Final Technical Report Template

Final Technical Report

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

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Intended for journal publication	NO
Results are incomplete	NO
Commercial/IP concerns	NO
Embargo date	None

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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 also saw significant spring frosts damage 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. In general, growers chose at least two crops that suited the local region and two that were more uncommon to the region. Growers compared the legume crops to lupins, which is currently the most familiar legume crop to growers in the Albany Port Zone. The demonstrations helped determine one or two profitable legume options for 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 contained 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 a two-year period for each demonstration site to determine 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 (of subsequent cereal), 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 may 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 discussed 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 within 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 considered/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 grain marketing as it can determine some 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 and may need cleaning.

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, soil types 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.

Contents

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

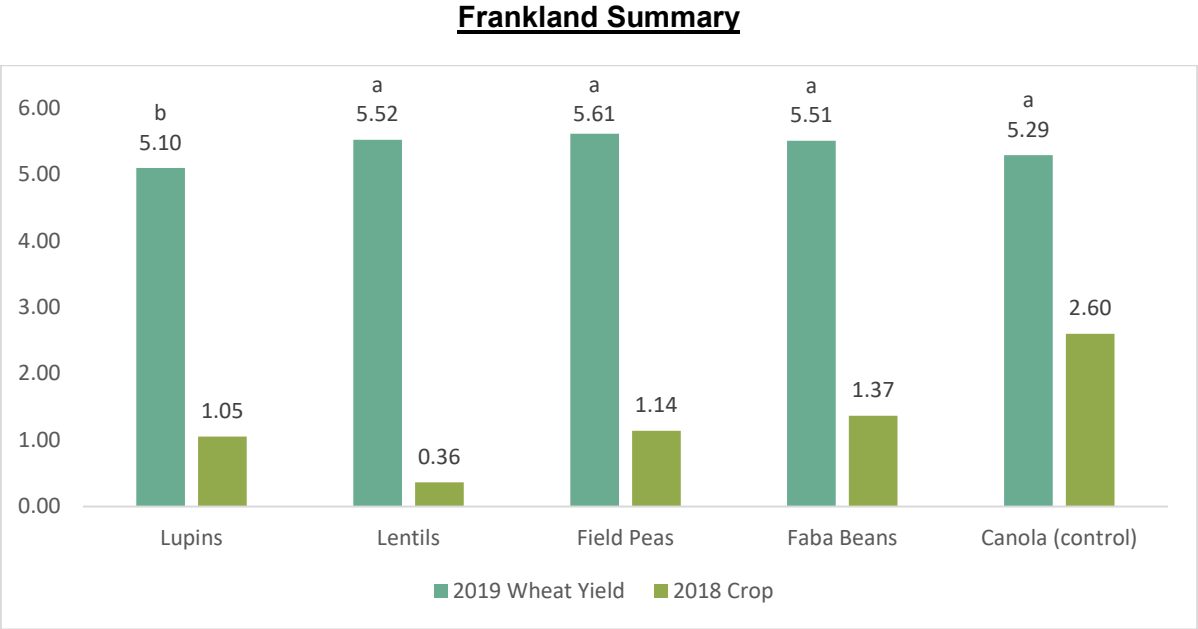

Figure 1: Summary of the grain yields achieved at the Frankland demonstration site (Simon Hilder) in 2018-19. The figures indicate the t/ha of grain yield for each crop. *Means followed by the same letter do not significantly differ (P = 0.05, LSD)*

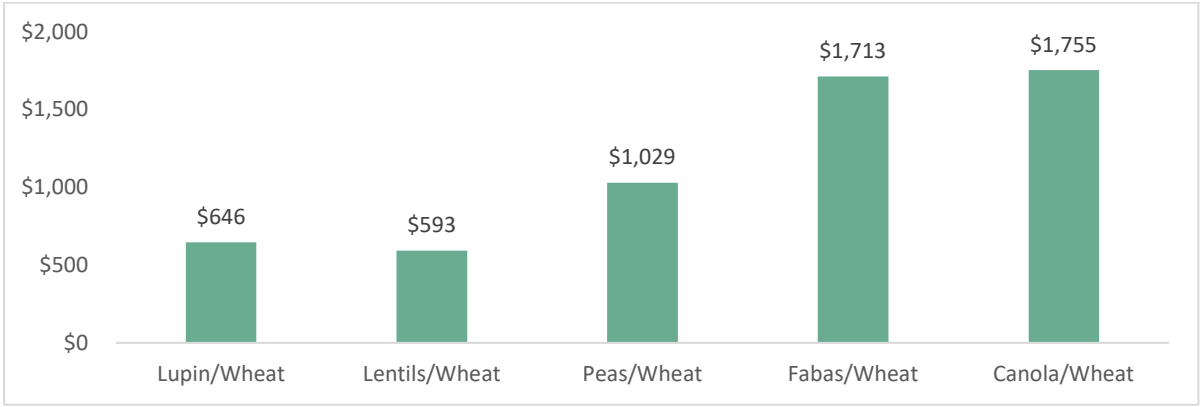

Figure 2. Shows the combined profit in dollars per hectare ($/ha) achieved with a wheat crop in 2019 sown over the 2018 legume demonstration in Frankland?. Farmanco analysed the economic data in 2021.

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

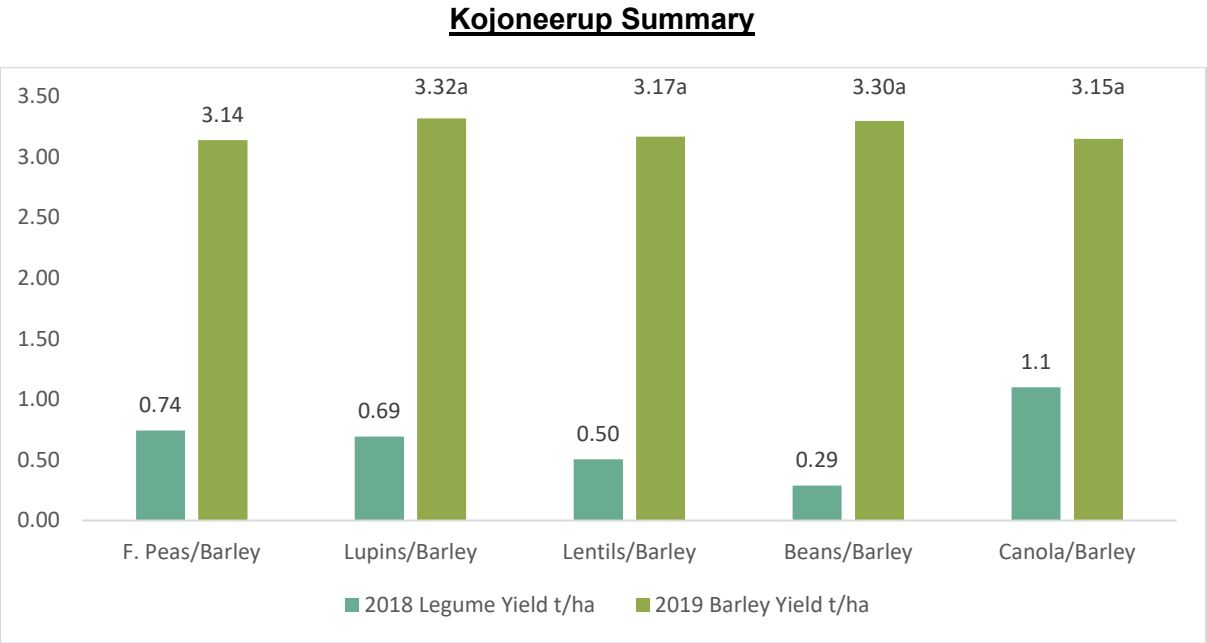

Figure 3: Summary of the grain yields recorded at the Kojaneerup demonstration site (Slattery) in 2018-19. The figures indicate the tonnes per hectare (t/ha) of grain yield for each crop. *Means followed by the same letter do not significantly differ (P = 0.05, LSD)*

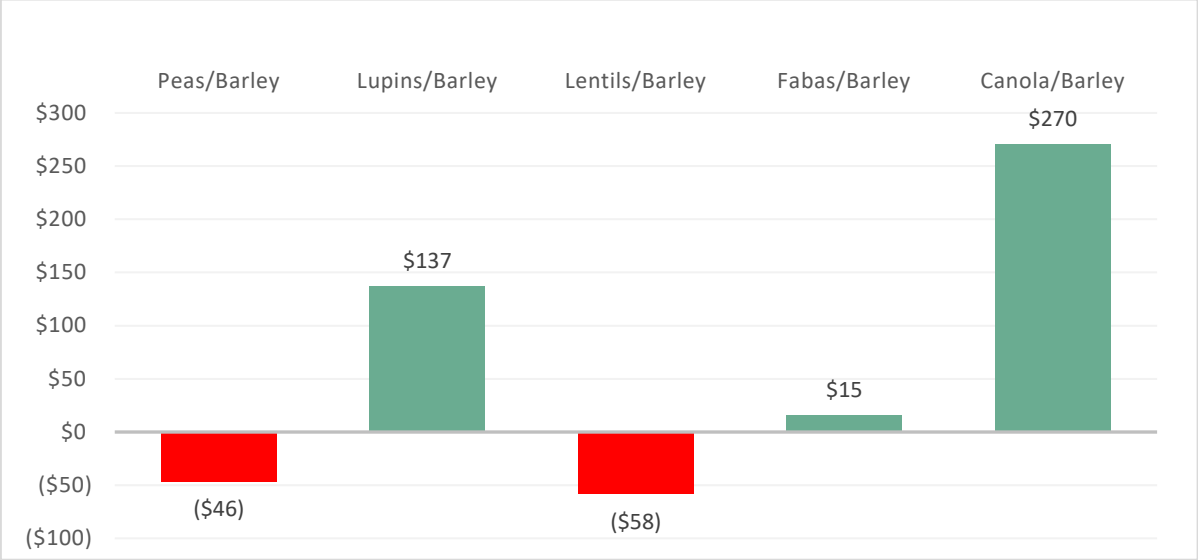

Figure 4. Shows the combined profit or loss in dollars per hectare ($/ha) achieved with a barley crop in 2019 sown over the 2018 Kojaneerup legume demonstration. The grower control was canola followed by barley in 2019. Farmanco consultants analysed the economic data in 2021.

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

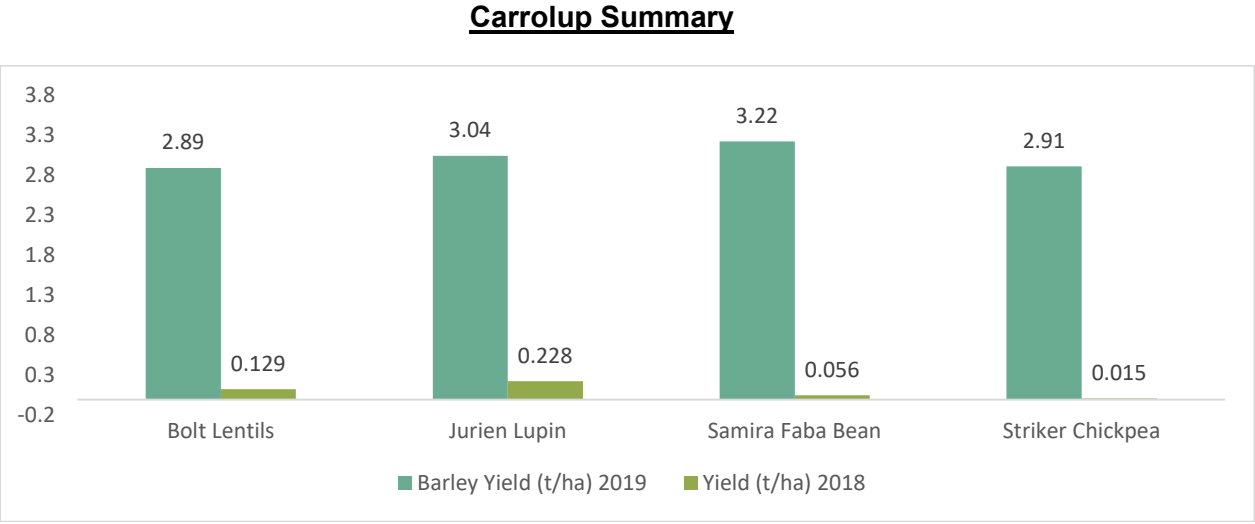

Figure 5: Summary of the barley grain yields (t/ha) achieved at the Carrolup demonstration site (Ladyman's) in 2019. The 2018 legume treatments (red bars) were sown over with barley in 2019.

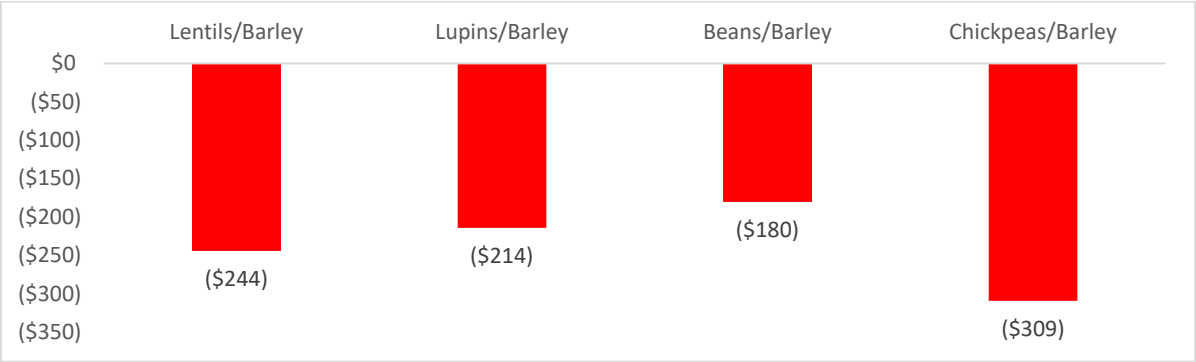

Figure 6. Shows the combined losses in dollars per hectare ($/ha) achieved with a barley crop in 2019 sown over the 2018 legume demonstration. Farmanco analysed the economic data in 2021.

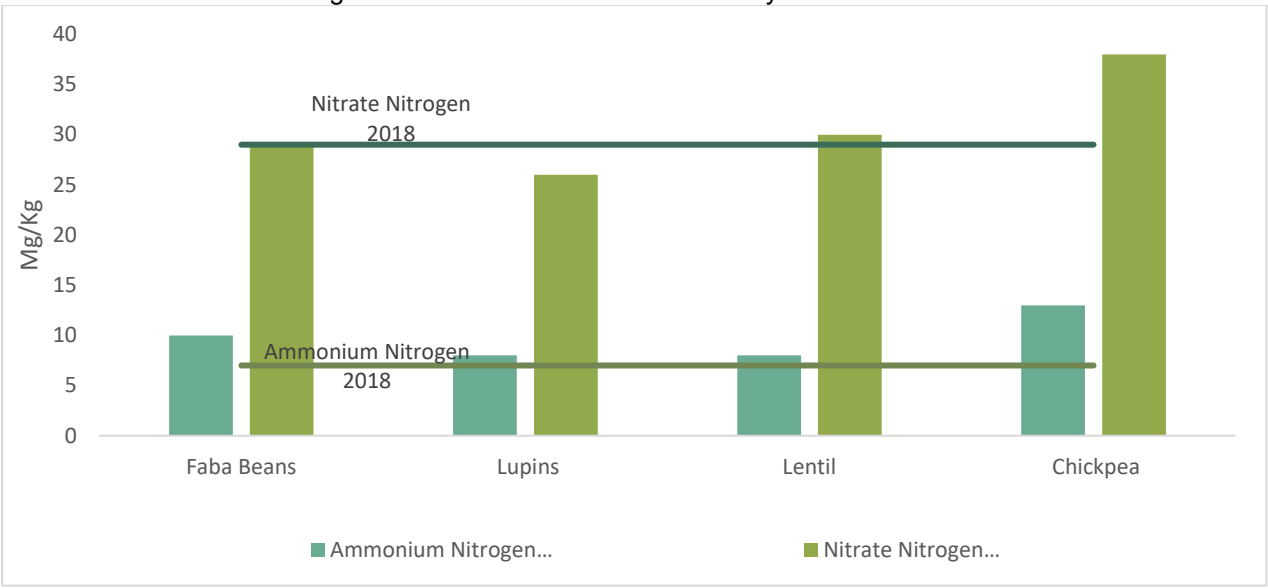

Figure 7: Soil data from the Carrolup legume demonstration in 2018 and 2019. Data displays Ammonium Nitrate and Nitrate Nitrogen changes (0-10cm layer) after the Legume crop was grown in 2018.

Muradup Summary

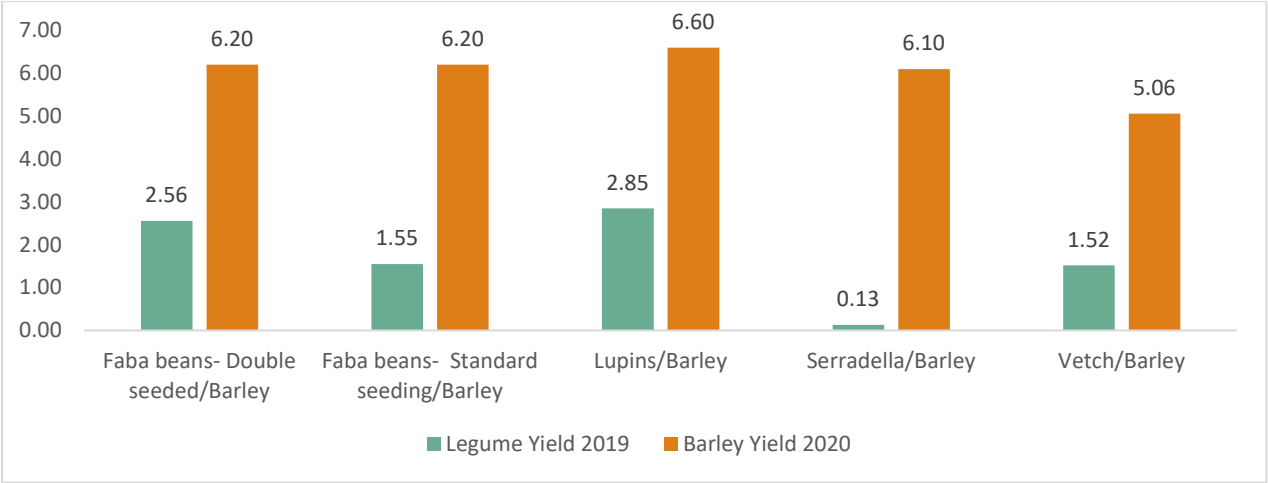

Figure 8: Summary of the grain yields achieved at the Muradup demonstration site (Webb's) in 2019 and 2020. The numbers on each bar indicate the t/ha of grain yielded for each crop in that year.

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**

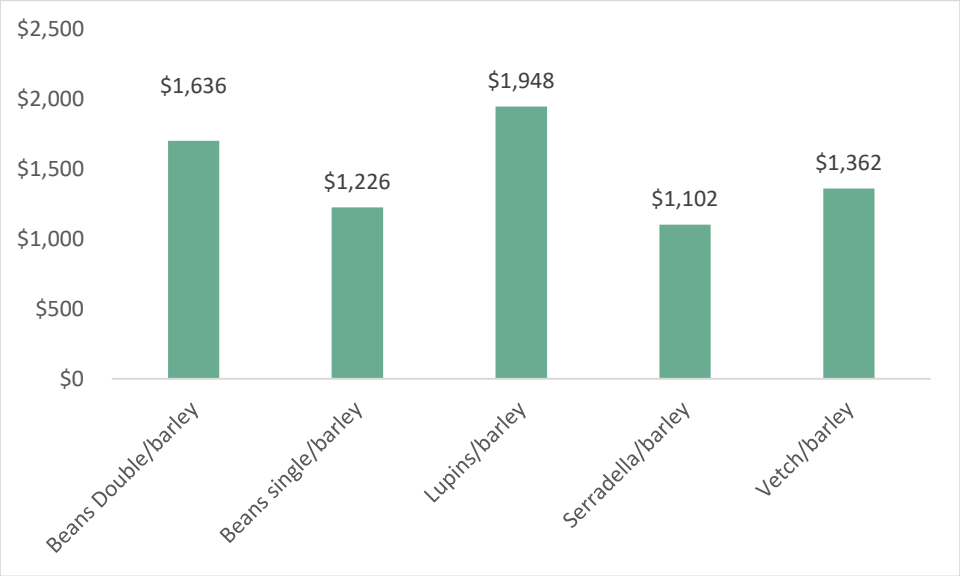

Figure 9: Shows the combined profits in dollars per hectare ($/ha) achieved with a barley crop in 2020 sown over the 2019 legume demonstration at Muradup (Webb's). Farmanco consultants analysed the economic data in 2021.

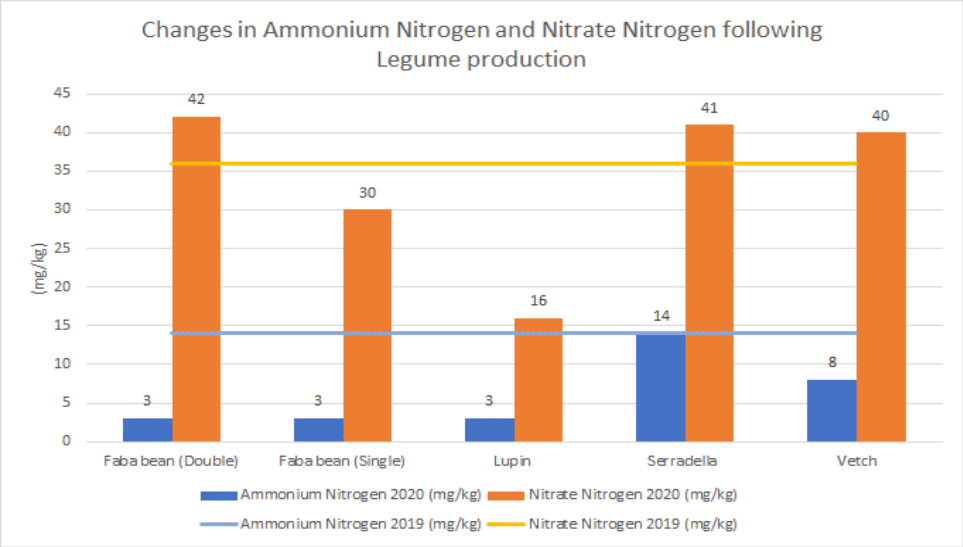

Figure 10: Soil data from the Muradup legume demonstration in 2019 and 2020. Data displays Ammonium Nitrate and Nitrate Nitrogen changes (0-10cm layer) after the Legume crop was grown in 2019.

Broomehill Summary

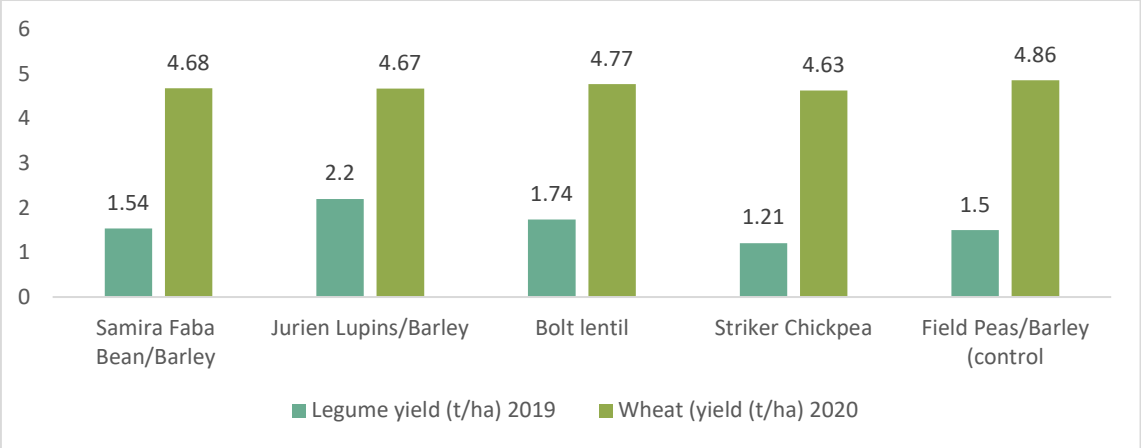

Figure 11: Summary of the grain yields achieved at the Broomehill demonstration site (Bignell's) in 2019 and 2020. The figures indicate the t/ha of grain yield for each crop.

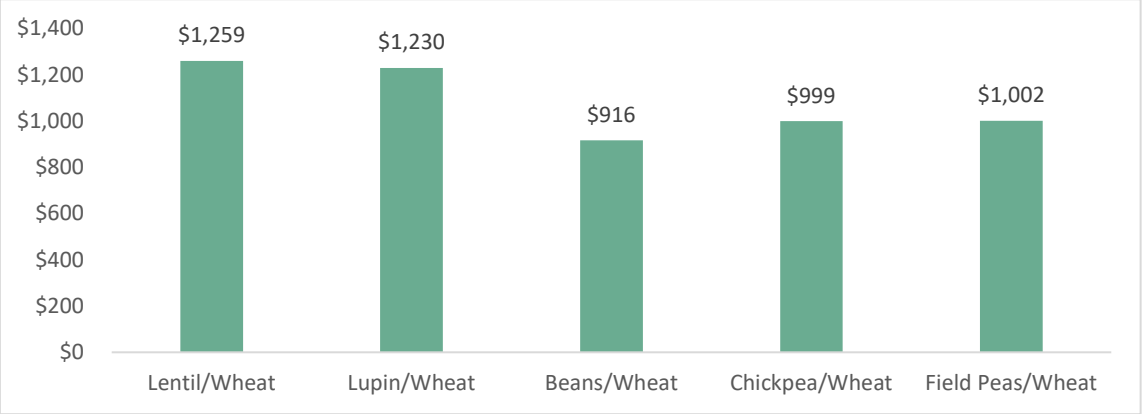

Figure 12. Shows the combined profit in dollars per hectare ($/ha) achieved with a wheat crop in 2020 sown over the 2019 legume demonstration. Farmanco analysed the economic data in 2021.

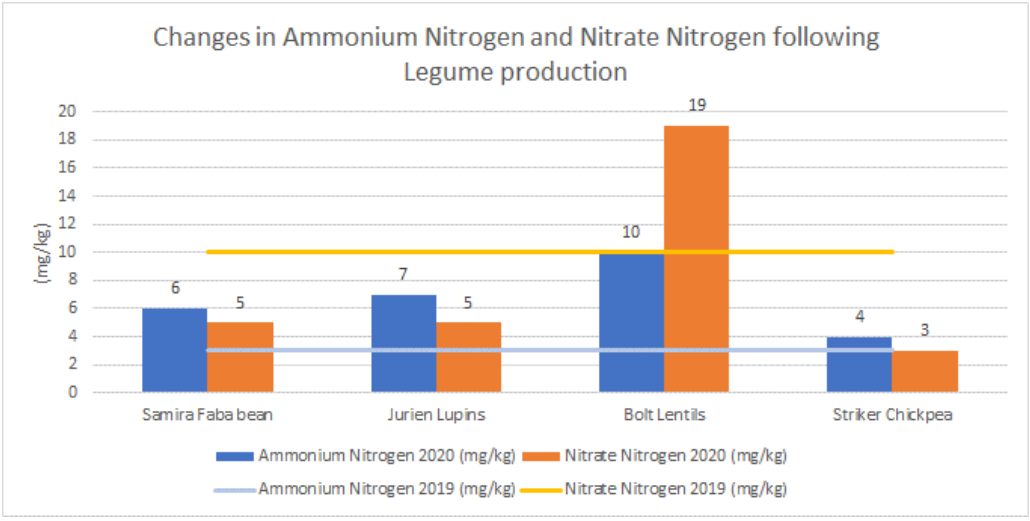

Figure 13: Soil data from the Broomehill legume demonstration in 2019 and 2020. Data displays Ammonium Nitrate and Nitrate Nitrogen changes (0-10cm layer) after the Legume crop was grown in 2019.

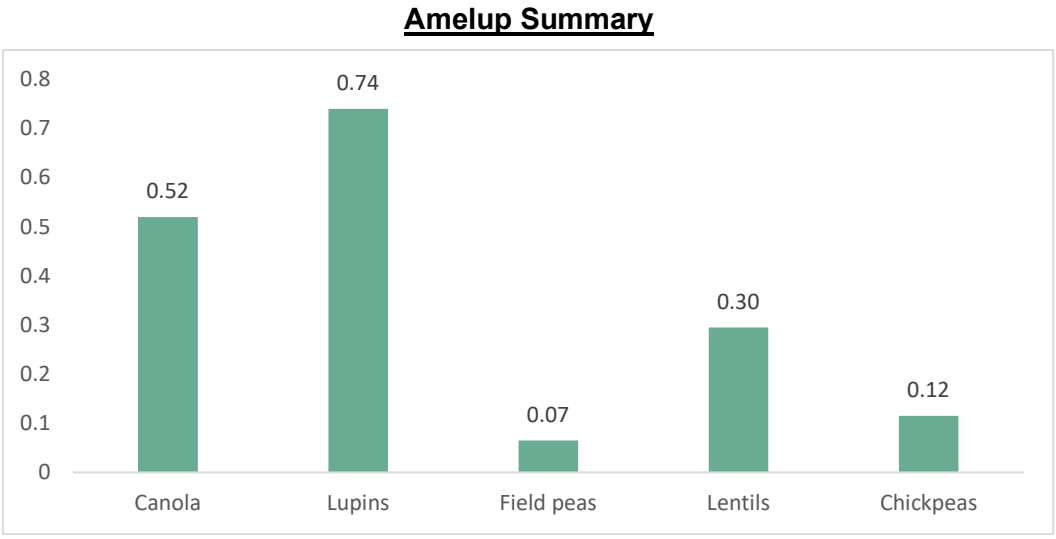

Figure 14: Summary of the grain yields achieved at the Amelup demonstration site (Moir's). The figures indicate the t/ha of grain yield for each crop. The demonstration site suffered from frosts and dry seasonal conditions.

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

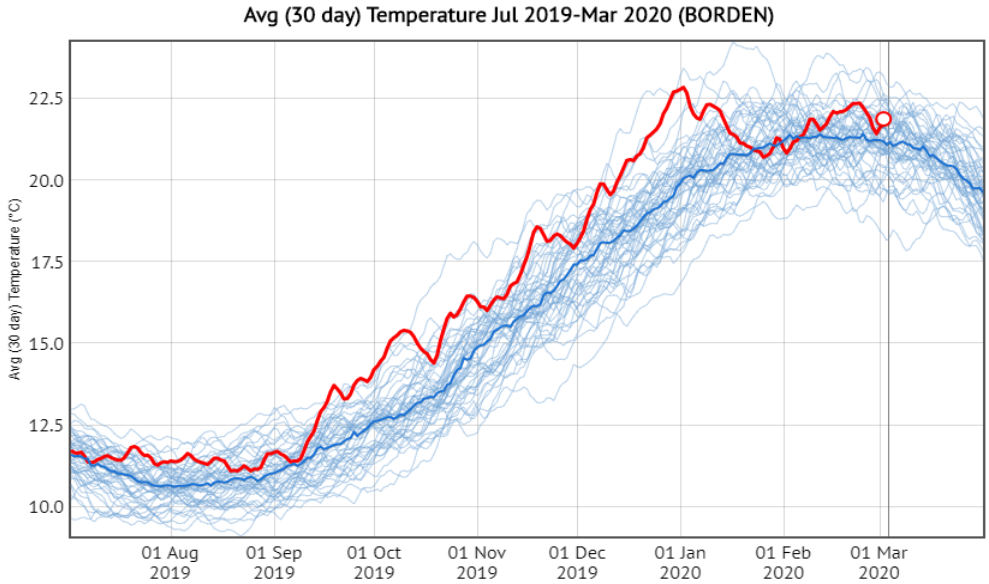

Figure 15: Shows the average temperature (1970- Present – light blue)) with the median average temperature shown in dark blue and the 2019 temperature data in red in Borden 23km northeast of Amelup. (Data: Australian CliMate 03/03/2020)

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.

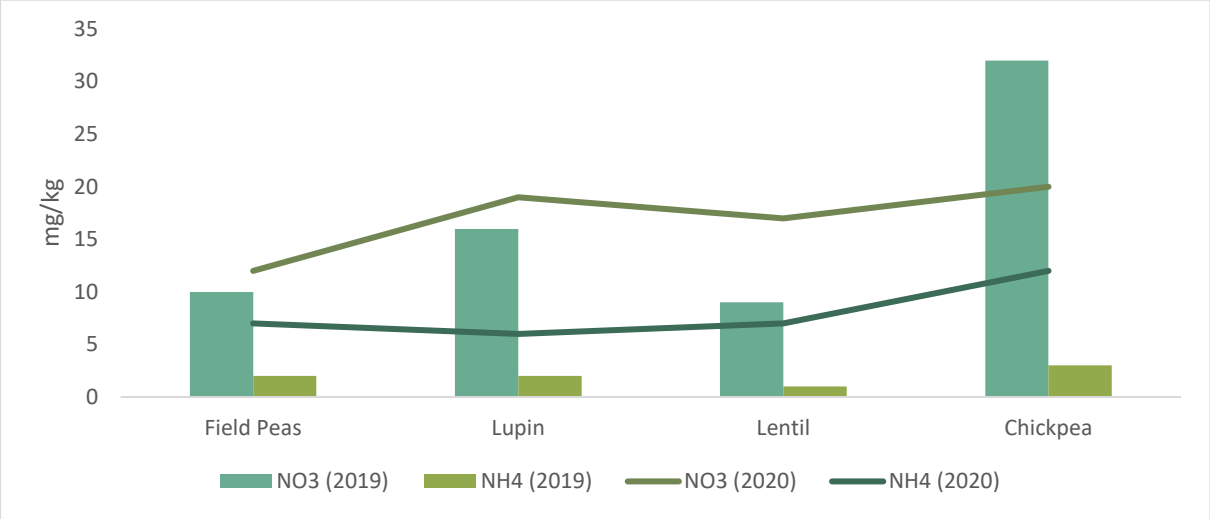

Figure 16. Shows changes in Ammonium Nitrate and Nitrate Nitrogen from Legume Production in 2019 (0-10cm) at the Amelup Legume Demonstration site in 2020.

Gnowellen Summary

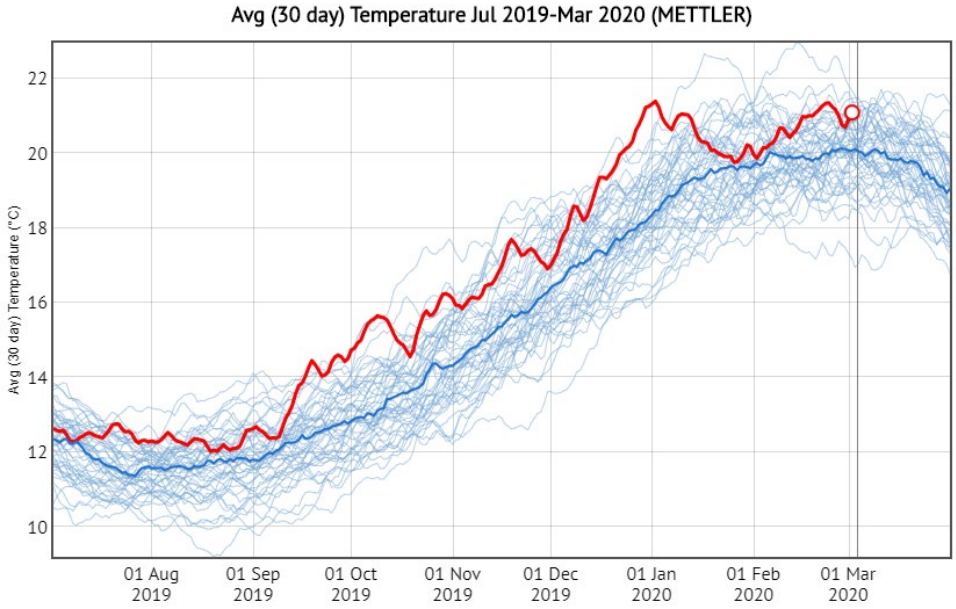

Figure 17: Shows the average temperature (1970- Present – light blue)) with the median average temperature shown in dark blue and the 2019 temperature data in red in Mettler 35km South of Gnowellen. (Data: Australian CliMate 03/03/2020)

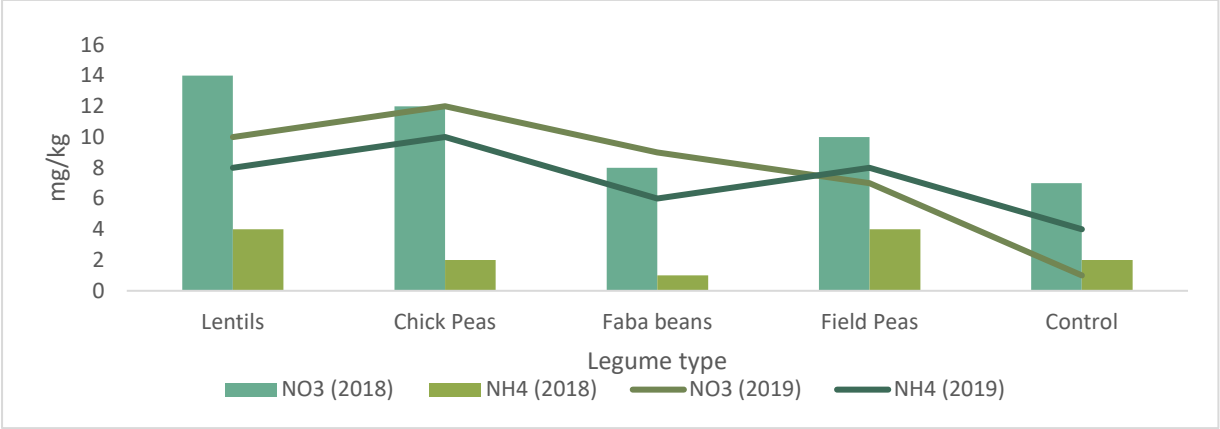

Figure 18. Shows changes in Ammonium Nitrate and Nitrate Nitrogen from Legume Production in 2018 (0-10cm) at the Gnowellen Legume Demonstration site in 2019.

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. Ammonium nitrogen increased across all the trial sites from a baseline of 3 mg/kg in 2019 to between 4 mg/kg (Striker chickpea) and 10 mg/kg (Bolt lentils) in 2020.

- 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**

Kojoneerup						2018
Crop Enterprise		**Peas**	**Lupins**	**Lentils**	**Faba Beans**	**Canola**
Yield	t/ha	0.74	0.69	0.50	0.29	1.10
Average Grain Price (FIS)	$/t	$361	$604	$486	$997	$570
Income	**$/ha**	**$267**	**$417**	**$243**	**$289**	**$627**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$35	$50	$38	$50	$70
Grain Freight (Up Country)		$5.3	$5.0	$3.6	$2.1	$7.9
Grain Handling Charges		$9	$8	$6	$4	$14
Crop Contract		$7	$7	$5	$3	$11
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		$100	$100	$100	$100	$100
Variable Operating Costs	**$/ha**	**$392**	**$405**	**$387**	**$394**	**$438**
Operating Gross Margin	**$/ha**	**($125)**	**$12**	**($144)**	**($105)**	**$189**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$499**	**$512**	**$494**	**$501**	**$545**
Operating Profit (BIT)	**$/ha**	**($232)**	**($95)**	**($251)**	**($212)**	**$82**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**($288)**	**($151)**	**($307)**	**($268)**	**$26**

Kojoneerup						2019
Crop Enterprise		**Barley after Peas**	**Barely after Lupins**	**Barley after Lentils**	**Barley after Faba**	**Barley after canola**
Yield	t/ha	3.14	3.32	3.17	3.30	3.15
Protein						
Grade						
Average Grain Price (FIS)	$/t	$285	$285	$285	$285	$285
Income	**$/ha**	**$895**	**$946**	**$903**	**$941**	**$898**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$23	$23	$23	$23	$23
Grain Freight (Up Country)		$23	$24	$23	$24	$23
Grain Handling Charges		$29	$30	$29	$30	$29
Crop Contract		$31	$33	$32	$33	$32
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**	**$491**	**$495**	**$491**	**$495**	**$491**
Operating Gross Margin	**$/ha**	**$404**	**$451**	**$412**	**$446**	**$407**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$598**	**$602**	**$598**	**$602**	**$598**
Operating Profit (BIT)	**$/ha**	**$297**	**$344**	**$305**	**$339**	**$300**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**$241**	**$288**	**$249**	**$283**	**$244**

Combined Enterprise Analysis Crop

Kojoneerup

Crop Enterprise 2018	**Peas**	**Lupins**	**Lentils**	**Faba Beans**	**Canola**
Profit 2018	**-288**	**-151**	**-307**	**-268**	**26**
Crop Enterprise 2019	**Barley after Peas**	**Barely after Lupins**	**Barley after Lentils**	**Barley after Faba**	**Barley after canola**
Profit 2019	**241**	**288**	**249**	**283**	**244**
Combined Crop Enterprise	Peas/Barley	Lupins/Barley	Lentils/Barley	Fabas/Barley	Canola/Barley
Combined 2018 and 2019 Profit	**($46)**	**$137**	**($58)**	**$15**	**$270**

BroomeHill 2019

Crop Enterprise		Lentils	Lupins	Faba Beans	Chickpea	Field Pea
Yield	t/ha	1.74	2.20	1.54	1.21	1.50
Average Grain Price (FIS)	$/t	$645	$510	$508	$735	$561
Income	**$/ha**	**$1,122**	**$1,122**	**$782**	**$889**	**$842**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$65	$51	$51	$74	$74
Grain Freight (Up Country)		$24	$30	$21	$16	$20
Grain Handling Charges		$21	$27	$19	$15	$18
Crop Contract		$17	$22	$15	$12	$15
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$45	$45	$45	$45	$45
Fuel & Oil		$30	$30	$30	$30	$30
Fertiliser, Lime & Gypsum		$75	$75	$75	$75	$75
Pesticide		$95	$95	$95	$95	$95
Variable Operating Costs	**$/ha**	**$442**	**$445**	**$421**	**$432**	**$442**
Operating Gross Margin	**$/ha**	**$681**	**$677**	**$361**	**$458**	**$399**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$549**	**$552**	**$528**	**$539**	**$549**
Operating Profit (BIT)	**$/ha**	**$574**	**$570**	**$254**	**$351**	**$292**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**$518**	**$514**	**$198**	**$295**	**$236**

BroomeHill 2020

Crop Enterprise		Wheat after Lentils	Wheat after Lupins	Wheat after Beans	Wheat after Chickpeas	Wheat after Field Peas
Yield	t/ha	4.77	4.67	4.68	4.63	4.86
Protein						
Grade						
Average Grain Price (FIS)	$/t	$300	$300	$300	$300	$300
Income	**$/ha**	**$1,431**	**$1,401**	**$1,404**	**$1,389**	**$1,458**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$24	$24	$24	$24	$24
Grain Freight (Up Country)		$71	$69	$69	$69	$72
Grain Handling Charges		$44	$43	$43	$42	$44
Crop Contract		$48	$47	$47	$46	$49
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$39	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$45	$45	$45	$45	$45
Fuel & Oil		$30	$30	$30	$30	$30
Fertiliser, Lime & Gypsum		$100	$100	$100	$100	$100
Pesticide		$95	$95	$95	$95	$95
Variable Operating Costs	**$/ha**	**$526**	**$523**	**$523**	**$521**	**$529**
Operating Gross Margin	**$/ha**	**$905**	**$878**	**$881**	**$868**	**$929**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$633**	**$630**	**$630**	**$628**	**$636**
Operating Profit (BIT)	**$/ha**	**$798**	**$771**	**$774**	**$761**	**$822**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**$742**	**$715**	**$718**	**$705**	**$766**

Combined Enterprise Analysis Crop

Broom Hill

Broom Hill Crop Enterprise 2018	Lentils	Lupins	Faba Beans	Chickpea	Field Pea
Broom Hill Profit 2019	**518**	**514**	**198**	**295**	**236**
Broom Hill Crop Enterprise 2019	**Wheat after Lentils**	**Wheat after Lupins**	**Wheat after beans**	**Wheat after Chickpeas**	
Broom Hill Profit 2019	**742**	**715**	**718**	**705**	**766**
Broom Hill Combined Crop Enterprise	Lentil/Wheat	Lupin/Wheat	Beans/Wheat	Chickpea/Wheat	Field Peas/Wheat
Broom Hill Combined 2018 and 2019 Profit	**$1,259**	**$1,230**	**$916**	**$999**	**$1,002**

Carrolup						2018
Crop Enterprise		**Lentils**	**Lupin**	**Faba Beans**	**Chickpeas**	**Wheat**
Yield	t/ha	0.13	0.23	0.06	0.02	
Average Grain Price (FIS)	$/t	$536	$351	$887	$660	$285
Income	**$/ha**	**$69**	**$80**	**$50**	**$10**	
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$35	$50	$38	$50	
Grain Freight (Up Country)		$1.9	$3.4	$0.8	$0.2	
Grain Handling Charges		$2	$3	$1	$0	
Crop Contract		$1	$2	$1	$0	
Other Crop Costs & Crop Ins		$31	$31	$31	$31	
Wages Gross		$39	$39	$39	$39	
R&M Mach./Plant/Vehicle		$45	$45	$45	$45	
Fuel & Oil		$30	$30	$30	$30	
Fertiliser, Lime & Gypsum		$75	$75	$75	$75	
Pesticide		$90	$90	$90	$90	
Variable Operating Costs	**$/ha**	**$350**	**$368**	**$350**	**$361**	
Operating Gross Margin	**$/ha**	**($281)**	**($288)**	**($300)**	**($351)**	
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	
Total Operating Costs	**$/ha**	**$457**	**$475**	**$457**	**$468**	
Operating Profit (BIT)	**$/ha**	**($388)**	**($395)**	**($407)**	**($458)**	
Finance Costs	$	$56	$56	$56	$56	
Earnings Before Tax (EBT)	**$/ha**	**($444)**	**($451)**	**($463)**	**($514)**	

Carrolup						2019
Crop Enterprise		**Barley after Lentils**	**Barley after Lupins**	**Barley after Beans**	**Barley after Chickpeas**	
Yield	t/ha	2.89	3.04	3.22	2.91	
Protein						
Grade						
Average Grain Price (FIS)	$/t	$285	$285	$285	$285	
Income	**$/ha**	**$824**	**$866**	**$918**	**$829**	
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$23	$23	$23	$23	
Grain Freight (Up Country)		$43	$45	$48	$43	
Grain Handling Charges		$26	$28	$29	$27	
Crop Contract		$29	$30	$32	$29	
Other Crop Costs & Crop Ins		$31	$31	$31	$31	
Wages Gross		$39	$39	$39	$39	
R&M Mach./Plant/Vehicle		$45	$45	$45	$45	
Fuel & Oil		$30	$30	$30	$30	
Fertiliser, Lime & Gypsum		$100	$100	$100	$100	
Pesticide		$95	$95	$95	$95	
Variable Operating Costs	**$/ha**	**$461**	**$466**	**$472**	**$462**	
Operating Gross Margin	**$/ha**	**$363**	**$400**	**$446**	**$368**	
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	
Total Operating Costs	**$/ha**	**$568**	**$573**	**$579**	**$569**	
Operating Profit (BIT)	**$/ha**	**$256**	**$293**	**$339**	**$261**	
Finance Costs	$	$56	$56	$56	$56	
Earnings Before Tax (EBT)	**$/ha**	**$200**	**$237**	**$283**	**$205**	

Combined Enterprise Analysis Crop

Carrolup

Carrolup Crop Enterprise 2018	**Lentils**	**Lupin**	**Faba Beans**	**Chickpeas**	
Carrolup Profit 2018	**-444**	**-451**	**-463**	**-514**	**0**
Crop Enterprise 2019	**Barley after Lentils**	**Barley after Lupins**	**Barley after Beans**	**Barley after Chickpeas**	**0**
Carrolup Profit 2019	**200**	**237**	**283**	**205**	**0**
Carrolup Combined Crop Enterprise	Lentils/Barley	Lupins/Barley	Beans/Barley	Chickpeas/Barley	
Carrolup Combined 2018 and 2019 Profit	**($244)**	**($214)**	**($180)**	**($309)**	**$0**

Muradup 2019

Crop Enterprise		Faba Beans Double	Faba Beans	Lupins	Serradella	Vetch
Yield	t/ha	2.56	1.55	2.85	0.13	1.52
Average Grain Price (FIS)	$/t	$508	$508	$510	$4,900	$783
Income	**$/ha**	**$1,300**	**$787**	**$1,454**	**$637**	**$1,190**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$102	$51	$51	$49	$23
Grain Freight (Up Country)		$35	$21	$39	$2	$21
Grain Handling Charges		$31	$19	$35	$2	$19
Crop Contract		$26	$16	$29	$1	$15
Other Crop Costs & Crop Ins		$31	$31	$31	$31	$31
Wages Gross		$45	$39	$39	$39	$39
R&M Mach./Plant/Vehicle		$55	$50	$50	$50	$50
Fuel & Oil		$40	$35	$35	$35	$35
Fertiliser, Lime & Gypsum		$75	$75	$75	$75	$75
Pesticide		$95	$95	$95	$95	$95
Variable Operating Costs	**$/ha**	**$535**	**$431**	**$478**	**$379**	**$403**
Operating Gross Margin	**$/ha**	**$766**	**$356**	**$975**	**$258**	**$787**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$642**	**$538**	**$585**	**$486**	**$510**
Operating Profit (BIT)	**$/ha**	**$659**	**$249**	**$868**	**$151**	**$680**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**$603**	**$193**	**$812**	**$95**	**$624**

Muradup 2020

Crop Enterprise		Barley after Vetch	Barley after Lupins	Barely after Beans	Barely after Beans (double seeded)	Barely after Serradella
Yield	t/ha	5.06	6.60	6.20	6.20	6.10
Protein						
Grade		Feed	Feed	Feed	Feed	Feed
Average Grain Price (FIS)	$/t	$285	$285	$285	$285	$285
Income	**$/ha**	**$1,442**	**$1,881**	**$1,767**	**$1,767**	**$1,739**
Variable Operating Costs	**$/ha**					
Seed, Treatment & EPR's		$23	$23	$23	$23	$23
Grain Freight (Up Country)		$36	$48	$45	$45	$44
Grain Handling Charges		$46	$60	$57	$57	$56
Crop Contract		$51	$66	$62	$62	$61
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**	**$541**	**$582**	**$571**	**$571**	**$569**
Operating Gross Margin	**$/ha**	**$901**	**$1,299**	**$1,196**	**$1,196**	**$1,170**
Fixed Operating Costs	**$/ha**	**$107**	**$107**	**$107**	**$107**	**$107**
Total Operating Costs	**$/ha**	**$648**	**$689**	**$678**	**$678**	**$676**
Operating Profit (BIT)	**$/ha**	**$794**	**$1,192**	**$1,089**	**$1,089**	**$1,063**
Finance Costs	$	$56	$56	$56	$56	$56
Earnings Before Tax (EBT)	**$/ha**	**$738**	**$1,136**	**$1,033**	**$1,033**	**$1,007**

Combined Enterprise Analysis Crop

Muradup

Crop Enterprise 2018	Faba Beans Double	Faba Beans	Lupins	Serradella	Vetch
Profit 2019	**603**	**193**	**812**	**95**	**624**
Crop Enterprise 2020	**Barley after Beans Double**	**Barley after Beans single**	**Barley after Lupins**	**Barely after Serradella**	**Barley after Vetch**
Profit 2020	**1,033**	**1,033**	**1,136**	**1,007**	**738**
Combined Crop Enterprise	**Beans Double/barley**	**Beans single/barley**	**Lupins/barley**	**Serradella/barley**	**Vetch/barley**
Combined 2019 and 2020 Profit	**$1,636**	**$1,226**	**$1,948**	**$1,102**	**$1,362**

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

Glossary and Acronyms

Below is a sample Abbreviations and Acronyms list. Be sure to include on this page all abbreviations and acronyms that appear in the report

DPIRD	Department of Primary Industries & Regional Development
Farmanco	Farm Management Consultants
SCF	Stirlings to Coast Farmers Inc. Grower Group (Albany)
APZ	Albany Port Zone
SD	Southern Dirt Grower Group (Kojonup)

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Social Media Posting

Facebook:

Stirlings to Coast Farmers

Southern DIRT

Twitter:

@Stirlings2Coast

@DirtSouthern

@dovey_nathan

Stirlings to Coast Farmers @Stirlings2Coast · May 7, 2019

Our trials program for 2019 is moving forward as seeding continues. SCF R&D Coordinator @dovey_nathan was out at Amelup today seeding one of our @theGRDC funded legume demonstration trials.

> **Nathan Dovey** @dovey_nathan · May 7, 2019
> Just finished seeding our legumes demonstration trial at Amelup today. Thanks to @GRDCWest for the project support. Field Peas, Chick Peas, Lentils and Lupins. @Stirlings2Coast

1 1 10

Stirlings to Coast Farmers
Published by Kathi McDonald · 4 December 2019 ·

2019 harvest at the SCF Legume Demonstration site at Frankland, WA. This year the site was sown to Sceptre wheat to determine if there are any differences to yield due to the different legume break crops sown in 2018. Results will be presented in our 2019 Trials Review Book and at the Trials Review Day in early 2020. This project was supported by funding from the Grains Research and Development Corporation. Special thanks to Sam Marsh for putting the video together for us.

135 People reached | 19 Engagements | Boost post

4

Like Comment Share

You Retweeted

Nathan Dovey @dovey_nathan · Dec 2, 2019

Harvested Scepter wheat at Frankland today where last years @GRDCWest Legumes Demo was grown. Will test the grain to check protein etc. Most treatment yields were similar but Lupins were slightly lower. Not sure why? @Stirlings2Coast

2 3 32

Stirlings to Coast Farmers @Stirlings2Coast · Dec 4, 2019

Harvest at the Legume Demo site, Frankland. This year the site was sown to Sceptre wheat to look at any benefits due to different legume crops sown in 2018. Project supported by @theGRDC. Special thanks to Sam Marsh for putting the video together for us.

GRDC Frankland Legume Demonstration Site Harv...
2019 harvest at the SCF Legume Demonstration site at Frankland, WA. This year the site was sown to ...
youtube.com

2 9

You Retweeted

Nathan Dovey @dovey_nathan · Aug 10, 2018

Field peas are getting a move on in our Legume demonstration site at Frankland. They must know they will be on camera next week! @GRDCWest @Stirlings2Coast @nevilljohn

1 1 9

You Retweeted

Nathan Dovey @dovey_nathan · Jul 6, 2018

Stirlings to Coast Legumes Demonstration site at Frankland. Lentils are looking okay. @GRDCWest @Stirlings2Coast @kathimac74 @SCFarmers

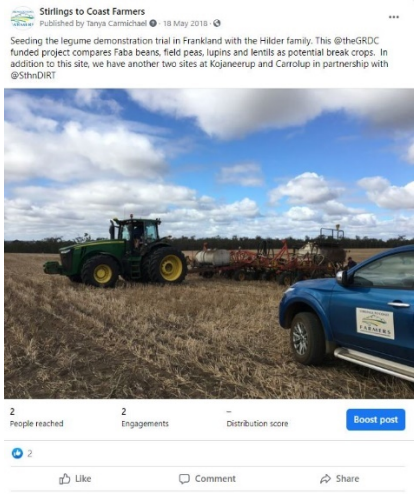
3 4 7

You Retweeted

Nathan Dovey @dovey_nathan · Aug 15, 2018

Simon Hilder doing an interview about @Stirlings2Coast Legumes demonstration project funded by @GRDCWest. Kaspa Field Peas looking the pick of the bunch right now.

2 1 11



Stirlings to Coast Farmers @Stirlings2Coast · May 18, 2018

Seeding the legume demonstration trial in Frankland with the Hilder family. This GRDC funded project compares Faba beans, field peas, lupins and lentils as potential break crops. Additional sites for this trial are at Kojaneerup and Carrolup
@DirtSouthern @theGRDC @GRDCWest

7

You Retweeted

Nathan Dovey @dovey_nathan · Aug 28, 2019

Lucky to have @ToMALDIID in the field to visit our @GRDCWest Legumes Demo. @ToMALDIID will identify the Rhyzobia in the root nodules to check the effectiveness of our inoculation technique. @richoman72 brushing up on his nodule scoring with Dr. Sophie DeMeyer. @Stirlings2Coast

2 9

You Retweeted

Nathan Dovey @dovey_nathan · Sep 28, 2018

Last stop yesterday was our @GRDCWest funded Legumes Demo site. The Fabas look pretty good in the pick, but the field peas are still the most consistent. Thanks to Mark Seymour from @DPIRDbroadacre for presenting to @Stirlings2Coast

2 14