grown be in rotation in the Great Southern. Bilton Linseed yielded 77% of canola and Croxton yielded 74.5% of canola. Bilton out yielded Croxton on two sites and Croxton out yielded Bilton on 1 site, though the below average rainfall reduced the final yield.

PredictaB results highlighted that nematode disease risk was considerably reduced in testing after the Linseed crop than before the Linseed crop. Linseed crops appear to be a positive option in the rotation for managing nematode disease pressure.

Further work is required to better understand the benefits of Linseed in the rotation, in particular the benefits of Nematode management and the following year's cereal yield. Additionally future work is required around broad leaf weed control options and required fertiliser regimes.

BACKGROUND

Linseed is not new to Western Australia or the Great Southern region as it was grown in the Boyup Brook region from the 1940's to the 1960's. It was grown for fiber and milled at the Boyup Brook flax mill. However the mill ceased operation when Russia flooded the market with cheap product. Linseed has not been grown on a commercial scale in Western Australia since that time. Global production is estimated at 2.50 million tonnes annually, with Canada, China and the USA being the major producers.

Linseed (flax) Linum usitatissimum is a niche product and has the potential to offer an alternative revenue steam for producers outside of the traditional crops. Originally linseed was used as a commercial fibre crop but has recently shifted to a health food. Linseed has several uses, it can be crushed for Linseed oil which is a rich source of linolic acid and Omega 3 fatty acid and the remaining linseed meal can then be used as livestock feed. It can also be eaten as a whole seed or ground, raw or toasted and added to salads, cereals, smoothies or incorporated into baked goods.

Linseed also has agronomic benefits being a potential break crop that provides both a disease break, the opportunity for alternative weed management strategies and provides an insect pest break. There are numerous Linseed varieties available in Australia both of which are not under any type of PBR. Two varieties have been trialled and bulked up in this project:

- Croxton, is a blue flowering long season variety, with good wilt resistance but a taller variety that can be prone to lodging

- Bilton is a blue flowered variety, medium to late maturing with a good standing ability.

The re-emerging demand for Linseed along with the crop rotational benefits is expected to see an increase in production in future years. In order for this increase in production to transition smoothly and efficiently it requires the agronomic package to be developed to enable the crop to be grown within the modern production systems and to be specifically designed for the Great Southern climate and soils of WA.

OBJECTIVES

The objective of this project is to support the introduction and scale up of commercial cultivation of Linseed in the Great Southern region of Western Australia and will support a larger initiative developed by Southern Dirt to develop a localised Linseed supply chain to take the crop from paddock to consumer on the back of renewed demand for Linseed's omega 3 oil composition and capturing additional value for local growers.

Consistent supply with volume is imperative to develop a market that has the ability to realise the full value of Linseed produced. In order for growers to take up production on a larger scale it is important they have a full agronomic package available to grow the crop successfully.

Additionally Linseed needs to generate an equivalent return per hectare of alternative rotational crops such as canola in order to expand into the rotation.

The key objectives of this project are:

A: To determine if Linseed can be successfully grown under dryland farming conditions in the Great Southern region of Western Australia with the potential to scale up to commercial cultivation.

B: To determine if any investment is required into machinery and infrastructure by growers to grow linseed.

C: To develop basic agronomic guidelines to grow linseed in the Great Southern region of WA.

D: To assess the yield potential of two commercially available linseed varieties (Bilton and Croxton) grown under dryland conditions in WA.

E: To determine the cost benefit analysis of growing Linseed against canola, a similar break crop in the rotation.

Methodology

In 2020 four demonstration/bulk up sites were established across the Great Southern Region of Western Australia covering a range of soil types, rainfall, rotations and growing conditions. The four sites were located in Katanning, Wagin, Darkan and Kojonup.

The method of the project was to bulk up the Linseed seed for future commercial production and to also integrate high level variety comparisons between the two varieties being utilized in the project Bilton and Croxton. Two sites, Wagin and Darkan, incorporated replicated plot treatments as a variety trial with the other 2 sites were predominantly bulk up sites.

Figure 1Field Walk Cummins property June 2020

Hall Trial Design - Katanning	**Treatments - 1 replicate**	
	1	Bilton
	2	Croxton
	3	Canola
Cummings Trial Design - Wagin	**Treatments - 4 replicates**	
	1	Croxton
	2	Bilton
	3	Bilton
	4	Croxton
	5	Canola
	6	Canola
	7	Bilton
	8	Croxton
	9	Croxton
	10	Bilton
	11	Bilton
	12	Croxton
	13	Canola
	14	Canola
Harrington Trial Design - Darkan	**Treatments - 2 replicates**	
	1	Bilton
	2	Croxton
	3	Canola
	4	Canola
	5	Bilton
	6	Croxton
Anderson Trial Design - Kojonup	**Treatments - 1 replicate**	
	1	Bulk up Croxton 12 Ha

Table 1: 2020 demonstration designs

Table 2 outlines the plot sizes for of the four demonstration sites and each of their agronomic packages.

Katanning:

Date	Operation	Product	Rate	Unit
	plot area	Bilton	8.5	Ha
		Croxton	1.5	Ha
		Mako Canola	35	Ha
20-Apr-20	Seeding	Bilton	45	kg/Ha
		Croxton	45	kg/Ha
		Mako Canola	4	kg/Ha
		Macro Pro Extra	100	kg/Ha
		Flexi N	40	L/Ha
27-Jun-20	Fert App 1	Urea	100	kg/Ha
10-Jul-20	Fert App 2	Flexi N	75	L/Ha
26-Mar-20		Roundup Ultra MAX	1	L/Ha
20-Apr-20		Trifluralin 480	2	L/Ha
22-Apr-20		Bifenthrin	0.08	L/Ha
		Chlorpyrofos	0.5	L/Ha
8-Jun-20		Clethodin	0.33	L/Ha
		Haloxyfop	0.1	L/Ha
		Clopyralid	125	g/Ha
10-Jul-20		MCPA	0.5	L/Ha

Wagin:

Date	Operation	Product	Rate	Unit
	plot area	Bilton	100 x 10	m
		Croxton	100 x 10	m
		Canola	100 x 10	m
16-May-20	Seeding	Bilton	50	kg/Ha
		Croxton	50	kg/Ha
		Canola	4	kg/Ha
		MAP blend	120	kg/Ha
		UAN	50	L/Ha
	Fert App 1	Urea	80	kg/Ha
19-Nov-20	Harvest			
17-May-20	PSPE	Bifenthrin 250	0.08	L/Ha
18-Jul-21		Verdict 520	0.1	L/Ha

Darkan:

Date	Operation	Product	Rate	Unit
	plot area	Bilton	100 x 12	m
		Croxton	100 x 12	m
		Canola	100 x 12	m
3-May-20	Seeding	Bilton	50	kg/Ha
		Croxton	50	kg/Ha
		Canola	4	kg/Ha
		NPK blend	150	kg/Ha
		Flexi N	50	L/Ha
	Fert App 1			kg/Ha
14-Dec-20	Harvest			
3-May-20		Paraquat	1	L/Ha
		Treflan	2	L/Ha
26-Jun-20		MCPA	0.5	L/Ha

Kojonup:

Date	Operation	Product	Rate	Unit
	plot area	Croxton	12	Ha
11-May-20	Seeding	Croxton	52	kg/Ha
		Agflow Cu ZN/MOP blend	110	kg/Ha
		Liquid Zn	0.2	L/Ha
		Lure (with seed)	1.5	L/Ha
28-Jun-20	Fert App 1	Urea/MOP	110	kg/Ha
15-Jan-21	Harvest			
		Glyphosate 450	1.5	L/Ha
11-May-20		Trifluralin 430	2	L/Ha
13-May-20		Bifenthrin 250	0.08	L/Ha
20-Jul-20		Factor	150	g/Ha
31-Jul-20		BromocideMA	1	L/Ha

Table 2: Agronomic packages for each demonstration site.

LOCATION

NOTE: Where field trials have been conducted please include location details: Latitude and Longitude, or nearest town, using the table below (please add additional rows as required):

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1	-32.069251	115.757783
Nearest Town	Katanning	

Trial Site #2	-33.28106	117.28060
Nearest Town	Wagin	
Trial Site #3	-33.511739	116.688189
Nearest Town	Darkan	
Trial Site #4	-33.740925	116.975314
Nearest Town	Kojonup	

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

RESULTS

Katanning Results

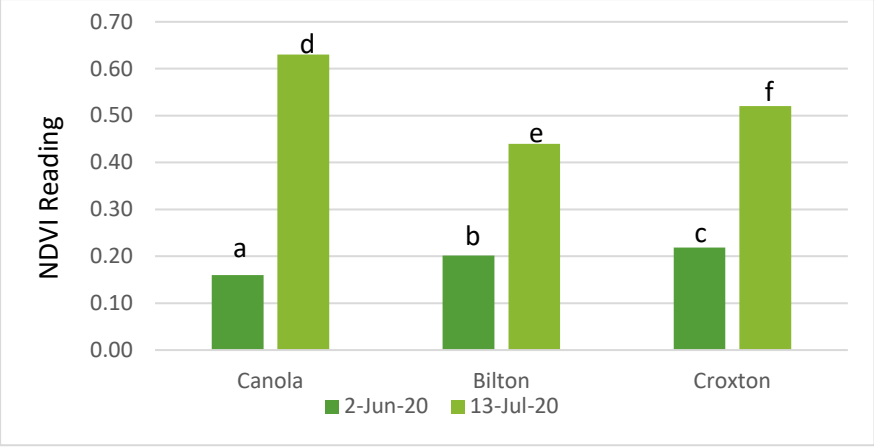


Chart 1: Katanning NDVI readings

The initial NDVI readings showed the Linseed varieties to be higher than the canola. However by the second NDVI reading, 6 weeks later, the canola's NDVI reading was much higher than the linseed crops, indicating a faster growth rate.

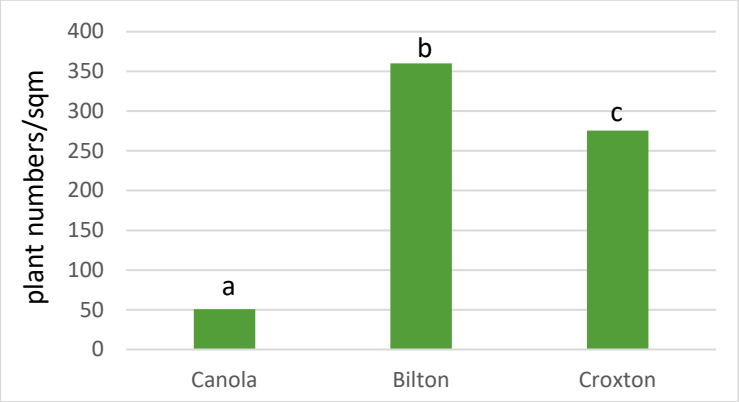


Chart 2: Katanning plant counts (2 June 2020)

As expected from sowing rates the plant counts for the Linseed were much higher than canola. All plant counts were within the required ranges to optimise crop yield. Interestingly the plant numbers for the Bilton plots was significantly higher than the Croxton plots.

Photo 1: Katanning 15th July 2020

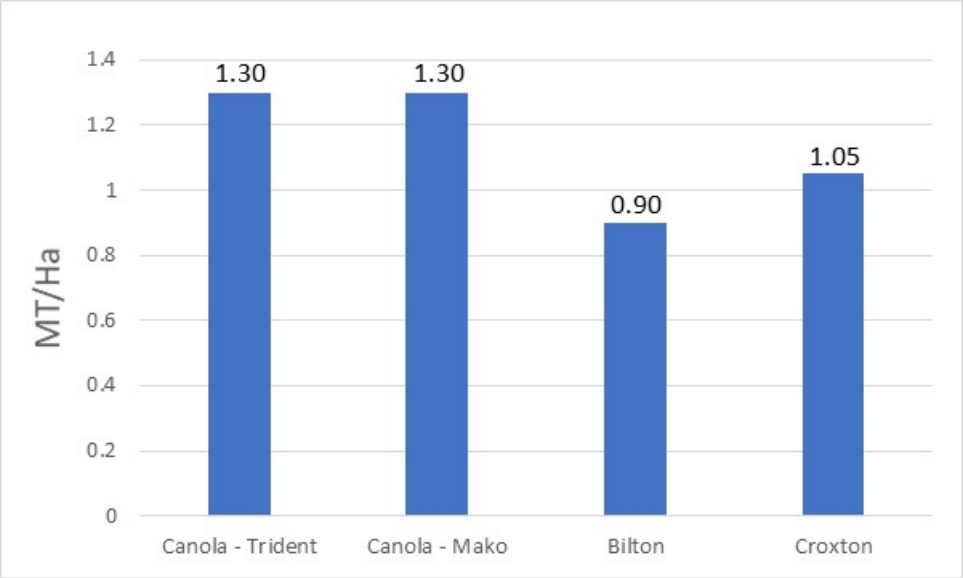


Chart 3: Katanning yield results

The yield results for Katanning are shown in chart 3. Croxton out yielded Bilton and both were below the 2 varieties on Canola Trident and Mako. It is worth noting there was difficulty in calibrating the yield monitor on the header when harvesting the trial plot due to the small area sown. The Linseed on average yielded 73% of the canola yields.

Wagin Results:

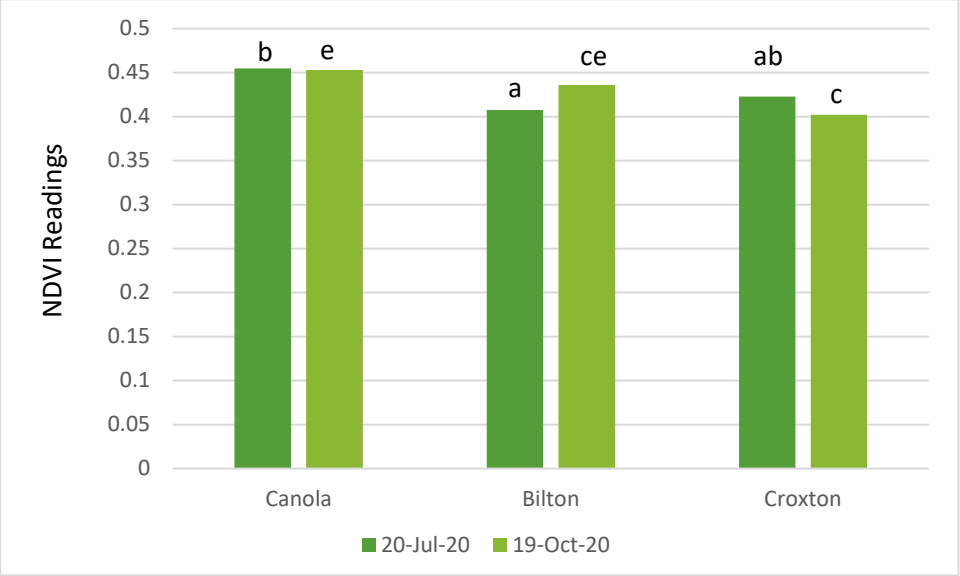


Chart 4: Wagin NDVI readings

The Wagin NDVI readings were taken later in the growing cycle than Katanning. There were significant differences between the readings with the key finding showing Bilton overtaking Croxton (though not significantly) between readings indicating better growth through the season.

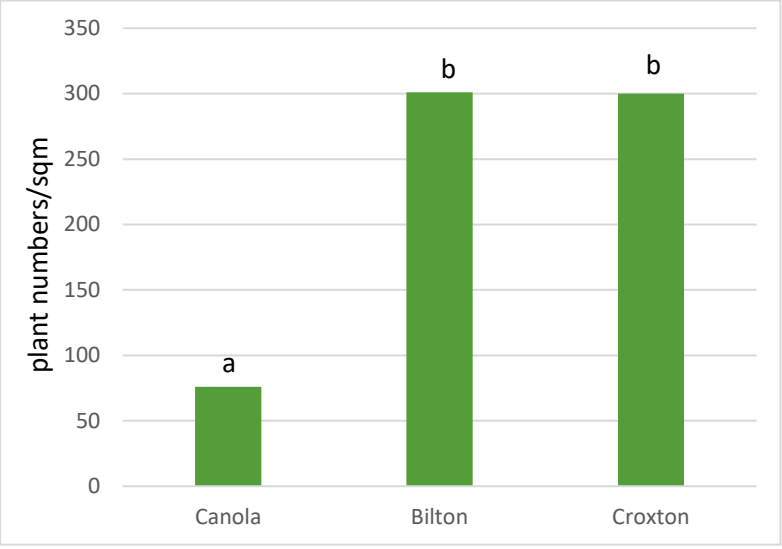


Chart 5: Wagin plant counts (20 July 2020)

Similar to the Katanning site the Linseed varieties had much higher plant counts than canola at the Wagin site.

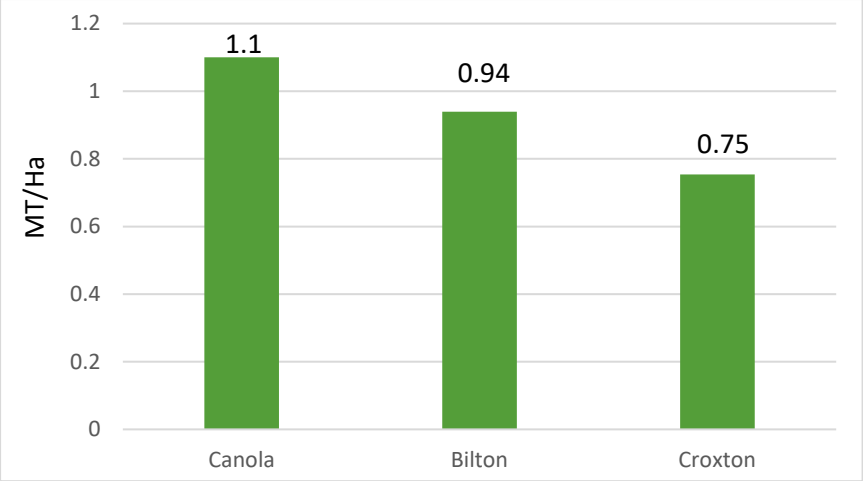


Chart 6: Wagin yield results

The harvest technique did not allow the individual plots to the weighed and therefore individual plot yields measured. The total yield of each of the varieties was measured and is shown in chart 5. It is expected that Bilton yielded significantly higher than Croxton with both being less than Canola.

Darkan Results:

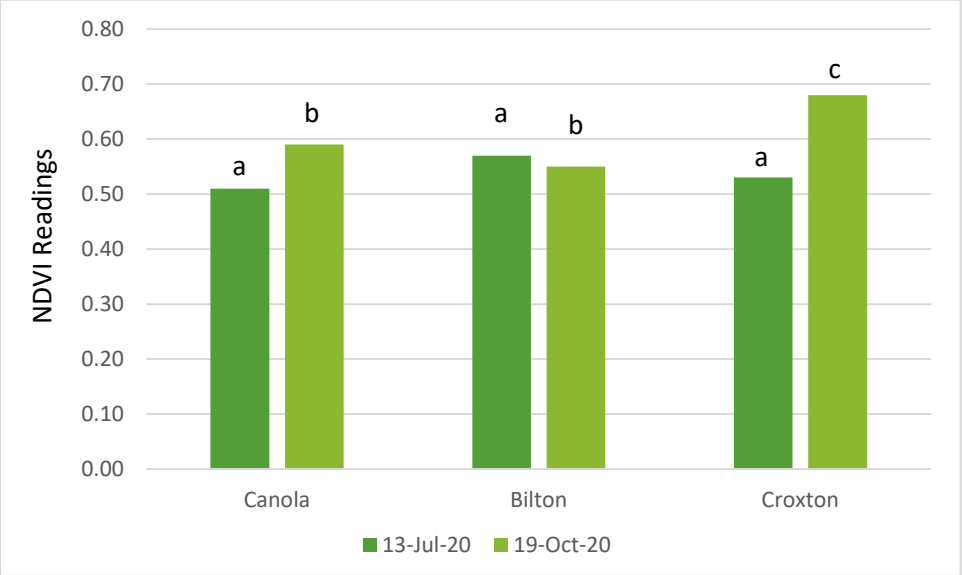


Chart 7: Darkan NDVI readings

The Darkan NDVI readings were inline with the Wagin readings with one key difference. In the Darkan demonstration Croxton had a significantly higher second NDVI reading over Bilton.

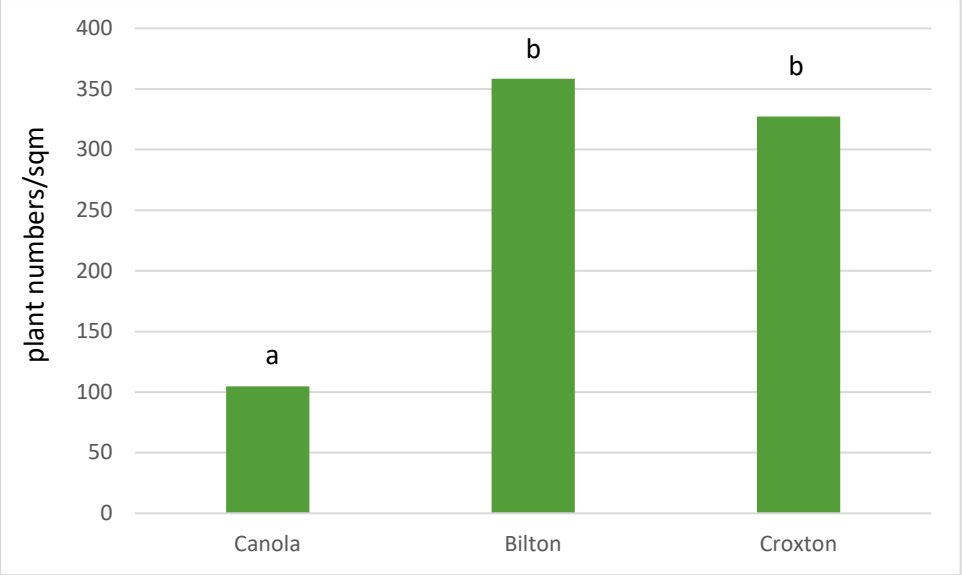


Chart 8: Darkan plant counts (13 July 2020)

The Darkan plant counts were all inline with required plant number per square meter.

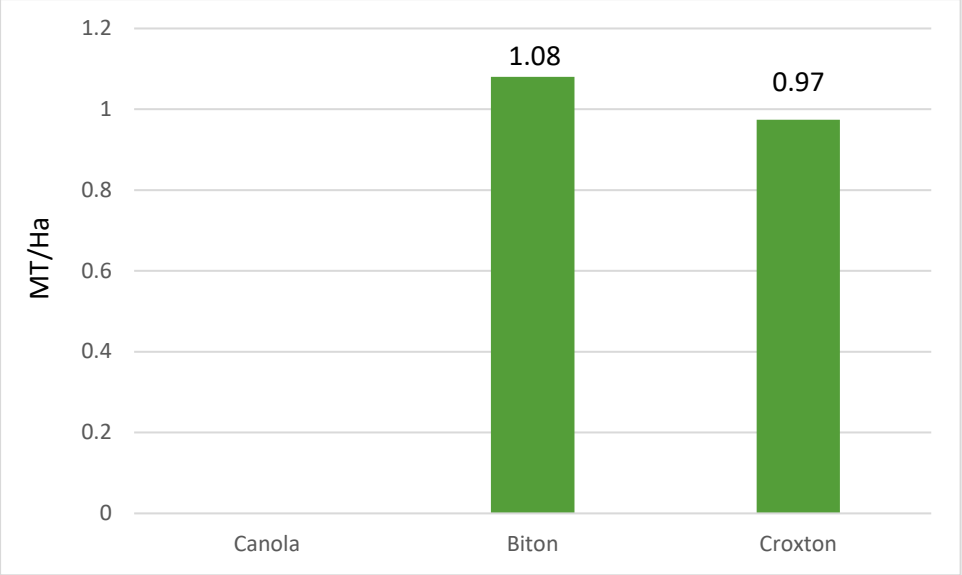


Chart 9: Darkan yield results

Despite Croxton having a higher second NDVI reading than Bilton, this did not translate into a higher yield. Bilton out performed Croxton at the Darkan site. The Canola yield results were not available from this demonstration due to a spray drift impacting plant growth early in the season

Kojonup Results:

Description	Result
Variety	Croxton
NDVI (3 July 2020)	0.37
Plant count (3 July 2020)	300
Yield (MT/Ha)	0.83

Table 1: Summary of Kojonup bulk up results

As the Kojonup site was the primary bulk up site with only 1 variety grown the only results available are those tabled in table 1. However, they do assist in giving a wider database of Linseed performance throughout the Great Southern of WA. A total of 9.96 mt of Linseed was grown at the Kojonup site.

Site	Rhizoctonia	Crown rot	Pratylenchus neglectus (nematodes)	Pratylenchus quasitereoides (nematodes)	Blackspot
Katanning	None	None	None	Medium	Low - medium
Wagin	None	None	None	Low	Medium - high
Kojonup	Medium - high	Low	Medium	Low - medium	None

Table 2: Predicta B results prior to planting Linseed.

The summary of the results from the Predicta B tests prior to planting Linseed from 3 of the sites are outlined in table 2. All site had nematodes along with other soil borne pathogens.

Site	Rhizoctonia	Crown rot	Pratylenchus neglectus (nematodes)	Pratylenchus quasitereoides (nematodes)	Blackspot
Katanning	None	None	None	Low	Low
Wagin	None	Low	None	Low	Medium – High
Kojonup	None	None	None	Low	None

Table 3: Predicta B results June 2021, post harvest of Linseed, with following crop planted.

The summary of the results from the Predicta B tests post the Linseed crop from 3 of the sites are outlined in table 3. The samples were taken in June of the following season once the subsequent crop had been established.

CONCLUSIONS

The key outcome of any variety demonstration is the final yield result. The summary of the yield results were:

- Bilton yield 77%% of Canola
- Croxton yielded 74.5% of Canola.
- Bilton out yielded Croxton on 2 sites.

- Croxton out yielded Bilton on 1 site.

The seasonal conditions may have contributed to Bilton out yielding Croxton. Bilton is a slightly shorter maturing variety and the below average rainfall received in 2020 is expected to have favoured shorter season varieties.

Plant counts across all the demonstration sites were well within the required plant densities to ensure the full yield potential can be achieved and demonstrates that Linseed can be seeded with a good germination with existing modern seeding equipment. There were no reports of seeding difficulties from any of the four demonstrations.

One of the key outcomes of this project is to continue to develop the agronomic package of Linseed for future commercial production. There are five main components to any agronomic package, handling (seeding and harvest), weed management and fertiliser requirements, disease control and pest management. Importantly from the demonstrations all the components were able to managed within the current available agronomic systems. Linseed has good grass control options being a Broadleaf crop however has limited broadleaf weed control options like other broadleaf crops. MCPA and BromocideMA were both used successfully within the demonstrations for weed control. For Linseed to continue to expand its footprint as an alternative option in the existing rotations further work will be required on broadleaf weed management options.

It is difficult to draw any conclusions from the fertiliser applications applied over the 4 demonstrations in relation to developing best practice fertiliser requirements for growing Linseed as there was no direct correlation between application rates and yield. Applications were all inline with canola best practice which appears to be excessive for the yields produced. However, this is quite likely due to the below average rainfall received in the spring which impacted yield potential.

Disease pressure and management options were realistically not tested due to the limited Linseed crops that are grown in the area and the very small history to develop disease pressure. However given Linseed will always only be a niche in any rotation it can be expected that disease pressure will not build up and therefore not impact long term crop performance. The dry spring resulted in a low pest pressure throughout the state. The Darkan demonstration was the only site to come under any pest invasion. Umiliotis native bud worm numbers built up in early November, was successfully sprayed and had no impact on yield.

Additionally both seeding and harvest didn't present any handling issues showing that Linseed is a crop that will fit into a rotation in the Great Southern and work within the existing machinery being utilised.

Cost benefit analysis:

The Linseed crops are currently being treated agronomically similarly to a canola crop. Linseed's fit into the current rotation would be through displacing canola. Production costs will be similar to canola with the ex

In order for Linseed to expand on its current niche production area it is important the profitability of growing it is comparable to other break crops such as canola. Production costs of growing Linseed will be very similar to a TT variety of canola given the similarities of the agronomy packages.

The cost benefit analysis result is determined by the final sale price and yield. From the demonstration results we know that Linseed yields 76% of canola. Therefore for Linseed to generate the same return for growers Linseed will need to trade at 131% of Canola. At the time of writing this report Canola was trading at $755/MT. Therefore Linseed will need to be trading at $993/MT to offer a similar return to Canola. It is worth noting that canola is trading in its 90 percentile.

Linseed production is very niche in WA and therefore pricing is not transparent and is difficult to determine. Increasing production to give consistent supply would work to secure firm pricing as wholesalers would have the ability to build market supply chains.

Linseed sales have been made from the demonstration production at prices between $1200 to $1500/MT into the birdseed market and as seed for production. These figures make Linseed a more profitable crop than canola and should encourage further production. Although these sales have been made on limited tonnes and until production is of a considerable size (in the thousands of tonnes) the true market price is difficult to determine with long term confidence.

Rotational benefits have not been considered in the cost benefit analysis and they are expected to be very similar to that of canola. The key rotational benefit of growing Linseed is its Nematode root disease control. Linseed is resistant to Nematodes and bringing the crop into rotation has the ability to drive down the parasitic numbers. Further work is required in this area to determine the longer term benefits of growing Linseed to manage this issue which currently has limited management strategies.

Soil borne pathogens pressure:

Three of the four sites which were tested for soil borne pathogens through the Predicta B test all contained nematodes along with other pathogens. There were no visible impacts on the crop from these pathogens and it is therefore expected the pathogens had no influence on yield. The same three sites were then retested after the Linseed crop had been harvested, once the following crop had been planted to determine if the Linseed crop was able to reduce nematode numbers and other pathogens.

Over the three sites there was a considerable drop in nematode pressure and overall soil borne pathogen pressure. Nematode pressure in particular was reduced from medium to medium to low disease risk down to low to zero disease risk.

This result is a very positive step forward for giving growers a strategy for managing nematodes, which at the moment have limited management options. Future work is required to determine if this result can be replicated in a replicated structured trial and also include testing the following seasons cereal crop to determine if the Linseed crop has the ability to reduce nematode numbers sufficiently to increase the following seasons cereal crops yield where there is a nematode concern.

Red Wheat Trials

2020 Annual Report

Author: Rachel Lancaster
Project Lead: Southern Dirt
Investment Partners: Bunge and GRDC

KEY MESSAGES

- A red wheat trial site was sown on 27 May 2020 at Muradup, near Kojonup.
- The comparative yields between the red wheat varieties were 6.15 t/ha for Illabo, 5.99 t/ha for Accroc and 5.00 t/ha for Zanzibar wheat.
- The average yield for the controls / local district practice was 6.49 t/ha for Maximus barley and 5.82 t/ha for Scepter wheat.
- Earlier planting of the red wheat may improve the yield, particularly for the long season varieties.

SUMMARY

The first year of results from the red wheat demonstration trials indicate the two red wheat varietiesyield are comparable to the yield of cereals currently grown in the district. Cereal yield from highest to lowest was as following: Maximus barley (6.49 t/ha), Illabo dual purpose wheat (6.15 t/ha), Accroc wheat (5.99 t/ha), Scepter spring wheat (5.82 t/ha) and Zanzibar red wheat (5.00 t/ha). There may be an improvement in yield if the long season red wheats are planted earlier in the growing season.

A second growing season is required to determine the effect of seasonal conditions on the growth ofthe red wheat. Plant establishment counts, tiller number, biomass assessment, weed and plant disease scores, yield and grain quality information will provide useful data for the assessment of the suitability of red wheat in the western high rainfall zone.

BACKGROUND

The Red Wheat Trials are being conducted in the western high rainfall zone (HRZ), with an outcome to demonstrate agronomic practices that will reduce the gap between current and potential yield ofred wheat varieties. The project aims to increase grower knowledge and awareness of red wheat and to determine if red wheat has a fit in the medium to high rainfall areas of southern WA throughfarmer scale trial demonstrations and extension activities.

This grower-scale demonstration compares local district practice with a set of system modifications. In year one, the project looks at the comparative yields of two red wheat varieties; Zanzibar and Accroc (system modification) compared to Maximus barley and a spring wheat variety; Scepter (localdistrict practice).

OBJECTIVES

The objective of this project is to demonstrate available agronomic information, raise awareness ofred wheat varieties for the western high rainfall zone (HRZ) and to determine yield potential and economic returns of red wheat varieties in the western HRZ farming system.

The trials will be run over a three year period, with associated extension activities. By 2022, growers will have the knowledge and confidence to use high yielding red wheat to address the gap between potential and realised yield to increase the value of the wheat cropping phase.

METHODS

Summary of trial management details:

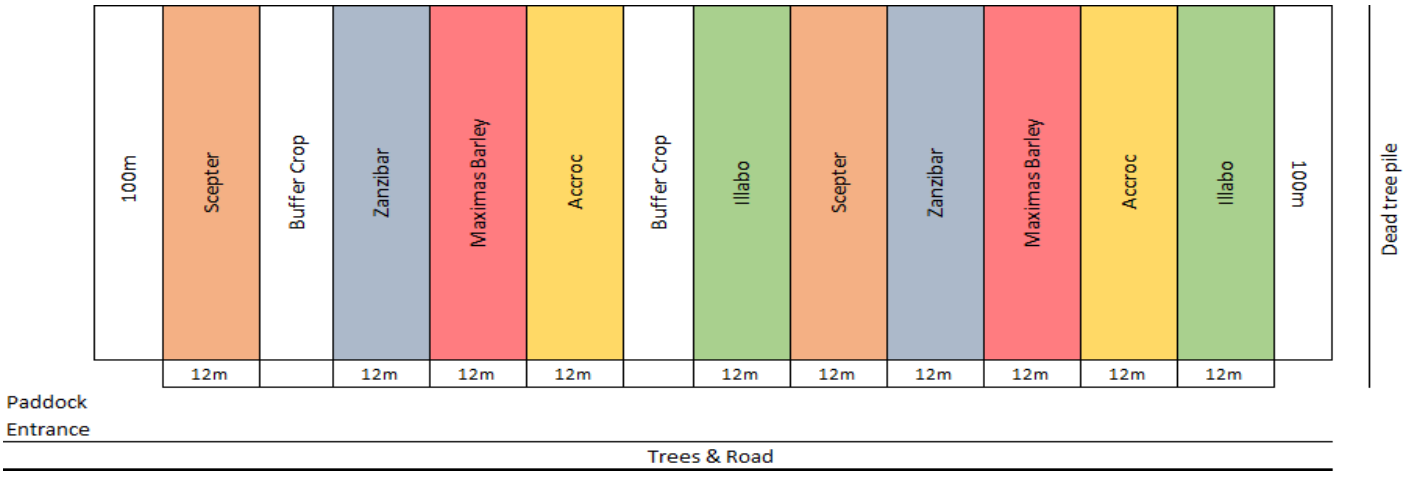
The demonstration site was established in 2020 on a farm located at Muradup, near Kojonup.

The site was planted to barley in 2018 and lupins in 2019 before being planted to two red wheat varieties, one spring wheat variety and barley on 27 May 2020. The wheat varieties planted were:

- Scepter - a spring wheat tolerant of drought stress typically cropped in the area, used as awheat control:
- Maximus barley – a quick to mid maturing barley, used as a barley control
- Zanzibar - a main season red wheat
- Accroc - a medium long season winter red wheat
- Illabo - a dual purpose winter wheat

Two replicates for each variety were included in the demonstration

(Figure 1).Figure 1: Red wheat demonstration plot layout: 2020



Representative soil samples of the trial plots were collected on 27 May 2020, at depth 0-10cm and10 to 30 cm. Samples were analysed for a range of soil properties including pH, electrical conductivity, major nutrients and organic carbon.samples for PredictaB

analysis at SARDI Plant and Soil Health were taken on 27 May 2020 toidentify soil-borne pathogens that may pose a significant risk to cropping.

Crop observations were recorded and plant counts conducted at each trial plot on 20 July 2020 to quantify seedling emergence. Tiller counts were conducted on 31 August 2020 and supported withNormalised Difference Vegetation Index (NDVI) measurements to further quantify the density of plant growth.

Plant tissue samples collected on 8 September 2020 were analysed for a range of nutrients.The trial plots were harvested by the farmer (Simon Zacher), who provided the yield data.

LOCATION

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1: Simon Zacher		
Nearest Town	Muradup, near Kojonup	

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

RESULTS

Soil Sampling 0-10cm and 10-30cm

Soil samples were collected on 27 May 2020, prior to seeding from the 0-10cm and 10-30cmhorizons and analysed at CSBP Laboratories.

The soil in the red wheat trial plots (0-30cm) was a light grey to grey brown sand, with 5% gravel. SoilpH ($CaCl_2$) was 6.3 in the 0-10cm horizon, decreasing to 4.8 in the 10-30cm layer. Soil organic carbon decreased from 1.42% at the surface to 0.47% in the 10-30cm layer. Electrical conductivity was low at 0.095 dS/m.

PredictaB

Sampling for PredictaB soil pathogen testing occurred on 27 May 2020, prior to seeding. The resultsshow a high risk of the pathogens Blackspot and Charcoal rot, with a medium risk of Take-all and Pythium clade f (Table 1).

Table 1: Summary of PredictaB results for the demonstration site.

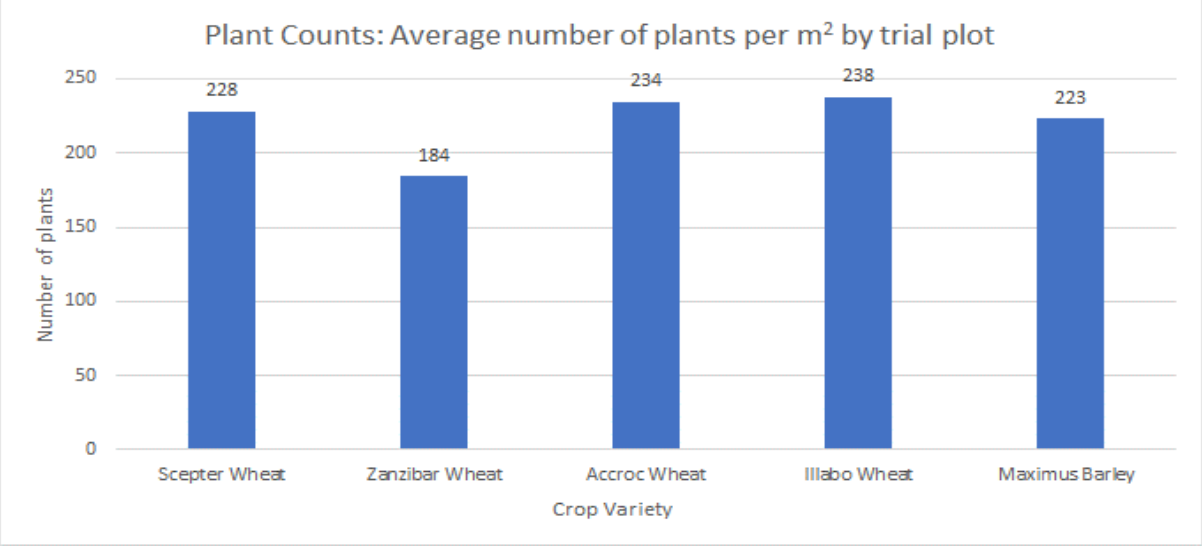
Test	Unit	Baseline 2020
Take -all	Log (pg DNA/g soil)	1.64
Rhizoctonia	Log (pg DNA/g soil)	1.02
Crown rot	Log (pg DNA/g soil)	1.62
Blackspot	Log (pg DNA/g soil)	3.21
Pythium clade f	Log (pg DNA/g soil)	2.65
Charcoal rot	Log (kDNA copies/g soil)	4.68
Sclerotinia stem rot	Log (kDNA copies/g soil)	0.21

Key: Yellow: Low disease risk, Orange: medium disease risk, Red: High disease risk

Plant Counts

Plant counts for the red wheat project trial sites occurred on 20 July 2020. The average number ofplants by variety ranged between 184 plants/ m^2 for Zanzibar wheat and 238 plants/ m^2 for Illabo wheat (Figure 2).

Figure 2: Average plant counts at 8 weeks after planting.



Crop Observations

No signs of pests or disease were evident during crop observations recorded on 20 July 2020,however weeds including volunteer lupins, capeweed and barley grass

were present.

Growth Stage Comparisons

Growth stage comparisons were recorded on 31 August 2020 (Table 2).

Table 2: Cereal growth stage – 31 August 2020

Variety	Growth Stage Replicate 1	Growth Stage Replicate 2
Scepter – spring wheat	Early booting	Jointing
Zanzibar – red wheat	Tillering - Start Jointing	Jointing
Accroc – red wheat	3 Leaf Stage	Tillering
Illabo wheat – dual purpose winter wheat	Tillering	Start of jointing
Maximus barley	Full boot	Early booting

Tiller counts

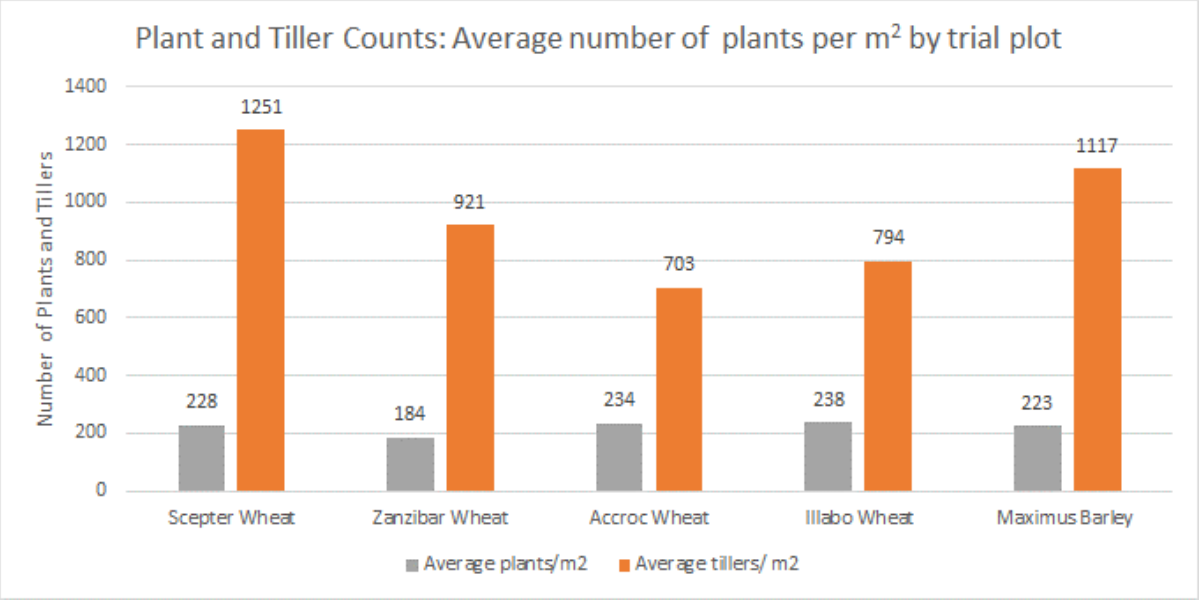
Tiller counts were conducted on 31 August 2020 (Table 3). Results show that the Scepter spring wheat had the highest average number of tillers (average of 5.5 tillers per plant and 1,251 tillers persquare meter), with the Accroc red wheat having the lowest average number of tillers (average of 3 tillers per plant and 703 tillers per square meter).

Table 3: Cereal tiller count – 31 August 2020

Variety	Average tillers per plant	Average tillers/ m^2
Scepter – spring wheat	5.5	1251
Zanzibar – red wheat	5.0	921
Accroc – red wheat	3.0	703
Illabo wheat – dual purpose winter wheat	3.5	794
Maximus barley	5.0	1117

The average number of plants (m^2) and the average number of tillers (m^2) are shown in Figure 3.

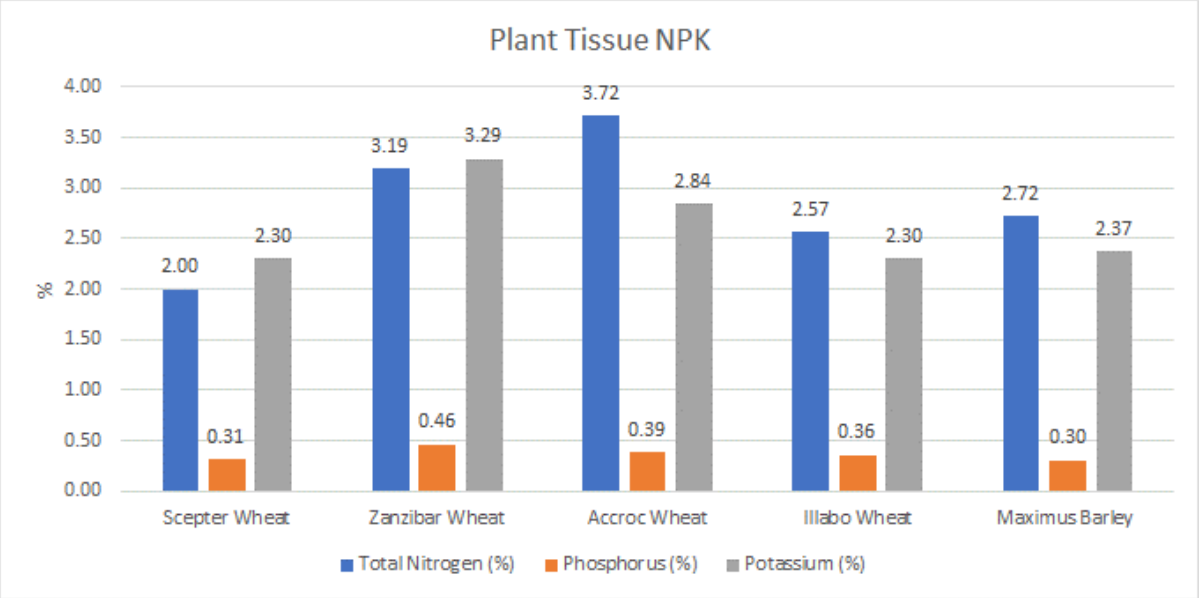
Figure 3: Average plant and tiller counts at 8 weeks after planting.



Tissue Analysis

Tissue samples collected on 8 September 2020 from each trial plot were analysed for a range of nutrients (Figure 4). Sceptre wheat had the lowest percentage of nitrogen (2%), while Accroc wheathad the highest percentage of nitrogen (3.72%).

Figure 4: Plant tissue nutrient status at 9 weeks after planting.



Normalized Difference Vegetation Index (NDVI)

The NDVI of the trial sites was measured on 31 August 2020 to quantify the density of plant growth.The crop weed status at this time is unknown. The NDVI values ranged from 0.66 for Maximus Barley to 0.81 for Accroc Wheat (Table 4).

Calculations of NDVI provides a number that ranges from minus one (-1) to plus one (+1). No green leaves give a value close to zero (ie: no vegetation). An NDVI close to +1 (eg: 0.8 - 0.9) indicates the highest possible density of green leaves.

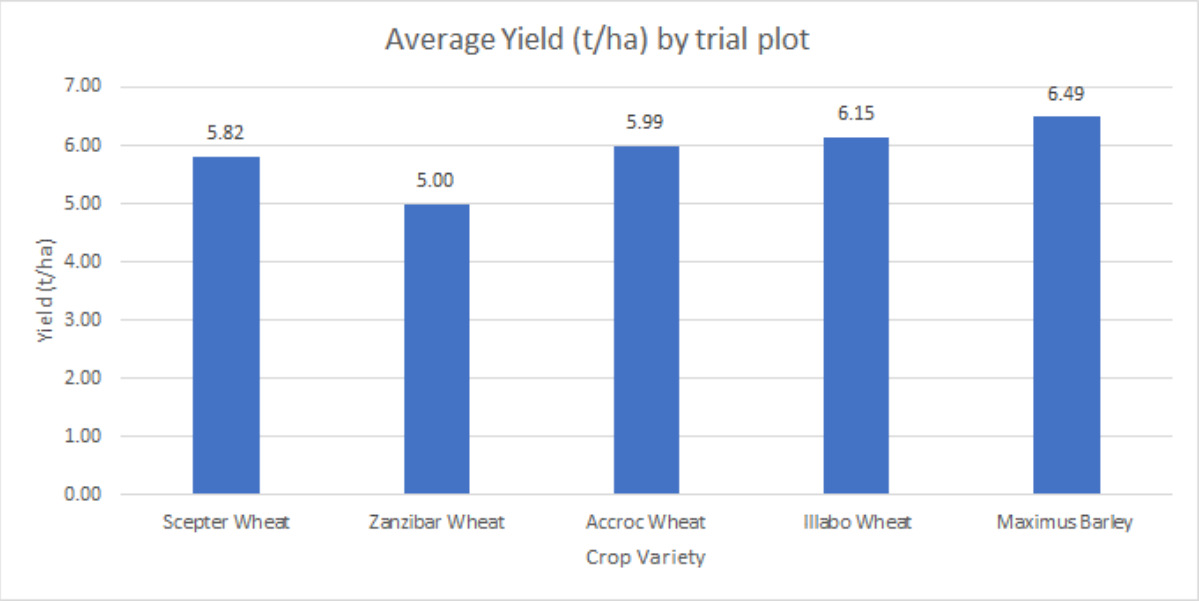
Table 4: NDVI counts at 8 weeks after planting

Variety	Average NDVI
Scepter – spring wheat	0.76
Zanzibar – red wheat	0.79
Accroc – red wheat	0.81
Illabo wheat – dual purpose winter wheat	0.79
Maximus barley	0.66

Harvest Yield Data

Across the trial, average yields ranged between 5.0 t/ha for Zanzibar wheat and 6.49 t/ha for Maximus Barley. Accroc wheat had the highest yield of the two red wheats at 5.99 t/ha (Figure 5).

Figure 5: Harvest 2020 yield.



CONCLUSIONS

The first year of results from the red wheat demonstration trials indicate the yield of the two red wheat varieties are comparable to yield of cereals currently grown in the district. Cereal yield fromhighest to lowest was as following: Maximus barley (6.49 t/ha), Illabo dual purpose wheat (6.15 t/ha), Accroc red wheat (5.99 t/ha), Scepter spring wheat (5.82 t/ha) and Zanzibar red wheat (5.00t/ha).

The second growing season will determine the effect of seasonal conditions on the growth of the redwheat. Plant establishment counts, tiller number, biomass assessment, weed and plant disease scores, yield and grain quality information will provide useful data for the assessment of the suitability of red wheat in the western high rainfall zone.

The red wheat be planted much earlier during 2021, with the long season variety (Accroc) beingplanted by early April, pending seasonal conditions. The yield of Accroc may have been compromised during 2020 by the late planting date of this long season red wheat.

Ripper Gauge demonstration sites
Albany Port Zone

2020 Annual Results

Authors: Nathan Dovey and Sheridan Kowald

Project Lead: Stirlings to Coast Farmers

Project Partner: Southern Dirt

KEY MESSAGES

- The two gravelly trial sites at Darkan and Tenterden did not respond to tillage treatments in the three years of the project indicating these soils are not responsive to the treatments installed.
- The Broomehill trial site, which had responsive tillage treatments in 2018 and 2019, had no significant yield differences from any treatments in 2020. The benefits from tillage have dissipated in the third season after treatment.
- The Kojanererup sandplain trial site was highly responsive to deep ripping to 50cm in 2020. The application of clay before seeding in 2020 removed the wind erosion risk and improved soil wettability and nutrient holding capacity. The grower plans to deep rip this paddock to achieve full amelioration of soil constraints and maximise grain yields.

SUMMARY

- **Tenterden**: There were no statistical yield increases from any tillage treatments compared to the untreated control in 2020, consistent with the 2019 results.
- **Kojoneerup:** Significant wind erosion in 2018-19 motivated the Goad family to spread clay over the demonstration paddock to reduce non-wetting expression and wind erosion risks. The machinery recompacted the soils through the claying process and removed the 2018 deep ripping benefits. After clay-spreading and incorporation in 2020, three 50m by 50m quadrants were deep ripped to 50cm using a Nufab Tilco ripper. Deep ripping to 50cm averaged a 1.3t/ha yield advantage over the un-ripped soil in 2020.
- **Darkan:** There were no significant improvements in grain yield from any tillage treatments compared to the untreated control in 2020. The 2020 results were consistent with the 2019 data.
- **Broomehill:** There were no significant improvements in grain yield from any tillage treatments compared to the nil treatment in 2020. Last year was the first time since the treatments were installed (2018) that there were no yield benefits from the soil amelioration over the untreated control.

BACKGROUND

Soil amelioration is a vital part of farming systems in Western Australia to overcome soil constraints, which limit crop yields. The removal of soil constraints such as compaction and water repellence through strategic tillage practices usually increases crop yield in successive years. One of the

limitations of deep tillage is that the compaction amelioration is not permanent, and the soil will recompact in the following years.

Currently, the solution is to repeat deep ripping or other ploughing treatments every few years, with the time between tillage operations dependant on the soil type and amount of wheeled traffic on the paddock. Deep ripping is a costly and repetitive process that may become unsustainable in the long term if soils become compacted to greater depths with successive tillage treatments and heavier machinery. While there is an extensive network of demonstration sites established across the port zones in WA, there are many soil types where the benefit and longevity of soil amelioration practices are unknown. The use of controlled traffic practices can be implemented to increase the longevity of soil amelioration practices by reducing soil compaction from farm machinery. However, the implementation of controlled traffic farming has been slow in the Albany port zone, especially in comparison to farmers in the Geraldton and Esperance port zones.

OBJECTIVES

Growers in the Albany port zone will use the 'Ripper Gauge' demonstration sites to increase knowledge and adoption of deep ripping and controlled traffic farming to alleviate non-wetting soils, compaction, and waterlogging on their soil types and farming systems. Growers will also understand that ripping benefits decline over time and re-compaction is accelerated in non-controlled traffic farming systems.

METHODS

Four ripping trial sites were established in 2018 in the Albany port zone on differing soil types. A fifth trial site was launched in Tenterden in 2019 to replace the site at Tambellup that was abandoned due to poor crop growth in 2018. Ripping at this site was extremely difficult in 2018 due to the dry summer conditions and high soil strength.

Table 1. Trial locations, hosts, crop and soil type, and treatment types

Location	Host	Soil type	Crop	Treatment date	Treatments
Kojaneerup	Josh Goad	Sandplain over Gravel	Mako Canola	20 March 2018	Tilco 40cm Tilco 65cm Depthcharger 40cm Depthcharger 50cm Nil-Control Scarifier 20cm
Tenterden	Lindsay Watterson	Gravelly loam	Planet Barley	4 April 2019	Plozza Plough Horsch Tiger Ripper Shallow disc Nil-Control
Broomehill	Craig Bignell	Gravelly duplex	Scepter Wheat	15 February 2018	M.B.P. & Rip 25cm Nil-Control "deep" Rip 25cm Plozza & Rip 25cm Plozza 20cm
Darkan	Paul Duffield	Non-wetting Gravel	Planet Barley	22 March 2018	Depth Charger 35cm Mouldboard 30cm Terraland 35cm Nil-Control

Trial

The demonstrations included different ripping treatments at each site; see table one above for a summary. Each trial had at least two replicates, which allowed for statistical analyses to be completed. Baseline measurements of soil fertility were collected before seeding in the initial year at all sites. The soil strength was measured for each treatment at each demonstration site in the winter of 2018. This was to ensure soil strength measurements were collected when the soil was at field capacity. The trial protocol stated that we would re-measure the soil strength in 2020 to evaluate the longevity of each treatment. Unfortunately, the dry season in 2020 meant the soil did not reach field capacity, and therefore accurate soil strength measurements were not possible. We will collect the soil strength data in the 2021 season to see if the soil has become recompacted during this time. Pre-season soil testing was carried out at the three 2018 established trials before seeding in 2019 and 2020.

Before seeding in 2020, the Goad family hosting the Kojaneerup site decided to spread clay on the entire trial paddock to reduce the risk of wind erosion and mitigate the effects of their non-wetting sandy topsoil. Applying and incorporating clay requires heavy machinery (>40 tonnes) moving over the paddock in random directions. The clay-spreading process recompacted the soil to levels similar to the untreated control in 2018. The grower planned to deep rip the paddock again before seeding the winter crop in 2020 to complete a total amelioration solution. However, he was unable to do this due to time constraints.

Researchers at SCF were able to mark three 50m by 50m quadrants in the paddock that the grower deep ripped before seeding in 2020. By utilising 3m satellite imagery, SCF researchers monitored the NDVI over the growing season. Yield data was collected from the grower's harvester, and the ripped quadrant yields were compared to the surrounding unripped area. We collaborated with DPIRD statistician Andrew Van Burgel to determine the most appropriate statistical method for yield comparisons between ripped and unripped treatments. Soil strength was measured at field capacity after heavy rainfall in early August. Results are being collated by project leaders, The West Midlands Group.

We are continuing to ascertain the costs of soil amelioration per hectare for each machine by talking to farmers and contractors familiar with each machine over various soil conditions and types. We are currently using the farmer experience to estimate the accurate costing of each machine and working depth. This information will be available to publish in the final trial report in 2023.

LOCATION

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1	-34.511306°	118.331189°
Nearest Town	**Kojaneerup**	
Trial Site #2	-34.25'30.45°	117.25'11.80°
Nearest Town	**Tenterden**	
Trial Site #3	-33.849625°	117.717228°
Nearest Town	**Broomehill**	
Trial Site #3	-33.272609°	116.632916°

Nearest Town	**Darkan**

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

RESULTS

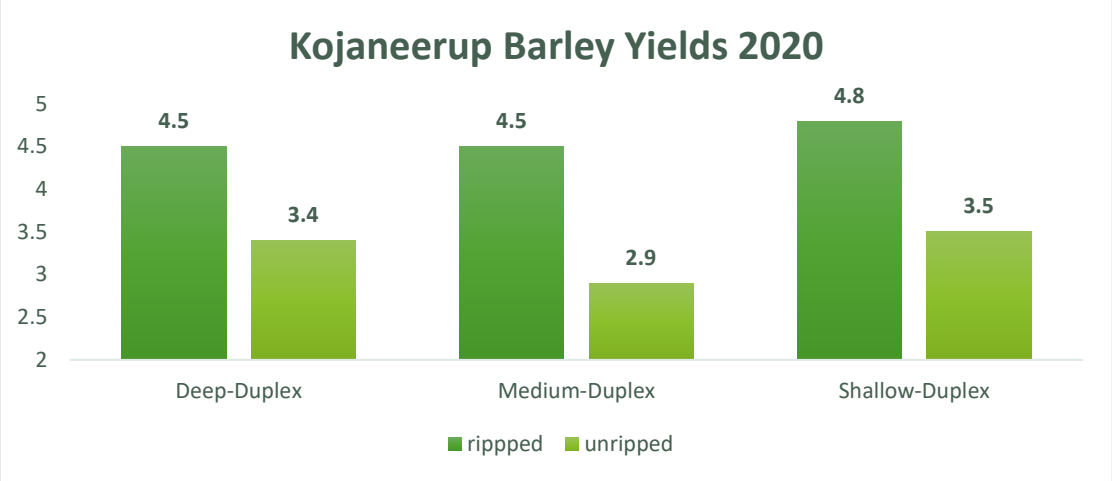


Figure 1. Ripper gauge site located at Kojaneerup, WA. The graph displays 2020 barley yields in (t/ha) comparing deep-ripped quadrants (50m by 50m) to the surrounding un-ripped soil.

Kojaneerup Summary

- Figure one shows a significant increase in grain yield from deep ripping to 50cm using a Tilco deep ripper. The yield increase ranged from 1.1t/ha in the deep-duplex soil to 1.6t/ha in the medium-duplex soil. Yield increases after deep ripping are similar to what was measured in 2018 in the same paddock.

- There were no statistical differences in any treatments for any of the NDVI data sets in 2020.

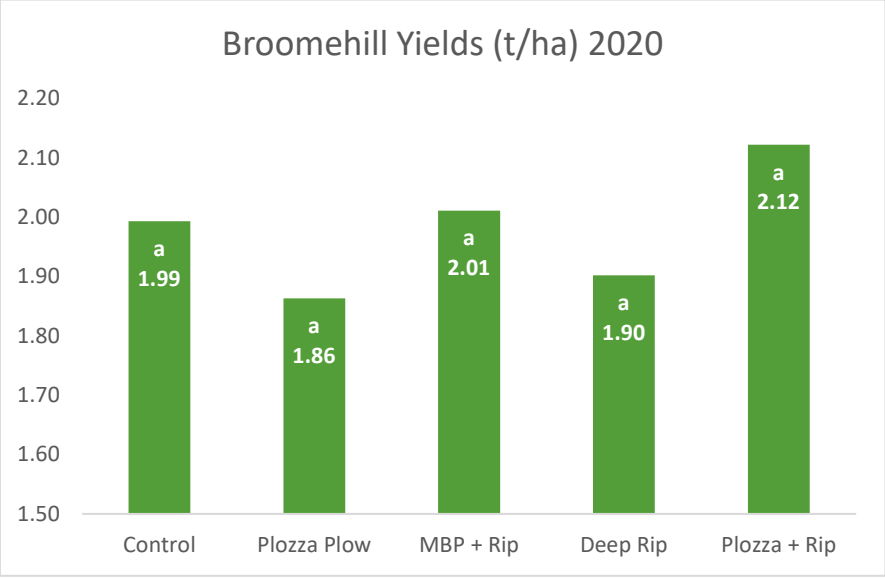
- The wind erosion in both 2018 and 2019 forced the growers to act to reduce further damage to their fragile sandy topsoil. Spreading and incorporating clay is a well-established method of reducing wind-erosion, non-wetting expression and increasing water and nutrient holding

capacity. The downside to applying clay is that it is expensive and time-consuming to complete. After the claying process, the grower wanted to deep-rip the paddock to complete the full soil amelioration package before seeding in 2020. Time constraints did not allow for deep ripping of the whole paddock but did allow SCF researchers to re-measure deep ripping effects on this paddock.

- In 2018, the treatment yields were affected by wind erosion, affecting plants numbers and early growth. Before seeding in 2020, the whole paddock had over 200 t/ha of clay spread and incorporated into the top 20cm of soil. Researchers worked with the grower to test a 'full amelioration' package, which combined spreading clay and deep ripping the soil to 50cm using a Tilco deep ripper. The yield improvement from ripping + clay compared to unripped + clay was significant. The minimum yield improvement was 1.1 t/ha of barley in 2020. An on-farm barley price of $270/t means that the deep ripping was $297/ha better than the unripped + clay treatment. Deep-ripping costs have been calculated at $90/ha, which means there was a minimum $207/ha benefit in the first year after deep ripping. Spreading & incorporating clay at 200 t/ha is estimated to cost between $800-1000 per hectare in the Kojaneerup region. Although highly expensive, the soil condition's improvement is permanent, allowing payback to occur over many years.

- The highest yield increase from the deep ripping was on the medium-duplex soil type, a 1.6t/ha barley yield increase in 2020. Using the same on-farm barley price of $270/t and deep ripping costs of $90/ha gave improved profits of $342/ha on this soil type.

- The Kojaneerup ripper gauge demonstration did not show significant yield improvements in the first year due to wind-erosion damage. In 2019, wind erosion and hail damage also combined to make meaningful yield analysis a challenge. Our 2019 data indicated no significant difference in yields for any treatment, including the untreated control. The 2020 data was essential to show the benefits of deep ripping in the first year on deep sandplain soils. The longevity of the ripping benefits is not known at this location. Based on results at other ripper gauge demonstration sites, a maximum of two years can be expected before deep ripping must be repeated to remove soil compaction.



Means followed by the same letter or symbol do not significantly differ (P=.05, LSD.)

Figure 2. Ripper gauge site located on the Bignell's Farm in Broomehill, WA. This graph displays the average 2020 Canola yields in (t/ha).

Table 1. Summary of the Normalised Difference Vegetation Index (NDVI) readings from 26 June and 2 September, at the Broomehill (Bignell),) Ripper Gauge demonstration site in 2020.

Treatment	Ave NDVI 26/06/2020	Ave NDVI 02/09/2020
Control	0.31 a	0.42 c
Plozza Plough	0.41 a	0.55 ab
Mouldboard Plough + Rip	0.26 a	0.49 b
Deep Rip	0.34 a	0.43 c
Plozza Plough + Rip	0.36 a	0.61 a

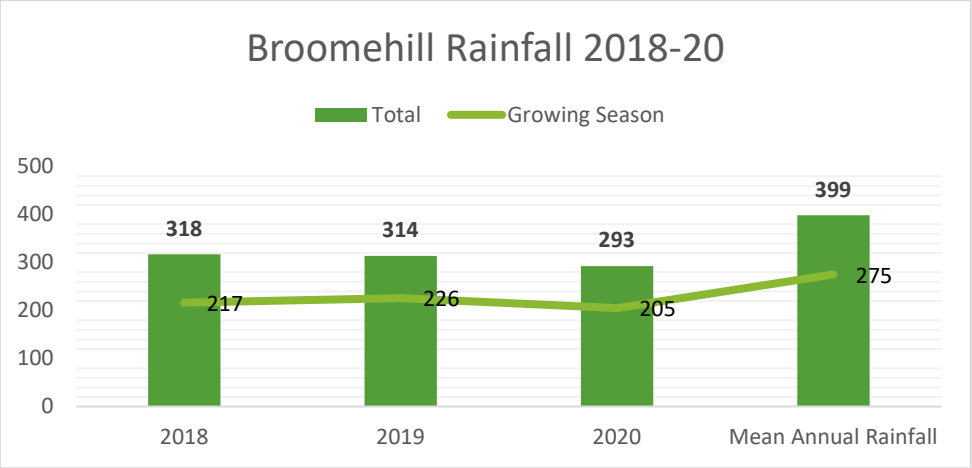


Figure 3. Rainfall data from the Gnowangerup Bureau of Meteorology site, which is the closest weather station to the Broomehill Ripper Gauge site. The graph displays the growing season and annual rainfall (millimetres) compared to the long-term average rainfall for both.

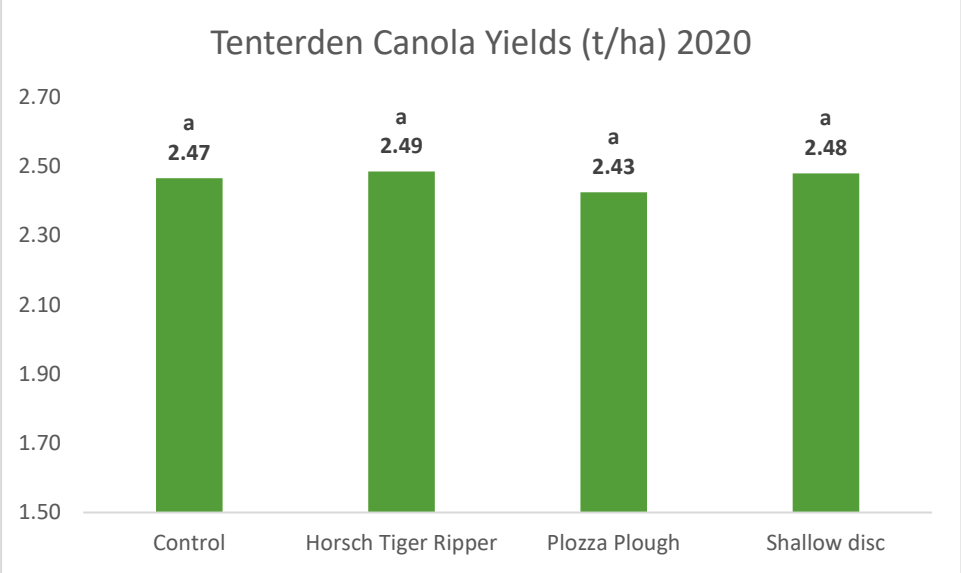
- None of the four soil amelioration treatments yielded significantly different to the untreated control (UTC) in 2020.

- In 2019, three of the four amelioration treatments yielded significantly higher than the untreated control. The Deep Rip treatment yield 200kg more than the control but was not significantly different from the control. *Data not shown in 2020 Annual Report*

- Growing season rainfall was marginally less (205mm) in 2020 than in the 2018 and 2019 seasons of 217mm and 226mm, respectively. All three years from 2018-20 received less growing season and total rainfall than the mean.

- The 2020 winter growing season was the third crop grown at the Broomehill Ripper Gauge demonstration site. Results showing no significant difference from the soil amelioration treatments indicate the benefits only last for two years.

- There were no statistical differences in any treatments for any of the NDVI data sets in 2020.



Means followed by the same letter or symbol do not significantly differ (P=.05, LSD.)

Figure 4: 2020 Canola yields (t/ha) at the Ripper Gauge Tenterden site hosted by the Watterson family.

Table 2: The Molarity of Ethanol Droplet (MED) test results from the Tenterden Ripper gauge site in February 2020. The MED test measures the concentration of ethanol required to penetrate the soil in under 10 seconds.

Molarity of Ethanol	Description of Severity
0	Not Apparent
0.1-1.1	Low
1.1-2.3	Moderate
2.3-3.5	Severe
>3.5	Very Severe
Treatments	***Average Molarity***
Horsch Tiger Ripper	0.85
Shallow Disc	1.27
Plozza Plough	0.7
Control	0.77

Note: Method taken from Cater, D.J. (2002) Water repellence. In NJ. McKenzie *et al.* Soil Physical Measurement and Interpretation, CSIRO Publishing, Collingwood.

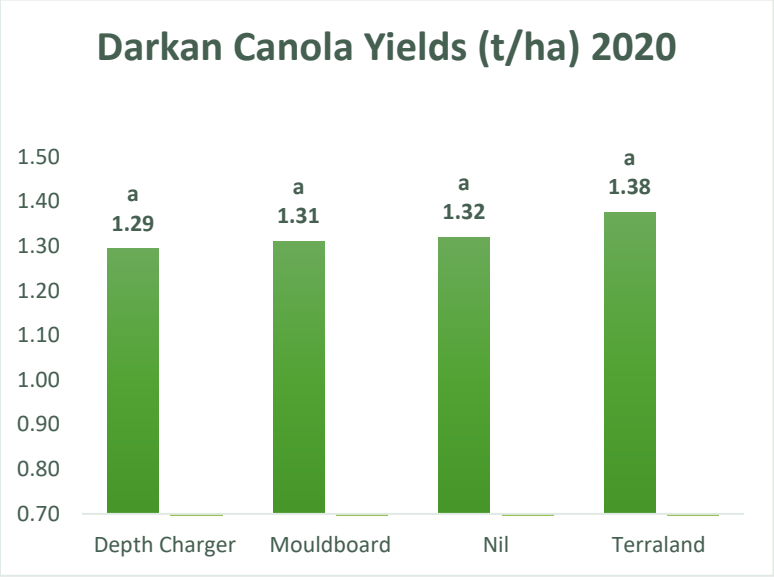
Table 3: Summary of the Normalised Difference Vegetation Index (NDVI) readings from 20 June, 21 July, 5 September and 29 October at the Tenterden (Watterson),) Ripper Gauge demonstration site in 2020.

	NDVI

Treatment	20/06/2020	21/07/2020	5/09/2020	29/10/2020
Control	0.48 a	0.76 a	0.68 a	0.45 a
Horsch Tiger Ripper	0.47 ab	0.74 a	0.70 a	0.43 a
Plozza Plough	0.45 b	0.74 a	0.69 a	0.43 a
Shallow disc	0.47 a	0.75 a	0.70 a	0.45 a

Means followed by the same letter or symbol do not significantly differ (P=.05, LSD.)

- All treatments in 2020 did not yield significantly different from each other. There were no significant yield differences in wheat in the 2019 season either.
- Normalised Difference Vegetation Index (NDVI) readings were taken at four different times during the growing season. The Plozza Plough treatment had significantly lower biomass on the 20 June only. Every other treatment and timing showed no significant NDVI differences during the 2020 growing season.
- In February 2020, we tested the severity of the non-wetting soil at the Tenterden site. The topsoil non-wetting ratings, using the Molarity of Ethanol Droplet (MED) test, were low for; the control, Horsch Tiger Ripper and Plozza Plough. The shallow disc treatment rated in the moderate range for M.E.D testing. The four treatments' non-wetting severity was not a significant factor at this ripper gauge site based on these results.
- Data from 2019 indicated that the Watterson trial site was not responsive to deep tillage treatments because there was no soil compaction. We surmise that the Tenterden (Watterson) and Darkan (Duffield) demonstration sites are not compacted due to their gravelly soil type. Research shows that high gravel content, > 15-20% by volume, acts as a supporting framework; therefore, it protects the soil matter considerably from compaction (Rucknagel et al.,2013). This hypothesis was also supported by the depth of root growth observed from soil pit observations made at a 2019 field walk by DPIRD Soils Researcher Jeremy Lemon.



Means followed by the same letter or symbol do not significantly differ (P=.05, LSD.)

Figure 5: 2020 Canola yields (t/ha) at the Ripper Gauge Darkan site hosted by the Duffield family.

Table 4: Summary of the Normalised Difference Vegetation Index (NDVI) readings from 8 June, 13 July and 1 September at the Darkan (Duffield),) Ripper Gauge demonstration site in 2020.

Treatment	NDVI 1 8/06/2020	NDVI 2 13/07/2020	NDVI 3 1/09/2020	Grain Yield %UTC
Depth Charger	0.17 a	0.56 a	0.41 a	98 a
Mouldboard	0.21 a	0.59 a	0.38 a	100 a
Nil	0.24 a	0.61 a	0.42 a	100 a
Terraland	0.19 a	0.61 a	0.42 a	105 a

- Figure 5 displays no significant yield differences in the canola crop grown in 2020.
- In 2019, there were also no significant yield differences between the treatments at this trial site. However, all tillage treatments yielded less than the untreated control indicating that tillage treatments were detrimental to grain yields. The 2020 data set supports the hypothesis that the Darkan site is not responsive to deep tillage treatments.
- NDVI data shows no significant differences between trial treatments at the three different growing season dates.

CONCLUSIONS

All tillage treatments from the 2018 applications at the Darkan and Broomehill sites yielded statistically equivalent to the untreated control (UTC) in 2020. Furthermore, the Tenterden site, installed in 2019, achieved no significant yield gains from the tillage treatments tested in 2019 or 2020. Due to the gravelly soils at the Tenterden and Darkan sites, compaction is likely not an issue due to the high gravel content. Research shows that high gravel content, >15–20% by volume, acts as a supporting framework; therefore, it protects the soil matter considerably from compaction (Rücknagel et al., 2013).

The Broomehill trial site was responsive to tillage treatments in the 2018 and 2019 seasons. In 2018 (lupins), the Plozza Plough and Mouldboard Plough + Deep Ripping treatments yielded significantly higher than the UTC. In 2019 (wheat), the same two treatments plus the Plozza Plough + Deep Ripping all yielded significantly higher than the UTC. None of the four soil amelioration treatments yielded significantly different to the UTC in 2020. Compaction data was not collected in 2020 due to the soil not reaching field capacity. Penetrometer data will be collected in the winter of 2021 to determine if the ground has recompacted and if that is why the loss of yield benefits in the tillage treatments that were responsive in 2018-19.

In 2020, the Kojaneerup site was finally able to measure the benefits of deep ripping sandplain soils. In 2018, the site was severely affected by wind erosion which also carried over into the 2019 season. Late in the 2019 growing season, the grower also received hail damage, with his insurance company paying out a 26% damage claim on the demonstration paddock. The complete amelioration package of spreading clay and deep ripping is expected to make the paddock highly productive, which we saw in 2020 with excellent yields given the difficult season. During the three-year project, soil researchers have speculated that re-compaction is caused by machinery traffic and water-logging events. There has been widespread waterlogging in the first half of 2021, which will provide SCF with an opportunity to test this

hypothesis. We will re-visit our three 50m by 50m quadrants, measure the soil strength, and collect the grain yield data from the grower after harvest.

Appendix:

The following three figures represent the soil strength measured by cone penetrometers in 2018. Soil strength was measured in the winter when the soil was at or near field capacity. Fifteen penetrometer measurements were taken per plot, and each replicate was combined to create the visual summaries displayed below. We planned to collect the final soil strength data in 2020, three years after application, for comparison. However, the dry season meant the soil profile never reached field capacity in 2020, and final soil strength measurements will be collected in 2021 instead. We are very interested in measuring the longevity of the soil loosening treatments. Given the grain yields have dissipated, even at the most responsive Broomehill site by 2020, we suspect the soil has recompacted to levels that restrict plant root growth.

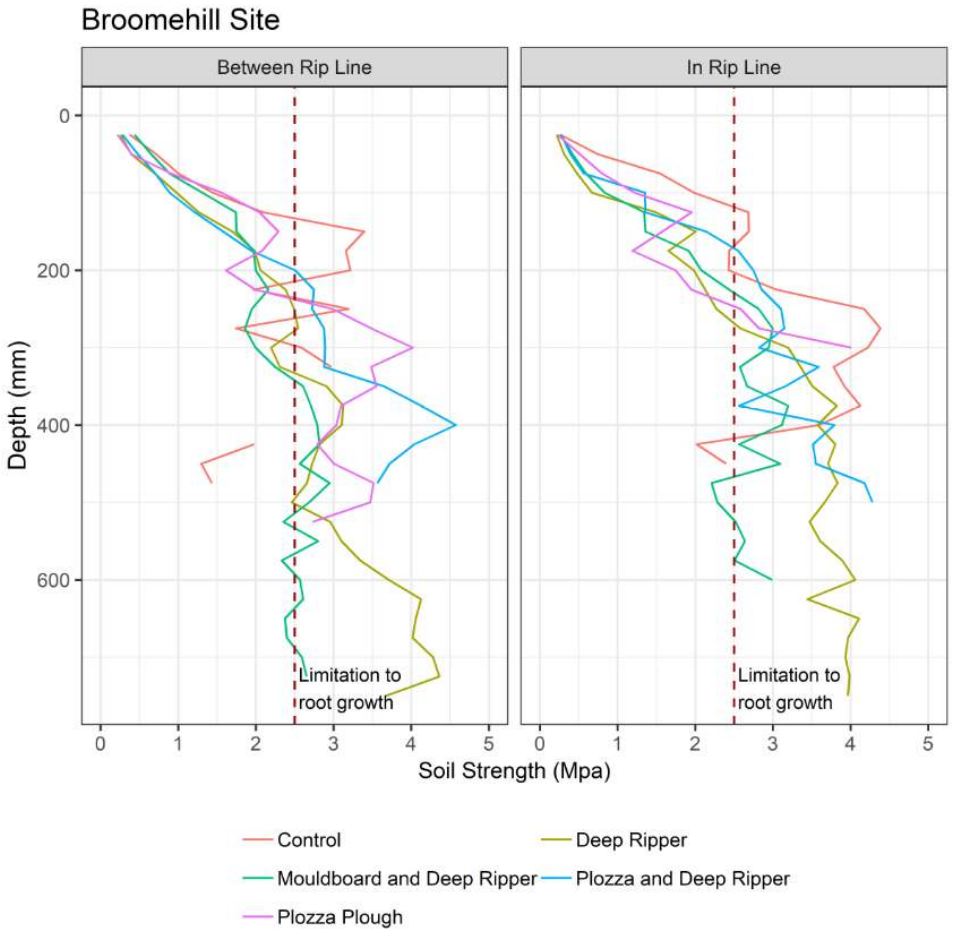


Figure 1 (Appendix): Summary of the soil strength measurements at the Broomehill Ripper Gauge demonstration site measured in the winter of 2018. Soil strength data is split into measurements taken from within the rip line or between the rip line (if applicable to that treatment).

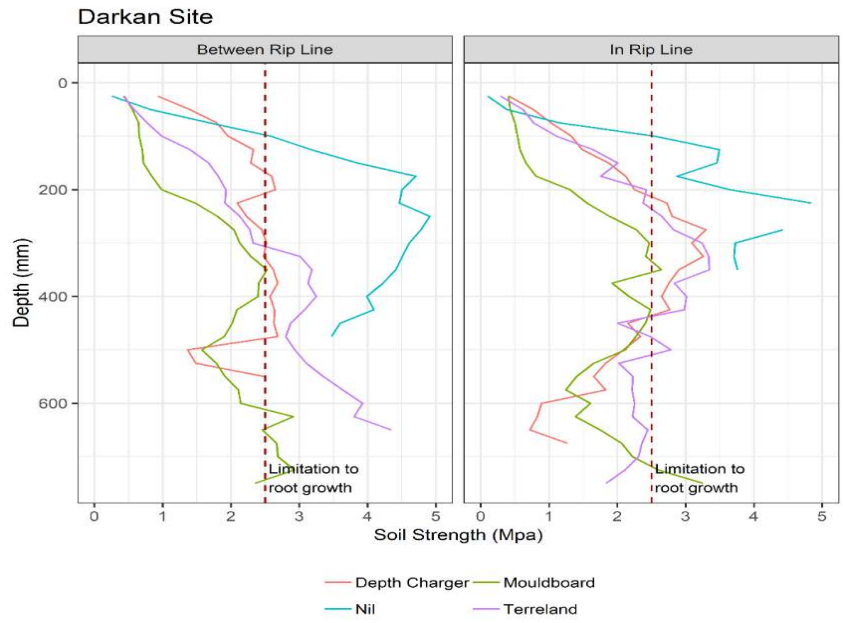


Figure 2 (Appendix): Summary of the soil strength measurements at the Darkan Ripper Gauge demonstration site measured in the winter of 2018. Soil strength data is split into measurements taken from within the rip line or between the rip line (if applicable to that treatment).

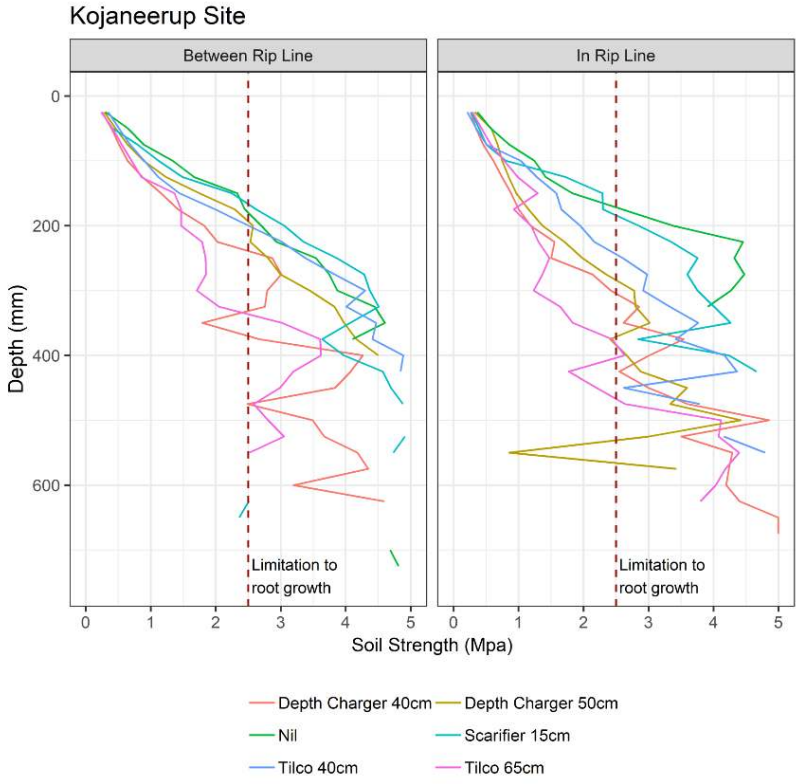


Figure 3 (Appendix): Summary of the soil strength measurements at the Kojaneerup Ripper Gauge demonstration site measured in the winter of 2018. Soil strength data is split into measurements taken from within the rip line or between the rip line (if applicable to that treatment).

REFERENCES & USEFUL LINKS

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

Managing wind erosion in southern Western Australia – Justin Laycock DPIRD - https://www.agric.wa.gov.au/wind-erosion/managing-wind-erosion-southern-western-australia

The changing options for soil compaction management in the WA wheatbelt - Bindi Isbister Department of Agriculture and Food WA, James Hagan, Department of Agriculture and Fisheries QLD, and Paul Blackwell, Department of Agriculture and Food WA

The influence of soil gravel content on compaction behaviour and pre-compression stress, Jan Rücknagel, Philipp Götze, Bodo Hofmann, Olaf Christen, Karin Marschall, Geoderma, Volumes 209–210, 2013, Pages 226-232, ISSN 0016-7061

Innovative ploughing method stands up to sand – GRDC groundcover page 43 of GC South; West issue 136 September – October 2018

Ripping benefits quickly negated by wheel traffic - GRDC groundcover GC West issue 118

‘Demonstrations of legume crops for reliable profitability in the Albany Port Zone’

Authors: Nathan Dovey

Project Lead: Stirlings to Coast Farmers

Project Partner: Southern Dirt

Abstract

The need for profitable pulse crops in the Albany Port Zone (APZ) is urgent due to the increased pressures from disease, weeds and poor soil health on the dominant cereal and canola rotations. Grain legumes are not widely grown in the APZ as they are considered high risk and unprofitable by growers. The project aimed to quantify the whole system benefits legumes bring to cropping rotations. By communicating the whole-system benefits of legume crops, the project aimed to increase the number of hectares grown in the APZ. Seven legume demonstrations were grown between 2018-2020. Each site grew at least four legume crops selected as suitable for the local environment. Five sites also recorded cereal yields and changes to soil nutrition and disease levels in the following year. Consultants ‘Farmanco’ completed an economic analysis looking at each legume and cereal crops’ two-year profitability. Legumes were profitable when grain prices are reasonable, agronomy is well-managed, and the seasonal conditions are average or better. When any of these three key pillars are compromised, legume crops struggle to be profitable. Demonstrations in this project indicated that lupins and faba beans were the most suitable legume crops for the high rainfall zone.

Executive Summary

The Farming systems in the Albany port zone would benefit significantly with the addition of pulse crops into current cropping rotations and the need for profitable pulse crops suitable for the zone is urgent. Growers are already experiencing increased pressures from common cereal and canola diseases, weeds and soil health issues due to a lack of crop diversification. Growing another crop species would allow growers to rotate more herbicide and fungicide groups to combat resistance pressures.

This project aimed to demonstrate to farmers that it is possible to break up the dominant cereal-canola-cereal-canola rotation with the addition of a legume pulse crop, slowing both foliar and root diseases across the region. Legumes can be an effective break for soil-borne pathotypes such as root-lesion nematodes, take-all and Rhizoctonia. They also provide a break from stubble-borne diseases such as Spot-Form Type Blotch (SFTB) and Net-Form Type Blotch (NFTB) in barley and *Septoria tritici* and *Septoria nodorum* in wheat.

There were seven different demonstration sites grown between 2018-2020 in the Albany port zone. Five of the seven sites had the cereal yields from the second year recorded, and Farmanco completed a two-year economic analysis comparing each legume crop. The data generated as part of this project was realistic to our growers' current experiences with legume crops.

The project began in 2018, which was a dry year for most of the Albany port zone. This was detrimental to the Carrolup and Kojaneerup demonstration sites but beneficial to the Frankland site in the high rainfall zone (HRZ) as it resulted in a reduced incidence of waterlogging. Due to the poor growing season in 2018, the GRDC invested in more demonstration sites located at Amelup, Gnowellen, Broomehill and Muradup in 2019. A second dry season in 2019 that also saw significant spring frosts damaged the eastern sites of Gnowellen and Amelup. The medium and high rainfall sites of Broomehill and Muradup produced decent legume yields in 2019. In 2020, a variation was obtained to measure the cereal yields from the second year at those sites.

Each legume demonstration grew at least four different cropping options for the local environment. Growers compared the new crops and varieties to lupins, which is the most familiar legume crop to growers in the Albany Port Zone. The demonstrations helped determine one or two legume options for other local growers to pursue and often a couple of legume crops that were not suitable for the local environment. For example, at Frankland, the project showcased the waterlogging tolerance of Faba beans compared to Lentils.

In summary, the project demonstrated that legume crops are less resilient than wheat, barley or canola to challenging environmental conditions such as heat stress, frost, and waterlogging. Additionally, the price volatility of legume grains during the project was apparent and was far greater than wheat, barley or canola. The variation in legume prices makes it challenging to create farm budgets. When legume prices are high, the profits are comparable to growers' current break-cropping options, which was a positive finding.

In all cases, the legume grower hosts gained a stronger understanding of the different legume crops' strengths and weaknesses, which encouraged most of them to continue planting small areas in the years after hosting a demonstration site. In one case, the grower was trying legumes for the first time in many years and copped a tough season, seeing all legumes perform poorly. However, the growers' control canola crop also yielded an unprofitable 520kg/ha, highlighting how tough the 2019 season was.

Despite knowing this, the grower was not prepared to continue exploring legume crops, citing the lack of profitability in 2019. Although disappointing, this scenario would represent what many WA growers experience when frost and heat stresses are encountered during flowering. The failure of a legume crop can validate a grower's pre-conceived idea that they are unreliable and unprofitable in WA cropping systems. We believe this is a significant factor in the current low uptake of legume cropping.

Throughout this project, grower group staff and participating growers experienced the typical difficulties of growing legume crops. For example, field peas lodged at Frankland River in 2018, and lost yield due to the harvester's inability to pick up the crop. Additionally, due to harvesting low to the ground on gravelly soil, the grain sample obtained lots of rocks which would have limited sales to feed only. From talking to regular field pea growers in the area, it is apparent that this can be a common problem, and commercial grain cleaners were also unable to remove rocks from the sample so the grain could be delivered to CBH.

Measurements were collected over the two-year demonstration sites on changes to the soil fertility, root and soil pathogen profile, and the grain quality of the following cereal crop. In general, little difference was found in the disease risks, grain quality and yield, and the nitrogen fixed by the legume crops. Some of these benefits would have been reduced because of the dry and frosty environmental conditions in 2018-19. Still, it is surmised that measurable benefits from growing legume crops are likely to accumulate over time, making it difficult to ascertain in only 12 months.

The Crop Sequence Modelling workshops were conducted at Wellstead and Kendenup in early 2021, with the Kendenup presentation recorded on video by Southern Dirt to be distributed later. Farmanco presenters Ben Curtis, Brent Pritchard and Mark Lawrence summarised the agronomic benefits from growing legumes and presented the economic analysis derived from the project demonstration sites. Farmanco also presented anonymous client data from the Esperance region showing the financial performance of different legume crops over time. Farmanco highlighted the legume price variability compared to standard crops and discuss how that affects grower budgeting.

Growers have absorbed the results of this project since the beginning of 2018. The problematic seasons of 2018 and 2019 need to be considered since proven break crops like canola also struggled in the same environmental conditions. The legume demonstrations highlighted that growers' experience is important in the success of growing a profitable legume crop, with the most successful sites, Frankland, Muradup and Broomehill, having hosts that regularly grow these types of crops.

Researchers, grower hosts and agronomists, saw the importance of correct legume agronomy for the seasonal conditions. Since the weather is not with the influence of growers, they need to ensure that they invest in

getting those factors they can influence, right, to give legume crops the best chance of success. For example, soil pH, weed burden, waterlogging risk, paddock frost history, time of sowing, and time of harvest can all be managed by growers and need to be optimised for a successful legume crop.

In addition, it was demonstrated that legume grain prices are much more volatile than wheat, barley and canola. The current price, when making seeding decisions, needs to be considered strongly. Growers also need to think about who they are marketing their grain to because it could make a difference in production costs. For example, if planning to use the grain for livestock feed, rocks in the grain sample are not problematic. However, if the grain is expected to be delivered to a grain handler, the sample needs to be rock free.

The demonstrations showed at least four legume species at each site. In general, growers could determine at least two crops that suited the local region and two that would not be suited in most years and, therefore, would be unlikely to be grown very often. The project has increased farmer experimentation with legume crops and should lead to more hectares being planted in the future.

The project has identified faba beans as the legume crop most suited to the HRZ near Albany. This is due primarily to faba beans tolerance to waterlogging and the reasonable yields at the Muradup, Frankland and Broomehill sites. Faba beans come with their challenges due to their large grain size and the requirement for very high seeding rates. Many air-seeders struggle to seed high rates of beans (150+kg/ha) and high starter fertiliser rates using wide air-seeder bars.

The results of these demonstration trials are most relevant to growers farming close-by to one of the sites. They can be confident that they have a similar environment and perhaps anticipate potential risks that would need to be addressed before growing a legume crop themselves. The results have mainly been circulated to Stirlings to Coast Farmers and Southern Dirt members, and via both groups' social media channels, during the 2018-20 period. The trial results are posted on the online Farm trials website where other growers in WA and Australia can look at the data for greater circulation, and in the SCF Trials Review Booklets produced during this time.

Agronomists advising growers in the Albany Port Zone gained a lot of value from the demonstration sites because they were able to see farm-scale demonstrations of legume crops like lentils, which they may not have seen before. Scrutiny of the results, interaction with the host grower, and physically seeing the crops growing gave enough information to determine which of their clients and client paddocks would suit legume crops and give them increased confidence in recommending them as a potential break-crop to their clients.

Background

Grain growers in the Albany port zone lack diversity during the cropping phase, with a canola-barley rotation the most frequently grown. Growers and agronomists are now encountering serious fungicide and, to a lesser degree, herbicide resistance problems in canola and barley crops. Adding a legume to the cropping phase is one option to improve diversity which will have soil health, disease and weed control benefits that should ultimately help farmers maintain or improve crop yields.

Legume crops are highly valued in the region, given most businesses are mixed farming enterprises where pulse grains are used for livestock feed. Legume crops fix extra nitrogen in the soil for the following season's crop. Growers are already experiencing increased disease pressures in their rotations due to lack of crop diversification and reliance on the same pesticides. Different chemical options to control diseases and weeds on legume crops mean farmers can rotate to other modes of action that will lengthen their effectiveness. Growing a grain legume can be an effective break crop for soil-borne pathotypes such as root-lesion nematodes, take-all and Rhizoctonia. It also provides a break from stubble-borne diseases such as Septoria tritici and
Septoria nodorum in wheat and spot-form type blotch (SFTB) and net-form type blotch (NFTB) in barley.

The problem with legumes traditionally has been that they struggle to be profitable in most seasons. They only appear to turn a profit with higher-than-average yields or prices. Growers need compelling reasons to include them in their cropping program when the profits are so much lower than other possible farming enterprises.

This project aims to quantify the whole system benefits that legumes can bring to growers cropping phase of the rotation. By quantifying and communicating the benefits of growing legume crops, the project aims to increase farmer confidence in planting pulses and ultimately increase the number of hectares planted in the Albany Port Zone.

The Legumes demonstration also aims to raise awareness of the new crop types and varieties available to growers with vastly improved agronomic traits. Growers from previous generations may have had poor experiences previously with legume crops, and this project hopes to reintroduce the idea of growing legume crops to these growers.

Over the past 10-15 years, many SCF growers have been investing heavily in soil amelioration through intensive liming, fertilising and claying programs. This provides more favourable soil conditions for growing grain legumes than 20 years ago. Claying has allowed earlier sowing due to the alleviation of non-wetting topsoils. Intensive liming has increased soil pH, encouraging rhizobia survival, pulse crop growth and nitrogen fixation.

Benefits to growing pulses:

Reduction in diseases

The addition of a profitable legume to a cropping rotation means that farmers can introduce canola, cereal (barley), legume, cereal (wheat) rotation. This rotation would provide a two-year gap between the profitable cereal phases and more than three years between canola crops. The build-up of stubble borne diseases in wheat and barley would be much slower if the rotations had longer intervals between cereal crops. In this example, canola crops would only be grown one year in four, which will reduce the incidence and occurrence of blackleg and sclerotinia, the two major canola diseases affecting WA canola crops.

The introduction of pulse crops can reduce root disease of cereal crops such as root-lesion nematodes (RLN), cereal cyst nematodes (CCN) and Rhizoctonia. However, some pulse crops will still act as hosts for certain diseases and not others. This complication means that a greater understanding of the overall agronomy is required to maximise the benefits of growing pulse crops. Greater diligence is needed to test for root diseases (predicta B), pre-sowing to understand each paddock's root disease profile and choosing the most appropriate pulse crop. This is an example of how agronomic knowledge has improved and increases farmers chances of gaining the maximum benefits from growing pulses.

Nitrogen Fixation

Nitrogen fixation for the following seasons' crop is probably the best-known benefit of growing pulse crops. Many farmers chose to follow a pulse crop with their highest gross margin crop to maximise yields. Previously, a lack of weed control in the pulse cropping phase has weakened this traditional farming strategy. Pulse crops now have increased weed control options, making growing them a reliable option and providing less chance of a weed "blowout" that can have detrimental effects on farming systems for years.

Improved weed control

There are now better pre-emergent weed control chemicals and in-crop weed control spraying

options. An important weed control strategy available to pulse growers is “crop topping”, a technique of spraying a broad-spectrum herbicide, like glyphosate, paraquat or diquat, near pulse maturity to reduce viable weed-set without negatively affecting yield. Crop-topping is a very effective tool for controlling weed seed set at harvest time, but it should always be used as part of an integrated weed management system for controlling weeds.

Improvements in soil biology.

Pulse crops produce many different compounds that feed soil microbes and benefit soil health. Pulse crops significantly impact soil biology by increasing soil microbial activity, even after the pulses are harvested. Pulses have also been shown to exude greater amounts, and different types, of amino acids than non-legumes, and the plant residues left after harvesting pulse crops have different Carbon/Nitrogen ratios than cereal or canola crop residues. The ability of pulses to feed the soil different compounds increases the number and diversity of soil microbes.
Crops grow better in soils that are more “alive” with a diverse array of soil organisms because these organisms break down and cycle nutrients more efficiently, feeding the crops as they grow.
A large, diverse population of soil organisms acts to ‘crowd out’ disease-causing bacteria and fungi, making healthier plants. Growing pulse crops in rotation with other crops enables the soil environment to support these large, diverse populations of soil organisms.

Feed benefits for mixed farmers

Pulse crops are a great source of animal feed for mixed farmers and provide financial savings in freight costs compared to buying in feed. Additionally, farmers growing their own pulse crops for feed have no risk of importing another farmer’s herbicide-resistant weed seeds. Pulse stubbles have a greater nutritional benefit than cereal and canola stubbles for livestock feed in the summer-autumn period.

Finally, pulse crops provide an alternate form of farm income, reducing financial risk and increasing overall profitability.

Project objectives

The majority of growers in the port zones will have access to agronomy packages for pulses/legumes and to whole farm modelling tools for their own farms to determine if particular legumes are profitable in their system. 20% of growers will be actively using these tools to assess the risks and rewards in growing a legume for a break crop on their property by 2021.

Output 1:

Delivery of 3 workshops per port zone on how to run simulations of different break crops; and the impact on profits from the various options. Each half-day workshop will be presented by relevant experts/growers with knowledge on break crops suitable for the port zone (could include researchers, private industry, marketers etc.). The workshops aim to up-skill growers and advisors on the economics of different legume options for the port zone. These workshops should include appropriate presenters and include an analysis (financial and risk) of all rotations pertinent to the port zone.

Output 2:

A total of 3 demonstration sites will be established across each port zone on varying suitable soil types (shallow clay soils, heavy soils, and duplex soil types) and across different management systems. • Year 1 will be a combination of different legume break crops seeded into cereal stubble and canola stubble • Year 2 of this rotation will be cereal seeded into the various break crops and legumes as noted above.

Output 3:

The crop rotation model LUSO (developed by CSIRO's Roger Lawes and others) will also be run alongside to ground-truth the applicability of this model to port zone conditions and upskill new users.

Methodology

In total, seven legume demonstration sites were set up in the Albany Port Zone over the 2018, 2019, and 2020 seasons. Five of these were monitored the following year with a cereal crop. The table below provides a summary of the trial locations and the legumes crops grown at each location.

Table 1: Summary of Legume Demonstration sites grown in the Albany Port Zone in 2019-2021 for the GRDC project PROC-9176077.

Grower	Location	Faba Beans	Field Peas	Chick Peas	Lupins	Lentils	Serradella	Vetch	Canola	Wheat	Barley
Slattery	S. Stirlings- SCF	2018	2018		2018	2018			2018		2019
Hilder	Frankland -SCF	2018	2018		2018	2018			2018	2019	
Moir	Amelup - SCF		2019	2019	2019	2019			2019		
Stanich	Gnowellen - SCF	2019	2019	2019		2019			2019		
Ladyman	Carrolup - S. Dirt	2018	2018	2018	2018				2018		2019
Webb	Muradup – S. Dirt	2019			2019		2019	2019			2020
Bignell	Broomehill – S. Dirt	2019		2019	2019	2019				2020	

Pre seeding tests:

The trials were physically marked out with markers and GPS to identify plots for field observations and field walks. Representative soil samples for 0 - 10 cm, 10 – 20 cm and 20 - 30cm depth were taken from each plot and sent to an approved laboratory for analysis. PreDicta B sampling and testing were collected at each of the sites.

Seeding:

Trials were managed using farm-scale equipment. A minimum of two replicated air-seeder strips were sown in a paddock approximately 200m long. The legumes crops were grown using the best practice agronomy possible, with most of the work being conducted by the growers hosting the sites. Stirlings to Coast Farmers (SCF) and Southern Dirt (SD) research staff sourced pedigree legume seed and inoculated the seed with peat-based inoculum or ALOSCA granules.

Trial Monitoring:

The sites were monitored for weeds, pests, diseases and other incidents, such as frost or heat damage. Plant counts were recorded after seeding to determine if plant germination was within the recommended ranges for each crop.

Harvest:

At harvest time, grower group staff used a weigh trailer to weigh each plot or utilised the harvester yield data to determine the yields of each treatment. SCF precision agriculture expert Philip Honey managed this process. Grain samples were also collected from some sites for testing and analysis.

Soil testing was conducted in each plot in March-April each year to measure any significant differences in the nitrogen fixed from each legume crop or used in the following cereal crop.

Farmanco conducted crop sequencing workshops in conjunction with SCF and SD. Farmanco used the yield data collected from the legume trials to determine the overall value of adding a legume crop into the cropping rotation. Farmanco also shared yield and gross margin data from their own farming clients that regularly grow legumes in their cropping rotations. The farmers that attended the workshops found the provision of real data on legume gross margins very insightful.

Mark Seymour from DPIRD addressing Stirlings to Coast Farmers (SCF) members at their 2018 Spring Field Day at the Frankland demonstration site hosted by the Hilder family. Mark was explaining the relative strengths and weaknesses of the legume crops represented at this demonstration site. Photo taken by Nathan Dovey (SCF R & D Coordinator) on the 27th of September 2018.

Drone image of the Frankland Legume Demonstration site hosted by the Hilder family in 2018. Photo was taken by John Blake (SCF) on November the 8th, 2018.

Location

NOTE: Where field trials have been conducted please include location details: Latitude and Longitude, or nearest town, using the table below (please add additional rows as required):

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1	34°19'39.36"S	117° 6'40.11"E
Nearest Town	**Frankland**	
Trial Site #2	34°28'24.15"S	118°26'50.53"E
Nearest Town	**South Stirlings**	
Trial Site #3	33°47'1.84"S	117°23'56.43"E
Nearest Town	**Carrolup**	
Trial Site #4	34°14'17.06"S	118°13'19.49"E
Nearest Town	**Amelup**	
Trial Site #5	34°22'0.28"S	118°30'9.41"E
Nearest Town	**Gnowellen**	
Trial Site #5	33°53'31.45"S	116°47'35.77"E
Nearest Town	**Muradup**	
Trial Site #5	33°31'30.72"S	117°25'58.44"E
Nearest Town	**Broomehill**	

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or 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	Choose an item. Choose an item. Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☐ WA Eastern ☐ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☒ WA Sandplain

Results

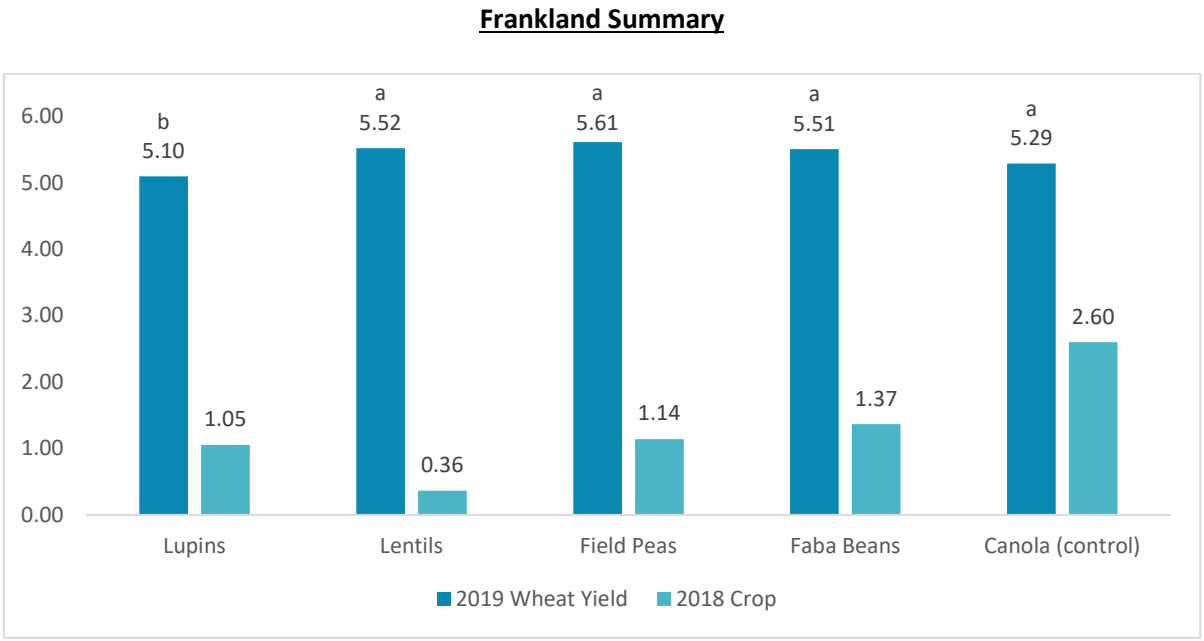


Figure 1: Summary of the grain yields achieved at the Frankland demonstration site (Simon Hilder) in 2018-19. The figures indicate the t/ha of grain yield for each crop. *Means followed by the same letter do not significantly differ (P = 0.05, LSD)*

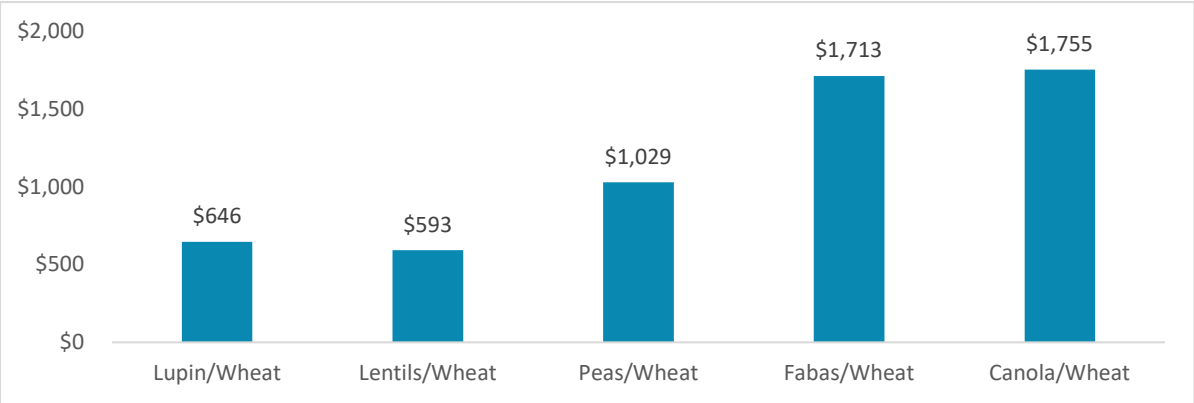


Figure 2. Shows the combined profit in dollars per hectare ($/ha) achieved with a wheat crop in 2019 sown over the 2018 legume demonstration. Farmanco analysed the economic data in 2021.

Table 2. Grain quality results from the 2019 Sceptre wheat grown over the 2018 legume demonstration site at Frankland. There were no statistical differences in grain quality between the 2018 legume treatments.

Averages						
Treatment	**Protein %**	**Screenings (g)**	**Screenings %**	**Hectolitre (g)**	**Hectolitre (g/hl) Test weight**	**Moisture %**
F Beans/Wheat	9.70	3.05	0.73	420.0	84.0	11.9
Lupins/Wheat	10.15	3.05	0.73	418.1	83.6	11.8
F peas/Wheat	9.85	2.65	0.63	419.4	83.9	11.7
Lentils	10.00	3.00	0.72	416.5	83.3	11.9

Table 3. Summary of the average soil quality changes measured in the 0-10cm (topsoil) layer at the Frankland Legume demonstration site in 2018 and 2019.

Soil Parameter	2018	2019
OC %	3.3	2.3
NO3 (Nitrate Nitrogen) mg/kg	13.3	14
NH4 (Ammonium Nitrogen) mg/kg	3.7	4.3

Kojoneerup Summary

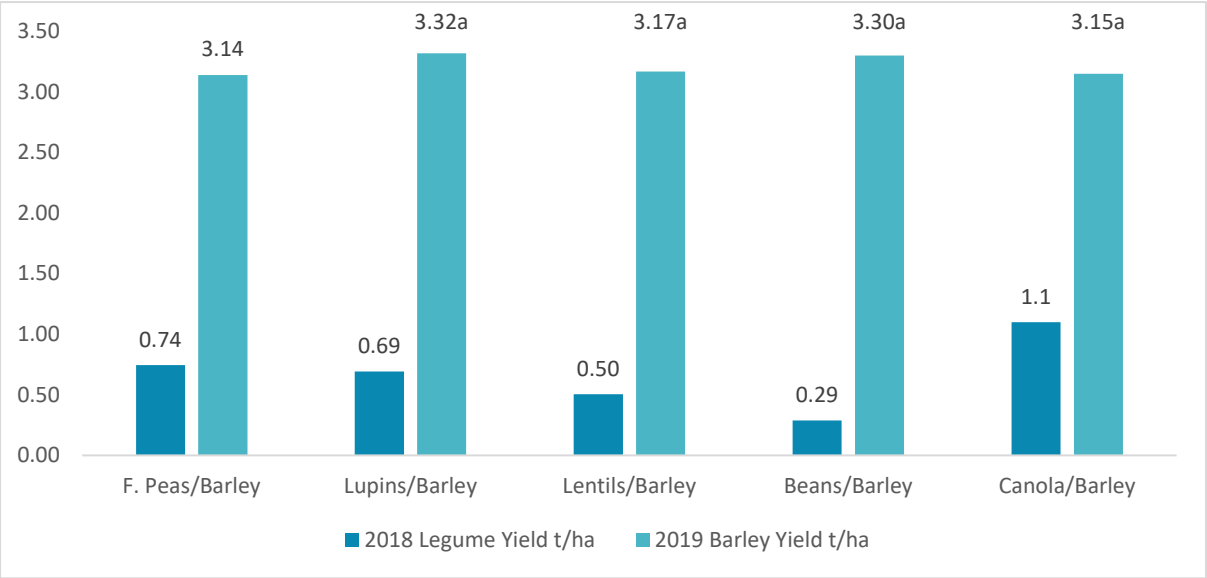


Figure 3: Summary of the grain yields recorded at the Kojaneerup demonstration site (Slattery) in 2018-19. The figures indicate the tonnes per hectare (t/ha) of grain yield for each crop. *Means followed by the same letter do not significantly differ (P = 0.05, LSD)*

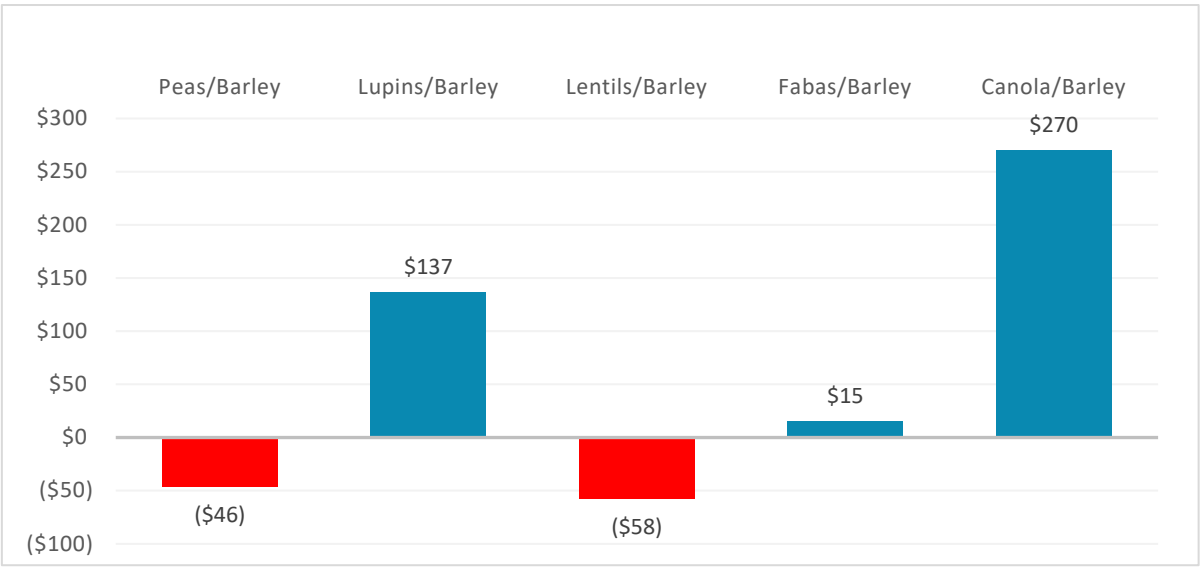


Figure 4. Shows the combined profit or loss in dollars per hectare ($/ha) achieved with a barley crop in 2019 sown over the 2018 Kojaneerup legume demonstration. The grower control was canola followed by barley in 2019. Farmanco consultants analysed the economic data in 2021.

Table 4. Shows the monthly rainfall in millimetres during 2018 and 2019 at Kojaneerup in WA (BOM Station number 10729) compared to the mean.

Month	2018	2019	Mean
January	6.6	1.4	18.8
February	5.1	1.4	20.2
March	16.4	54	25.5
April	12.8	24.2	33
May	6.8	19.3	45.8
June	40.4	25.9	44.5
July	25.7	27.3	43.9
August	61.4	69.3	42.8
September	11.8	17	40.4
October	26.7	21.5	39.6
November	26.7	4.6	25.3
December	19.4	4.5	20.4
Total	**259.8**	**270.4**	**400.2**

Table 5. Summary of the average soil quality changes measured in the 0-10cm (topsoil) layer at the Kojaneerup Legume demonstration site in 2018 and 2020.

Soil Parameter	2018	2020
OC %	1.8	2.2
NO3 (Nitrate Nitrogen) mg/kg	12	10.75
NH4 (Ammonium Nitrogen) mg/kg	2.3	7

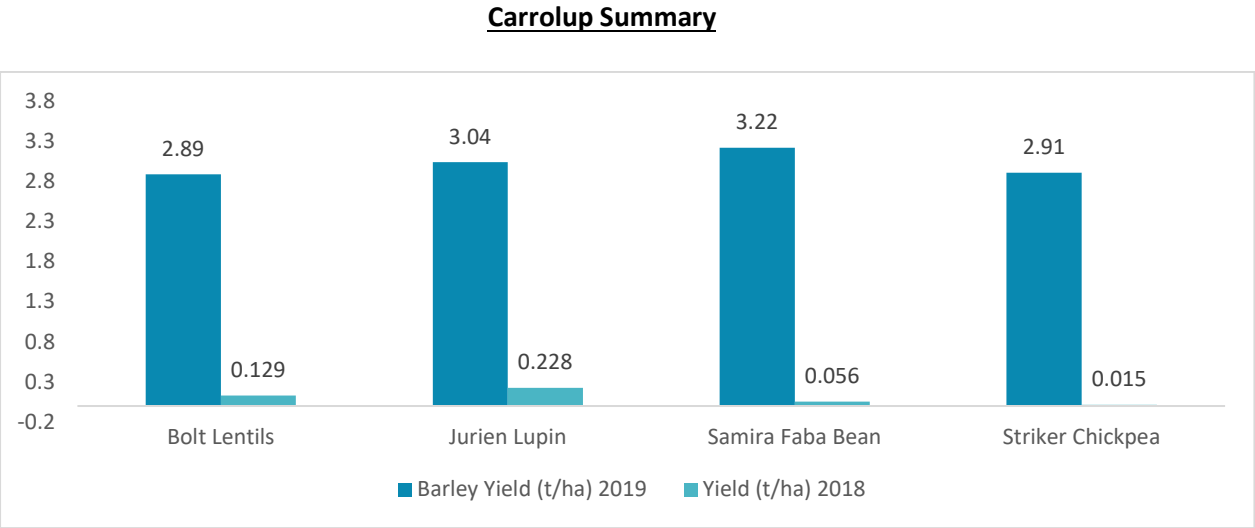


Figure 5: Summary of the barley grain yields (t/ha) achieved at the Carrolup demonstration site (Ladyman's) in 2019. The 2018 legume treatments (red bars) were sown over with barley in 2019.

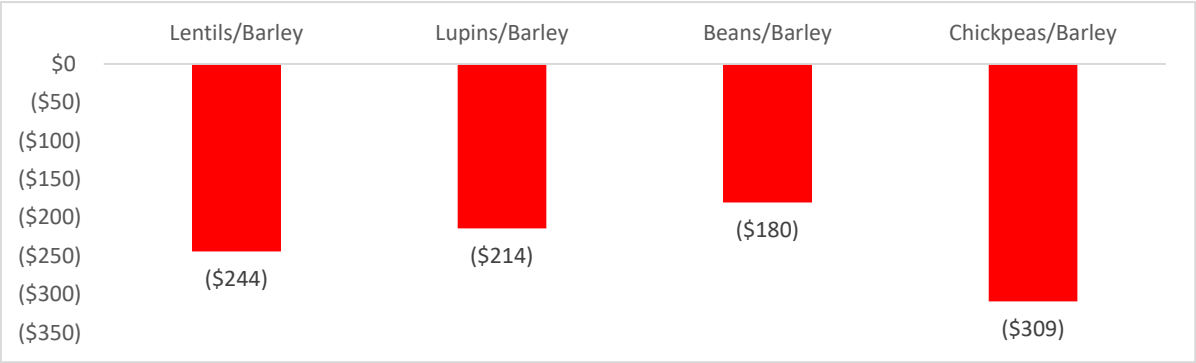


Figure 6. Shows the combined losses in dollars per hectare ($/ha) achieved with a barley crop in 2019 sown over the 2018 legume demonstration. Farmanco analysed the economic data in 2021.

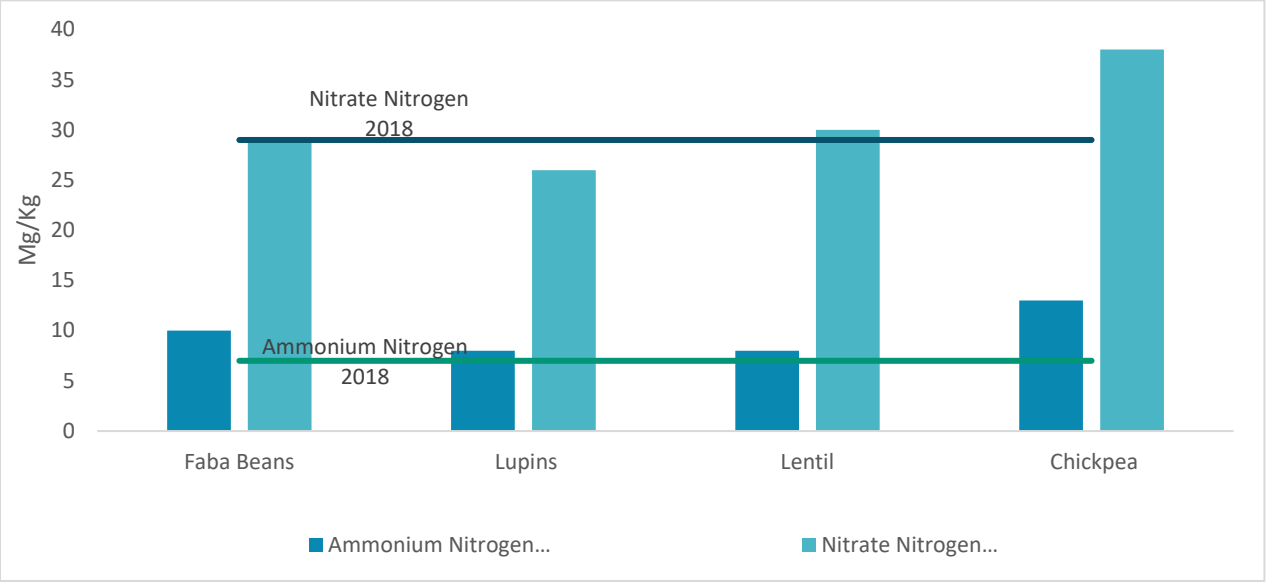


Figure 7: Soil data from the Carrolup legume demonstration in 2018 and 2019. Data displays Ammonium Nitrate and Nitrate Nitrogen changes (0-10cm layer) after the Legume crop was grown in 2018.

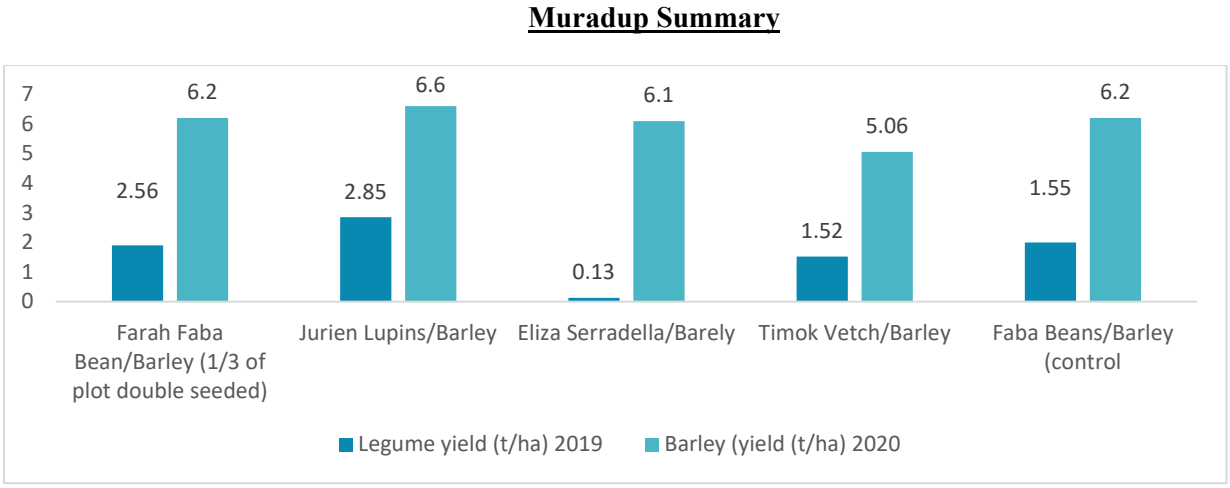


Figure 8: Summary of the grain yields achieved at the Muradup demonstration site (Webb's) in 2019 and 2020. The numbers on each bar indicate the t/ha of grain yielded for each crop in that year.

Table 6. Shows the revenue in dollars per hectare ($/ha) achieved from each legume treatment in 2019 at the Muradup Legume Demonstration site.

Treatment	Yield (t/ha)	Price (t/ha)	Revenue ($/ha)
Farah Faba Beans (double seeded)	2.56	$ 508	**$ 1300**
Jurien Lupin	2.85	$ 510	**$ 1454**
Farah Faba Bean	1.55	$ 508	**$ 787**
Eliza Serradella	0.13	$ 4900	**$ 637**
Timok Vetch	1.52	$ 783	**$ 1190**

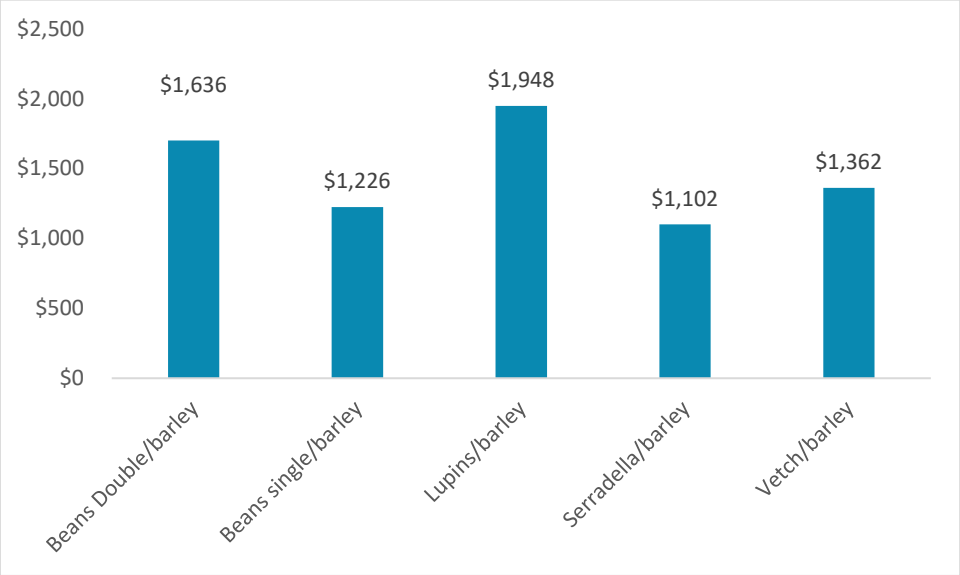


Figure 9: Shows the combined profits in dollars per hectare ($/ha) achieved with a barley crop in 2020 sown over the 2019 legume demonstration at Muradup (Webb's). Farmanco consultants analysed the economic data in 2021.

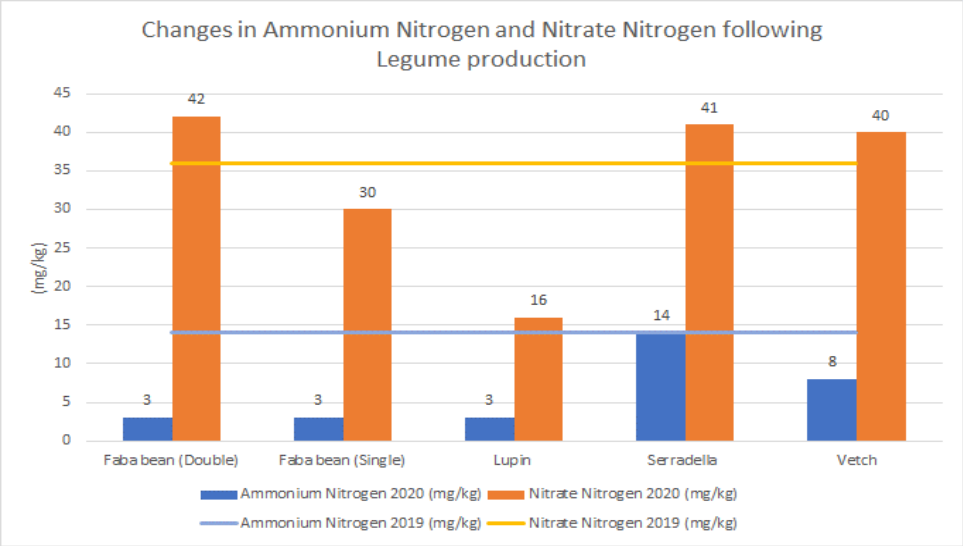


Figure 10: Soil data from the Muradup legume demonstration in 2019 and 2020. Data displays Ammonium Nitrate and Nitrate Nitrogen changes (0-10cm layer) after the Legume crop was grown in 2019.

Broomehill Summary

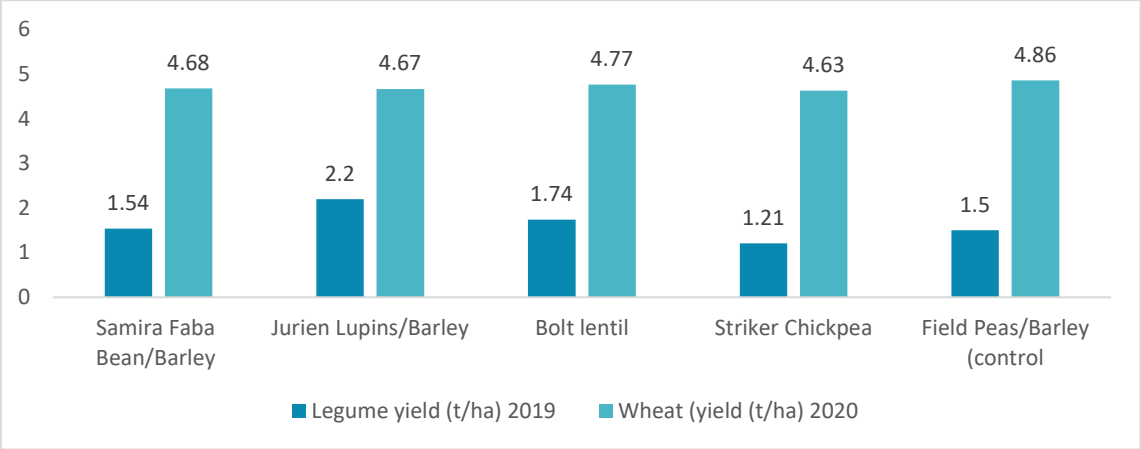


Figure 11: Summary of the grain yields achieved at the Broomehill demonstration site (Bignell's) in 2019 and 2020. The figures indicate the t/ha of grain yield for each crop.

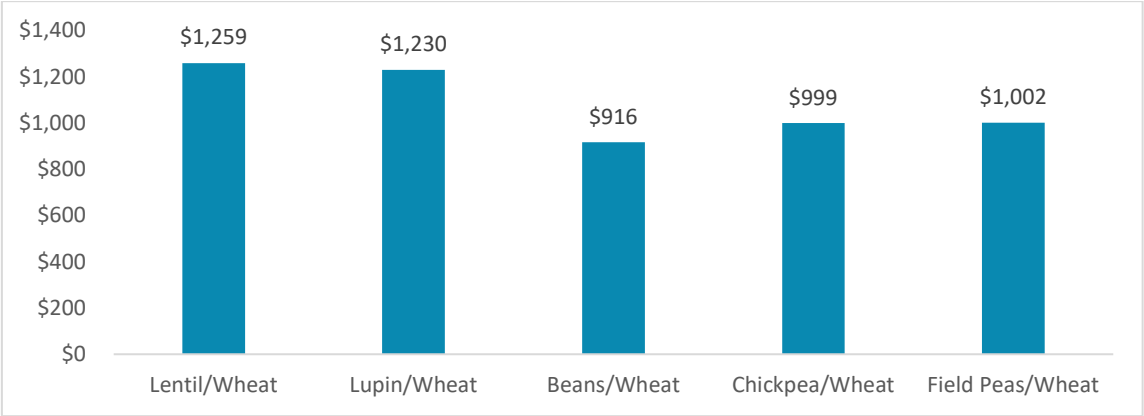


Figure 12. Shows the combined profit in dollars per hectare ($/ha) achieved with a wheat crop in 2020 sown over the 2019 legume demonstration. Farmanco analysed the economic data in 2021.

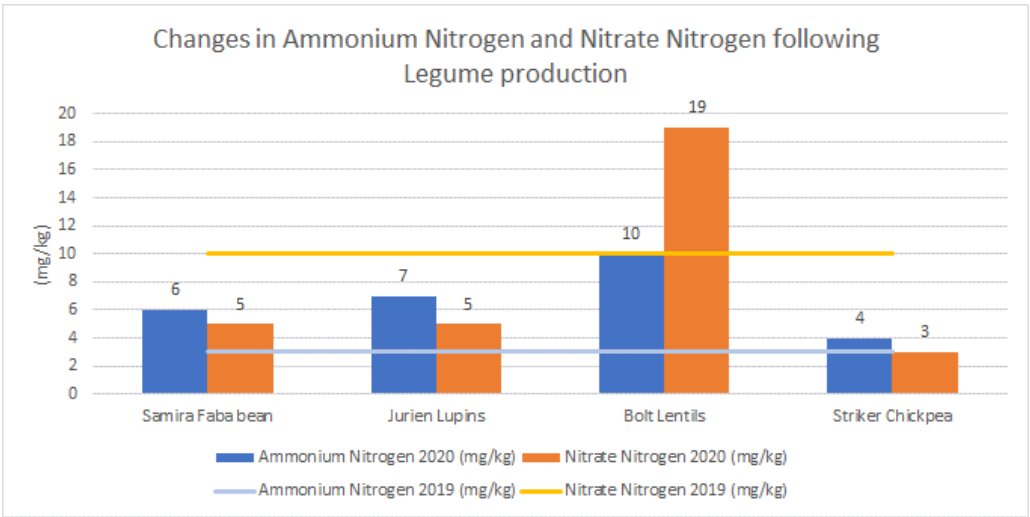


Figure 13: Soil data from the Broomehill legume demonstration in 2019 and 2020. Data displays Ammonium Nitrate and Nitrate Nitrogen changes (0-10cm layer) after the Legume crop was grown in 2019.

Amelup Summary

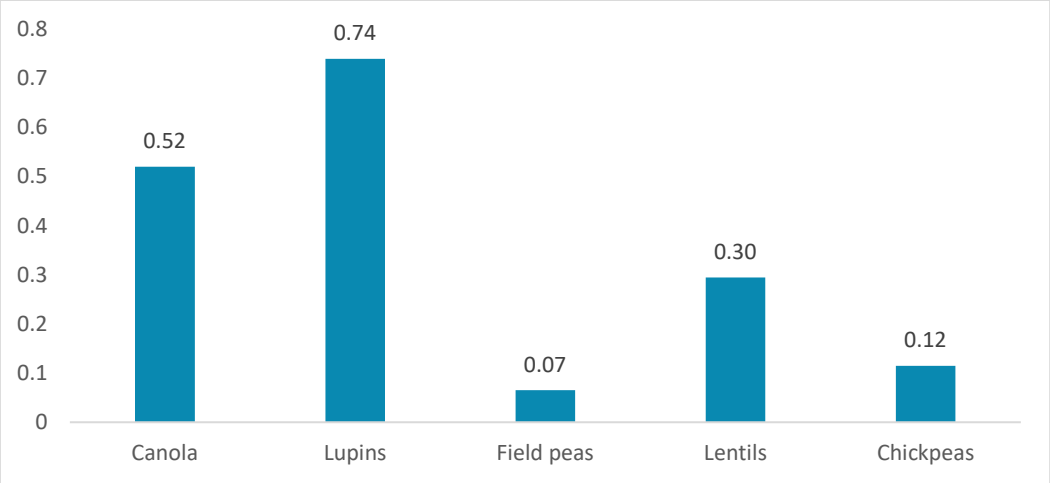


Figure 14: Summary of the grain yields achieved at the Amelup demonstration site (Moir's). The figures indicate the t/ha of grain yield for each crop. The demonstration site suffered from frosts and dry seasonal conditions.

Table 7. Shows the revenue ($/ha) achieved from each legume treatment in 2019 at the Amelup Legume Demonstration site.

Treatment	Yield t/ha	Price (t/ha	Revenue ($/ha)
Canola	0.52	$ 650	$ 338.00
Lupins	0.74	$ 510	$ 377.40
Field peas	0.07	$ 540	$ 35.10
Lentils	0.30	$ 645	$ 190.28
Chickpeas	0.12	$ 735	$ 84.53

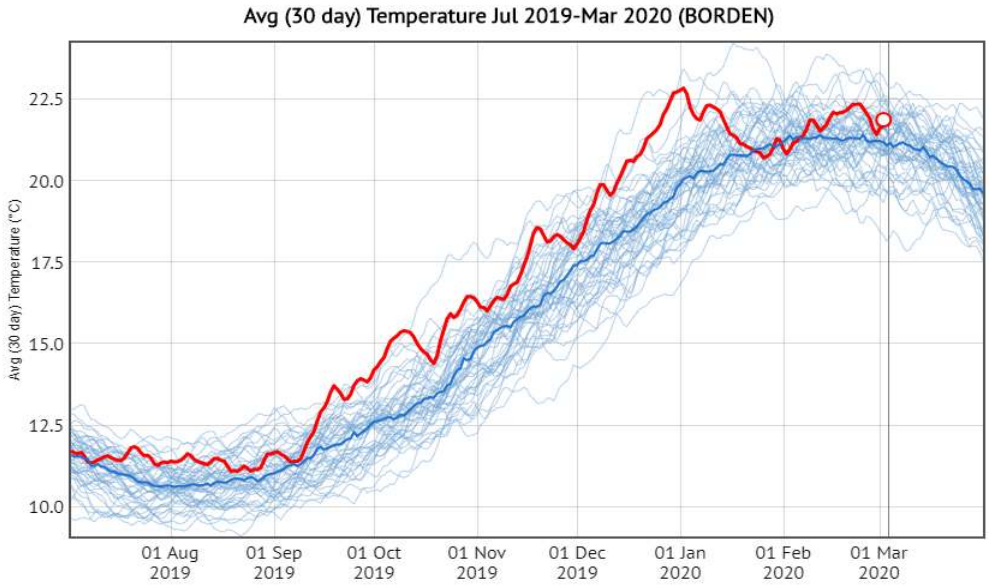


Figure 15: Shows the average temperature (1970- Present – light blue)) with the median average temperature shown in dark blue and the 2019 temperature data in red in Borden 23km northeast of Amelup. (Data: Australian CliMate 03/03/2020)

Table 8. Displays the average NDVI and Plant count numbers (per m^2) taken at the Amelup demonstration site on 3rd July. 12th August and 11th September 2019.

Crop type	Average NDVI 3rd Jul 2019	Average NDVI 12th Aug 2019	Average NDVI 11th Sep 2019	Plant/m^2 3rd July 2019
Lentils	0.21	0.71	0.63	92
Lupins	0.20	0.68	0.57	47
Chickpeas	0.18	0.67	0.65	25
Field peas	0.21	0.71	0.61	29
Canola	0.25	0.49	0.44	60

Table 8. Displays the average NDVI and Plant count numbers (per m^2) taken at the Amelup demonstration site on 3rd July. 12th August and 11th September 2019.

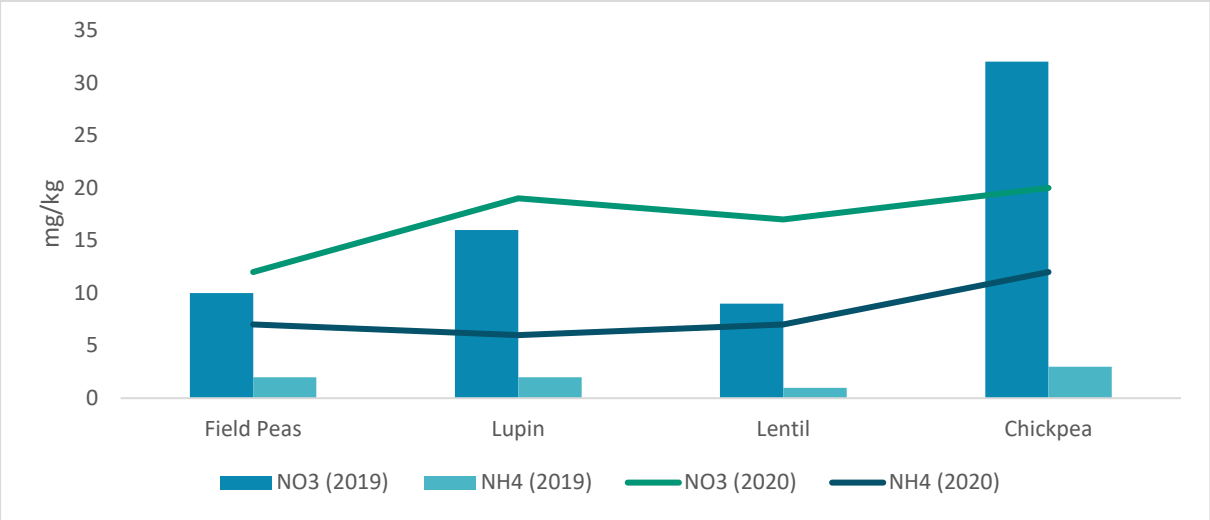


Figure 16. Shows changes in Ammonium Nitrate and Nitrate Nitrogen from Legume Production in 2019 (0-10cm) at the Amelup Legume Demonstration site in 2020.

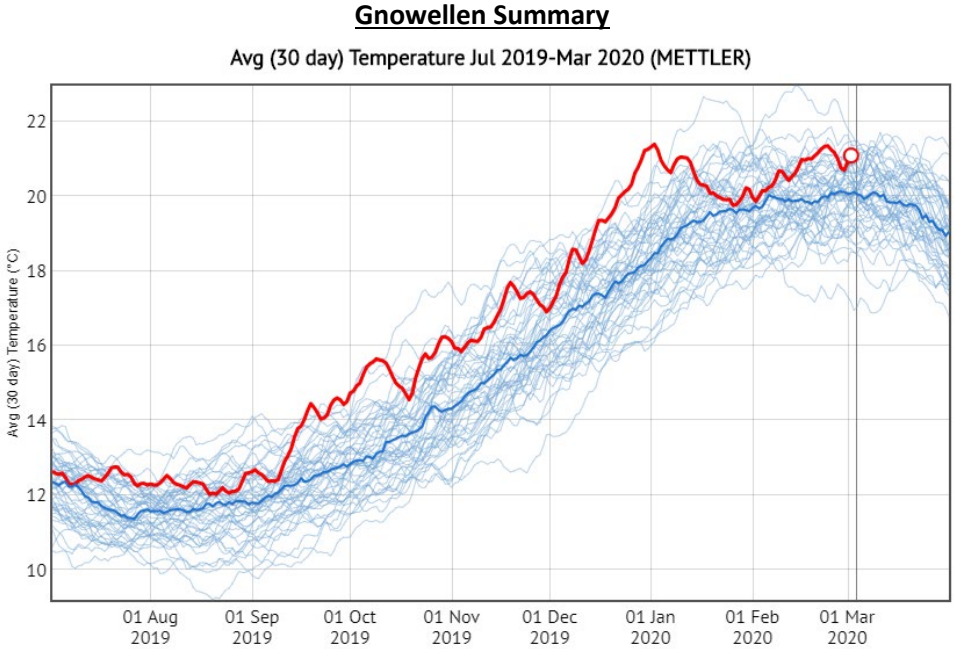


Figure 17: Shows the average temperature (1970- Present – light blue)) with the median average temperature shown in dark blue and the 2019 temperature data in red in Mettler 35km South of Gnowellen. (Data: Australian CliMate 03/03/2020)

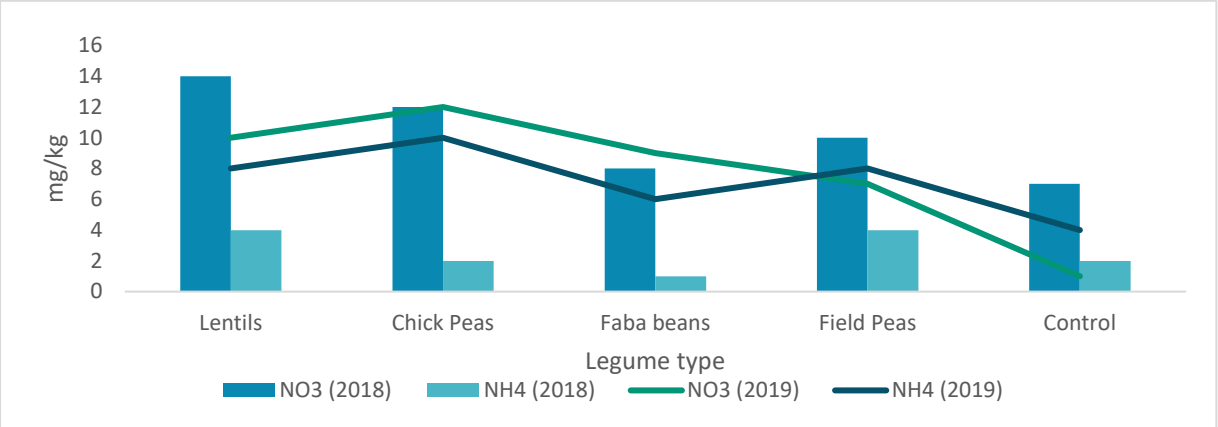


Figure 18. Shows changes in Ammonium Nitrate and Nitrate Nitrogen from Legume Production in 2018 (0-10cm) at the Gnowellen Legume Demonstration site in 2019.

Discussion of Results

Frankland Summary

- Grower control rotation: Canola/Wheat = $1,755 revenue over two years

  Best Legume rotation: Faba beans/wheat = $1,713 revenue over two years

- Despite a very high Faba bean price of $997/t in 2018, the grower rotation of canola followed by wheat was more profitable than any legume treatment. This is significant given the average 10-year Faba bean price is only $508/t.

- The Faba bean/Wheat treatment revenue was nearly $700 more than the next best legume treatment of Field peas/Wheat ($1,029).

- Faba beans and field peas were the only profitable legumes in 2018, with lentils and lupins both making losses.

- There was no significant difference between the average wheat grain quality in 2019 between the 2018 legume treatments or the canola control.

- There were no significant changes in soil organic carbon, nitrate nitrogen and ammonium nitrogen measured in the topsoil from growing legume crops after one year.

Kojoneerup Summary

- Canola/Barley (grower control) was $133/ha more profitable than the most profitable legume crop (lupins/barley). The canola/barley rotation achieved a $270 profit over the two years.

- Lupins and Faba beans were the only legumes to achieve a two-year profit in the demonstration and this was largely because prices were above average in 2018 at $604 for lupins and $997 for Faba beans.

- There were no significant differences in feed barley yields sown over the 2018 legume treatments in 2019.

- Both 2018 and 2019 were below average rainfall years at Kojaneerup, which were difficult conditions for legumes to thrive. Growing season rainfall (April-October) was only 64% and 71% of the long-term average in 2018 and 2019.

Carrolup Summary

- The Carrolup site suffered from a late break and significant weed control issues in 2018. Legume yields were poor which highlighted the value of timely agronomy when growing pulse crops. The poor yields in 2018 meant the combined crop revenue from both years led to financial losses for all four legume crops demonstrated.

- There were no significant differences in barley grain yield sown over the 2018 legume trial at the Carrolup site in 2019 Fig. 5.

- The Carrolup site was a fair replication of what can happen to legume crops in tough seasons and sub-optimal management. When growers experience similar results at a paddock-level they question the value of legume crops to their farming enterprises.

Muradup Summary

- The legume yields achieved at the Muradup site were excellent and likely due to having an experienced legume host grower and a more favourable environment than some of the other demonstration sites.

- The grower's experiment with double-seeding the Faba beans provided some interesting results that we did not anticipate. The double seeded Faba beans yielded 2.56t/ha compared to the single sown Faba beans which yielded 1.55t/ha. The double seeded faba beans sowing rate was 250kg/ha and had 220kg/ha of starter fertiliser applied. The single-seeded faba beans had half of those inputs.

- The profits of the double seeded faba beans were $410/ha more than the single-seeded treatment after the seed and fertiliser costs were accounted for. It is unknown if the main driver of the faba bean yield increase was due to the higher seeding rate or luxury amounts of fertiliser.

- The Jurien lupins achieved the highest yields and legume revenue/ha in the 2019 trial. The 10-year average lupin price is $334; the 2019 price of $510 was well above average. The double seeded Faba beans returned $154/ha less than lupins and their price of $508/tonne was on par with the 10-year average.

- The Eliza Serradella and Vetch were hand-harvested because the header front could not pick up the pods at such a low height. However, dry matter cuts collected on 31st September calculated a 5.8t and 11.7t/ha dry matter yield for Serradella and Vetch, respectively. This amount of biomass would have made for excellent sheep feed.

Broomehill Summary

- All legume treatments were profitable over the two-year period of the demonstration in 2019 and 2020 ranging from $198/ha to $518/ha.

- The Jurien lupins yielded much higher than the lentils, faba beans and chickpeas in 2019. The lupins yielded approximately 1 t/ha more than the chickpeas (Figure 11).

- Despite the lupins achieving the highest yield in the 2019 demonstration, the Bolt lentils achieved the same revenue. If Farmanco used the average 10-Year pricing of $334/t for lupins, they would have had the lowest legume income of $734 in 2019. The 2019 lupin price of $510 was above the 10-year average.

- The bolt lentils improved the soil nitrate levels from 10 to 19 mg/kg in the 0-10cm soil layer. Soil nitrate levels were 14 mg/kg higher in the lentils than the next best legumes of faba beans and lupins. The beans, lupins and chickpeas dropped nitrate lower than the baseline measurements (10 mg/kg) collected before the legumes were grown.

Amelup Summary

- Frost and dry conditions resulted in significant yield losses to the 2019 legume demo site at Amelup. The yield data from the header data shows the Lupins were the highest yielding legume, which yielded 0.74t/ha. Lentils were 0.30t/ha, chickpeas 0.12t/ha and field peas 0.07t/ha. The canola yielded 0.52t/ha on average as the control, which was less than lupins.
- Before the frost event in September, the Amelup demonstration site was performing well. NDVI data showed each crop was growing well; see table six.
- The ammonium nitrate (NH4) levels in the soil samples taken post the legume growing season (2020) showed an increase in NH4 in comparison with the baseline soil samples collected pre-seeding (2019). Nitrate (N03) increased in three of the four legume treatments.
- A frost event on 5th September followed by warm weather significantly impacted the trial (Figure 10). Legumes and canola are particularly susceptible to frost at pod filling, which causes the pods to be empty or have distorted seeds (Ryan 2017). Heat stress also has detrimental effects on legumes at the reproductive stage, severely limiting yields through flower abortion and reduced seed filling (Sita et al., 2017).
- 2019 was an uncharacteristically tough season at Amelup, which should be well suited to growing legume crops most years. Despite the dry season, the best legume (lupins at 0.72t/ha) yielded higher than the farmer control break-crop of canola (0.52t/ha).

Gnowellen Summary

- The frost event and warm, dry conditions also significantly impacted the Gnowellen legume demo in 2019. The trial was so severely damaged that the farmer sprayed it out to prevent weeds from growing and impacting the 2020 crop.
- The ammonium nitrate (NH4) levels in the soil samples taken post the legume growing season showed an increase in NH4 compared to the baseline soil samples collected preseeding. Nitrate (N03), however, was the same or reduced post-growing season compared to the preseeding samples despite the demonstration not being harvested.
- The lack of N mineralisation is due to the dry summer and lack of rain from October 2019 to mid-February when the soil samples were collected. 16.8mm was recorded between these dates.

Crop Sequence Modelling Workshops

Farmanco conducted crop sequencing workshops in conjunction with SCF and Southern Dirt (SD). The two SCF workshops were completed on March 30 and 31 at Wellstead and Kendenup respectively. Each workshop had approximately 15 growers that attended. The Kendenup workshop was filmed by Southern Dirt with a view to creating a video presentation to share with their members via a YouTube video. At the time of writing, Southern Dirt were waiting for approval of the raw footage from the GRDC, before editing the video for public consumption.

Farmanco presenters Ben Curtis, Brent Pritchard and Mark Lawrence summarised the agronomic benefits from growing legumes and presented the economic analysis derived from the project demonstration sites. Farmanco also presented anonymous client data from the Esperance region showing the financial performance of different legume crops over time. Farmanco highlighted the legume price variability compared to standard crops and discuss how that affects grower budgeting. The farmers that attended the workshops found the provision of real data on legume gross margins very insightful.

Conclusion

The project experienced the highs and lows of growing legume crops in a realistic simulation of what grain growers are likely to experience when including grain legumes in their cropping rotations. Legumes can be profitable for growers when prices are reasonable, agronomy is well managed, and the season is average or better. When either of these three key pillars is compromised, legume crops struggle to be profitable. The same key factors are essential to growing all crops in Australia. However, the losses in unfavourable circumstances are much higher for legumes than established crops like wheat, barley, and canola.

We did not measure significant improvements to grain yield or quality in subsequent crops, or to soil health through nitrogen fixation one year after legumes in this project. Reduction in soil and root pathogens is likely to occur, however, we did not measure significant changes, which could be due to the dry seasons and the relatively short time frame of the project.

The 2018 and 2019 seasons were not favourable for legumes in most of the Albany port zone due to dry and frosty conditions. Ironically, hot daytime temperatures after the frosts struck in September also reduced yields. The three most successful demonstration sites in the project were Muradup and Frankland in the high rainfall zone (HRZ) and Broomehill in the medium rainfall zone. The drier than average season made the HRZ environment ideal for legume crops in 2018 and 2019.

A significant factor that influenced the successful demonstrations was having experienced grower hosts. Growers with legume experience managed the agronomy and timing of applications much better than those growing legumes for the first time in years. This observation cannot be highlighted enough, because for growers to gain more experience with legumes, they need to try them for themselves.

Throughout this project, grower group staff and participating growers experienced the typical difficulties of growing legume crops. For example, field peas lodged at Frankland River in 2018, and lost yield due to the harvester's inability to pick up the crop. Additionally, due to harvesting low to the ground on gravelly soil, the grain sample obtained lots of rocks which would have limited sales to feed only. Local field pea growers informed SCF researchers that this is a common problem, and commercial grain cleaners are usually unable to remove rocks from the sample so the grain cannot be delivered to CBH.

The crop sequence modelling workshops from Farmanco highlighted the price volatility for legumes. Legume grain prices are generally twice as volatile compared to wheat, barley or canola. Growers were already aware of the unpredictability of legume grains but seeing the ‘real-world’ data presented from the project demonstrations and the private Farmanco database solidified this viewpoint.

From an agronomic point of view, our best results were achieved from faba beans and lupin crops. The faba beans were the most promising legume crop for the high rainfall zone due to their water-logging tolerance relative to other legume crops. They also have high top-end prices and are an excellent protein source for sheep if farmers want to sell or keep themselves. Faba beans require specialty agronomy, such as high seeding rates and wide-row spacings. Seeding equipment capable of both is not always congruent with growers seeding set-ups aimed at wheat, barley and canola.

Legume crops are not as hardy or resilient as wheat, barley or even canola. Environmental stresses, which growers can do little to manage, can reduce final yields significantly. Legume growers need to tightly manage the agronomic factors they can control, such as soil pH, elevation, sowing time, seed rates, rhizobia inoculation, weed burdens and harvest timeliness. Growers need to give pulse crops preferential treatment while they are perfecting the art of growing them successfully. If they take this approach and only grow a small percentage of the total crop each year, they can successfully build their knowledge and confidence in growing pulse crops. Growers who have taken this approach are now, with the help of an enthusiastic agronomist, growing significant hectares of faba beans. Increased legume grain adoption is not likely to come until profitable results, like those seen at the Muradup and Broomehill sites, are experienced more regularly by early adopters.

Implications

The best legume demonstration sites were hosted by experienced growers who were already growing at least one legume crop before hosting a site as part of this project. This highlights that experience is a valuable

component of successfully growing legume crops. Many growers remain skeptical about the value of adding a legume to their cropping rotations.

The benefits measured in the following year were not outstanding in terms of soil nitrogen fixed, reduction of soil and root pathogens and improvements in either grain quality or yield. Benefits to growing legumes crops would likely need to be measured over a more extended period, with paddocks that have had at least 2-3 legumes crops in the system.

Legume prices are highly volatile, and we saw that profits from decile ten prices were on par with the farmer's current break crop, which was usually canola. However, predicting the harvest price of a legume crop before seeding is impossible to know with any certainty. From conversations with regular legume growers, it was apparent that most already had a market for their grain organised, often their own enterprise or a local farmer wanting grain to feed livestock. To mitigate against poor prices, growers are often prepared to keep the grain and use themselves for livestock feed. We saw that in the 2020 season with faba bean prices around $350/tonne, growers stored the grain on-farm hoping for a price change or would use the grain for livestock feed.

Recommendations

This project found that Faba beans and lupins were the two most likely legume crops to succeed in the HRZ due to their relative ability to handle waterlogged soils. At the MRZ Broomehill site, the legume options appeared to be more diverse. The multitude of legume options is a factor in the slow overall adoption of legume crops into cropping rotations. Growers need to understand which legume crop is the best agronomic fit for their local environment and then stick with that crop to improve their agronomic management over time. This project has helped identify winners and losers for each demonstration site. However, in the case of Broomehill, growers are still unclear as to which legume is the best option for their farm.

We recommend more localised research in either small plot trials or farm-scale trials to promote legume crops and identify the best options in each environment. Extension of these trial results to local agronomists and advisors would be vital to increasing the uptake of legume plantings. The agronomic data should also be cross-checked with the market data to ensure growers are planting legume crops with the most robust and resilient markets. It is equally as crucial for growers to select the most marketable legume crop for their locality and the best agronomic fit.

We recommend capturing the stories of how some growers successfully implemented legume crops and sharing that experience with other WA growers. The extension of these success stories needs to be in multiple formats, for example, written case studies, podcasts, videos and oral presentations to growers at field days. Growers enjoy learning from their colleagues and are more likely to absorb positive legume messages from fellow farmers. By sharing what they have learnt, growers will improve legume agronomy and promote the value of adding a legume to a cropping rotation.

More demand for legume grains would reduce the price volatility and increase average prices, encouraging farmers to grow more legumes more often. Trying to develop markets was not within this project's scope, but growers and researchers alike acknowledge the importance of increased demand. Stirlings to Coast Farmers recommend the industry maintains the ongoing work seeking and growing international pulse markets. The value of adding a profitable legume crop would be immense for the Australian grain grower.

Appendix A.

Frankland 2018

Crop Enterprise		Lupins	Lentils	Field Peas	Faba Beans	Canola
Yield	t/ha	1.05	0.36	1.14	1.37	2.60
Average Grain Price (FIS)	$/t	$351	$536	$561	$997	$570
Income	**$/ha**	**$369**	**$193**	**$640**	**$1,366**	**$1,482**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$35	$50	$35	$43	$21
Grain Freight (Up Country)		$7.9	$2.7	$8.6	$10.3	$19.6
Grain Handling Charges		$13	$4	$14	$17	$32
Crop Contract		$11	$4	$11	$14	$26
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$55	$55	$55	$55	$55
Fuel & Oil		$35	$35	$35	$35	$35
Fertiliser, Lime & Gypsum		$75	$75	$75	$75	$75
Pesticide		$105	$105	$105	$105	$105
Variable Operating Costs	**$/ha**	**$406**	**$401**	**$409**	**$424**	**$438**
Operating Gross Margin	**$/ha**	**($38)**	**($208)**	**$231**	**$942**	**$1,044**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$513**	**$508**	**$516**	**$531**	**$545**
Operating Profit (BIT)	**$/ha**	**($145)**	**($315)**	**$124**	**$835**	**$937**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**($201)**	**($371)**	**$68**	**$779**	**$881**

Frankland 2019

Crop Enterprise		Wheat after Lupins	Wheat after Lentils	Wheat after Field Peas	Wheat after Faba	Wheat after Canola
Yield	t/ha	5.10	5.52	5.61	5.51	5.29
Protein		10.15	10.00	9.85	9.70	
Grade		APW2	APW2	ASW	ASW	ASW
Average Grain Price (FIS)	$/t	$305	$305	$300	$300	$300
Income	**$/ha**	**$1,556**	**$1,684**	**$1,683**	**$1,653**	**$1,587**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$24	$24	$24	$24	$24
Grain Freight (Up Country)		$38	$42	$42	$41	$40
Grain Handling Charges		$47	$51	$51	$50	$48
Crop Contract		$51	$55	$56	$55	$53
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$55	$55	$55	$55	$55
Fuel & Oil		$35	$35	$35	$35	$35
Fertiliser, Lime & Gypsum		$120	$120	$120	$120	$120
Pesticide		$105	$105	$105	$105	$105

Variable Operating Costs	**$/ha**	**$545**	**$557**	**$559**	**$556**	**$550**
Operating Gross Margin	**$/ha**	**$1,010**	**$1,127**	**$1,124**	**$1,097**	**$1,037**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$652**	**$664**	**$666**	**$663**	**$657**
Operating Profit (BIT)	**$/ha**	**$903**	**$1,020**	**$1,017**	**$990**	**$930**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**$847**	**$964**	**$961**	**$934**	**$874**

Combined Enterprise Analysis Crop

Frankland

Crop Enterprise 2018	**Lupins**	**Lentils**	**Field Peas**	**Faba beans**	**Canola**
Profit 2018	**-201**	**-371**	**68**	**779**	**881**
Crop Enterprise 2019	**Wheat after Lupins**	**Wheat after Lentils**	**Wheat after Field Peas**	**Wheat after Faba**	**Wheat after Canola**
Profit 2019	**847**	**964**	**961**	**934**	**874**
Combined Crop Enterprise	Lupin/Wheat	Lentils/Wheat	Peas/Wheat	Fabas/Wheat	Canola/Wheat
Combined 2018 and 2019 Profit	**$646**	**$593**	**$1,029**	**$1,713**	**$1,755**

Appendix Title

Appendix 1: Displays the average 10-year prices for the seven legume crops that were sown in the 2018 and 2019 Legume trials in the Albany Port Zone (Australian Bureau of Statistics 2020)

LEGUME TYPE	AVERAGE PRICE $/T
CHICKPEAS	$ 736
FABA BEAN	$ 509
FIELD PEA	$ 490
LENTIL	$ 645
VETCH	$ 784
ELIZA SERREDELLA	$ 4,900
LUPIN	$ 334

Non-Wetting Management Options for Growers in the Albany Port Zone

Authors: Phillip Mackie and Nathan Dovey

Project Lead: Stirlings to Coast Farmers

Project Partner: Southern Dirt

KEY MESSAGES

- Placing soil wetter behind the seed boot was more effective at improving germination and early biomass than dribbling on the furrow surface behind the press wheel.
- Seeding on-row or near-row significantly increased early biomass growth compared to off row sowing.
- Canola plants can compensate for low plant densities and therefore significant yield differences between treatments were hard to determine in this trial.
- There is high variability in expression of water repellence across paddocks and soil types along with response to soil wetter.

SUMMARY

Low summer rainfall and dry growing seasons have led to reduced crop establishment and early plant biomass in non-wetting forest gravel soils. Soil wetters are a possible mitigation tool that can economically alleviate the problem in any given year. Stirlings to Coast Farmers investigated 11 different wetter placements and rates in forest gravel soil. We found the best placement of SE14 is in the seed contact zone with significant improvement over the control in plant germination and early biomass. Increasing SE14 rates from 2 L to 4 L did not significantly improve plant germination or biomass for any wetter placements. There was a significant improvement in early biomass when seed placement was on or near last years' furrow compared to off-row. There were no significant yield increases for any treatments compared to the UTC. This result was not unsurprising since canola plants can compensate for low plant density in favourable conditions, such as the high rainfall zone.

BACKGROUND

Over the past few years, grain growers in the Albany port zone have found it more challenging to achieve good crop germination. Early growing season conditions have been very dry with below-average rainfall before June. Non-wetting expression is particularly nasty for growers with forest gravels, which rely on late summer and early season rains to alleviate the soil's non-wetting properties for plant germination. Non-wetting soils result in patchy and delayed crops, staggered weed germination, increased water erosion, and difficulty spraying crops with different growth stages. Growers are looking at cheaper alleviation rather than expensive mechanical soil amelioration to improve non-wetting soils.

Conventional methods of managing non-wetting involve mechanical disturbance of the soil structure to mix the non-wetting particles with wettable particles. Mechanical disturbance includes claying, deep ripping with inclusion plates, ploughing and spading. These are expensive to implement for grain growers; however, they usually have long-lasting results. Mechanical disturbance also has significant economic risk due to the cost and environmental risk from soil eroding winds. Previous local trials

such as the GRDC Ripper Gauge found that mechanical tillage did not alleviate non-wetting in forest gravels. The SCF western R & D committee were especially keen to focus on wetting agents and their possible effects on local forest gravel soils.

Recent non-wetting mitigation options that have been explored include wetters, on-row seeding, near-row seeding and stubble retention. There are a range of wetting agents on the market. Wetters can be placed on the seed, below the seed, in the seed contact zone or on the furrow surface. Previous research by Glenn McDonald (DPIRD) found that wetting agents will help crop germination and water infiltration at the end of the season, which assists in grain filling. He also noted a long-term cumulative benefit of using soil wetters in paddocks. Anecdotally, growers have also observed an incremental benefit from applying soil wetters year after year.

This trial aims to determine the best rate and placement of soil wetters for growers to mitigate non-wetting effects and achieve the best possible crop emergence without mechanical disturbance of non-wetting forest gravel soils.

OBJECTIVES

By 2021, growers in the Albany port zone will have updated knowledge on the use of soil wetting agents to effectively manage non-wetting forest gravel soils that is applicable to their situation.

METHODS

One trial site was set up for the 2020 season in a highly non-wetting forest gravel location, SW of Tenterden. The site had a previous history of cropping, with barley being the last rotation followed by oats and an annual pasture after five years of cropping before. The grower has used wetter in his system at seeding for the previous three years. The trial layout included 11 different treatments described in the list below in plot strips 200m long over three replicates. Soil samples from each of the three replicates were taken shortly before seeding for MED testing and a BASF Divine test for their specific product recommendations. The Divine test returned three varied recommendations for each replication. One recommended was no wetting agent, replicate two was a 20% Agri and 80% Integrate ratio and replicate three recommended a 100% Integrate ratio. Overall, we applied a 20% Agri and 80% Integrate to each replicate for the BASF Divine treatments.

A large proportion of the treatments involved the SACOA product SE14. The reason SE14 was selected was because it is most commonly used by local growers. One aim of the project was to investigate different placement effects with the seed or even directly on the seed. Research from Glenn McDonald indicates soils responsive to one wetter are often responsive to other wetters as well. Investigating some different market wetters would be an excellent addition to any further research in the future.

- Untreated Control
- 2 Lt/tonne SE14 directly on seed
- 4 Lt/tonne SE14 directly on seed
- 2 Lt/tonne SE14 behind press wheel
- 4 Lt/ha SE14 behind press wheel
- 2 Lt/tonne SE14 directly on seed and 1 Lt/ha behind press wheel
- 2 Lt/ha SE14 behind seed boot
- 4 Lt/ha SE14 behind seed boot
- 1 Lt/ha SE14 behind seed boot and 1 Lt/ha behind press wheel

- 2 Lt/ha SE14 behind seed boot and 2 Lt/ha behind press wheel
- 2 Lt/ha BASF Divine (80% integrate / 20% Agri) behind press wheel

The trial site was sown with 2.3 kg of 44Y90 IT canola using farm-scale equipment where possible. However, wetter treatments applied behind the seed boot needed a temporary 2m applicator attached to the seeder bar. Seeding occurred on 6th May after 25mm rainfall the day before, yet the seed was still placed into dry soil (See photo in appendices). Treatments applied behind the press wheel were done in 10.3m strips in a water rate of 50 l/ha. The treatments involving placement behind the seed boot were done in 2m strips using a water rate of 100 /l/ha.

Plant counts were completed shortly after germination with ten counts per plot to mitigate the spatial variation within treatments. It was noted whether each plot was sown off last season stubble rows, on-row or near-row where the seeder bar swayed on and off. Due to the high spatial variation seen during the start of the season, drone imagery was used at the end of July to create an orthomosaic image of the trial site. Using mapping programs, the images' colour spectrum could be analysed to determine each plot's ground cover percentage.

To best account for the variation across plots, the 10.3 m plots were swathed and harvested by the grower. The use of yield maps to collect harvest information allowed for yield analysis of those treatments. For the remaining 2m wide and 10.3 m wide plots, a small-plot harvester was used to collect grain yields from a representative 27.3m length of each plot. A grain sample was also taken from these plots and analysed using CBH equipment.

The results from plant density and yield were analysed using the REML model with spatial analysis to account for paddock variability over the trial. The ground cover results could not be analysed spatially; however, due to the significant difference from seed placement in proximity to last year's furrow, it was statistically accounted for.

LOCATION

NOTE: Where field trials have been conducted please include location details: Latitude and Longitude, or nearest town, using the table below (please add additional rows as required):

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1	-34.413005	117.465451
Nearest Town	Tenterden	

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 Choose an item. Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall

		☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☐ WA Eastern ☒ WA Mallee	☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☐ WA Sandplain

RESULTS

The plant density analysis determined that the placement of SE14 into the seed contact zone behind the seed boot were the only two treatments to be significantly higher than the untreated control for crop establishment. Increasing the SE14 rate, from 2Lt/ha to 4Lt/ha, behind the seed boot had no significant increase in plant density, indicating that 2 L/ha of SE14 in 100 L/ha of water was sufficient to mitigate this non-wetting forest gravel soil.

The placement of SE14 directly on the seed or behind the press wheel resulted in no significant difference to plant densities. The combination of SE14 behind the seed boot and the press wheel averaged higher plant densities than the control; however, they were not statistically significant. The plant densities in the BASF' Divine' and 'Integrate' combination treatment were not significantly different from the untreated control.

The application technique can explain the lower plant densities from the high rate of SE14 (4Lt/tonne) placed directly on the seed. At the high rate, the individual seed was observed sticking to each other and not flowing naturally in the seeder box. The seed's reduced flow and stickiness likely led to reduced seed numbers planted per row and probably reduced seed placement uniformity. If the treatment were to be tried again, we would need to find a way to mitigate this problem.

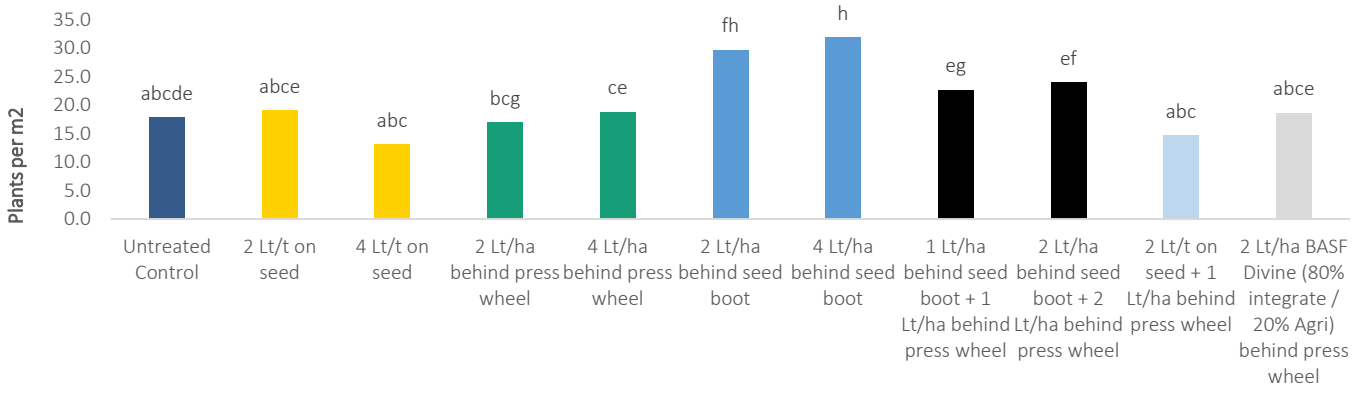


Figure 2: Plant density counts for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest gravel at Tenterden WA in 2020.

The plant establishment data was positively correlated to ground cover assessments taken on 28th July via drone imagery. The only two treatments that had significantly greater ground cover percentages than the untreated control were:

1. 4Lt/ha SE14 behind the seed boot and;
2. 2Lt/ha SE14 behind the seed boot

The "2Lt/ha SE14 behind the seed boot and 2Lt/ha behind the press wheel" treatment was statistically equivalent to the 2Lt/ha SE14 behind the boot. However, it was not significantly different from the untreated control, despite having a 20% higher Ground cover percentage.

The plant density and ground cover data indicate that 4 L/ha of SE14 behind the seed boot was the most effective mitigation strategy for non-wetting soils in this trial. Although, the high cost of applying 4Lt/ha may not suit many grain growers.

The ground cover results also identified a significant difference between the seed proximity to the last years seeding furrow. The off-row seed placement resulted in a significantly lower ground cover compared to the near-row and on-row. On-row placement had the highest ground cover percentage, although it was not significantly different to the near-row. The differences in canola establishment based on proximity to the previous season furrow is consistent with other research and field observations**.** Data from this trial suggest that seeding equipment that can consistently seed on or near the last season row is most beneficial to canola establishment and early season growth.

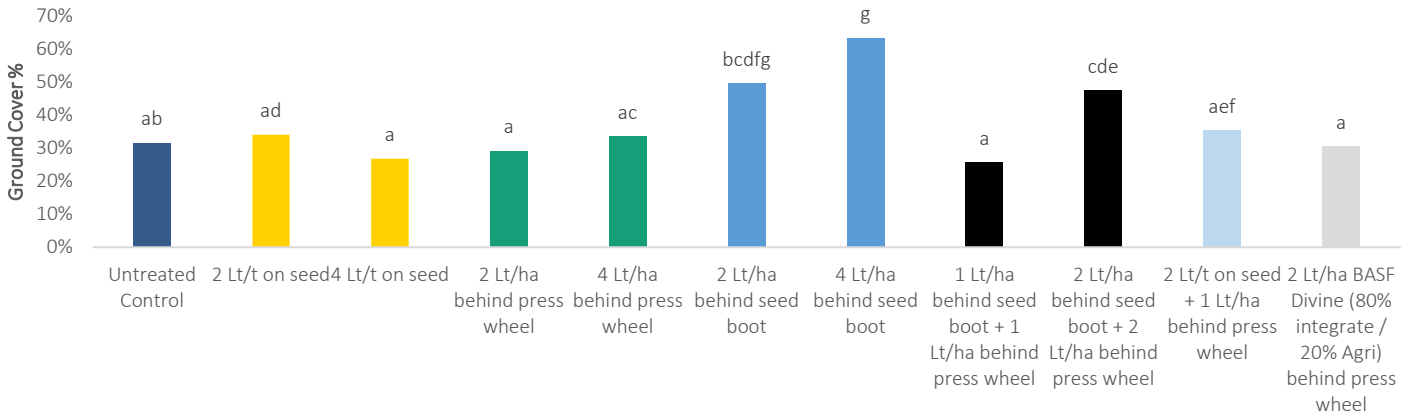


Figure 3:Ground Cover for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest gravel at Tenterden, WA. Percentages of ground cover were determined through calculations with drone imagery collected on 28/7/2020.

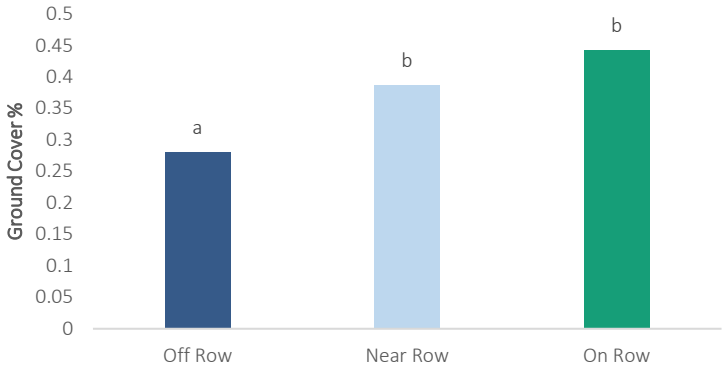


Figure 4: Ground cover for seed placement in proximity to last year's cereal furrow in a forest gravel soil type at Tenterden, WA. Percentage calculations determined through drone imagery taken on the 28/7/2020.

Grain Yields

The grain yields for the trial were analysed using analysis of variance (ANOVA). Initial results indicated there were no significant differences in grain yield between any of the treatments. When a spatial analysis model was used, significant differences were found, with the untreated control yielding the highest. Three treatments grew significantly less grain yield than the untreated control, and they were;

1. 4Lt/tonne SE14 applied directly to the seed
2. 2Lt/ha SE14 behind seed boot
3. 1Lt/ha SE14 behind seed boot and 1Lt/ha SE14 behind press wheel

Reviewing the three replicates that made up each treatment's means provide a plausible explanation for why the mean yields were significantly lower than the untreated control. One of the three replicates for the 4Lt/tonne of SE14 applied directly to the seed was only 1.37t/ha, which dropped the average yield for the treatment. Likewise, the 1Lt/ha SE14 behind the seed boot with 1Lt/ha SE14 also placed behind the press wheel had one replicate that yielded 1.16t/ha. Each outlier was in plots where the seeder had randomly placed the seed off-row, which could explain the poor result.

The 2Lt/ha of SE14 placed behind the seed boot also had one outlier that yielded 1.40t/ha. However, unlike the treatments mentioned previously, this plot was sown on-row, which means we have no explanation for the low yield. Out of the 33 plots in the trial, only six had yields of less than 1.5t/ha. The other three plots, not mentioned above, were in the following treatments:

1. 2Lt/ha SE14 behind the press wheel (1.16t/ha and seeded near-row)
2. 4Lt/ha SE14 behind the seed boot (1.08t/ha and seeded off-row)
3. 2Lt/ha BASF Divine/Integrate 80:20 mixture (1.13t/ha and seeded on-row)

Only one of the low-yielding plots mentioned above could be explained by being seeded off-row. Without evidence to support another conclusion, we suspect the outlier plot yields could result from site variability or soil type.

Soil wetting trials on canola have traditionally struggled to determine significantly different grain yield responses between treatments. Canola plants have an excellent ability to compensate for lower plant numbers. Once canola plant densities are above a critical level, the plants increase vigour and heads per pod. Previous work by M. Harries, M. Seymour & S. Boyce (2016) found that canola densities as low as 10 plants/m^2 can yield 2.5 t/ha. They also noted as plant densities increased, so did grain yield. The highest yield in this trial was 2.14 t/ha, which suggests that the plant density was not a limiting factor.

file:///C:/Users/pmack/Downloads/Harries+Martin+Seeding+uniformity+and+canola+tield.pdf

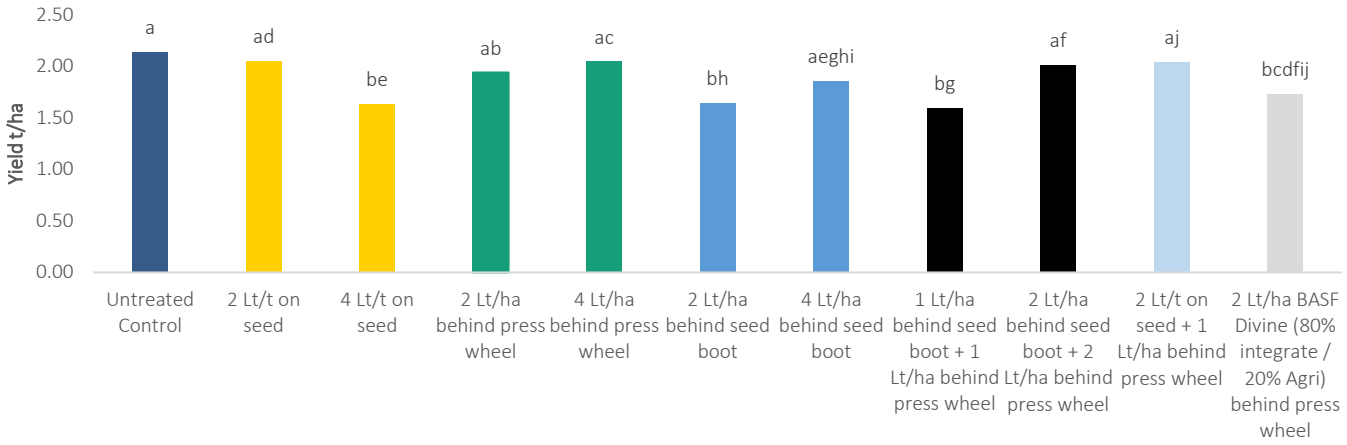


Figure 5: Grain yields of canola for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest gravel at Tenterden WA in 2020.

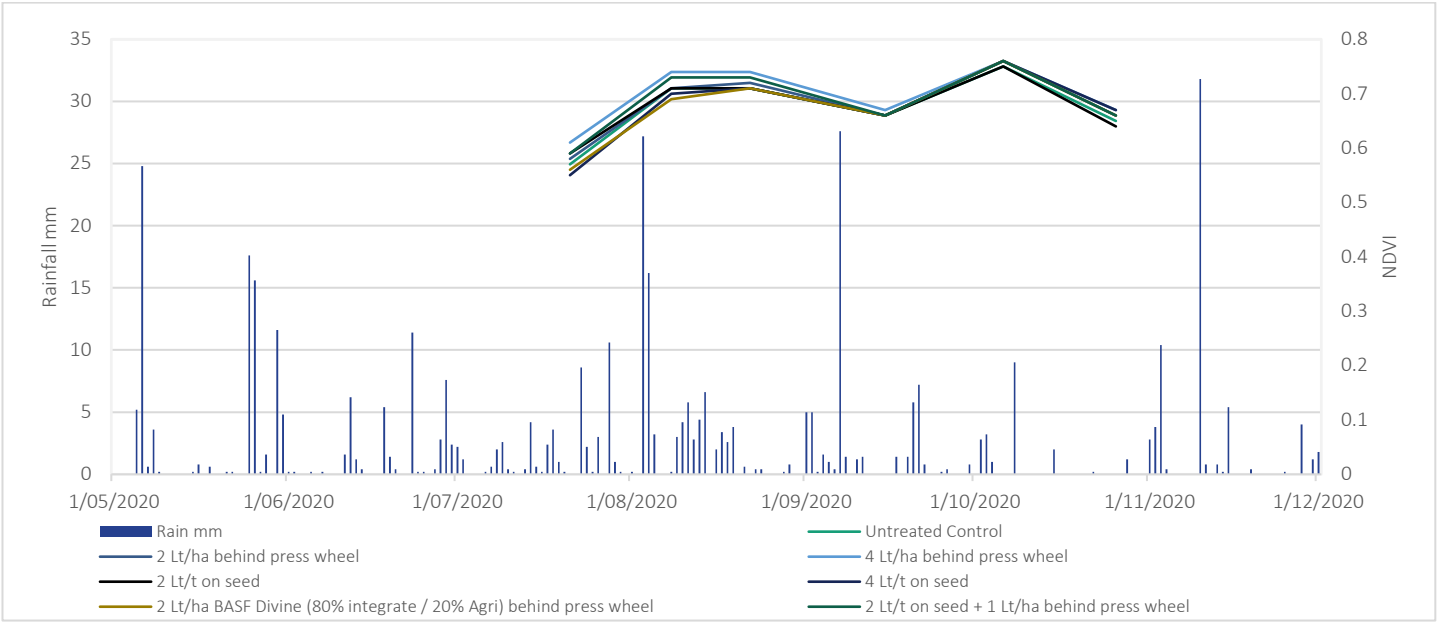


Figure 6: Rainfall and NDVI for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest gravel at Tenterden WA in 2020.

Table 1: Results from the Molarity of Ethanol Droplet (MED) testing conducted by Phillip Mackie in 2020. Replicate 1,2, and 3 represent a composite soil sample taken from each replicate within the trial demonstration site.

Molarity of Ethanol	**Description of Severity**	**Replicate**	**Score**
0	None	**1**	**3.4**
0.1-1.1	Low	**2**	**3.4**
1.1-2.3	Moderate	**3**	**3.6**
2.3-3.5	Severe		
>3.5	Very Severe		

The Molarity of Ethanol Droplet (MED) testing conducted before seeding in 2020 showed our trial site had topsoils that were rated severe or very severe in the third replicate. These results were not surprising to the farmer hosts who identified this paddock as one of the worst non-wetting paddocks on their Tenterden farm.

CONCLUSIONS

There were many variables in this trial that we could not control adequately with broad scale machinery. The largest mitigating factor was seeding on-row, off-row or near-row. Additionally, the natural soil variability of a five hectare trial site meant we can only confidently draw broad conclusions from this trial.

We found that the most efficient use of soil wetters was by placement in the seed contact zone for increased germination and early biomass. Placement of SE14 behind the press wheel and directly on the seed did not improve plant germination or early biomass.

Increasing the SE14 rate from 2 Lt/ha to 4 Lt/ha did not significantly increase grain yield for the following treatments:

1. SE14 placed behind the seed boot
2. SE14 placed behind the press wheel and
3. The combination of SE14 behind the seed boot and press wheel.

This data indicates that 2Lt/ha of SE14 is sufficient on responsive soil, and there were no economic benefits from applying the higher rate.

An unintentional finding was that the best early biomass growth occurred when seeds were placed close to last year's furrow. On-row and near-row had significantly higher early biomass than the off-row placements. These results suggest that growers could expect a furrow tracking and adjusting system, such as the 'ProTrakker' to improve plant germination and early biomass accumulation.

There was high spatial variation across the trial site. Growers will likely experience response variations across their soil landscapes, with economic returns in some areas and not others. Consultation with Glenn McDonald from DPIRD suggested soil wetters work best on loamy gravels and not sandy gravels. Glenn's previous research also suggests a cumulative effect from long-term soil wetter applications that are very hard to quantify.

Future research is needed into the effectiveness of soil wetters in sand. Soil chemistry can change the responses seen, and the results from forest gravels do not necessarily translate to sandy soils.

Increasing Profits with Dual Purpose Crops

Author: Dan Hester
Project Lead: Southern Dirt
Investment Partners: MLA

Abstract

Dual purpose crops are specific crops sown to be grazed during winter to cover feed gaps and reduce supplementary feeding plus to be harvested as a cash crop. The aim of this project is to demonstrate the benefits of dual-purpose crops in a mixed farming enterprise.

Three producer demonstration sites were set up in 2020 by the Southern Dirt group but due to adverse seasonal conditions only one site progressed to the grazing phase. The Kojonup site grazed lambs on a Williams oat crop for 14 days and gained 314.95 g/hd/day compared to the lambs that grazed a pasture paddock for 13 days and gained 215.84 g/hd/day. The daily benefit from grazing an oat crop with lambs during winter compared to a pasture was a weight gain benefit of $0.27/head/day plus the additional benefit of lambs reaching sale weight earlier, reducing the grazing pressure on the property.

The PDS will be continued for another 3 years targeting 3, 3 and 2 sites each year respectively, to total 9 sites and will aim to collate a more detailed cost benefit analysis of implementing crop grazing plus determine the key metrics available to producers to use as a guide when implementing such a strategy in their own operation.

Project objectives

The aim of this project is to demonstrate the benefits and synergies of dual-purpose crops in a mixed farming enterprise, and how they enable increasing carry capacity of stock numbers through winter without impacting crop area and only have a minor impact on yield. Growers in Western Australia are becoming more interested in the opportunities that long season wheats or other dual purpose crops can provide to them in their mixed farming enterprises. Research has shown that a wide range of options exist to optimize future available feedstock. One of these options are Dual purpose crops such as long season wheats. Dual Purpose crops give growers the opportunity to address the winter feed gap through grazing with minimal or no impact to yields if managed correctly. It can provide value to the livestock part of an enterprise by providing high quality feed in June – July which replaces supplementary feeding. It also can allow the time for new pastures to establish, or to increase dry matter for later in the season.

By February 2023, the project aims to:

Demonstrate and quantify the benefits of integrating dual purpose crops into mixed farming systems to address the autumn feed gap with three new demonstration sites each year (9 in total).

- 80% of core producers will have adopted dual purpose crops as a part of their whole farm management system.
- 10% of Southern Dirt members will have adopted dual-purpose crops as part of a whole farm management (currently there is less than 5% of members using dual purpose crops in their mixed farming enterprises)
- Demonstrate the impact of grazing crops on harvest yield (kg/ha) and live weight gain (expected less than 10% yield penalty and 10% increase in liveweight gain (kg/hd/day) on dual purpose crops compared to grazing pasture paddocks).
- Conduct an economic analysis on grazing the dual-purpose crops which will include crop yield and weight gain of sheep (considering factors such as reducing supplementary feed costs, crop yield penalties and weight gain)
- Undertake communication activities (6 field walks and 2 events / workshops) to extend the results to encourage adoption of the practice by Southern Dirt members (target to increase knowledge and confidence in implementing grazing crops into farming management practices by a minimum of 80 farmers by 15%)

MER Report

a. Inputs & Outputs – What did we do?

3 core producers involved in the demonstration

1. Geoff Kowald – Katanning
    a. 2,117 – total Ha managed
    b. 3,000 – total number of sheep
2. Alisdair Staniforth-Smith – Boyup Brook
    a. 1,500 – total Ha managed
    b. 4,200 – total number of sheep
3. Kojonup District High School – Kojonup
    a. 195 – total Ha managed
    b. 1,300 – total number of sheep

Year 1 on farm producer demonstration sites

- 2 sites were both seeded to the dual purpose crop but were deferred due to seasonal conditions, late start to the season and the below average rainfall. The deferred sites were the Katanning and the Boyup Brook sites.
- The Kojonup site progressed through the full demonstration with the below data recorded
    - Agronomic inputs
    - Lamb entry/exit weights
    - Kg/head live weight gain
    - Days grazing
    - DSE equivalent stocking rates
    - Food on Offer assessments and square cuts
    - NDVI recordings

An event was held at the Kojonup District High School farm on the 21st of July and involved Southern Dirt project officers, local growers, Farm manager and the year 9/10 students.

Figure 2: Participants enjoy the Dual Purpose Crops Farm Event.

The participants learnt about crop growth stages and the 'twist and pull' test. From the day it was determined the crop was well established and the entry date and weighing was scheduled for the 4th of August.

Data Results Collated and Analysed

The 2020 sites were located in Boyup Brook, Katanning and Kojonup. Due to seasonal conditions the Boyup Brook and Katanning sites were deferred. All details surrounding the inputs and locations for these two sites are available in the Milestone report 3. The Kojonup site was grazed, data collected and it is analysed below.

Site 3-Kojonup District High School methodology

The Kojonup DHS (KDHS) Farm, made up of 195 Ha and manages approximately 600 merino ewes, along with a smaller number of crossbreds. Two (2) paddocks were selected for the project. The cropping paddock, "Red Dam", is 25 hectares and the pasture paddock, "Orchard", is 12 hectares (Figure 3). The crop paddock was seeded on the 7th of June (Table 1). The pasture paddock, "Orchard" has a mix of perennial pastures (Table 2).

Table 1: Kojonup Applications- Crop Paddock

Date	Product	Rate
9/04/2020	Lime	1000kg/ha
7/06/2020	Seeding-Williams Oats	110kg/ha
	Agro Extra 75% Mop 25%	100kg/ha
4/08/2020	Sheep entered trial	25ha/144 lambs
	Urea	
8/08/20	Additional ewes added to site	

Table 2: Kojonup Applications- Pasture Paddock

Date	Product	Rate
9/04/2020	lime	1000kg/ha
19/05/2020	super phos	100kg/ha
4/08/2020	Sheep entered trial	12ha/75 lambs

Key dates:

7th June – William oats crop sown

4th August – sheep weighed and condition scored and entered trial paddocks at 58 days after sowing.

Crop paddock – 34 wether lambs + 110 ewe lambs

Pasture paddock – 17 wether lambs + 58 ewe lambs

8th August – additional sheep added to the crop paddock per recommendation from DPIRD researchers who noted the crop was getting close to reaching stem elongation and the window for grazing this season was so very narrow.

17th August – sheep removed from pasture paddock and exit weights recorded and mob condition scores assessed

18th August - sheep removed from crop paddock and exit weights recorded and condition scores assessed

Site 3-Kojonup District High School results

The average daily weight gain from the lambs put in the pasture paddock was **215.84 g/head/day** compared to the lambs grazing the Williams oats which gained **341.95 g/head/day**. The daily weight gain as a percent of body weight was:

- 0.83% DWG as % of BW Crop grazing lambs

- 0.52% DWG as % of BW Pasture grazing lambs

The DSE equivalent for each grazing plot was

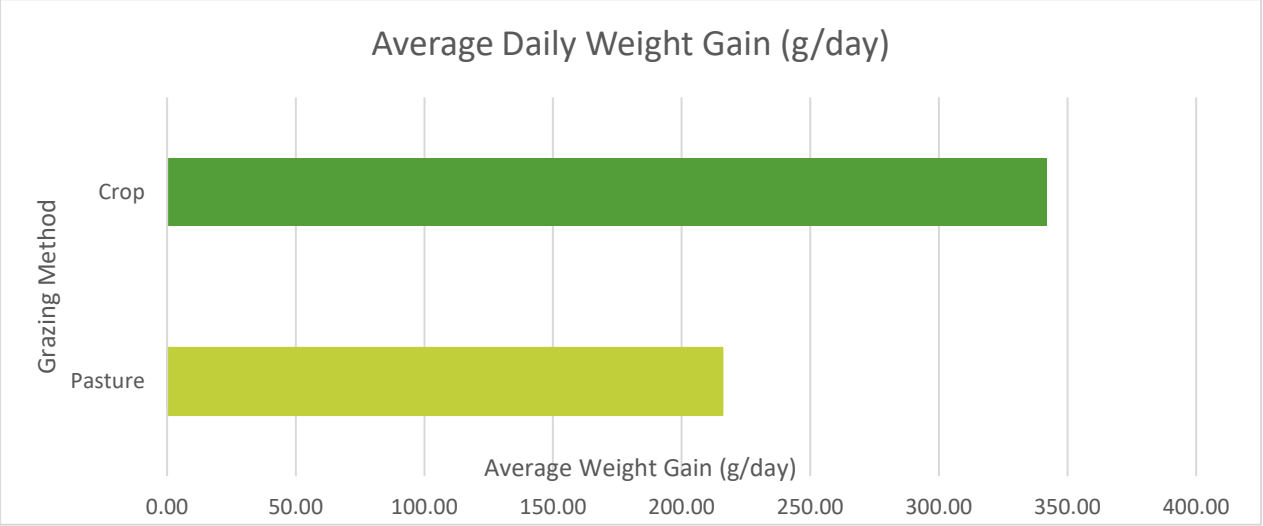
Crop grazing lambs

- 144 lambs @ ave 41.425kg = 119 x 50kg wethers
- 119 equivalent wethers on 25 Ha = 4.77 DSE/Ha

Pasture grazing lambs

- 75 lambs @ ave 41.655kg = 62.5 x 50kg wethers
- 62.5 equivalent wethers on 12 Ha = 5.21 DSE/Ha

Figure 2: Sheep Weight Data in Crop v Pasture



Note: To determine the average exit weight of the crop grazing lambs only 73 were weighed. Also the additional lambs put into the crop paddock were not weighed on entry.

Table 3: Average Daily Weight Gain in Crop v Pasture plus estimated average carcass weight

	Average Initial Weight (kg)	Average Final Weight (kg)	Days Grazed	Weight Gain (kg)	Daily Weight Gain (g/day)	Estimated Av Carcass Weight (@42%)
Pasture	40.25	43.06	13	2.81	215.84	16.91
Crop	39.03	43.82	14	4.79	341.95	16.39

Food On Offer (FOO) assessments were taken during the grazing phase of this project. Results are in the graph and tables below (Tables 6 and 7).

FOO assessment methods:

The crop paddock was assessed with

- Physical pasture cuts
- Crop FOO ruler
- Pastures from Space.

The pasture paddock was assessed with

- Visual Assessments against photography
- Pastures From Space.

Table 4: Crop FOO Measurements

Crop	Square Cut (DM kg/ha)	FOO Ruler (DM kg/ha)	Pastures From Space (DM kg/ha)
4-Aug	1500	900	
5-Aug	1700	1100	500-750
11-Aug	1920	1600	750-1500
18-Aug	1850	1600	1000-1500

Table 5: Pasture FOO Measurements

Pasture	Visual (DM kg/ha)	Pastures From Space (DM kg/ha)
4-Aug	1000	750-1000
11-Aug	1000	750-1000
18-Aug	1000	750-1000

NDVI Readings were taken weekly during the grazing phase of this project. Results are in Figure 5.

Figure 3: Average NDVI Readings at the Crop and Pasture Paddocks (crop blue / pasture green)

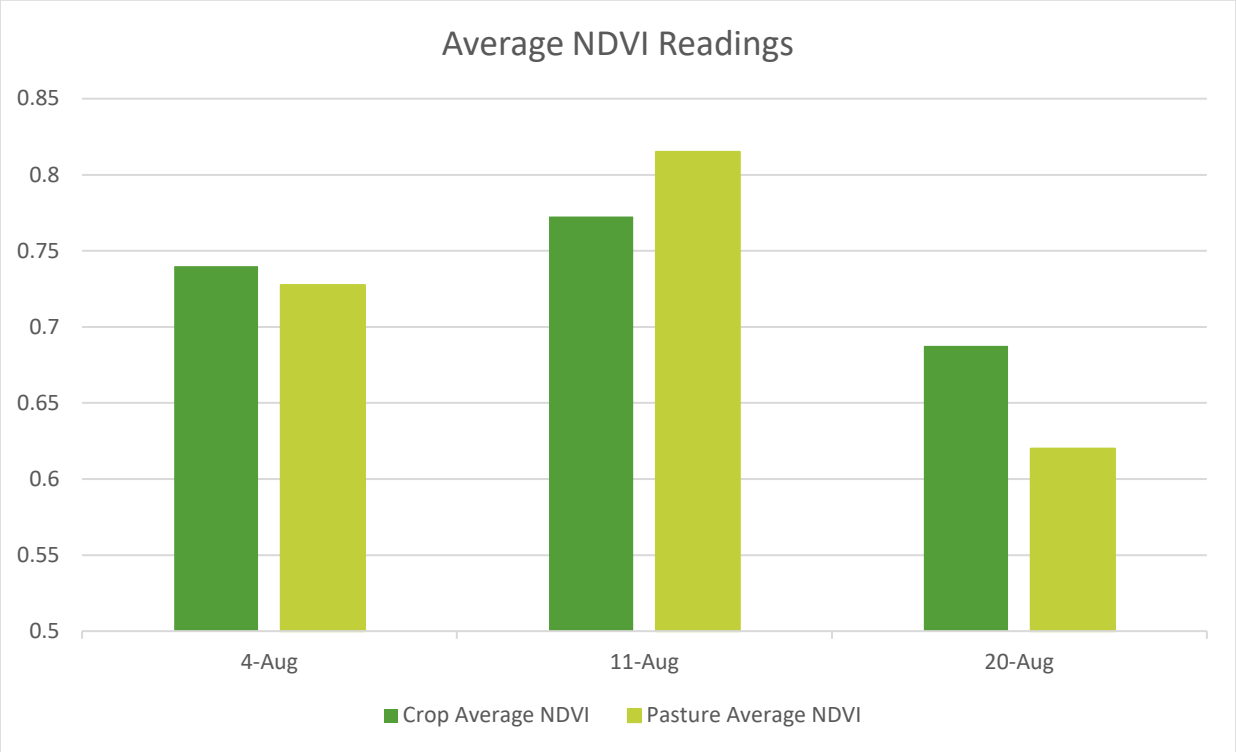


Table 6: Final crop yield

Crop	Total MT Harvested	Grazed crop final yield (MT/Ha)
12 Dec	100	4.00

Site 3-Kojonup District High School discussion and conclusions

Daily growth rates for both groups of lambs was higher than expected in relation to the performance of merino lambs in Kojonup in the middle of winter. Table 8 gives DPIRD's expected daily live weight growth rates for Merino lambs on different feeds. Lot fed Merino lambs are only expected to gain at a maximum of 250 g/hd/day. Both results were high in relation to this rate with pasture grazed grazing lambs growing at 215.84 g/hd/day and crop grazing lambs growing at 341.95 g/hd/day.

Table 7: Expected growth rates ranges for Merino and first cross lambs in various finishing systems units are in grams per head per day (g/hd/day).

Lamb finishing system	Merino weight gain in g/hd/day	First cross weight gain in g/hd/day
Sucker lambs to 14 weeks	240–280	300–360
Weaned lambs on green fodder crops	140–170	160–200
Weaned lambs on lupin stubble	80–160	80–200
Weaned lambs on self-feeders of grain in stubble or dry pasture paddock	130–150	150–220
Lot fed lambs	150–250	250–350

While the daily growth rates were high the relative difference between both systems was inline with expectation. Short term grazing of crops has the ability to give a boost to the growth rates of lambs on grazing pastures. Additional benefits from this management system include allowing the short-term resting of pastures enabling then to 'get away' during the slow growth period of winter. The strategy also allows increased carrying capacity as the total grazing capacity of the property increases through encompassing the crop paddocks.

Stock rates for crop grazing can be highly variable depending on the management targets of different operations. In this demonstration a light stocking rate of circa 5 DSE/Ha (4.77 and 5.21 DSE) was implemented. From the FOO recordings it can be seen that this stocking rate only had a limited impact on the crop. The crop was able to continue growing on average while under the grazing pressure for the 2 week period. It is therefore expected, under this strategy, the short-term light grazing would have little impact on the eventual crop yield. Although the NDVI improved 1 week after the lambs were put into the paddocks and then declined after the second week, suggesting the lambs were starting to reduce the FOO of both paddocks and that they were removed at the correct time.

Daily growth rate as percent of body weight is a good measurement to compare different size lambs daily weight gain and how they are performing relative to each other. The daily live weight gain of 0.83% and 0.52% (crop and pasture respectively) as a percent of body weight are both much higher than expected.

The reason for the higher than expected growth remains unknown although it is potentially due to the actual method of physically weighing the lambs. There may have been a delay in recording the entry weight, in between getting the mob in and recording the weights allowing the lambs to partially empty out. Another potential cause could be the time of day of each weighing operation was different and the feed/water intake impacted weight and final daily weight gain. Moving

forward it will be important to develop weighing protocols for the remaining producer demonstration sites to ensure the actual daily weight gains are recorded accurately.

Finally capturing the complete benefit cost analysis from integrating crop grazing into a mixed operation is problematic to model from data from a producer demonstration site. Individual operations benefit from overall increased carrying capacity, improved pasture growth from rotational grazing and reduced supplementary feeding needs to be considered when implementing crop grazing into a mixed farming strategy. More in depth data collation and analysis will be required from the future demonstrations.

The weight gain benefit from this demonstration using 500 c/kg carcass weight was:

Crop grazing

- Total live weight gain 4.79kg
- Total carcass weight gain @ 42% yield 2.01kg
- Daily weight gain $0.72/head/day

Pasture grazing

- Total live weight gain 2.81kg
- Total carcass weight gain @ 42% yield 1.18kg
- Daily weight gain $0.45/head/day

The daily benefit from grazing an oat crop with lambs during winter compared to a pasture is $0.27/head/day. An additional benefit is that the lambs will reach a sale weight earlier reducing the grazing pressure on the property.

The final yield of the grazed crop was 4.00 MT/Ha however the non-grazed crop yield was not recorded at the end of the season and therefore the cost benefit from the grazing is unable to be determined after year 1. From the actual yield, NDVI and FOO data it is predicted there would have been a minimal impact as the 4.00 MT/Ha yield at the higher end of the expected range of an oat crop in Kojonup on a below average rainfall season. The impact of grazing crops will be determined over the next 3 seasons in more detail while the PDS continues.

Alternative Fodder Crops for Turning Off Weaner Lambs/Hoggets

Author: Dan Hester
Project Lead: Southern Dirt
Investment Partners: MLA

Executive Summary

This producer demonstration site project being run by the Southern Dirt group in Western Australia aims to establish an economical alternative fodder (standing) crop system to the current system of weaning lambs onto a standing oat crop. The project aims to increase live weight gain (LWG) in lambs/hoggets over the late spring and summer period utilizing alternative crops such as lupins, vetch or other legumes.

The demonstration is scheduled to run from 2020 to 2022 and will involve a total of 9 sites. Due to seasonal conditions, only one site was in place in 2020. The average LWG achieved in the first year of the demonstration was 84 g/day over the late spring autumn period. However, this included grazing on other stubbles and growth rates while on the lupin fodder crop are expected to have been considerably higher.

The PDS is targeting four sites for each of the next two years. Future sites will aim to establish a more detailed weight gain benefit and cost benefit analysis from grazing an alternative fodder crop compared to a standing oat crop.

Project Background

The Great Southern area is the core sheep production area of Western Australia with this industry integral to grower's production system. Growers are reliant on the live export shipping industry being one of their key markets for wethers and cull ewes.

With the real possibility that the live shipping market will be disbanded across Australia, it is important to find an economical way to maximise businesses, and to diversify and expand into other market opportunities as they arise.

The current lamb production system in the Great Southern entails the following:

- Lambs are born in July/August
- Weaned onto an oat fodder crop (grown entirely for the lambs)
- Stocked at 40-50 lambs/ha in fodder crops over summer (with low rates of lupins to increase protein)
- Shorn in late summer, aiming for a minimum of 60mm wool length
- Run through winter and shorn in late spring
- Sold into live shipping market over late spring/summer as a hogget

The Pro's of this system are:

- Simple to manage lambs over summer
- Lower summer stocking rates on the rest of the farm
- Wethers can be used as a release valve if poor start to the growing season

The Con's of this system are:

- Slow lamb growth rates
- Uncertainty of live export market

Project Purpose

The project, 'alternative fodder crops for turning off weaner lambs/hoggets' is a producer demonstration which aims to investigate

1 - the economical strategies surrounding alternative fodder crops to increase weight gain in weaner lambs/hoggets over the late spring, summer period.

2 – to reduce the reliance on live export shipping.

3 – to provide alternative livestock management systems to increase profitability by targeting specific markets.

Project Objectives

The producer demonstration is to be completed over the three seasons 2020/21, 2021/22 and 2022/23 with the objectives to be reached by the project completion date of April 2023.

By April 2023 the project is targeting to have the following objectives complete:

1. Demonstrate and assess the benefits via an increase in hogget live weight gain of alternative fodder crops to the traditional oat fodder crop with 3 sites each year over 3 years being a total of 9 demonstration sites.

    a. If possible one site will operate across the three years to account for seasonal variation

    b. Other sites will be rotated across years (i.e. different producers) but if a producer who has trialed fodder crops in the previous year decides to continue the practice, then they will provide measurement data to the project.

2. Each site to have an oats control and one alternative fodder crop variety

    a. Control: Oat fodder crop (This is a commonly used fodder crop within the Compass Ag group))

    b. Alternative fodder crops depending on availability and suitability to local conditions: For example: vetch, lupins, Brassica species and fodder mixes.

3. Conduct a cost benefit analysis to determine the relative economic performance of the varieties on lamb/hogget weight.

4. 80% of core producers will continue to adopt an alternative fodder crop into production systems if demonstration site results in increased weight gain.

5. 20% of observer producers will have adopted or intend to adopt an alternative fodder crop into production systems if demonstration site results in increased weight gain.

6. 100% of core producers and 50% of observer producers will have improved their knowledge and skills in relation to alternative fodder crops in their farming system and alternative options for hogget sale

The results of the PDS will be disseminated via targeted extension activities (e.g. one field day / farm walk per year and three demonstration/workshops) to showcase the demonstration sites

Additional benefits:

Building organic nitrogen in soil for following years cereal/oilseed crop

Cleaning up grass weeds through using stronger grass selective herbicides

2 Methodology

The demonstration for the first year was limited to 1 site, hosted on Andrew Scanlon's property Quailerup, located south of Arthur River on Beaufort Rd. The project builds on the previous 2 years of data generated by Andrew of weaning lambs onto alternative fodder crops. A second site was sown in 2020 however due to seasonal conditions the site was unable to progress to grazing.

The demonstration for year 1 didn't include a comparison oat fodder crop as previous season's work had determined the growth rates were slower and mortality rates were higher and therefore the cost of implementing the demonstration (slower growth rate and higher mortality) of grazing lambs on oats outweighed the benefit of the demonstration.

The data required for grazing lambs on oats has been sourced from the Department of Primary Industry and Regional Development industry standards in year 1 but this comparison will be included in year 2 and 3 of the project.

From the demonstration there are 6 key outcomes which are being measured:

1) daily growth rates from weaning and during the grazing period of the alternative fodder crops

2) Wool production

3) Mortality

4) Time to turn off

5) cost benefit analysis

6) Following year crop production analysis

2.1 2018 & 2019 Methodology

2018 and 2019 fodder crops were prior to the demonstration project however Quailerup as part of their normal operations were already using lupin crops to wean merino lambs on to.

For these two seasons the final weights exiting the fodder crops have been recorded and detailed along with the total and average wool production.

2.2 2020 Methodology

a. Alternative fodder crop - production

Two paddocks totaling 113Ha were both sown to Jurien lupins on the 18th of May to be part of the demonstration.

Soil type – York gum/white gum

Paddock 1 - Goldfields, 66Ha Paddock 2 - First Field, 47Ha

Figure 1: Google Earth of the 2 fodder paddocks

2019 crop - Barley

2020 crop – 113 Ha Lupins - PBA Jurien (see Figure 1)

Agronomic package used on both paddocks is available in Appendix 1.

Measurements

1. Variable production costs
2. Dry matter production estimate pre-grazing

b. Alternative fodder crop - grazing

5,403 lambs entered trial paddock on 30 October 2020

135 ram lambs weighed on entry

154 ram lambs weighed on exit

Measurements:

1. Entry and exit dates
2. Ram lamb growth rates
3. Wool production
4. Lamb stocking rates and total DSE days
5. Cost benefit analysis

3 Results

3.1 Dry matter production

The two lupin paddocks were sown on the 18th of May into sufficient moisture enabling the crop to germinate. As evident in Figure 2 weed control was very good however due to the well below average seasonal rainfall the dry matter production was lower than average (see table 1). To aid in dry matter production estimation a third paddock of lupins alongside the demonstration crops had a grain yield of 1.8mt/Ha at harvest.

Grazeable Dry Matter Production in the two demonstration paddocks (Goldfields and First Field) is estimated to have been between 2.40 – 2.60 MT/Ha on average across the paddock prior to the lambs entry (see figure 2).

Figure 2: Alternative fodder crop, Jurien lupins, prior to grazing.

Table 1: Arthur River rainfall 2020 (source BoM)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2020	n/a	16.4	18.2	5.8	45.4	58.0	39.3	37.2	39.8	11.6	38.7	n/a	310
Mean	10.8	16.1	20.7	28.2	59.2	81.6	77.3	64.3	44.5	33.2	18.3	13.1	467.3

3.2 Live Weight Gain

2020 LWG results

5,403 lambs entered the trial paddock on the 22nd of October 2020. The paddock was 113 Ha to give an average stocking rate of 48 lambs per hectare. 135 ram lambs were weighed on the 30th of October for the trial and averaged 24.03 kg.

The lambs late spring into summer grazing rotation is outlined in Table 3. It is worth noting that during the period while grazing on the barley stubble it is thought that the lambs were not on a rising plain due to the poor feed quality which impacted the results.

The lambs exited the Lupin fodder paddock on the 4th of Feb and were weighed on the 5th of Feb. 154 ram lambs were weighed and averaged 32.28kg.

Over the 98 day period the ram lambs put on an average of 84 grams/day.

Table 2: 2020 lambs paddock/feed rotation

Feed type	Start date	Finish Date	Number of days
Lupins fodder crop	22 Oct 2020	28 Nov 2020	37 days

Lupin/vetch (stubble)	28 Nov 2020	14 Dec 2020	16 days
Barley stubble	14 Dec 2020	7 Jan 2021	24 days
Lupin fodder crop (original)	7 Jan 2021	4 Feb 2021	28 days

Figure 3: weighing ram lambs prior to entry of alternative fodder crop.

Figure 4:

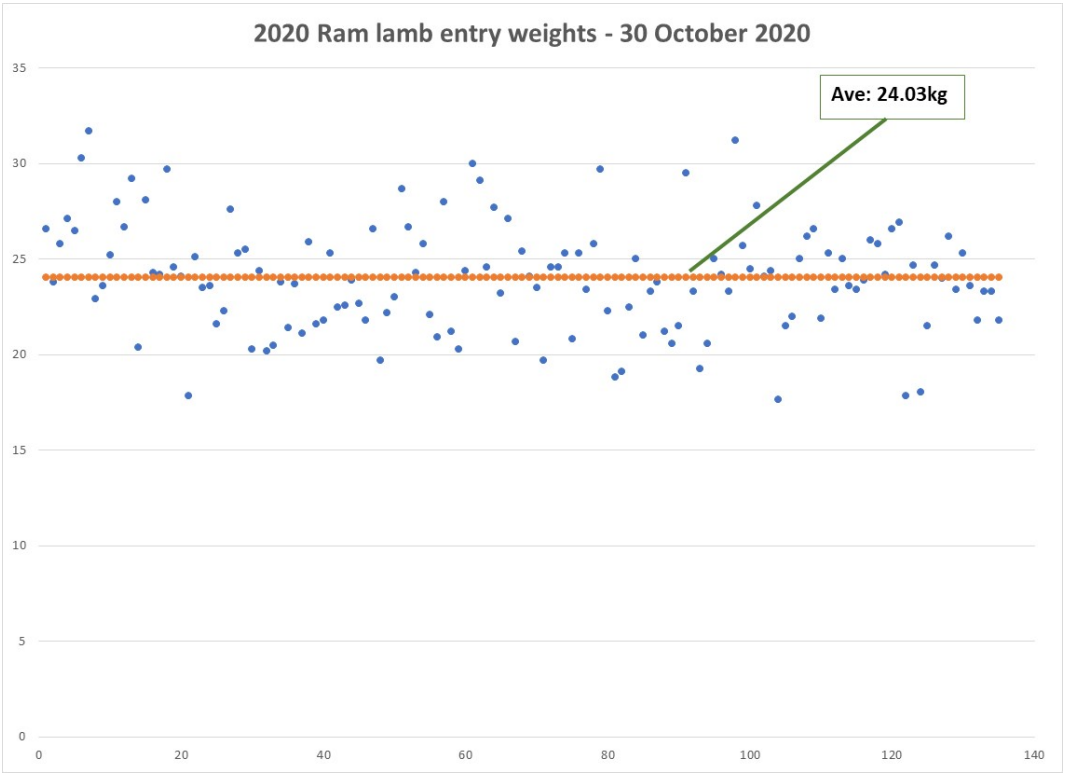
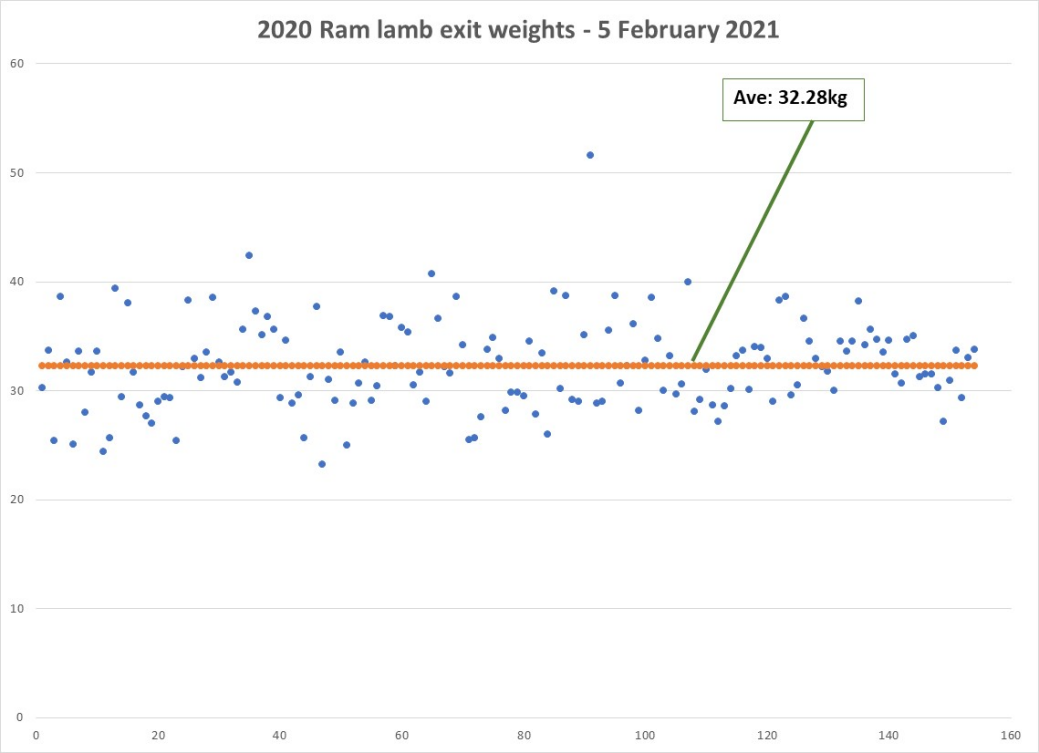


Figure 5:



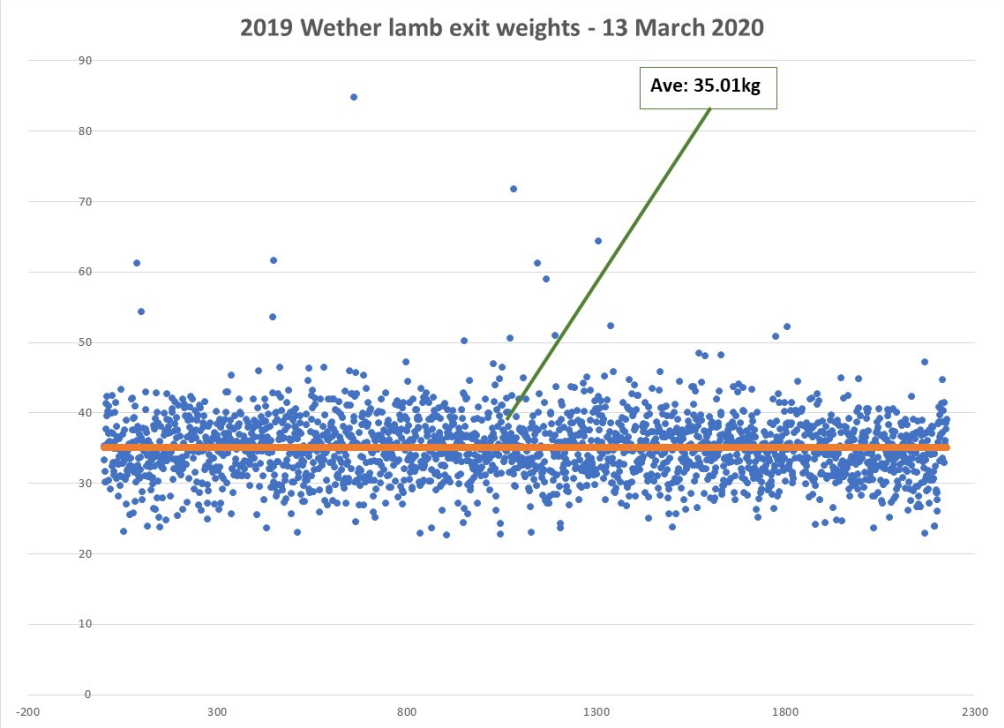
2018 – 2019 Final Weight Results

Prior to the demonstration commencing in 2020 similar lamb finishing programs onto standing lupin crops were implemented on Quailerup in 2018 and 2019. The lamb stocking rates and wether lamb exit weights are outlined below.

2019 Exit weight results

Fodder Crop –	Lupins
Ha -	118 Ha
Total Lambs on crop -	4,887
Lambs/Ha -	41
Wether lambs on exit -	2,238
Exit weigh date -	13 Mar 2020
Average exit weight -	35.01

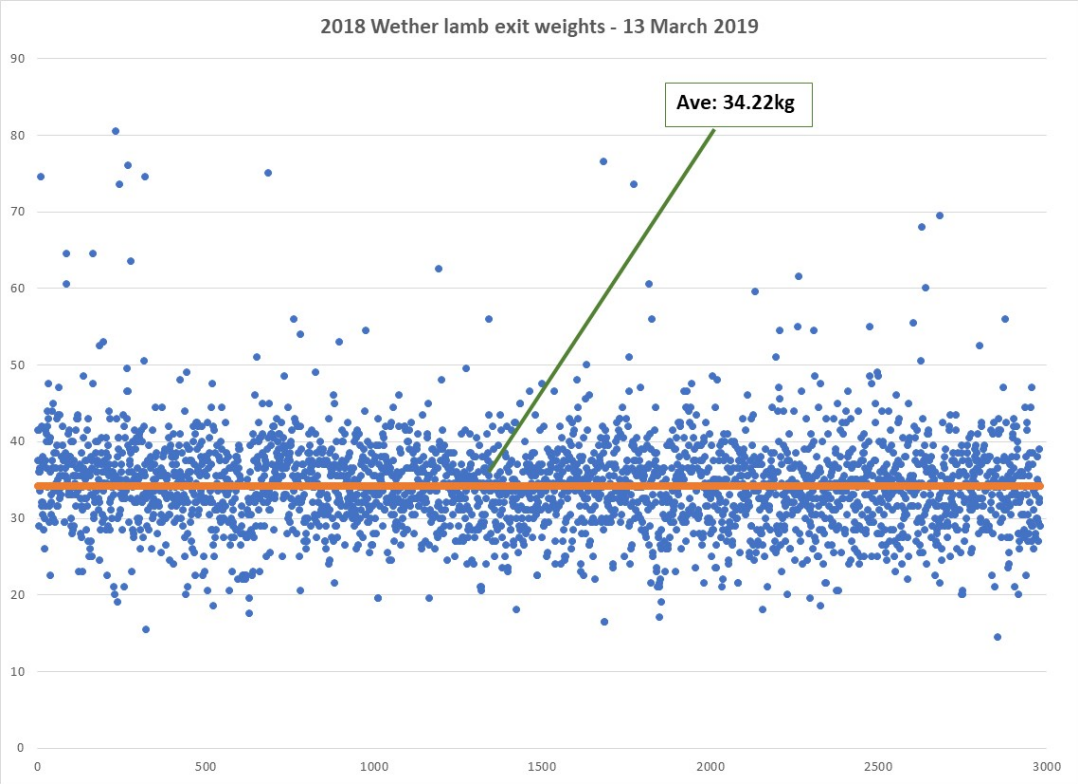
Figure 6:



2018 Exit weight results

Fodder Crop –	Lupins
Ha -	122 Ha
Total Lambs on crop -	5,545
Lambs/Ha -	45
Wether lambs on exit -	2,981
Exit weigh date -	13 Mar 2019
Average exit weight -	34.22

Figure 7:



3.3 Wool Production

2020 Wool production

Not available as shearing had not occurred at the time of writing the report

2019 Wool production

12,564 kg lambs wool sold

4,670 lambs shorn

2.69 kg wool/head

2018 Wool production

14,102 kg lambs wool sold

5,430 lambs shorn

2.59 kg wool/head

3.4 Mortality

2020 Mortality results

5,403	22 October 2020, lambs on entry of lupin fodder paddock
5,345	4 February 2021, lambs on exit of summer grazing rotation
58	Total mortality or 1.07%.

4 Discussion

The average daily live weight gain was 84 grams/day. While this daily live weight gain is at the low end of the expected growth rate range (see Table 3) it is thought, the period while on the barley stubble, considerably impacted the growth rate of the lambs over the demonstration period. This is due to the poorer than expected feed quality of the barley stubble. Growth rates while on the lupin fodder crop are expected to have been considerably higher.

Water quality is essential to keeping lambs on a rising plain. Very high stocking rates puts pressure on water quality and they can become 'fouled' due to the high number of lambs concentrated around the dam. The lambs in the demonstration were moved off the lupin fodder crop due to the dam becoming fouled and requiring time to clean up. The lambs weren't moved due to the paddock running out of feed. It is important for producers to consider water supply strategies that will be able to sustain the concentration while feeding lambs at such high stocking rates.

Table 3: Forecast lamb growth rates

Table 1 Expected growth rate ranges for Merino and first cross lambs in various finishing systems. Note units are in grams per head per day (g/hd/day)

Lamb finishing system	Merino weight gain in g/hd/day	First cross weight gain in g/hd/day
Sucker lambs to 14 weeks	240–280	300–360
Weaned lambs on green fodder crops	140–170	160–200
Weaned lambs on lupin stubble	80–160	80–200
Weaned lambs on self-feeders of grain in stubble or dry pasture paddock	130–150	150–220
Lot fed lambs	150–250	250–350

Using a 50kg wether as the standard DSE the average stocking rate for the trial paddock was 29.25 DSE/Ha (assuming the average entry/exit weighed ram lambs was representative of the entire mob). The lupin fodder crop maintained the 226.92 DSE stocking rate for the 65 days it was grazed.

Stocking rates rules of thumb:

Quailerup have utilized this summer grazing system for the past 4 seasons and have developed the following stocking rate rules of thumb for weaning merino lambs onto lupin fodder crops from late Spring through to Autumn.

- 30 lambs/Ha: every lamb sold onto the boat in Autumn
- 40 lambs/Ha: A high percent will go straight onto the boat with the bottoms requiring finishing
- 50 lambs/Ha: The lambs will survive the summer, slowly move forward and allow minimal management through harvest but a considerable portion will require finishing before making weight to go on a boat.

Using a minimum weight of 35kg as the target weight for selling into the live export market, the following exit weight correlate from the rule of thumb, stocking rates:

2020 – 48 lambs/Ha

The lambs moved forward and allowed for a reduced management harvest however they will require additional finishing to meet the live export minimum weight.

2019 – 41 lambs/Ha

The lowest stocking rate and the highest average exit weight with 50.98% being above 35kg and the bottoms requiring further finishing.

2018 – 45 lambs/Ha

44.75% of wether lambs exiting above 35kg.

The above rules of thumb stocking rates will continue to be quantified over the duration of this project, 2 additional seasons, as this will develop an excellent management tool for producers to know the Ha required to be planted for the number of lambs being produced.

Reduced mortality rates has been one of the key benefits of the alternative fodder or lupin crop grazing system. The mortality rate of 1.07% is an exceptional improvement over grazing oat fodder crops in previous years where the mortality rates can be circa 7% – 9%. This improvement aides in the reduced management.

The key metrics to come out of the demonstration for the cost benefit analysis are:

- $140.71/Ha - Variable input costs for lupin crop.
- 65 grazing days for 5,403 lambs on 113 Ha
- Weed management and increased organic nitrogen for the next seasons cereal/oilseed crop
- Maintained a DSE stocking rate of 26.92 for 65 days over summer
- Targeting 35 kg lambs into the live export market removes the lambs from the property prior to winter allowing higher carrying capacity of ewes and increased lamb production.

Conclusions/Recommendation

Weaning and managing merino lambs over the summer period to have them heavy enough for the live export market before the end of Autumn is important for the overall operational strategy of properties in the Great Southern. Alternative fodder crops, in this case lupins, have demonstrated they have the ability to maintain high stocking densities for long periods and keep the lambs on a rising plain to meet the required live weight to be sold before the end of Autumn. The ability to sell lambs prior to the end of Autumn and not have to carry them through winter and into the following spring can have a large impact on flock structure and operational strategies which will be one of the key outcomes for the remaining demonstrations over the next 3 years.

Another key outcome of the project is to demonstrate the benefit of an alternative fodder crop over the current finishing lambs strategy of grazing a standing oat crop. In this demonstration there was no standing oat crop or 'control' and therefore the benefit of these alternative standing crops cannot be verified. Control crops alongside the alternative fodder crops for comparison will be part of the demonstrations moving forward.

The recommendations that have developed from the year 1 demonstration are:

- Improve understanding of the stocking rate rules of thumb for fodder crops
- Develop water quality protection strategies to allow longer grazing periods on the fodder crop
- Measure live weight gains of the lambs while on the fodder crop
- Measure the additional benefit of the fodder crop on the following years cereal/oilseed crop
- Explore additional marketing options outside of the live export trade
- Impact on flock structure and cost benefit analysis selling lambs in late Autumn
- Inclusion of a control oat crop in each demonstration

6 References

Roberts D 2019, Growing weaner sheep, Department of Primary Industries and Regional Development, 7th March 2021, <https://www.agric.wa.gov.au/management-reproduction/growing-weaner-sheep> .

7 Appendix

Appendix 1. Agronomic packages for the lupin fodder crops

Field Nutrition (kg/ha): N 6.12 P 7.2 K 6.72 S 3.6 Cu 0.06 Zn 0.1 2 **10 First Field -** 48 of 73

2020 2019 2014

Narrow Leaf Lupin - PBAJurien 113 ha Barley - RGT Planet 47.21 ha

SITUATION/ TIMING	INPUTS	RATE	TOTAL	COST/ HA	COST
PRE PLANT	Total Application Rate	70 L/ha	7,910 L		
KNOCKDOWN	Ammonium Sulphate Herbicide Adjuvant	1 kg/l00L	79.1 kg	$0 .56	$63.28
22 Apr 2020	Hammer 400EC Herbicide	0.015 L/ha	1.695 L	$3.00	$339.00
	Glyphosate 450	1.5 L/ha	169.5 L	$6.60	$745.80
	Wetter 1000	0.1 %	7.91 L	$0.42	$47.46
			Total	**$10.58**	**$1,195.54**
IBS LUPINS 01 May 2020	Total Application Rate Simazine 900 WG	70 L/ha 1.1 kg/ha	7,910L 124 .3 kg	$7.70	$870 .10
	Rustler Selective Herbicide	1 L/ha	113 L	$20 .00	$2,260 .00
	Alpha Duo 250 SC	0.04 L/h a	4.52 L	$0.66	$74 .58
	Chlorpyrifos 500EC	0.1 L/h a	11.3 L	$0.85	$96.05
	Gramoxone 250 Herbicide	1 L/ha	113 L	$5.00	$565 .00
			Total	**$34.21**	**$3,865.73**
SEEDING	PBAJurien	100 kg/ha	11.3 t	$40 .00	$47.00
LUPINS	Becker Underwood Nodulator Group G	5 kg/ha	565 kg	$15.00	$1,695 .00
02 May 2020	K-Tlll Extra	60 kg/ha	6.78 t	$0.00	$0.00
	Field Nutrition (kg/ha): N 6.12 P 7. 2 K 6.72 S 3.6 Cu 0.06 Zn 0.12				
GRASS	Total Application Rate	70 L/ha	7,910L		
SELECTIVE	Ammonium Sulphate Herbicide Adjuvant	1 kg/l 00L	79.1 kg	$0.56	$63.28
01 Jun 2020	Clethodim 240 EC	0.5 L/ha	56.5 L	$7.50	$847 .50
	Quizalofop 99.5 EC	0.3 L/ha	33.9 L	$3.00	$339.00
	Hasten S ra Ac!juvant	1 L/l00L	79.1 L	$4.20	$474.60
			Total	**$15.26**	**$1,724.38**
IIA'iUS'il: SPRAY	Total Applicati on Rate	70 t/ ha	7,910 L		
IN LUPINS	Metribuzin 750 WG	0.06 kg/ha	6.78 kg	$2.40	$271.20
20 Jun 2020	Brodal OJ>tions Selective Herbicide	0.15 L/ha	16.95 L	$6.00	$678.00
			Total	**$8.40**	**$949.20**
GRASS	Total Application Rate	70 L/ha	7,910 L		
SELECTIVE	Ammonium Sulphate Herbicide Adjuvant	1 kg/l00L	79.1 kg	$0.56	$63.28
01 Aug 2020	Clethodim 240 EC	0.5 L/ha	56.5 L	$7.50	$847 .50
	Hasten Se rai Adjuvant	1 L/l00L	79.1 L	$4.20	$474 .60
			Total	**$12.26**	**$1,385.38**
CROP- TOPPING	Total Application Rate Gramoxone 250 Herbicide	70 L/ha 1 L/ha	7,910 L 113 L	$5.00	$565.00
LUPINS 10 Oct 2020			**Total**	**$5.00**	**$565.00**
		Total	- $5 5 0 $6 , 2 1 5		
			Chem Total	$100 .71	$11,380.23
			Fert Total	$0.00	$0.00
			Seed Total	$40 .00	$4,5 20 .00
			Plan Total	**$140.71**	**$15,900.23**

Field Nutrition (kg/ha): N 6.12 P 7.2 K 6.72 S 3.6 Cu 0.06 Zn 0.12

11 Goldfields

2020 2019 2014

Narrow Leaf Lupin - Barley - RGT Planet

PBAJ Jurien 66.21 ha

106 ha

SITUATION/ TIMING	INPUTS	RATE	TOTAL	COST/ HA	COST	
PRE PLANT	Total Application Rate	70 L/ha	7,420 L			
KNOCKDOWN	Ammonium Sulphate Herbicide Adjuvant	1 kg/l00L	74.2 kg	$0.56	$59 .36	
22 Apr 2020	Hammer 400EC Herbicide	0.015 L/ha	1.59 L	$3.00	$318.00	
	Glyphosate 450	1.5 L/ha	159 L	$6.60	$699.60	
	Wetter 1000	0.1 %	7.42 L	$0.42	$44.52	
				Total	**$10.58**	**$1,121.48**
IBS LUPINS 01 May 2020	Total Application Rate Simazine 900 WG	70 L/ha 1.1 kg/ha	7,420 L 116.6kg		$7.70	$816.20
	Rustler Selective Herbicide	1 L/ha	106 L		$20 .00	$2,1 20 .00
	Alpha Duo 250 SC	0.04 L/ha	4.24 L		$0.66	$69 .96
	Chlorpyrifos 500EC	0.1 L/ha	10.6 L		$0.85	$90 .10
	Gramoxone 250 Herbicide	1 L/ha	106 L		$5.00	$530.00
				Total	**$34.21**	**$3,626.26**
SEEDING	PBAJurien	100 kg/ha	10.6 t		$40.00	$4,240.00
LUPINS	Becker Underwood Nodulator Group G	5 kg/ha	530 kg		$15 .00	$1,590 .00
02 May 2020	K-Tlll Extra	60 kg/ha	6.36 t		$0.00	$ 0.00
	Field Nutrition (kg/ha):	N 6.12 P 7.2	K 6.72 S 3.6	Cu 0.06 Zn 0.12		
				Total	**-$5 5 .**	**$5,830.00**
GRASS	Total Application Rate	70 L/ha	7,420 L			
SELECTIVE	Ammonium Sulphate Herbicide Adjuvant	1 kg/l00L	74.2 kg		$0.56	$59 .36
01 Jun 2020	Clethodim 240 EC	0.5 L/ha	53 L		$7.50	$795.00
	Quizalofop 99.5 EC	0.3 L/ha	31.8 L		$3.00	$318.00
	Hasten S ra Ad'uvant	1 L/l00L	74.2 L		$4.20	$445.20
				Total	**$15.26**	**$1,617.56**
'i.l,\I)iSH SPRAY	Total Application Rate	70 L/ha	t,420 L			
IN LUPINS	Metribuzin 750 WG	0.06 kg/ha	6.36 kg		$2.40	$254.40
20 Jun 2020	Brodal OEti ons Selective Herbicide	0.15 L/ha	15 .9 L		$6.00	$636.00
				Total	**$8.40**	**$890.40**
GRASS	Total Application Rate	70 L/ha	7,420 L			
SELECTIVE	Ammonium Sulphate Herbicide Adjuvant	1 kg/l00L	74.2 kg		$0.56	$59.36
01 Aug 2020	Clethodim 240 EC	0.5 L/ha	53 L		$7.50	$795.00
	Hasten S ra Ad·uvant	1 L/l00L	74.2 L		$4 .20	$445 .20
				Total	**$12.26**	**$1,299.56**
CROP- TOPPING	Total Application Rate Gramoxone 250 Herbicide	70 L/ha 1 L/ha	7,420 L 106 L		$5.00	$530 .00
LUPINS 10 Oct 2020				**Total**	**$5.00**	**$530.00**
				Chem Total	$100 .71	$10,675.26
				Fert Total	$0.00	$0.00
				Seed Total	$40.00	$4,240.00
				Plan Total	**$140.71**	**$14,915.26**

Controlling red legged earth mites using intensive spring grazing

2020 Annual Results

Authors: Svetlana Micic and Paul Sanford, Department of Primary Industries and Regional Development

Key words

Red legged earth mite, grazing

Key messages

Maintaining feed on offer at around 2 t DM/ha for four weeks in spring can effectively control RLEM in the following growing season.

Aims

To demonstrate if short periods of intensive grazing in spring will control red legged earth mites (RLEM) effectively without the use of insecticides.

Introduction

Research conducted in the 1990's found that intensively grazing pastures for the whole of spring controls RLEM as effectively as insecticides. Yet the tactic has not been adopted by producers due to the impractical number of sheep required for months for one paddock. It is however reasonable to expect that some if not all of the benefits could be realised by much shorter periods of intensive grazing.

Insecticide resistance has recently arisen in RLEM populations in parts of the grain belt renewing interest in alternative control methods such as intensive spring grazing around the Timerite® period. Grazing is an attractive option as it possibly has multiple benefits such as improved yields in following grain crops and better weed control in spring pasture.

While any producer with a mixed farming enterprise could benefit from a spring grazing package aimed at controlling RLEM we expect the largest benefits to be for those in the medium to high rainfall zones with more pasture FOO and bigger RLEM populations. The cost to implement this spring grazing package in most cases would be zero however it would require some additional labour.

Given that in the absence of chemical control options resistant RLEM's could reduce crop yields by up to 30% at a loss of around $74/ha. A spring grazing package could recover a substantial proportion of these losses.

Method

In 2019 and 2020, three on farm-demonstrations at Boyup Brook, Cranbrook and Kalgan compared intensive grazing for 2 and 4 weeks in spring, around the Timerite® date, to an ungrazed control. Intensive grazing involved maintaining pasture feed on offer (FOO) at approximately 1.4 tonne dry matter per hectare (t DM/ha). Pastures were assessed weekly and RLEM were sampled fortnightly in spring and following the break of the growing season in the following year.

RLEM were suction sampled using a Stihl™ blowervac BG55. The nozzle of the blowervac had a sieve with fine mesh (holes at ~10 µm) placed 5 cm into the aperture of the blowervac. The nozzle of the

blowervac was held on the ground for 2 seconds and 10 suction samples were taken per sample jar containing 10 mL of 70% ethanol. A total of 10 sample jars were collected per treatment. In spring collections were taken at fortnightly intervals starting from around the Timerite® date and in the following year collections were taken after the break of the growing season and again one month later. Mites were counted under a dissecting microscope.

Pasture FOO was determined using the calibrated visual assessment technique of Campbell and Arnold (1973). At each sampling 60 individual visual assessments were made for each treatment using a quadrat (0.1 m^2) these estimates were related to actual FOO by taking 7 to 10 calibration cuts.

Results and Discussion

Boyup Brook

The intensively grazed plots were maintained at approximately 2 t DM/ha of dry matter in 2019 and 1.9 t DM/ha of dry matter in 2020 (Figure 1).

In 2019, by the end of two weeks grazing (2 Oct 2019), there were 95% less RLEM compared to the control (Figure 2). Two weeks after livestock had been removed from this treatment, the numbers of RLEM had increased 5 fold (84%), whereas FOO only increased by 0.5 t DM/ha (Figures 1, 2). Four weeks of grazing led to a 98% reduction of RLEM compared to the ungrazed control and a fortnight later (6 Nov 2019) RLEM populations had crashed, indicating the population was undergoing summer diapause.

Similar trends were seen in 2020, by the end of two weeks of grazing there was a 50% reduction in RLEM as compared to the control (Figure 2); however, when livestock were removed from this treatment RLEM did not increase. And four weeks of grazing led to a 98% reduction in RLEM numbers.

Sampling in early autumn of the following year, RLEM were only found in the ungrazed treatment. In early autumn 2020, only the 4 week grazed treatment had less than 500 RLEM per square metre ($P<0.05$) (Figure 2). This is ten times less than the threshold for mites in cereals (equivalent to 5000 mites per square metre) and 5 times less than the threshold for canola (equivalent to 1000 mites per square metre).

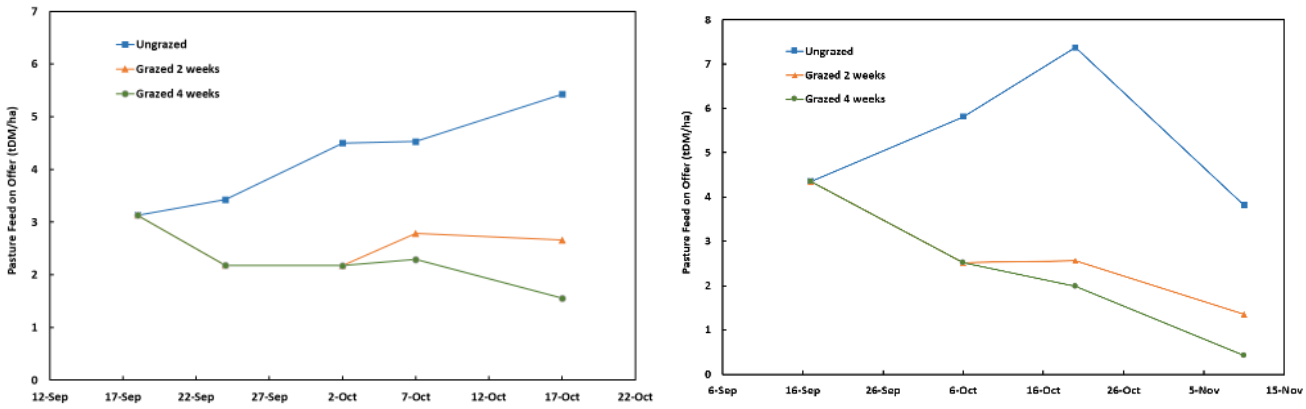


Figure 1. Feed on offer (t DM/ha) of clover based pasture at Boyup Brook in 2019 (left) and in 2020 (right) that was ungrazed, grazed for 2 weeks or grazed for 4 weeks.

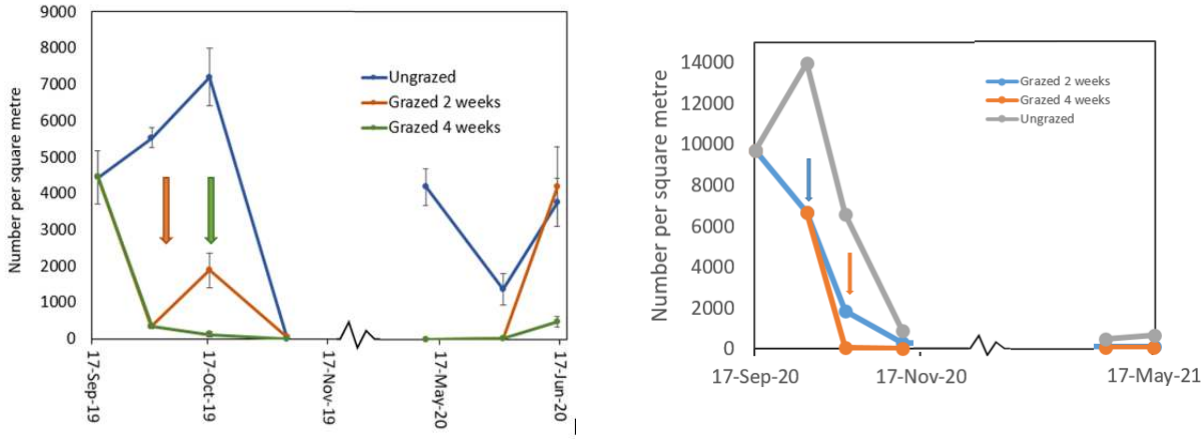


Figure 2. Number of RLEM in pasture at Boyup Brook that was ungrazed, grazed for 2 weeks or grazed for 4 weeks in 2019 (left) and 2020 (right) ± standard error of mean (SEM). Arrows indicate when livestock were removed, colour indicates treatment.

Kalgan

In 2019, within a week of imposing the intensive grazing treatment pasture FOO had fallen to 1.6 t DM/ha however by the end of the 4 week grazing period FOO had risen to 3 t DM/ha due to late rain lifting pasture growth rates. In 2020, grazing treatments maintained pastures at approximately 1.9 t DM/ha. (Figure 3).

Compared to the ungrazed control, 2 and 4 weeks of grazing resulted in a 90% reduction in RLEM numbers. When livestock were removed after 2 weeks grazing, in 2019 RLEM numbers only increased by 10%, however, in 2020 numbers increased by 90% (Figure 4). In both years, the 4 week grazing treatment, when livestock were removed, RLEM numbers had decreased to less than 100 per square metre.

When treatments were resampled in the following autumn, in 2020 the ungrazed treatment had 3 times as many mites as the grazed treatments. Both grazed treatments had an average of 1400 mites per square metre, which is below the threshold for growing a cereal crop (Figure 4). However, in 2021, by the end of April (not shown in Figure 4), the four week grazing treatment had RLEM that were six times the threshold for cereal crops, however, this treatment had 70% less RLEM when compared to the control.

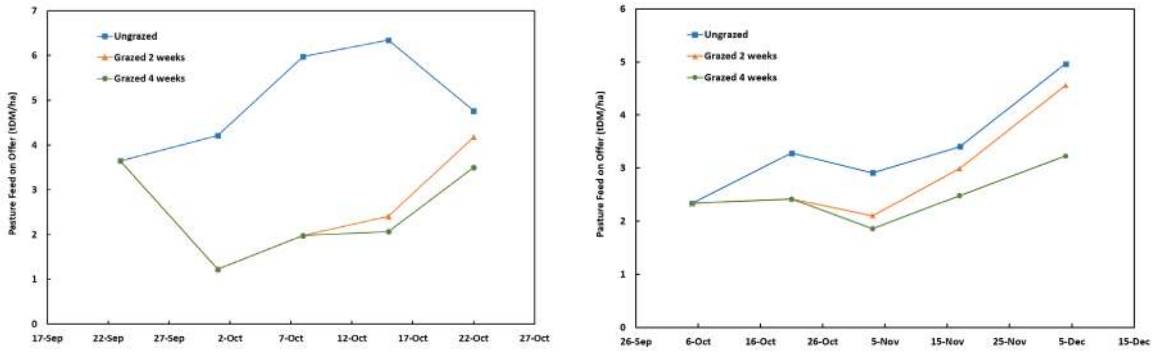


Figure 3. Feed on offer (t DM/ha) of kikuyu based pasture at Kalgan in 2019 that was ungrazed, grazed for 2 weeks or grazed for 4 weeks.

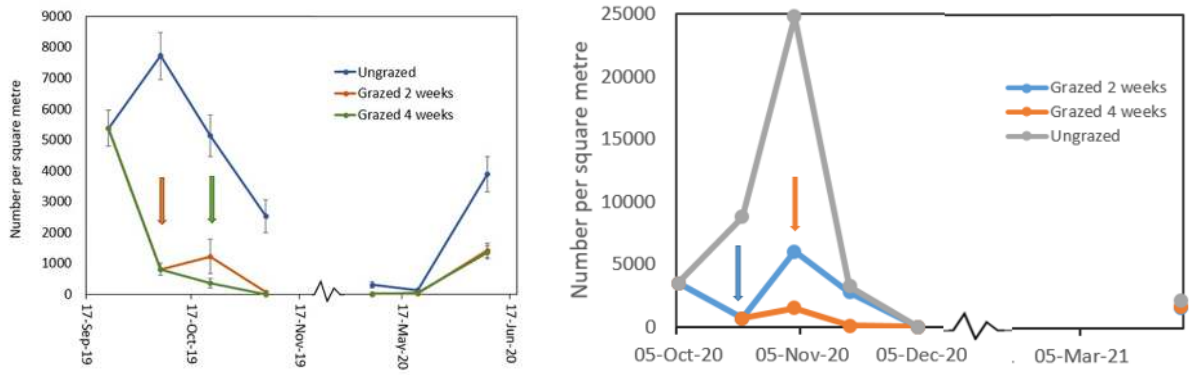


Figure 4. Number of RLEM in pasture located at Kalgan that was ungrazed, grazed for 2 weeks or grazed for 4 weeks in 2019 (left) and 2020 (right) ± standard error of mean (SEM). Arrows indicate when livestock were removed, colour indicates treatment.

Cranbrook

In 2019 at the commencement of the demonstration pasture FOO was low for a spring pasture at 2.5 t DM/ha. Grazing for either 2 or 4 weeks only reduced FOO to around 2 t DM/ha. At the end of this 4 week period FOO in the ungrazed treatment had only increased by around 0.7 t DM/ha FOO indicating the relatively low pasture growth rates compared to the Boyup Brook and Kalgan sites (Figures 1, 3, 5).

And grazing in 2019 did not cause a significant reduction in RLEM numbers as the population, unlike at the other sites, had declined in the ungrazed plot due to dry conditions. By mid-October, RLEM numbers had crashed (Figure 6). However, by the end of May 2020, the ungrazed plot had 40% more mites than grazed plots, but by mid-June RLEM numbers across all treatments had dropped below 500 mites per square metre.

In 2020, the trial was moved to another property in the same locality. Grazing for 2 weeks reduced FOO to an average 2.9 t DM/ha and for four weeks to 2.2 t DM/ha. Similar, results were found at this site to Boyup Brook and Cranbrook, where by grazing reduced RLEM on average by 90% when compared to ungrazed treatments.

In early spring 2021 there was little differentiation between the treatments (Figure 6). However, by late April (not shown in figure) all treatments had RLEM above crop damage thresholds. The ungrazed treatment had 8 times more mites than the cereal threshold. The grazing treatments had less mites, with treatments that were grazed for 2 weeks having 6 times and the 4 week grazing treatment 2 times the threshold of mites for cereal crops.

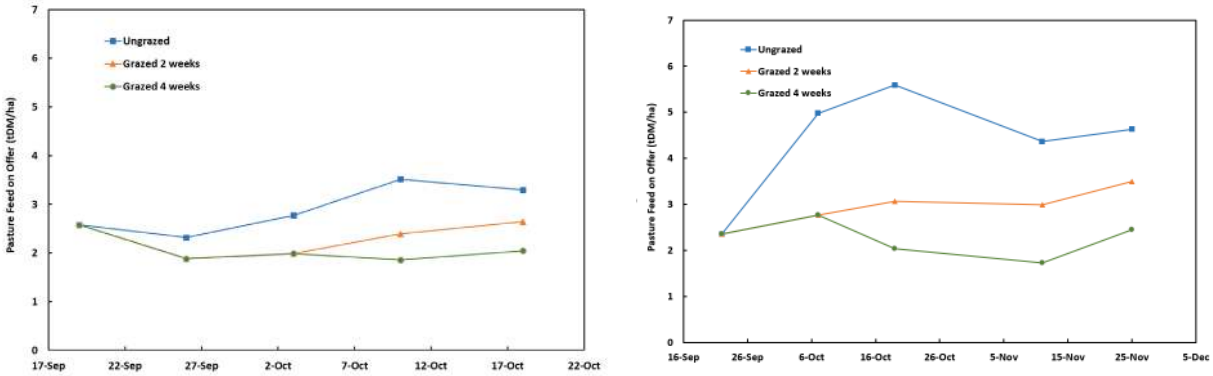


Figure 5. Feed on offer (t DM/ha) of clover, ryegrass based pasture at Cranbrook in 2019 that was ungrazed, grazed for 2 weeks or grazed for 4 weeks.

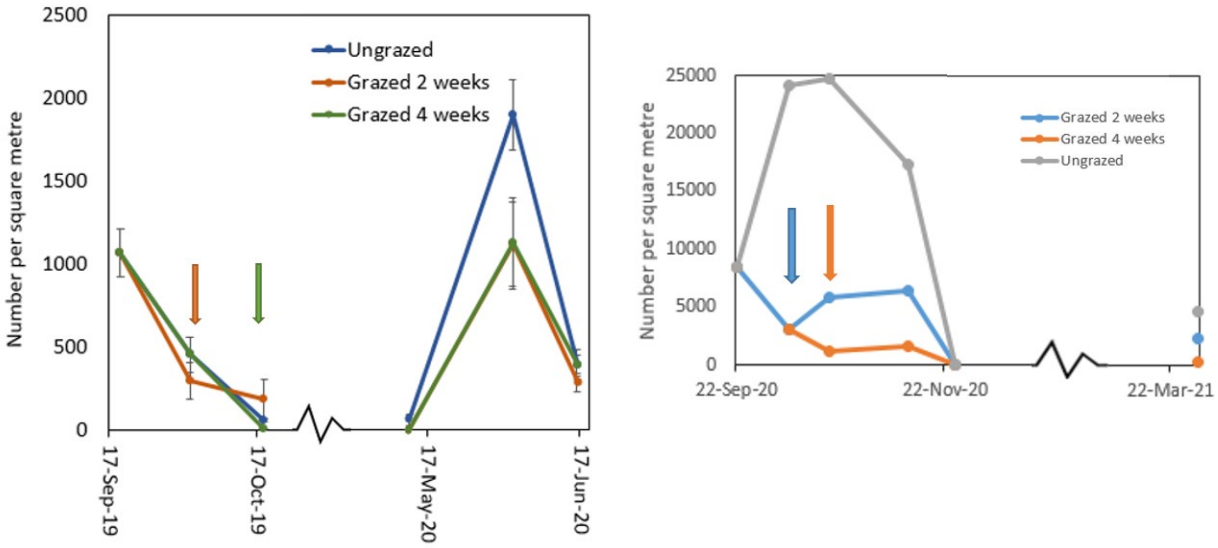


Figure 6. Number of RLEM in pasture located at Cranbrook that was ungrazed, grazed for 2 weeks or grazed for 4 weeks in 2019 (left) and 2020 (right) ± standard error of mean (SEM). Arrows indicate when livestock were removed, colour indicates treatment.

Conclusion

Intensive grazing in spring appears promising as a tactic for suppressing RLEM for the following season. However, it should only be used when the population of mites is above 5000 per square metre and FOO is more than 3 t DM/ha. To reduce RLEM's the pasture needs to be grazed to a FOO of 2 t DM/ha or less for 4 weeks around the Timerite period to achieve a significant reduction in mites the following season. The aim is to have less than 1000 mites per square metre in the following season which is below the damage threshold for canola. Control measures for canola, such as seed dressings, may be still be required to protect the crop from RLEM damage.

Acknowledgments

This research has been made possible by funding from the Small Farms, Small grants, Department of Agriculture and Water Resources. The authors wish to thank Fitzgerald Biosphere Group, Southern Dirt, Gillami and the farmers on whose properties these demonstrations were conducted.

References

Campbell NA, Arnold GW 1973 The visual assessment of pasture yield. *Australian Journal of Experimental Agriculture and Animal Husbandry* **13**, 263-267.

Contact details

Svetlana Micic
Department of Primary Industries and Regional Development
444 Albany Hwy, Albany, WA 6330
Ph: 08 9892 8591
Email: svetlana.micic@dpird.wa.gov.au

Paul Sanford
Department of Primary Industries and Regional Development
444 Albany Hwy, Albany, WA 6330
Ph: 08 9892 8475
Email: paul.sanford@dpird.wa.gov.au