Southern Dirt

Research Annual

2021 Results

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Red Wheat Trials

Project code:	BGS1911-001SAX/9177476
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Date submitted to GRDC:	20th January 2022

REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES/NO	
Results are incomplete	YES/NO	
Commercial/IP concerns	YES/NO	
Embargo date	YES/NO	If Yes, Date: DD/MM/YYYY

Key Messages

- The second season of the red wheat demonstration was completed in 2021 with the site sown between the 18th March and the 20th May 2021 (due to seed availability) at Muradup, near Kojonup.
- The comparative yields between the red wheat varieties were 7.67 MT/ha for Accroc and 5.09 MT/ha for Zanzibar wheat. A portion of the yield difference between the varieties needs to be associated with the earlier sowing date and establishment. Zanzibar demonstrated the potential of these types of wheat even with a late sowing window.
- The average yield for the controls / local district practice was 3.96 t/ha for Planet barley and 2.12 t/ha for Catapult wheat.
- The red wheat varieties performed much better in 2021 than in the 2020 (ave. 6.38 MT/Ha vs 5.49 MT/Ha) demonstration as a result of the early sowing and germination demonstrating their place in the rotation as ideal wheats for April sowing.
- The demonstration site was impacted by frost during grain filling. The red wheat varieties, in particular Accroc, were not effected by frost like the spring wheat variety demonstrating their key benefit in enabling growers to sow wheat early without increasing their frost risk like spring wheats.

Summary

The second year of results from the red wheat demonstration trials indicate the two red wheat varieties can yield above the current spring wheat varieties with a March or May sowing window. Cereal yields from highest to lowest from the Muradup site were as follows: Accroc red wheat (7.67 MT/ha), Zanzibar red wheat (5.09 MT/ha) Planet Barley (3.96 MT/ha), and Catapult (spring type) wheat (2.12 MT/ha).

The varieties were sown across a range of dates due to the availability of seed. The sowing dates across the demonstration were:

- 18 March 2021 Accroc
- 28 April 2021 Catapult
- 28 April 2021 Planet Barley
- 20 May 2021 Zanzibar

The red wheat varieties, in particular Accroc, were able to take advantage of the exceptional season experienced in 2021 converting the long season and high rainfall into yield. The average yield of the red wheats was 6.38 MT/Ha compared to Catapult a standard spring wheat grown in the area which yielded 2.12 MT/Ha. However, the yield of Catapult and planet barley was affected by frost which was experienced at the site late in the season. Despite the later sowing, Zanzibar was able to show the ability of red wheat varieties to adapt to a later sowing, still yield well and avoid the frost window.

The project has been successful in demonstrating the fit of red wheat varieties in the current rotation. These types of wheat fit in the early seeding window of late March to late April and potentially early May, have the ability to take advantage of the longer growing season resulting in improved yields and, reduce the frost risk associated with sowing wheat early due to their longer maturity.

Background

The red wheat trials were 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 of red 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 through farmer scale trial demonstrations and extension activities.

The grower-scale demonstrations will be carried over three seasons 2020,2021 and 2022. The red wheat demonstration site will work in collaboration with the small plot trials of the Applied R&D component of the project (run by DPIRD). These sites will require close consultation and participation of local growers and advisors. In year one, red wheat varieties will be compared with traditionally grown wheat and barley varieties. In addition, in years two and three of the field trial, local practice farming systems will be compared to a range of system modifications as identified in the Applied R&D project. In 2020, the project looked at the comparative yields of two red wheat varieties; Zanzibar and Accroc compared to Maximus barley and a spring wheat variety; Scepter (local district best practice).

In the second year of the project (2021), the yields of Zanzibar and Accroc Red Wheat were compared to Planet Barley and Catapult spring wheat both representing the local district best practise varieties.

The third year of the project will explore system modifications, some of which may be identified from the DPIRD/FAR applied R&D component of the HRZ project.

Objectives

The objective of this project is to demonstrate available agronomic information, raise awareness of red 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 2021 on a farm located at Muradup, near Kojonup.

The trial varieties planted were:

- Catapult -   An AH long season variety similar to Scepter suited to early sowing typically cropped in the area, used as a wheat control.
- Planet Barley – A malt high yielding mid season type variety suited to early to mid sowings typical to the area and used as the barley control.
- Zanzibar - a main season red wheat
- Accroc - a medium long season winter red wheat

The site was planted to Canola in 2020 and then sown across a range of dates due to the availability of seed. The trial was sown on 250mm spacing with a DBS. The sowing dates across the demonstration were:

- 18 March 2021 Accroc

- 28 April 2021 Catapult
- 28 April 2021 Planet Barley
- 20 May 2021 Zanzibar

Two replicates for each variety were included in the demonstration (Figure 1).

T8	T7	T6	T5	T4	T3	T2	T1
Planet Barley	**Planet Barley**	**Catapult**	**Accrock**	**Accrock**	**Accrock**	**Zanzibar**	**Catapult**

Figure 1: Red wheat demonstration plot layout 2021

The trial area had 50 kg/Ha of MoP spread in February 2021 and was sown with 90 kg/Ha of MAP plus trace elements plus 5 kg/Ha MnSO4.It received 150 kg/Ha of urea on the 15th of June, 80 L/Ha UAN on the 15th of August and then was topped up with 40 L/Ha of UAN on the 11th of September.

Representative soil samples of the trial plots were collected on 10th of April 2021, at depth 0-10cm, 10 – 20cm and 10 to 30cm. Samples were analysed for a range of soil properties including pH, electrical conductivity, major nutrients and organic carbon.

Crop observations were recorded and plant counts conducted at each trial plot on 3rd June 2021 to quantify seedling emergence and tiller counts were conducted on 6th September 2021.

The trial plots were harvested by the producer (Kent Stone), who provided the yield data.

Location

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1:	S33.5344	E116.5740
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.	☐ Qld Central	☐ NSW Central

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

Results

Soil samples were collected on the 10th of April 2021, prior to seeding from the 0-10cm, 10–20cm and 10-30cm horizons and analysed at CSBP Laboratories. The results are detailed in Table 1.The soil in the red wheat trial plots was dark grey in the top 10 cm and changed to yellow brown at 20 – 30 cm, with 0 - 10% gravel. Soil pH ($CaCl_2$) was 4.8 in the 0-10cm horizon, decreasing slightly to 4.5 in the 10-30cm layer. Soil organic carbon decreased from 1.80% at the surface to 0.39% in the 20-30cm layer. Electrical conductivity was low at 0.237 dS/m.

	Lab No	UES21092	UES21093	UES21094	UES21095	UES21096	UES21103
	Name	D	A	B	E	C	F
	Code	Site Kent B 0 10cm	Site Kent A 1 10mm	Site Kent A 10 20mm	Site Kent B 10 20cm	Site Kent 20 30mm	Site Kent B 20 30 cm
	Sampled Date	10/04/2021	10/04/2021	10/04/2021	10/04/2021	10/04/2021	10/04/2021
	Barcode	SOILB0042739	SOILB0042737	SOILB0042736	SOILB0042725	SOILB0042735	SOILB0042724
	Depth	0-10	0-10	0-10	0-10	0-10	0-10
	Latitude	-33.8358490929842	-33.8357457722036	-33.8357285056459	-33.8357053907325	-33.8357215433232	-33.8357182014081
	Longitude	117.160179913044	117.159358486533	117.159315235913	117.15947650373	117.159495949745	117.159511707723
Colour		DKGR	DKGR	BRGR	DKBR	YWBR	YW
Gravel	%	5-10	5	5-10	0	5	5
Texture		1.5	1.5	1.5	1.0	1.5	1.0
Ammonium Nitrogen	mg/kg	6	28	2	9	< 1	2
Nitrate Nitrogen	mg/kg	64	55	13	10	5	5
Phosphorus Colwell	mg/kg	31	34	36	27	19	24
Potassium Colwell	mg/kg	55	47	43	41	28	21
Sulfur	mg/kg	60.4	47.5	13.3	13.1	9.2	7.3
Organic Carbon	%	1.89	1.71	1.20	1.26	0.40	0.38
Conductivity	dS/m	0.217	0.258	0.069	0.053	0.034	0.031
pH Level (CaCl2)		4.8	4.8	4.6	4.5	4.6	4.4
pH Level (H2O)		5.4	5.6	5.6	5.6	5.8	5.4
PBI		58.8	79.6	92.8	103.1	57.5	49.1

Table 1: Soil Sample results for red wheat 2021 demonstration.

Plant Counts

Plant counts for the red wheat project trial sites occurred on 3rd of June 2021. The average number of plants by variety ranged between 172 plants/ m^2 for Planet Barley and 233 plants/ m^2 for Catapult wheat (Figure 2).

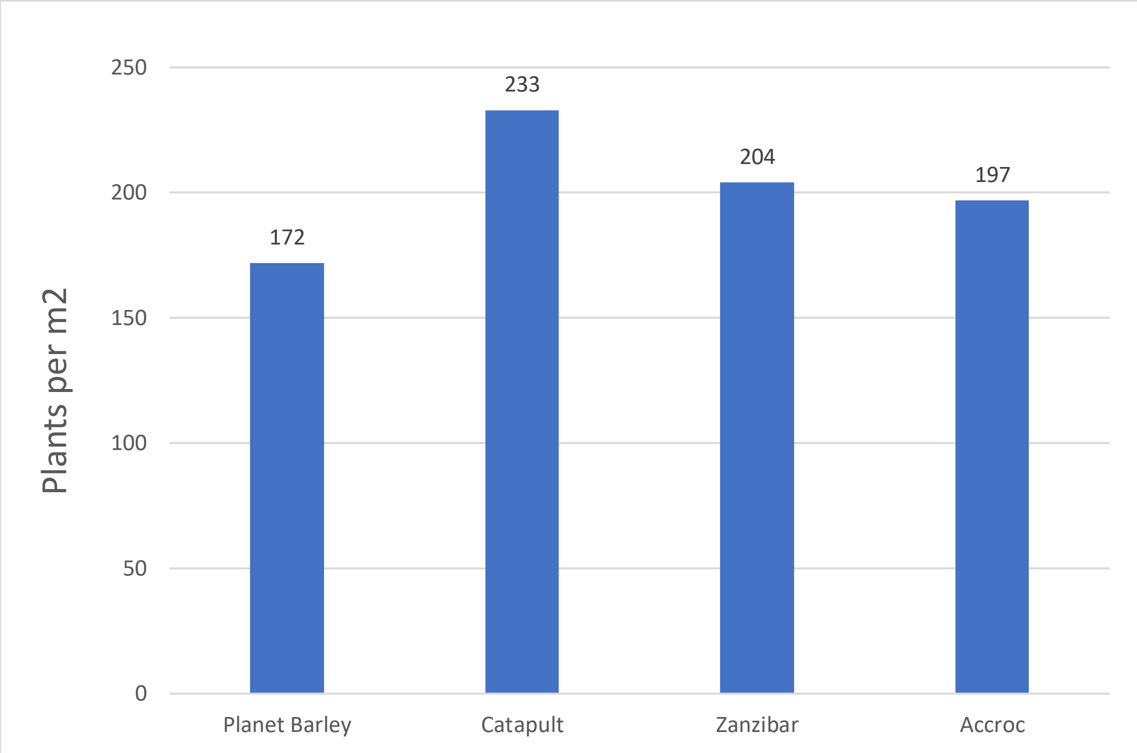

Figure 2: Average plant counts at 8 weeks after planting.

Photo 1: Crop stage on 3rd June 2021 when plant counts were recorded

Tiller counts

Tiller counts were conducted on the 6th of September 2021 (Figure 3). Results show that the Accroc red wheat had the highest average number of tillers per square meter at 661. Catapult had the least tiller per square meter at 502.

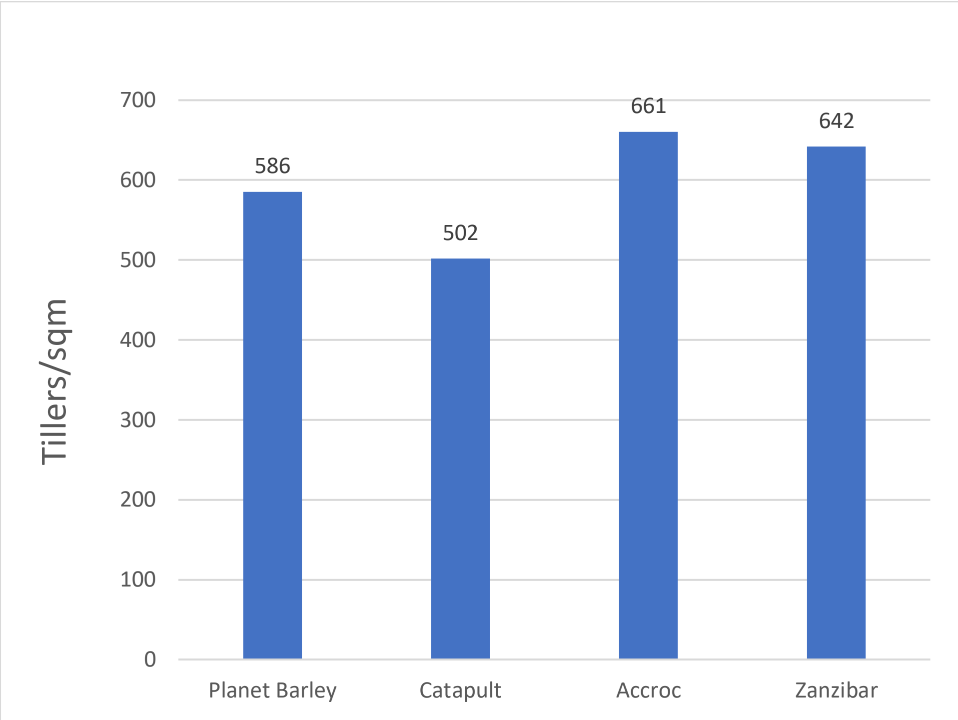

Figure 3: Average tiller counts at 8 weeks after planting.

Harvest Yield Data

Across the trial, average yields ranged considerably due to the frost damage caused during grain production. Accroc was the highest yielding variety and appeared to be largely unaffected by the frost events yielding 7.67 MT/Ha. The other three varieties in the trial all appeared to be affected by frost with Zanzibar yielding 5.09 MT/Ha, the Planet barley 3.96 MT/Ha and Catapult spring wheat 2.12 MT/Ha (Figure 5).

Accroc yielded significantly higher than Catapult. Statistical analysis was not able to be measured between the other varieties as there was no replicated data for Zanzibar or Planet Barley measured at harvest.

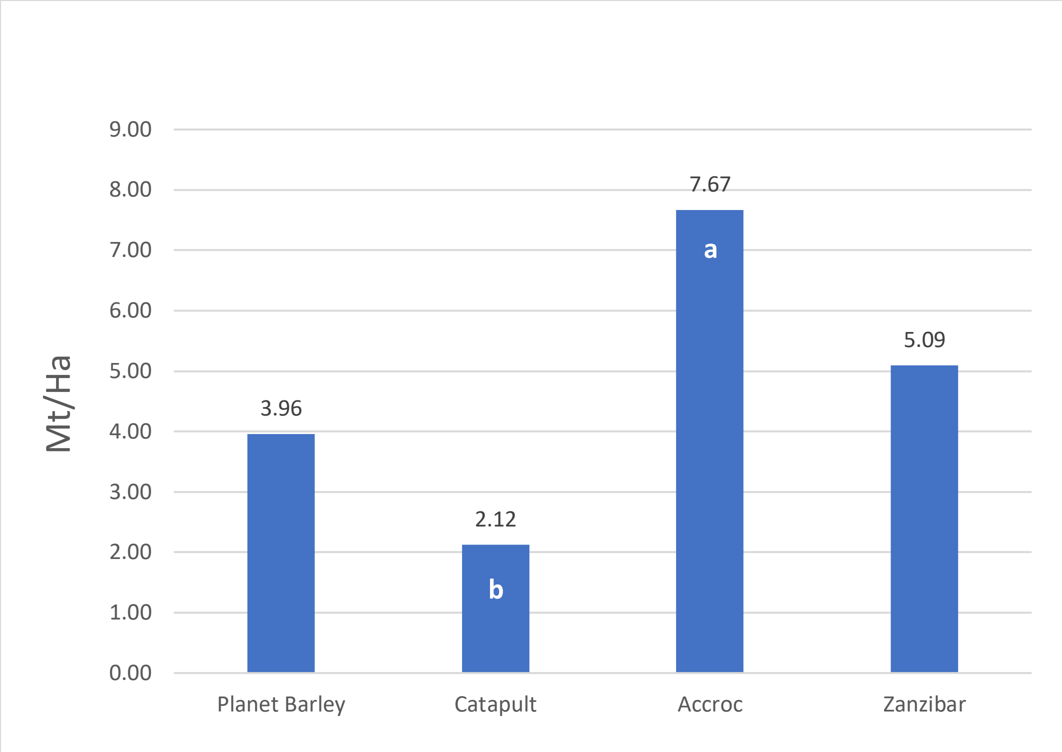

Figure 3: Harvest 2021 yield.

Conclusions

The second year of results from the red wheat demonstration project showed the yields of the red wheat varieties (Accroc 7.67 MT/Ha and Zanzibar 5.02 MT/Ha) are well above a standard spring wheat (Catapult 2.12 MT/Ha) grown in the district and are comparable to a high yielding barley (Planet 3.96 MT/Ha). While Accroc appears to have yielded well above the other three varieties, the primary reason for the lower yield in Planet and Catapult was as result of frost events that occurred late in the season and for Zanzibar, most likely the delayed sowing time, hence reducing the growing season.

Frost events are a common event in late spring in this region and wheat is often the most affected crop. This demonstration has shown that red wheats, and in particular Accroc, offer protection against frost (particularly when sowing early) and are able to yield within the seasons potential. The yield of the spring wheat variety Catapult is typical of what can happen to spring wheats in the event of a frost.

The highest yielding red wheat variety was Accroc which was also the highest yielding red wheat in the 2020 demonstration. 2021 was an exceptional season for the great southern region of WA and this demonstration shows that the red wheat is a very good fit in the rotation in years such as this. With an early break to the season and a mild finish, they are able to maximise on a season's potential and convert the rainfall into yield.

The later sowing of Zanzibar also showed the ability of red wheats to adapt to shorter seasonal conditions and still produce high yields whilst avoid the damaging frost window.

In 2022, project will explore agronomic system modifications, some of which may be identified from the DPIRD/FAR applied R&D component of the HRZ project.

Social Media Postings

Photos were taken onsite and posted regularly on both twitter and Facebook feeds for Southern Dirt.

Social Media Accounts

Facebook: https://www.facebook.com/theGRDC

Twitter: https://twitter.com/theGRDC

YouTube: http://www.youtube.com/user/theGRDC

LinkedIn: http://www.linkedin.com/company/thegrdc

Project Social Media Accounts

Facebook: @Southerndirt Twitter:@Southerndirt

Contact the social media team at socialmedia@grdc.com.au with any questions.

Please note that publication of content to GRDC social media accounts is at the discretion of GRDC's social media team.

References and Useful Links

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

Investment in WA-Focused Linseed Agronomy.

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Date submitted to GRDC:	

Abstract

Western Australia’s southern cropping regions have a need for further diversification in crop rotations for disease and weed management and for the development of more robust and sustainable farming systems. Current rotations revolve around cereal grains with break crops being heavily reliant on canola.

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. Linseed (flax) *Linum usitatissimum* is a potential break crop that provides both a disease break and the opportunity for alternative weed management strategies. With an increasing consumer recognition of the nutritional value of flax seed and flax seed oil due to its high alpha-linolenic acid (ALA) content an omega-3 fatty acid there is potential for an increase in market demand.

The key objectives of this project were to determine if Linseed can be successfully grown under dryland farming conditions in southern WA, if any investment is required into machinery and infrastructure by growers to grow linseed, to develop basic agronomic guidelines and to assess the yield potential of three commercially available linseed varieties grown under dryland conditions in WA, Croxton, Glenelg and Bilton. All these outcomes were successfully achieved within the project.

Three small plot trials in 2019 and four producer demonstration sites in 2020 were undertaken in the Great Southern region of WA to determine if linseed could be successfully grown as a break crop under dry land growing conditions in Western Australia. In 2019 two commercially available linseed varieties were trialed assessing the response to time of sowing, seeding rates and nitrogen application rates. Harvest was by direct heading with the trial site average yields ranging from 0.56 to 0.99t/ha. In 2020 two commercially available linseed varieties were demonstrated Croxton and Bilton as part of the bulk up process of Linseed seed for future commercial production and to also integrate high level variety comparisons between the two varieties. Bilton yielded on average 0.95 MT/Ha and 85% of Canola and Croxton yielded on average 0.86 MT/Ha and 72% of Canola. Over the two seasons the trials and demonstrations were conducted, agronomic guidelines were developed and the crops were grown successfully in 2020 utilising producers existing cropping equipment.

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.

The project has successfully set in the place the ability for growers in the Great Southern region to scale up production of Linseed and demonstrated its ability to fit within the current rotations with the additional benefit of assisting in the long-term management of soil borne root pathogens.

While the agronomic building blocks for growers to scale up production in the Great Southern have been put in place, a remaining obstacle is the post farm gate marketability. For widespread adoption, there will need to be consistent year in year out demand, storage and handling options and Linseed oil processors (domestic and/or overseas). Positively however, grower adoption beyond the project has continued with over 60 Ha planted in southern WA in 2021 across 4 growers.

Executive Summary

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 fibre and milled at the Boyup Brook Flax

Mill. Linseed (flax) Linum usitatissimum is a niche product and has the potential to offer an alternative revenue steam for producers outside of the traditional crop. Demand for Linseed 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 or it can also be eaten as a whole seed or ground.

Linseed also has agronomic benefits as a potential break crop that provides a disease break, the opportunity for alternative weed management strategies, provides an insect pest break and can be effective in reducing some soil borne root diseases and soil borne pathogens namely root lesion nematodes. Canadian research has demonstrated that cereal yields were higher when planted on linseed stubble compared to wheat stubble.

The aim of the project is to investigate agronomic packages which support the introduction and scale up of commercial cultivation of Linseed in the Great Southern region of Western Australia.

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

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

The project was conducted over two years in 2019 and 2020. In 2019 the trials were conducted in small plots across three sites. In 2020 the trials were conducted as producer demonstration sites utilising grower machinery and large-scale plots.

In 2019 three sites were located across the Great Southern Region of Western Australia covering a variety of soil types, climates, paddock histories and growing conditions. The trials sites were in the shires of Darkan, Wagin and Kojonup. The trials involved growing two commercially available varieties Croxton and Glenelg over three times of sowing (TOS) 10 to 14 days apart at three seeding rates (SR): 35, 40 and 45 kg/ha and applying three top dressed nitrogen application rates (low, optimal and high) 40, 80 and 120 units N/ha.

Over the three trial sites, the seeding rates and nitrogen application rates trialed did not consistently result in significant differences in grain yield or oil quantity and quality. Time of sowing had the greatest impact, with the earliest time of sowing generally resulting in higher grain yields. Glenelg on average had a higher grain yield and oil quantity, with Croxton having the highest oil quality.

Trial Site	**Average Site Yield** **t/ha**
Darkan	0.562

Wagin	0.914
Kojonup	0.998

Table 1: Average Site Yields in 2019 (Below average rainfall)

The Darkan site plant counts were the highest, however this was not reflected in the yield. Darkan was the lowest yielding of the three sites. This may be due to the below average rainfall and lack of finishing rains experienced on the non-wetting forest gravel soils at this trial site. Kojonup and Wagin on average achieved nearly double the yield of the Darkan site despite lower plant counts and early plant disease.

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

The methodology in the second year 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 being predominantly bulk up sites.

The key outcome of any variety demonstration is the final yield result. Due to operational difficulties within the demonstration some yield data is not available however the key findings from the data available was:

- Bilton yielded on average 0.95 MT/Ha and 85% of Canola
- Croxton yielded on average 0.86 MT/Ha and 72% of Canola.
- Bilton out yielded Croxton on both sites.

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.

The project has successfully set in the place the ability for growers in the Great Southern region to scale up production of Linseed and demonstrated its ability to fit within the current rotations with the additional benefit of assisting in the long-term management of soil borne root pathogens.

However, for the scale up of the commercial cultivation of Linseed there is the requirement for beyond farm gate systems to be in place before producers will scale up production. An active market to determine a fair price, storage and handling facilities off farm to enable harvested grain to be stored before delivery to consumers, supply chains in place which enable efficient delivery of the grain anywhere around the world and long-term buyers/processors who will receive the grain year in year out. There is still a lot of process to be put in place before Linseed production will scale up to a considerable level.

Grower adoption beyond the project has continued with over 60 Ha planted in southern WA in 2021 across 4 growers. Confidence in the supply chain beyond the farm gate remains as the major obstacle stopping increased uptake and requires addressing before increased production can be expected.

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 crop. Traditionally 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. It has been found that linseed grown after a cereal crop can be effective in reducing some soil borne root diseases including crown rot (*Fusarium pseudograminearum*), common root rot (*Bipolaris sorokiniana*), yellow leaf spot (*Pyrenophora tritici-repentis*) and spot form of net blotch *(Pyrenophora teres f maculate*), it is also resistant to two of the main species of root lesion nematodes *Pratylenchus thornei and P neglectus* (Hertel 2016).

Research conducted in Canada found that cereal yields were higher when planted on linseed stubble compared to wheat stubble. Canola and legume yields were also higher when grown on linseed stubble except in a drought year when yield was reduced. Increase in yields are associated with disease and insect pest breaks and weed control. (FCOC 5th Ed)

Linseed grown on canola stubbles has been found to perform poorly compared to other cereal and legume stubbles. This yield reduction is thought to be due to the negative impact canola has on soil arbuscular mycorrhizae and to the sensitivity of linseed to phytotoxic compounds release during canola stubble degradation. Canola also has high moisture and nitrogen requirements that can lead to soil depletion impacting on the subsequent crop. Linseed has a high soil arbuscular mycorrhiza fungi (AMF) dependency and significant yield losses can result if grown in low AMF situations. (FCOC 5th Ed)

Canadian research shows that linseed grown on cereal stubbles increased yield, with wheat and barley stubbles outperforming oat stubbles. Linseed grown on legume stubbles such as pea had similar yields to linseed grown on wheat stubbles. Linseed grown on linseed produced the lowest yields due to major plant pathogen build up. (FCOC 5th Ed)

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.

Project objectives

The objective of the 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 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 WA.

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

Methodology

The Linseed agronomy production project was conducted over two seasons 2019 and 2020. In 2019 the trials were conducted in small plots across three sites. In 2020 the trials were conducted as producer demonstration sites utilising grower machinery and large-scale plots.

2019 Methodology

Three sites were located across the Great Southern Region of Western Australia covering a variety of soil types, climates, paddock histories and growing conditions. Trials sites were in the shires of Darkan, Wagin and Kojonup.

Trial Site	Soil Type	*Average Annual Rainfall (mm)	*Rainfall 2019 (mm)	Paddock cropping History
Darkan	Forest Gravel (Non-wetting)	547	350	2017: Barley, 2018: Canola
Wagin	Loam	430	310	2017: Pasture, 2018: Barley

Kojonup	Loam/ sandy loam	524	387	2017: Pasture, 2018: Pasture

* Rainfall data from BOM.

Small Plots Trials:

- 1.5m x 10m.
- 162 plots/site with 3 replications at each time of sowing (TOS) in a randomised trial design. Trial design by SAGI.

Varieties:

Two commercially available varieties: Croxton and Glenelg.

Time of Sowing:

Three times of sowing (TOS) 10 to 14 days apart:

- The time of seeding was determined by seed availability, seasonal conditions (soil moisture), current seeding window for other crops and sowing time recommendations from eastern Australia.

Table 1: Times of Sowing

Time of Sowing	Darkan	Wagin	Kojonup
TOS1	30/5/2019	29/5/2019	29/5/2019
TOS2	12/6/2019	12/6/2019	13/6/2019
TOS3	25/6/2019	25/6/2019	26/6/2019

Table 2: Soil Moisture at TOS.

Time of Sowing	Darkan	Wagin	Kojonup
TOS1	Dry	Dry	Dry
TOS2	Slightly wet, moist	Slightly wet, moist	Slightly wet, moist
TOS3	Slightly wet, moist	Wet/ boggy conditions	Slightly wet, moist

Trials were seeded with a small Plot Air Seeder

- Direct Drilled
- Seeding depth: 0.5cm
- Tyne spacing: 24cm

Seeding Rates:

Three seeding rates (SR): 35, 40 and 45 kg/ha:

- Based on the linseed agronomic recommendations from Agriculture Victoria.

Fertiliser: 120kg/ha of Gusto Gold banded below the seed

Nitrogen Application Rates:

Three top dressed nitrogen application rates (low, optimal and high) 40, 80 and 120 units N/ha.

- Based on canola fertiliser recommendations.
- Nitrogen was as urea.
- Top dressed nitrogen applications of urea were applied on the 8/7/2019.

LowN	40 units N/ha
OptimalN	80 units N/ha
HighN	120 units N/ha

Insecticide and Herbicide Applications

All sites had a blanket insecticide application across the trial site prior to TOS 1 with Bifenthrin 200ml/ha, Alpha Forte 200ml/Ha and Chlorpyrifos 1L/Ha.

	TOS 1	**TOS 2**	**TOS 3**
Darkan	Trifluralin 2L/ha Sprayseed 2L/ha BS 1000 0.1%	Trifluralin 2L/ha Sprayseed 2.5L/ha BS 1000 0.1%	Trifluralin 2L/ha Roundup 3L/ha BS 1000 0.1%
Wagin	Trifluralin 2L/ha Sprayseed 2.5L/ha BS 1000 0.1%	Trifluralin 2L/ha Sprayseed 2.5L/ha BS 1000 0.1%	Trifluralin 2L/ha Roundup 3L/ha BS 1000 0.1%
Kojonup	Trifluralin 2L/ha Sprayseed 2.5L/ha BS 1000 0.1%	Trifluralin 2L/ha Sprayseed 2.5L/ha BS 1000 0.1%	Trifluralin 2L/ha Roundup 3L/ha BS 1000 0.1%

Table 2: Time of Sowing Herbicide Applications

Post emergent broad leaf weed control: Bromicide MA 1000ml/ha as required.

Post emergent grass control: Verdict 520 100ml/ha, Uptake 0.5%: as required.

Heliothis and Budworm Control: Alpha cypermethrin 300ml/ha, Chlorpyrifos 300ml/ha

2020 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 being predominantly bulk up sites.

Trial		Treatments - 1 replicate
Hall Trial Design - Katanning	1	Bilton
	2	Croxton
	3	Canola

Trial		Treatments - 4 replicates
Cummings Trial Design - Wagin	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

Trial		Treatments - 2 replicates
Harrington Trial Design - Darkan	1	Bilton
	2	Croxton
	3	Canola
	4	Canola
	5	Bilton
	6	Croxton

Trial		Treatments - 1 replicate
Anderson Trial Design - Kojonup	1	Bulk up Croxton 12 Ha

Table 3: 2020 demonstration designs

Table 4 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 4: Plot size and agronomic packages for each demonstration site.

2021 Methodology

In 2021 Predicta B soil tests were taken on 3 of the 4 producer demonstration sites to test the impact of growing Linseed on soil borne pathogen root lesion nematode levels. The results were compared to the results from the soil tests taken prior to sowing the Linseed crop in 2020.

The following seasons crop yields on the Linseed and canola stubbles were measured to see if the impact of the Linseed crop on the root lesions nematodes was able to translate through to an impact on yield.

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):

2019 Locations:

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1	-33.50291	116.70377
Nearest Town	Darkan	
Trial Site #2	-33.28106	117.28060
Nearest Town	Wagin	
Trail Site #3	-33.89466	117.03954
Nearest Town	Kojonup	

2020 Locations:

	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 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

2019 small plot trial results

Harvest Results:

Harvest was completed on the 11/12/2019. All plots were harvested on the same day having all reached maturity at the same time regardless of the TOS. Plots were harvested by direct heading using a small plot harvester.

The main effects at the Darkan site were of variety and time of sowing with TOS1 being an important factor for producing the highest yields with the variety Glenelg generally out yielding Croxton. At the Kojonup site TOS1 was a factor in producing the highest yields but less so than at Darkan. At Kojonup the bottom 15 treatment combinations all involved Croxton. Unlike the other sites the Wagin site did not produce notable yield differences between the TOS or variety.

<u>Darkan Harvest Results</u>

Two of the plot treatments Glenelg TOS1; SR45; OptimalN and Glenelg TOS1; SR45; HighN had a mean yield significantly higher than the lowest yielding plots at the Darkan site. The two plots treatments with significantly higher yields appear to be anomalies in the data set with significant variability between the yields of the individual plots. The reason for the higher mean yields in these two plots alone was not able to be determined.

The average yield for the Darkan site was 0.562t/ha.

The seeding rates trialed did not produce significant yield differences at the Darkan site. Nitrogen rates were rated as significant however showed no consistent correlation with the other treatment variables. Variety and TOS produced the main effects with TOS1 on average producing the highest yields, and Glenelg on average out yielding Croxton.

Variety: TOS Average Yield, Darkan: t/ha			
	TOS1: 30/5/2019	**TOS2: 12/6/2019**	**TOS3: 25/6/2019**
Croxton	0.603	0.534	0.439
Glenelg	0.7	0.613	0.483

Table 5: Darkan average yield by TOS and Variety

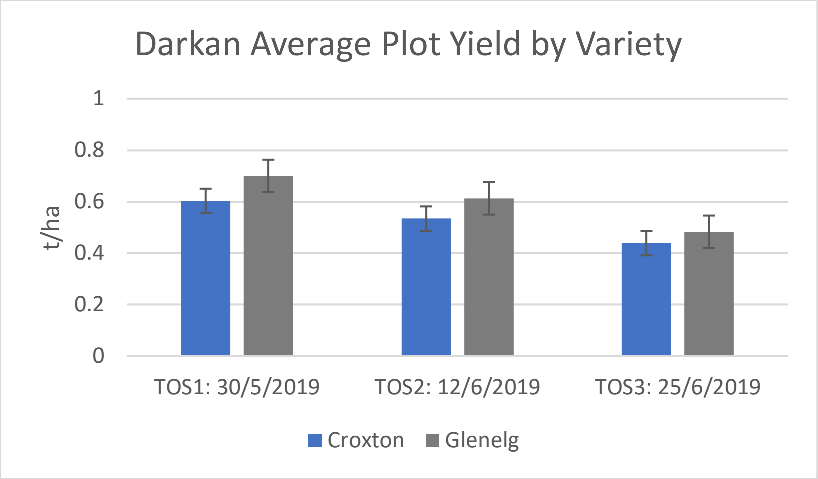

Chart 1: Darkan Average Yields of Glenelg and Croxton for all TOS.

Glenelg consistently yielded higher at the Darkan site. On average TOS1 produced the highest yields followed by TOS2 then TOS3.

Wagin Harvest Results

There were no significant differences between the plot mean yields at the Wagin site.

The average yield for the Wagin site was 0.914t/ha.

TOS3 was not harvested as it failed to germinate. TOS3 at Wagin on the 25/6/2019 occurred after a rainfall event of over 30mm two days prior to seeding. The site became boggy which significantly impacted the ability to control seeding depth. Seed was sown too deep and failed to emerge.

Image 1: Wagin 20/8/2019, from left TOS3- 3 rows, TOS1- 3 rows, TOS2- 3 rows (B. Copestake)

The seeding rates trialed did not produce a significant yield difference at the Wagin site. There was a response to nitrogen, but this was not consistent between the TOS. TOS1 mean yields were highest in the High N followed by Low N then Optimal N. TOS2 mean yields were highest in the High N followed by Optimal and then Low N.

Variety: TOS Average Yield, Wagin: t/ha			
	TOS1: 30/5/2019	**TOS2: 12/6/2019**	**TOS3: 25/6/2019**
Croxton	0.903	0.883	0
Glenelg	0.957	0.914	0

Table 6: Wagin average yield by TOS and Variety

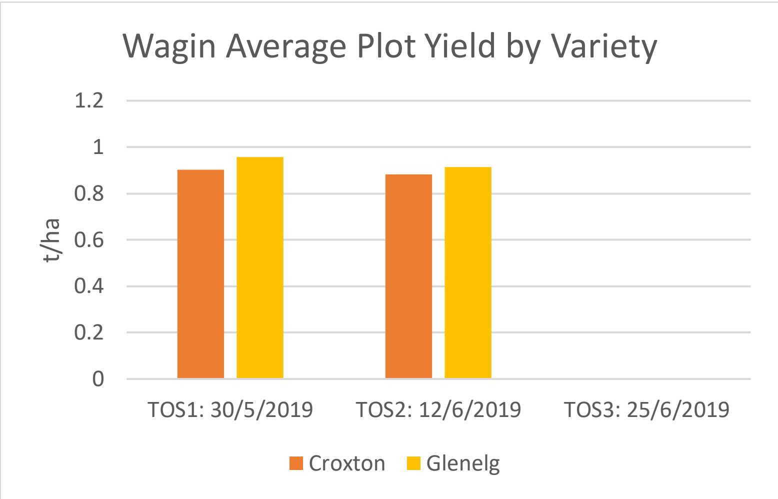

Chart 2: Wagin Average Yields of Glenelg and Croxton for all TOS.

Glenelg on average was slightly higher yielding than Croxton at the Wagin site, with TOS1 yielding slightly higher than TOS2 for both varieties. Overall, Croxton showed more variability in yield than Glenelg.

Kojonup Harvest Results

There were no significant differences between the plot mean yields at the Kojonup site.

The average yield for the Kojonup site was 0.998t/ha.

The seeding rates and top-dressed nitrogen application rates trialed did not produce a significant yield difference at the Kojonup site. Variety and TOS produced the main effects with Croxton mean yields being consistently higher for each TOS.

Variety: TOS Average Yield, Kojonup: t/ha			
	TOS1: 29/5/2019	**TOS2: 13/6/2019**	**TOS3: 26/6/2019**
Croxton	0.924	0.947	0.86
Glenelg	1.227	1.034	0.996

Table 7: Kojonup average yeild by TOS and Variety

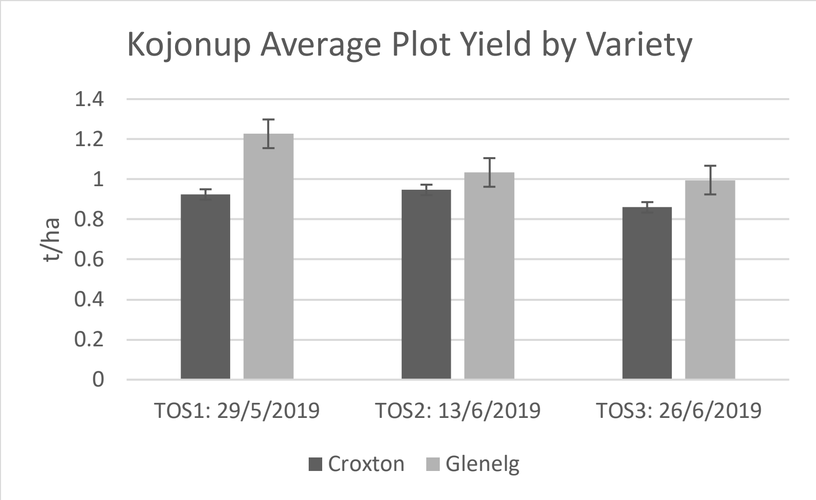

Chart 3: Kojonup Average Yields of Glenelg and Croxton for all TOS.

Glenelg on average was significantly higher yielding than Croxton at the Kojonup site for each TOS. Glenelg yields on average decreased with each TOS. Croxton yields were less variable between the 3 times of sowing, however the 15 lowest ranked yields involved the variety Croxton.

Oil Quality and Quantity Analysis Results

Grain samples of Croxton and Glenelg SR45 from TOS 1: low, optimal and high N from each site were collected for oil analysis performed by Symbio Laboratories. (See Appendix C for results).

Oil quantity was lower than expected ranging from 29.6 to 40.6%. Glenelg consistently had a higher oil content than Croxton.

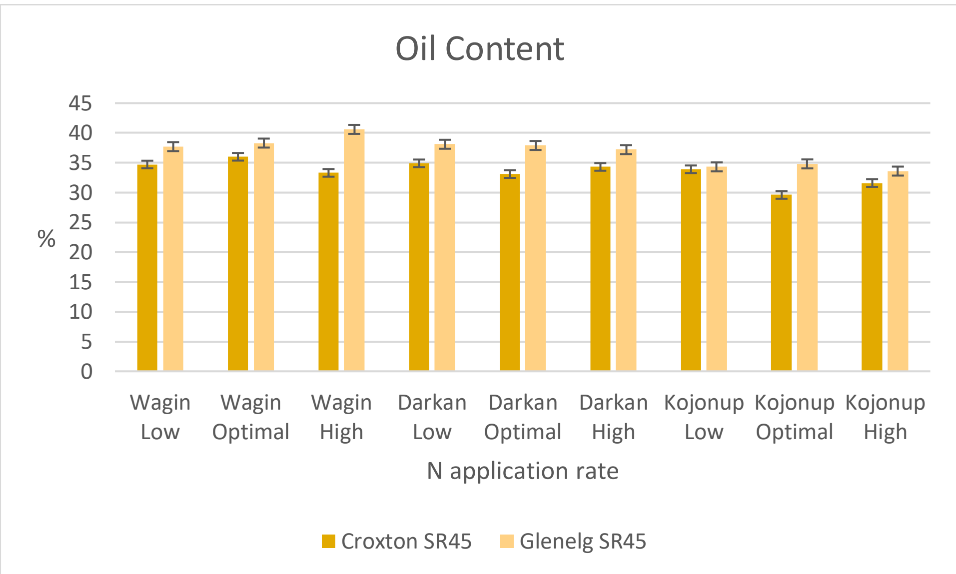

Chart 4: Oil Content

There were no consistent correlations between N rate and oil quality and quantity across the sites.

Croxton had a higher alpha-linolenic acid content ranging from 54.1- 58.3% than Glenelg 52.2- 55.4% with the exception being the high N application rate at the Wagin site.

2019 Results Summary:

Over the three trial sites, the seeding rates and nitrogen application rates trialed did not consistently result in significant differences in grain yield or oil quantity and quality. Time of sowing had the greatest impact, with the earliest time of sowing generally resulting in higher grain yields. Glenelg on average had a higher grain yield and oil quantity, with Croxton having the highest oil quality.

Trial Site	Average Site Yield t/ha
Darkan	0.562
Wagin	0.914
Kojonup	0.998

Table 8: Average Site Yields in 2019 (Below average rainfall)

The Darkan site plant counts were the highest, however this was not reflected in the yield. Darkan was the lowest yielding of the three sites. This may be due to the below average rainfall and lack of finishing rains experienced on the non-wetting forest gravel soils at this trial site. Kojonup and Wagin on average achieved nearly double the yield of the Darkan site despite lower plant counts and early plant disease.

2020 producer sized plots results

Wagin Results:

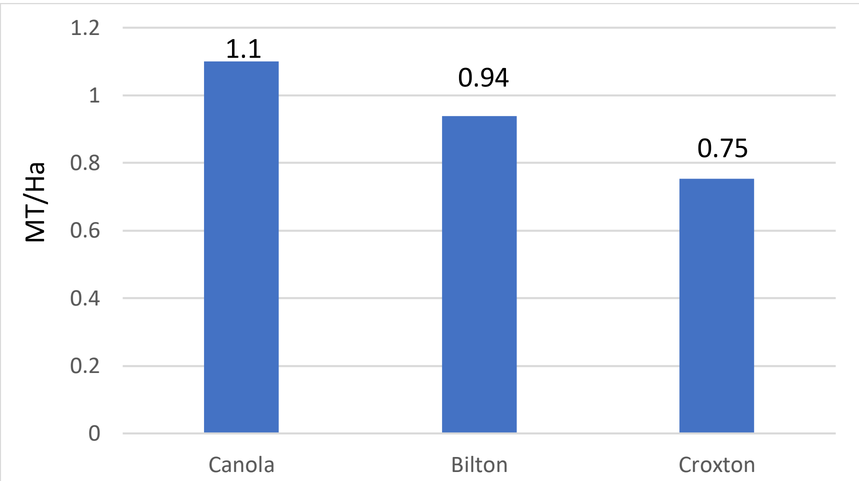

Chart 5: Wagin yield results

The harvest technique did not allow the individual plots to be weighted and therefore individual plot yields measured. The total yield of each of the Linseed varieties across all plots was measured and is shown in chart 5. The canola yield was not recorded Bilton yielded higher than Croxton it is expected that both yielded less than Canola.

Darkan Results:

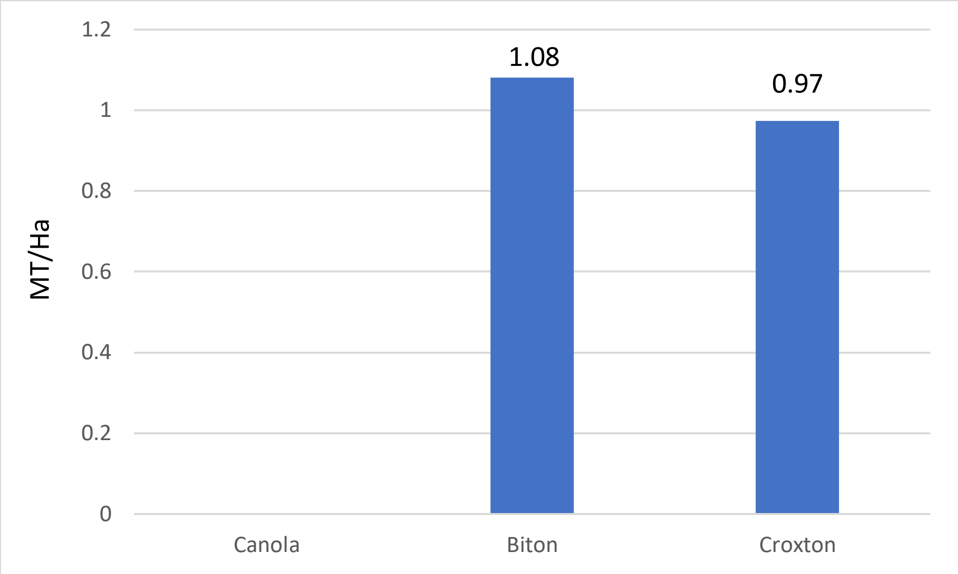

Chart 6: Darkan yield results

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.

Kojonup Results:

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

Table 9: 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

2021 Results

In 2021 the canola and Linseed stubbles were tested for soil borne pathogens (PredictaB) and the following crops yields measured to determine if there was a benefit to the following crop from the potential drop in disease pressure.

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

Site	Pratylenchus penetrans	Pratylenchus thornei	Pratylenchus neglectus	Pratylenchus quasitereoides
Katanning	None	None	None	Medium
Darkan	None	None	None	Low
Kojonup	None	None	Medium	Low - medium

Table 1: Predicta B results prior to planting Linseed.

Site	Pratylenchus penetrans	Pratylenchus thornei	Pratylenchus neglectus (nematodes)	Pratylenchus quasitereoides (nematodes)
Katanning	None	None	None	Low
Darkan	None	Low	None	Low
Kojonup	None	None	None	Low

Table 2: Predicta B results June 2021, post harvest of Linseed, with following crop planted.

2021 Crop summary and Harvest dates

Location	Crop type	Harvest date	Yield recording method
Darkan	Barley	13 December 2021	Yield Map
Katanning	Lupins	6 December 2021	Weight trailer
Kojonup	Lupins	31 December 2021	Yield map

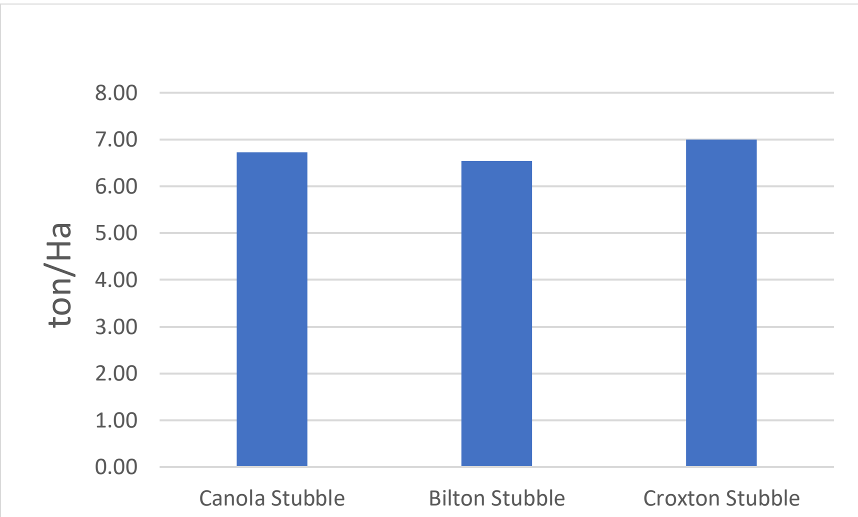

Chart 7: 2021 Barley yields grown on canola and Linseed stubbles at Darkan.

Katanning yields

1.55 ton/Ha	Lupins on Linseed stubble
1.23 ton/Ha	Lupins on Canola stubble

Kojonup yield

2.90 ton/Ha	Lupins on linseed bulk up site

Discussion of Results

2019 small plot trial results

The growing season of 2019 experienced below average rainfall across all trial sites, with TOS1 at all sites being dry seeded. TOS2 and TOS3 were seeded into moist soil.

Patchy areas of plant disease and deaths occurred in some plots at both the Wagin and Kojonup sites during the early growth stages. It occurred in both the Glenelg and Croxton plots with neither variety being observed to be more susceptible. The symptoms were of a Damping Off disease. Fungicides were not applied at any stage throughout the trial, as available fungicides were not registered for use on linseed. The use of fungicides in furrow or as a seed dressing may be of benefit to control early fungal disease.

Plant counts from all sites were not reflective of the final yield. Darkan with the highest plant counts had the lowest grain yields. However, it is worth noting the plant counts at Darkan were well above the recommended number for Linseed by Agriculture Victoria. Darkan plant numbers ranged between 485 to 675 plants/m2 compared to the recommended 300 plants/m2. It is likely the very high numbers had a negative impact of yield. Wagin plant counts ranged between 213 – 348 and Kojonup ranged between 260 to 432.

In general, Croxton plots had higher plant counts compared to the equivalent Glenelg plots. A germination test of the seed was not done prior to seeding. Glenelg overall out yielded Croxton. Sites and plots with higher plant densities may have suffered a yield penalty due to the lack of soil moisture with a below average rainfall and dry finish.

The seeding rates trialed were the recommended seeding rates from Agriculture Victoria and may not best suited for the Great Southern Region of WA with a lower rainfall. Results from the trial showed no significant differences in yield between the three seeding rates trialed. To establish a recommended seeding rate further seeding rate trials over successive seasons needs to be undertaken.

Results of the time of sowing (TOS) from these trials indicate that an earlier time of sowing has yield benefits with the 2 varieties trialed. Further trials are required to determine if these results were due to a lower than average rainfall year with limited finishing rains or if these linseed varieties require a longer growing season to maximise yield potential.

Utilising the existing canola seeding window (April) to seed linseed would provide the benefits of earlier seeding along with seeding machinery already calibrated for small seed and a shallow seeding depth.

The top-dressing rates of nitrogen trialed did not result in a consistent difference in grain yield or oil quantity and quality. Further work is required to determine optimal N requirements for linseed grain yield and oil quantity and quality.

2020 Producer demonstration sites results

The key outcome of any variety demonstration is the final yield result. Due to operational difficulties within the demonstration some yield data is not available however the key findings from the data available was

- Bilton yield 85% of Canola
- Croxton yielded 72% of Canola.
- Bilton out yielded Croxton on both sites.

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 ensuring the full yield potential could be achieved and demonstrates that Linseed can be seeded and germinated 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 be 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 fertilser requirements for growing Linseed as there is no direct correlation between application rates and yield. Applications were all in line 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 able to be 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 and therefore impact 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 built up in numbers in early November, was successfully sprayed and had no impact on yield.

Additionally, both seeding and harvest didn’t present any handling issues showing Linseed is a crop that will fit into a rotation in the Great Southern.

Cost benefit analysis:

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 85% of canola. Therefore, for Linseed to generate the same return for growers Linseed will need to trade at 117% of Canola. At the time of completing the cost benefit analysis Canola was trading at $755/MT. Linseed will need to be trading at $883/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 produce a consistent supply would work to secure firm pricing as wholesalers would have the ability to build market supply chains.

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 the issue which currently has limited management strategies.

2021 yield results from Linseed and Canola stubbles

The results from the crop yields in the season following the linseed or canola crops were mixed. The PredictaB results certainly demonstrated a reduction in soil borne disease pressure however this wasn't always able to translate into final yield. The Katanning site did demonstrate an advantage in growing lupins after linseed compared to canola however due the very wet season a large portion of the canola area was damaged by water logging which impacted the validity of the findings. The Darkan site gave mixed results with one Linseed variety stubble producing a higher barley yield than canola stubble and the other variety lower.

Overall 2021 was an exceptional season with good rainfalls received across the entire season. In good seasons it is difficult for soil borne pathogen trials to show differences in results as roots that may be impacted by disease are still able to access enough moisture to grow a healthy crop. It is in poorer seasons that the benefits of reducing soil disease can be shown in crop yields as better developed root systems are able to access more moisture.

Conclusion

The objective of this project was to support the introduction and scale up of commercial cultivation of Linseed in the Great Southern region of Western Australia by specifically determining if Linseed can be successfully grown under dryland farming conditions in the Great Southern, if any investment is required into machinery and/or infrastructure, to develop basic agronomic guidelines to grow linseed in WA and to assess the yield potential of two commercially available linseed varieties, Croxton and Bilton.

The four main objectives of the project were successfully achieved. Current farming equipment can be utilized to grow Linseed and there is no requirement for any investment into machinery or infrastructure. The four growers who conducted the demonstrations on their properties were able to use their existing equipment.

A basic agronomic package was collated throughout the project which enabled the participating producers the ability to grow a weed free, productive crop. There is however a lot of scope for further work to refine the agronomic package. Fertiliser response curves, sowing windows, seeding rates, variety selection and most importantly expanded broadleaf management options as the herbicides used within the project of MCPA and BromicideMA will limit the uptake of Linseed due to resistance concerns.

The yield potential of the two commercially available linseed varieties, Croxton (0.75 – 0.97 MT/Ha) and Bilton (0.83 – 1.08 MT/Ha), was demonstrated within the project. Between the two varieties they on average yielded 78.5% of the canola crop alongside.

The project has successfully set in the place the ability for growers in the Great Southern region to scale up production of Linseed and demonstrated its ability to fit within the current rotations with the additional benefit of assisting in the long-term management of soil borne root pathogens.

However, for the scale up of the commercial cultivation of Linseed there is the requirement for beyond farm gate systems to be in place before producers will scale up production. An active market to determine a fair price, storage and handling facilities off farm to enable harvested grain to be stored before delivery to consumers, supply chains in place which enable efficient delivery of the grain anywhere around the world and long-term buyers/processors who will receive the grain year in year out. There is still a lot of processed to be put in place before Linseed production will scale up to a considerable level.

Grower adoption beyond the project has continued with over 60 Ha planted in southern WA in 2021 across 4 growers. Confidence in the supple chain beyond the farm gate remains the primary reason for the lower than expected uptake and requires addressing before improved scale up of production can be expected.

Implications

Linseed has been demonstrated through the project to fit as a further option in the cropping rotation to increase crop diversity and lengthen crop rotations in the Great Southern of WA. Linseed has the potential to be a profitable break crop with the additional benefit of providing soil borne pathogen management, fits seamlessly into existing machinery resources and within the readily available cropping inputs (fertilisers/chemicals) to grow a weed free productive crop.

The project has demonstrated the fit and potential for Linseed within the cropping rotation in the Great Southern however there are two key implications that need to be addressed before the large scale up of Linseed can reasonably be expected:

1) Supply chain beyond the farm gate

While it has been demonstrated that Linseed can be successfully grown, what will happen beyond the farm gate should production reach a reasonable scale of 10,000 MT or even 50,000 MT? Is there demand for this amount of linseed, enough competition within the market to set a fair price and the supply chain infrastructure to receive the grain once produced?

2) Improved Agronomic Production Packages

The project was successful in generating basic agronomic guidelines for the production of Linseed there is a lot of further work required to enable growers to optimize the production of Linseed through developing an optimal agronomic package. Fertiliser rates were modelled around canola and response curves need to be developed for Linseed, more robust broadleaf control strategies are required and variety selection trials are needed to determine the most suited variety for Western Australia. The varieties chosen for the project were over 40 years old and there are more modern varieties available.

In summary the platform for the scale up of Linseed has been set through this project however there is still further development required before a considerable production of Linseed can be expected out of the Great Southern region of WA.

Recommendations

The finding from this project are that linseed can successfully be grown in the Great Southern Region of WA under dryland farming conditions. There are two key recommendation platforms that have come out of the project which are:

1) To further develop the agronomic guidelines for growing Linseed in WA, successive years of growing experience and trials are required.

Recommended areas for further trials:

- Time of sowing
- Seeding rates
- Variety trials
- Yield response to previous and successive crops in rotation
- In furrow and seed dressing applications of fungicides to control early damping off disease. Currently no APVMA registered products for use on linseed.
- Weed control options, specifically broadleaf control strategies
- Nutrient response curves and in particular Nitrogen requirements

- Harvesting techniques: direct heading vs swathing vs desiccation
- Expansion of growing region
- Farmer scale trials

There is a need for the breeding and development of high yielding disease resistant varieties with good oil quantity and quality that are suitable for dryland farming in WA.

2) Investigation into the supply chain beyond the farm gate. It is recommended that a project is developed and funded to investigate the potential of large scale Linseed production to be handled efficiently beyond the farm gate within the existing infrastructure and supply chains or if there will be a need for further infrastructure to be developed in the event Linseed production is increased.

As part of this project there is a need to understand where demand for Linseed is both domestically and offshore plus number of potential participants in the market, processing capacity and the size of the end market or consumer demand to ensure if the linseed grain is produced that there is demand for it and at profitable prices.

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

DAFWA	Department of Agriculture and Food, Western Australia
DAP	di ammonium phosphate
DArT	Diversity Arrays Technology
DAT	days after treatment
Db	bulk density
DAFWA	Department of Agriculture and Food, Western Australia

References

Growing Linseed and Linola, Agriculture Victoria, Note Number: AG0418 (Drafted in May 2008 and incorporating Agnote AG0123, Diseases of linseed, which was published by Steve Marcroft and Rod Clarke in November 1999.)

Growing Flax: Production Management and Diagnostic Guide, Flax Council of Canada (FCOC), 5th Edition

Hertel K (2016) Tactical Agronomy of Safflower and Linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Project code: DAN00197

Linseed a Growers Guide. Premium Crops, Hampshire, UK

Purse J (1990) A Flax Mill by the River, Janet Purse, Boyup Brook

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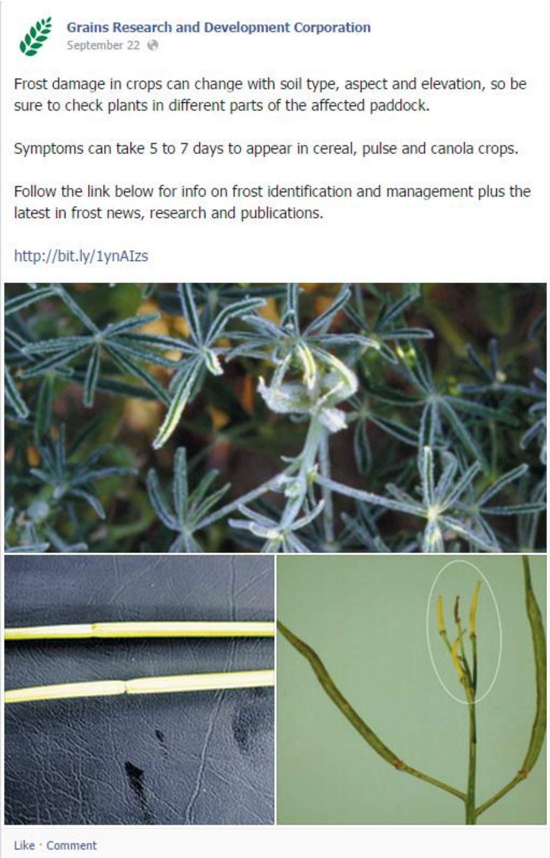

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Final Technical Report

Using long season wheats for increases in profits and grazing opportunities

Project code:	9177492 / SDI1906-005RTX
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Date submitted to GRDC:	16 June 2022

Abstract

Growers in the southern region of Western Australia aim to sow their cereal crops in mid-May to maximise yield potential whilst managing frost risk, however later sowing can lead to a reduced yield potential. Early sowing opportunities through summer rainfall events or early breaks in the season often present themselves and producers are not able to take advantage of this opportunity without facing a significant frost risk.

Long season wheats offer a cropping option that can be sown March – Mid April, without excessive frost risk reducing yields and are able utilise the available early moisture and warmer temperatures.

The aim of the project is to assist growers in introducing long-season wheats into their farming systems to best utilise summer rainfall and early-sowing opportunities. The primary objective of this project is to demonstrate to growers the agronomic and enterprise fit and associated benefits of including a long season wheat into their rotation and to encourage the adoption through the farmer scale demonstrations and economic analysis.

Over the two years of the project three demonstration sites were established in the Albany Port Zone and four were established in the South-East Kwinana Port Zone. All demonstrations were replicated allowing the appropriate statistical analysis on each site to be conducted. All trial sites had 3 long season wheat varieties and a control spring wheat variety.

In the Albany port zone Illabo was the highest yielding variety in the 2020 Muradup trial followed by Accroc then Scepter and Nighthawk. Illabo a long season winter wheat was able to match the high yielding spring variety despite the late seeding date of 26th of May. In 2021 Accroc was the highest yielding variety across both demonstrations. Accroc yielded 8.40 tons/Ha at the Murradup site. Overall the demonstrations at Muradup/West Muradup shows there is a fit for these varieties in the rotation in the high rainfall zones of the Great Southern.

In 2020 at the Corrigin site Catapult was the highest yielding variety followed by Scepter then Denison. In 2020 at the Kurrenkutten site Denison yielded significantly higher than the other three varieties achieving a yield of 2.79 MT/Ha. 2021 was a much better growing season than 2020 with the yields reflecting the better growing season. Denison was the highest yielding variety at 3.32 ton/Ha. Mt Walker in low rainfall zone showed that long season wheats may not really suited to the low rainfall areas even in better seasons.

Executive Summary

Traditionally, many growers in the southern region of Western Australia have mixed farming enterprises and aim to sow their cereal crops in mid-May to maximise yield potential whilst managing frost risk. However, this later sowing can lead to a reduced yield potential. Farmers in southern WA are sometimes presented with early sowing opportunities through summer rainfall events or early breaks in the season and are not able to take advantage of this opportunity without facing a significant frost risk.

Long season wheats offer a cropping option that can be sown March – Mid April and utilise the available early moisture and warmer temperatures without excessive frost risk reducing yields.

The aim of the project is to assist growers in introducing long-season wheats into their farming systems to best utilise summer rainfall and early-sowing opportunities. Growers in south western WA are also interested in adding wheat back into their crop rotations and reducing their reliance on continual canola barley rotations to maximise profits.

The primary objective of this project is to demonstrate to growers the agronomic and enterprise fit and associated benefits of including a long season wheat into their rotation and to encourage the adoption through the farmer scale demonstrations and economic analysis

In 2020 one demonstration site was established in the Albany Port Zone and two were established in the South-East Kwinana Port Zone. In 2021 two demonstrations were established in both the Albany Port Zone and the South-East Kwinana Port Zone. All demonstrations were replicated allowing the appropriate statistical analysis on each site to be conducted. All trial sites had 3 long season wheat varieties and a control spring wheat variety.

In the Albany port zone Illabo was the highest yielding variety in the 2020 Muradup trial followed by Accroc then Scepter and Nighthawk. Illabo a long season winter wheat was able to match the high yielding spring variety despite the late seeding date of 26th of May.

In 2021 Accroc was the highest yielding variety across both demonstrations. Accroc yielded 8.40 tons/Ha at the Murradup site which was affected by frost impacting all the other varieties. The 2021 season was ideal for growing long season wheats with both demonstrations sown in late March and April. The long season wheats were the highest yielding varieties across both sites and Accroc demonstrated the yield potential of these varieties when the seasonal opportunities present. The long season wheats produced up to $2,688/Ha (Accroc) well above the standard spring wheat variety which was frost effected and only able to generate $678/Ha (Catapult). Overall the demonstration at Muradup/West Muradup shows there is a fit for these varieties in the rotation in the high rainfall zones of the Great Southern.

In 2020 at the Corrigin site Catapult was the highest yielding variety followed by Scepter then Denison with Longsword yielding significantly lower than the other three varieties. The trial was sown in the preferred window for long season wheat on the 15th of April. In 2020 at the Kurrenkutten site Denison yielded significantly higher than the other three varieties achieving a yield of 2.79 MT/Ha. Yitpi was the next highest yielding variety.

2021 was a much better growing season than 2020 with Kurrenkutten receiving 368 mm for the year and 299.5mm for the growing season (Apr – Oct). The yields reflected the better growing season at Kurrenkutten. Denison was the highest yielding variety at 3.32 ton/Ha followed by Vixon, Yitpi and finally Rockstar. Denison generated gross proceeds of $1062/Ha compared to the standard spring wheat producing $931/Ha (Vixon). Mt Walker lies east of Kurrenkutten receiving less rainfall which showed in the yields. Scepter was the highest yielding variety followed by Denison, Kinsei and finally Rockstar. This site demonstrates that long season wheats may not be suited to the low rainfall areas even in better seasons.

Similarly to the conclusions drawn from the Muradup site, three of the four demonstrations in the Corrigin region showed there is a fit for longer season wheats in the medium rainfall zones when the seasonal conditions present themselves. The highest yeilding longer season wheat varieties suited to this region from this project were Denison and Catapult which are both longer season spring wheats The longer season spring wheat appears to be the preferred longer season wheat for this area over the true winter wheat. The economic results from the demonstration have shown that the longer season type of wheats have a place in the rotation for growers in areas with longer growing seasons and give producers the ability to increase total revenues and capture more of the production potential of longer growing seasons. This result was particularly evident in better seasons, like 2021, with an early break and softer finish.

Further work has been uncovered from the project primarily around better understanding the frost risk benefits, developing a detailed agronomic package and understanding the full yield potential of these types of wheat in higher rainfall growing seasons.

Background

Traditionally, sowing wheat in Western Australia is not recommended before the 25th of April (Brenda Shackley et al., 2017). This is due to higher frost risk. Many growers in the southern region of Western Australia have mixed farming enterprises and aim to sow their cereal crops in mid-May to maximise yield potential whilst managing frost risk. However this later sowing can lead to a reduced yield potential. Farmers in southern WA are sometimes presented with early sowing opportunities through summer rainfall events or early breaks in the season.

Farmers are looking for a cropping option to utilize this early available moisture without excessive frost risk reducing yields. Long season wheats can be sown March – Mid April and utilise the available early moisture and warmer temperatures.

The aim of the project is to assist growers in introducing long-season wheats into their farming systems to best utilise summer rainfall and early-sowing opportunities. Growers in south western WA are also interested in adding wheat back into their crop rotations. Currently, many growers are relying on continual canola barley rotations to maximise profits. Growing more wheat will add diversity to their cropping rotations which will combat fungicide and herbicide resistance issues in all crops.

There is limited information, on which varieties to grow with a very early sowing opportunity in Southern WA. The key to successful early sown wheat is for growers to match their region's optimal flowering window with the correct varieties and sowing dates. There is a requirement to produce localised data to aide growers about which varieties to grow and when to sow them. Since 2000, there has been a general increase in summer rainfall and a corresponding decrease in winter rainfall (AEGIC data 2018). As a result, not only are traditional crop yields being affected, but there is an opportunity to take advantage of early available moisture and a longer growing season to achieve higher yields when these seasonal opportunities are presented.

Grazing winter crops can be the key to mixed farming profitability and is starting to gain traction through programs such as grain and graze, whereby oats, barley, wheat and canola have been sown early to capture the benefits of grazing. Therefore, an additional opportunity for sowing long season wheats is an enhanced ability to graze them with minimal yield penalty and greater management flexibility. Winter type wheats are easier to graze than spring wheats because they remain vegetative for much longer. This means they can be grazed for longer periods of time compared to spring type wheats, with less risk of yield loss. Having early sown established wheat crops will help address the autumn feed gap that growers face every year.

These varieties can provide value to the livestock component 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 pasture dry matter for later in the season.

Project objectives

There is growing interest from growers in southern Western Australia around the opportunities that long season wheats can provide them in a mixed or 100% cropping farming enterprise. The primary objective of this project is to demonstrate to growers the agronomic and enterprise fit and associated benefits of including a long season wheat into their rotation and to encourage the adoption through the farmer scale demonstrations and economic analysis

The project will demonstrate time of sowing, best available varieties suited to the areas of the demonstration sites and season permitting, the opportunity for grazing without yield penalty. It is worth noting the 2020 season did not allow the opportunity to graze any of the demonstrations. The project will also provide practical guidelines or agronomic packages for production of long season wheat in the medium to high rainfall zones of South Western Australia. The key outcomes of this project are:

- Demonstrate the yield potential of different long season wheat varieties relative to spring wheat varieties with an early sowing window

- Develop economic analysis comparing long season and spring wheat varieties and time of sowing regarding yield to assist producers in making informed decisions

- Begin the development of an agronomic package on growing long season wheats, time of sowing, seeding rates and fertiliser application and timing will be examined within this project.

- Develop protocols around the importance of time of sowing for long season wheat varieties that are best suited to different areas within southern Western Australia

- Where seasonal conditions allow, demonstrate the ability of sowing long season wheats to manage the feed gap in Autumn and winter through crop grazing with having minimal yield penalty

Methodology

In 2020 one demonstration site was established in the Albany Port Zone within the Southern Dirt Region and two were established in the South-East Kwinana Port Zone within the Corrigin Farm Improvement Group's region. In 2021 two demonstrations were established in both the Albany Port Zone and the South-East Kwinana Port Zone. All demonstrations were replicated allowing the appropriate statistical analysis on each site to be conducted.

All trial sites had 3 long season wheat varieties (or long spring wheats) and a control spring wheat variety. The chosen varieties, both long season and spring wheats were selected as the most agronomically appropriate varieties for the trial locations.

In-crop assessments were taken during the growing season which included NDVI readings, plant counts, tissue and soil tests, grain yield and grain quality sampling completed via a CBH analysis. All demonstration sites were managed as a commercial crop. All inputs were recorded plus operations to allow a gross margin and return calculation to be generated.

Albany Port Zone

		Plot Number									
Year	**Location**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2020	**Murradup**	Nighthawk	Nighthawk 160 kg/Ha	Scepter	Accroc	Nighthawk	Nighthawk 160 kg/Ha	Illabo	Scepter	Accroc	Illabo

Figure 1 – 2020 Albany Port Zone trial design

		Plot Number									
Year	**Location**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2021	**West Muradup**	Scepter	Catapault	Denison	Illabo	Accroc	Illabo	Catapault	Scepter	Accroc	Denison
2021	**Muradup**	Illabo	Denison	Illabo	Catapault	Accrock	Accrock	Accrock	Denison	Zanzibar	Catapault

Figure 2 - 2021 Albany Port Zone trial design

Kwinana South East Port Zone

Year	Location	Plot Number 1	2	3	4	5	6	7	8	9	10	11	12
2020	Corrigin	Scepter	Longsword	Catapault	Denison	Scepter	Catapault	Longsword	Denison	Scepter	Catapault	Denison	Longsword
2020	Kurrenkutten	Yitpi	Longsword	Catapault	Denison	Yitpi	Catapault	Longsword	Denison	Yitpi	Catapault	Denison	Longsword

Figure 3 – 2020 Kwinana South East Port Zone trial design

Year	Location	Plot Number 1	2	3	4	5	6	7	8	9	10	11	12
2021	Kurrenkutten	Yitpi	Vixen	Rockstar	Denison	Yitpi	Rockstar	Vixen	Denison	Yitpi	Rockstar	Denison	Vixen
2021	Mt Walker	Kinsei	Scepter	Rockstar	Denison	Kinsei	Rockstar	Scepter	Denison	Kinsei	Rockstar	Denison	Scepter

Figure 4 – 2021 Kwinana South East Port Zone trial design

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	-33.843119	115.757783
Nearest Town	Muradup	
Trial Site #2	-32.33383	117.87181
Nearest Town	Corrigin	
Trial Site #3	-32.3131	118.0647
Nearest Town	Kurrenkutten	
Trial Site #4	-33.5344	116.5740
Nearest Town	Muradup	
Trial Site #5	-33.89865	116.80532
Nearest Town	Muradup (West Muradup site)	
Trial Site #6	-32.339197	118.079314
Nearest Town	Kurrenkutten	
Trial Site #7	-32.034167	118.765972
Nearest Town	Mount Walker	

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	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☐ WA Sandplain

		☐ WA Mallee	

Results

Grain Yield Results – Albany Port Zone 2020 & 2021

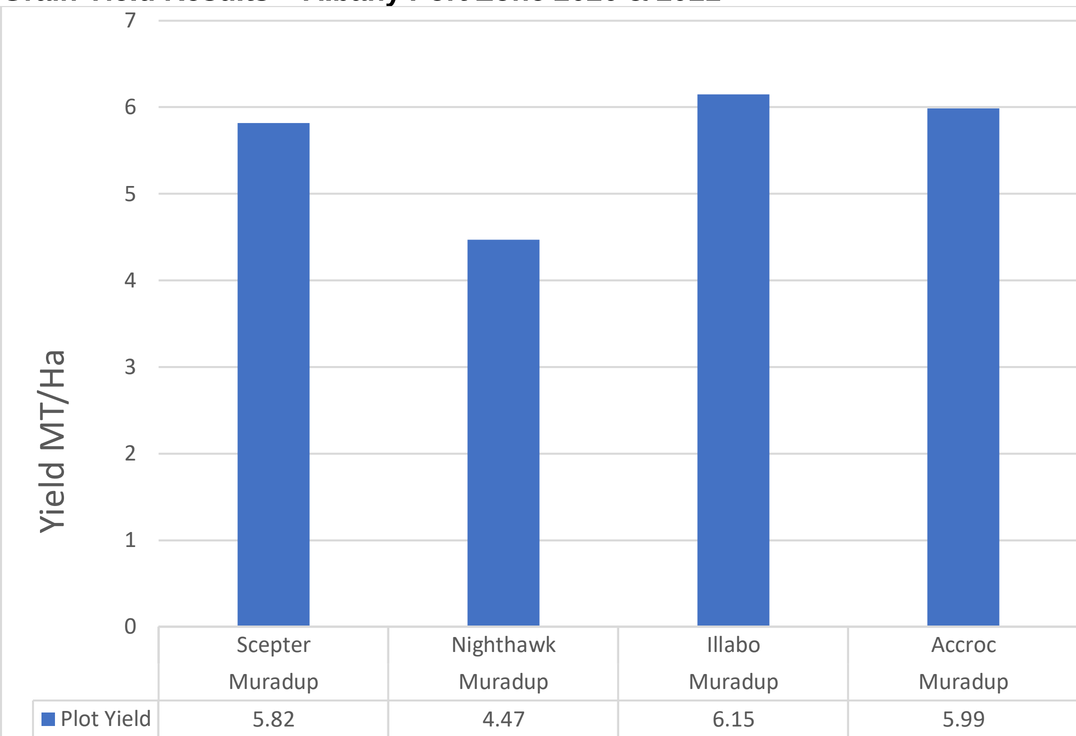


Chart 1: 2020 Wheat Yields Albany Port Zone

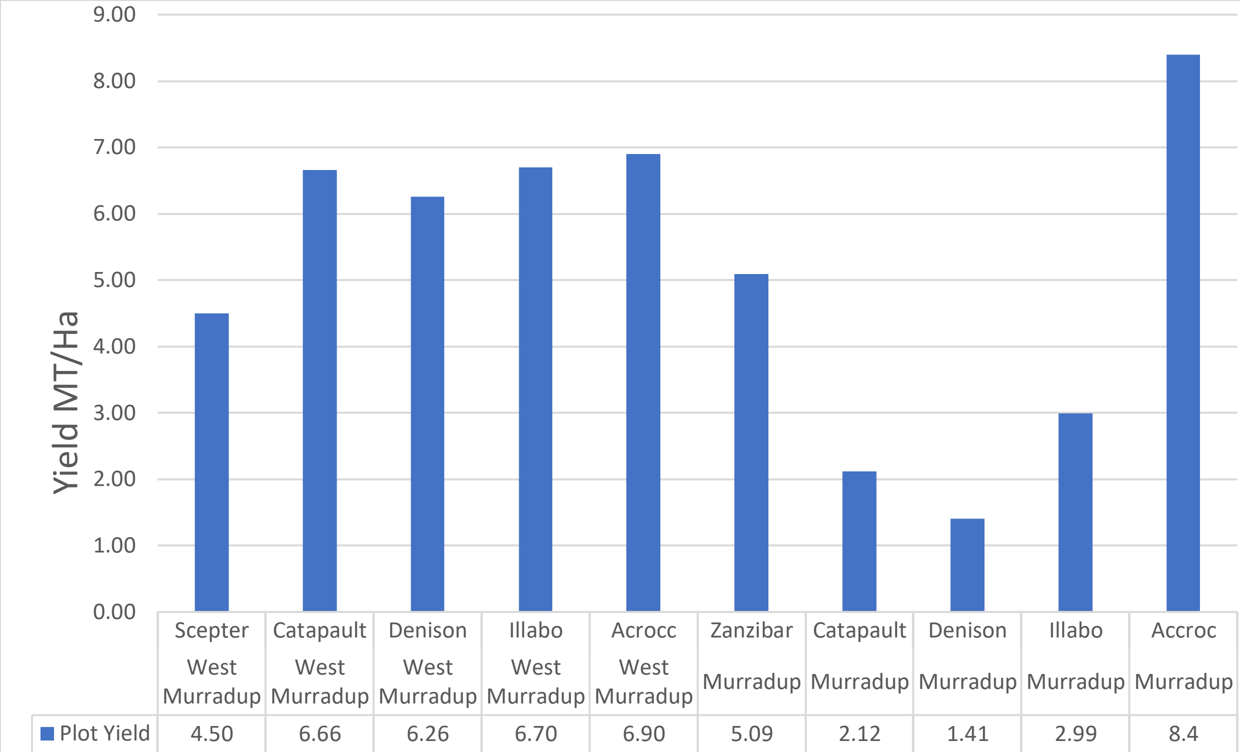


Chart 2: 2021 Wheat Yields Albany Port Zone

Crop Grazing Results – Albany Port Zone 2021

The demonstration and surrounding paddock was grazed by 1,600 ewe hoggets when the wheat was between the Zaddock growth stage, GS22 – GS24. The total area of paddock was 80 Ha giving an average DSE rate of 20 DSE/Ha. The hoggets entered the paddock on the 14th June and exited on the 16th July. Grazing cages (1m x 1m) were erected within each of the demonstration plots to measure the impact of the grazing on the final yield. The caged control areas were hand harvested to measure yield. To calculate the results the average of the ungrazed area was compared to the average of the grazed areas. As can be seen in Chart 4 the grazed area yield 99.6% of the ungrazed area.

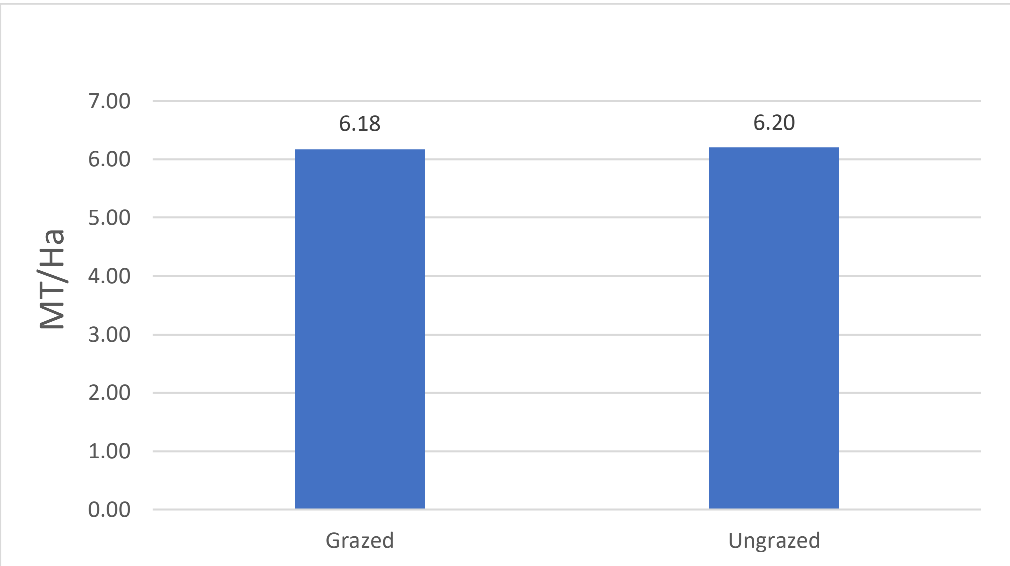


Chart 3: West Muradup 2021 Wheat Yields from Crop Grazing Trial

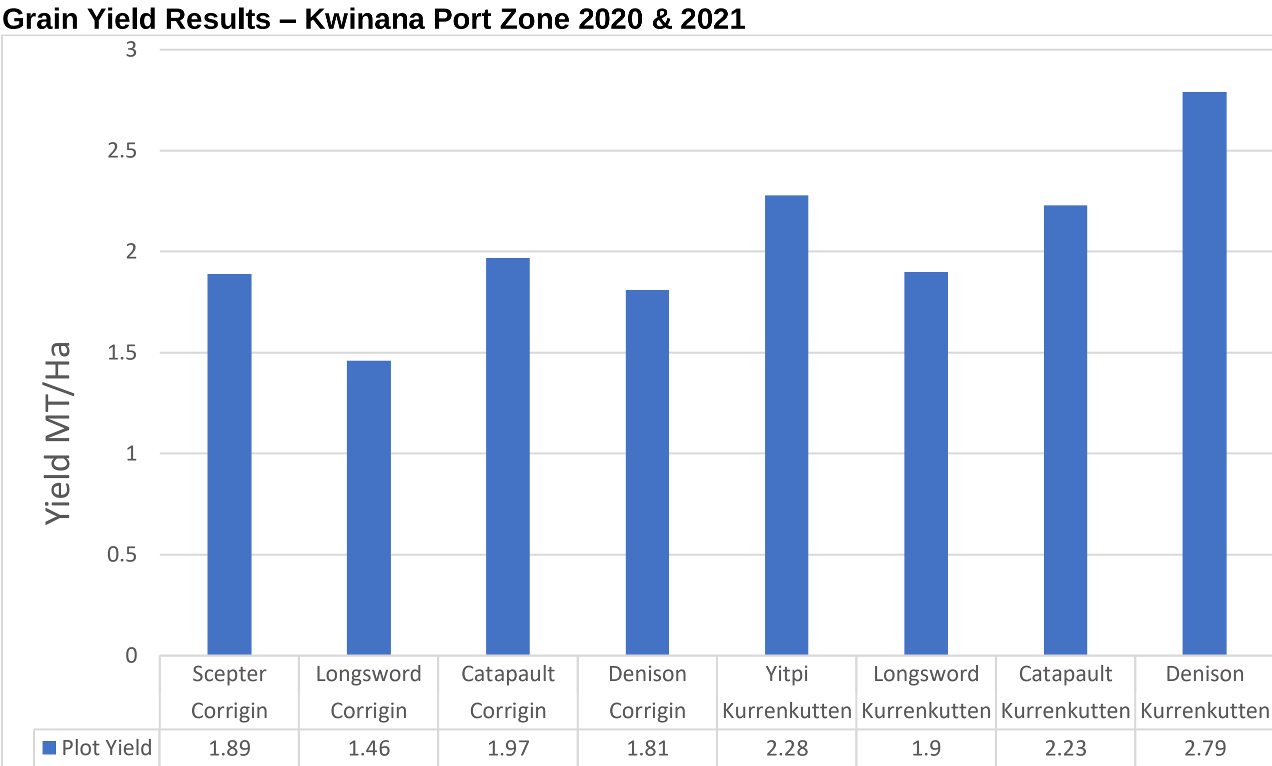


Chart 4: 2020 Wheat Yields Kwinana South East Port Zone

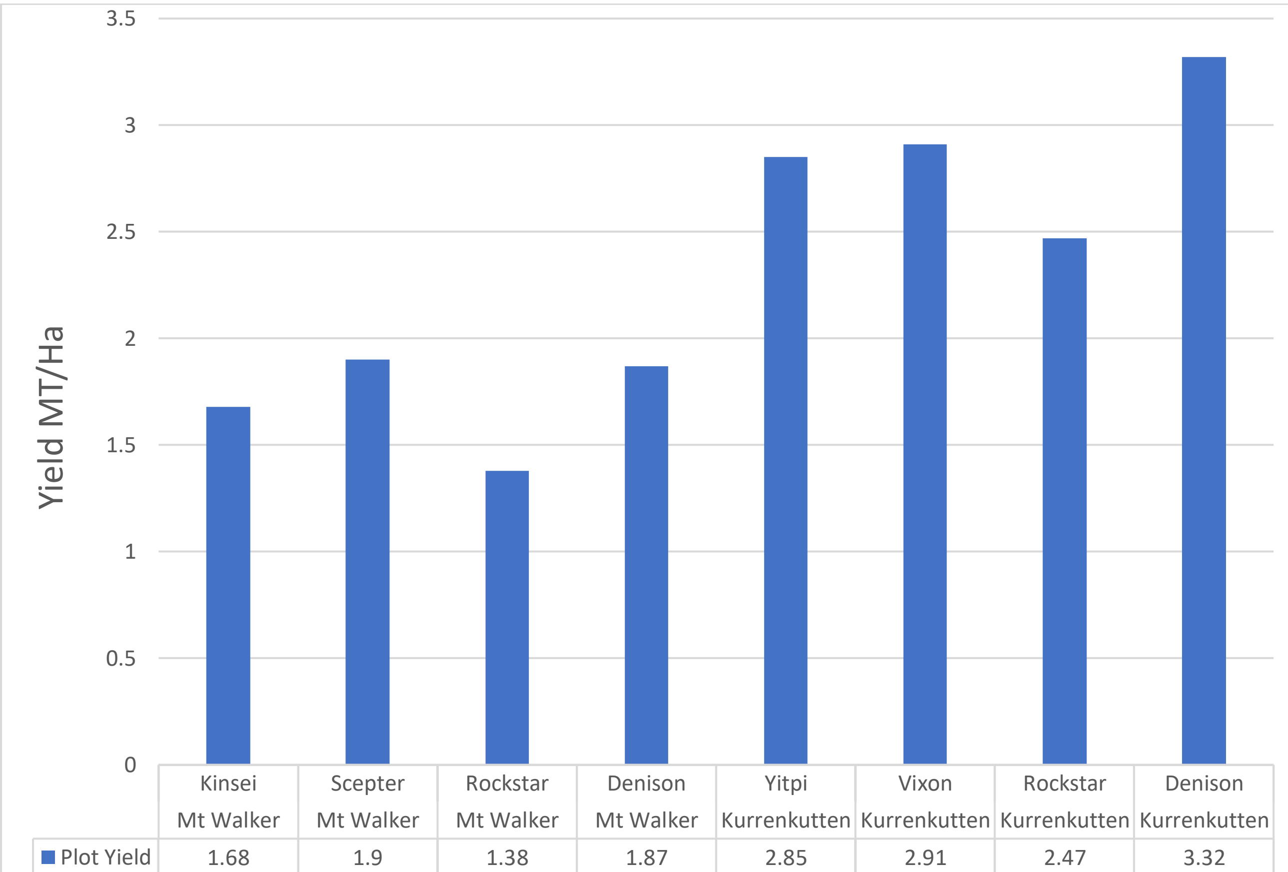


Chart 5: 2021 Kwinana Wheat Yields South East Port Zone

Results for other in-crop assessments such as NDVI readings, plant counts, tissue and soil tests, grain yield and grain quality sampling are available from Southern Dirt on request. The grain harvest results have been presented only as these are most impactful for growers.

Economic Returns - Gross Proceeds

Economic returns have only been examined as a gross proceeds per hectare as each plot within each trial was treated equally therefore the input or production costs are the same within each trial. Grain qualities at the Albany sites were not measured. Grain quality for the Kwinana sites was measured. All the varieties averaged ASW1 except for Kinsei which was ANW2. An average harvest wheat price of $320/ton FIS was used to generate the gross proceeds per varieties per hectare.

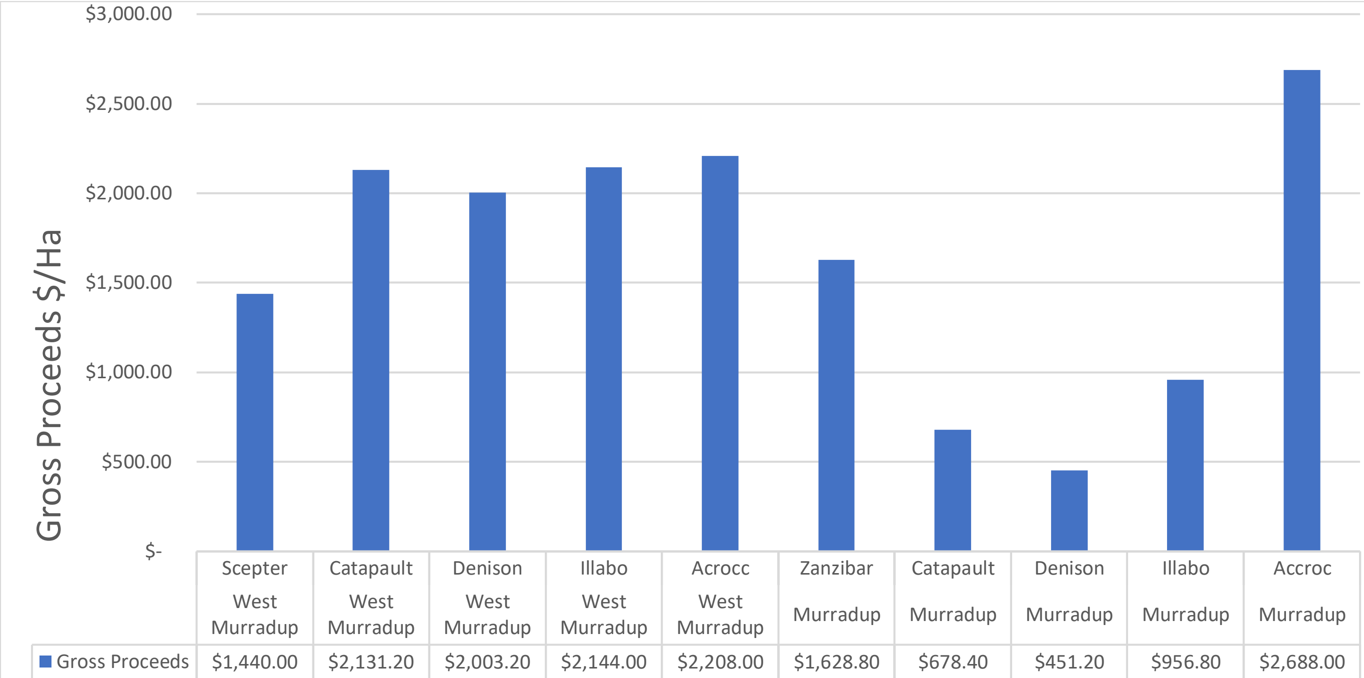


Chart 6: 2021 Gross Proceeds per hectare Albany Port Zone

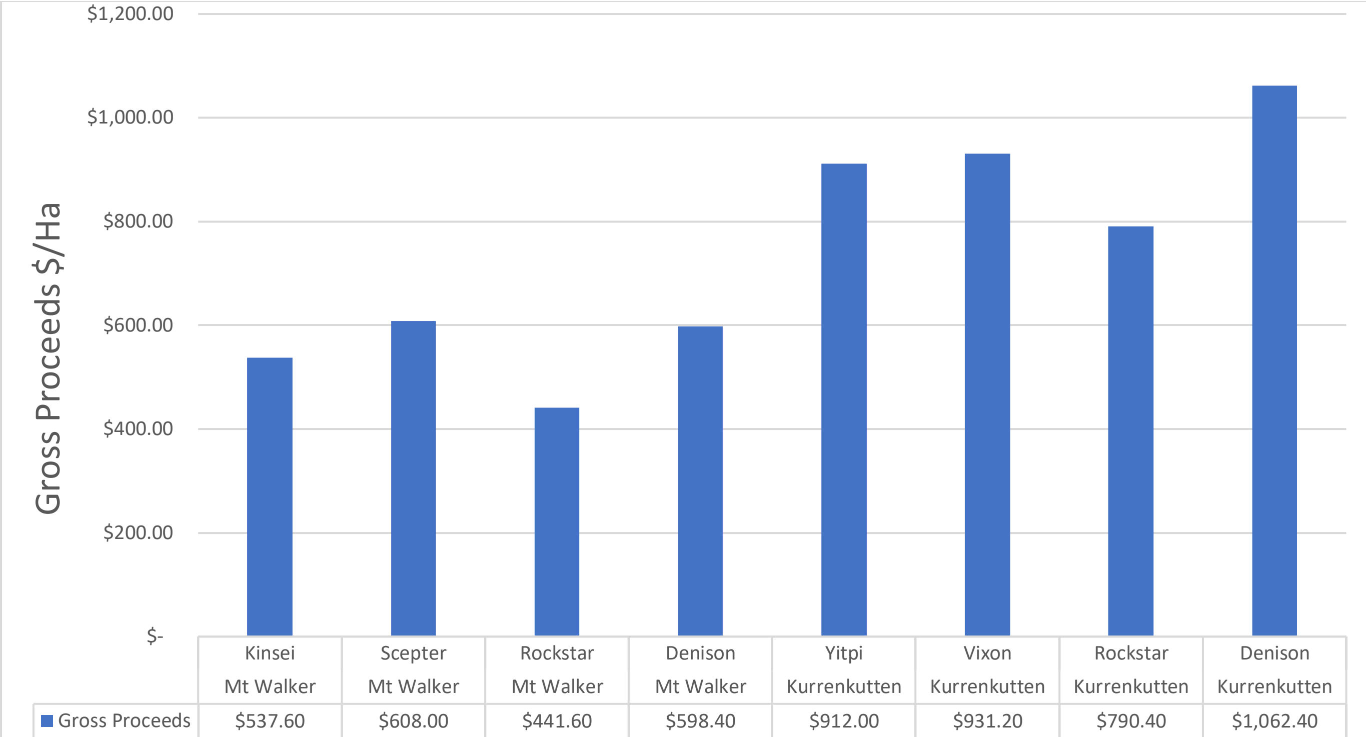


Chart 7: 2021 Kwinana Gross Proceeds per hectare South East Port Zone

Discussion of Results

The seven long season wheat demonstrations were conducted across two seasons over 2 different regions within WA. Muradup lies on the Western region of the high rainfall zone and the Great Southern and the Corrigin/Mt Walker trials lie in the middle of the medium rainfall regions in the wheatbelt of WA. Muradup's mean long term rainfall is 540mm and Corrigin's mean long term rainfall is 371.5mm.

Due to these environmental differences the data generated from each region will be analysed separately as the varieties that are suitable to Corrigin will generally not be the best variety for Muradup.

Albany Port Zone

Illabo was the highest yielding variety in the 2020 Muradup trial followed by Accroc then Scepter and Nighthawk. While the yield differences between the first three varieties was not significant it is reassuring that the long season winter wheat were able to match the high yielding spring variety despite the late seeding date of 26th of May. Nighthawk (a very slow spring wheatt) yielded significantly lower than the other three varieties and does not appear to be an optimal variety for the Muradup region.

In 2021, Accroc was the highest yielding variety across both demonstrations. Accroc yielded 8.40 tons/Ha at the Muradup site which was affected by frost impacting all the other varieties. The 2021 season was ideal for growing long season wheats with both demonstrations sown in April and late March. The long season wheats were the highest yielding varieties across both sites and Accroc demonstrated the yield potential of these varieties when the seasonal opportunities present.

Overall, the demonstration at Muradup/West Muradup shows there is a fit for these varieties in the rotation in the high rainfall zones of the Great Southern. The long season wheats were the highest yielding varieties in all three trials with both an early and a late break to the season. The long season wheats appear to have the ability to yield similarly to the best spring wheats in a late break and can considerably outyield these types of wheat on an early break.

Corrigin, Kurrenkutten and Mt Walker

The four sites in the Corrigin region had the same 3 long season varieties with the different spring wheat controls the only difference. Yitpi and Scepter are both popular wheat varieties in the area.

In 2020 at the Corrigin site Catapult was the highest yielding variety followed by Scepter then Denison with Longsword yielding significantly lower than the other three varieties. The trial was sown in the preferred window for long season wheat on the 15th of April. The average yield across the 4 varieties of 1.78 MT/Ha was also impacted by the heavy ryegrass and barley grass competition across the trial site. Despite the weed burden the yields are encouraging for the potential of these varieties and the fit for early sowing wheat when there are early sowing seasonal opportunities.

In 2020 at the Kurrenkutten site Denison yielded significantly higher than the other three varieties achieving a yield of 2.79 MT/Ha. Yitpi was the next highest yielding variety followed by Catapult and then Longsword, the lowest yielding variety at both sites. The time of sowing was inside the preferred sowing window for the long season varieties. Similarly, to the Corrigin site the varieties were sown at different seeding rates and at this site on different dates.

2021 was a much better season for growing wheat than 2020 with Kurrenkutten receiving 368 mm for the year and 299.5 mm for the growing season (Apr – Oct). The yields reflected the better growing season at Kurrenkutten. Denison was the highest yielding variety at 3.32 ton/Ha followed by Vixon, Yitpi and finally Rockstar. The varieties were sown into their preferred sowing window and the season allowed them to yield to their potential. Mt Walker lies east of Kurrenkutten receiving less rainfall which showed in the yields. Scepter was the highest yielding variety followed by Denison, Kinsei and finally Rockstar. This site demonstrates that long season wheats may not be suited to the low rainfall areas even in better seasons.

Similarly to the conclusions drawn from the Muradup site, three of the four demonstrations in the Corrigin region showed there is a fit for longer season wheats in the medium rainfall zones when the seasonal conditions present themselves. The best longer season wheat varieties suited to this region from this project are Denison and Catapult which are both longer season spring wheats. The longer season spring wheat appears to be the preferred type of longer season wheat for this area over true winter wheats. Early sown long season varieties can out yield the current best performing spring wheats and perform very well on limited growing season rainfall, particularly in cooler regions. Further work is still required on the overall agronomic package to extract the full yield potential from these types of wheat.

Economic Analysis

The results from the project help to demonstrate the fit and ability of long season wheats to generate extra income for producers which is particular evident in better seasons. Long season wheats in the 2021 demonstration sites in the Albany Port zone produced up to $2,688/Ha (Accroc) well above the standard spring wheat variety which was frost effected and only able to generate $678/Ha (Catapult).

Determining the full economic benefit of grazing long season wheat crops to the overall farm operation is beyond the scope of this project, however it is worth noting the economic results from the grazing demonstration conducted at the West Muradup site. The yield cost of grazing the wheat crop in June/July was 20 kg/Ha or $6.40/Ha. The sheep enterprise was able to graze the crop for 32 days at 20 DSE. The economic benefit of this grazing to the overall operations can be determined through either increased sheep numbers as the overall carrying capacity has improved or increased cropping area with the same sheep numbers. It is worth noting that the demonstration was carried out in a good season which allowed the crop to be early sown and established early enough in the season to start grazing on the 14th of June. Grazing the crops early in the growing season is important to minimise the impact on final yield.

Similar economic results were evident in the demonstrations in the south east Kwinana zone although not as pronounced. At the 2021 Kurrenkutten site Denison generated gross proceeds of $1062/Ha compared to the standard spring wheat producing $931/Ha (Vixon).

Overall the results from the demonstration have shown that the longer season type of wheats have a place in the rotation for growers in areas with longer growing seasons and give producers the ability to increase total revenues and capture more of the production potential of longer growing seasons. This result was particularly evident in better seasons, like 2021, with an early break and softer finish.

Conclusion

The primary objective of this project was to demonstrate to growers the agronomic and enterprise fit and associated benefits of including a long season wheat into their rotation and to encourage the adoption through the farmer scale demonstrations and economic analysis.

The outcomes from the demonstrations have met the primary objectives of the project demonstrating the fit for growing long season wheat in the current rotation in the medium to high rainfall zones. Long season wheat varieties have the ability to outperform the current spring wheat varieties in both early and late break scenarios (particularly in cooler climates). This gives growers the confidence to plant these types of wheat across a range of dates and dry sown if required, reducing the need to hold multiple varieties.

The fact that Accroc was not affected by frost at the Muradup site in 2021 should also give producers a level of confidence that long season wheats can avoid the impact of frost in some scenarios. Further work is required to better understand why Accroc was not impacted by frost as Ilabo (the other true winter wheat in the trial) was.

While the project primarily focused on comparing the yields of long season and spring wheat varieties, the demonstrations did highlight areas that require further work (see section below).

There was some minor varietal inconsistency however in the high rainfall zone Accroc was the highest yielding variety closely followed by Illabo. In the medium rainfall zone Denison was the highest yielding variety with Catapult appearing to be the next best option however this variety wasn't in the 2021 demonstrations.

The economic results from the demonstration have shown that the longer season type of wheats have a place in the rotation for growers in areas with longer growing seasons and give producers the ability to increase total revenues and capture more of the production potential of longer growing seasons. This result was particularly evident in better seasons, like 2021, with an early break and softer finish.

Growers in the medium to high rainfall zones can take a great deal of confidence around bringing in long season wheats into their rotations. Long season wheats can be utilized in conjunction with spring wheats to add more flexibility to growers rotations and increase the seeding windows allowing more hectares to be covered by each machine. Additionally when seasonal conditions are suitable, early established long season wheats are well suited to grazing with minimal impact of final yield.

Implications

There are two main implications from the project:

1) Long season wheats have a fit in the cropping rotation of growers in the medium to high rainfall zones in the southern regions of Western Australia. Prior to this project many growers were starting to use these types of wheat and the uptake of these wheats can be expected to increase in the coming years.
    a. The benefits to adding long season wheat to a rotation include:
        i. Longer sowing window
        ii. Reduced frost risk
        iii. Higher yield potential in particular on early breaks
        iv. Grazing opportunities on early established crops

2) The second implication is around the importance of better understanding the full yield potential of long season wheats in the high rainfall zone when the season breaks early and the crop can germinate in April. Accroc at Muradup in 2021 showed the potential of a long season wheat grown in a long season, yielding 8.40 ton/Ha. Is this type of yield achievable across a large area and is there further potential under a more developed agronomic package that matches this yield potential?

Recommendations

Like all projects while the demonstration certainly met the key objectives it did also unveil some further questions which should be further explored by industry over the coming seasons.

1) Reduced frost risk – How do long season wheats reduce frost risk and can this be quantified. Accroc yielded 8.40 ton/Ha at the demonstration at Muradup in 2021, Zanzibar 5.09 ton/Ha and the remaining three varieties all under 3.00 ton/Ha. The key driver for the poor yields was frost damage. There is a need to better understand the ability of long season wheat to withstand frost events which will enable growers to better plan their farm rotations.

   Additionally future work is required to compare the ability of long season wheat to withstand frost in comparison to other cereal varieties such as oats and barley.

2) The project has helped give growers the confidence to bring long season wheats into the rotation, however there still remains further work to develop a specific agronomic package around long season wheats especially in the case of an early break to enable producers to really optimize the yield potential.

3) Demonstration plot sites are generally selected to be in the premium soil type within the paddock and yields are therefore higher than what can be achieved across the paddock or as general farm averages. Better understanding the yields of long season wheats across large areas will better determine the financial impact to growers who adopt the addition into their rotation and at what level it should be integrated.

4) Defining marketing and supply chain options should also be examined and extended to producers to ensure growers who produce a long season wheat understand their options at harvest.

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

DAFWA	Department of Agriculture and Food, Western Australia
DAP	di ammonium phosphate
DArT	Diversity Arrays Technology
DAT	days after treatment
Db	bulk density
DAFWA	Department of Agriculture and Food, Western Australia

References

This section provides the information a reader would need to locate the articles, journals, and/or other publications referred to in the report.

Social Media Posting

Refer to ‘GRDC Long Season Wheat Communication and Extension Plan’.

Producer Demonstration Site

Annual / Progress report

Date: 10 Jan 2022

Group name: Southern Dirt62

PDS project code: L.PDS.1904
Milestone #: 6
Facilitator name: Daniel Hester/Adele Scarfone
Phone: 0434 644 881
Email: danielhester@pedaga.com.au

<table>
<tr><td colspan="3">Is your project on track to achieve its objectives? Yes / No. If not, why not and how will you adjust the project to achieve the objectives?
Yes</td></tr>
<tr><td>Number of core producers engaged currently (please make a note if this number has changed)

5 core producers</td><td>Number of observer producers involved to date (if known)

16 observer producers</td><td>Number of unique demonstration sites

4 producer demonstration sites</td></tr>
<tr><td>Location of sites in year 1

1 site completed
- Kojonup District High School
2 sites deferred due to seasonal condition
- Geoff Kowald
- Alisdiar Staniforth-Smith</td><td>Location of sites in year 2

3 sites completed
- Jeremy Kowald
o Katanning
- Ben Webb
o Kojonup
- Rod Hester
o Bridgetown</td><td>Location of sites in year 3</td></tr>
</table>

<table>
<tr><td>Achievement criteria for this milestone as per your contract (please copy criteria from your contract).

The milestone requirements are as follows:

• Annual Report
• MER report
• Case Study 2 written and approved by MLA and published in Southern Dirt newsletter/website</td><td>Report your progress against each criteria for the period

0) Annual Report
Completed and submitted 10 January 2022

0) MER Report
Completed and submitted 10 January 2022</td></tr>
</table>

3 x on farm event delivered field walks/workshop - Data results collated and analysed Communications delivered as per plan	0) **Case Study 2** Completed and submitted 22 December 2021 0) **3 x on farm event delivered field walks/workshops** 1 x field walk/field day completed on 10th October 2021. 0) **Data results collated and analysed** Completed and submitted 5th January 2022 **Communications delivery** The project was communicated to the producers in the region through several channels as outlined below: - Only 1 of the 3 field days/field walks was completed in 2021. - The case study on dual purpose crops was released to producers through the Southern Dirt web site. - The project was communicated through social media posts making up part of the communication plan - The projects results from 2020 were communicated to the Southern Dirt members through the web site and included in the annual trials booklet which is also released to all members.

Summary of key outputs and findings from project

PDS 1 – Ben Webb
Crop – Long season wheat

Sowing date – 5 May 2021

Growth stage – GS22 – GS24

Sheep – 1,600 ewe hoggets (1 DSE)

Area – 80 Ha

Stocking rate – 20 DSE / Ha

Entry – 14 June 2021

Exit – 16 July 2021

Controls

- Grazing cages erected in crop to measure ungrazed yield

Results

Photo 1: Grazed wheat on 11 November 2021

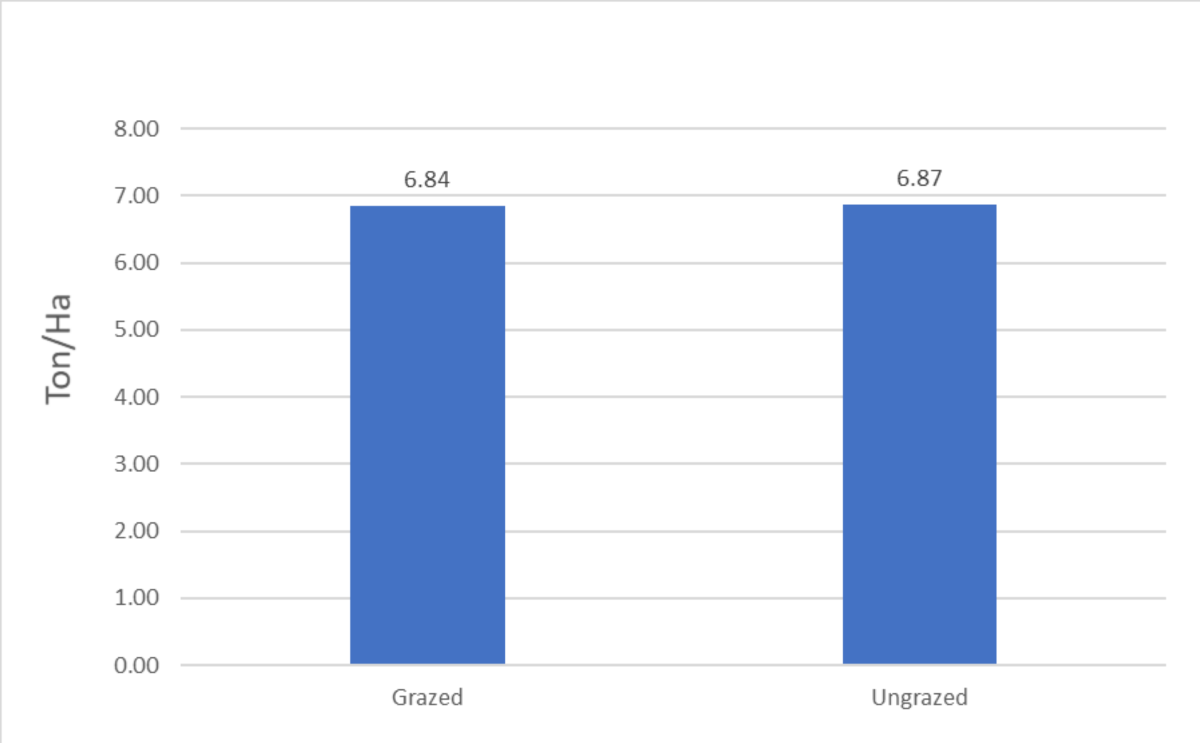


Chart 2: Final yields on wheat at West Muradup PDS site (P=NSD)

Key Findings:

- The grazing period was in line with best practice for this demonstration, June/July.
- The stocking rate of 20 DSE was below normal practice however this allowed for a longer grazing period of 32 days.
- The grazed wheat yielded 0.40% lower than the ungrazed wheat.
- The grazing of the hoggets allowed pasture to establish and increase FOO during the tight winter period of late June into July
- Early sowing is important to allow crop to establish itself to allow grazing in late June or early to mid July.

PDS 2 – Rodney Hester

Crop – Bannister Oats

Sowing Date – 27 May 2021

Growth stage – GS.22 – GS.24

Sheep – 136 Ewes and Lambs (1.3 DSE)

Area – 4.5 Ha

Stocking rate – 40 DSE / Ha

Entry – 12 August 2021

Exit – 21 August 2021

Controls

- Grazing cages erected in crop to measure ungrazed yield
- Pasture control paddock in place

Results

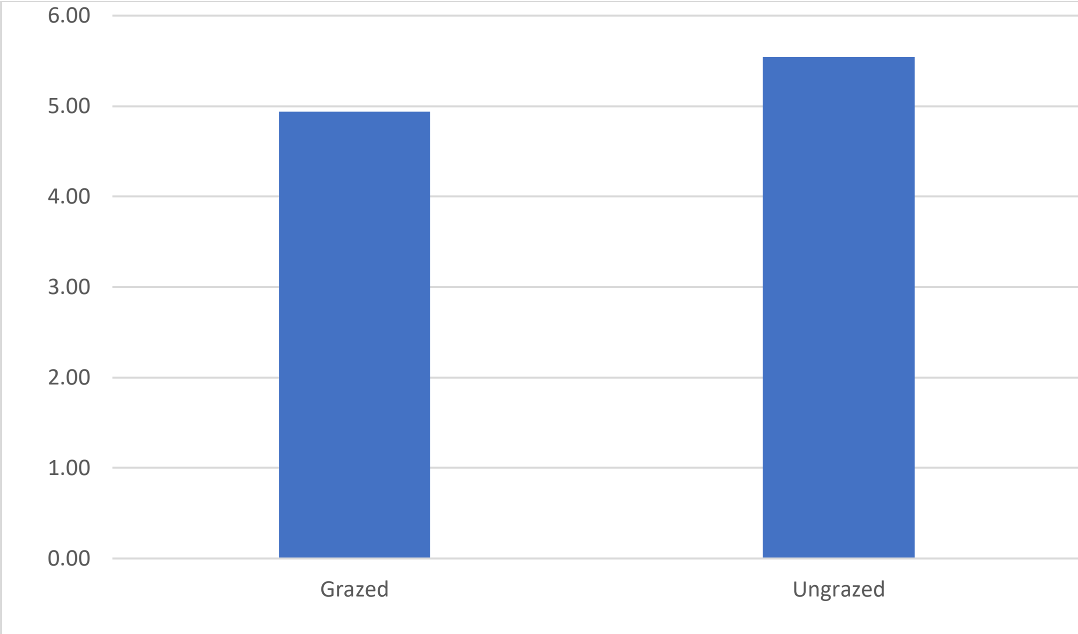


Chart 2: Final yields on Bannister oats at Bridgetown PDS site (P=NSD)

	Oats – grazed	**Oats – ungrazed**	**Pasture**
Pre-grazing – 12 August	0.564	0.564	0.728
Post Grazing – 21 August	0.54	0.677	0.748

Table 1: NDVI readings of oats and pasture

Pasture Growth:

12 August: Feed of Offer – 1,500 kg DM/Ha

21 August: Feed on Offer – 2,000 kg DM/Ha

Photo 2: Immediately post grazing with grazing cage removed

Key Findings:

- Yield reduction due to grazing of 10.85% or 4.94 MT/Ha vs 5.54 MT/Ha
- Grazing period was later than preferred which impacted the final yield difference
- By bringing the grazing period forward into July it is expected the impact on yield would be reduced to below 5%.
- Considerable improvement in Food on Offer in the pasture paddock was grown with an increase of 500 kg DM/Ha recorded over the grazing window.
- Sheep grazing were ewes and lambs and therefore no weight gain data was recorded
- Through crop grazing an increased area of crop can be planted within the total mixed farming operation while still maintaining the same livestock numbers.

PDS 3 – Jeremy Kowald

Crop – Moby Barley and Serradella

Sowing date – 27th May 2021

Growth stage – GS.23 – GS.25

Sheep – 68 ewe hoggets (1 DSE)

Area – 1.61 Ha

Stocking rate – 42 DSE /Ha

Entry – 13 August 2020

Exit – 20 August 2020

<u>Controls</u>

- Paddock divided into 2 with one half grazed and the other ungrazed
- Pasture control paddock in place

Results

Ewe Hogget weight gain:

48.9 kg average entry weight

50.0 kg average exit weight

0.157 kg average daily weight gain

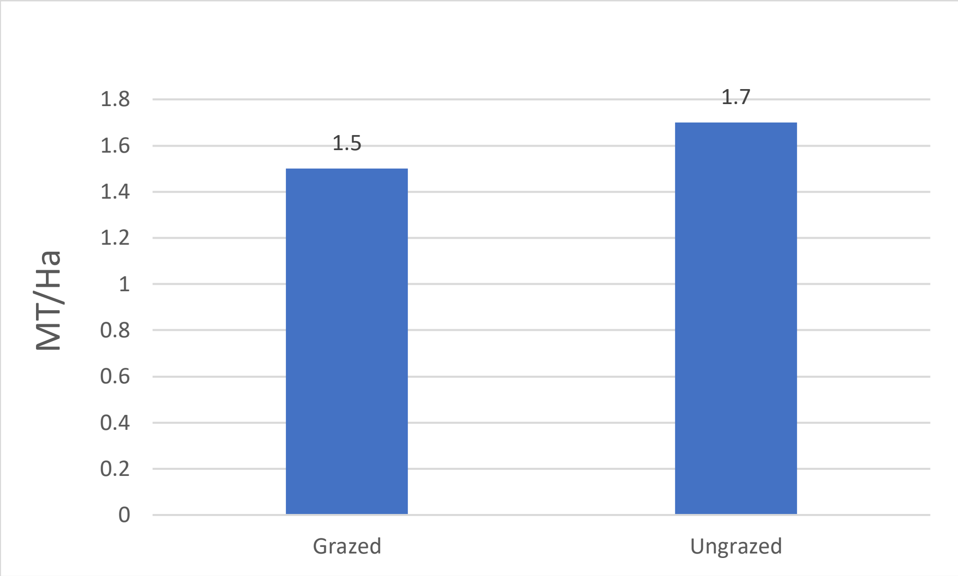


Chart 3: *Final yields on Moby Barley at West Katanning PDS site (P=NSD)*

Key Findings:

- Yield reduction due to grazing of 11.77% or 1.5 MT/Ha vs 1.7 MT/Ha
- Grazing period was later than preferred which impacted the final yield difference
- By bringing the grazing period forward into July it is expected the impact on yield would be reduced to below 5%.
- Ewe hogget achieved good weight gain of 157 grams/day while grazing the barley crop
- Later sown crops can result in later grazing period which will increase impact on final yield

Photo 3: Ewe hoggets pre grazing ready to weigh

Communication and extension activities

Activities have included:

- Extension through social media posts, example below
- Outcomes and results written up in Southern Dirt annual results report and delivered to growers plus on website
- PDS site included in Southern Dirt Annual Field Day/field walk.
- In depth article completed in September and promoted on website.

Photo 2: Field walk held on the 10th of October to promote the benefits of Dual Purpose crops

Screen shot 1: Example of social media promotion around the dual purpose crop

- **Producer surveys**

Pre project core and observer surveys were completed in 2019 and submitted with milestone 2 report. Post surveys to be completed at the end of the project

- **Adoption / impact**
-
- Adoption and impact of the project will be evaluated at the conclusion of the project via the post project survey's.

What is to be done in the next six months?

In the next 6 months the following activities are to be completed:

- Go / No Go decision teleconference to be held with MLA, National PDS co-ordinator and Southern Dirt representatives
- 1 x in depth article completed
- Meeting with core group members prior to implementation of trial work
- 3 sites selected and grazed during the correct period and at preferred stocking rates
- All data recorded around the grazing period and uploaded to the Master Schedule.
- Interim report to be submitted August 2022.
- **Please advise if there are any changes to method, sequence of activities or budget. Are there any risks or issues that need to be addressed?**
- No all activities are unchanged from the projects current methodology

Is your monitoring, evaluation, and reporting (MER) plan being fully implemented? Please provide a summary of the key findings below. (Please submit a copy of you MER plan with a column on the right-hand side which lists progress against each item.)

The monitoring, evaluation and reporting plan has been fully implemented as per the MER report which has been attached alongside the submission of this milestone report.

The key findings from year 2 are:

- Daily weight gain in ewe hoggets of 157 grams/day
- Pasture Food on Offer average growth of 55 kilograms/day or 500 kilograms/Ha in 9 days
- Crop yield penalty of between 0.4% to 11.77%
- Early sowing allowing earlier grazing window (June/July) resulted in minimal yield impact of 0.4%
- Later grazing, mid August, resulted in higher yield impact of 11.77% and 10.85%

The data to be generated this year is on target to be inline with the projects outcomes around demonstrating the benefits of integrating dual purpose crops into mixed farming systems which include minimal yield penalty from grazing, improved weight gain on lambs or hoggets, increased farm carrying capacity, reduced supplementary feeding and a more detailed benefit costs analysis.

Include 100+ words and hyperlinks to any articles summarising the progress of your PDS towards its objectives for inclusion on the MLA website and sharing with SALRC, NABRC &

WALRC or other communication activities. Please include who is managing the project and where it is operating.

Southern Dirt in collaboration with MLA have been operating the project, 'Increasing profit with dual purpose crops', since 2020. The aim of this project is to demonstrate the benefits of dual purpose crops in a mixed farming enterprise. The project is being conducted through a series of nine producer demonstration sites covering the Great Southern region of Western Australia through to 2023.

In 2021 the three crops grazed were Barley, Wheat and Oats. The key findings were the crop yield penalty ranged between 0.4% to 11.77% and this variation was driven by the grazing window. Two of the sites were grazed in mid-August and had yield penalties of 11.77% and 10.85% compared to the demonstration with the sheep removed in mid-July had a yield penalty of 0.4%.

At the Katanning site the daily weight gain of ewe hoggets grazing Moby Barley was 157 g/day and at the Bridgetown site the pasture being rested from grazing improved from 1500 kilograms/Ha to 2000 kilograms/Ha over the 9 day grazing period. Finally grazing DSE's/Ha across the three demonstrations were from 20, 40 and 42 DSE/Ha. The lower DSE of 20 allowed for a much longer grazing period of 32 days compared to the other two site which could only grazed for 7 and 9 days at the higher stocking rate.

Producer Demonstration Site
Annual / Progress report

Date: 27 March 2022

Group name: Southern Dirt

PDS project code: L.PDS. 2006 Alternative Fodder Crops for Turning Off Weaner Lambs/Hoggets
Milestone #: 5
Facilitator name: Daniel Hester/Adele Scarfone
Phone: 0434 644 881
Email: danielhester@pedaga.com.au

<table>
<tr><td colspan="6">Is your project on track to achieve its objectives? Yes / No. If not, why not and how will you adjust the project to achieve the objectives?
Yes</td></tr>
<tr><td colspan="2">Number of core producers engaged currently (please make a note if this number has changed)

6 core producers</td><td colspan="2">Number of observer producers involved to date (if known)

13 observer producers</td><td colspan="2">Number of unique demonstration sites

8 Producer Demonstration Sites</td></tr>
<tr><td colspan="2">Location of sites in year 1
1 site completed
- Andrew Scanlon (Quailerup/Wagin)</td><td colspan="2">Location of sites in year 2
3 sites completed
- Andrew Scalon
  ○ Wagin
- Narrogin Ag College
  ○ Narrogin
- Ben Webb
  ○ Kulikup</td><td colspan="2">Location of sites in year 3
4 sites in progress
- Emily Stretch
  ○ Kojonup
- Ben Webb
  ○ Kulikup
- Rob Edgerton Warberton
  ○ Franklin River
- Scott Newbey
  ○ Broomehill</td></tr>
<tr><td colspan="3">Achievement criteria for this milestone as per your contract (please copy criteria from your contract).

Annual Report
• MER report
• Summary of key activities or data over past 6 months
• Update against communication and wider engagement plan activities
• Year 2 project results.
• Year 2 on-farm event completed, results reported</td><td colspan="3">Report your progress against each criteria for the period

1) <u>MER report:</u>
Completed and submitted March 2022
2) <u>Summary of key activities or data over past 6 months:</u>
See section below on key outputs and findings
3) <u>Update against communications plan:</u></td></tr>
</table>

• Year 3 Sites selected	Up to date against communication plan social media posts, in depth article completed and extended and annual report released through Southern Dirt annual trials book. 4) Update of key activities: 3 sites completed in 2021, crops finished and grazed over the summer. Entry and exit lamb weights recorded and results collated and summarized. 4 sites for 2022 selected. 5) Year 2 project results: See section below on Key outputs and findings. 6) Year 3 sites selected: 4 sites for 2022 selected.

Key outputs and findings from the project:

PDS 1 – Wagin
Crop – Lupins

Stocking rate – 31.84 lambs per Ha or 17.74 DSE/Ha

Entry Date: 10 November 2021

Exit Date: 16 – 4 March 2022

Days on feed – 126 days

Sheep type – Merino ewe and ram lambs

Control – 2020 Lupin Crop (higher stocking rates 48 lams/ha)

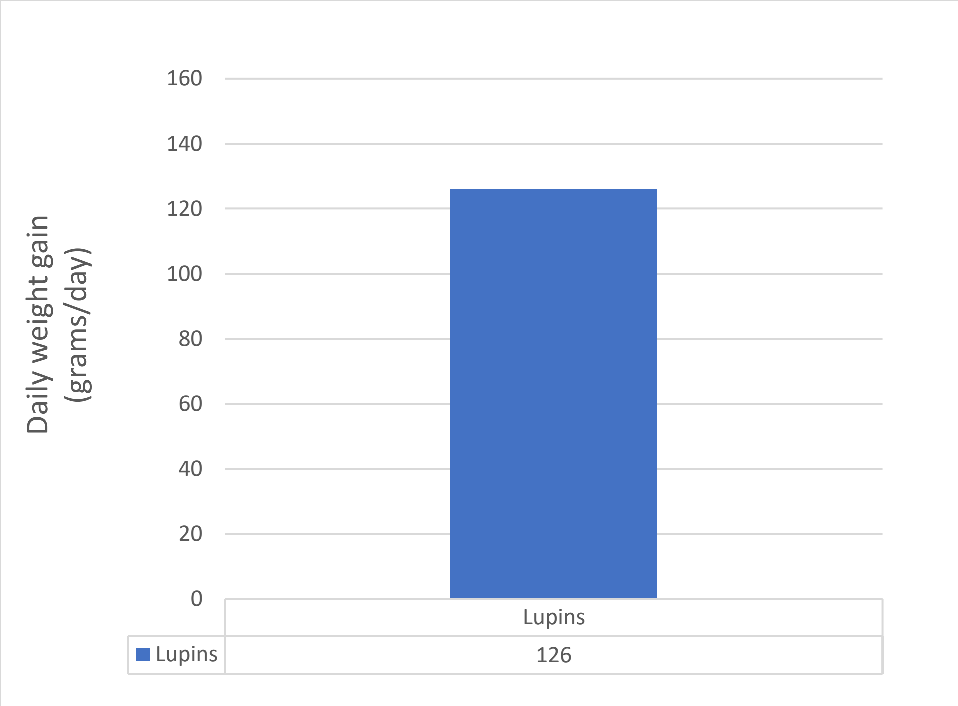


Chart 1: Average daily weight gain of Merino Ewe and Ram Lambs on a lupin fodder crop

Key Findings:

- 32 lambs or 18 DSE/Ha stocking rate allowed the lambs to be held in the paddock for the entire summer and maintain a good daily weight gain of 126 grams/day
- Over the 2020 – 2021 summer the stocking rate was 48 lambs/Ha or 25 DSE/Ha which saw the lambs gain an average 84 grams/day.
- In addition to the reduced weight gain the higher stocking rate in 2020/21 saw the water being fouled due to the higher stocking density and the lambs being removed for a period to allow the water to recover.
- The key finding from this demonstration site is that stocking rates on fodder crops are very important to enable
    - Longevity of the grazing period within the paddock
    - Maintaining good weight gains over the summer period
    - Allowing the water to remain clean over long periods and to not be fouled due to the high stocking pressure.

PDS 2 – Narrogin Ag College

Crop 1 – Tetraploid ryegrasses/Balanse clover/Persian clover/Yannicun sub clover

- Heavy lambs starting average weight 44.50 kg
- 98 head on 2 Ha

Crop 2 – Crop 2 + Serradella

- Medium lambs starting average weight 39.15 kg
- 107 head on 2 Ha

Crop 3 – Bannister Oats/Diploid ryegrass mix

- Light lambs starting average weight 33.50 kg
- 64 head on 2 Ha

Controls - Oat/Ryegrass crop

The mob of lambs were drafted into three weight groups, heavy medium and light and each weight group then put onto the different fodder crops. The lambs each had electronic tags for tracking individual weight gains.

Stocking rate – between 32 - 53 lambs per Ha

Entry Date: 25 October 2021

Exit Date: 16 November 2021

Days on feed – 22 days

Sheep type – Crossbred lambs

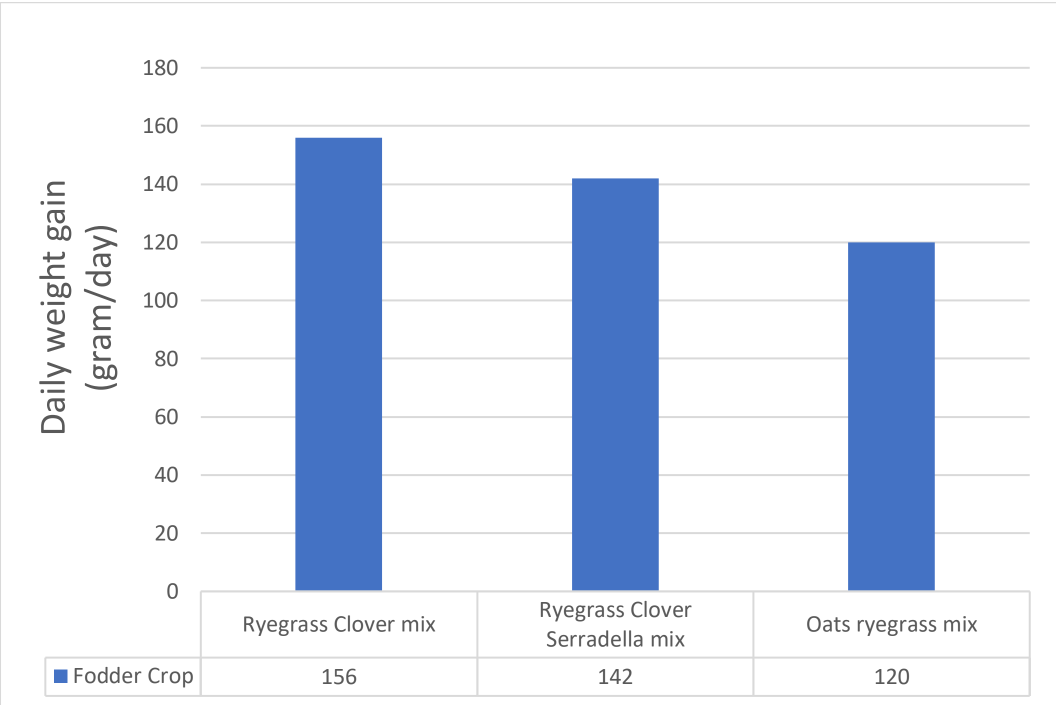


Chart 2: Average daily weight gain of Crossbred Lambs across the 3 types of fodder crops

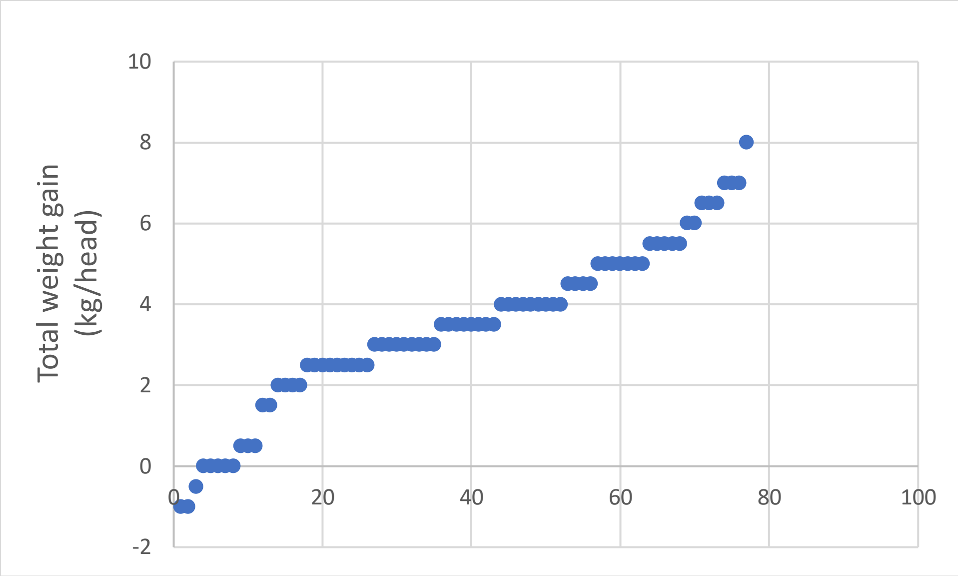


Chart 3: Individual total weight gain for the lambs grazing the Ryegrass/clover mix.

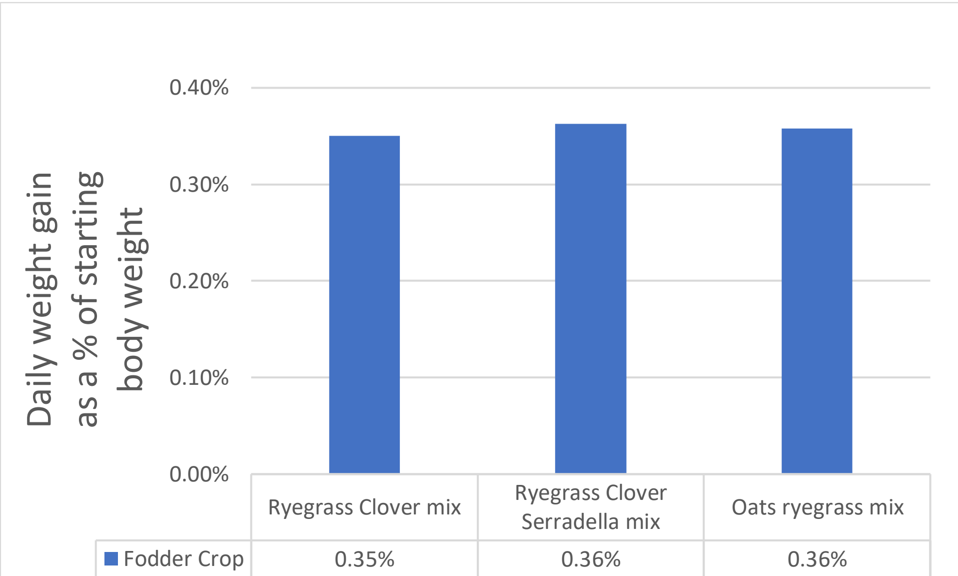


Chart 4: Average daily weight gain as a % of body weight of Crossbred Lambs across the 3 types of fodder crops

Key Findings:

- Daily weight gains across the fodder crops were between 120 to 156 grams/head/day.
- The highest daily weight gain of 156 grams/day was on the Ryegrass/clover mix. However these lambs were the heaviest starting weight.
- Due to the lambs being drafted into weight ranges the best method to compare weight gains is as a percent of body weight (Chart 4).
- There was no difference in weight gain as a percent of body weight between the different fodder crops.
- The short grazing period may have impacted realizing the true weight gain potential of the individual fodder crops as the lambs adjusted to the change in feed source.

- Additionally, the similarity between the fodder mixes reduced the potential to see a weight gain difference between the fodder crops.
- Chart 3 shows individual lambs total weight gain over the 22 day grazing period, generating an inverse S curve in line with expectation.

Note short grazing period due to lambs being sold prior to students finishing for end of school year.

PDS 3 – Franklin River

Crop 1 – Clover

Crop 2 – Oats

Sheep – Merino lambs

PDS incomplete due to excessive rainfall over seeding and the crops were not able to be planted

PDS 4 – Kulikup

Crop 1 – Oats/Turnip/Vetch/Clover

Crop 2 – Lupins

Crop 3 – Pasture then lupins stubble with Sorghum

Controls - Pasture

Stocking rate – 54 ewe lambs per Ha or 28.3 DSE/Ha

Entry Date: 5 December 2021

Exit Date: 16 – 17 February 2022

Days on feed – 73/74 days

Sheep type – Merino ewe lambs

Results

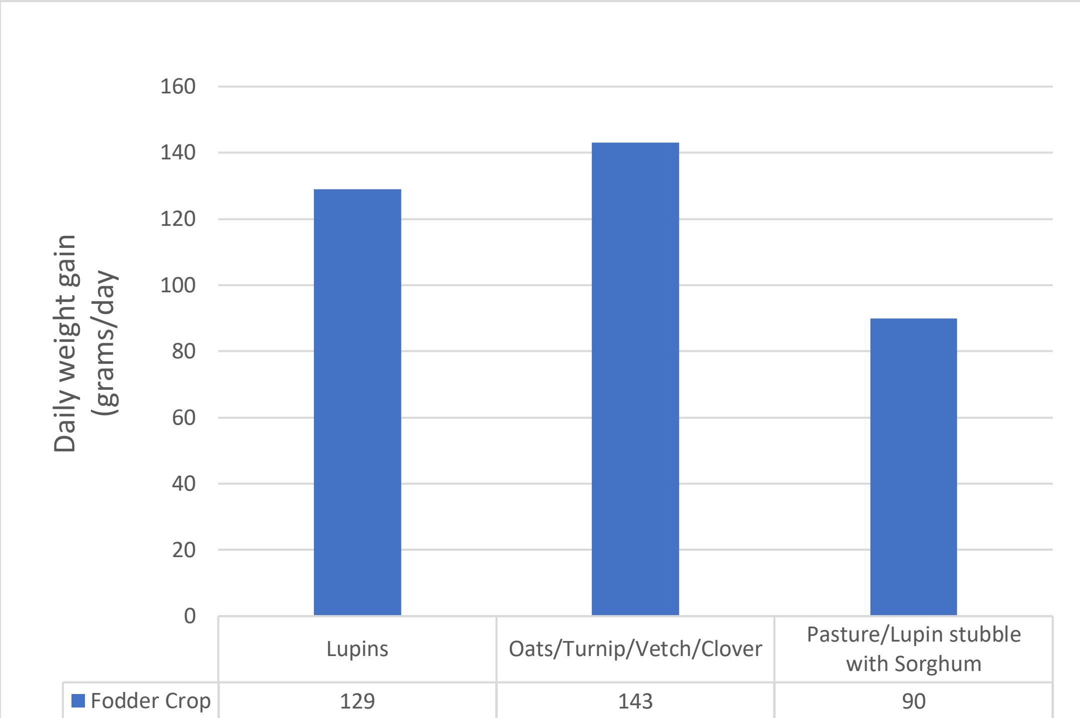
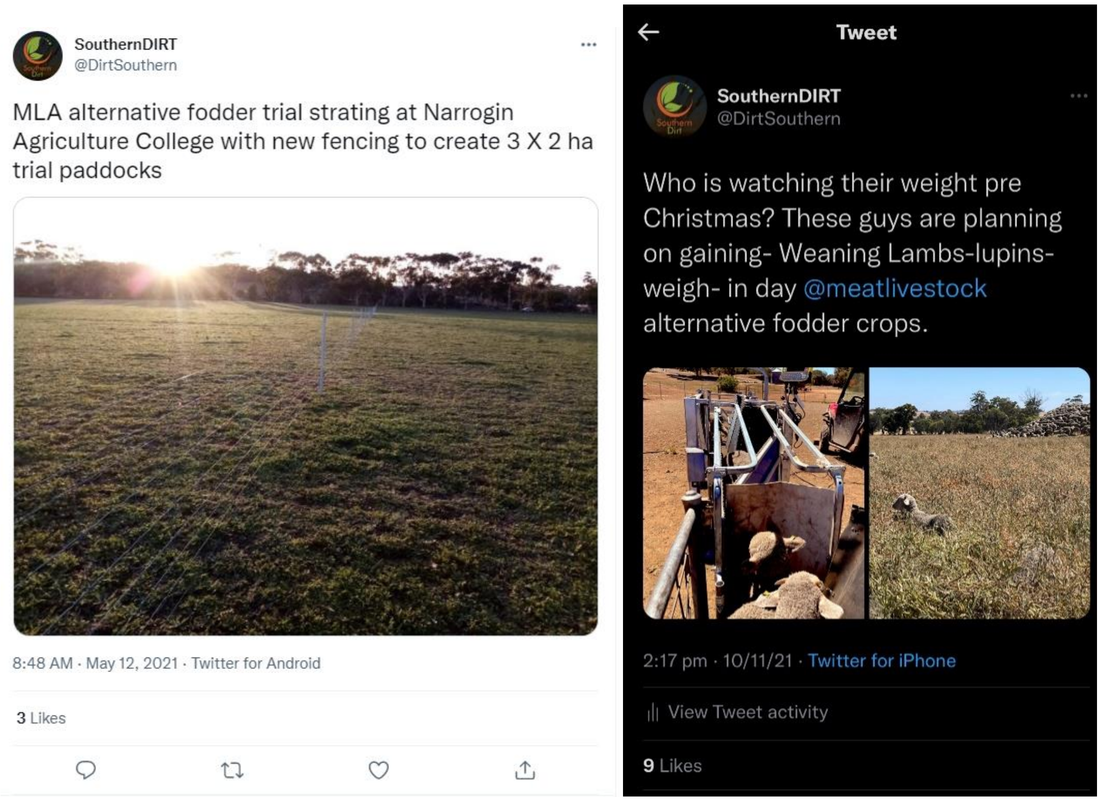


Chart 3: Average daily weight gain of Merino Ewe Lambs across the 3 types of fodder crops

Key Findings:

- The Oats/Turnip/Vetch/Clover fodder crop produced the best daily weight gain of 143 grams/day in Merino ewe lambs over 73 days. This mix outperformed the standing lupin crop of 129 grams/day and was well ahead of the Pasture/Lupin stubble with sorghum at 90 grams/day.
- The weight gain of merino lambs on standing lupin fodder crops at Wagin and Kulikup were within 3 grams/head/day of each site (126 and 129g/day).
- Further work is required to determine the benefit of Turnip as a fodder crop for carrying lambs over summer.

- **Communication and extension activities**
- Extension through social media posts, example below
- 2020 outcomes and results written up in Southern Dirt annual results report and delivered to growers plus on website: https://southerndirt.com.au/wp-content/uploads/2020-Research-Annual.pdf
- 2021 outcomes and results to be reported through Southern Dirt extension channels.
- PDS site included in Southern Dirt Annual Field Day/field walk on the 10th of October 2021. It was attended by 13 People which included industry representatives and growers
- In depth article completed in October 2021 and promoted on website.



Screen shot 1: Example of social media promotion around the alternative fodder crops

- **Producer surveys**

Pre project core and observer surveys were completed in 2020 and submitted with milestone 2 report. Post surveys to be completed at the end of the project

- **Adoption / impact**

Adoption and impact of the project will be evaluated at the conclusion of the project via the post project survey's.

What is to be done in the next six months?

In the next 6 months the following activities are to be completed:

- Go / No Go decision teleconference to be held with MLA, National PDS co-ordinator and Southern Dirt representatives held by the 9th April
- Case study 3 and in depth article completed
- Meet with core group members prior to implementation of trial work
- All relevant data recorded around the around the fodder crops and uploaded to the Master Schedule.
- Interim report to be submitted September 2022.
- **Please advise if there are any changes to method, sequence of activities or budget. Are there any risks or issues that need to be addressed?**
- There are no changes to methods currently expected within the demonstration

Is your monitoring, evaluation and reporting (MER) plan being fully implemented? Please provide a summary of the key findings below. (Please submit a copy of you MER plan with a column on the right-hand side which lists progress against each item.)

The monitoring, evaluation and reporting plan has been fully implemented as per the MER report which has been attached alongside the submission of this milestone report.

The key findings from year 2 are:

- By reducing the stocking rate on the lupin fodder crop at Wagin the Merino lambs increased there daily weight gain year on year from 84 grams/day to 126 grams/day and were able to stay on the fodder crop for the entire summer.
- The Oats/Turnip/Vetch/Clover fodder crop mix produced the best daily weight gain across all the demonstration sites of 143 grams/day in Merino ewe lambs over 73 days.
- The weight gain of merino lambs on standing lupin fodder crops at Wagin and Kulikup were within 3 grams/head/day of each site (126 and 129g/day).
- Further work is required to determine the benefit of Turnip as a fodder crop for carrying lambs over summer.
- The oats/ryegrass mix only generated a daily weight gain of 120 g/day in 33.50 kg crossbred lambs.

The data generated this year is in line with the projects outcomes around demonstrating the benefits

of shifting away from oat fodder crops and into alternatives which are legume based. The daily weight gains achieved over summer in legume-based fodder crops continue to be ahead of oat based fodder crops while maintaining carrying capacity and longevity. The demonstration work will continue to explore alternative fodder crops into it third and final year over the summer of 2022/23.

Include 100+ words and hyperlinks to any articles summarising the progress of your PDS towards its objectives for inclusion on the MLA website and sharing with SALRC, NABRC & WALRC or other communication activities. Please include who is managing the project and where it is operating.

Southern Dirt in WA in collaboration with the MLA have been operating the Producer Demonstration Site (PDS) project, 'Alternative Fodder Crops for Turning Off Weaner Lambs/Hogget's', since the start of 2020. The aim of this project is to demonstrate an economical alternative fodder crop system to standing oats, to increase weight gain in weaner lambs/hogget's, to reduce reliance on live shipping and to provide alternative livestock management systems to increase profitability by targeting markets.

The project is being conducted through a series of eight producer demonstration sites covering the Great Southern region of Western Australia. One site was completed in Wagin in 2020 and three sites were completed in Wagin, Kojonup and Narrogin over 2021. Four sites are on track to be completed over 2022.

A wide range of fodder crops were in the demonstration over 2021 including a range of legumes and oat grass fodder mixes. The Oats/Turnip/Vetch/Clover fodder crop mix produced the best daily weight gain across all the demonstration sites of 143 grams/day in Merino ewe lambs over 73 days. By reducing the stocking rate on the lupin fodder crop at Wagin over the second year the Merino lambs increased their daily weight gain year on year from 84 grams/day to 126 grams/day and were able to graze the fodder crop for the entire summer. The weight gain of merino lambs on standing lupin fodder crops at Wagin and Kulikup were within 3 grams/head/day of each site (126 and 129g/day). Further work is required to determine the benefit of Turnip as a fodder crop for carrying lambs over summer. The oats/ryegrass mix was the poorest performing fodder crop only generating a daily weight gain of 120 g/day in 33.50 kg crossbred lambs.

The four 2022 sites will be in Broomhill, Kojonup, Kulikup and Franklin River and will include a wide range of alternative fodder crop incorporating the findings from the first two seasons of the project. The results will include daily growth rates, wool production, morality, days equivalent grazing and cost benefit analysis with the outcomes reported in March 2023

Compost extracts impacts on soil carbon and microbial activity and crop yield

Prepared by: Daniel Hester

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Date published: 10 December 2021

Project Background

Farming – takes up half of the world's habitable land, accounts for 10% of our annual GHG emissions and can have severe long-term implications for biodiversity, ecosystem services, and food security. However the potential to convert agricultural land into carbon sinks is considerable. Globally, soil organic matter contains nearly 4 times as much carbon as either the atmosphere or terrestrial vegetation.

There are many benefits of building more carbon into our soils through techniques called regenerative farming – whether it's cutting concentrations of CO2 in the atmosphere, boosting food security, creating resilience against changing weather patterns or halting biodiversity loss. Regenerative agriculture is helping farmers to redesign the farming system to work together with nature, instead of against it.

One of the first steps in improving soil health and to increase soil organic matter and carbon which is central to regenerative agriculture is to shift away from synthetic fertilisers across to natural fertilisers. By using natural fertilisers the soil biome is enhanced which increases soil organic carbon and builds new soil. Humate levels increase, improving the soil's ability to absorb and hold water, reducing the toxic effect of residual amounts of herbicides and retaining more nutrients.

Typical natural fertilizers include mineral sources, all animal waste including meat processing, manure, slurry, and guano, plant based fertilizers, such as compost, and biosolids.

This project is the first step in the greater process of shifting to regenerative agriculture. It will examine the ability and help develop the strategy for grain growers to transition from synthetic fertilisers to natural fertilisers while maintaining production and profitability.

Project Objectives

The key objective of the project is to reduce barriers to adoption of natural fertiliser inputs in broadacre farming through a trial demonstrating a proposed 'transitional' methodology of conventional to biological fertilisers at time of seeding. This will be completed by examining the impacts on soil microbial activity, organic carbon and yield plus the requirement for herbicide/pesticide application through the application of different compost extracts, synthetic fertilisers and a combination of both.

The key outcome that is being explored through this project ‘can we transition from conventional agriculture to regenerative practices using biological inputs while still maintaining a productive farm enterprise?’

• Set up an agricultural multi-plot trial in order to:

• Provide technical knowledge in how to transition to Regen Ag practices using ‘30% rule’ with Compost Extract as the biological component.

• Provide quantitative evidence of Regen Ag practices being successful within low rainfall zones.

• Run a field day to review:

• application techniques and results

• advice for transitioning, and

• seek input on next steps and future trials of Regen Ag inputs.

Look at the changes to production outcomes from variation to nutrient inputs including:

• Changes to soil microbes,

• Organic carbon levels

• Requirements for herbicide/pesticides application

Questions to address from trial

1. Which product / combination produces best yield?

2. Which product / combination produces best profit?

3. Which product / combination produces best soil / plant health?

Methodology

The first hypothesis of the trial is to test if fertiliser usage can be transitioned across from conventional synthetic fertilisers to the use of biological inputs while maintaining a farming operation of similar productivity.

The hypothesis was tested in a replicated trial in West Broomehill by growing a Scepter wheat crop treated with the following fertiliser regimes:

- Best practice conventional fertiliser
- High rates of conventional fertiliser
- Low rates of conventional fertiliser
- Three types of biological inputs each at 2 different rates
- Combination of conventional fertilisers at high and low rates with 30% of the biological inputs.

The methodology was comprised of 15 treatments over 3 replications which were developed to test the hypothesis as outlined in table 1.

The trial was sown on the 7th of June 2021 to Scepter wheat at a sowing rate of 91.2kg/Ha. Herbicide, Insecticide and Fungicides were applied within best district practices and the crop was kept weed, pathogen free. Due to the very wet conditions experienced in 2021 and the late sowing there were periods of water logging experienced through the eastern end of the plots. For this reason some on the plots were reduced by 2 meters to be 8 meters long.

The three types of biological inputs are detailed below:

Biological input 1: Liquid Wormcasting (Natural Soil Conditioner)

Liquid worm castings are a natural product made from worm castings. A single controlled feed source is utilised that allows for constant growth of the worms as well as a consistent nutrient content in the worm castings, which is then liquefied. The wormcasting liquid can be applied directly (recommended in very poor-quality soils with no bacterial life) or diluted in a ratio of up to 1:5. The recommended application rate is between 20L and 40L per hectare, depending on soil condition and density of the crop.

Biological input 2: Verigrow

Verigrow is an innovative all-purpose fertiliser and soil improver made using 100% Australian low grade wool. Wool is a sustainable and rich source of amino acids (more than 75% of wool is made of amino acids). Verigrow contains an organic (from amino acids) and an inorganic source of nitrogen (12% w/v total N). The inorganic nitrogen provides an immediate source of nitrogen while the organic nitrogen provides a slow release and longer lasting effect. The recommended application rate is 10L/Ha

Biological input 3: Nutri-Tech Solutions

The Nutri-Tech solutions biological input is comprised of four products which include Gyp-Life Organic plus NTS Fulvic Acid Powder plus Tri-Kelp plus Nuri-Life BAM. The products combine cutting edge technology with proven biological essentials to maximise productivity, crop quality and profitability.

Soil Testing

The second hypothesis being tested in the project is to test that by applying biological inputs with and without synthetic fertilisers that there will an improvement in organic carbon levels and improvements in soil microbes. A further hypothesis being explored is that any improvement in organic carbon and soil microbes may translate into a reduction in the need for herbicides and/or pesticides as the plants health is improved and the natural defences are able resist damage from insects and overcome weeds.

The methodology to test this hypothesis is being completed by conducting a detailed baseline soil test across the trial site before the crop and treatments are implemented and then retesting the individual plots for each of the treatments to assess any changes in the soil parameters. The soil parameters being tested are:

1) pH (h20)

2) Microbial Biomass C (MBC) (mg/kg)

Microbial biomass carbon is a measure of the carbon (C) contained within the living component of soil organic matter (i.e. bacteria and fungi). Microbes decompose soil organic matter releasing carbon dioxide and plant available nutrients.

3) Microbial Biomass N (MBN) (mg/kg)

The microbial biomass consists mostly of bacteria and fungi, which decompose crop residues and organic matter in soil. This process releases nutrients, such as nitrogen (N), into the soil that are available for plant uptake. About half the microbial biomass is located in the surface 10 cm of a soil profile and most of the nutrient release also occurs here (figure 1). Generally, up to 5 % of the total organic carbon and N in soil is in the microbial biomass. When microorganisms die, these nutrients are released in forms that can be taken up by plants. The microbial biomass can be a significant source of N, and in Western Australia can hold 20 – 60 kg N/ha.

4) % Total Nitrogen

5) % Total Carbon

6) Dissolved Organic Carbon (microgram/gram soil

Dissolved organic carbon (DOC) is the fraction of organic carbon operationally defined as that which can pass through a filter with a pore size typically between 0.22 and 0.7 micrometers.[2] The fraction remaining on the filter is called particulate organic carbon (POC).

Reps: 3 **Plots: 1.8 by 12 meters**

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	Appl Date	Appl Description	Treatments Summary	Rep 1	2	3
1	Agstra Extra	100	kg/ha	A	7/06/2021	banded at seeding	Control normal conventional farming fert inputs	101	214	303
	NKS21	70	kg/ha	C	14/07/2021	4 - 5 leaf				
	Flexi-N	40	L/ha	D	3/08/2021	mid tillering				
2	Agstra Extra	140	kg/ha	A	7/06/2021	banded at seeding	High inputs conventional	102	210	309
	NKS21	100	kg/ha	C	14/07/2021	4 - 5 leaf				
	Flexi-N	40	L/ha	D	3/08/2021	mid tillering				
	Flexi-N	30	L/ha	E	23/08/2021	late tillering				
3	Agstra Extra	60	kg/ha	A	7/06/2021	banded at seeding	Low inputs conventional	103	202	310
	Urea	50	kg/ha	C	14/07/2021	4 - 5 leaf				
4	Liquid Wormcasting	20	L/ha	B	7/06/2021	liquid IF at seeding	Compost extract 1 rate 1	104	207	311
5	Liquid Wormcasting	40	L/ha	B	7/06/2021	liquid IF at seeding	Compost extract 1 rate 2	105	211	301
6	Verigrow	10	L/ha	B	7/06/2021	liquid IF at seeding	Compost extract 2 rate 1	106	205	315
7	Verigrow	20	L/ha	B	7/06/2021	liquid IF at seeding	Compost extract 2 rate 2	107	204	314
8	Gyp-Life Organic	3	L/ha	B	7/06/2021	liquid IF at seeding	Compost extract 3 rate 1	108	201	308
	NTS Fulvic Acid Powder	100	g/ha	B	7/06/2021	liquid IF at seeding				
	Tri-Kelp	100	g/ha	B	7/06/2021	liquid IF at seeding				
	Nuri-Life BAM	2	L/ha	B	7/06/2021	liquid IF at seeding				
9	Gyp-Life Organic	5	L/ha	B	7/06/2021	liquid IF at seeding	Compost extract 3 rate 2	109	208	304
	NTS Fulvic Acid Powder	200	g/ha	B	7/06/2021	liquid IF at seeding				
	Tri-Kelp	200	g/ha	B	7/06/2021	liquid IF at seeding				
	Nuri-Life BAM	3	L/ha	B	7/06/2021	liquid IF at seeding				
10	Agstra Extra	140	kg/ha	A	7/06/2021	banded at seeding	High input conventional +30% compost extract 1	110	215	312
	Liquid Wormcasting	6	L/ha	B	7/06/2021	liquid IF at seeding				
	NKS21	100	kg/ha	C	14/07/2021	4 - 5 leaf				
	Flexi-N	40	L/ha	D	3/08/2021	mid tillering				
	Flexi-N	30	L/ha	E	23/08/2021	late tillering				
11	Agstra Extra	60	kg/ha	A	7/06/2021	banded at seeding	Low input conventional + 30% compost extract 1	111	209	307
	Liquid Wormcasting	6	L/ha	B	7/06/2021	liquid IF at seeding				
	Urea	50	kg/ha	C	14/07/2021	4 - 5 leaf				
12	Agstra Extra	140	kg/ha	A	7/06/2021	banded at seeding	High input conventional + 30 % compost extract 2	112	203	313
	Verigrow	3	L/ha	B	7/06/2021	liquid IF at seeding				
	NKS21	100	kg/ha	C	14/07/2021	4 - 5 leaf				
	Flexi-N	40	L/ha	D	3/08/2021	mid tillering				
	Flexi-N	30	L/ha	E	23/08/2021	late tillering				
13	Agstra Extra	60	kg/ha	A	7/06/2021	banded at seeding	Low input conventional + 30% compost extract 2	113	212	302
	Verigrow	3	L/ha	B	7/06/2021	liquid IF at seeding				
	Urea	50	kg/ha	C	14/07/2021	4 - 5 leaf				
14	Agstra Extra	140	kg/ha	A	7/06/2021	banded at seeding	High input conventional + 30% compost extract 3	114	206	305
	Gyp-Life Organic	0.9	L/ha	B	7/06/2021	liquid IF at seeding				
	NTS Fulvic Acid Powder	30	g/ha	B	7/06/2021	liquid IF at seeding				
	Tri-Kelp	30	g/ha	B	7/06/2021	liquid IF at seeding				
	Nuri-Life BAM	0.6	L/ha	B	7/06/2021	liquid IF at seeding				
	NKS21	100	kg/ha	C	14/07/2021	4 - 5 leaf				
	Flexi-N	40	L/ha	D	3/08/2021	mid tillering				
	Flexi-N	30	L/ha	E	23/08/2021	late tillering				
15	Agstra Extra	60	kg/ha	A	7/06/2021	banded at seeding	Low input conventional + 30% compost extract 3	115	213	306
	Gyp-Life Organic	0.9	L/ha	B	7/06/2021	liquid IF at seeding				
	NTS Fulvic Acid Powder	30	g/ha	B	7/06/2021	liquid IF at seeding				
	Tri-Kelp	30	g/ha	B	7/06/2021	liquid IF at seeding				
	Nuri-Life BAM	0.6	L/ha	B	7/06/2021	liquid IF at seeding				
	Urea	50	kg/ha	C	14/07/2021	4 - 5 leaf				

Table 1: Summary of trial treatments

Results

The pre trial soil tests are outlined in table 1 and table 2. The soil samples for the soil nutrient analysis were taken on the 16th of April 2021 and the soil samples for the soil health and organic matter were taken on the 27th of April 2021 as detailed in Table 2.

Organic Carbon levels are very good in the top 10cm across the trial site averaging 3.04%. Microbial Biomass Carbon is however low in relation to the OC averaging 140.0 mg/kg indicating the micro biological activity that is attainable in the soil is well below potential.

		Site 1			Site 2			Site 3		
	Lattitude	33.78065496			33.78065496			33.78065		
	Longitude	117.7561865			117.7561865			117.7562		
	Depth	0 - 10	10 - 20	20 - 30	0 - 10	10 - 20	20 - 30	0 - 10	10 - 20	20 - 30
Colour		DKGR	GR	GR	BRBK	GR	GR	BR	DKBR	DKBR
Gravel	%	0	0	0	0	0	0	5	5 - 10	0
Texture		2.5	2.5	3	2.5	3	3.5	2	2.5	2.5
Ammonium Nitrogen	mg/kg	3	2	2	3	2	2	3	< 1	2
Nitrate Nitrogen	mg/kg	34	6	7	40	6	5	46	4	3
Phosphorus Colwell	mg/kg	33	5	7	65	6	5	80	36	14
Potassium Colwell mg/kg	mg/kg	200	135	155	180	338	146	125	63	69
Sulfur	mg/kg	23	11.9	9.3	27.1	5.4	21.9	43.2	10.5	12.5
Organic Carbon	%	2.97	0.93	0.85	3.41	1.09	0.6	2.75	1.1	0.59
Conductivity	dS/m	0.146	0.072	0.115	0.195	0.092	0.158	0.241	0.056	0.124
pH Level	(CaCl2)	5.2	5.8	6.3	5	6.1	5.6	4.9	4.5	4.6
DTPA Copper	mg/kg	2.26	3.05	3.19	2.09	2.4	2.37	1.23	1.07	1.52
DTPA Iron	mg/kg	102.3	47.5	39.2	211.8	50.1	90	207.3	246.4	133.9
DTPA Manganese	mg/kg	5.74	5.64	4.05	7.05	5.37	1.53	4.8	3.33	7.72
DTPA Zinc	mg/kg	2.52	0.49	0.63	4.95	0.47	0.54	4.33	1.37	0.55
PBI		58.5	65.6	75.2	78.9	72.8	65.3	76.3	79.4	62.7

Table 1: Pre-trial soil nutrient analysis results.

	Site A	Site B	Site C
pH(H2O)	5.2	5.0	4.9
Moisture %	6.3	7.7	6.4
Microbial biomass C (MBC) (mg/kg)	124.6	212.9	82.6
Microbial biomass N (MBN) (mg/kg)	82.5	140.9	54.6
%Total N	0.3	0.3	0.2
%Total C	4.0	3.3	3.0
Dissolved Organic C (microgram/g soil)	100.6	74.6	93.3

Table 2: Pre-trial soil health and organic matter results.

The post-trial soil samples were taken on the 10th of February 2022. Samples were taken from each individual plot and then combined before being sent away for testing. The soil health and organic matter results for each of the treatments are outlined below in Table 3.

There was very limited change across the treatments for % total N and % total C. There was however a considerable increase in Microbial Biomass C (MBC) and in Microbial Biomass N (MBN) between the baseline soil tests and the post trial/treatment soil test results. The average MBC increased from 140 to 903 and the average MBN increased from 93 to 597. These results were an average across all plots and not related to any individual treatment.

Plot	N [%]	C [%]	MBC (mg/kg)	MBN (mg/kg)
T1 control normal conventional farming fert inputs	0.247	3.45	1062.6	703.2
T2 high inputs conventional	0.236	3.26	866.0	573.1
T3 low inputs conventional	0.193	2.59	816.8	540.5
T4 compost extract 1 rate 1	0.226	2.87	1078.3	713.6
T5 compost extract 1 rate 2	0.216	2.90	808.5	535.1
T6 compost extract 2 rate 1	0.249	3.32	676.7	447.8
T7 compost extract 2 rate 2	0.213	3.06	775.0	512.8
T8 compost extract 3 rate 1	0.284	4.30	1179.0	780.2
T9 compost extract 3 rate 2	0.242	3.32	1287.0	851.7
T10 low input conventional + 30% compost extract 1	0.199	2.80	889.6	588.7
T11 high input conventional + 30% compost extract 1	0.217	3.17	798.6	528.5
T12 low input conventional + 30 % compost extract 2	0.230	3.18	707.4	468.1
T13 high input conventional + 30% compost extract 2	0.268	3.81	961.8	636.5
T14 low input conventional + 30% compost extract 3	0.254	3.75	944.3	624.9
T15 high input conventional + 30% compost extract 3	0.243	3.41	692.1	458.0

Table 3: Post trial soil health and organic matter results.

Plant counts and NDVI readings were taken on the 30th of July. There was no significant difference between any on the treatments. Plant counts were all inline with industry best practice to achieve full yield potential.

The NDVI readings (Figure 2) taken at the 7 week stage of the crop mirrors very closely to the final yield figure.

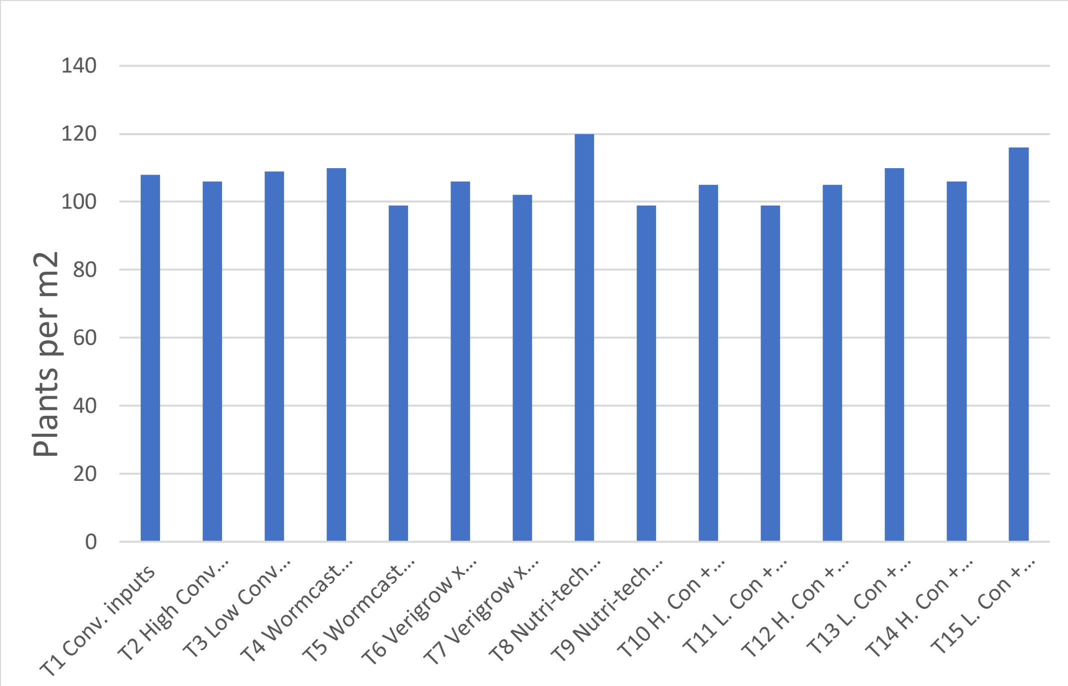

Figure 1: Landcare trial plant numbers per square meter (P=NSD)

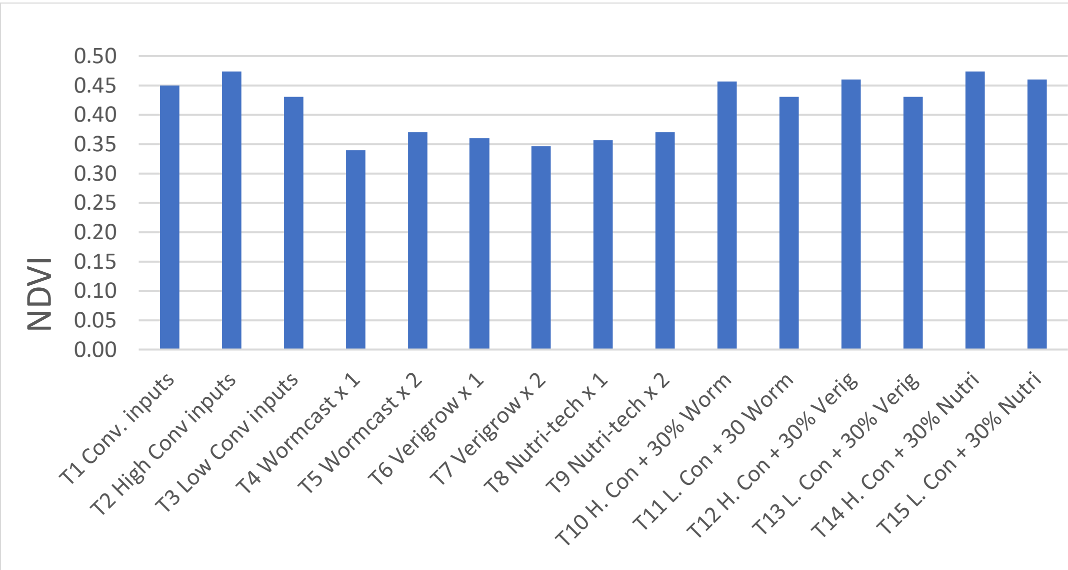

Figure 2: Landcare trial NDVI readings at 30 July 2021(P=NSD)

The trial was harvested on the 21st of December 2021. Figure 3 outlines the average yields across the different treatments. The High inputs conventional had the highest yield at 7.58 MT/Ha closely followed by the high input conventional + 30% compost extract at 7.33 MT/Ha.

The three straight biological inputs treatments, both high and low (treatments 4 – 9) all yielded very similarly between 4.51 – 5.10 MT/Ha and considerably below the conventional input treatments. There didn't appear to be any production benefit in combining the biological inputs with the conventional fertiliser and shown in treatments 10 to 15.

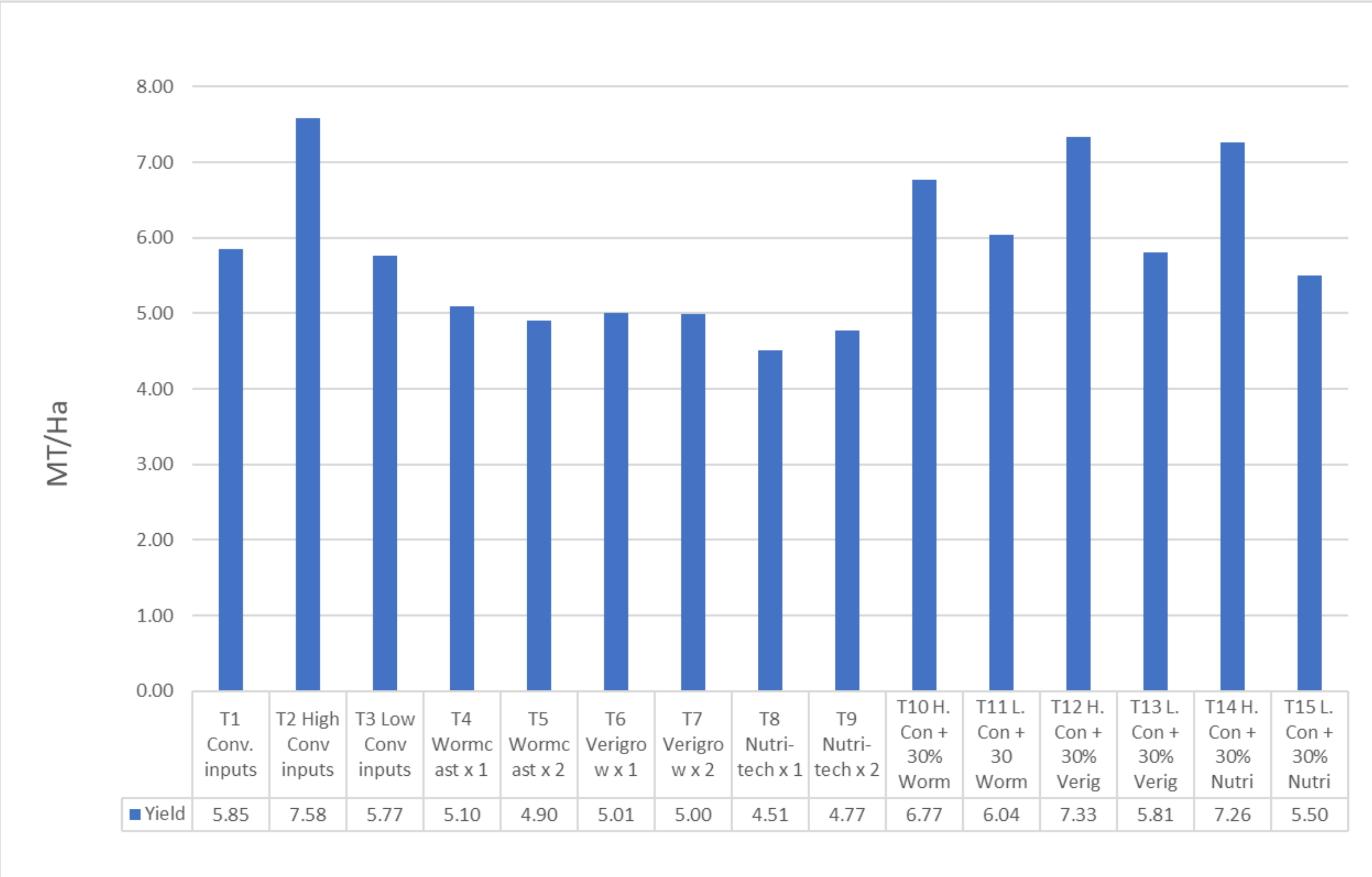

Figure 3: Landcare trial harvest yield data (P=NSD)

Benefit Cost Analysis

The benefit cost analysis was determined by calculating the net change in farm gate return. The baseline farm gate return was represented by treatment 1 or normal farm fertiliser inputs and was calculated by multiplying the yield by the farmgate price of APW1 less the cost of the fertiliser. It was assumed all other inputs were equal across each treatment.

Each treatments total farmgate return was the calculated less the cost of the fertiliser and compared to the control or treatment 1. Figure 4 shows the difference in net return compared to treatment one and the cost of each treatment.

As expected the highest yielding treatment (T2) was the best returning treatment. There was a cost of shifting away from the conventional fertiliser to the biological inputs as seen with the negative change in farm gate return across treatments 4 to 9, despite the considerable reduction in cost/Ha. The best returning treatments were all associated with the high conventional input regime.

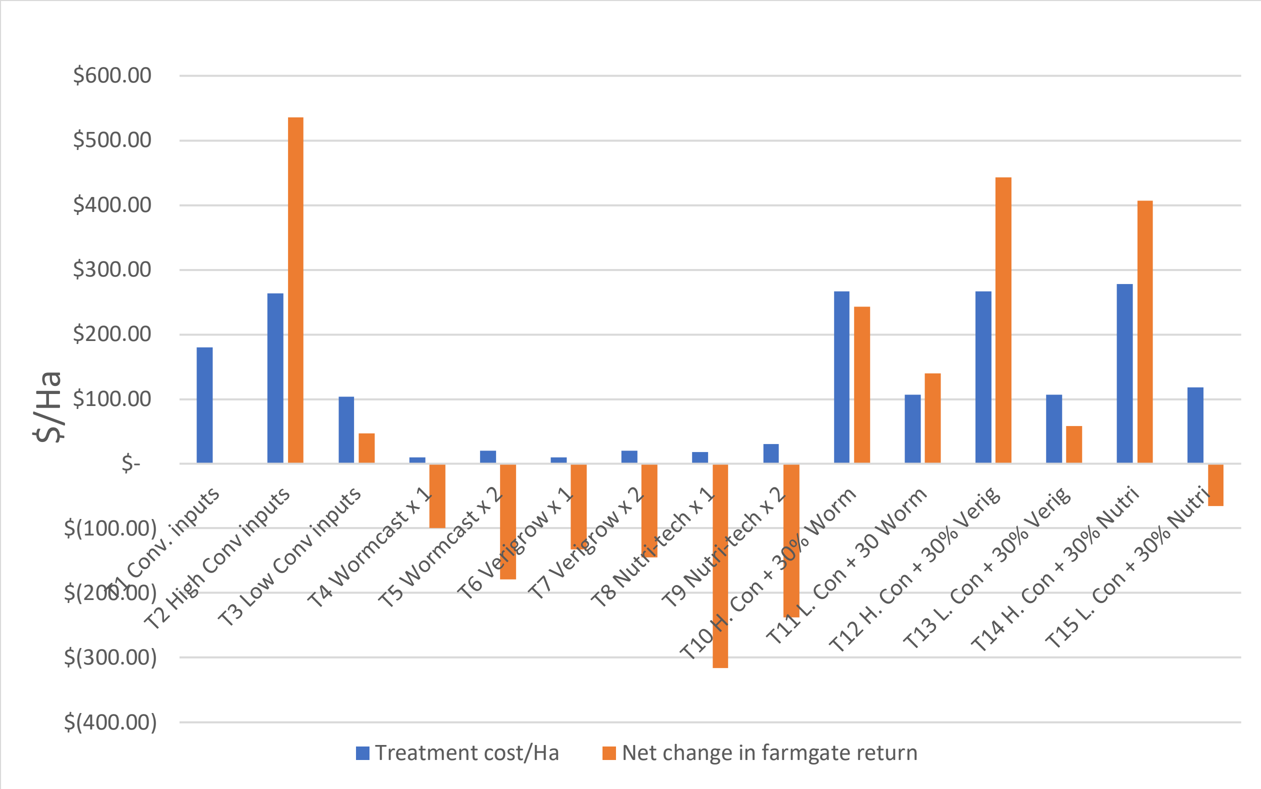

Figure 4 – Landcare trial benefit cost analysis

Discussion

The key outcomes of this project is to reduce barriers to adoption of natural fertiliser inputs in broadacre farming and to demonstrate a transitional methodology to producers to shift away from conventional fertilisers over to biological inputs. This is to be achieved by examining the impacts of the conventional and biological treatments on soil microbial activity, organic carbon and yield.

The primary driver for most producers decision making process is yield and gross margin. The yield and net farm gate return results in this project have demonstrated that there is a considerable reduction in yield and drop in farm gate returns if the transitioning from conventional fertilisers to biological inputs is assessed over a one-year period as is the case in this project.

The product or combination of products which produced the highest yield is the high conventional input treatment. This treatment also produced the best net farm gate return or profit. The product that produced the lowest yield and net farm gate return was the Nutri-tech solutions product at rate 1. The three products producing the worst net change in farm gate returns were the three biological fertilisers at both application rates.

For producers to transition across to using biological inputs for crop production the products will need to demonstrate their ability to produce equivalent yielding crops as conventional fertilisers and return similar profits.

While this project does not supported the hypothesis that 'we can transition from conventional agriculture to regenerative practices using biological inputs while still maintaining a productive farm enterprise', there have been some important outcomes generated from the trial.

1) Changing organic matter levels and soil microbial activity takes considerable time. To see a meaningful change takes up to 4 – 5 years. For a trial to demonstrate the ability of natural fertilisers to

perform as well as conventional fertilisers the trial need to be run over several seasons to allow the potential improvement in soil health to occur and translate into production.

2) For producers to transition to biological fertilisers the impact on their production and profit through the transition process needs to be well understood. It is expected to generate the benefits of the biological fertilisers within the soil micro-biology and in turn production that there will be a drop in production while the soil is changing. This trial has helped define what can happen during the early stages of transioning.

3) There is a requirement for a more detailed scientific explanation to be developed to enable producers to understand how spraying a worm extract, a wool extract or a kelp product can deliver the required nutrients to a wheat crop expected to yield 7 ton/Ha.

4) The trial was unable to address the questions which product / combination produces the best soil / plant health. This was primarily due to the results from the before and after soil tests. Both Microbial Biomass C (MBC) and in Microbial Biomass N (MBN) increased 6 fold on average across the trial area between the testing periods without any relationship to the treatments.

Conclusion

For producers to make the decision on whether to change from conventional fertilizer to biological fertilisers from this trials results alone the uptake would be very low due to the considerable fall in net farm gate returns generated by the biological fertilisers.

The project's key aim was to answer the question 'can we transition from conventional agriculture to regenerative practices using biological inputs while still maintaining a productive farm enterprise?' The answer from this trial's outcomes is *no*!

However it is important to understand the results before placing weight on them in making a decision. A fall in production is expected when transitioning between conventional to biological fertilisers and this trial has demonstrated:

- The potential fall in production and farmgate returns that can be experienced in year 1 (-$100 - $300/Ha).
- Any transition process needs to be managed well to ensure a smooth change over.
- The reasons and desired outcomes and expectation for the transition need to be clearly understood before beginning the change.

The next steps and future trials of Regen Ag inputs will be very important in influencing the uptake of biological fertilisers. The key step in future trials is to complete the trials over several seasons to better understand the long term impacts and production potential of biological fertilisers. Any change in soil health will take years and not months. The degradation of WA's soils organic matter has taken decades not a few years.

The second important next step is to develop a better knowledge of how the biological fertilisers will improve soil health, what are the key levels of microbial biomass required and what yields are actually achievable. One ton of wheat seed removes 23 kg of nitrogen, if the target yield is 6 ton/Ha then the crop will require 138 units of N plus what is required to produce the plant.

20L of worm castings puts out between 34 - 750 grams/Ha of N. To grow a 6 ton/Ha wheat crop a further 137 units of nitrogen is required by the crop. Can a soil stimulated with microbiology generate enough plant available N to grow a crop with the equivalent gross margin's.

If Regen Ag and biological fertilsers are to transition into mainstream agriculture these questions are required to be answered. The outcome of these questions will be key to driving long term change.

Appendix

Soil Test Results – 16 April 2021

75584
Southern Dirt Incorporated

Lab No		UIS21024	UIS21025	UIS21026	UIS21027	UIS21028	UIS21029	UIS21030	UIS21031	UIS21032
Name		D	I	F	A	C	E	H	G	B
Code		Site c scott newbey	Site c scott newbey	Site c scott newbey	Site c scott newbey	Site c scott newbey	Site c scott newbey	Site c scott newbey	Site c scott newbey	Site c scott newbey
Sampled Date		16/04/2021	16/04/2021	16/04/2021	16/04/2021	16/04/2021	16/04/2021	16/04/2021	16/04/2021	16/04/2021
Barcode		SOILB0042729	SOILB0061034	SOILB0061035	SOILB0042719	SOILB0061037	SOILB0042741	SOILB0061043	SOILB0042727	SOILB0042723
Depth		0-10	20-30	20-30	0-10	20-30	10-20	10-20	0-10	10-20
Latitude		-33.7806549612196	-33.7806549612196	-33.7806549612196	-33.7806549612196	-33.7806549612196	-33.7806549612196	-33.7806549612196	-33.7806549612196	-33.7806549612196
Longitude		117.756186537445	117.756186537445	117.756186537445	117.756186537445	117.756186537445	117.756186537445	117.756186537445	117.756186537445	117.756186537445
Colour		BRBK	DKBR	GR	DKGR	GR	GR	DKBR	BR	GR
Gravel	%	0	0	0	0	0	0	5-10	5	0
Texture		2.0	2.5	3.5	2.5	3.0	3.0	2.5	2.0	2.5
Ammonium Nitrogen	mg/kg	3	2	2	3	2	2	< 1	3	2
Nitrate Nitrogen	mg/kg	40	3	5	34	7	6	4	46	6
Phosphorus Colwell	mg/kg	65	14	5	33	7	6	36	80	5
Potassium Colwell	mg/kg	180	69	146	200	155	338	63	125	135
Sulfur	mg/kg	27.1	12.5	21.9	23.0	9.3	5.4	10.5	43.2	11.9
Organic Carbon	%	3.41	0.59	0.60	2.97	0.85	1.09	1.10	2.75	0.93
Conductivity	dS/m	0.195	0.124	0.158	0.146	0.115	0.092	0.056	0.241	0.072
pH Level (CaCl2)		5.0	4.6	5.6	5.2	6.3	6.1	4.5	4.9	5.8
pH Level (H2O)		5.9	6.2	7.1	6.2	7.3	7.5	6.1	5.7	7.3
DTPA Copper	mg/kg	2.09	1.52	2.37	2.26	3.19	2.40	1.07	1.23	3.05
DTPA Iron	mg/kg	211.80	133.90	90.00	102.30	39.20	50.10	246.40	207.30	47.50
DTPA Manganese	mg/kg	7.05	1.72	1.53	5.74	4.05	5.37	3.33	4.80	5.64
DTPA Zinc	mg/kg	4.95	0.55	0.54	2.52	0.63	0.47	1.37	4.33	0.49

Lab No		UIS21024	UIS21025	UIS21026	UIS21027	UIS21028	UIS21029	UIS21030	UIS21031	UIS21032
Exc. Aluminium	meq/100g	0.150	0.320	0.130	0.120	0.150	0.200	0.410	0.180	0.160
Exc. Calcium	meq/100g	9.05	2.72	5.00	10.07	8.73	10.20	3.33	5.92	6.17
Exc. Magnesium	meq/100g	2.75	3.48	7.53	3.41	7.29	8.07	1.55	1.57	5.03
Exc. Potassium	meq/100g	0.39	0.16	0.35	0.40	0.39	0.74	0.12	0.22	0.26
Exc. Sodium	meq/100g	1.02	1.43	2.66	0.83	1.50	1.74	0.66	1.01	0.98
Boron Hot CaCl2	mg/kg	1.28	1.01	2.30	1.73	4.14	2.10	0.69	1.06	2.67
PBI		78.9	62.7	65.3	58.5	75.2	72.8	79.4	76.3	65.6

Non-Wetting Management Options for Growers in the Albany Port Zone – SCF Component (wetters)

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Date submitted [14th, March 2022]

Abstract

Forest gravels are notorious for having non-wetting topsoils but are otherwise well suited to high rainfall cropping. If non-wetting topsoils could be economically alleviated, growers would consistently produce more grain by sowing earlier. The aim of the Stirlings to Coasts component of the investment was to evaluate the effectiveness of soil wetters on forest gravels. A farm-scale trial was established at Tenterden in 2020 on highly non-wetting forest gravel. The replicated seeder width trial included 11 treatments over 200m long. In 2021, the grower sowed wheat directly over the 2020 canola plots without using wetter or engaging the Pro-Trakker. The main finding was that seed placement had a greater impact on canola germination and early biomass than the rate and placement of wetters in the first year (2020). Despite these findings, there were no differences in canola yields in 2020 or wheat in 2021. Canola seeded on-row or near-row had significantly greater early canola biomass than plots planted off-row, regardless of wetter application. The grains industry requires more research on wetting agents to determine the correct rate, application method and product for major soil types. The effectiveness of guidance systems for air-seeder bars needs to be independently evaluated over more crops and seasons to help growers make informed investment decisions.

Executive Summary

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

Why was the work done?

Forest gravels are notorious for having non-wetting topsoils but are otherwise well suited to HRZ cropping systems. Forest gravels generally have high organic matter and are well suited to grow wheat, barley, canola and pulse crops in the appropriate soil pH. If germination issues associated with non-wetting topsoils could be alleviated, growers on these soils could produce even more grain by sowing crops earlier.

Mechanical soil amelioration on sandy soils is very effective and widely adopted by other growers in the Albany Port Zone (APZ); however, the process is slow and expensive. Mechanical options are not as well suited to forest gravels because of the rocks bought to the surface by ploughing etc. Soil wetting agents have been successful on forest gravels or gravelly loam soils, which has led to many growers installing liquid streaming systems on their seeding equipment. Questions still linger regarding the effectiveness of wetting agents due to inconsistent responses combined with the high cost of the products. Hence the interest in this project from growers and researchers alike.

Significant Results

The two most significant results were obtained in the 2020 season. Placement of wetting agent in the subsoil closer to the seed achieved significantly better germination and early plant biomass than wetter applied on the furrow above ground. Secondly, the seed placement in relation to last season's furrow had a more significant effect on canola germination and early vigour than the wetting agent treatments. Canola planted on or near last year's furrow had a significantly higher ground cover percentage than canola planted inter-row, regardless of a wetting agent treatment was applied or not. Despite observing differences in canola germination and early vigour in 2020, there were no significant differences measured in grain yields indicating the canola could compensate for lower plant numbers in some treatments.

In 2021, wheat was grown over the 2020 canola plots with the grower's standard agronomic package. No new wetter treatments were added so that we could determine if there was any residual benefit in the second year from the wetting agents applied in 2020. Satellite imagery was collected to analyse NDVI at different times during the 2021 growing season, but no significant differences were detected. There were no significant yield differences in 2021 between any treatments applied in 2020. This result confirms the recommendation that soil wetters be used every year on responsive soils. The 2021 season was exceptionally wet, and the expression of non-wetting was likely very low.

What was achieved?

Michael Webster, the grower host, found clarity on his strategy for treating non-wetting soils. They had previously set up the liquid application on their seeding bar that placed the SE14 wetter onto the furrow behind the press wheel. In 2020 we saw better responses to SE14 applied in the soil close to the seed rather than a surface application. Additionally, the improvement in canola germination from plants seeded near or on last year's furrow motivated Michael's family to purchase a Pro-Trakker hydraulic hitch for their bar so they could have better control of the seed location. The Pro-Trakker guidance system was used in 2021, although differences were hard to observe in the extremely wet season. Michael continues to work with SCF to validate the value of using wetting agents and the Pro-Trakker. In 2021, SCF helped Michael assess some new wetter products compared with SE14. The results of this demonstration are yet to be analysed. A similar trial was conducted by another SCF member at Manypeaks in 2021 on sandplain soil. The results of these farmer demonstrations will be shared with SCF members once the yields have been analysed.

Conclusions

The seed placement in relation to last year's furrow was enormously important for the canola germination in 2020. The improved canola germination and early biomass was the catalyst for Michael Webster to invest in a Pro-Trakker guidance system for his seeding bar in 2021. Placement of the SE14 wetting agent underground near the seed was significantly better than applying the same rate of SE14 on the furrow surface. There was no measurable benefit to the 2021 wheat crop from treatments used in 2020. Despite significant differences in plant germination and early biomass in the 2020 canola crop, the final grain yields were not significantly different to the untreated control. Even without yield increases from the wetter application in 2020, growers still valued the significantly improved plant germination and early biomass, which should translate to greater yields in seasons where water availability at grain filling is limited.

When and how can the industry benefit from the work done?

Our demonstration work highlighted the inconsistencies around soil wetter research in WA. The only way to gain more clarity is to conduct more scientifically valid demonstrations and trials. When wetting agents work, the differences are evident, encouraging growers to use the products on those soils. Other growers, particularly those on sandplain soils, are trying wetting agents in the hope they will gain some advantage. Mechanical soil amelioration is expensive and time-consuming, which rules those options out for some farming businesses. Applying soil wetting agents is still costly but cheaper than a mechanical option.

Recommendations for future actions

The longer-term implications of seeding on-row or near-row need to be explored. Is the 2020 canola result repeatable for different crops? Does soil and root disease build up over time? Do you still need a wetting agent when seeding on or near last year's furrow? Growers posed these questions to the SCF researchers throughout the project.

We could not detect a significant improvement in the 2021 yields associated with the treatment applied to the canola in 2020. However, 2021 was an exceptionally wet season at Tenterden, which would likely have masked any possible benefits from soil wetter applications. Trials over multiple seasons need to be conducted to account for seasonable variability and the effects on different soil types and environmental factors. Longer-term work needs to be completed to ascertain if there are improvements in soil wettability from prolonged use of wetting agents. Growers believed their soil wettability was improving year on year with wetter applications.

From the limited products we tried, SE14 from SACCOA was the best product on this soil type. However, there are more and more wetting agent products entering the market, and some independent analysis needs to be completed to help growers decide which products to use. There also needs to be more independent trial work looking at rates of soil wetter on different soil types. Given they are expensive, growers are always wanting to use the most economical product and amount.

Background

Over the past few years, grain growers in the Albany port zone (APZ) 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 soils 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. 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. The range of wetting agents on the market is growing. 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, assisting 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 aimed to determine the best rate and placement of soil wetters for growers to mitigate nonwetting effects and achieve the best possible crop emergence without mechanical disturbance of nonwetting forest gravel soils.

Project objectives

Objective of the 2020-21 trial demonstration at Tenterden
By 2021, growers in the Albany port zone will have updated knowledge on using soil wetting agents to effectively manage non-wetting forest gravel soils that apply to their situation. Grain growers in the HRZ around the Kendenup, Tenterden and Frankland River areas enjoy consistently high growing season rainfall and relatively mild temperatures during grain-filling, especially compared to the traditional Wheatbelt regions of WA. Growers in these regions have two main constraints to their cropping enterprises, one being waterlogging and the other being nonwetting topsoils. In this project, we tackled the non-wetting constraint.

Forest gravels are notorious for having non-wetting topsoils but are otherwise well suited to HRZ cropping systems. Although waterlogging is a problem, gravelly soils tolerate high rainfall better than most soils in WA. Forest gravels generally have high organic matter and are well suited to grow wheat, barley, canola and pulses, where the soil pH is 5 ($CaCl_2$) and above. If the germination issues associated with non-wetting topsoils could be effectively alleviated, growers in these regions would produce more grain on average by being able to establish crops earlier and achieve a more even crop.

Mechanical soil amelioration on sandy soils is very effective and widely adopted by some SCF members in the APZ; however, the process is slow and expensive. Most mechanical options are not as well suited to forest gravels because of the rocks hidden below the surface that would be bought up by ploughing etc. Soil wetting agents work well on forest gravels or gravelly loam soils, which has led to many growers installing liquid streaming systems on their seeding equipment. Questions still linger regarding the effectiveness of wetting agents due to a lack of consistency combined with the high cost of the products. New products are regularly entering the market, but growers are unsure of their efficacy. Hence the interest in this project from growers and researchers alike.

Methodology

In 2019 three trials were set up with Anthony and Murray Hall in West Kendenup. The trials looked at the effects of applying 2.0 litres of SE14 per tonne of seed to see if it assisted germination numbers in non-wetting soils on three crop types (canola, wheat and oats). The results of these three on-farm experiments have previously been reported. A copy of the 2019 report written for the Stirlings to Coast Farmers Annual Trials Review Booklet has been included in the appendix of this report.

2020-2021 Trial

A trial site was set up southwest of Tenterden for the 2020 season on a highly non-wetting forest gravel Soil. The demonstration had a strong cropping history, with barley grown in 2019 and only one pasture year in the seven seasons before that. The grower has used wetter in his system at seeding for the previous three years. The trial layout included 11 treatments, described in the list below, seeded in 200m long strips over three replicates. Soil samples from the three replicates were taken before sowing for MED testing to measure water repellency under field conditions. NB: MED stands for Molarity of Ethanol Droplet test- a measure of soil repellency. Staff also took soil tests and sent them to CSBP to determine the specific recommendations from BASF for their wetting agent product “Divine”. The Divine test returned three different suggestions 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 that local growers most commonly use it. The project aimed 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.

- Untreated Control
- 2 Lt/tonne SE14 directly on the seed
- 4 Lt/tonne SE14 directly on the 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 wide applicator attached to the seeder bar. Seeding occurred on the 6th of May 2021 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 10.4m strips at 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 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 10.4 m plots were swathed and harvested by the grower. The 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, they were statistically accounted for due to the significant difference from seed placement in proximity to last year's furrow.

2021 Method

In 2021, wheat was grown over the 2020 canola plots with the grower's usual agronomic practice minus wetting agents or engaging the newly installed ProTrakker. No new treatments were added because we aimed to see if there was any residual benefit in the second year from the wetting agents applied in 2020. Satellite imagery was collected to analyse the Normalised Difference Vegetation Index (NDVI) at different times during the 2021 growing season, but no significant differences were detected.
Harvest was completed with a plot header for all 33 plots in 2021. Plot length and grain weight were measured on the day of harvest, while grain quality was analysed at CBH in Albany three weeks later. Plot yields were calculated from the plot weight and the measured plot area. DPIRD biometrician Andrew VanBurgel analysed the grain yields in 2021.

Figure 1: Photo of the liquid delivery system used to apply soil wetting agents by Michael Webster and his family. The
wetter is applied directly onto the seeding furrow behind the press wheel. The photo was taken by Nathan Dovey- Stirlings
to Coast Farmers on the 6th of May 2021.

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, WA	

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	Western Region 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

2020 Results

Germination

The plant density analysis found two treatments with significantly higher plant numbers than the untreated control (UTC). These treatments were placed behind the seed boot rather than applied on top of the furrow (behind press wheel). Increasing the SE14 rate, from 2L/ha to 4L/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 the non-wetting nature of this soil.

The placement of SE14 directly on the seed or behind the press wheel resulted in no significant difference in 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 UTC.

The lower plant densities from the high rate of SE14 (4L/tonne) placed directly on the seed can be explained by the application method. At the high rate, the individual seed was observed sticking to each other and not flowing naturally in the air-seeder box. The reduced flow of grain and stickiness likely led to reduced seed numbers planted per row and probably reduced seed placement uniformity. If treatments applying wetter directly on the seed are to be tried again, we 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 vertical column represents the number of plants per m2.

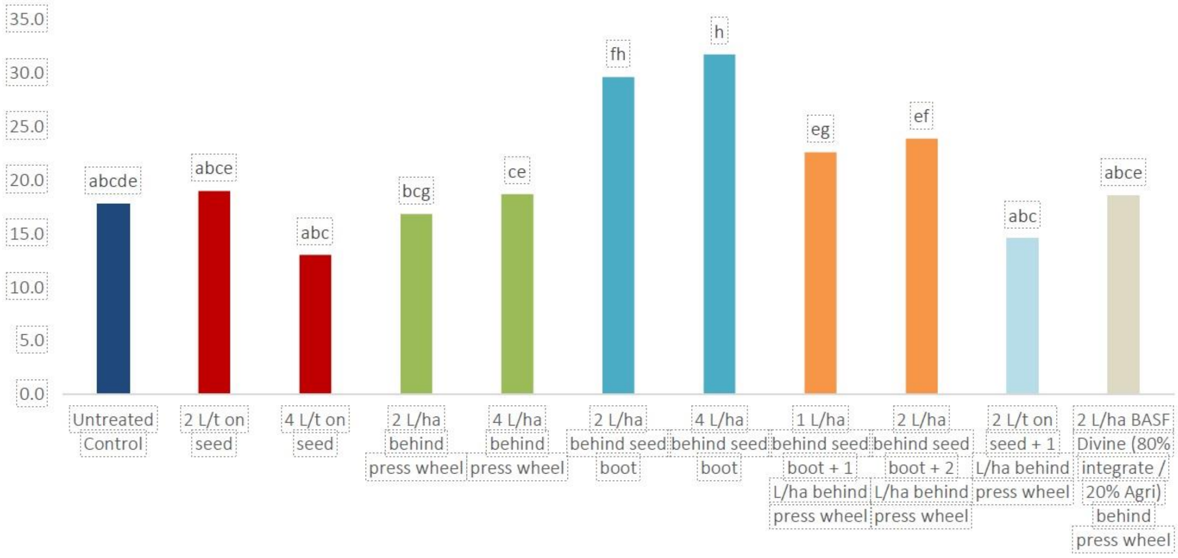

Figure 2: Plant density counts for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest gravel at Tenterden WA in 2020. The vertical column represents the number of plants per m2.

Early biomass

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

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

The 2L/ha SE14 behind the seed boot and 2L/ha behind the press wheel treatment was statistically equivalent to the 2L/ha SE14 behind the boot. However, it was not significantly higher than the UTC, despite having a 16% 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 4L/ha may not be economical for some grain growers.

The ground cover results identified a significant difference between the seed placement in relation to the previous year’s seeding furrow. The off-row seed placement resulted in a significantly lower ground cover than the near-row and on-row. The 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.

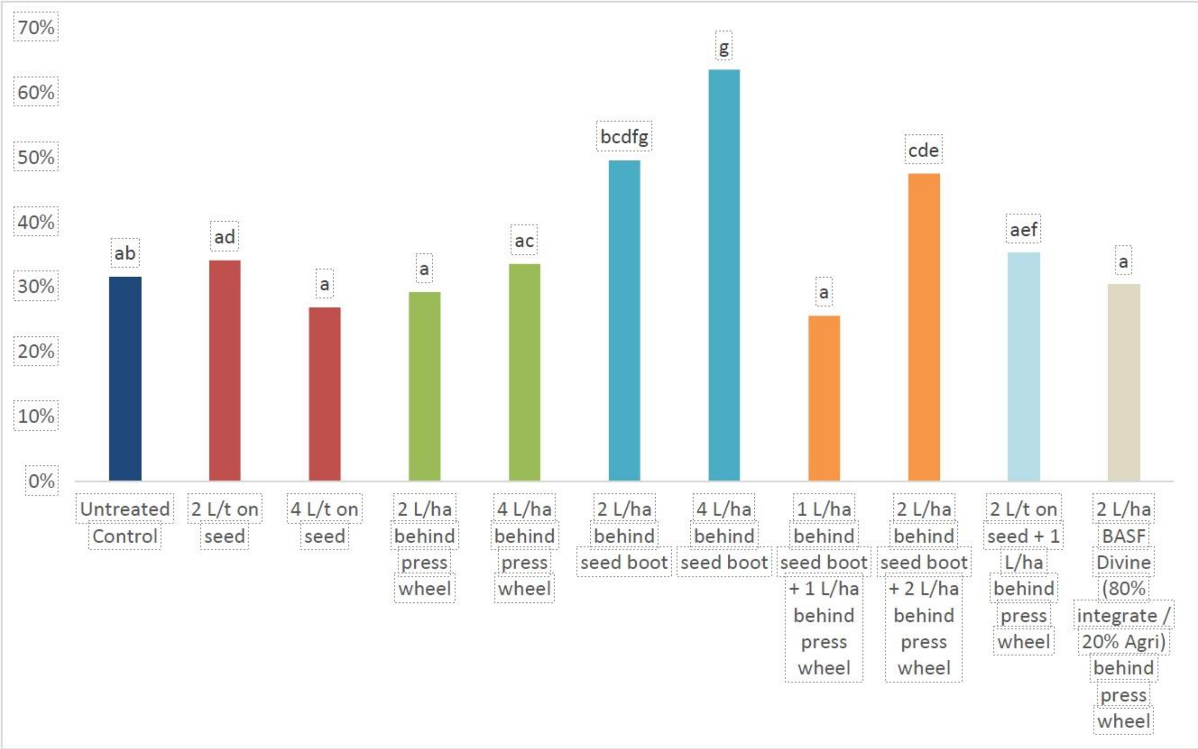

Figure 3: Ground cover for different placements and rates of soil wetters, SE14 and BASF Divine, in a forest gravel soil at Tenterden, WA. Percentages of ground cover were determined through calculations with drone imagery collected on 28/7/2020. Percentage ground cover is represented on the vertical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

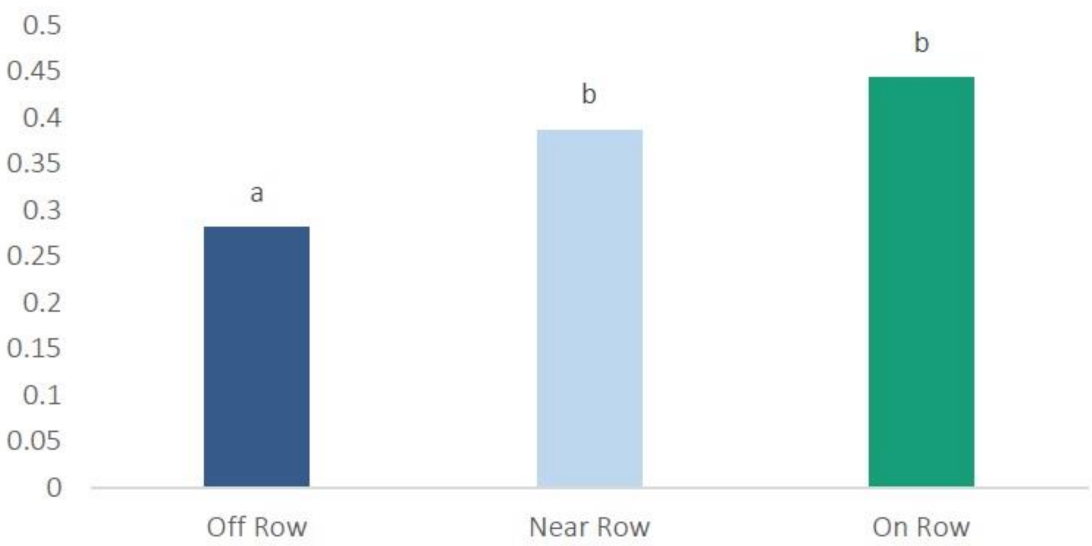

Figure 4: Percentage round cover for seed placement in proximity to last year's cereal furrow in a forest gravel soil type at

Tenterden, WA. Percentage calculations were determined through drone imagery taken on 28/7/2020.

Grain Yields

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

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

Reviewing the three replicates that made up each treatment mean provided a plausible explanation for why the mean yields were significantly lower than the UTC. One of the three replicates for the 4L/tonne of SE14 applied directly to the seed was only 1.37t/ha, which reduced the average yield for the treatment. Likewise, the 1L/ha SE14 behind the seed boot with 1L/ha SE14 also placed behind the press wheel had one replicate that yielded 1.16t/ha. Each outlier was in plots where the air-seeder had randomly placed the seed off-row, explaining the poor result.

The 2L/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. 2L/ha SE14 behind the press wheel (1.16t/ha and seeded near-row)
2. 4L/ha SE14 behind the seed boot (1.08t/ha and seeded off-row)
3. 2L/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 planted 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 ten plants/m2 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 plant density was not a limiting factor.

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

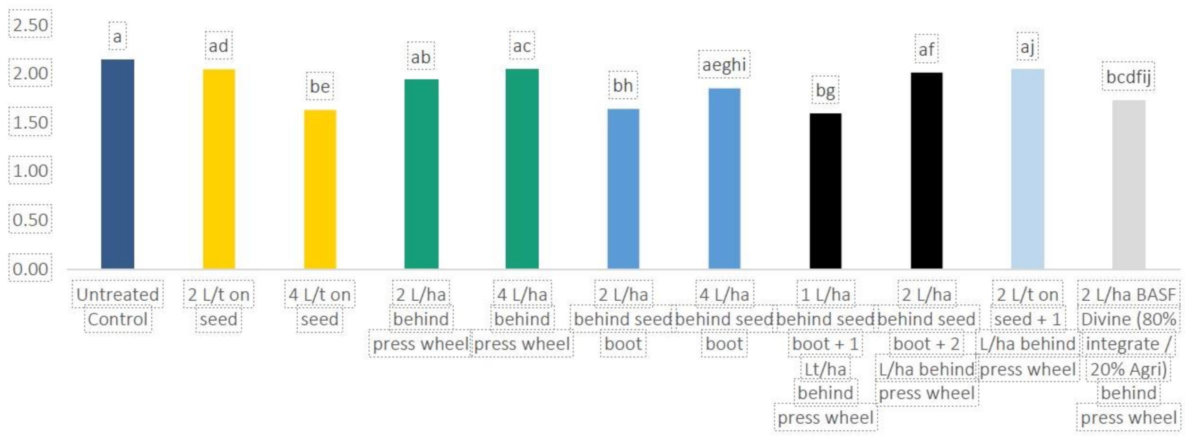

Figure 5: Grain yields of canola for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest

gravel soil at Tenterden WA in 2020. Grain Yield is represented on the vertical axis, and the units are t/ha.

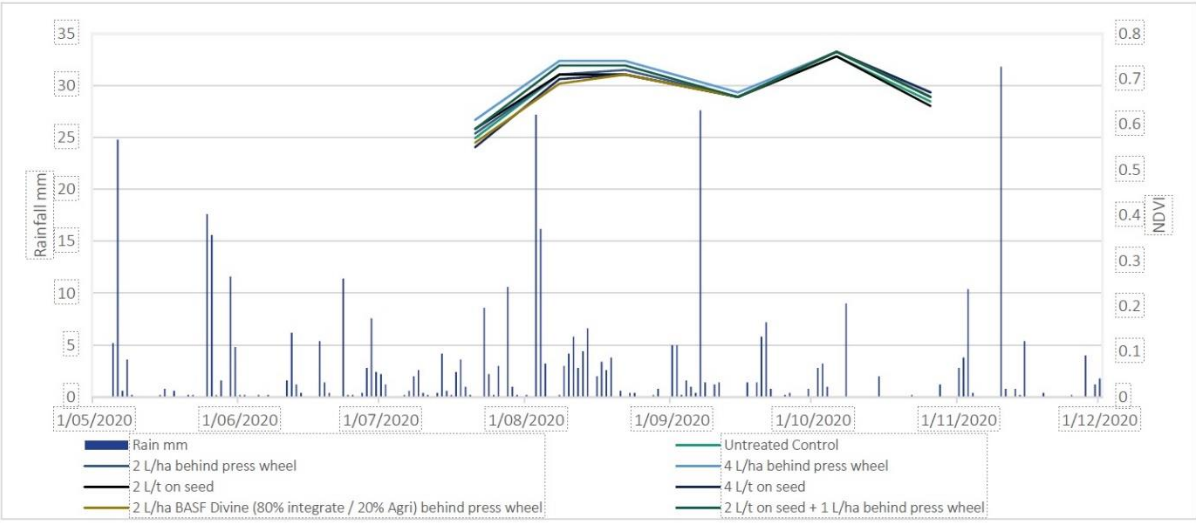

Figure 6: Rainfall and NDVI for different placements and rates of the soil wetters, SE14 and BASF Divine in a forest gravel at Tenterden WA in 2020.

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		

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

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 for non-wetting expression. 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.

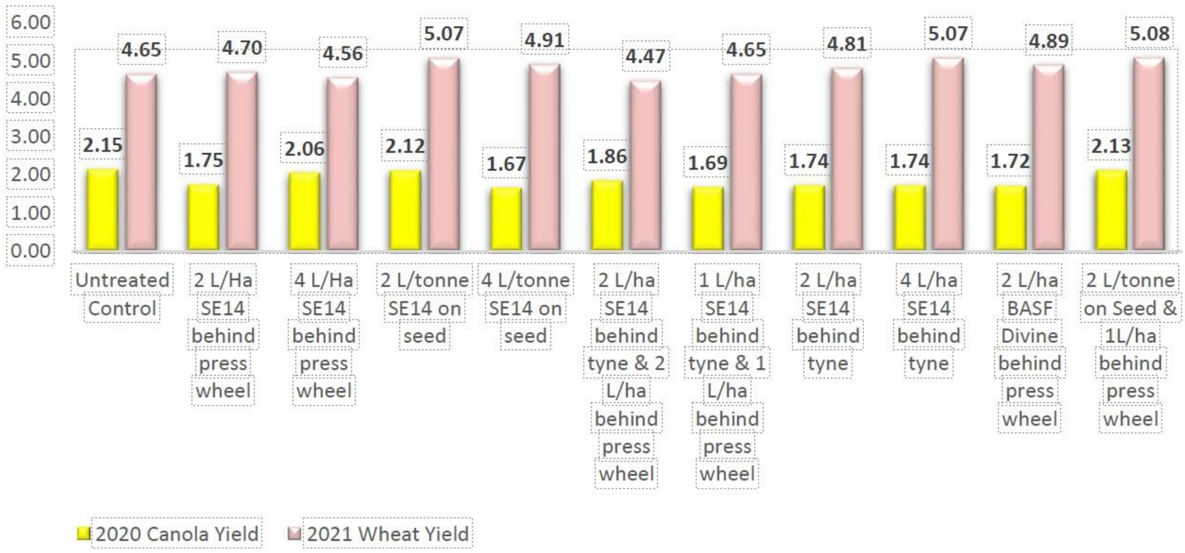

Figure 7: The Grain yields (t/ha) recorded in 2020 (canola) and 2021 (wheat) at the Webster/Beech non-wetting trial site in Tenterden. No statistical differences were measured between treatments in 2020 or 2021 (data not shown).

Treatment	2020 Canola Yield (t/ha)	2021 Wheat Yield (t/ha)	Cumulative Yield (t/ha)
Untreated Control	**2.15**	**4.65**	**6.80**
2 L/Ha SE14 behind press wheel	1.75	4.70	6.45
4 L/Ha SE14 behind press wheel	2.06	4.56	6.62
2 L/tonne SE14 on seed	2.12	5.07	7.19
4 L/tonne SE14 on seed	1.67	4.91	6.58
2 L/ha SE14 behind tyne and 2 L/ha behind press wheel	1.86	4.47	6.33
1 L/ha SE14 behind tyne and 1 L/ha behind press wheel	1.69	4.65	6.34
2 L/ha SE14 behind tyne	1.74	4.81	6.55
4 L/ha SE14 behind tyne	1.74	5.07	6.81
2 L/ha BASF Divine behind press wheel	1.72	4.89	6.61
2 L/tonne on Seed & 1L/ha behind press wheel	2.13	5.08	7.21
Mean Yield of Trial (t/ha)	**1.88**	**4.81**	**6.06**

- There were no significant differences between wheat yields in 2021 from the wetting agent treatments applied in 2020.
- There were no residual yield benefits in 2021 from any wetting agent treatments applied in 2020.
- 698.4mm of rainfall (Decile 10) between April 1-October 30 at the West Kendenup DPIRD weather station, effectively removing the non-wetting soil constraint in 2021.

Figure 8: Harvesting the 2021 wheat demonstration trial at Michael Websters in Tenterden. Kelly Gorter (SCF) and Cameron
Quenby (David Gray's Agronomist) look on. The photo was taken by Nathan Dovey (SCF) on the 15th of December, 2021.

Discussion of Results

2020 Trial at Tenterden

In 2020, only two wetting agent treatments had statistically higher canola germination than the UTC. These two treatments were 2L/ha and 4L/ha of SE14 behind the tyne. These results had two important outcomes. Firstly, SE14 was more effective when placed close to the seed behind the tyne compared to a surface application behind the press wheel. Secondly, the higher rate of 4L/ha did not significantly improve canola germination compared to 2L/ha of SE14. This shows that in responsive soil, 2L/ha of SE14 is enough to enhance canola establishment. This is an essential economic outcome because SE14 is an expensive product, and growers are loathed to apply more than needed.

The ground cover percentages of the canola plots were measured in late July 2020, and the results were consistent with the establishment data. However, only the 4L/ha of SE14 behind the tyne had significantly higher biomass than the UTC. The 2L/ha of SE14 behind the tyne had higher biomass than the UTC, but it was not statistically significant.

The differences in these treatments did not translate to the final grain yields of the canola. No treatments yielded significantly higher than the UTC in 2020. We think the canola compensated for differences in plant numbers because the plant populations were not low enough to be yield-limiting. The improved plant germination and early ground cover will have long-lasting agronomic benefits to growers through improved weed competition, but quantifying the benefit is complex and beyond this project's scope.

The most significant result from 2020 was the observations recorded regarding plant germination and early biomass compared to the seed placement in relation to last year's seeding furrow. The improvements in germination and early biomass from 'on' or 'near-row' placement convinced the grower to invest in a Pro-Trakker hydraulic hitch for his seeding bar to control their seed placement better. In the case of canola on a barley stubble, the seed placement 'on' or 'near row' was a more important factor than whether the treatment received a wetting agent or not.

In 2021, there were no significant yield differences between any of the treatments applied in 2020. This result was not unexpected since wetting agents are recommended to be used every year on responsive soils. The 2021 season was exceptionally wet, and the expression of non-wetting was likely very low. From the limited products we tried, SE14 from SACOA was the best product on this soil type. However, there are more and more wetting agent products entering the market, and some independent analysis needs to be completed to help growers decide which products to use. There also needs to be more independent trial work looking at rates of soil wetter on different soil types. Given they are expensive, growers are always wanting to use the most economical amount.

Unexpected results from the 2020 trial

In 2020, SCF researchers, in collaboration with Glenn McDonald (DPIRD), observed the distinct differences in germination based on the proximity to last year's seeding furrow. Researchers detailed whether each plot was seeded, on last year's row, just off last year's row or in the middle of last season's furrow. The data was then integrated into our statistical analysis by DPIRD biometrician Andrew VanBurgel, and the results were apparent.

The significant improvement in germination and early biomass from sowing close to last year's furrow was attributed to greater access to fertiliser and previous root channels. The existing root channels increase moisture penetration and provide the plant with preferred growth pathways. When sowing on last year's furrow, the plant can access unused nutrients from previous years combined with the fresh fertiliser applied in that season.

Conclusion

The project found that SE14 needed to be placed near the seed underground to increase the canola germination and early biomass. We tried to assess if combining applications behind the tyne and on top of the furrow would improve the wetting agent's (SE14) effectiveness compared to behind the tyne only or on top of the furrow only. Results were inconclusive, but site variability made it hard to determine statistical differences. The combination concept deserves further research to ascertain if it is a more efficient way to apply soil wetter.

Growers ultimately want yield gains that were not observed in either 2020 or 2021. The reasons for this have been examined in the report. Yield gains in the first year are more likely for crops other than canola, and perhaps more research in small plot trials would better determine significant differences than broad-scale trials. However, SCF has had collaborative discussions with fellow researchers, and they have also found it difficult to find significant differences in yields from using wetting agents like SE14.

In our two-year trial, we observed two clear outcomes that growers should note. Firstly, the placement of SE14 behind the seed-boot (underground) was much more effective in increasing canola germination and early biomass than a soil surface application behind the press wheel. We had discussions with SACOA (manufacturer of SE14), and they have reached the same conclusion in their own research over more trial sites and seasons. Secondly, seed placement in relation to last year's furrow had a massive impact on plant germination and early biomass growth. Seeding canola on or near row, regardless of the wetting agent treatment applied, had significantly higher early biomass than the off-row plots. The data generated in 2020 was convincing enough for our grower host to upgrade their seeding machinery with a Pro-Trakker hydraulic hitch. Utilising a ProTrakker may prove to be a cheaper and more effective solution to non-wetting soils in the long term than adding soil wetter every year.

Growers have anecdotally observed long term cumulative benefits from applying a soil wetting agents year on year. We attempted to measure this in the trial design, but the unusually wet 2021 season minimised the non-wetting expression making this hypothesis impossible to support with our trial results. This idea deserves further validation attempts since it would add utility to the SE14 investment made by growers.

Implications

Assessing the benefits of wetting agents is a difficult task because the response varies depending on the season, soil type and other environmental factors. Forest gravels are the most responsive to wetting agents, whereas, in different soil types, results are less certain. Some of our grower members (Stirlings to Coast Farmers) on sandplain soils are applying high rates of SE14 (4-5L/ha) out of desperation because outside of major soil amelioration (clay applications, delving etc.), they do not have a viable solution. Further fieldwork needs to continue to refine the application rates and responses in differing soil types. Many new products on the market also need to be assessed for efficacy and economic value.

Recommendations

Independent testing of new non-wetting products
SE14 by SACOA is the product most commonly used by growers in southern WA. Despite being perceived as being the best non-wetting product on the market, there are still many situations where the product does not give an economic response for growers. The lack of economic response is due to its high cost and uncertainty about which soil types the product will be effective. Growers have to test the product themselves, which is costly and inefficient. Growers need access to more independently generated soil wetter testing in their local environments.

Additionally, new products are being bought to market to challenge SE14's market share. Despite there not being enough research on the effectiveness of SE14's efficacy across all WA non-wetting soils, there is next to nil information on most new wetter products. Once again, growers are forced to test products themselves, which is slow, and data is poorly shared beyond small groups or even within individual companies.

There needs to be independent testing of new products on the market in different soil conditions. Growers are always sceptical of industry research conducted by companies that could potentially be biased. Growers would like to see an independent organisation like the GRDC or DPIRD conduct trials to guide grower choices. Some of the products on the market from companies appear to have very little of their own research that has been conducted in Australian conditions.

Economic Analysis of Air-Seeder bar guidance like Pro-Trakker

The data gathered from our Tenterden site suggested a Pro-Trakker on the air-seeder bar was going to be far more effective than using soil wetting products. Expanding the observations made in 2020 needs to be made to see if the substantial benefit is seen in other years on other soils and different cropping rotations. The grower host (Michael Webster) is keen to continue testing non-wetting solutions on his property because it is his number one soil constraint.

This type of assessment could be made by organising multiple on-farm demonstrations/trials with growers with the help of precision agriculture technologies. For example, growers that use wetting agents could leave untreated control strips in multiple paddocks and give researchers access to the harvest data to assess possible yield differences. This would not be a simple project, but it would be possible with collaboration between grower groups, technology providers and biometricians. The project's success would depend on the ability to collect a large enough data-set for analysis.
Multi-year analysis of soil wetting agents

The expression of soil wettability is dependent mainly on the seasonal conditions experienced, most notably the timing and amount of rainfall received. To accurately understand a soil wetters performance, the product(s) needs to be tested in multiple seasons to determine how effective it is on average. We recommend trying new products over numerous seasons to understand the economic returns for growers.

Appendix A.

Non-wetting management options for growers in the Albany port zone 2019

Key Points

- The lack of significance in plant count shows there were no adverse effects to the seed in the three crop
- types when wetter was seed coated prior to sowing.
- There were no significant improvements in yield from applying SE14 as a seed coating over the
- untreated control
- Water repellence was not likely an issue in the trials in 2019 as the site received adequate rainfall postseeding
- and throughout the growing season.
-

Background

It is often difficult to identify which issue is the most constraining, with the added difficulty in some instances of multiple problems such as non-wetting soils, compaction, acidity, sodicity and transient salinity. This can make adoption decisions difficult when deciding which are the best management options when paddocks may have
several constraints occurring at a local level. In the APZ, paddocks often have areas of non-wetting sands along with areas of exposed cap rock making the use of mechanical amelioration, such as one-way ploughs and other soil inversion tools difficult. A wrong decision in these soil types can have long term negative consequences and exposes soils to a variety of risks such as wind erosion.
Deep soil cultivation has been shown to reduce repellence on these soils but impacts on crop establishment and causes variability in productivity. Claying sandy soils has been relatively common in the APZ for the last 20 years. It has been highly effective at ameliorating non-wetting topsoils, reducing wind erosion and improving grain yields. However, time and cost of claying and incorporation is a large barrier to more wide-spread adoption. Local growers counter this by investing in small amounts of claying on an annual basis. Non-mechanical management options such as soil

wetters placed in-furrow at seeding are becoming a more common tool in alleviating non-wetting constraints on these soil types. Recent research by Geoff Anderson looked at the efficacy of seed coated wetters (as opposed to being applied in-furrow) saw an improved cereal establishment by up to 109% (Anderson et al. 2018). The non-wetting management options for growers in the APZ project aims to improve the confidence in diagnostic methods for delineating and implementing practices to overcome non-wetting in most soil types, and to improve the confidence of growers in the decision making for improving soil productivity. In 2019 three trials were set up with Anthony and Murray Hall in West Kendenup. The trials looked at the effects of applying 2.0 litres of SE14 per tonne of seed to see if it assisted in germination numbers in non-wetting soils on three crop types (canola, wheat and oats).

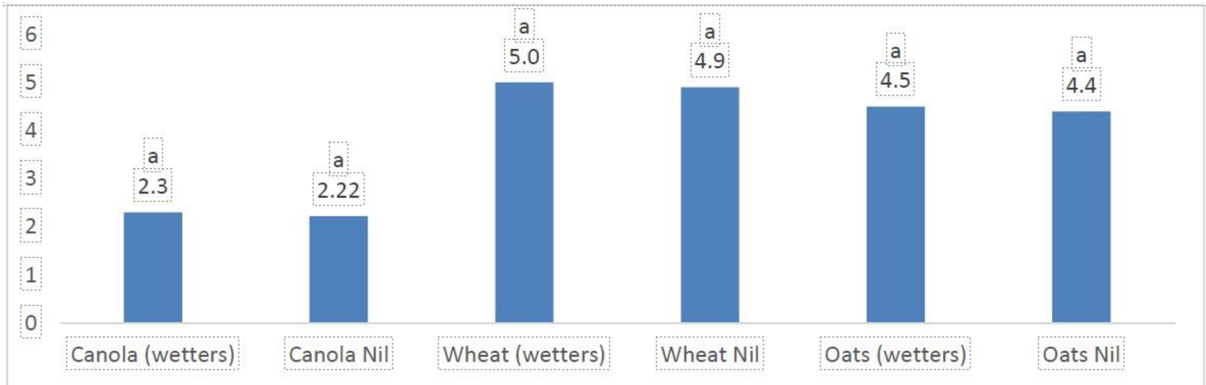

Figure 1 shows the yields (t/ha) of each crop type with a SE14 wetter seed coating and untreated control
at Hall's Family Farm in West Kendenup in 2019

Canola Grain Quality Average							
	Protein	**L Admix (g)**	**L Admix %**	**S Admix (g)**	**S Admix %**	**Moisture**	**Oil**
Canola (wetter)	20.20	2.83	0.57	4.23	0.85	4.23	46.23
Canola Nil	20.27	6.77	1.35	5.63	1.13	4.13	46.27

Table 1: displays grain quality from the canola with SE14 wetter seed coating and untreated control in 2019

There were no significant improvements in yield from applying SE14 as a seed coating over the untreated control in the canola, wheat or oats in 2019 Fig 1.

- Grain quality analysis in the canola trial shows there are no significant differences in protein, moisture or oil Table 1
- There were no statistical differences in any treatments in plant counts (per m2) that were collected from each of the crop and treatment types Fig 2.
- Plants were also divided into different growth stages to identify if more plants germinated on the first or second rains (Data not shown). Unfortunately, there were no significant differences observed for the three crops tested.

Crop Type and Treatment	July 5 2019 Ave plant count p/m²		July 12 2019 Ave plant count p/m²	
Canola (wetters)	43.3	a	56.1	a
Canola Nil	44.1	a	53.3	a
Wheat (wetters)	19	a		
Wheat Nil	17	a		
Oats (wetters)	39	a		
Oats Nil	32	a		

Discussion

The main aim of applying the wetter directly to the seed in these trials was to aid in improving wetting of the seeding
zone and help improve seed germination in both cereals and canola (Anderson et al. 2018). The lack of significance in plant count shows there were no adverse effects to the three crops with 2.0 litres of SE14 wetter applied directly to the seed before seeding. Generally, poor crop establishment on non-wetting soils occurs when crops are dry sown with limited rainfall pre- and post-seeding (Anderson et al., 2018). In 2019 despite the drier start to the season June through September achieved adequate rainfall at West Kendenup. Therefore, water repellence was less likely to be an issue in 2019 with greater than 65mm falling in June, July and August. Anderson et al. 2018 stated that seed coating with wetters improved cereal establishment, which increases plan density and tillers, which is an important role in final yields. Despite no significant increases in yield or grain quality, the three trials had excellent yields, which indicates that water was not a limiting factor in 2019. In 2020 two trials will be established, one with a steel-based amelioration (i.e. ploughing, ripping or other tillage machines) and anther trial with seed coating with wetter. Testing will be carried out to select sites with severely water repellent soils to investigate to impacted on crop establishment. Different rates of wetter will be added to the treatments in 2020.

Figure 9: A photograph highlighting the non-wetting nature of the trial demonstration site hosted by Michael Webster in 2020 and 2021. The photo was taken on the 6th of May, 2021, the day after receiving 25mm of rainfall. The photo was taken by Nathan Dovey- Stirlings to Coast Farmers.

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

SCF Stirlings to Coast Farmers Inc.
DPIRD Department of Primary Industries and Regional Development

APZ Albany Port Zone
HRZ High Rainfall Zone
SE14 Moisture Retention Agent Produced by SOCOA
MED Molarity of Ethanol Droplet Test -Measure of soil water repellency
CSBP Australian Fertiliser and Chemical Company
CBH Cooperative Bulk Handling
REML Restricted Maximum Likelihood
ProTrakker Precision guidance system that ensures the seeding tractor and seeder stay on the same path year after year via a hydraulic tow-hitch.
NDVI Normalised Difference Vegetation Index
Divine Agri Product from BASF (Chemical Company) to treat non-wetting soils
Divine Integrate Product from BASF (Chemical Company to treat non-wetting soils

References

This section provides the information a reader would need to locate the articles, journals, and/or other publications referred to in the report.

file:///C:/Users/pmack/Downloads/Harries+Martin+Seeding+uniformity+and+canola+tield.pdf
Guidance systems a plus for on and edge-row sowing | Groundcover (grdc.com.au)

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a. Pre-seeding and seeding
3. On which of GRDC's social media accounts would you like this content posted? Please provide text (2-3 sentences for Facebook and LinkedIn and 140 characters for Twitter), images, graphs, or charts that support the content. Where applicable, please include any relevant Twitter handles (usernames) for project staff.
a. Twitter

Nathan Dovey @dovey_nathan · Dec 15, 2021

Harvested our @GRDCWest Non-wetting soils demo at Tenterden today. 2021 is 2nd Yr after applying different rates & placements to canola in 2020. No wetting agents were applied in 2021, (just decile 10 rainfall). R there residual benefits from the wetting agents in yr 2?

2 19

3534 Impressions and 126 impressions

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Stirlings to Coast Farmers @Stirlings2Coast · Apr 19, 2021

Recent low summer rainfall and dry growing season starts have led to a growing non-wetting soil issue for crop germination. SCF looked into this issue in partnership with @DirtSouthern & @theGRDC.
Head to the link below to find out more.

youtube.com

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6 7

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Philip Honey @phil_honey · Mar 3, 2021

Great to have @Stirlings2Coast project officer @pmackie6324 providing the @theGRDC Albany Grains Research Update crowd, an update on some of the many interesting interactions/results found in wetting trials comparing wetters/rate, placement location across on-row &off-row sowing

Phillip Mackie and 4 others

1 3 18

Contact the social media team at socialmedia@grdc.com.au with any questions

Showcasing the Crossover between Regenerative and Traditional Farming Practice to Encourage Awareness and Adoption in the Great Southern Region of WA

KEY POINTS

- Research has shown farm businesses using Regenerative agriculture practices restore landscape function, increase nutrient and water cycling and sequester carbon in the soil.
- Conventional farming is a form of modern farming that refers to the industrialized production of crops and animals and animal products like eggs or milk.
- There is the incorrect perception in the wider community the conventional farmers are not focused on protecting the landscape and implementing practices that ensure the long-term sustainability of their property.
- By examining the common practices of conventional farmers there is a clear cross over of practices and long-term management strategies between both conventional and regenerative producers.
- This case study aims to outline the crossover between both types of producers and demonstrate that the goals are similar.

Introduction

Research has shown farm businesses using Regenerative agriculture practices to restore landscape function, increase nutrient and water cycling and sequester carbon in the soil. These practices increase biodiversity, productivity and are profitable and low risk while being personally sustainable for farmers and their communities as well as acting as a significant ameliorant to climate change.

There is a general perception in the community and through information channels that the only producers around Australia and the world that are concerned about the long term sustainability within a farming operation are those that practice regenerative agriculture. Traditional, conventional or industrial agriculture is seen as being very detrimental to the long term health of the environment and that the general farming operations practiced by these growers is driven by short term production and profit and not long term sustainability despite many growers having been on the land they farm for multiple generations.

Googling “conventional farming” returns a very negative response with references to fossil fuels, synthetic fertilisers, chemicals, herbicides and pesticides and a constant comparison to organic farming. A reader with limited background knowledge is immediately directed to the point of view that conventional farmers are driven to maximise short term production and profits irrespective of the impacts to the environment and that organic farmers are the only ones who are concerned about the long-term sustainability of the property they farm.

‘Regenerating the system rather than degrading it’, is a term often referred to when describing regenerative farmers. The beginning refers to Regenerative Farmers and the end refers to conventional farmers. Is this a true statement? Is it a fair statement to assume that conventional farmers are not inclined to put practices in place that regenerate their land to ensure the land they farm is productive and sustainable for future generations.

This Case Study explores regenerative farming principles, objectives and practices and how many of these practices are already common practice by many conventional farmers who rank natural resource protection, landscape management and long term sustainability as one of their key objectives when detailing long term management plans.

What is Regenerative Farming

Regenerative agriculture has no universal definition, the term is often used to describe practices aimed at promoting soil health by restoring soil’s organic carbon. Two summaries that describe regenerative agriculture are below:

1. Regenerative agriculture is a system of farming principles and practices that seeks to rehabilitate and enhance the entire ecosystem of the farm by placing a heavy premium on soil health with attention also paid to water management, fertiliser use, and more. It is a method of farming that “regenerates the system rather than degenerates it”

2. The Department of Primary Industry and Regional Development (DPIRD) defines Regenerative landscape management as: “The application of techniques which seek to restore landscape function and deliver outcomes that include sustainable production, an improved natural resource base, healthy nutrient cycling, increased biodiversity and resilience to change."

There are five standards in relation to regenerative agriculture which are generally accepted as the key five principles of regenerative agriculture, which are:

1) Minimise Soil Disturbance

Reducing soil disturbance increases soil organic matter, creating healthier environment for plants to grow in while continuing to lock up more carbon.

2) Keep the soil covered

Keep cover on the soil, preferably green growing cover, because it is plants that feed the soil micro-organisms.

3) Maintain living root in the ground year-round

Diversity in root ecology means more diversity in soil ecology which will result in more carbon in the soil.

4) Maximize crop diversity

Different plants release different carbohydrates which support different microbes. Increasing plant diversity improves soil health and leads to more productive yields.

5) Integrate livestock (break crops)

Rotational grazing gives the soil and pasture more time to recover or regenerate.

These five key principles work together to help bring together the five objectives of Regenerative Agriculture which are:

1) Solar Function

Maximising green leaf potential through perennials and managed grazing to maximise photosynthetic potential

2) Water Cycle

Improve water availability to plants through improving soil organic carbon which will increase soils water holding capacity and plant available water.

3) Soil mineral cycle

Increasing soil biology to increase soil nutrient availability to plants through microbiology. Increasing the exchange of sugars/carbon from plants with nutrients from microbes.

4) Dynamic Eco farming

Increasing the diversity and use of bugs and animals to improve soil structure. Managed grazing and utilizing good insects to control the negative insects. Creating a balanced environment.

5) Human function

Increasing the importance of peoples and communities health and wellbeing through promoting the human-social aspect by focusing on human agency triggering landscape regeneration by working in harmony with natural systems).

What is Conventional Farming or Industrial Agriculture

Text book definitions of conventional farming, also known as industrial or traditional agriculture is a form of modern farming that refers to the industrialized production of crops and animals and animal products like eggs or milk. The methods of industrial agriculture include innovation in agricultural machinery and farming methods, genetic technology, techniques for achieving economies of scale in production, the creation of new markets for consumption, the application of patent protection to genetic information, and global trade. These methods are widespread in developed nations and increasingly prevalent worldwide. Most of the meat, dairy, eggs, fruits, and vegetables available in supermarkets are produced using these methods of industrial agriculture.

Industrial Agriculture is typically referred to as a farming system which includes the use of synthetic chemical fertilizers, pesticides, herbicides and other continual inputs, genetically modified organisms, concentrated animal feeding operations, heavy irrigation, intensive tillage, or concentrated monoculture production. Thus, conventional agriculture is typically highly resource-demanding and energy-intensive, but also highly productive.

These definitions are very high level and only highlight a very small part of the practices employed by conventional producers. Water way management, minimum tillage, pasture diversity, native corridors and shelter belts, integrated livestock, soil cover, maintaining green leaf and maximising solar function are all function's integrated into the management practices of a conventional farmer.

Defining conventional farming practices is as complex as defining regenerative farming practices and therefore requires a much more in depth probe into the complete extent of practices implemented by the majority of conventional producers to better complete the definition.

A brief outline of the crossover between regenerative and conventional farming practices

The rest of the case study will examine the cross over between regenerative and conventional farming practices under the key headings of the five principles and five functions of regenerative farming.

Regenerative Farming Practices

1) Minimise soil disturbance

Since the 1980's conventional farmers have been shifting over to zero and minimum tillage practices, well before the development of regenerative farming. The majority of conventional crops are now planted with minimal soil disturbance.

Conventional farming has developed this further through the practice of controlled traffic which is the practice of driving all machines on the same set of tracks for all operations minimising all soil disturbance one set of driving tracks.

2) Keep the soil covered

Maintaining soil cover has become a key priority to conventional farmers who have developed systems to ensure soil cover can be maintained all year round.

Cutting low, chopping straw, changing the structure of seeding bars to have 4th rows and wheels outside of the bar to improve trash flow, spraying pre-emergent's at very high water rates have all been brought in as common farming practices to ensure full stubble retention, reduce the need to burn and to maintain ground cover.

Confinement feeding, rotational grazing, sowing longer season varieties along with perennials and planting shelter belts all assist in maintaining soil cover over 12 months of the year.

3) Maintain living root in the ground year-round

Maintaining living root in the ground all year is difficult in a Mediterranean climate especially one as dry as Western Australia. However conventional farming practices have been developed to maximise the potential of plants to not only maintain living roots for as long as possible but to also develop an extensive root system. These practices include:

- Planting perennials on lower land area to access rising water tables
- Rotational grazing to restrict plants moving from the vegetative phase to the reproductive phase extending the plants lifecycle at the end of the season
- Crop grazing over winter extending the plants life cycle at the end of the season
- Shifting from spring wheats to growing winter wheats extending the growing season due to the plants life cycle
- Planting native trees and perennial shrubs
- Summer crops generally planted in lower lying wetter areas can extend the lifecycle of living roots in the soil well into Summer and Autumn especially if out of season summer rainfall is received.

4) Maximize crop diversity

Conventional farming practices do not maximise crop diversity. Conventional cropping does not encourage maximising crop diversity due to the severe impact on yield and it is very difficult to see this becoming a management practice in the future.

However controlled and not maximum pasture diversity is a common practice among conventional farmers. The majority of pastures are clover based plus a combination of grasses such as ryegrass and broadleaf species such as capeweed. While the aim is not to maximise diversity there is certainly diversity within pasture crops.

5) Integrate livestock (break crops)

Integrating livestock into the conventional farming systems is common practice in the Great Southern region of WA. A large majority of producers have the majority of their farm in a 3 – 4 years cropping rotation followed by a 2 – 4 year pasture rotation before going back into the cropping rotation again.

Operating as a mixed farm is beneficial to both operations including:

- Increased soil fertility during the pasture phase
- Broader weed control strategies
- Better suitability of land use
- Reduced reliability on synthetic fertilisers
- Improved organic carbon levels
- Higher carrying capacity on sheep during winter
- Diversification of markets and revenue streams

Regenerative Farming Objectives

1) Solar Function

Maximising green leaf potential is a high priority for conventional farmers as well and regenerative growers. Along with perennials and rotational grazing conventional growers use many strategies to improve their solar function as improved solar function translates through to improved production. Dry and early sowing, seeding with paired rows and liquid fertilisers speeds up canopy closure and increases solar function. Crop grazing and improving year on year average yields also both work to improve solar function.

There are practices in conventional farming which work to reduce solar function such as summer spraying and in crop weed control, however the overall aim of conventional farmers is to maximise solar function where possible.

2) Water Cycle

Similarly to solar function conventional farmers aim to maximise water use. Water use efficiency is a key gauge that is monitored closely by growers, however rainfall can exceed evapotranspiration in the Great Southern during the winter months which does impact the validity of the statistic.

Larger crops will use more water, reduce runoff and water logging and the overall impact of the excess water in the environment. Conventional growers growing much larger crops than regenerative growers will have less impact downstream due their much higher water use efficiency.

Recent rainfall patterns are typically lower than 100 year long term average, and showing even higher declines in Autumn and Spring. Along with the declining rainfall short periods of hotter weather are also becoming more common, which are working to impact average yields.

Improving soil organic carbon which will increase soils water holding capacity and plant available water would both work to assist in crop and pasture production survive in better condition through these hotter and drier events. Improving soil carbon is a priority for conventional and regenerative producers however there has been limited success in conventional producers developing practices that have been shown to improve soil carbon within the current farming systems on a widespread scale.

It is worth noting the management strategies of non-wetting in soils does work to improve the water holding capacity and plant available water for crops and pastures and is common practice by conventional growers through the use of wetting agents and mechanical soil amelioration.

3) Soil mineral cycle

Improving soil biology to increase soil nutrient availability to plants through microbiology remains on the radar of conventional growers however there are very limited practices which work to improve this objective. The use of fungicides, residual herbicides and synthetic fertilisers all potentially work against improving the soils mineral cycle.

Increasing root growth or more specifically root depth by reducing hardpans through deep ripping and soil amelioration does work to increase the exchange of sugars/carbon from plants with nutrients from microbes due to plants having larger root mass and being able to interact with a wider source of microbes.

4) Dynamic Eco farming

Similarly to the soil mineral cycle there are very limited practices in conventional farming to increasing the diversity and use of bugs and animals to improve soil structure. There is however a broadscale decline in the use of insecticides by conventional growers with insecticides used more as a cure rather than the traditional prevention method that was the norm previously. There is a general recognition by conventional farmers around the importance of improving diversity however the practices that allow this improvement still need to be developed.

5) Human function

People and communities health and wellbeing will always remain extremely important to both conventional and regenerative growers as without productive landscapes the people and community within them will not be able to be sustained in the long term

Conclusions

There is a general perception outside of the farming community that conventional farmers do not prioritise sustainability and that they are mostly focused on the short term. As outlined above and covered in the ten case studies on growers farming in the Great Southern this perception is incorrect and there is a requirement for the actual priorities of conventional growers to be promoted correctly to the wider community.

Sustainability is one of the key management priorities for all conventional growers with many of the families having been on the properties they operate for many generations with the intention to be there for many more generations in the future. There is a need for the term conventional, industrial or traditional farming to be re-label as these terms all have the implication that the practices being employed by these growers are not developing or evolving which couldn't be further from the truth. Also there is the implication that there is a lack awareness that conventional producers are not concerned about managing the landscape which again is incorrect and in all case studies was demonstrated to be a key priority.

The use of synthetic fertilisers and chemicals is the primary difference between a conventional grower and a regenerative grower. The practices and objectives are otherwise very similar and while conventional growers are well aware of the importance of soil mineral cycle and dynamic eco farming and are working towards practices that promote these functions there remains the global need for sufficient food to be produced to feed the ever growing human population at affordable prices. If all farmers shifted to regenerative farming global food supplies would decline considerably and the access to affordable food as we know it would cease due the marked shift in the supply and demand ratio.

There have been large advances by conventional growers in recent years to protect and promote their landscape function and this will continue into the future.

Soilborne Pathogen Identification and Management Strategies for Winter Cereals Project – Southern Dirt

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Key Messages

- Seasonal conditions influenced the presence and absence of pathogens in the trial. The trial was to concentrate on reducing the impact of the diseases take-all and Rhizoctonia bare patch in cereal crops. The crops sampled showed symptoms of Pythium root rot.
- Technical issues resulted in the final testing not being completed. A new trial will be established in 2022.

Aim

This project aims to provide growers with knowledge and experience in diagnosing soilborne pathogens from symptom expression on plant roots. It will also provide them with knowledge of management of these pathogens and demonstrate some management options in field situations and deliver extension activities nationally.

Background

Despite the significance of the issue, diagnosing soilborne pathogens can be difficult. Currently, the presence or absence of soilborne pathogens can be ascertained through diagnostic services (e.g. PREDICTA® B, and DDLS), through the observation of root symptoms, and to a lesser extent, above-ground crop symptoms. Unfortunately, it has become apparent that growers frequently rely on above-ground crop symptoms to diagnose crop issues.

Above-ground symptoms for soilborne disease diagnosis can be problematic and incorrect for several reasons. Firstly, several of the observable crop symptoms can be similar between different pathogens and plant parasitic nematodes and even other crop issues such as nutrient deficiency. Secondly, some in-crop symptoms of soilborne diseases can be affected by seasonal conditions. For example, last year's higher rainfall reduced the visual symptoms (patches) in the field. Another example, *Rhizoctonia solani* crown root infection can be more prevalent with early sowing but is more difficult for growers to diagnose as there is no typical bare-patch and variation between a crown root infected crop and a healthy crop is not as easily discernible.

Thirdly, some pathogens co-exist and impact cereals in a complex interaction that may increase the complexity of visual identification above and below crop. Reliance on a single method of identification increases the likelihood of incorrect management strategies being implemented, and a holistic approach to identification with all available tools is ideal.

Soilborne disease management differs according to which soilborne disease and/or nematode pests are present, it is reliant on correct identification of the causal pathogen. Grower and advisors need to have the knowledge and experience to be able to achieve this. The purpose of this investment is to extend to growers and advisors the different methods for correctly identifying soilborne pathogens.

This report summarises the 2021 demonstration trial.

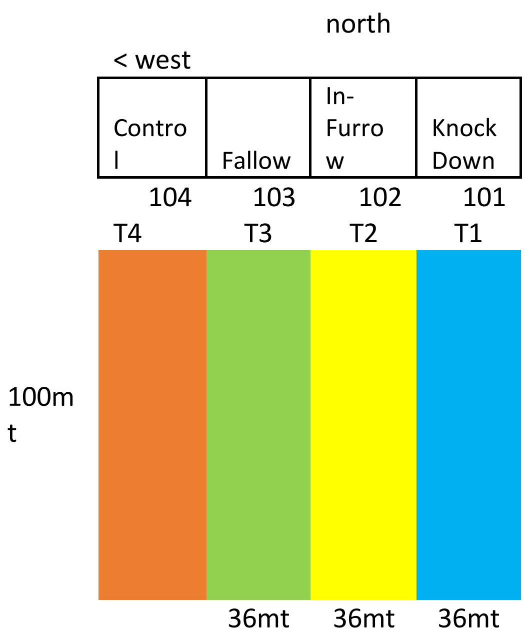
Table 1: Field Trial Details and treatments

Trial Location	Lynford Farms, Williams
Plot size & replication	36m x 100m x 1 replication
Paddock rotation	2018: Fallow, 2019: Fallow, 2020: Fallow
Sowing date	22/6/2021
Sowing rate	100 kg/ha Planet & Roslyn Barley
Fertiliser	22/6/2021: 40 L/ha FlexiN 80 kg/ha MacroPro Plus 13/7/2021: 70 kg/ha Super Phos
Herbicides, Insecticides & Fungicides	22/6/2021: 2 L/ha Trifluralin, 0.1 L/ha Oxyflurofen, 2.4 L/ha Glyphosate, 0.015 L/ha Trojan, 2.5 L/ha Prosulfocarb, 0.2 L/ha Calisto & 0.06 L/ha Evergol Energy
Growing Season Rainfall - Darkan	555.2 mm (April – Oct) Annual rainfall 2021 – 688.2 mm Ave Annual Rainfall (10yr) – 459.7 mm

Treatments

	Crop	Treatment
1	Barley, Planet	Knock-down Glyphosate
2	Barley, Planet	In-furrow fertiliser
3		Fallow
4	Barley, Roslyn	Control

Trial Layout at Williams site for the Soil pathogen project



Results and Discussion

At site selection in April 2021, PREDICTA® B results for the trial area had a high risk of take-all and oat strain take-all (>3.01 log(pg DNA/g soil)), medium risk of rhizoctonia (1.93 log(pg DNA/g soil)), and low risk of *Pratylenchus quasitereoides* (1.4 nematodes/ g soil). The barley (Planet or Roslyn) crop sown, and treatments considered for 2021 focused on rhizoctonia management.

Start of season (Table 1 & 3)

The PREDICTA® B results showed that were medium levels of *Rhizoctonia solani* and take-all DNA present at the start of the season from three treatments (Table 3). Unfortunately, the control sample went missing at start of season sampling. Pythium (clade F) was detected in all three samples (29-156 pg DNA/g sample).

Crop Establishment: Establishment counts were not impacted by the three treatments, ranging from 179 to 192 plants/m^2.

In season plant root assessment (at GS30) for soilborne disease pathogens (Table 2)

Patches were not evident, and 20 plants were collected at random from each of the three barley plots on 16 August 2022.

Rhizoctonia was only detected in the in-furrow fungicide plot, while *Pythium* was detected in all three plots (Table 2). *Pythium* can cause a root rot under very wet conditions. No root lesions nematodes were detected in any of the three plots.

Table 2. Live plant assessment of disease for 2021 Southern DIRT trial in Williams.

Treatments	**Live plant results**		
	Rhizoctonia solani	*Pythium* spp.	*Pratylenchus* spp. number per g of root
Knock Down Glyphosate	Not detected	Detected	Not detected
Uniform coated fertiliser in-furrow	Detected	Detected	Not detected
Roslyn - Control	Not detected	Detected	Not detected

Technical issues resulted in Fallow (Treatment 3) being a highly weedy plot. The control plot was also unfortunately sown to a different variety (Roslyn instead of Planet). No further soil sampling was done at the end of season and grain yield was not recorded.

Table 3. Baseline PREDICTA® B testing at the start of the trial sown in 20221 and at the end of season (not completed). PREDICTA® B risk categories indicate the potential for developing disease in the following season (in parenthesis for each result).

Treatments	**Pathogens detected from initial PREDICTA® B tests (pg DNA/g sample)**			**Pathogens detected from final PREDICTA® B tests (pg DNA/g sample)** [1]		
	Rhizoctonia solani	*Take-all (wheat + oat strains)*	*Pratylenchus quasitereoides*	*Rhizoctonia solani*	*Take-all (wheat + oat strains)*	*Pratylenchus quasitereoides*
Control	missing	missing	missing	-	-	-
Weed plot	48 (Medium)	81 (Medium)	0 (BDL)	-	-	-
Uniform coated fertiliser in-furrow	79 (Medium)	54 (Medium)	0 (BDL)	-	-	-
Knock Down Glyphosate	75 (Medium)	13 (Medium)	2 (BDL)	-	-	-

[1] Three samples were taken at end of season; the average and the range are presented

[2] Below detection limit

[3] Trial abandoned, so data not collected