HART
premier cropping field site

2020

HART TRIAL RESULTS

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Front cover photo by Sandy Kimber.

Thanks also Sandy Kimber, Sarah Noack, Rebekah Allen, Brianna Guidera and Gabrielle Hall for other photos used within this publication.

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Hart 2021 calendar

HART FIELD DAY

September 21

Our main Field Day attracts over 600 visitors from all over the South Australia and interstate.

Every half hour a block of eight sessions are run simultaneously with highly regarded specialists speaking at each trial. A comprehensive take-home Field Day Book is included in the entry fee.

This is Hart's main event of the year.

Hart AGM

October 12

8am via Zoom

All welcome

Please register with Sandy on 0427 423 154

Getting The Crop In

March 10

8am – 12:30pm

At this annual seminar, industry guest speakers from across the county cover a wide range of topics, all relevant to broadacre cropping.

Winter Walk

July 20

9am – 12pm

An informal guided walk around the trial site; the first opportunity to inspect the site post seeding, with guest speakers presenting their observations on current trials.

They are on hand to answer questions and will also share their knowledge on all the latest cropping systems and agronomic updates.

Spring Twilight Walk

October 19

5pm followed by BBQ

Another informal opportunity to inspect the trial site, this time just prior to harvest, again with industry researchers & representatives presenting in the field.

This event is followed by drinks and a BBQ in the shed - a great opportunity to network.

Acknowledgements

The success of our research program could not be achieved without the contribution of a large number of people and organisations.

Supporters

We thank the numerous growers and consultants who provide various contributions, from knowledge and experience through to land and equipment for conducting trials.

Peter Baker
Shawn Cadzow
Chris Clarke
Andrew Cootes
Rob & Dennis Dall
Matt Dare
Mick Faulkner
Leigh Fuller
Wayne Heading
Simon Honner
Peter Hooper
Michael Jaeschke
Brendan Johns
Jim Maitland
Mid North High Rainfall Zone Group
Daniel Neill
Ruben & Gareth Ottens
Anthony Pfitzner
Stefan Schmitt
Stuart Sherriff
Damien & Ben Sommerville
Sam Trengove
Tom & Ashley Robinson
Rob & Glenn Wandel
Anthony Williams
Justin, Bradley & Dennis Wundke

We would also like to thank various organisations for the provision of seed and/or products that were trialed in the 2020 research program.

ADAMA
Advanta Seeds
Australian Grain Export
Australian Grain Technologies
Barenbrug
BASF
Bayer Crop Science
Clare Metal Fabrication
Corteva Agriscience
Crop Care
Durum Breeding Australia
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Site Management

SARDI, Agronomy Clare:
Patrick Thomas, John Nairn, Phil Rundle, Sarah Day, Richie Mould, Navneet Aggarwal, Penny Roberts, Dylan Bruce, Greg Walkley, Amber Spronk, Trevor Lock & Jacob Nicolai.

Hart Field-Site Group:
Rebekah Allen, Sarah Noack & Brianna Guidera

Our guiding principles

OUR PURPOSE

To deliver value to growers and make agriculture better

(in productivity, sustainability & community)

OUR VISION

To be Australia’s premier cropping field site, providing independent information and enhancing the skills of the agricultural industry

---

OUR VAULES

Independence

in order to provide unbiased results

Relevance

to issues facing farmers

Integrity

in all dealings

Credibility

through providing reliable, quality information

Professionalism

in the management of the site and presentation of trials

Value for money

low cost of information to farmers

Hart management

Hart Field-Site Group board

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Or find out more about us…

HART
SA's premier cropping field site

Hart Field Day

September 21, 2021

www.hartfieldsite.org.au

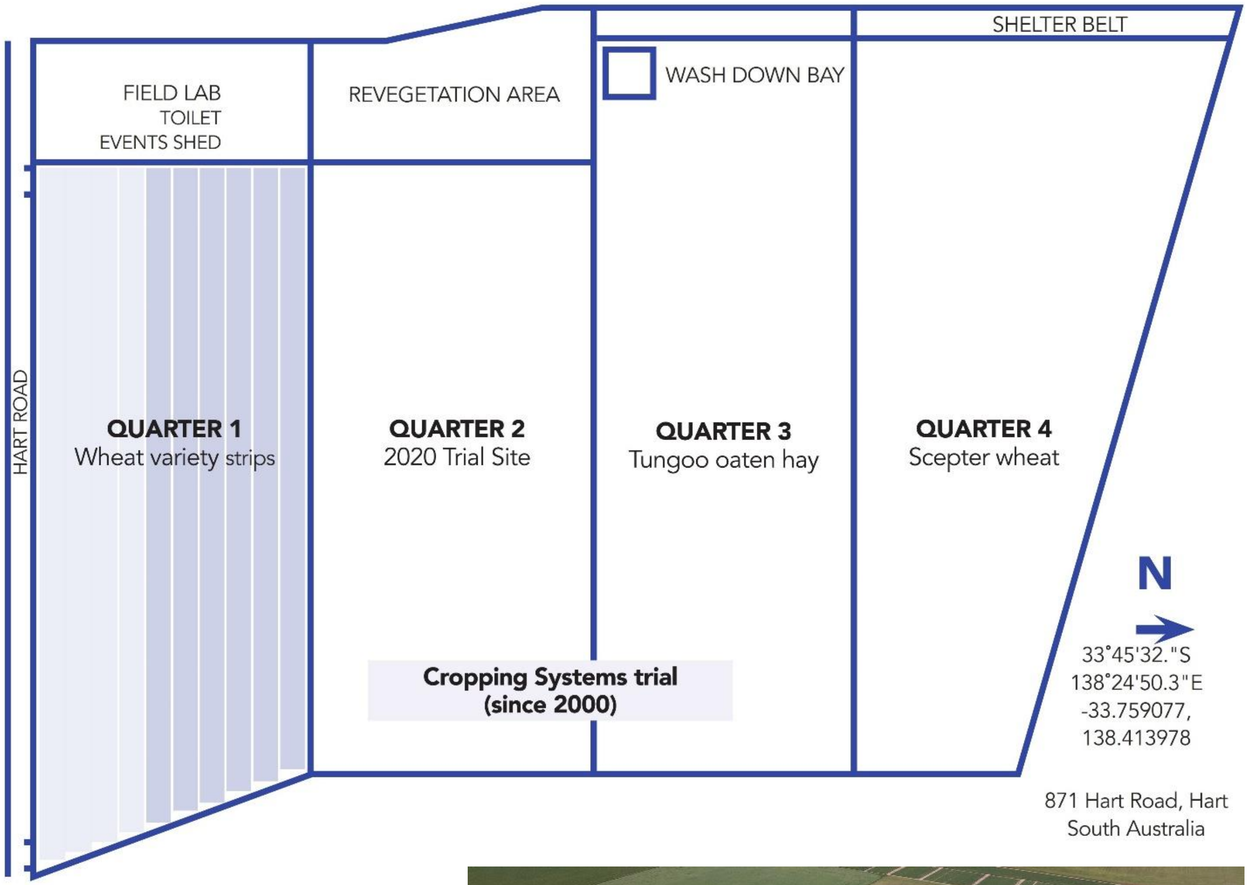
The Hart site

The Hart field site (40 ha owned by the group) is managed as four quarters that are rotated each year.

In 2020, Quarter 2 hosted our trials.

Quarter 3 was sown with Tungoo oats and was cut for hay to tidy the site in preparation for 2021 trials.

Quarters 1 and 4 were sown with wheat as our commercial crop.
**Quarter 1 included a wheat variety demonstration strip.*



Hart field site 2020 - Quarter 2.

Hart commercial crop report

Matt Dare; Hart Field-Site Group

This season's commercial crop was sown to Scepter wheat in Quarters 1 & 4 on May 29 (for more Q1 information, see next page).

Quarter 3 of the site and the car park (8 ha) was sown to Tungoo oats for hay on May 29 in preparation for the 2021 trial site. Seed was kindly donated by local grower Jim Maitland. Also thanks to Rob Wandel for rolling the hay.

Nitrogen was applied to Quarter 1 as 100 kg/ha urea on July 10 and was applied to Quarter 4 at 70 kg/ha on August 10. Thanks to Jim Maitland for spreading Quarter 1.

Russian wheat aphid has been present in the commercial crop and a selective insecticide was applied recently with the broadleaf herbicide.

The commercial crop was harvested on December 9 by Justin Wundke and yielded 2.65 t/ha (H2).

The whole site was sprayed by Rob Wandel in early January for summer weed control.

Quarter 1 - 8ha Commercial wheat crop - wheat variety strips x 2 TOS

	TOS1	TOS2
Spray:	April 27, 2020 1.5 L/ha Glyphosate 520 g/L + 100 ml/ha Striker + 210 ml/ha SakuraFlow + 1% AmmSulfate v/v +0.25% LI700 v/v @ 100 L/ha	May 27, 2020 2 L/ha Glyphosate 520 g/L + 100 ml/ha Striker + 160 ml/ha Dicamba750 + 3 L/ha Prosulfocarb + 2% AmmSulfate v/v +0.4% LI700 v/v @ 100 L/ha
Seeding date:	April 27, 2020	May 29, 2020
Crop & Variety:	wheat variety strips	
Seeding rate:	75 kg/ha	100 kg/ha
Fertiliser:	75 kg/ha DAP	
Post Em Spray: June 26, 2020	Spray ~ 5 ha early sown wheat varieties in Q1. 25 g Paradigm + 470 ml MCPA LVE 570 g/L + 75 ml Dicamba 750 g/L + 0.5% Uptake Oil @ 85 L/ha	
Post Em Nitrogen spread: July 10, 2020	100 kg/ha Urea spread on Q1 (7.43ha) by Jim Maitland	
Post Em Spray: August 26, 2020	Spray ~ 3 ha late sown wheat varieties in Q1. 25 g Paradigm + 500 ml MCPA LVE 570 g/L + 200 g Pirimicarb + 500 ml Epoxiconazole + 0.5% Uptake Oil @ 85 L/Ha	
	Spray ~5 ha early sown wheat varieties in Q1. 200 g Pirimicarb + 500 ml Epoxiconazole	

Quarter 2 - 8 ha 2020 trial site

Quarter 3 - 8 ha Oaten hay (2021 trial site & carpark)

Spray: May 27, 2020
2.0 L/ha Glyphosate 520 g/L + 100 ml/ha Striker + 2% AmmSulfate v/v + 0.4% LI700 v/v @100 L/ha

Seeding date: May 29, 2020	**Crop & Variety:** Tungoo oats (donated by Jim Maitland)
Seeding rate: 100 kg/ha	**Fertiliser:** 50 kg/ha DAP

Quarter 4 - (incl. east of Crop systems trial) 10 ha Scepter wheat

Spray: May 27, 2020 - 2 L/ha Glyphosate 520 g/L + 100 ml/ha Striker + 160 ml/ha Dicamba 750 + 3L/ha Prosulfocarb + 2% AmmSulfate v/v +0.4% LI700 v/v @ 100 L/ha

Seeding date: May 29, 2020	**Crop & Variety:** Scepter wheat	**Seeding rate:** 100 kg/ha
Fertiliser: 70 kg/ha DAP	**Post Em Nitrogen spread:** August 10, 2020 70 kg/ha Urea spread	

Post Em Spray: August 26, 2020 25 g Paradigm + 500 ml MCPA LVE 570 g/L + 200 g Pirimicarb + 500 ml Epoxiconazole + 0.5% Uptake Oil @ 85 L/ha

Quarter 1 – more information

Wheat variety strips were sown in Quarter 1 on April 27 (Figure 1). In addition, Scepter and a strip of Vixen was sown on May 29.

They were sown as a broad acre demonstration of a range of longer season wheat varieties better suited to earlier (April) sowing in terms of maturity and flowering time.

Early sown variety strips established well in adequate available soil moisture. The later sown Scepter experienced some moisture stress prior to August rain.

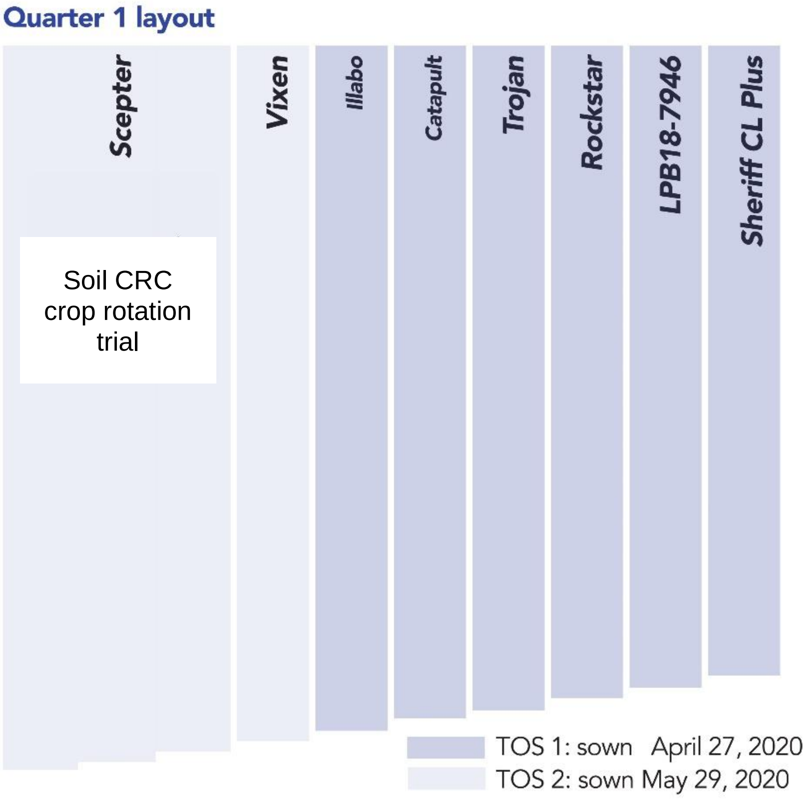


Figure 1. Wheat demonstration strips; varieties sown in 2020.

Thanks to seed company reps Josh Reichstein (Inter Grain), Dan Vater (AGT) and Col Edmondson (Pac-Seeds) for organising seed for the variety strips in Quarter 1.

The 2020 season at Hart; rainfall, temperature and soil analysis

Rebekah Allen and Brianna Guidera; Hart Field-Site Group

The Mid-North had a promising start to the season receiving above average summer rainfall (Figure 1). This meant there was an increase in stored soil moisture available leading into the growing season (Figure 2).

Seeding at Hart commenced on April 20, utilising an optimal sowing window for early sown wheats. The majority of Hart's trial program was sown early to mid-May, with the final plots sown on May 29.

The site received above average rainfall during April, with 60 mm. Although there was an optimistic start to the seeding program, well below average rainfall of 19 mm was received for May (Table 1) affecting early crop establishment in some trials. Rainfall received on site for both June and July was well under average, with a combined total of 38.4 mm. Temperatures were also mild during winter months (Figure 3). These dry conditions resulted in many trials progressing quickly from early vegetative stages to reproductive phases.

August rainfall relieved crops from both moisture and nitrogen stress with a total of 67.5 mm rainfall (Figure 4). Above average rainfall was received in September and October, bringing Hart's growing season rainfall to a decile 7 with 336 mm.

Annual rainfall received was 503 mm, placing Hart at a decile 9 for the year. This was significantly higher when compared to 2019 when an annual rainfall of 189.2 mm (decile 1) was recorded.

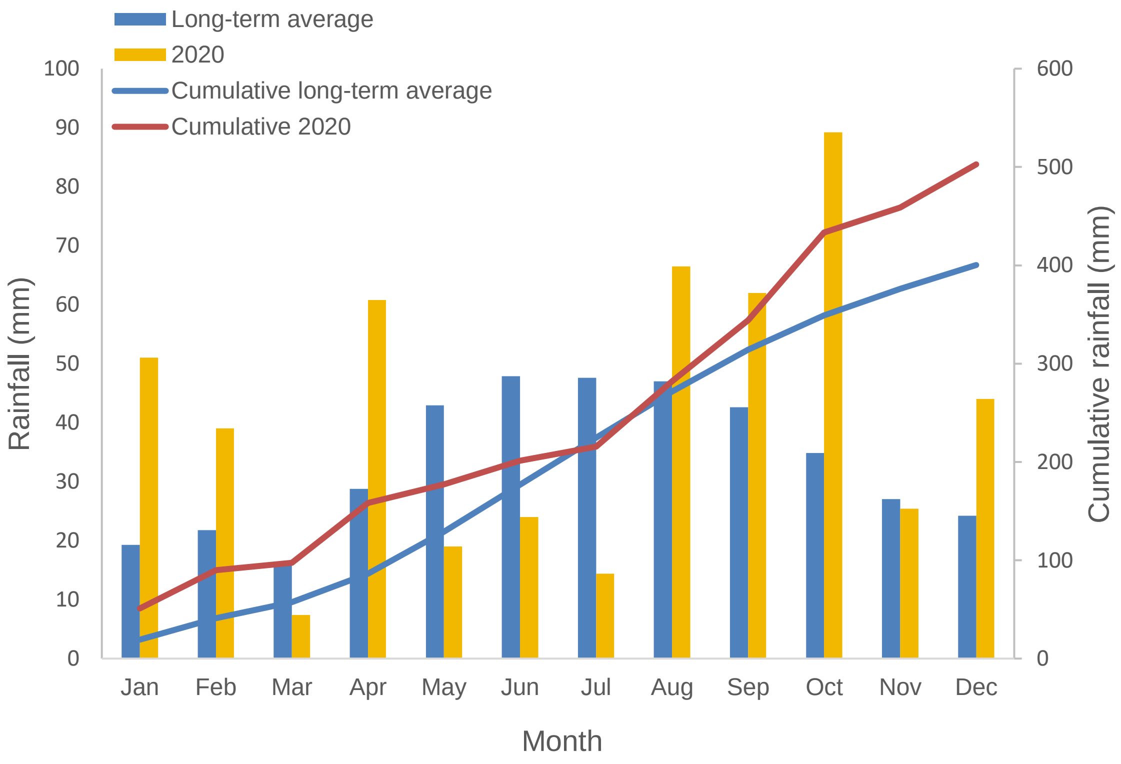


Figure 1. Hart rainfall graph for the 2020 season and long-term average. Lines are displayed to present cumulative rainfall for long-term average (blue) and 2020 (red).

Table 1. Hart rainfall chart 2020 (AgByte weather station and Mesonet).

	January	February	March	April	May	June	July	August	September	October	November	December
1	0	38	1.4	0	1.6	1.6	0	0	0	0	0	8.6
2	0	0	0	0	5.4	0.4	0	0	0	0	0	0.2
3	0	0	0.2	10.4	0	0.8	2.2	0	0	0	0	0
4	0	0	0	4	0	0	2.6	0	0	0	0	0
5	5.8	0	0	2.8	0	0	0.4	0	0	19.4	3.4	4
6	0	0	0	0	0	0	0.4	0	0	0	0	16
7	0	0	0	0	0	0	0	0	0	8.8	0	2.2
8	0	0	0	0	0.2	0	0	0	0.2	11.8	0	0.6
9	0	0	0	0.8	1	0	0	0	0.4	0.2	0	0
10	1.4	0	0	0	3.8	0	2.8	0	0	0	0	0
11	0	0	0	0	0.2	0	4	0	0	0	12	0
12	0	0	0	0	0	0	0.2	23	1.9	0	0	0
13	0	0	0	0	0	4.6	0.4	5	3.3	0	0.4	0
14	0	0.8	0	0	0	0	0.4	11.5	0	0	0	0
15	0	0.2	0	0	0	0	0	0	0.1	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	6.2
17	0	0	0	0	0	0	0	10.8	0	4.8	0	0
18	0	0	0	4	0	0	0	0	0	0	0	0
19	1.6	0	0	0	0	0	0	0	3.8	0	0	0
20	2.6	0	0	0	1.4	3.6	0	0	1.3	0	0	0
21	0	0	0	0	0.2	11.6	0	0	0.6	0	0	5.4
22	0	0	0	0	1.2	0.5	0	0	1	0	0	0.8
23	0.2	0	0	7.6	3.6	0.6	0	0	8	8	9.2	0
24	0	0	5.4	0	0	0	0.2	16	1.3	13.4	0	0
25	0	0	0	8.4	0	0.3	0	0	9.2	0	0	0
26		0	0	6	0	0	0	0	0.6	0	0	0
27	0	0	0	0	0	0	0.8	0	0	0.4	0	0
28	0	0	0	0	0	0	0	0.2	0	0	0	0
29	0	0	0.4	7.4	0	0	0	0	17	0	0.4	0
30	0		0	9.4	0.4	0	0	0	13.3	21.8	0	0
31	39.4		0		0		0	0	0	0.6	0	0
Montly total	**51.0**	**39.0**	**7.4**	**60.8**	**19.0**	**24.0**	**14.4**	**66.5**	**62.0**	**89.2**	**25.4**	**44.0**
GSR rainfall				60.8	79.8	103.8	118.2	184.7	246.7	335.9		
Total rainfall	51.0	90.0	97.4	158.2	177.2	201.2	215.6	282.1	344.1	433.3	458.7	502.7

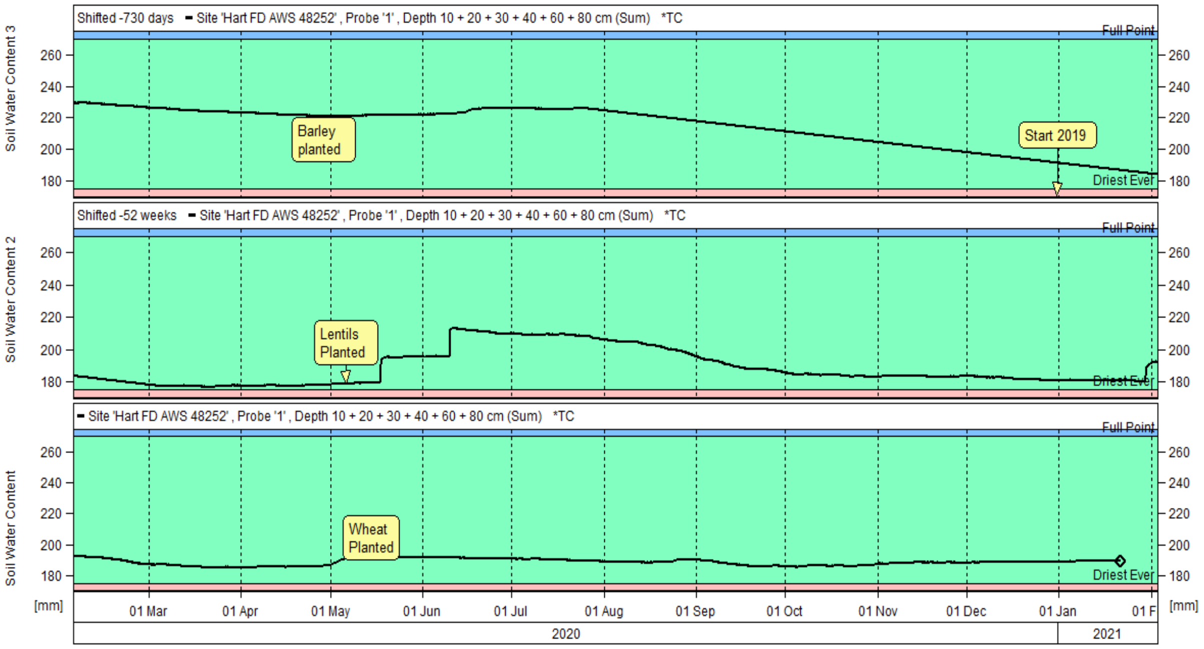


Figure 2. Soil moisture probe summed comparison (80cm) for 2018 (top), 2019 (middle) and 2020 (bottom) at the Hart Field-Site.

Hart soil moisture data is free to view courtesy of Agbyte:
http://www.hartfieldsite.org.au/pages/live-weather/soil-moisture-probe.php

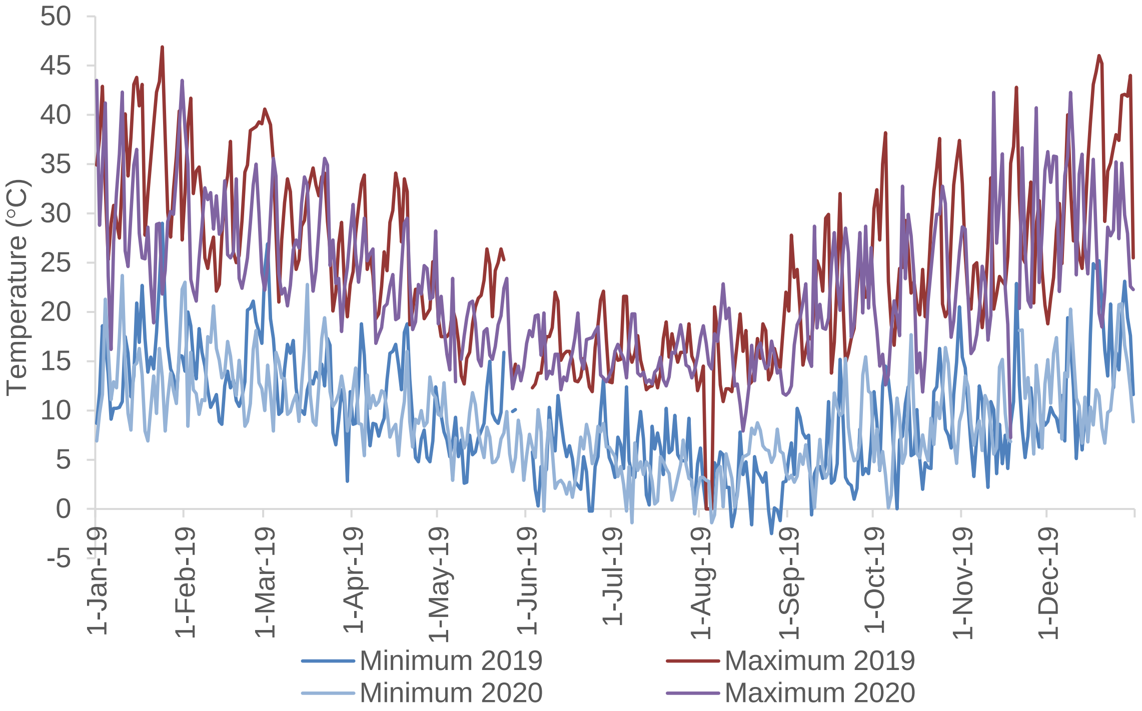


Figure 3. Daily minimum and maximum daily temperature (°C) from January 1 to December 30 at Hart in 2019 and 2020.

Table 2. Actual soil physical and chemical properties for the Hart field site, sampled April 24, 2020. Note: Soil profile depth at Hart is 75-105 cm; however, below properties are to 30 cm only.

		Sampling depth (cm)			
Soil property	**Units**	**0-10cm**	**10-20cm**	**20-30cm**	**Total profile (0-60cm)**
Texture		Loam	Clay loam	Clay loam	Loam - clay loam
Gravel	%	0	0	0	
Phosphorus Colwell	mg/kg	31	11	8	
Potassium Colwell	mg/kg	605	322	230	
Available soil N	kg/ha				53
Sulphur	mg/kg	10	8.4	9.7	
Organic carbon	%	1.8	1.1	0.9	
Conductivity	dS/m	0.21	0.19	0.23	
pH ($CaCl^2$)		7.6	7.8	7.2	

Yield Prophet® performance in 2020

Brianna Guidera, Rebekah Allen and Sarah Noack; Hart Field-Site Group

Key findings

- Yield Prophet® predictions for wheat grain yield at Hart in 2020 were less accurate when compared to previous years, predicting 1.93 t/ha above actual yield.
- Although Hart had a wet spring finish, both moisture and nitrogen were limiting factors to grain yield due to below average winter rainfall. Differences between the 20%, 50% and 80% yield probabilities in the final simulation (October) were small.

Why do the trial?

Wheat growth models such as APSIM are highly valuable in their ability to predict wheat yield.

Yield Prophet® is an internet-based service using the APSIM wheat prediction model. The model relies on accurate soil character information such as plant available water (PAW) and soil nitrogen (N) levels, as well as historical climate data and up to date local weather information to predict plant growth rates and final hay or grain yields.

This early prediction of grain yield potential means it can be used to directly influence crop input decisions. No other tool is currently available to growers, which can provide information of this accuracy at such a useful time of the season.

How was it done?

Seeding date	May 1, 2020	**Fertiliser**	May 1: 30 kg N/ha
Variety	Scepter wheat @ 180 plants per square metre		July 10: 20-40 kg N/ha

Yield Prophet® simulations were run throughout the season to track the progress of wheat growth stages and changes in grain yield predictions. This data was published for 8 sites across the Mid-North in Hart's Hart Beat Newsletter.

The 20%, 50% and 80% levels of probability refer to the percentage of years where the corresponding yield estimate would have been met, according to the previous 100 years of rainfall data.

Soil at the Hart field site ranges from a loam to clay-loam texture (0-30 cm) and provides moderate infiltration and PAW (Table 1). The starting available soil N into Yield Prophet® was 63 kgN/ha.

Results

The first simulation on June 22 predicted wheat sown on May 1 would yield 4.35 t/ha in 50% of years. In 20% of years the same crop would yield 5.15 t/ha, and in 80% of years, 2.95 t/ha (Figure 1). The 50% yield prediction in June and July was high due to above average April rain and moisture stored in the profile (Figure 2).

With well below average rainfall for May, June and July and stored moisture used by the crop by the August 19 prediction, wheat grain yield was reduced to 2.85 t/ha in 50% of years (Figure 2). By this date, 66 mm of rainfall had been received since the first simulation in June. Growing season rainfall totalled 168 mm. Plant available water had decreased to 33 mm (Figure 3), which reduced crop N uptake.

After receiving above average rainfall in late August, the simulation on September 2 predicted a grain yield of 3.55 t/ha in 50% of years. The final simulation on October 21 predicted a grain yield of 4.45 t/ha in 50% of years, 4.55 t/ha in 20% of years and 4.40 t/ha in 80% of years (Figure 1). This increase in predicted grain yield was attributed to high rainfall received late in the season (late August – October). Growing season rainfall was close to the long-term average for Hart at 300 mm and PAW at 78 mm (Figure 2). The yield predictions reflected the wet finish to the growing season.

Scepter wheat at Hart in 2020 yielded below the 50% predicted yield at 2.52 t/ha. The differences between the simulation and actual yield can be attributed to the inability of the model to predict yields under a dynamic season of wet-dry-wet conditions reducing actual N uptake, crop access to soil moisture and utilising these for growth. Across the district, many growers also noted varieties matured quicker when compared to previous seasons.

A model of predicted and actual yields at Hart over nine years (2012-2020) shows that there is a moderate to strong correlation between Yield Prophet® predictions and observed yields. Over nine years, 77% of yields at Hart were close to those predicted by Yield Prophet® (Figure 3).

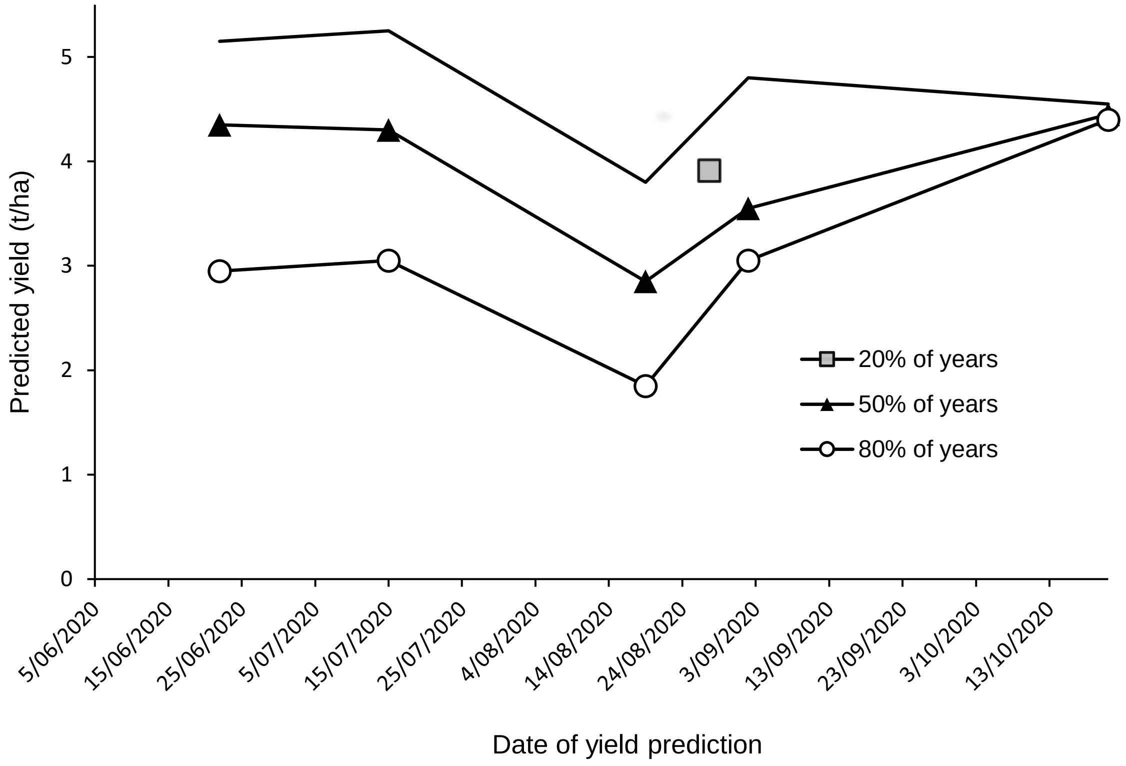


Figure 1. Yield Prophet® predicted yields at 20%, 50% and 80% probabilities at Hart, 2020.

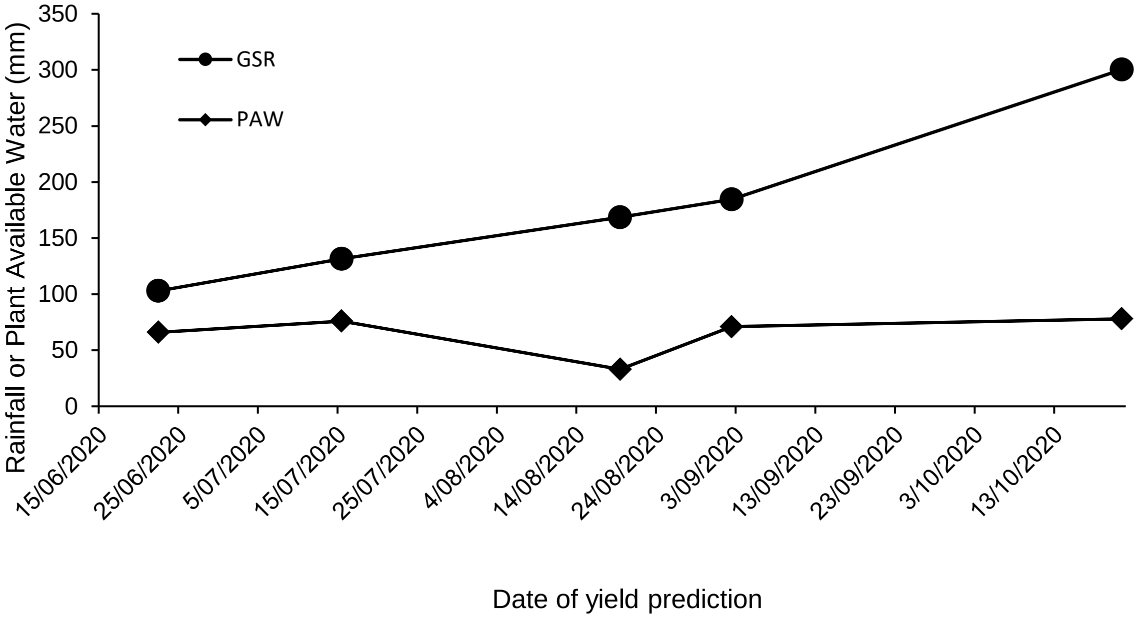


Figure 2. Growing season rainfall (GSR) and plant available water (PAW) on simulation dates at Hart in 2020.

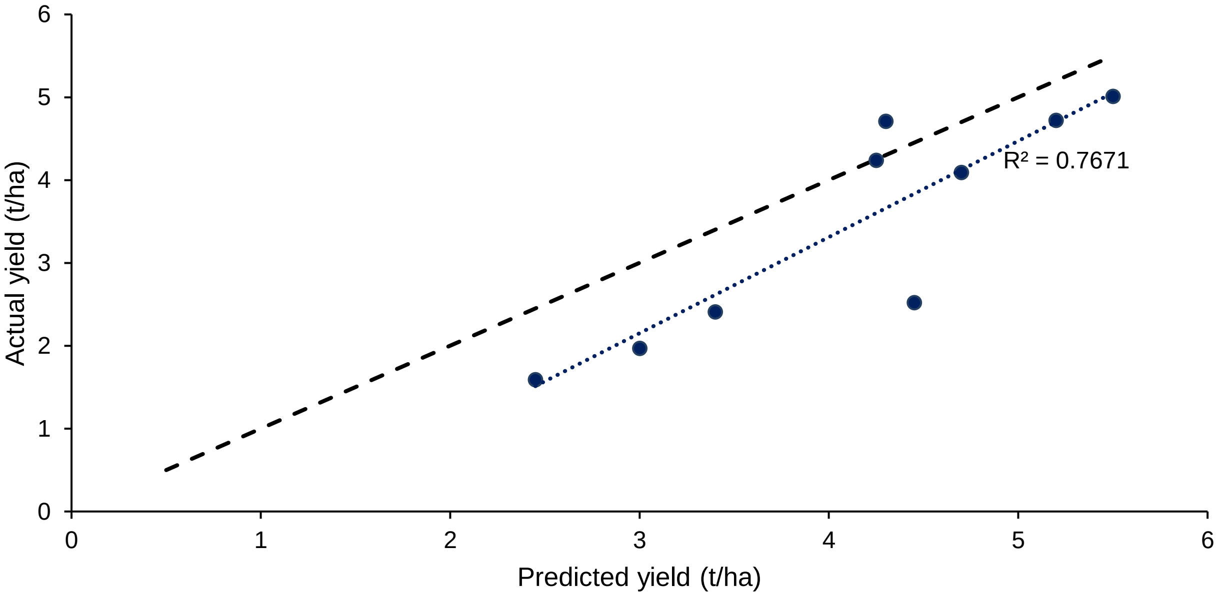


Figure 3. Relationship between Yield Prophet® predicted yields and observed yields at Hart across nine seasons (2012 – 2020). Predicted yields have been generated from August simulations.

Acknowledgements

The Hart Field-Site Group would like to thank Andrew Cootes, Daniel Neill, Justin Wundke, Rob Dall, Kelvin Tiller, Damien Sommerville, Anthony Pfitzner and the Mid North High Rainfall Zone Group for providing weather data and paddocks for soil sampling in 2020, which allows us to run these simulations in our Hart Beat newsletters.

HART BEAT - yield predictions through the growing season for 8 Mid-North sites

HART

BEAT

Yield Prophet® simulations for 8 sites across the Mid-North of SA

Definitions | Site information

Hart | Spalding | Condowie
Kybunga | Farrell Flat | Pinery
Eudunda | Tarlee

Plus...
How you can access more Hart research in 2020

ISSUE 54
October 21, 2020

VIEW & SUBSCRIBE ON THE HART WEBSITE

The *HART BEAT* newsletter, first introduced in 2009, is an initiative of the Hart Field-Site Group.

It is aimed at providing farmers and agronomists with regular updates of current and predicted crop and soil conditions as a season progresses.

We believe it will assist in making informed choices on the need for additional nitrogen and fungicide applications.

The Yield Prophet® simulations featured are not a crystal ball but provide a realistic prediction of the available soil water and nitrogen status of your crop.

Current (and historical) editions are all available online now, for free:

www.hartfieldsite.org.au

Interpretation of statistical data

The results of replicated trials are presented as the average (mean) for each of the replicates within a treatment.

Authors generally use ANOVA, in which the means of more than one treatment are compared to each other. The least significant difference (LSD $P \leq 0.05$), seen at the bottom of data tables gives an indication of the treatment difference that could occur by chance. NS (not significant) indicates that there is no difference between the treatments. The size of the LSD can be used to compare treatment results and values must differ by more than this value for the difference to be statistically significant.

So, it is more likely (95%) that the differences are due to the treatments, and not by chance (5%). Of course, we may be prepared to accept a lower probability (80%) or chance that two treatments are different, and so in some cases a non-significant result may still be useful.

Interpretation of replicated results: an example

Here we use an example of a replicated wheat variety trial containing yield and grain quality data (Table 1). Statistically significant differences were found between varieties for both grain yield and protein. The LSD for grain yield of 0.40 means there must be more than 0.40 t/ha difference between yields before that variety's performance is significantly different to another. In this example Trojan is significantly different to all other varieties as it is the only variety followed by a superscript (a). Scout, Mace and Cosmick are not significantly different from each other and are all followed by a superscript (b) as they all yielded within 0.4 t/ha of each other.

Similarly, for grain protein a varieties performance was significant from another if there was more than 0.9% difference in protein. In the example, Arrow contained a higher protein level compared to all other varieties which were not different to one another.

Where there are no significant differences between treatments, NS (not significant) will be displayed as seen in the screenings column (Table 1).

Table 1. Wheat variety grain yield, protein and screenings from a hypothetical example to illustrate interpretation of LSD.

Variety	**Grain yield (t/ha)**	**Protein (%)**	**Screenings (%)**
Arrow	3.50^{c}	10.3^{a}	0.2
Cosmick	3.98^{b}	8.4^{b}	1.0
Mace	3.75^{bc}	9.1^{b}	0.5
Scout	4.05^{b}	8.9^{b}	0.9
Trojan	4.77^{a}	8.4^{b}	0.4
LSD ($P \leq 0.05$)	0.40	0.9	NS

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Comparison of wheat varieties

Rebekah Allen; Hart Field-Site Group

Key Findings

- The average wheat grain yield at Hart this season was 2.5 t/ha.
- The highest yielding AH varieties were Emu Rock, Vixen, Devil, Rockstar, Mace, Scepter, LongReach Scout, Hammer CL Plus and Catapult ranging between 2.49 – 2.77 t/ha.
- Sheriff CL Plus and Chief CL Plus were the highest yielding APW varieties, yielding 2.50 t/ha and 2.82 t/ha respectively.
- Grain test weight and screenings across all varieties averaged 83.1 kg/hL and 2.8%.

Why do the trial?

To compare the performance of new wheat varieties alongside current industry standards.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 1% Zn + Impact @ 80 kg/ha
Seeding date	May 6, 2020		Easy N (42.5:0) 80 L/ha on June 18, 2020
Location	Hart, SA		Easy N (42.5:0) 50 L/ha on August 5, 2020
Harvest date	November 26, 2020		

The trial was a randomised complete block design with three replicates and 18 wheat varieties. This trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy. All plots were assessed for grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%). The in-season nitrogen budget was managed to target a wheat grain yield of 2.5 t/ha.

Results and discussion

Wheat grain yields at Hart this season ranged from 1.86 – 2.82 t/ha across all varieties with a trial average of 2.5 t/ha (Table 1). The highest yielding Australian Hard (AH) varieties were Emu Rock, Vixen, Devil, Rockstar, Mace, Scepter, LongReach Scout, Hammer CL Plus and Catapult.

Long-term yield data (Table 2) shows that the varieties Scepter and Scout have consistently yielded above the trial average over five seasons. Newer varieties Vixen, Devil, Rockstar and Catapult have also performed well across multiple seasons of evaluation at Hart.

Sheriff CL Plus and Chief CL Plus were the highest yielding Australian Premium White (APW) varieties, yielding 2.50 t/ha 2.82 t/ha respectively. Long-term yield data for the APW varieties trialed at Hart is variable. Nighthawk, Cutlass and Trojan are longer season spring wheats and historical data shows Cutlass and Trojan have performed well in three out of five seasons. Newer varieties still need further evaluation across a range of season at Hart.

Wheat protein levels for all varieties ranged between 10.3% and 13.1%. All AH varieties were below AH1 receival standards (>13%) with APW and ASW varieties meeting protein requirements (>10.5%).

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) for wheat varieties at Hart in 2020. Values shaded within each column show the highest performing varieties.

Quality	**Variety**	**Grain yield t/ha**	% of site average	**Protein %**	% of site average	**Test Weight kg/hL**	% of site average	**Screenings %**	% of site average
AH	Ballista ⓓ	2.38	95	10.3	89	81.6	98	3.4	120
	Catapult ⓓ	2.68	107	11.2	97	84.0	101	2.8	98
	Devil ⓓ	2.74	109	10.9	94	82.9	100	3.6	126
	Emu Rock ⓓ	2.77	111	12.5	108	83.8	101	2.1	74
	Hammer CL Plus ⓓ	2.66	106	12.0	103	83.6	101	2.5	90
	LongReach Scout ⓓ	2.65	106	11.4	99	84.8	102	3.1	109
	Mace ⓓ	2.49	99	11.8	102	84.0	101	2.0	72
	Rockstar ⓓ	2.70	108	10.8	93	82.6	99	3.3	117
	Scepter ⓓ	2.52	101	11.1	96	83.9	101	3.4	120
	Vixenⓓ	2.72	109	11.6	100	81.8	98	2.9	103
	AH1 receival standard			>13.0		>76		<5.0	
APW	Chief CL Plus ⓓ	2.82	113	12.0	104	82.3	99	2.4	84
	Cutlass ⓓ	2.02	81	11.6	100	83.3	100	2.4	86
	Grenade CL Plus ⓓ	2.33	93	12.0	103	82.1	99	2.2	79
	Nighthawk ⓓ	1.86	74	13.1	113	81.3	98	3.2	115
	Sheriff CL Plus ⓓ	2.50	100	11.4	98	82.6	99	3.2	112
	LongReach Trojan ⓓ	2.34	93	11.4	98	84.0	101	3.5	123
	APW1 receival standard			>10.5		>76.0		<5.0	
ASW	Razor CL Plus ⓓ	2.45	98	11.9	103	83.8	101	2.3	81
	ASW1 receival standard			>10.5		>76		<5.0	
Unclassified	LRPB- 2485	2.45		11.4	98	83.9	101	2.6	91
	Site Average	2.50	100	11.6	100	83.1	100	2.8	100
	LSD (P≤0.05)	0.37		ns		0.95		0.95	

The soil available nitrogen at Hart pre-seeding was 53 kg N/ha (0-60 cm) after oaten hay in 2019.

The nitrogen budget consisted of an additional 70 kg N/ha applied at seeding and throughout the growing season, targeting a grain yield of 2.5 t/ha. Grain yield potential was impacted by a dry winter profile; however, it is likely that the late application of nitrogen in August increased grain protein with spring rainfall of 177 mm.

Grain test weights averaged 83.1 kg/hL across all varieties, ranging between 81.3 – 84.8 kg/hL. All varieties were above 76 kg/hL (minimum required for maximum grade). Trial screenings were also low with all varieties below 5%.

Table 2. Long-term wheat variety performance at Hart (expressed as % trial average).

		% trial average					Grain yield (t/ha)
Quality	**Variety**	**2016**	**2017**	**2018**	**2019**	**2020**	**2020**
AH	BallistaⓅ (RAC2598)					95	2.38
	CatapultⓅ				97	107	2.68
	DevilⓅ				104	109	2.74
	Emu RockⓅ	99	98	104	104	111	2.77
	Grenade CLPlusⓅ	96	95	110	93	93	2.33
	Hammer CL PlusⓅ					106	2.66
	MaceⓅ	94	102	95	95	100	2.49
	RockstarⓅ				104	108	2.70
	ScepterⓅ	106	111	113	106	101	2.52
	LongReach ScoutⓅ	103	107	107	107	106	2.65
	VixenⓅ				111	109	2.72
APW	Chief CL PlusⓅ			87	85	113	2.82
	CutlassⓅ	119	104	117	98	81	2.02
	LongReach TrojanⓅ	121	113	106	102	94	2.34
	NighthawkⓅ					74	1.86
	Sheriff CL PlusⓅ				96	100	2.50
ASW	Razor CL PlusⓅ		103	104	109	98	2.45
Unclass	LPB15-2485				98	98	2.45
	Trial average yield (t/ha)	**3.87**	**3.83**	**2.13**	**1.50**	**2.50**	
	Sowing date	May 10	May 8	May 14	May 15	May 6	
	Apr-Oct rain (mm)	356	191	160	162	336	
	Annual rain (mm)	485	331	224	189	503	

Acknowledgements

The Hart Field-Site Group would like to acknowledge InterGrain, Australian Grain Technologies (AGT) and Pacific Seeds for providing wheat seed to conduct this trial.

Early sown winter and awnless wheats

Sarah Noack, Rebekah Allen & Brianna Guidera; Hart Field-Site Group

Key Findings

- This season, highest yields were achieved from early May sowing with Scepter and Catapult at 3.03 and 2.92 t/ha, respectively.
- Long season spring and winter wheats were unable to match the yield of Scepter sown in its optimal window at Hart this season.
- Breeding line LPB18-7982 was the highest yielding (2.66 t/ha) awnless variety trialed.

Why do the trial?

Early sown winter wheats

The recent GRDC 'Management for Early Sown Wheats' investment had a number of outcomes for low-medium rainfall farmers in the southern region. Some of the key learnings were (Porker et al 2019):

- For sowing prior to April 20, winter varieties are required, particularly in regions of high frost risk.
- Winter wheats will not progress to flower until their vernalisation requirement is met (cold accumulation) whereas spring varieties will flower too early when sown early. The longer vegetative period of winter varieties also opens opportunities for grazing.
- Winter wheat varieties allow wheat growers in the southern region to sow much earlier than currently practiced, meaning a greater proportion of farm can be sown on time.

From 2017—2019 at Hart, this project demonstrated winter varieties flowered within a period of 7-10 days across all sowing dates, whereas spring varieties were unstable and ranged in flowering dates over one month apart. Across three seasons, the mid developing winter wheats such as Illabo and Kittyhawk were best suited to achieve the optimum flowering period of September 15-25 for Hart.

During the three years of this investment an early break was not received (that is, all plots were irrigated with 10 mm to achieve germination). The aim of the trial this season was to evaluate winter and spring wheats under field conditions prior to Anzac Day (April 25) and early May if rainfall was received.

Awnless wheats

A management tactic to reduce wheat production risk in frosty areas is the use of awnless varieties. These dual-purpose wheats can be grazed, made into hay in frost events or taken to grain yield. Breeding investment into awnless varieties has been limited over the past decade. Orion, the most commonly grown awnless variety in the Mid-North, was released over 10 years ago. Growers are seeking new awnless varieties with hard classification to given them a hay-cutting option without awns, but a hard wheat option when the season is right. The aim of this trial was to evaluate new awnless wheat varieties from the LongReach Plant Breeding compared to current commercial standards.

How was it done?

Plot size	1.75 m x 10.0 m
Seeding date	TOS 1 – April 20 TOS 2 – May 6
Location	Hart, SA
Harvest date	November 26, 2020
Fertiliser	DAP (18:20) + 1% Zn + Impact @ 80 kg/ha at seeding TOS 1 Urea (46:0) @ 100 kg/ha June 19 + Easy N (42.5:0) @ 50 L/ha August 5 TOS 2 Urea (46:0) @ 100 kg/ha July 10 + Easy N (42.5:0) @ 50 L/ha on August 5

The trial was a split plot block design with three replicates and nine wheat varieties. Varieties were selected based on development speed and newly released / bred lines (Table 1). The trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy.

Awnless varieties were assessed for dry matter production (t/ha) by sampling 4 x 1 m sections of row at watery ripe (GS71) for each variety. Plant samples were oven dried at 60°C for 48 hours and weighed. All plots were assessed for grain yield (t/ha) and quality.

Table 1. Summary of wheat varieties, including development and quality.

Variety	Release year	Company	Development	Quality	Awnless
Illabo	2018	AGT	Mid-fast winter	AH	N
DS Bennett	2018	Dow	Mid-slow winter	ASW	Y
Nighthawk	2019	LRPB	Very slow spring	APW	N
Catapult	2019	AGT	Mid-slow spring	AH	N
Denison	2020	AGT	Slow-very slow spring	APW	N
Orion	2010	LRPB		ASFT	Y
LPB18-7982	2022 (?)	LRPB	Mid-slow spring*	?	Y
LPB18-7946	2021 (?)	LRPB	Slow spring*	?	Y
Scepter	2015	AGT	Fast spring	AH	N

**provisional development rating*

Results and discussion

Winter wheats

This season, highest yields were achieved from early May sowing with Scepter (optimal sowing window) and Catapult at 3.03 and 2.92 t/ha, respectively. The remaining winter and long season spring wheats were unable to match the yield of Scepter sown in its optimal window (Table 2). This is in contrast to previous years at Hart, where Illabo (winter wheat) and Nighthawk (very slow spring wheat) were able to match Scepter yields (Porker *et al.* 2019). This season, varieties, in particular winter wheats matured 7-10 days earlier than normal in the Hart area. Daily temperatures in May and June were slightly cooler (see ‘The 2020 season at Hart; rainfall, temperature and soil moisture’; page 13 of this publication) and vernalisation was saturated earlier than expected, resulting in flowering times outside the optimal window.

Grain yields were also lower at Hart in 2020 compared to previous year’s research. A faster maturing variety such as Longsword may have been better suited to this season.

Despite this outcome, previous research (>20 trials) has shown the best performing winter wheats can yield similar to the fast-developing spring variety Scepter sown at the optimal time (Porker *et al.* 2019).

Table 2. Dry matter (t/ha) and grain yield (t/ha) for wheat varieties trialed at Hart, 2020. Numbers appended by different letters within the grain yield columns are different from each other.

Variety	**April 20**	**May 6**	**April 20**	**May 6**
	Dry matter (t/ha)		Grain yield (t/ha)	
Catapult			2.13^{def}	2.92^{ab}
Denison			1.91^{ef}	2.43^{bcd}
Illabo			1.65^{f}	2.00^{def}
Scepter			1.65^{f}	3.03^{a}
Nighthawk			2.28^{cde}	1.97^{def}
DS Bennett	4.23	3.88	2.19^{cde}	2.25^{cde}
LPB18-7982	4.49	4.31	2.02^{def}	2.64^{abc}
LPB18-7946	4.27	4.81	1.98^{def}	2.04^{def}
Orion	4.46	4.03	2.06^{def}	2.00^{def}
	NS		LSD ($P \leq 0.05$) 0.50	

Awless wheats

Dry matter production at the watery ripe (GS71) cutting stage ranged from 3.88 t/ha to 4.49 t/ha for all awnless varieties. The new awnless varieties did not improve dry matter production compared to DS Bennett and Orion.

At harvest, LPB18-7982 was the highest yielding (2.66 t/ha) awnless variety when sown in early May (Table 2). This variety was similar yielding to Scepter and Catapult at this time of sowing. LPB18-7982 is derived from a Scout and Yitpi cross and preliminary data shows it has similar maturity to Tojan / Catapult. All other awnless varieties DS Bennett, Orion and LPB18-7946 yielded similarly at 2.00 – 2.25 t/ha.

Acknowledgements

The Hart Field-Site Group would like to acknowledge Australian Grain Technologies (AGT), Seednet, LongReach Plant Breeding & Mick Faulkner for providing wheat seed to conduct this trial.

References

Porker K, Bruce D, Spriggs B, Buderick S, Hunt J, Harris F, Brooke G, Noack S, Moodie M, Brady M, McDonald T, Straight M, Fettell N, McMillan H, Haskins B, Clarke G and Angel K (2010) Emerging management tips for early sown winter wheats. GRDC Update Paper https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/emerging-management-tips-for-early-sown-winter-wheats

Additional resource

TEN TIPS FOR EARLY SOWN WHEAT

Click here or find the link on the Hart website

(look for Resources / Grower Guides in the main menu)

Comparison of barley varieties

Brianna Guidera and Sarah Noack; Hart Field-Site Group

Key Findings

- Barley yields for all varieties trialed at Hart in 2020 ranged from 2.84 – 3.56 t/ha.
- Fathom, RGT Planet, Leabrook and Laperouse were the highest yielding varieties.
- All malt varieties met Malt 1 receival standards for protein (%), test weight (kg/hL), screenings (%) and retention (%).
- All feed varieties trialed met the requirements for BAR1 (F1) receival standard this season.

Why do the trial?

To compare the performance of new barley varieties against the current industry standards.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) Zn 1% + Impact @ 80 kg/ha June 18: Easy N (42.5:0) @ 80 L/ha August 5: Easy N (42.5:0) @ 50 L/ha
Seeding date	May 6, 2020		
Harvest date	November 9, 2020		
Location	Hart, SA		

The trial was a randomised complete block design with three replicates of 12 barley varieties. The trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy. Plot edge rows were removed at harvest and only the four remaining rows were harvested and used to calculate grain yield. All plots were assessed for grain yield, protein, test weight (kg/hL), screening (with a 2.2 mm screen) and retention (with a 2.5 mm screen).

Compass was re-sown by hand on May 21 due to low seedling emergence from a poor-quality seed source. Yield and quality data was not analysed for this variety.

Results and discussion

Grain yield

RGT Planet was the highest yielding malt variety at 3.53 t/ha. All other malt varieties yielded similarly with the exception of Spartacus CL, Scope CL and Commander which were lower yielding this season (Table 1). Historic yield data from Hart shows Compass, La Trobe and RGT Planet have performed similar or better than the trial average over a number of years (Table 2). The long-term data also shows Spartacus CL has generally out yielded Scope CL over the past five years.

For the varieties currently pending malt accreditation, Leabrook, Laperouse and Beast were all high yielding at 3.40, 3.34 and 3.15 t/ha respectively. Long-term data for these varieties is not available. Maximus CL was lower yielding at 3.03 t/ha (Table 1). This is the second season of evaluating Maximus CL at Hart and in both years it has yielded similar to Spartacus CL.

Fathom was the highest yielding feed variety trialed at 3.56 t/ha. Rosalind yielded close to the trial average at 3.19 t/ha (Table 1). Historic data shows that both varieties yield well at Hart across a range of different seasons (Table 2).

Grain quality

The protein content for all malting varieties was within Malt 1 receival standard range of 9-12%, with protein contents ranging from 9.9% to 11.7%. Spartacus CL, Commander and Scope CL had the highest protein contents (Table 1). Feed varieties Rosalind and Fathom had protein contents of 10.3 and 9.8% respectively. All varieties pending malt accreditation also contained protein levels within the Malt 1 receival standard (Table 1).

Test weights across the trial ranged from 65.2 kg/hL to 69.3 kg/hL. All malting varieties had acceptable test weights for Malt 1 standards. Commander had the highest test weight of malting varieties at 68.2 kg/hL. Feed varieties Rosalind and Fathom were above test weight requirements for BAR1 (F1) receival (Table 1). All varieties pending malt accreditation also had test weights higher than 65 kg/hL (minimum required for maximum grade).

Screening levels were low this season. All varieties (malt and feed) contained screening levels less than 5.0% which met Malt 1 (<7%) and BAR1 (F1) (<15%) receival standards.

Retention in all malting varieties were greater than the minimum of 70% for Malt 1 receival (Table 1). Similarly, varieties pending malt accreditation had retention values greater than 70%.

Table 1. Barley grain yield and quality results from Hart in 2020. Values shaded blue in the same column show the highest performing varieties.

Quality	Variety	Grain yield t/ha	% of site average	Protein %	% of site average	Test weight kg/hL	% of site average	Screenings %	% of site average	Retention %	% of site average
Feed	Fathomⓟ	3.56^{e}	112	9.8^{a}	92	66.4^{abcd}	99	2.9^{abc}	88	85.7^{de}	103
	Rosalindⓟ	3.19^{bcd}	100	10.3^{abc}	96	67.7^{de}	101	3.7^{bcd}	115	81.2^{bc}	97
BAR1 (F1) Receival Standards				NA		>62.5		<15%		NA	
Malt	Commanderⓟ	3.01^{abc}	95	11.1^{cd}	104	68.2^{ef}	102	3.2^{abcd}	97	83.8^{cd}	100
	LaTrobeⓟ	2.99^{ab}	94	10.7^{c}	100	66.9^{bcde}	100	5.0^{e}	154	77.6^{ab}	93
	RGT Planetⓟ	3.53^{e}	111	9.9^{ab}	93	65.9^{ab}	98	4.1^{cde}	125	79.0^{b}	95
	Scope CLⓟ	2.97^{ab}	93	11.0^{cd}	103	66.2^{abc}	99	4.4^{de}	134	73.4^{a}	88
	Spartacus CLⓟ	2.84^{a}	89	11.7^{d}	109	67.1^{bcde}	100	4.1^{cde}	125	78.4^{b}	94
Malt 1 Receival Standards				9-12%		>65		<7%		>70%	
Pending malt accreditation	Beastⓟ	3.15^{bcd}	99	11.1^{cd}	104	67.4^{cde}	100	2.0^{a}	63	87.5^{de}	105
	Laperouseⓟ	3.34^{cde}	105	10.8^{c}	101	68.2^{ef}	102	2.1^{a}	64	88.1^{de}	106
	Leabrookⓟ	3.40^{de}	107	10.4^{abc}	97	65.2^{a}	97	2.6^{ab}	81	89.9^{e}	108
	Maximus CL (IGB1705T)ⓟ	3.03^{ab}	95	11.0^{cd}	102	69.3^{f}	103	2.8^{ab}	85	87.9^{de}	105
	Site average	**3.18**	**100**	**10.7**	**100**	**67.1**	**100**	**3.2**	**100**	**83.5**	**100**
	LSD ($P \leq 0.005$)	0.29		0.8		1.4		1.2		4.5	

Retention levels varied among the malt varieties ranging from 52.0 – 88.4%. A large number of varieties fell below 70% required for Malt 1 including; GrangeR, LaTrobe, Navigator, RGT Planet and Scope (Table 1). In contrast Commander, Compass and Spartacus CL all had high retention levels along with Maximus CL (pending malt accreditation).

Table 2. Long-term barley variety performance at Hart for 2016 – 2020 (expressed as % of trial average).

		% of trial average					Grain yield (t/ha)
Quality	**Variety**	**2016**	**2017**	**2018**	**2019**	**2020**	**2020**
Feed	Banksⓟ			103	99		
	Fathomⓟ	104	94	109	104	112	3.56
	Fleetⓟ	100	104	106	100		
	Hindmarshⓟ	92	98	100	103		
	Keel	97	102	105	101		
	Rosalindⓟ	104	91	102	107	100	3.19
Malt	Commanderⓟ	92	102	104	93	95	3.01
	Compassⓟ	86	106	105	106		
	GrangeRⓟ	103	108	89	93		
	La Trobe ⓟ	94	104	99	107	94	2.99
	Navigator	113	111	96	93		
	RGT Planetⓟ		134	97	101	111	3.53
	Scope CLⓟ	94	89	89	91	93	2.97
	Spartacus CLⓟ	95	98	98	100	89	2.84
Pending malt accreditation	Beastⓟ					99	3.15
	Laperouseⓟ					105	3.34
	Leabrookⓟ					107	3.40
	Maximus CL (IGB1705T)ⓟ				102	95	3.03
	Average yield (t/ha)	**4.62**	**4.36**	**2.86**	**2.25**	**3.18**	
	Sowing date	May 10	May 8	May 14	May 15	May 6	
	April - Oct (mm)	356	191	160	162	355	
	Annual rainfall (mm)	485	331	224	189	503	

Acknowledgements

The Hart Field-Site Group would like to acknowledge Seednet, InterGrain and AGT for donating seed to conduct this trial.

Comparison of durum varieties

Rebekah Allen; Hart Field-Site Group

Key findings

- All durum varieties yielded similarly at Hart this season with a trial average of 2.10 t/ha.
- Grain test weights were high ranging between 81.5 – 84.8 kg/hL.
- Grain protein levels were below DR1 standards averaging 12.4% across all varieties.
- Screening levels for all durum varieties were below 5%.

Why do the trial?

To compare the performance of new durum varieties alongside current commercial standards.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 1% Zn + Impact @ 80 kg/ha
Seeding date	May 6, 2020		Easy N (42.5:0) 80 L/ha on June 18, 2020
Harvest date	November 26, 2020		Easy N (42.5:0) 50 L/ha on August 5, 2020
Location	Hart, SA		

The trial was a randomised complete block design with three replicates and six durum varieties. This trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy. All plots were assessed for grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%).

The newest durum varieties in this trial were Bitalli (AGTD088), Westcourt (AGTD090) and DBA Artemis (UAD1154197). These varieties were also included in Hart's 2019 durum variety trial as pre-commercial material, prior to their release later the same year.

Results and discussion

No yield differences were observed for durum varieties at Hart this season. The average durum grain yield for all varieties was 2.10 t/ha (Table 1).

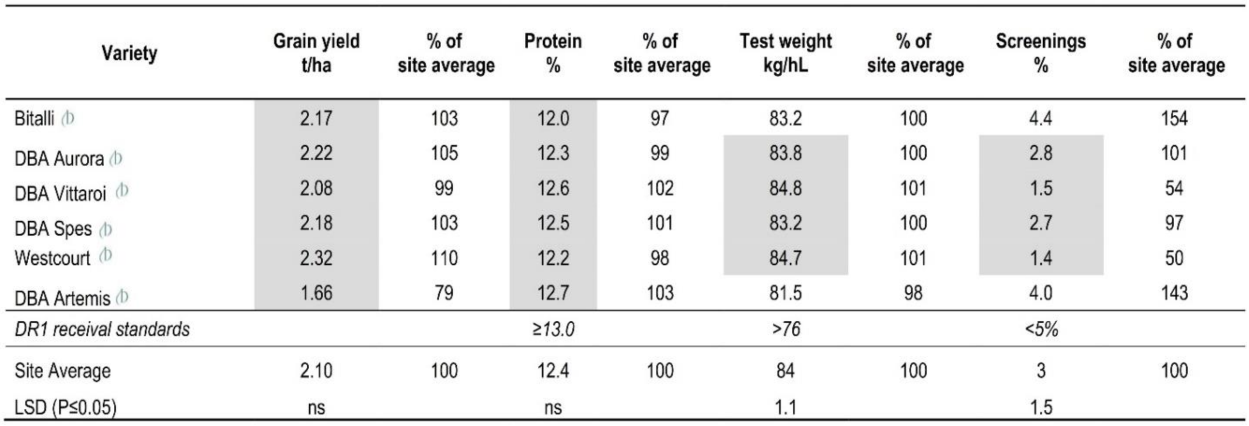
Long-term yield data shows that DBA Aurora, DBA Spes and Westcourt continue to perform well at Hart across multiple seasons (Table 2). DBA Aurora, DBA Spes, DBA Vittaroi, DBA Artemis and Bitalli were also present among the top ten performing varieties for the Mid-North 2020 National Variety Trials (NVT) at Spalding and Mintaro.

Grain protein levels for all varieties ranged between 12 – 12.7%.

Grain test weights were high for all durum varieties, averaging 84 kg/hL.

Screenings were below 5% for all durum varieties complying with DR1 receival standards. Bitallli and DBA Artemis had the highest level of screenings at Hart this season and were ≥4% (Table 1).

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) for durum varieties at Hart in 2020. Values shaded within each column show the highest performing varieties.



Variety	Grain yield t/ha	% of site average	Protein %	% of site average	Test weight kg/hL	% of site average	Screenings %	% of site average
Bitalli ⓓ	2.17	103	12.0	97	83.2	100	4.4	154
DBA Aurora ⓓ	2.22	105	12.3	99	83.8	100	2.8	101
DBA Vittaroi ⓓ	2.08	99	12.6	102	84.8	101	1.5	54
DBA Spes ⓓ	2.18	103	12.5	101	83.2	100	2.7	97
Westcourt ⓓ	2.32	110	12.2	98	84.7	101	1.4	50
DBA Artemis ⓓ	1.66	79	12.7	103	81.5	98	4.0	143
DR1 receival standards			*≥13.0*		*>76*		*<5%*	
Site Average	2.10	100	12.4	100	84	100	3	100
LSD (P≤0.05)	ns		ns		1.1		1.5	

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Table 2. Long-term durum variety performance at Hart (expressed as % trial average).

	% trial average					Grain yield (t/ha)
Variety	**2016**	**2017**	**2018**	**2019**	**2020**	**2019**
Bitalli ⓓ				99	103	2.17
DBA Aurora ⓓ	102	100	102	103	106	2.22
DBA Vittaroi ⓓ			104	96	99	2.08
Hyperno ⓓ	101	96	95	95		
Saintly ⓓ	85	100	90	97		
DBA Spes ⓓ			102	105	104	2.18
Westcourt ⓓ				107	110	2.32
DBA Artemis ⓓ				95	79	1.66
Trial average yield t/ha	**4.08**	**4.24**	**2.31**	**2.63**	**2.10**	
Sowing date	May 10	May 9	May 15	May 15	May 6	
Apr-Oct rain (mm)	356	191	160	162	336	
Annual rain (mm)	485	331	224	189	503	

Acknowledgements

The Hart Field-Site Group would like to acknowledge AGT and The University of Adelaide for providing durum seed to conduct this trial.

Comparison of lentil and field pea varieties

Rebekah Allen; Hart Field-Site Group

Key findings

- Lentil grain yields ranged between 1.50– 1.74 t/ha, with a trial average of 1.62 t/ha.
- The average grain yield for all field pea varieties at Hart was 1.38 t/ha with yields ranging between 1.15 and 1.55 t/ha.
- New lentil and field pea varieties at Hart in 2020 performed similar to current industry standards.

Why do the trial?

To compare the performance of newly released pulse varieties; PBA Kelpie XT and GIA Leader (lentil) and GIA Kastar and GIA Ourstar (field pea) alongside current commercial standards.

How was it done?

Plot size (field pea)	2.0 m x 10.0 m	**Fertiliser**	DAP (18:20) + 1% Zn + Impact @ 80 kg/ha
Plot size (Lentil)	1.75 m x 10.0 m		
Seeding date	May 18, 2020		
Field pea harvest date	October 10, 2020		
Lentil harvest date	November 12, 2020		
Location	Hart, SA		

Each trial was a randomised complete block design with three replicates and six varieties. Both trials were managed with the application of pesticides to ensure a weed, insect and disease-free canopy. All plots were assessed for grain yield (t/ha).

Results and discussion

Lentil

The average grain yield for lentils at Hart was 1.62 t/ha (Table 1), with a range of 1.50 t/ha – 1.74 t/ha. Lentil variety grain yields were similar with no single variety out yielding another.

Field pea

Field pea grain yields ranged from 1.15 – 1.55 t/ha (Table 1), with a trial average of 1.38 t/ha. Visual plant height differences were observed at flowering through to harvest (Figure 1). Newly released varieties GIA Kastar and GIA Ourstar yielded similarly to current commercial standards this season.

Table 1. Average grain yield for lentil and field pea varieties (t/ha) at Hart, 2020.

Field pea	**Grain yield t/ha**	**Lentil**	**Grain yield t/ha**
GIA Kastarᶲ	1.35	PBA Kelpie XTᶲ	1.74
GIA Ourstarᶲ	1.54	PBA Hallmark XTᶲ	1.57
Kaspaᶲ	1.55	PBA Hurricane XTᶲ	1.50
PBA Ouraᶲ	1.40	PBA Highland XTᶲ	1.64
PBA Butlerᶲ	1.30	PBA Jumbo2ᶲ	1.71
PBA Whartonᶲ	1.15	GIA Leaderᶲ	1.58
Average grain yield	1.38	Average grain yield	1.62
LSD (P≤0.05)	NS	LSD (P≤0.05)	NS

Figure 1. (L-R) Kaspa, GIA Ourstar, PBA Oura, PBA Butler, PBA Wharton and GIA Kastar.

Acknowledgements

The Hart Field-Site Group would like to acknowledge Global Grain Genetics, Pulse breeding Australia and Seednet for providing seed to complete the trial.

Comparison of oat varieties including imidazolinone (IMI) tolerant variety

Brianna Guidera and Sarah Noack; Hart Field-Site Group

Key findings

- Kingbale produced similar or slightly lower hay yields compared to Wintaroo at Hart across two seasons.
- Kingbale grain yields matched or exceeded Wintaroo at Hart in 2019 and 2020.

Why do the trial?

The first imidazolinone (IMI) tolerant oat variety Kingbale was released by InterGrain in 2019. Kingbale offers hay growers flexibility in their rotation and can be used where IMI residues are of concern from previous crops. A Sentry® (imazapic and imazapyr) registration has been submitted to APVMA for pre-emergent use only, with earliest potential registration for use in oaten hay production in March 2021. Preliminary data suggests Kingbale has similar agronomic and disease characteristics to Wintaroo. The trial aim was to assess the performance of Kingbale against the commonly grown oat varieties Mulgara and Wintaroo in the Mid-North.

How was it done?

2019			
Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) @ 75 kg/ha July 10: Easy N (42:5:0) @ 55 L/ha
Seeding date	May 30, 2019		
Location	Hart, SA		
Harvest date	November 27, 2019		
2020			
Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) + Impact @ 80 kg/ha June 18: Easy N (42:5:0) @ 80 L/ha August 5: Easy N (42:5:0) @ 50 L/ha
Seeding date	May 6, 2020		
Location	Hart, SA		
Harvest date	November 14, 2020		

The trial was a randomised complete block design with three replicates and three varieties. The trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy. Biomass cuts were taken at watery-ripe stage (GS71) by cutting 4 x 1 m sections of row at 15 cm (‘coke can’) height per plot and hay yields (t/ha) were determined. Feed test values from the same trial in 2019 were provided by Balco. Quality parameters including acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP), water soluble carbohydrates (WSC) were measured. Grain yields were recorded at harvest.

Results

Hay yields

Mulgara and Wintaroo had the highest hay yields at 3.21 and 3.09 t/ha respectively this season. Kingbale produced lower biomass at 2.63 t /ha (Table 1). Throughout the season Kingbale was visually shorter than Mulgara and Wintaroo. Data from 2019 also showed in a low-rainfall year (189 mm annual) Kingbale produced less dry matter than the commonly grown variety Yallara, and yielded the same as Wintaroo (Table 1). Similar trials conducted in the medium rainfall zones of Western Australia have also found Kingbale either matched or was slightly lower yielding compared to Wintaroo (Agrifutures 2020). These results demonstrate Kingbale is capable of matching Wintaroo yields and also provides the additional benefit of IMI tolerance, therefore giving greater rotation flexibility. This was expected as Kingbale is a close derivative of Wintaroo.

Grain yields

Grain yield for Kingbale was the same or higher than other commercially available oat varieties trialed at Hart in 2019 and 2020. In 2019, Kingbale grain yields were the same as Wintaroo and lower than Yallara, however, yields were low ranging from 0.5-0.9 t/ha (Table 1). In 2020, Kingbale had the highest grain yield of 2.23 t/ha followed by Wintaroo at 2.08 t/ha and Mulgara 1.98 t/ha.

Hay quality

The 2019 hay quality results again showed Kingbale performed similarly to Wintaroo. Across the various feed quality parameters; acid detergent fibre (ADF), crude protein (CP), water soluble carbohydrates (WSC) and neutral detergent fibre (NDF), results were the same for both varieties (Table 1). In all cases except CP, Yallara performed differently. Yallara had a high WSC % compared to Kingbale and Wintaroo. WSC % is an important parameter for the export market and higher values are desirable. As found in this trial, when WSC % increases, fibre content decreases (Table 1) and palatability increases (Department of Agriculture and Food 2017). Domestic markets place emphasis on the nutritional value of hay such as CP. Levels of >8% CP are sought after (Department of Agriculture and Food 2017) which all varieties exceeded.

Table 2. Grain, hay yields (t/ha) and hay quality data at Hart in 2019 and 2020.

Variety	**Grain yield (t/ha)**	**Dry matter (t/ha)**	**Acid detergent fibre (%ADF)**	**Crude protein (% CP)**	**Water soluble carbohydrates (% WSC)**	**Neutral detergent fibre (%NDFom30)**
2019						
Kingbaleⓟ	0.54^{a}	2.31^{a}	29.70^{b}	8.80	16.90^{a}	23.10^{b}
Wintarooⓟ	0.59^{a}	2.60^{a}	29.10^{b}	9.80	11.20^{a}	22.60^{b}
Yallaraⓟ	0.91^{b}	3.57^{b}	25.00^{a}	9.00	34.50^{b}	16.40^{a}
LSD (P≤0.05)	0.17	0.55	3.00	NS	5.90	4.20
2020						
Kingbaleⓟ	2.23^{c}	2.63^{a}				
Mulgaraⓟ	1.98^{a}	3.21^{b}				
Wintarooⓟ	2.08^{b}	3.09^{b}				
LSD (P≤0.05)	0.04	0.41				

Summary

Across two seasons of trials, Kingbale hay and grain yields were similar compared to Wintaroo. Kingbale provides a new option for growers to include oats in their rotation where IMI residues are of concern. In the future (pending current APVMA application) there may also be a registration for the use of Sentry® (imazapic and imazapyr) pre-emergent only.

Acknowledgements

The Hart Field-Site Group would like to thank InterGrain, Jim Maitland and Wayne Heading for donating the seed for this trial.

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Management options for producing oaten hay

Brianna Guidera[1], Courtney Peirce[2], Kenton Porker[2], Sarah Noack[1], Rebekah Allen[1]

[1]Hart Field-Site Group, [2]South Australian Research & Development Institute (SARDI)

Key findings

- The 2020 season was challenging for oaten hay at Hart with spring rainfall arriving too late to benefit hay yields, falling when most grower's hay was already cut.
- Higher hay yields were achieved from early May sowing, the same trend experienced in the 2019 season.
- Slower developing oat varieties adapted poorly to Hart conditions in both 2019 and 2020.
- Hay yields ranged from 2.3 – 3.5 t/ha with Brusher, Carrolup, Yallara, Wintaroo and Durack were the highest yielding varieties.
- Plant height at cutting date was strongly correlated with hay yield but had no effect on grain yield.
- Responses to N were different for hay yields compared to grain yield
- Nitrogen applied at 30 kg N/ha was sufficient to produce the highest hay yield; 90 kg N/ha was sufficient to produce the highest grain yield in a N responsive soil.
- All varieties except Vasse met the export hay recommendations for Neutral Detergent Fibre (NDF) and Water Soluble Carbohydrates (WSC).

Background

The National Hay Agronomy (NHA) trial is a four-year investment by AgriFutures Australia. The project was developed to address current knowledge gaps in the Australian export fodder industry and aims to reduce barriers to adoption of new varieties and agronomic practices. Georgie Troup from the Department of Primary Industries and Regional Development (DPIRD) in WA leads the project with support from the South Australian Research and Development Institute (SARDI), Agriculture Victoria, New South Wales Department of Primary Industries (NSW DPI) and grower groups such as Hart Field-Site Group and Birchip Cropping Group.

Trials across Western Australia, South Australia, New South Wales and Victoria commenced in 2019 and will be completed in 2021. The aim of the core field research program is to develop new management guidelines for oat growers, based on field experimentation on oat variety selection, nutrition, time of sowing management and their impact on hay yield, quality and returns.

Why do the trial?

To update guidelines that optimise variety selection, seeding date and in-crop nutrition requirements for export oaten hay in South Australia.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) + Impact @ 60 kg/ha In-season application rates of N, supplied as urea (see management treatments below)
Seeding date	May 6, 2020 & May 25, 2020		
Harvest date	November 14, 2020		
Location	Hart, SA	**Starting soil nitrogen**	53 kg N/ha (0-60 cm)

Management treatments

- Two times of sowing (TOS), early May (TOS 1) and late May (TOS 2).
- Nine oat varieties, listed below.
- Three N rates: 30, 60 and 90 kg N/ha. Yallara, Mulgara and Wintaroo received additional treatments of 10 kg N/ha, 120 kg N/ha and 150 kg N/ha, acting as N deficient and rich plots.
- Nitrogen treatments were applied as a split of two thirds at seeding and one third at tillering. This aimed to achieve good early vigour, plant establishment and thin stems.
- The Hart target seeding rate was 320 plants/m^2; all seeding densities were adjusted depending on grain weight to ensure the target seeding rate.

Varieties grown at Hart in 2020 were: Brusher, Carrolup, Durack, Koorabup, Mulgara, Vasse, Williams, Wintaroo and Yallara. Vasse, a long-season variety, was selected to replace Forester in the trial due to poor performance of Forester in low-rainfall conditions at Hart in the 2019 season. For varietal information, refer to the 2019 Hart Trial Results Book.

Plant development was tracked by regularly monitoring growth stages from mid-booting and when the top florets were at the watery ripe growth stage (GS71), hay cuts were taken from each plot (4 x 1 m rows, 15 cm off the ground). Samples were dried immediately at 60°C for two days preserving hay quality before hay yields were calculated. The samples were then ground to <1 mm and various hay quality parameters analysed by NIR. Additionally, Normalised Difference Vegetation Index (NDVI), used to measure canopy cover and crop health (higher NDVI values indicate less exposed soil and greener vegetation), was tracked during the season and plant height (from the base of the plant to the bottom of the panicles) was measured at the cutting date. The trial was managed to ensure the canopy was weed, insect and disease-free.

Results and discussion

2020 season

Hart experienced a wet season, receiving a decile 7 growing season rainfall (GSR) of 335 mm and a decile 9 annual total of 503 mm. This was higher rainfall compared to 2019, during which 162 mm GSR and 188 mm annual rainfall was received.

However, in 2020 it was not only the total rainfall but when this rain was received that determined hay yield and quality. Higher than average rainfall during summer and April meant stored soil moisture was available to the crop at seeding.

Below average rainfall was received in May and this continued throughout winter with a June/July combined rainfall of 38 mm. The trial presented symptoms of water and N stress such as red leaf tipping, dull colouring and an overall lack of vigour and biomass during this dry winter period. Concurrently, warm conditions caused rapid progression through plant growth stages, resulting in varieties which normally have a spread in cutting date all reaching watery ripe on the same date.

Time of sowing 1 plots reached the watery-ripe stage over a short time period, beginning with Durack and ending with Vasse 15 days later in mid-September. However, all varieties except Vasse reached watery-ripe nine days after Durack.

Treatments from TOS 2 plots matured within seven days, again beginning with Durack and ending with Vasse in late September. All varieties but Vasse were at the watery-ripe stage four days after Durack. From August to the end of October, 209 mm was received which relieved plant stress and assisted grain fill.

Hay and grain yields

Time of sowing

Early May sowing resulted in higher hay yields (3.4 t/ha) compared to mid-May sowing (2.7 t/ha). Visually, TOS 2 plots appeared smaller and had less biomass than TOS 1 plots during the growing season. TOS 1 plots were advantaged by having greater access to the early season rainfall which fell prior to seeding. Despite the late rain it was still too late to favour TOS 2, likely because they failed to accumulate enough biomass and were too stressed in the drier period of June and July to recover significant biomass yield.

Variety

Hay yields across the trial ranged from 2.3 to 3.5 t/ha. Brusher, Carrolup, Yallara, Wintaroo and Durack were the highest yielding varieties (Table 1). These varieties, with the exception of Durack, are mid-maturing and consistently yielded well at Hart because they are well suited to shorter, drier and warmer seasons. Vasse, a long-season variety replacing Forester in 2020, was low yielding. It also flowered in the boot and presented with poor head emergence at cutting date. This was also observed in several varieties at Hart in 2019 due to the hard finish to the season (lack of rainfall and warm temperatures). This indicates that Vasse and other longer season oat varieties are not well suited to the Hart environment.

Grain yields ranged from 2.12 to 2.87 t/ha. Vasse, Williams, Koorabup and Yallara were high yielding (Table 1). This is similar to 2019 in which Brusher, Mulgara and Wintaroo had high hay yields. Higher hay yields did not necessarily correlate to higher grain yields and this is likely a reflection of rainfall timing. Fast developing varieties were most efficient at producing biomass prior to flowering under dry conditions and favoured high hay yields, while late rainfall favoured grain development in slower developing varieties post flowering. For example, despite having the highest hay yields, Brusher had the lowest grain yields. This suggests the early to mid-maturity of Brusher was advantageous for hay yields resulting in higher biomass but was too fast to take advantage of the spring rainfall and convert it to grain. In contrast, Williams, Koorabup and particularly Vasse, with their slower development speed, were able to use the additional spring rainfall and convert a larger proportion of their biomass into grain yield in the post flowering period.

Table 1. Hay and grain yields (t/ha), Neutral Detergent Fibre (NDF) and Water Soluble Carbohydrate (WSC) contents of hay at Hart in 2020. Values shaded blue in the same column are not statistically different.

Variety	Hay yield (t/ha)	Grain yield (t/ha)	NDF %	WSC %
Vasse	2.3^{a}	2.8^{d}	53.8^{g}	15.3^{a}
Williams	2.9^{b}	2.9^{d}	50.2^{ef}	21.2^{b}
Koorabup	2.9^{b}	2.9^{d}	50.1^{def}	23.5^{c}
Mulgara	3.0^{bc}	2.4^{c}	49.3^{cde}	23.9^{c}
Durack	3.1^{bcd}	2.3^{bc}	50.9^{f}	21.4^{b}
Wintaroo	3.2^{bcd}	2.1^{ab}	48.9^{cd}	24.1^{c}
Yallara	3.2^{bcd}	2.8^{d}	47.4^{a}	25.9^{d}
Carrolup	3.4^{cd}	2.4^{c}	47.6^{ab}	25.9^{d}
Brusher	3.5^{d}	2.1^{a}	48.7^{bc}	25.9^{d}
LSD ($P \leq 0.05$)	**0.39**	**0.15**	**1.24**	**1.09**
Sowing date				
May 5	3.5^{b}	2.6	49.8	24.3^{b}
May 25	2.7^{a}	2.5	49.5	21.7^{a}
LSD ($P \leq 0.05$)	**0.44**	**NS**	**NS**	**2.03**

Nitrogen management

Hay yield response to N fertiliser rate was significant but of little consequence in practical terms this season. Across both TOS treatments, rates up to 30 kg N/ha resulted in yield response, increasing the average hay yield from 2.7 to 3.3 t/ha. At all rates above 30 kg N/ha, there was no response to increased N applications (Table 2). The low response to N fertiliser rates can be explained by the lack of in-season winter rainfall limiting crop N uptake.

Grain yields were maximised by higher rates of N (Table 2). Plots treated with 90, 120 and 150 kg N/ha had the highest grain yields and 10 kg N/ha resulted in the lowest yields. Therefore, while applying above 30 kg N/ha did not benefit hay yields, higher N rates were required to achieve the highest grain yields. Despite this outcome, in an economical sense the costs of applying high rates of N would have outweighed the income from grain yield gains in 2020.

Table 2. Hay and grain yields (t/ha) for nitrogen treatments at Hart in 2020. Values shaded blue in the same column are not statistically different.

N rate (kg/ha)	Hay yield (t/ha)	Grain yield (t/ha)
10	2.7^{a}	2.3^{a}
30	3.2^{b}	2.4^{b}
60	3.1^{b}	2.5^{c}
90	3.2^{b}	2.5^{d}
120	3.2^{b}	2.6^{de}
150	3.1^{b}	2.6^{e}
LSD ($P \leq 0.05$)	**0.05**	**3.13**

Crop vigour

Overall plant height was short in 2020, due to mid-season water and N stress. Crop height measurements taken at hay cutting showed TOS 1 was taller than TOS 2 (Figure 1). Nitrogen rate did not affect crop height. Vasse and Williams were the shortest at 46 cm and 49 cm respectively and Brusher was the tallest at 66 cm. Plant height was strongly correlated to hay yields, accounting for 55% of yield variation in this trial (Figure 1). As plant height increased, the hay yield also increased. Therefore, at Hart in 2020 and in low to medium rainfall zones where lodging is unlikely to affect the crop, taller plants and earlier sowing benefited hay yields.

NDVI measurements taken at hay cutting showed differences between N rates. The average NDVI value increased from plots treated with 10 kg N/ha to 30 kg N/ha, then again from plots treated with 30 kg N/ha to 60 kg N/ha. Rates above 60 kg N/ha did not result in NDVI increases (Figure 2). This indicates that rates up to 60 kg N/ha resulted in greater biomass density and more green foliage however rates above 60 kg N/ha gave no additional benefit. Nitrogen accessibility to plants is heavily reliant on rainfall therefore seasonal conditions may have caused this result.

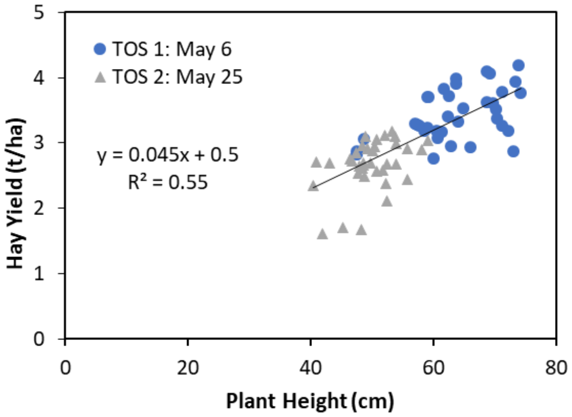

Figure 1. Relationship between plant height (cm) and hay yield (t/ha) at Hart in 2020.

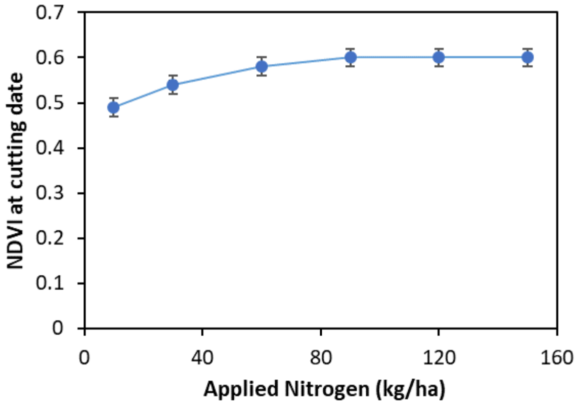

Figure 2. NDVI response to nitrogen rates at Hart in 2020. Measurements were taken on cutting date. Error bars represent LSD.

Hay quality

Neutral detergent fibre (NDF) was different between varieties, ranging from 47.4% in Yallara to 53.8% in Vasse (Table 1). All varieties were below the export hay threshold of <57% (AEXCO 2016). As NDF% increases, the amount of dry matter consumed by animals generally decreases (AEXCO 2016) therefore higher values such as seen in Vasse may be less desirable than lower values such as seen in Yallara and Carrolup. Time of sowing did not affect NDF%.

Water soluble carbohydrates (WSC) content varied between varieties and ranged from 15.3 to 25.9%. Brusher, Carrolup and Yallara had the highest WSC content, and Vasse had the lowest (Table 1). Vasse did not meet the minimum of 18% WSC recommended for export quality hay (AEXCO 2016). Both sowing date treatments met export market requirements. TOS 1 had a higher WSC content than TOS 2. WSC content affects palatability and higher contents are favourable (DPIRD 2016) therefore earlier sowing and/or growing one of the listed high-performing varieties was suitable at Hart in 2020.

Implications for growers

- In 2019 and 2020, the oat varieties Brusher, Carrolup, Yallara, Wintaroo, Durack and Mulgara had high hay yields in the Hart environment.
- Across two seasons, early May-sowing resulted in higher hay yields than late-May sowing as a result of access to soil moisture and early rainfall in challenging seasons.
- Low rates of N fertiliser (up to 30 kg N/ha) provide the most hay yield benefit in dry years or years with a dry winter. The outcomes in a higher rainfall year are expected to favour higher N rates.

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Can gibberellic acid improve oat head emergence?

Brianna Guidera; Hart Field-Site Group, Courtney Peirce; SARDI and Sarah Noack; Hart Field-Site Group

Key findings

- Gibberellic acid had either a nil or negative effect on oat head emergence from the boot.
- There were crop differences between varieties trialed including head emergence, dry weight and plant height. Brusher was in all cases a high-performing variety for the parameters measured.

Why do the trial?

Export hay has become a large part of farming systems in the medium to high rainfall zones. It can benefit farm business risk management and is an option for controlling herbicide resistant weeds (GRDC 2017). Oats are a common hay option with a multitude of rotational benefits including some cereal disease resistance, suitability to early sowing and ease of establishment, reliability as a break crop where broadleaves are unsuitable and versatility in their end-use (GRDC 2017).

In lower rainfall areas or late sown oat crops, particularly in seasons with a dry spring, poor head emergence from the boot has been observed. This places growers in a difficult situation because crops cut with heads in the boot require a longer curing time, extending the amount of time the hay is exposed to the elements. However, waiting for the head to emerge can also lead to a decline in hay quality as the crop advances beyond the recommended watery- ripe (GS71) growth stage. Previous research (DPIRD 2020) has shown there is a sharp decrease in hay quality as the crop moves into grain fill.

Gibberellic acid (GA), is a plant hormone known for its effect on plant growth, causing stem elongation and leaf expansion. Gibberellic acid is commonly used in horticulture and on pastures to stimulate out of season growth, or to accelerate early growth, stem elongation and to promote flowering (Matthew *et al.* 2009).

The aim of the trial was to investigate the potential for GA to promote head emergence from the boot in oats to benefit growers in the Southern region.

How was it done?

A glasshouse trial was set up at the Waite Campus, Urrbrae in June, 2020 to assess the effect of different timing of GA application on plant height, dry weight and head emergence (Figure 1). The trial was a randomised complete block design with four replicates of seven GA treatments applied to three oat varieties, Williams, Brusher and Mulgara.

Four seeds of the same variety were sown in each pot on June 15 and watered to saturation every few days or more frequently if necessary. The average daily maximum temperature in the glasshouse was 34°C, the average daily minimum temperature was 11°C. All varieties had emerged by June 26 and were hand thinned to one plant per pot on July 6 at the 2.5 leaf growth-stage.

Figure 1. Setup of the GA oat glasshouse trial.

ProGibb was applied to plants by spraying onto the leaves from each side of the plant and above at six growth stage timings (Table 1). The rate was 1.73 mg /pot, diluted from the target rate of 40 g / 100 L, therefore 692 µg GA per application (400 g/kg active ingredient).

Plants were harvested at ground level on October 8 at early-mid dough (GS83-85). Prior to harvest tiller numbers were counted and measurements were taken prior to and after harvest including:

1. Distance between flag leaf (FL) ligule and soil surface (Figure 2).
2. Distance between FL ligule and base of the head (Figure 2).
3. Plant height from the soil surface to the top of the tallest leaf (Figure 2).

Once the samples had air-dried, the distance between the FL ligule and head was measured for each tiller and the total biomass was determined.

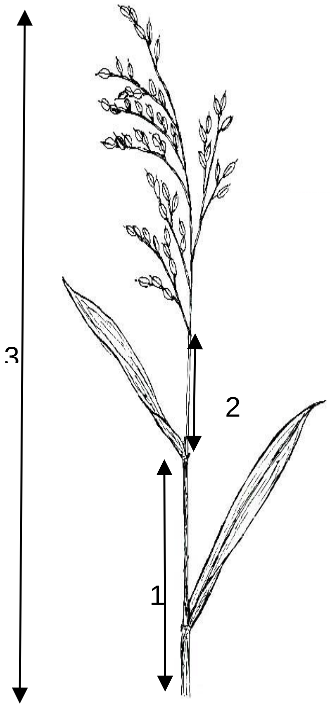

Figure 2. Measurements taken on oat plants prior to and after harvest.

Table 1. Targeted growth stages for GA applications.*

Treatment (application timing)	Growth stage	GS score
Control	-	-
T1	Three leaf, early tillering	13
T2	Main stem + four tillers	24
T3	Stem elongation	30-32
T4	Flag leaf emergence	37
T5	Ear emergence	51-59
T6	Anthesis	61-69

**Due to the warm and well-watered glasshouse conditions, plants advanced rapidly through growth stages and plants within the same treatments were at different growth stages. Therefore, to account for the variability in growth stages, a range of GS scores have been presented.*

Results and discussion

Distance between FL ligule and head (main stem)

Variety affected the distance between the FL ligule and head, with Brusher having a greater distance on average than Mulgara and Williams (Table 2). As described in the GRDC Oat Variety Sowing Guide, Brusher was generally a taller variety and this was observed during the experiment. However, there were no differences in this measurement between GA treatments. This indicates GA did not result in extension of the head from the boot in any of the varieties trialed.

Distance between ligule and panicle (tillers)

Gibberellic acid applications had a negative effect on the average distance between the ligule and head on plant tillers. The difference was just significant ($P \leq 0.04$). Applying GA at ear emergence resulted in a shorter distance between the ligule and head. All other treatments were not different to the control (Table 2). Therefore, there was no benefit from applying GA to oats in this trial.

Average plant height

Brusher and Mulgara were taller than Williams when accounting for the height from the soil surface to the top of the flag leaf (Table 2). There was no effect of GA on overall average plant height in any of the oat varieties trialed.

Dry weight

Brusher and Mulgara had greater dry weights compared to Williams (Table 2). This is unsurprising given that these two varieties were also taller than Williams, contributing to greater biomass and bulk. Gibberellic acid applications did not affect dry weight compared to the control.

Table 2. Gibberellic acid treatment and variety effects on various plant growth measures. Values highlighted blue in the same column are not significantly different to each other.

Application timing	Average dry weight (g)	Average plant height (cm)	MS distance between FL ligule and base of head (cm)	Distance between ligule and base of head on tillers (cm)
Gibberellic acid applications				
Control	60.9	120.2	34.0	8.8^{bcd}
T1	62.3	121.3	33.5	10.1^{cd}
T2	64.1	118.9	32.1	6.6^{ab}
T3	61.5	121.6	32.9	10.9^{d}
T4	65.5	116.3	31.0	7.5^{abc}
T5	63.4	118.6	32.3	5.9^{a}
T6	65.3	113.9	31.3	6.4^{ab}
LSD (P≤0.05)	ns	ns	ns	2.9
Variety				
Brusher	67.2^{b}	128.1^{b}	36.0^{b}	10.1^{b}
Mulgara	65.9^{b}	126.9^{b}	30.6^{a}	6.9^{a}
Williams	56.6^{a}	101.7^{a}	31.3^{a}	7.3^{a}
LSD (P≤0.05)	4.1	8.0	4.2	1.8

Conclusion

Gibberellic acid had a nil or negative effect on oat head emergence from the boot. Dry weight, plant height, distance between the FL and base of the head on the main stem were not affected by GA applications. The average distance between the ligule and base of the head on tillers was negatively affected by GA or, in most cases, was the same as the control. However, it is worth noting that the trial was performed in a controlled environment and plants were not at any stage under stress as may be seen in the field where heat, frost and moisture stress are incurred. Further investigation is required to ascertain whether there is any effect of GA on head emergence in oats.

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Increasing vetch dry matter production through the application of gibberellic acid

Rebekah Allen, Sarah Noack and Brianna Guidera; Hart Field-Site Group

Key findings

- When comparing the average yield of all varieties, vetch dry matter yields were increased by up to 0.27 t DM/ha with applications of Gibberellic acid at 20 g/ha.
- Rates of Gibberellic acid at 10 g/ha did not increase dry matter (DM) when compared to the nil treatment.
- The highest yielding vetch varieties (2.09 t DM/ha - 2.10 t DM/ha) were Studenica and Timok.

Why do the trial?

Vetch is a common rotational option in the Mid-North region and is widely utilised within mixed farming systems as a low-input grazing option.

Gibberellic acid (GA) is a plant hormone used within the horticultural industry to manipulate crop production and flowering dates. Gibberellic acid is also used within highly intensive grazing systems to stimulate pasture production in grasses, commonly phalaris, cocksfoot and perennial or annual ryegrass.

Limited research is published on the use of GA within the agricultural industry, specifically vetch production. This trial investigates the use of GA with the aim to increase vetch dry matter (DM) prior to grazing livestock.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 1% Zn + Impact @ 80 kg/ha
Seeding date	April 20, 2020		
Seeding rate	45 kg/ha		
Location	Hart, SA		

The trial was a split plot block design with three replicates, three GA treatments and three varieties, including; Morava, Timok and Studenica.

Vetch varieties achieved 115% establishment (80 plants/m^2) after good April rainfall. Gibberellic acid treatments (Table 1) were applied to vetch plots on June 11 at branching, 7 weeks after seeding. Post application conditions were relatively warm and dry with rainfall for June totalling 24 mm.

Observations from previous research has shown that maximum plant growth is typically observed between 21-28 days after GA application as labelled. In this trial, biomass cuts were taken 28 days after GA application, on July 9, 2020.

To determine vetch dry matter (t DM/ha), 1 x 1 m^2 cuts were taken from each plot at ground level. Samples were then dried at 60°C for 48 hours and weighed. A feed quality analysis was conducted using Near Infrared (NIR) technology to observe the effect of GA on vetch crude protein (CP%), acid detergent fibre (ADF%), neutral detergent fibre (NDF%), metabolisable energy (ME) (MJ/Kg DM) and digestibility (%). It is important to note that the feed quality analysis conducted in this trial is un-replicated and should be used as a guide only.

Table 1. Gibberellic acid treatments applied at Hart in 2020.

Treatment	Product name	Active Ingredient	Rate (g/ha)
1	Nil	N/A	N/A
2	ProGibb	Gibberellic acid	10
3	ProGibb	Gibberellic acid	20

Results and discussion

Dry matter yield

There was no interaction observed between vetch variety and GA application this season at Hart.

A response to the application of GA was observed, irrespective of variety (Figure 2). The total average vetch DM yield was increased when GA was applied at 20 g/ha, providing a yield benefit of 0.27 t DM/ha when compared to the nil treatment. No yield increase was observed for applications of GA at 10 g/ha.

This trial was conducted under dry winter conditions with 27 mm rainfall received post application, however favourable conditions for applications of GA are cold and wet environments when minimal plant growth is observed. Visual observations showing increased plant height were seen seven days after application (Figure 1). Plots treated with GA also displayed pale discolouration on leaves. Seasonal conditions providing increased rainfall and cooler winter conditions may increase physiological plant responses to GA.

Similar research conducted in North Central Victoria showed applications of GA at equivalent rates did not increase hay yield (t DM/ha) when applied to Morava and Poppany vetch mid-winter (BCG 2019). A second trial conducted in Murray Plains, SA similarly found no GA effect on Morava, Timok or Studenica hay yields (t/ha) when applied at 20 g/ha at two timings; mid and late winter. Biomass cuts were taken at commercial hay timing, late September (MSF 2019).

These studies suggest the response to GA is variable and most commonly, no response in DM has been observed for vetch, more specifically, hay yield.

When analysed alone, there were differences in DM production at Hart between vetch varieties trialed. Morava was lower yielding (1.88 t DM/ha) when compared to Timok and Studenica which had a yield average of 2.09 t DM/ha and 2.10 t DM/ha, respectively (Figure 3).

Figure 1. (L-R) Morava (nil treatment) and Morava + gibberellic acid at 20 g/ha, seven days after application.

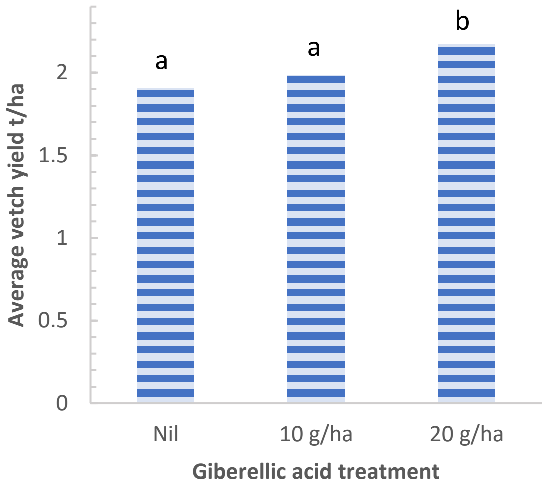

Figure 2. Gibberellic acid treatments showing average yield (t DM/ha) for all vetch varieties. Bars with different letters are significantly different.

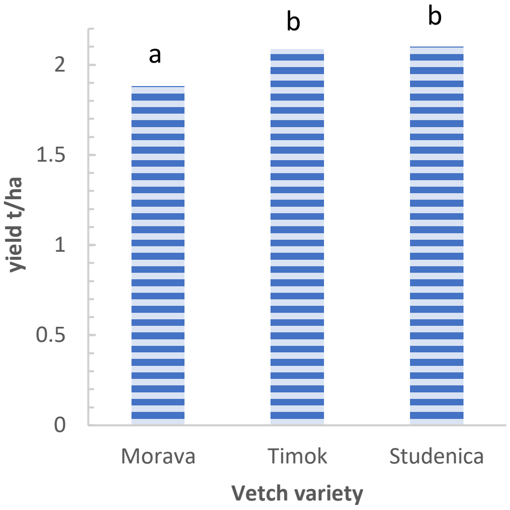

Figure 3. Average vetch yield (t DM/ha) for Morava, Timok and Studenica. Bars with different letters are significantly different.

Snapshot of Timok feed quality

Applications of GA did not affect feed quality in treated plots of Timok vetch (Table 2). The CP%, ME%, and digestibility feed values in GA treated plots were similar to the nil treatment. ADF% and NDF% increased slightly as GA rates increased. ADF% can lead to lower feed digestibility as it comprises tough, indigestible fibres (Moran 2005). However, digestibility remained similar to the nil treatment, meaning no adverse effects were seen with the increase in ADF%.

Table 2. Feed quality analysis data for Timok vetch and GA treatments on crude protein (CP%), acid detergent fibre (ADF%), neutral detergent fibre (NDF%), metabolisable energy (ME) (MJ/Kg DM) and digestibility (%).

Treatment	**Crude protein (CP) (%)**	**Acid detergent fibre (ADF) (%)**	**Neutral detergent fibre (NDF) (%)**	**Metabolisable energy (ME) (MJ/Kg DM)**	**Digestibility (%)**
Nil	29.9	22.7	34.7	11.8	72.8
ProGibb @ 10 g/ha	29.9	24.8	34.1	11.9	73.5
ProGibb @ 20 g/ha	29.4	25.3	35.4	11.6	72.1

Acknowledgements

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Evaluating intercropping systems

Shahnaj Parvin[1], Sarah Noack[2], Terry Rose[1] and Rebekah Allen[2]

[1]Southern Cross University, [2]Hart Field-Site Group

Key findings

- In 2019 and 2020 intercrops of field pea-canola (peaola) and chickpea-linseed did not increase the land use equivalent ratio (LER) above 1. This indicates intercrops were not able to improve crop productivity compared to the respective individual crops.
- Wheat sown after the 2019 cropping treatments yielded the same for all previous crops, ranging from 1.8 – 2.0 t/ha.

Why do the trial?

Intercropping is the practice of growing two grain crops in the same paddock. It is a production system adopted by a small number of farmers in dryland systems for its productivity and environmental benefits. Generally, intercrops are recognised for providing multiple benefits including resilience, weed and disease suppression and improved soil health. However, there is little research and information undertaken in Australia (Fletcher *et al.* 2016), to demonstrate the potential of these systems to be more productive than growing the components as monoculture (single crop per paddock).

The aim of this four-year trial is to assess the viability of integrating diverse species through intercropping into our current winter rotation options. We also examined whether these systems impacted the yields of a subsequent cereal crop.

How was it done?

2019			
Plot size	4.20 m x 36.0 m	**Fertiliser**	MAP (10:22) + 2% Zn @ 75 kg/ha Urea (46:0) @ 100 kg/ha (canola and canola + field pea only) Aug 6
Seeding date	May 28, 2019		
Location	Hart, SA		
Harvest date	November 26, 2019		
2020			
Plot size	4.20 m x 36.0 m	**Fertiliser**	MAP (10:22) + 2% Zn @ 80 kg/ha Urea (46:0) @ 100 kg/ha (canola and canola + field pea only) July 3
Seeding date	May 25, 2020		
Location	Hart, SA		
Harvest date	December 14, 2020		

The trial was a randomised complete block design. In 2019 there were six crop treatments within the trial including both monocrops and intercrops;

1. Canola (Stingray)
2. Field pea (Wharton)
3. Chickpea (Genesis090)
4. Linseed (Croxton)
5. Canola (Stingray) + Field pea (Wharton)
6. Chickpea (Genesis090) + Linseed (Croxton)

A standard knife-point plot seeder was modified to sow both the monocrop and intercrop treatments. The intercrop plots were sown in a double skip arrangement (Photo 1). That is, for treatment five (Photo 1) two rows of canola were sown next to two rows of field pea and repeated. In the following season (2020) all plots were sown with Scepter wheat to assess any carryover effects from the previous crop treatments.

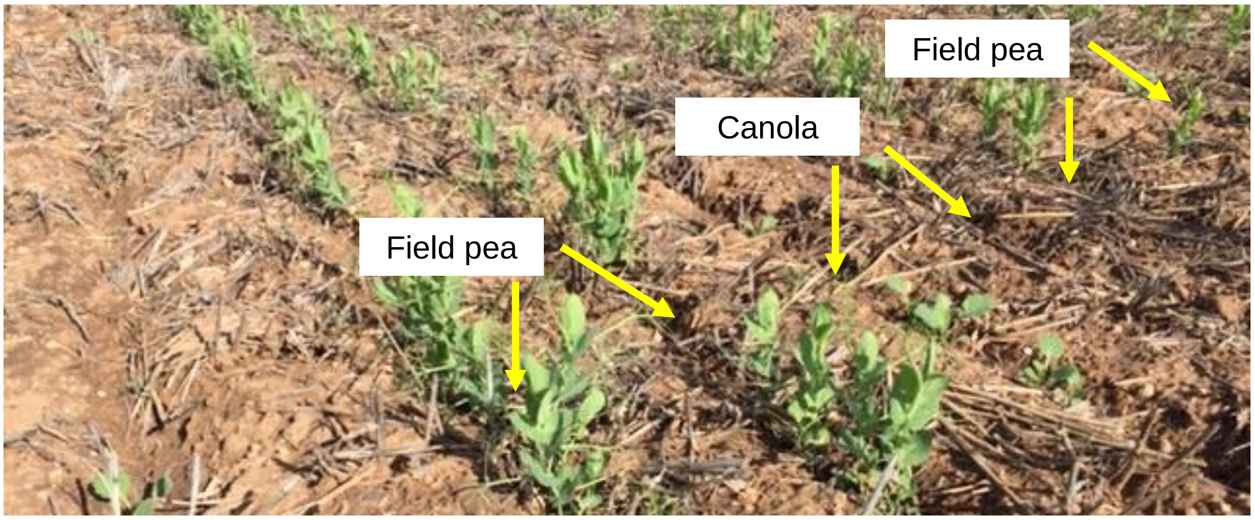


Photo 1. Canola and field pea intercrop (peaola) sown at Hart in double skip row arrangement.

Soil assessments

Soil moisture probes were installed on June 5, 2019. The configuration of the capacitance probes was EnviroPro 80 cm EP100GL-08's and contained sensors at 10 cm intervals, starting at 15 cm through to 85 cm. A total of 15 moisture probes were installed in all treatments (except the linseed monocrop) and replicates.

Plant assessments

Plant establishment counts and NDVI assessments were undertaken in all plots on July 24 and August 2 2019, respectively. Biomass cuts were completed on the same date for all treatments. The canola was at the end of flowering and field pea mid-pod fill. The chickpea was at the end of flowering and linseed had just started to flower. Cuts were completed by sampling 4 rows x 1 m sections in two areas of the plot. All samples were oven dried at 60°C for 48 hours and weighed.

All plots were harvested for grain yield. For intercrop treatments the whole plot grain sample was retained, sieved to separate seed sizes and weighed to calculate the individual crop yield.

Land equivalent ratio (LER)

LER values were calculated to give an indication of intercropping productivity relative to the monoculture treatments. The LER is expressed as: LER = (intercrop yield A / sole yield A) + (intercrop yield B / sole yield B).

An LER value of 1.0 means the productivity of the intercrop was equivalent to the monoculture components. An LER value of <1.0 means the productivity of the intercrop is lower than the monoculture components, while an LER value >1.0 means the intercrop is more productive than the monoculture components and is referred to as 'over-yielding'.

Results and discussion

NDVI and Biomass

In early August NDVI was highest in linseed followed by canola. Other treatments including the intercrop of chickpea-linseed and canola-field pea (peaola) produced similar canopy cover (Figure 1). Chickpea, linseed and their intercrop had similar biomass accumulation patterns at pod filling (Figure 1). Biomass accumulation was greater in field pea than canola with the peaola yielding an intermediate biomass (Figure 1).

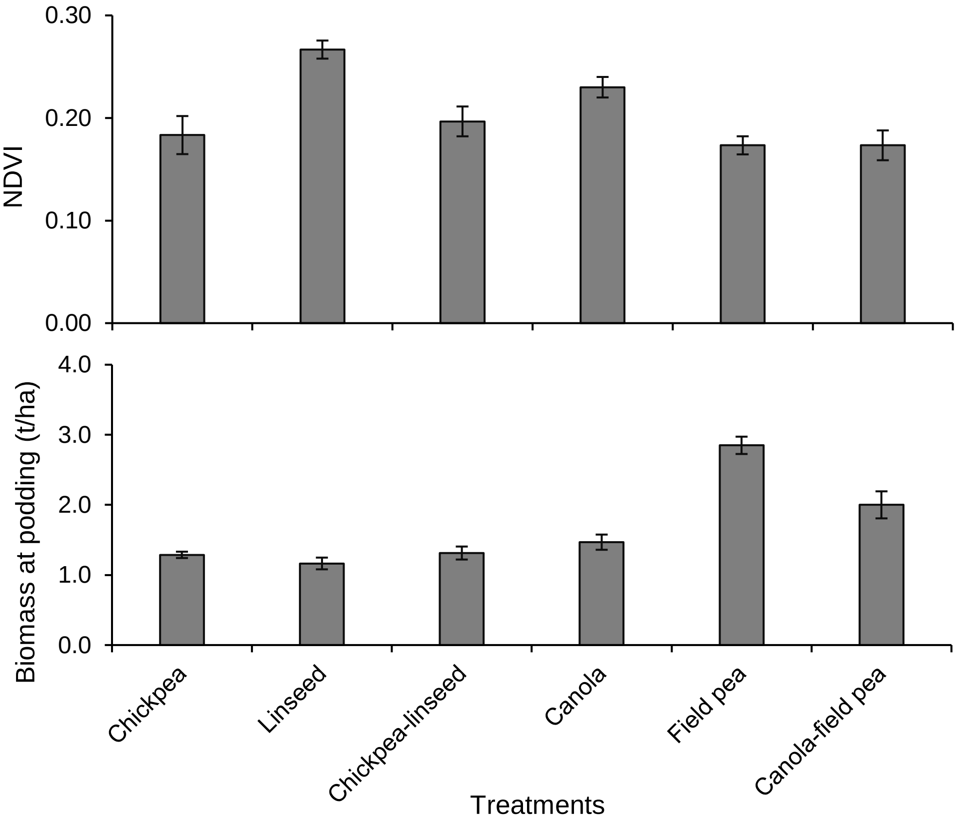


Figure. 1 NDVI (top) and biomass accumulation (bottom) of monocrop and intercrops at pre-flowering and at podding stage, Hart, 2019. Error bars indicate the standard error of the average NDVI or biomass.

Grain yield and LER

Grain yields across all monocrop treatments were below average for Hart in 2019. The field peas were the highest yielding crop at 1.06 t/ha (Figure 2). This was followed by chickpea, linseed and canola which had similar yields. In this trial the LER for chickpea-linseed intercrop was less than 1, which indicates grain yield was reduced when grown together compared to the monocrop yields (Figure 2). For peaola the LER was close to 1 suggesting the intercrop of field pea-canola maintained productivity relative to these crops sown on their own.

In 2020 wheat grain yields were similar for all previous crop treatments. Intercropping treatments did not increase or decrease wheat grain yield relative to the individual crops (Figure 3).

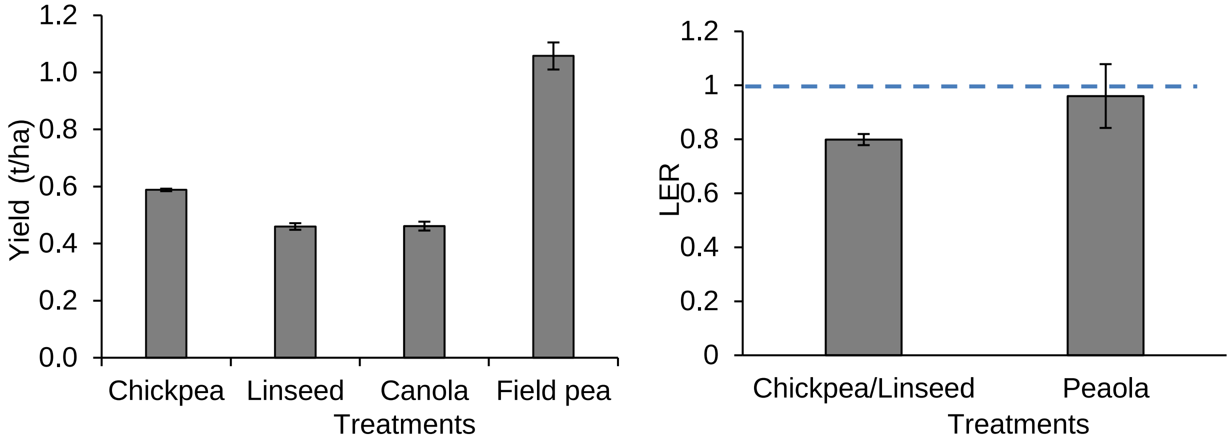


Figure 2. Grain yield of chickpea, linseed, canola, field pea monocrop (left) and LER (right) of intercrops at maturity Hart, 2019. The dashed blue line displays an LER value of 1.0, indicating no difference in yield between the intercrop and the collection of monocultures.

Intercrop performance in 2020

This season a small intercropping trial was repeated at Hart to assess the mono and intercrop combinations. The LER was similar to 2019 for peaola at 0.96. The chickpea-linseed LER was higher this season at 1.0. However, none of the intercropping treatments at Hart in 2019 or 2020 increased LER >1. This suggests there no yield advantage obtained by growing two species as an intercrop, compared to growing the same crops as monocultures.

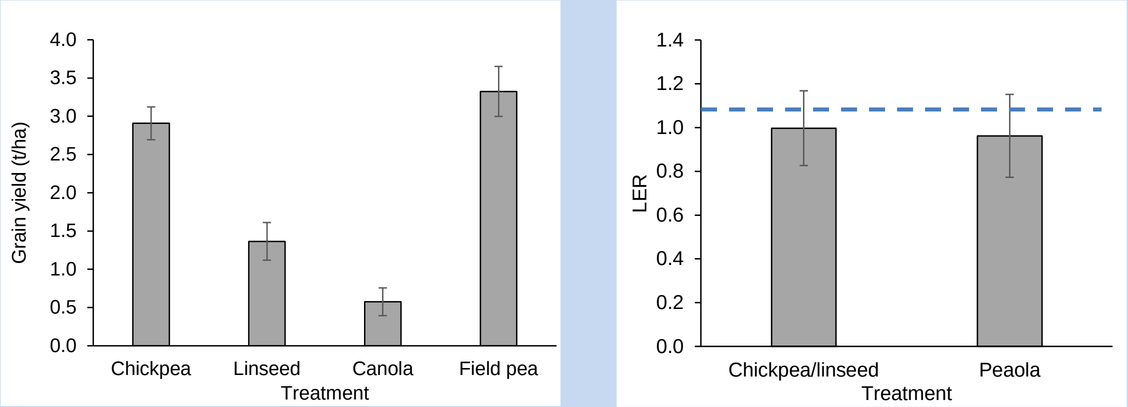


Photo: Intercropping trial at Hart in 2020; canola (Stingray) + field pea (Wharton) on September 9.

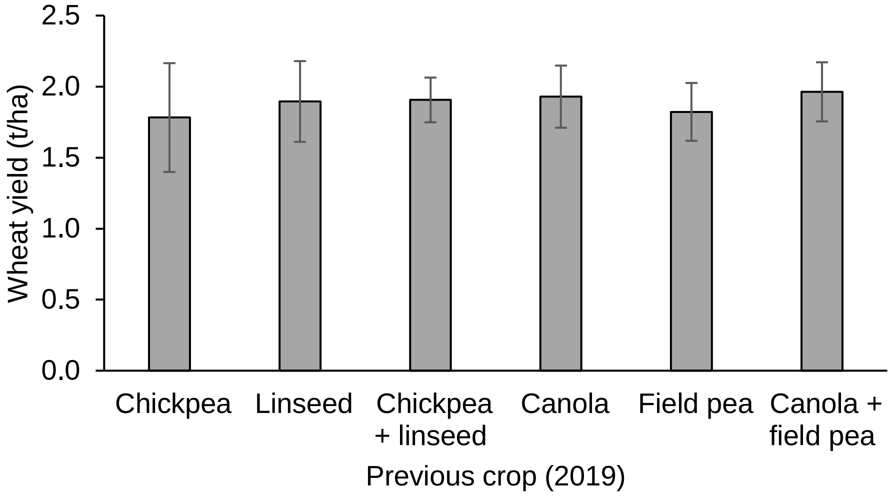


Figure 3. Grain yield for wheat sown over previous mono and intercrop treatments at Hart, 2020 (P≤0.05 LSD = NS).

Soil water dynamics

Total profile soil water is presented in Figure 4 and 5 for all treatments (except linseed monocrop) in both seasons. There was little difference in soil water use across all crop types. In 2019 the two intercrop treatments started to draw down more soil water in early August (Figure 4). However, once the profile become full again the draw down was similar for all treatments from mid-August through to harvest. This was unexpected due to the differences in soil moisture use / root architecture for the crops selected. Well below average rainfall at Hart in 2019 (162 mm compared to long-term average 400 mm) meant any rainfall or soil moisture received was quickly used by the crop. In an average to above average rainfall season there may be potential to see differences in total soil water use under the various crop types.

Coming in to the 2020 season there was no difference in residual soil moisture (data not shown). The following wheat crop was able to access similar amounts of moisture (Figure 5) whether the previous treatment was a mono or intercrop.

Photo: Intercropping trial at Hart, 2020.

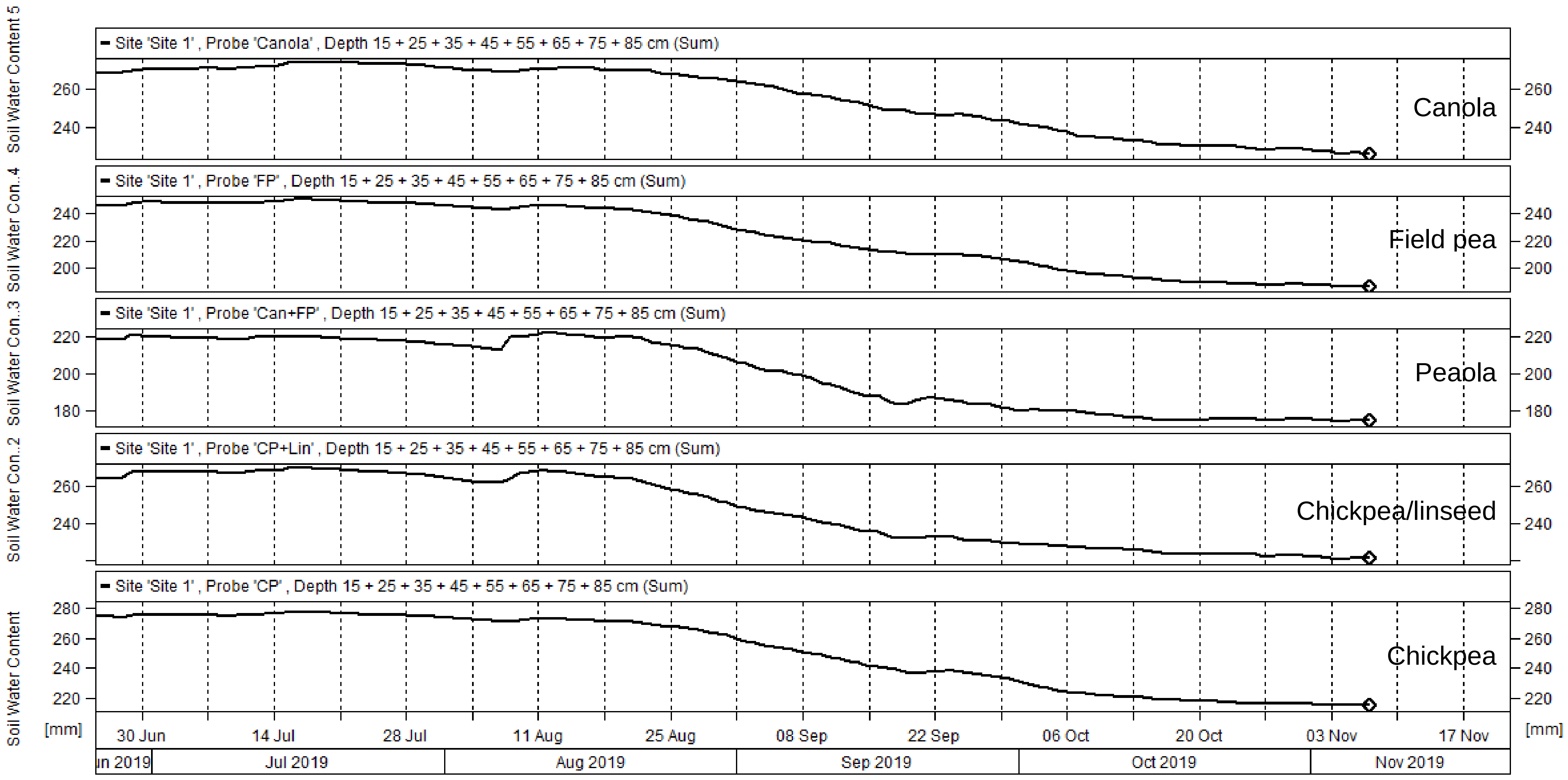
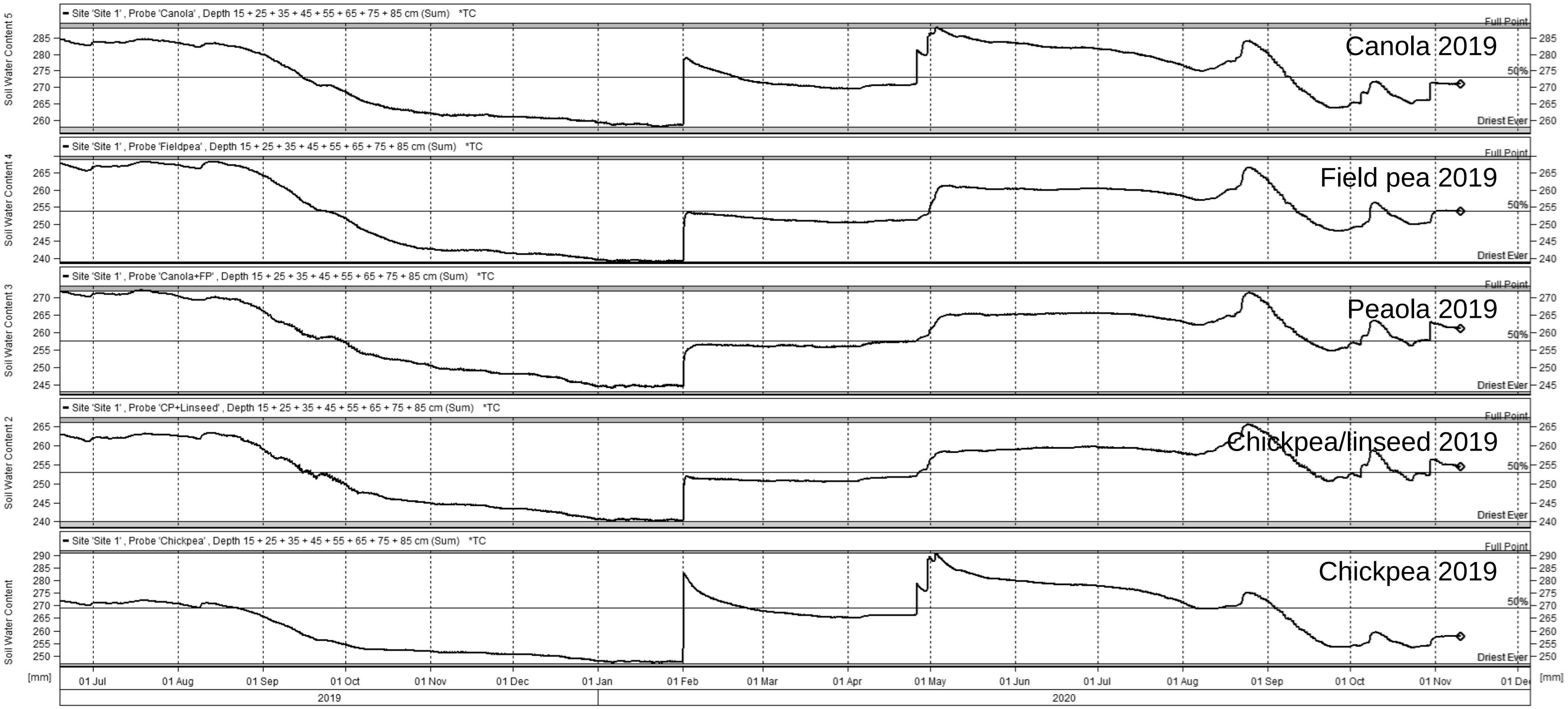


Figure 4. Soil water content measured by capacitance probes (EnviroPro 80 cm EP100GL-08) presented as the average for canola, field pea, peaola, chickpea and chickpea-linseed treatments at Hart, 2019.



Generated by IrriMAX™ Sentek Pty Ltd

Figure 5. Soil water content measured by capacitance probes (EnviroPro 80 cm EP100GL-08) under Scepter wheat sown across the previous intercrops at Hart, 2020.

Acknowledgements

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Canola

Chickpea + linseed

Chickpea

Field peas

Linseed

Peaola

Photos: Hart intercropping trial on August 6, 2020.

Legume and oilseed herbicide tolerance

Rebekah Allen; Hart Field-Site Group

Key findings

- Most incorporated by sowing (IBS) treatments were safe to use across several crop types at Hart in 2020.
- A range of post-emergent herbicides applied at 3-6 node, provided excellent control of all oilseed and legume crops in this trial.
- Dry surface soil conditions were observed post-seeding due to below average winter rainfall, affecting herbicide activity.

Why do the trial?

To compare the tolerance of canola and legume varieties to a range of herbicides and timings.

How was it done?

Plot size	2.0 m x 3.0 m	**Fertiliser**	MAP (10:22) + 1% Zn + Impact @ 80 kg/ha
Seeding date	May 29, 2020		

This trial was set up as a demonstration and is a non-replicated matrix. Sixteen varieties were sown in strips across eight crop types which include canola, faba bean, field pea, chickpea, lentil, vetch, sub clover and barrel medic. Fifty herbicide treatments were applied across all 16 crops at various timings.

Application timings:

Incorporated by sowing (IBS)	May 29
Post seeding pre-emergent (PSPE)	May 29
Early post emergent (3-4 node)	July 8
Post emergent (5-6 node)	July 24

Treatments were visually assessed and scored for herbicide effects approximately six weeks after application (Table 1).

Crop damage ratings were:

1 = no effect
2 = slight effect
3 = moderate effect
4 = increasing effect
5 = severe effect
6 = death

IBS treatments were re-assessed 12 weeks after application, due to an increase in visual crop damage after rainfall events in August. Conditions at Hart post-seeding were dry with a total of 3.2 mm rainfall received within two weeks of the applied IBS treatments.

Many of the herbicides used in this demonstration are not registered for crops that have been sprayed. It is important to check herbicide labels before following these strategies used. In 2020, a number of herbicide treatments displayed varying crop tolerances that were not expected. Care should be taken when interpreting these results, as herbicide effects can vary between seasons and is also dependent upon conditions at application, soil type and weather conditions.

Results and discussion

IBS

A new pre-emergent herbicide, Callisto® was included in the 2020 trial at Hart.

Callisto® (480 g/L Mesotrione) is a pre-emergent herbicide registered for the control of various broadleaf weeds in wheat and barley. Callisto® provided moderate suppression across most crops 12 weeks after application (Table 1). The delay in observed crop damage was due to dry surface soil conditions across the months of June and July (38.4mm). As expected, Reflex® provided moderate crop damage (rating 3) across all canola varieties and was seen to be safe across all other legumes. Sentry® also offered very good control (rating 5-6) for canola varieties that did not have Clearfield® (imidazolinone tolerant) traits.

Most IBS treatments included in this trial, had no effect on crop growth compared to nil treatment (Table 1).

PSPE

Post sowing pre-emergent treatments (PSPE) including Palmero TX® and Balance® + Simazine, had moderate to high damage across almost all crops in this trial but were safe to use on faba beans, field peas and chickpeas at Hart in 2020. Severe damage was observed across all crop types for these herbicides at Hart in 2019, except for chickpeas where these products are registered.

Post-emergent (3-4 node)

Simazine has continued to be the safest option across all oilseed and legume crops at the 3-4 node timing across many seasons, with nil to slight effects (rating 1-2) observed in 2020. Saracen® (50 g/L Florasulam) plus Banjo® was a new addition to this trial and is registered for post-emergent control of broadleaf weeds in wheat and barley. Saracen® provided excellent control of all oilseed and legume crops (rating 5-6).

Thristrol Gold® plus Banjo® was a new addition to this trial in 2019 and is registered for use on medic (2 L/ha) and clover (2-4 L/ha) and has shown to be safe on Sultan SU medic and Zulu II clover.

Ecopar® is registered in faba beans, vetch, field peas and pastures; however slight to moderate damage (rating 2-3) was seen across both pasture varieties. It is important to note that poor crop establishment and vigour was observed across pasture varieties due to very dry conditions and late emergence, causing some herbicides like Ecopar® to show an increase in crop damage.

Metribuzin was safe on canola at Hart in 2020 (rating 1-2); however, this result was not expected, and the application is not recommended.

Post-emergent (5-6 node)

Lontrel Advanced® was safe on canola and the new pre-commercial GIA1703L lentil (Group I, B tolerant) when applied at the 5-6 node timing. It also had very good control of all other legume varieties, which are not registered for on-label use. Talinor® + Hasten has been the most robust herbicide in this section across a number of years, providing excellent control (rating 5-6) across all oilseed and legume crops. Pixxaro® has shown to be safe on canola over several years at Hart while also providing good legume control. Flight® EC, Triathlon®, Quadrant® and frequency® provided moderate suppression and crop damage to most oilseed and legume crops at hart in 2020 (Table 1).

Table 1. Crop damage ratings for the legume and oilseed herbicide tolerance trial at Hart in 2020.

				Canola				Bean		Pea		C/pea	Lentil			Vetch		Medic	Clover
				Nuseed Quartz	HyTTec Trophy	Pioneer 44Y90	CT90008	PBA Bendoc	PBA Samira	Wharton	GIA Ourstar	Genesis090	Jumbo 2	PBA Hallmark XT	GIA1703L	RM4	Timok	Sultan SU	Zulu II
	Timing	Treatment	Rate																
1	IBS August 27	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2		Trifluralin	1500 ml	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
3		Sakura	118 g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4		Boxer Gold	2500 mL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5		Propyzamide	560 g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6		Butisan	1800 ml	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7		Devrinol C	2000 g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8		Ultro	1700 g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9		Reflex	1000 ml	3	3	3	3	1	1	1	1	1	1	1	1	2	1	1	1
10		Luximax	500 ml	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11		Overwatch	1250 ml	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12		Callisto	200ml	4	2	3	2	3	3	4	4	1	3	3	2	4	3	2	5
13		sentry	50g	5	6	1	1	1	1	1	1	1	1	1	1	4	1	1	6
14		Terrain	180g	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	6
15	PSPE May 29	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16		Diuron (900 g/kg)	825 g	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1
17		Simazine (900 g/kg)	825 g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
18		Metribuzin (750 g/kg)	280g	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
19		Terbyne (750 g/kg)	1000 g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20		Balance + Simazine	99 g + 830 g	3	3	5	4	2	1	1	1	1	3	3	3	3	3	5	6
21		Palmero TX	1000 g	3	3	5	3	2	1	1	1	1	3	3	3	2	2	5	6
22	3-4 Node July 8	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23		Simazine (900 g/kg)	850 g	1	2	2	2	1	1	1	1	1	1	1	2	1	1	1	1
24		Metribuzin (750 g/kg)	280 g	2	2	1	2	1	1	3	2	3	1	1	2	3	3	1	1
25		Broadstrike + Wetter 1000	25 g + 0.2%	5	5	1	2	2	2	3	1	3	1	1	2	4	3	1	1
26		Thistrol Gold + Banjo	2000 mL + 0.5%	6	6	5	5	2	3	3	2	3	4	5	4	5	4	2	1
27		Brodal Options	150 mL	3	3	3	3	3	3	2	1	4	3	1	2	4	3	3	3
28		Brodal Options + MCPA Amine 750	150 mL + 100 mL	3	3	3	3	3	4	1	1	4	3	1	2	4	4	3	3
29		Spinnaker + Wetter 1000	70 g + 0.2%	5	5	1	1	2	1	2	2	3	4	1	2	2	3	1	2
30		Raptor + Wetter 1000	45 g + 0.2%	5	5	1	3	2	1	2	1	4	4	1	2	3	3	1	3
31		Ecopar + Wetter 1000	800 mL + 0.2%	3	3	2	3	2	2	4	4	3	3	5	4	2	3	2	1
32		Intercept	750ml + 1.0%	5	5	1	1	1	2	3	1	5	4	1	1	5	3	1	4
33		Saracen + Banjo	100 mL + 1.0%	6	6	5	5	5	5	6	5	6	6	5	5	6	5	5	5
34	5 - 6 node July 24	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35		Ally + Wetter 1000	7 g + 0.1%	5	5	1	3	4	6	5	5	6	6	4	4	6	4	5	3
36		Atrazine + Hasten	1000 g + 1%	2	1	3	1	2	1	2	3	4	2	3	2	3	4	5	6
37		Lontrel Advanced	150 mL	1	1	1	1	6	6	4	5	6	6	6	1	6	6	6	6
38		Ecopar + MCPA Amine 750	400 mL + 330 mL	1	1	1	3	3	3	1	2	3	1	2	2	3	2	3	2
39		Carfentrazone + MCPA Amine 750	100 mL + 330 mL	1	1	3	4	2	3	2	2	4	2	1	2	3	2	4	3
40		Velocity + Uptake	670 mL + 0.5%	5	5	5	6	5	5	6	6	3	5	5	5	6	6	6	3
41		Talinor + Hasten	750 mL + 1 %	5	6	6	5	6	6	6	6	6	6	6	6	6	6	6	5
42		Paradigm + MCPA LVE + Uptake	25 g + 500 mL + 0.5%	6	5	4	4	5	5	5	5	6	6	5	5	6	6	5	6
43		**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
44		Flight EC	720 mL	3	3	4	4	4	3	1	2	2	3	2	3	4	4	3	2
45		Triathlon	1000 mL	3	4	5	5	4	3	2	3	3	3	2	4	4	4	2	1
46		Quadrant	1000 mL	4	5	4	5	2	3	4	4	2	3	4	4	5	4	6	4
47		Frequency	200 mL + 1.0%	4	4	4	4	4	4	2	3	4	3	3	2	4	4	3	3
48		Pixxaro + Uptake	300 mL + 0.5%	1	2	2	2	5	5	5	5	6	6	6	6	6	6	6	6
49		Rexade + Wetter 1000	100 g + 0.25%	3	3	2	3	4	5	5	4	5	5	4	4	6	5	5	6
50		Atlantis OD + Hasten	330 mL + 0.5%	5	5	2	2	4	5	5	5	5	4	1	1	6	5	5	5

Annual ryegrass control with new pre-emergent herbicides and mixtures

Chris Preston; University of Adelaide and Rebekah Allen; Hart Field-Site Group

Key findings

- Luximax and Overwatch improved annual ryegrass control (10-26 plants/m^2) compared to existing pre-emergent herbicides (45 -158 plants/m^2).
- Annual ryegrass (heads/m^2) were reduced when Luximax and Overwatch were applied standalone or in mixtures.
- Post-seeding conditions at Hart were dry with well below average rainfall, favouring the more soluble pre-emergent products, Luximax and Overwatch.
- No yield penalties were observed for Scepter wheat across all pre-emergent herbicides at Hart in 2020.

Why do the trial?

Herbicide resistance in grass weeds is a major constraint to crop production. Due to resistance to post-emergent herbicides, the main control tactics used in wheat for annual ryegrass control are now pre-emergent herbicides. It is important that pre-emergent herbicides are used as effectively as possible. New mode of action herbicides are being developed for annual ryegrass; however, there is limited information about the efficacy of mixtures of these new herbicides with existing herbicides to obtain higher levels of annual ryegrass control in wheat.

This trial aims to evaluate the effect of new pre-emergent herbicides Luximax (active ingredient, cinmethylin) and Overwatch (active ingredient, bixlozone) alone or in mixtures with existing pre-emergent herbicides on annual ryegrass control.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) + 1% Zn + Impact @ 80 kg/ha
Seeding date	May 20, 2020		Easy N (42.5:0) 80 L/ha on June 18, 2020
Location	Hart, SA		Easy N (42.5:0) 50 L/ha on August 5, 2020
Harvest date	December 3, 2020		

Ryegrass seed at 5 kg/ha was broadcast on May 19 and was lightly incorporated. Pre-emergent herbicides were applied IBS on May 20.

Scepter wheat was sown after IBS applications were applied with a standard knife-point press wheel system, 22.5 cm (9") row spacing. Herbicides and rates used are listed in Table 1.

Table 1. Pre-emergent herbicide treatments applied for the management of ryegrass in wheat at Hart in 2020.

Herbicide treatment		Product rate (/ha)
1.	Nil	-
2.	Arcade	3 L
3.	Avadex Xtra	2 L
4.	Sakura	118 g
5.	Sakura Flow	210 mL
6.	Sakura + Avadex Xtra	118 g + 2 L
7.	Arcade + TriflurX	3 L + 1.5 L
8.	Luximax	500 mL
9.	Luximax + Sakura	500 mL + 118 g
10.	Luximax + Avadex Xtra	500 mL + 2 L
11.	Luximax + Arcade	500 mL + 3 L
12.	Overwatch	1.25 L
13.	Overwatch +Sakura	1.25 L + 118 g
14.	Overwatch + Avadex Xtra	1.25 L + 2 L
15	Overwatch + Arcade	1.25 L + 3 L

Results and discussion

Annual ryegrass control

Excellent rains occurred in early autumn leading to a moist soil profile at sowing (Figure 1). However, rainfall during May and June was below average. This likely influenced the ability of Sakura to be activated and control annual ryegrass.

There was no significant effect of herbicide treatment on crop emergence in 2020 (Table 2).

Most pre-emergent herbicides are safe on wheat when used with a knife-point press wheel seeding configuration. However, damage can occur with some pre-emergent herbicides if the furrow wall collapses or herbicide-treated soil is moved into the crop row.

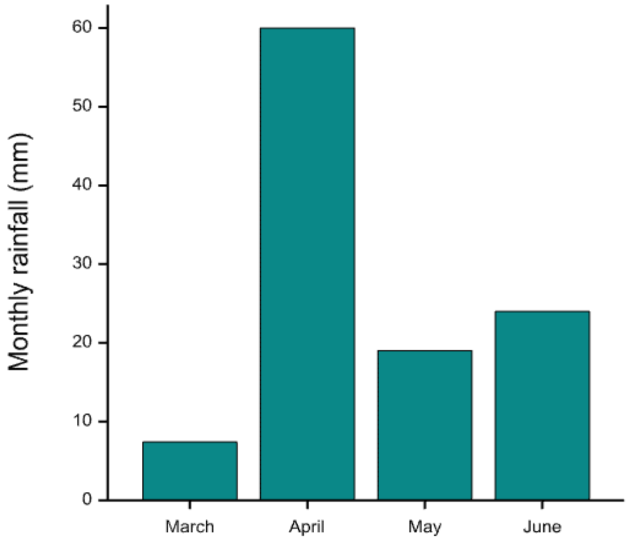

Figure 1. Monthly rainfall at Hart in 2020.

Table 2. The effect of various pre-emergent herbicides on wheat establishment, annual ryegrass plant numbers (4 weeks after sowing) and annual ryegrass head numbers at Hart in 2020.

	Herbicide treatment	Crop establishment (plants m^2)	Annual ryegrass (plants m^2)	Annual ryegrass (heads m^2)
1.	Nil	164	183	215
2.	Arcade	174	123	158
3.	Avadex Xtra	165	120	154
4	Sakura	158	85	70
5.	Sakura Flow	168	70	45
6.	Sakura + Avadex Xtra	165	48	49
7.	Arcade + TriflurX	174	82	135
8.	Luximax	144	10	28
9.	Luximax + Sakura	160	11	17
10.	Luximax + Avadex Xtra	145	11	21
11.	Luximax + Arcade	161	16	26
12.	Overwatch	188	26	68
13.	Overwatch +Sakura	156	20	28
14.	Overwatch + Avadex Xtra	171	20	43
15.	Overwatch + Arcade	158	12	48

Shaded values indicate best performing herbicides for annual ryegrass control.

Both Luximax and Overwatch provided good control of annual ryegrass (10 – 26 plants m^2). Weed control was improved with these, compared to existing pre-emergent herbicides with annual ryegrass numbers between 45 -158 plants/m^2. The rate of Avadex Xtra (2 L/ha) used in this trial is too low to control annual ryegrass alone.

Luximax is the most soluble of the herbicides used and would have been least affected by the relatively dry conditions after sowing. Overwatch is a little more soluble than both Sakura or Arcade and this would have assisted its performance in the drier conditions after sowing. While pre-emergent herbicides have generally worked well in 2020, situations with low rainfall after sowing, such as at Hart, have seen reduced performance of Sakura, while Overwatch and Luximax have performed well.

Overwatch and Luximax applied alone or in mixtures reduced the number of annual ryegrass heads when compared to existing pre-emergent herbicides, Arcade and Avadex Xtra. Sakura, while less effective at controlling annual ryegrass emergence was effective at reducing weed seed heads. The persistence of Sakura allows it to disrupt growth of established annual ryegrass once the herbicide is activated by sufficient rainfall.

Grain yield

Overwatch often produces crop effect on wheat as bleaching of young leaves. Crops grow out of the effect and in our trials there has been no effect on crop yield to date. Mixtures of Group K herbicides with Luximax can result in crop yield loss and are not recommended. The mixture with Sakura used here can be particularly problematic. While the crop establishes normally, growth is affected leading to yield loss. At a trial at Inverleigh in Victoria in 2019 there was a 1 t/ha reduction in wheat yield for Luximax + Sakura.

There was no yield penalty observed for Scepter wheat across all pre-emergent herbicides at Hart in 2020.

Acknowledgements

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Management of Group A, J and K resistant annual ryegrass in pulses

Navneet Aggarwal and Penny Roberts; SARDI, Clare

Key findings

- Ultro® (a new Group E herbicide with active carbetamide) and Group D propyzamide proved equally effective for annual ryegrass control in lentil and chickpea.
- Boxer Gold® and Sakura® herbicides need to be rotated with other mode of action herbicides, especially with Group D propyzamide and Group E Ultro, in the pulse crop phase.
- Integrated weed management tactics of wick wiping and clipping + wick wiping reduced annual ryegrass seed set.

Why do the trial?

The increased adoption of herbicide tolerant break crops, such as triazine tolerant (TT) canola, Group B imidazolinone (IMI) tolerant Clearfield® canola and XT lentil, has produced an increased reliance on Group A chemistry (fops and dims) to control annual ryegrass, leading to rapid development of resistance to these herbicides.

There is currently an increase in the uptake of alternative pre-emergent chemistry like Group D, J and K herbicides for managing dim-resistant annual ryegrass in break crops. However, annual ryegrass populations starting to evolve resistance to these Group J and K herbicides in South Australia (Aggarwal *et al*. 2019) might lead to severely reducing herbicide options available for the control of annual ryegrass in pulse crops. Therefore, research trials were conducted to identify effective management options for annual ryegrass resistant to Group A, J and K herbicides in lentil and chickpea. The preliminary work was presented in Eyre Peninsula Farming Systems (EPARF) 2019, pp 146-148.

How it was done?

Plot size	1.35 m x 10.0 m	**Fertiliser**	MAP @ 80 kg/ha
Seeding date	Lentil May 16, 2019 & May 25, 2020 Chickpea May 29, 2019		
Location	Hart, SA		

Research trials were sown at the Hart field site (Mid-North) with SARDI Group C tolerant lentil germplasm line (M043) in 2019, PBA Hurricane XT and Group C lentil germplasm line GIA 2004L in 2020, and kabuli chickpea Genesis 090 in 2020. The new pre-emergent herbicide Ultro® (active carbetamide, Group E) was included for controlling annual ryegrass applied as incorporated by sowing (IBS) in all three trials. Ultro (IBS) + clethodim post-emergence (POST) at 5-node growth stage was compared to growers' practices of propyzamide (IBS) + clethodim (POST), Boxer Gold® (IBS) + clethodim (POST), Sakura® (IBS) + clethodim (POST) in lentil 2019 and chickpea 2020 trials (Table 1).

In addition, the potential of integrated weed management tactics such as clipping and clipping + wick wiping annual ryegrass at embryo development stage was studied in addition to pre-emergent herbicides in 2020 lentil (Figures 1 and 2) and chickpea trials (Table 2). A gravity-based wick wiper was used for wick wiping with Glyphosate + LVE MCPA + water mixed 1:1:1, and clipping of annual ryegrass growing above the crop canopy was done manually. All herbicide doses are mentioned in terms of the commercial product (Tables 1, 2 and 3; Figures 1, 2 and 3). Seeds of annual ryegrass resistant to Group A clethodim, Group J and K herbicides were broadcast at 250 and 500 seeds/m2 in 2019 and 2020, respectively. This was completed ahead of seeding and weed seeds were incorporated prior to IBS herbicide application with a shallow pass of the seeder with roller attached to it. Ryegrass head density and seed set was assessed near crop harvest from three randomly selected spots using a quadrant of 50 cm × 50 cm. The dead heads resulting from wick wiping treatments were not included in the final head count in 2020 trials. Harvesting of lentil was completed on October 29, 2019 and November 17, 2020 and chickpea on December 9, 2020.

Results and discussion

Effect on annual ryegrass in lentil

In 2019, propyzamide (IBS) + clethodim (POST) and Ultro (IBS) + clethodim (POST) proved equally effective for Group A, J and K resistant annual ryegrass control (Table 1). Both of these Group D and Group E herbicide treatments proved more effective than growers' practices of Sakura (IBS) + clethodim (POST) and Boxer Gold (IBS) + clethodim (POST) for reducing annual ryegrass head density and seed set. Furthermore, herbicide treatment propyzamide (IBS) + clethodim (POST) and Ultro (IBS) + clethodim (POST) reduced annual ryegrass seed set up to 99% and 97%, respectively over unsprayed control.

In 2020, propyzamide (IBS) and Ultro (IBS) proved equally effective for controlling Group A, J and K resistant annual ryegrass (Figures 1 and 2). Both herbicides resulted in a 74-78% reduction in annual ryegrass head density and a 74-76% reduction of seed set, compared to the unsprayed control in Group C lentil. Furthermore, integrated weed management tactics of wick wiping annual ryegrass at embryo development stage resulted in 54% and 69% reduced head density and seed set, respectively, as compared to no clipping/wick wiping.

The treatment of clipping alone did not prove effective in reducing annual ryegrass head density and its seed set, as the clipped annual ryegrass plants could regrow, producing a similar seed set to no clipping/wick wiping. Both combined treatments of clipping and wick wiping reduced annual ryegrass head density and its seed set, as compared to clipping alone and no clipping/wick wiping, but were not significantly different to the treatment of straight wick wiping.

Table 1. Annual ryegrass management in Group C lentil at Hart in 2019.

Herbicide treatment		**Ryegrass heads/m^2**	**Ryegrass seed set/m^2**
T_1	Sakura 118 (IBS) + clethodim 500 (POST)	19.6^{c}	650^{c}
T_2	Boxer Gold 2500 (IBS) + clethodim 500 (POST)	57.3^{b}	2228^{b}
T_3	Propyzamide 1000 (IBS)	6.2^{cd}	246^{cd}
T_4	Propyzamide 1000 (IBS) + clethodim 500 (POST)	0.6^{def}	23^{de}
T_5	Ultro 1700 (IBS)	4.7^{de}	156^{de}
T_6	Ultro 1700 (IBS) + clethodim 500 (POST)	3.1^{def}	108^{de}
T_7	Unweeded control	136.7^{a}	5506^{a}

Figures labelled with the same letter are not significantly different (P≤0.05).

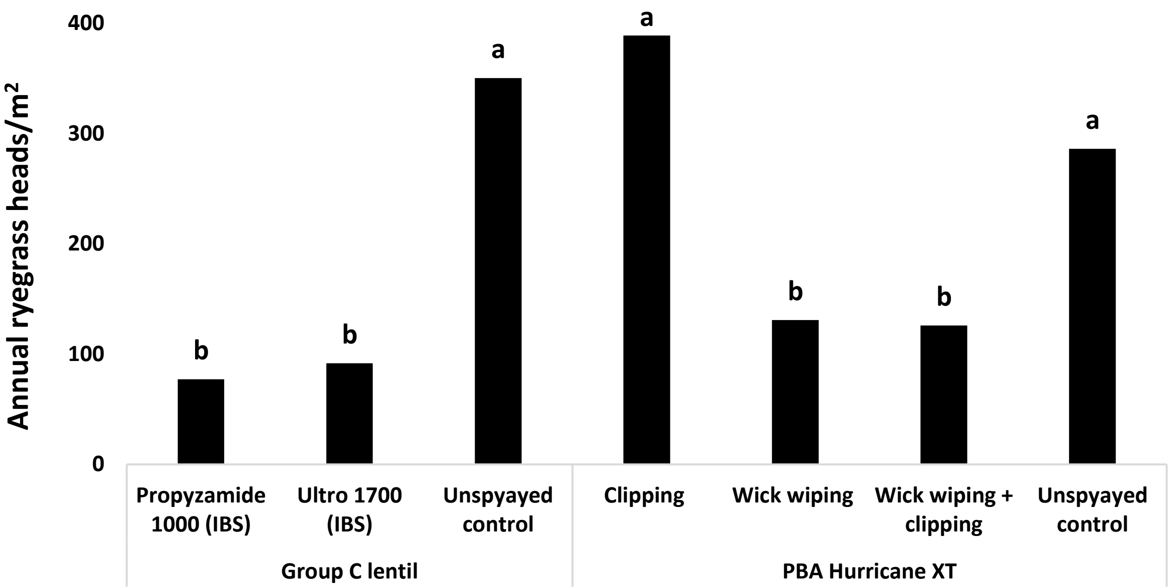

Figure 1. Annual ryegrass head density response to weed control treatments in lentil at Hart 2020. Bars labelled with the same letters are not significantly different (P≤0.05).

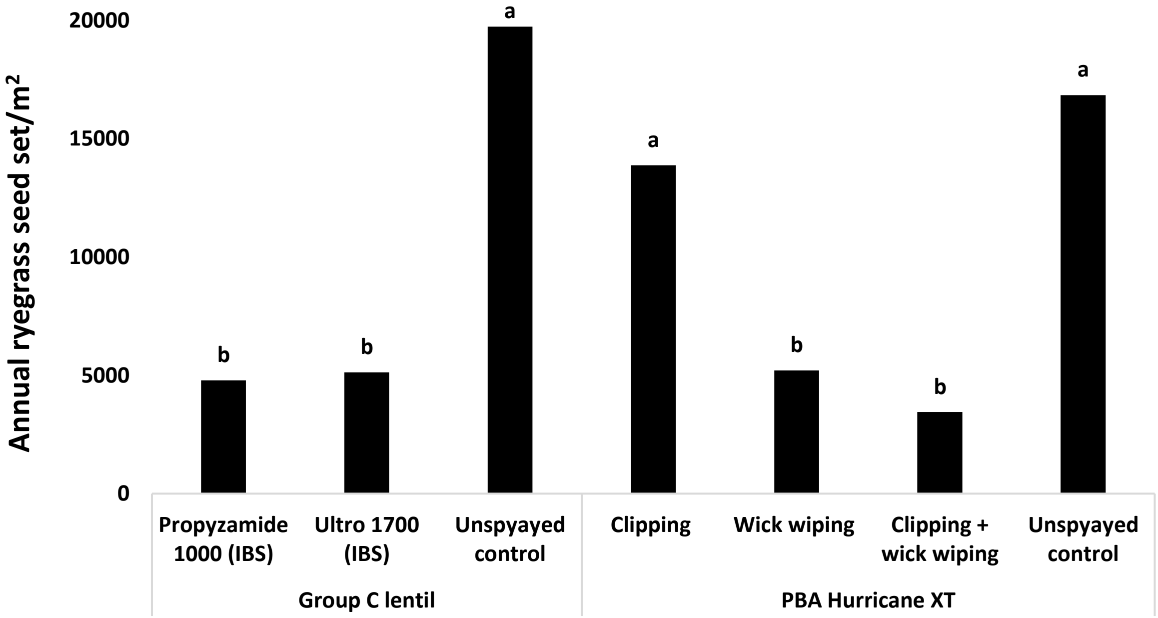

Figure 2. Annual ryegrass seed set response to weed control treatments in lentil at Hart 2020. Bars labelled with the same letters are not significantly different (P≤0.05).

Effect on Annual ryegrass in chickpea

Application of propyzamide (IBS) + clethodim (POST) and Ultro (IBS) + clethodim (POST) proved equally effective for Group A, J and K resistant annual ryegrass control in chickpeas (Table 2). Annual ryegrass produced 62 heads in propyzamide (IBS) + clethodim (POST) that were 83% and 70% less than Boxer Gold (IBS) + clethodim (POST) and Sakura 118 (IBS) + clethodim (POST), respectively. Similarly, Ultro (IBS) + clethodim (POST) reduced annual ryegrass heads density by 71% and 51% relative to Boxer Gold (IBS) + clethodim (POST) and Sakura 118 (IBS) + clethodim (POST), respectively. Ryegrass seed production reflected the similar trends observed in head density data. Application of propyzamide (IBS) + clethodim (POST) and Ultro (IBS) + clethodim (POST) resulted in a reduction in annual ryegrass seed set as compared to both Boxer Gold (IBS) + clethodim (POST) and Sakura 118 (IBS) + clethodim (POST).

Furthermore, a protective inter-row spray of Spray.Seed before chickpea canopy closure proved equally effective to pre-emergent herbicides propyzamide and Ultro for annual ryegrass control. As in lentil crop, integrated weed management tactics of wick wiping and clipping + wick wiping proved more effective in reducing annual ryegrass head density and its seed set, compared to clipping alone.

Table 2. Ryegrass management in chickpeas at Hart in 2020. Numbers with the same letter in a column are not significantly different ($P \leq 0.05$).

Herbicide treatment		**Ryegrass heads/m^2**	**Ryegrass seeds/m^2**
T_1	Boxer Gold 2500 (IBS) + Clethodim 500 (POST)	357^{ab}	23256^{a}
T_2	Sakura 118 (IBS) + clethodim 500 (POST)	210^{c}	12679^{b}
T_3	Propyzamide 1000 (IBS) + clethodim 500 (POST)	62^{d}	3819^{c}
T_4	Ultro 1100 (IBS) + clethodim 500 (POST)	104^{d}	6610^{c}
T_5	Protective inter-row spray of Spray.Seed before canopy closure	104^{d}	6384^{c}
T_6	Clipping at reproductive stage	380^{a}	11946^{b}
T_7	Clipping + wick wiping	221^{c}	4264^{c}
T_8	Wick wiping at reproductive stage	266^{bc}	4343^{c}
T_9	Unsprayed control	426^{a}	26896^{a}

Effect on grain yield of lentil

In 2019, all the herbicide treatments resulted in a significantly higher lentil grain yield over the unsprayed control (Figure 3). Application of Ultro (IBS) + clethodim (POST) produced similar grain yield as achieved with Propyzamide (IBS) + clethodim (POST) and Sakura (IBS) + clethodim (POST). Poor annual ryegrass control with Boxer Gold (IBS) + clethodim (POST) resulted in the lowest lentil yield as compared to other pre-emergent herbicides. In 2020, propyzamide (IBS) application produced similar lentil grain yield (0.73 t/ha) as achieved with Ultro (IBS) (0.82 t/ha).

Effect on grain yield of chickpeas

Application of propyzamide (IBS) + clethodim (POST) produced higher grain yield compared to growers' practice of Boxer Gold (IBS) + clethodim (POST), and Sakura (IBS) + clethodim (POST) (Table 3). Application of Ultro (IBS) + clethodim (POST) produced similar yields as with propyzamide (IBS) + clethodim (POST) and Sakura (IBS) + clethodim (POST).

Integrated weed management tactics of wick wiping and clipping + wick wiping, though resulting in similar annual ryegrass seed set as in propyzamide (IBS) + clethodim (POST) and Ultro (IBS) + clethodim (POST), produced chickpea yields no different to the unsprayed control. This was due to the competition from annual ryegrass before applying agronomic tactics of wick wiping and clipping + wick wiping. Therefore, early season annual ryegrass control with pre-emergent herbicides is crucial for achieving good chickpeas yields, and late season weed seed set control tactics such as wick wiping and clipping + wick wiping reduce the weed seed burden for the following seasons' crops.

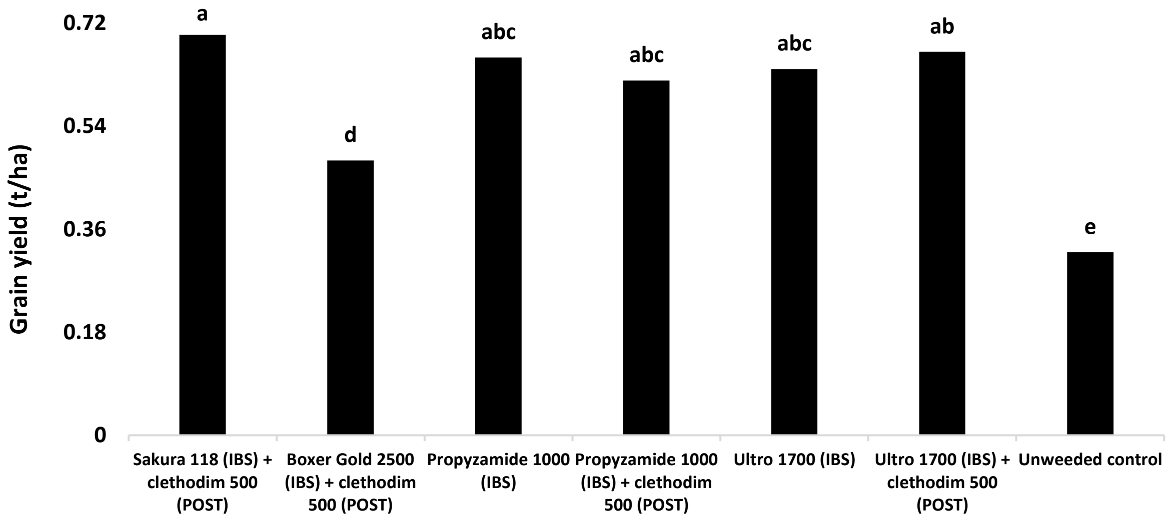

Figure 3. Lentil grain yield at Hart 2019. Bars labelled with the same letters are not significantly different (P≤0.05).

Table 3. Chickpea grain yield response to ryegrass management at Hart in 2020. Numbers with the same letter are not significantly different (P≤0.05).

Herbicide treatment		**Grain yield (t/ha)**
T_1	Boxer Gold 2500 (IBS) + Clethodim 500 (POST)	0.98^{c}
T_2	Sakura 118 (IBS) + clethodim 500 (POST)	1.27^{b}
T_3	Propyzamide 1000 (IBS) + clethodim 500 (POST)	1.64^{a}
T_4	Ultro 1100 (IBS) + clethodim 500 (POST)	1.39^{ab}
T_5	Protective inter-row spray of Spray. Seed before canopy closure	1.29^{b}
T_6	Clipping at reproductive stage	0.51^{d}
T_7	Clipping + wick wiping	0.54^{d}
T_8	Wick wiping at reproductive stage	0.44^{d}
T_9	Unsprayed control	0.52^{d}

What does this mean?

Availability of the new mode of action herbicide Ultro (active carbetamide, Group E) makes it an important tool, along with Group D propyzamide, in reducing selection pressure for existing Group J and K pre-emergent, and dim chemistry post emergent herbicides for annual ryegrass control in pulse crops. In addition, adopting proven strategies for stopping annual ryegrass to set seeds such as crop topping and wick wiping, and collecting remaining seed through harvest weed seed collection measures across different phases of the crop rotation, are important to reduce soil weed-seed bank and delay resistance build-up to herbicides.

Ultro (IBS) + clethodim (POST)

Unsprayed control

Figure 3. Ryegrass management in lentil at Hart in 2019.

Propyzamide (IBS)

Ultro (IBS)

Unweeded control

Figure 4. Ryegrass management in lentil at Hart in 2020.

Ultro (IBS) + clethodim (POST)

Propyzamide (IBS) + clethodim (POST)

Sakura (IBS) + clethodim (POST)

Boxer Gold (IBS) + clethodim (POST)

Interrow spray of spray. seed

Unsprayed control

Figure 5. Ryegrass management in chickpeas at Hart in 2020.

Acknowledgements

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Hart 2020


Sowing trials at the Hart field site

Prof Chris Preston presenting at our mini-event; Managing Weeds

New QR codes at every trial


Social distancing at the Hart Winter Walk

Managing crown rot – fungicide seed treatment and variety resistance

Margaret Evans; SARDI, David Hosking; Syngena Australia and Lyndon May; Elders

Key findings

- The Syngenta Australia fungicide seed treatment (working name, Tymirium) improved yields of durum wheat, bread wheat and barley in the presence of crown rot.
- Yield improvements were greatest for durum wheat (VS) – 24%-32% and lower for bread wheat (MS-S) – 4%-29% and barley (S) – 7%.
- New Elders Limited bread wheat lines EDGE-19-SA-0178 and EDGE-19-SA-1098 improved crown rot resistance and yielded well in the presence of crown rot when compared with Trojan.
- Tymirium seed treatment reduced crown rot incidence (% main stems with basal browning), severity of basal stem browning and white head expression in durum and bread wheats and severity of basal stem browning in barley.
- Fungicide seed treatment and bread wheat varieties with improved resistance to crown rot (even if combined) will not eliminate crown rot inoculum carryover in the season they are used. However, it is likely that both management options will assist in managing crown rot inoculum levels in the medium to long-term, particularly where they are used together and where breaks from cereal are included in the rotation.

Why do the trial?

Crown rot infected stubble can take three to four years to break down, making crown rot difficult to manage in current farming systems, particularly where durum wheat is part of the rotation. To date, fungicides registered for use in controlling crown rot have not been available and resistance levels in commercial wheat varieties have been limited. These management options are generally the simplest and most economic to implement and are particularly advantageous for managing crown rot.

At the start of 2020, there was an opportunity to work with Syngenta Australia to assess efficacy of a promising new fungicide seed treatment (Tymirium – working name) in the process of being evaluated for crown rot management. In addition to this, Elders Limited have advanced bread wheat lines with crown rot resistance levels which were assessed in these trials. This also provided the opportunity to assess the level of crown rot resistance of the new AGT durum variety Bitalli when compared with DBA Aurora. These opportunities were taken up to ensure any options for better managing crown rot would be made available to the South Australian Grains Industry in a timely manner.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	Seeding: DAP (18:20) Zn 1% + Impact @ 80 kg/ha
Seeding date	May 25, 2020		
Harvest date	November 26, 2020		July 2: Easy N (42.5:0) @ 80 L/ha
Location	Hart, SA		August 5: Easy N (42.5:0) @ 50 L/ha

Plot size	1.80 m x 12.0 m	**Fertiliser**	Seeding: DAP (18:20) @ 105 kg/ha **In-season N application data not available for this site*
Seeding date	May 18, 2020		
Harvest date	December 19, 2020		
Location	Pinery, SA		

Trial layout was a split-plot design at Hart and a randomised block design at Pinery with treatments (Table 1) in three replicates at each site.

All plots were inoculated with crown rot by adding sterilised grain colonised with crown rot to treatments at sowing. The same seed sources were used for all treatments in both trials and the Tymirium fungicide was supplied and applied to seed by Gereon Schnippenkoetter (Syngenta Australia).

Table 1. Treatments applied at Hart and Pinery in 2020 to assess the efficacy of variety resistance and fungicide (Tymirium) seed treatment for managing crown rot expression and yield losses due to crown rot.

Entries	**Crown rot resistance**	**Hart**		**Pinery**	
		Tymirium[1]	Control	Tymirium[1]	Control
Bitalli	Very susceptible	✓	✓		
Aurora	Very susceptible	✓	✓	✓	✓
Scepter	Susceptible	✓	✓	✓	✓
Trojan	Moderately susceptible	✓	✓	✓	✓
Spartacus		✓	✓		
Elders bread wheat lines bred for improved crown rot resistance					
EDGE-19-SA-0178		✓	✓	✓	✓
EDGE-19-SA-1098		✓	✓	✓	✓
EDGE-SA-0944					✓
EDGE-SA-1071					✓
EDGE-SA-058					✓
EDGE-SA-054					✓

[1] Fungicide seed treatment (applied to grain for these trials by Syngenta Limited). This product is in the process of being evaluated for crown rot management. Planned for release in 2023-2024.

Plant samples were collected at early grain fill for assessment of plant density, whitehead expression and browning on main stem bases. Plot yield was recorded, and grain quality assessed (grain quality results not yet available). Crown rot incidence (% of main stems with basal stem browning) and expression (extent of browning on main stems) was scored visually on a 0-5 scale:

0 = 0%	No yield loss
1 = 1-10%	Possibility of minor yield loss
2 = 10-25%	Possibility of some yield loss
3 = 25-50%	Probably some yield loss
4 = 50-75%	Significant yield loss likely
5 > 75%	High yield loss likely

Results and discussion

Trials established well and weeds, pests and other diseases were adequately controlled, except for Russian wheat aphid at Pinery. Although good rains around sowing allowed the trials to establish well, at both sites there were significant moisture stress periods across the season. Plant densities (data not presented) were not influenced by seed treatment and so plant density effects on crown rot expression and grain yield did not need to be considered during data interpretation. For simplicity, mainly Hart data is presented here, but Pinery data also support the general trends seen at Hart.

Fungicide seed treatment

Tymirium seed treatment significantly reduced stem browning expression (Figure 1) and this was reflected in whitehead expression (Figure 2) and yields (Figure 3). Yield improvements ranged from 4% - 26% at Hart and from 13% - 32% at Pinery (Table 2), with the very susceptible durum wheat varieties having the greatest yield improvements. These magnitudes of yield improvement are consistent with those seen at an industry trial undertaken at Balaklava in 2020. The economics of using this seed treatment still needs clarification in trials with a range of crown rot inoculum levels, including a control with no crown rot present.

Numerous industry trials in New South Wales, Victoria and South Australia with the new seed treatment (Tymirium) developed by Syngenta, have indicated that it has efficacy against crown rot caused by *Fusarium pseudograminearum*. The trials run at Hart and Pinery in 2020 support this contention and once this seed treatment is registered and released (2023 to 2024), it will provide a powerful tool for managing yield losses due to crown rot. Importantly, Tymirium application to seed will allow durum wheat to be grown in paddocks with crown rot inoculum present (probably up to medium risk levels). This has the potential to increase the area sown to durum wheat and to decrease the length of the break between durum crops.

An incidence of 20% or more of plants with basal stem browning presents a significant risk of yield loss due to crown rot for a subsequent cereal crop. Even where the seed treatment was applied to the more resistant bread wheats, the incidence of crown rot was above 20% at both trial sites (data not presented). As the seed treatment also reduces the severity of expression of crown rot, it is still possible that it will reduce inoculum carryover, however, further research will be required to quantify effects of seed treatment on inoculum carryover.

Until the effects of the seed treatment on inoculum carryover is better understood, risk levels for crown rot should still be assessed (e.g. PREDICTA B® soil analysis) in paddocks being sown to susceptible cereals, particularly durum wheat.

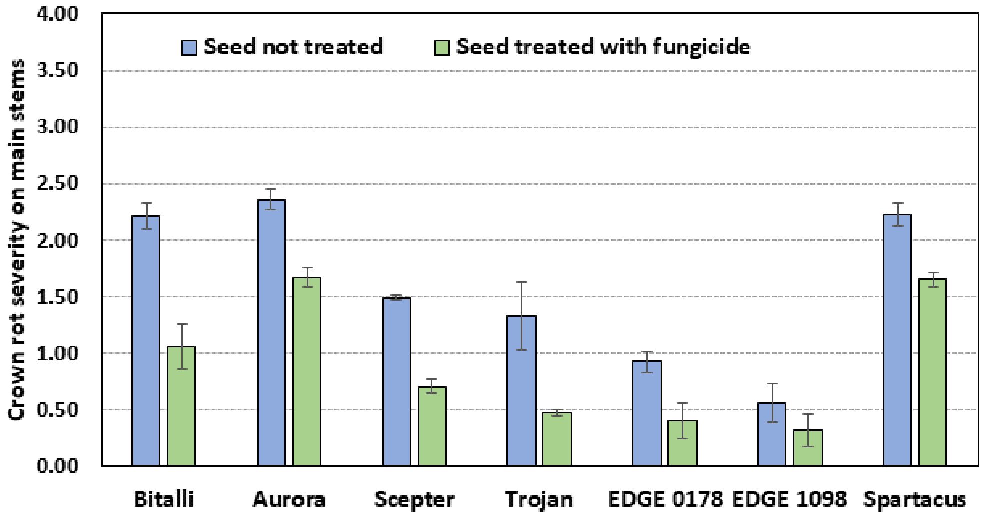

Figure 1. Effects of Tymirium seed treatment and varietal resistance on crown rot expression at Hart in 2020. A basal stem browning score of around 2.00 is often associated with some yield loss.

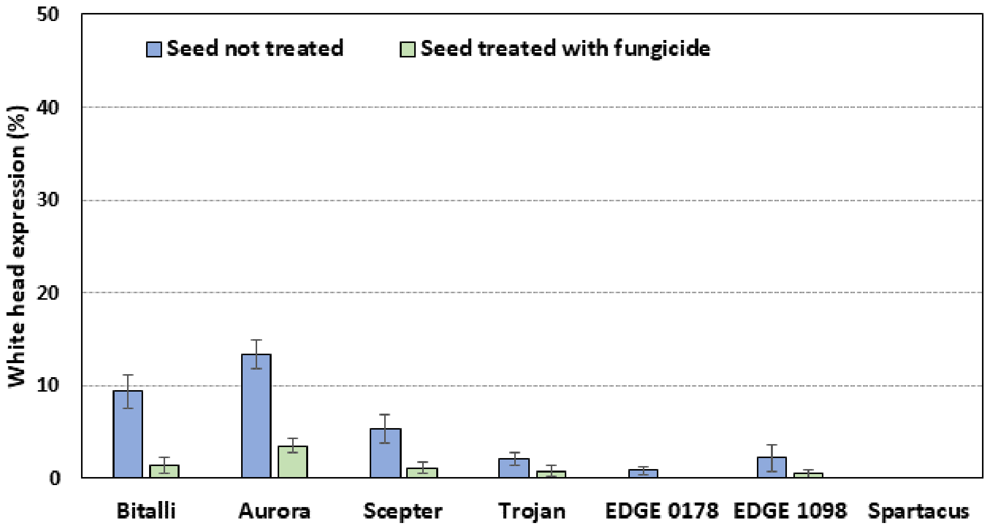

Figure 2. Effects of Tymirium seed treatment and varietal resistance on white head expression at Hart in 2020.

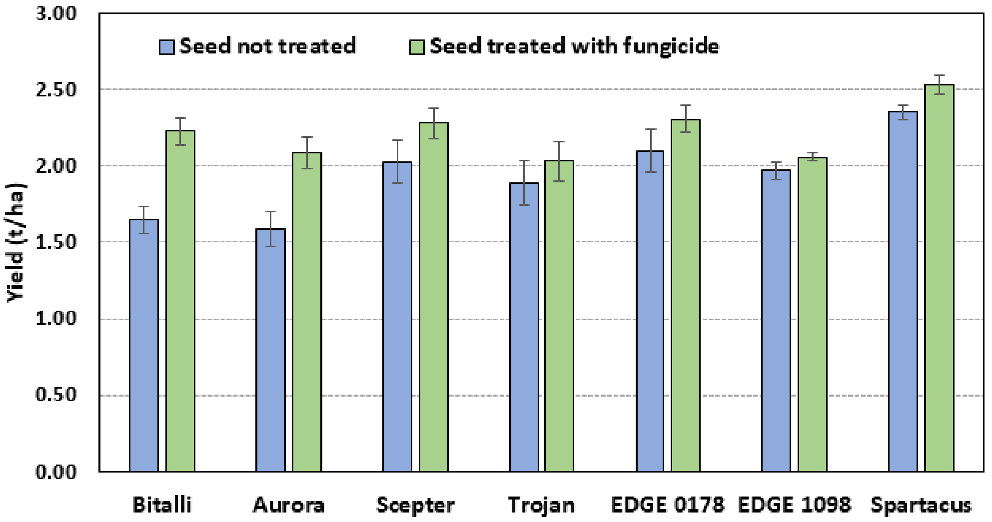

Figure 3. Effects of Tymirium seed treatment and varietal resistance on grain yield at Hart in 2020.

Table 2. Yield improvements (%) associated with application of Tymirium fungicide to seed of varieties with different resistances to crown rot, Hart 2020.

	Hart	**Pinery**
Bitalli	26	np[1]
Aurora	24	32
Scepter	11	18
Trojan	7	20
Spartacus	7	np
EDGE 0178	9	13
EDGE 1098	4	29

[1] *np was not present at Pinery.*

Resistance to crown rot

All results discussed below are for treatments in the presence of crown rot and the absence of Tymirium seed treatment and no data are presented for Pinery findings.

The Elders lines EDGE-19-SA-0178 and EDGE-19-SA-1098 had lower crown rot expression than Trojan (MS) at both Hart (Figure 1) and Pinery. These lines had yields similar to, or better than Scepter and Trojan at Hart (Figure 3) and better than Trojan at Pinery.

EDGE SA 1071, assessed only at Pinery, had lower crown rot expression than Trojan but also had lower yields than Trojan, EDGE-19-SA-0178 and EDGE-19-SA-1098. Three other lines assessed only at Pinery had greater crown rot expression than Scepter (S) but had reasonable yields when compared with Trojan.

The Elders bread wheat lines EDGE-19-SA-0178 and EDGE-19-SA-1098 demonstrated that, compared with current commercial bread wheat varieties, they have improved resistance to crown rot combined with competitive yields in the presence of crown rot. If these lines are released commercially, they will be useful alternatives to current varieties, particularly if they also have good grain quality and yield well in seasons where crown rot does not express.

Basal stem browning on Bitalli and Aurora was present at similar levels at Hart in 2020 (Figure 1). This suggests that Bitalli is as susceptible to crown rot as Aurora.

Acknowledgements

Thanks to Syngenta Australia and Elders Limited for funding this work. Thanks also to the Southern Australian Durum Growers Association for their sponsorship and to the Hart Field-Site Group for supporting this research and for provision of sowing, management and harvest for the Hart trial.

Photo: Researcher Marg Evans, SARDI demonstrating crop sampling techniques to a group of early career farmers at Hart.

Are root diseases limiting pulse yields?

Blake Gontar, Tara Garrard, Kelly Hill, Steve Barnett, Entesar Abood and Alan Mckay; SARDI

Key findings

- Root disease is common in pulses and appears to be causing varying levels of yield loss.
- Across two years of a national survey (three years in SA), *Pythium* spp., root lesion nematode, *Phoma pinodella* and *Rhizoctonia solani* AG8 are common across a range of pulses.
- Less common but potentially more damaging *Aphanomyces* and *Phytophthora* spp. continue to be detected – these are found across Australia but only infrequently at this stage.
- *Fusarium* species are more common. Isolates vary in pathogenicity, but little is known about their role in causing root disease in Australian pulses.
- Partial control of root disease in field trials in 2020 corresponded with yield increases of up to 0.62t/ha.

Introduction

This research is investigating the causes and effects of root diseases in pulse crops.

Growers are increasingly incorporating pulses into rotations for benefits such as nitrogen fixation, grass weed control and disease break effects. More recently, high prices for food legumes such as lentil and faba bean have driven high frequency pulse cropping (e.g. wheat-lentil). However, despite an eagerness to grow more pulses, growers remain wary due to poor performance and occasional crop failure.

Poor performance of pulses is likely due to multiple factors. Many obvious above-ground issues have been resolved through resistance breeding and the development of insecticide and fungicide strategies and products. However, unexplained poor performance continues to be an issue, with soil abiotic and biotic constraints implicated.

Experience in North America and Europe indicates that soilborne diseases become important as pulse cropping frequency increases. Priority targets for international research include *Aphanomyces euteiches*, *Fusarium* spp. and *Phoma pinodella*. *Phytophthora* spp. appear more common in Australia and have a history of significance in pasture legumes and chickpea. This paper summarises the findings of surveys of pulse root diseases (three years in SA and two years nationally) and preliminary results of yield loss trials conducted in 2020.

Detecting pathogens in pulse roots

Methods

Since 2018, SARDI has encouraged growers and agronomists to submit root and lower stem samples from poor performing pulse and oilseed crops in SA. In 2019, the survey expanded nationally in collaboration with AgVic, NSW DPI, DPIRD (WA) and USQ (QLD).

In 2020, 533 samples were processed nationally, including 58 samples from the mid-north/Adelaide plains (MN), upper north (UN) and Yorke Peninsula (YP) regions of SA. Samples were scored for root health, photographed, and DNA was extracted. A suite of qPCR tests was used to quantify known pulse pathogens in the roots, and next generation sequencing (Illumina® MiSeq®) used to identify potentially important pathogens for which SARDI does not have qPCR tests. Three DNA libraries were prepared using primer pairs that target oomycetes (e.g. *Aphanomyces*, *Phytophthora* and *Pythium* spp.) and fungal species (e.g. *Fusarium* and *Sclerotinia*). The 2020 samples are currently being sequenced and the results will be reported later, however qPCR results are discussed herein.

Results

The survey is providing insight into crop symptoms which were previously unexplained e.g. poor establishment, poor vigour (as seen in Figure 1) or early/uneven senescence.

Figure 1. Poor vigour is a sign of root disease in this lentil crop grown near Curramulka, YP in 2020. The roots were assessed as part of the National Pulse Root Disease Survey; next generation sequencing identified multiple pathogens, including Phytophthora 'dreschleri' and Fusarium avenaceum.

The most common pathogens detected using qPCR were *Pythium* spp., *Pratylenchus* spp. (root lesion nematodes), *Rhizoctonia solani* AG8, and *Phoma pinodella* (Figure 2). Of the 58 MN/UN/YP samples, 55 samples contained *Pythium* clade F, with 24>100pgDNA/g root, 50 samples contained *P. neglectus* with 0>100 eggs/g root, 47 samples contained P. pinodella with 30>100pgDNA/g roots and 27 samples contained R. solani AG8 with only 4 samples >100 pgDNA/g root. DNA levels in root tissue have not been correlated to yield loss, however experience over the course of the survey suggests a threshold of 100 pgDNA/g root often correlates with moderate root damage.

Pythium and *Pratylenchus* spp. are known to have broad host ranges, *R. solani* AG8 prefers cereals but will infect a broad range of plants. *Phoma pinodella* along with *Didymella pinodes* causes blackspot of field pea, but it has a much broader host range.

There were also infrequent detections of *Aphanomyces* and *Phytophthora* genera nationally. *Aphanomyces* has been reported to cause severe and widespread yield losses in pulses in Europe and North America while *Phytophthora* spp. are important pathogens in Australia.

Phytophthora medicaginis, a known problem in northern NSW, was detected in 26 (25 chickpea, 1 faba bean) samples from northern NSW; *P. megasperma* was detected in 33 samples (multiple crop types) across Australia including one lentil sample from YP, and *P. drechsleri* (tentative identification), was detected in 14 samples, mostly lupins from WA; this species was also detected in SA, Vic and southern NSW. SARDI is currently undertaking work to confirm the identity of this species.

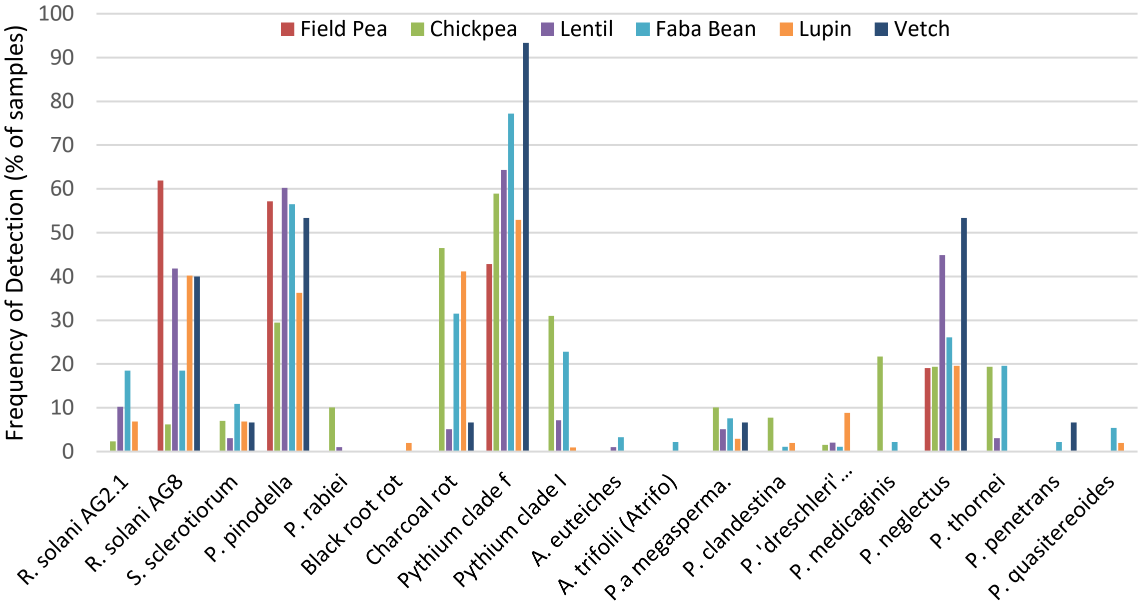

Figure 1. Frequency of detection over threshold levels of pathogens using qPCR in pulse samples received nationally in 2020.

Yield effects of pulse root diseases

In 2020, SAGIT project SUA920 was funded to investigate yield losses caused by soilborne diseases of pulses using a mixture of fungicides at 20 sites associated with the GRDC funded Southern Pulse Agronomy program, including seven sites in the Mid-North, two sites in the Upper North and two sites on the Yorke Peninsula.

Methods

At each site, two locally suited legume crops were sown with seed and soil-applied pesticides to control multiple fungal/oomycete/nematode targets. At Hart, only one crop type (lentil) was sown. Pathogen inoculum at each site was characterised through replicated soil samples. At each site, six treatments were applied, including 'untreated' and 'full treatment' (combination of three products), as well as four other individual or combination treatments. Treatments are all currently unregistered across the range of pulse crops used in these experiments. For simplicity, only the visual disease scores for the 'untreated' and 'full' treatments are presented here. Root disease was scored (0 to 5 scale) for 15 plants per plot in early spring.

Plant samples were visually assessed and DNA was extracted from the roots of those samples and tested using the Pulse Research test panel. Trials were harvested to measure yield effects. Preliminary results are presented in this paper, data analysis is progressing.

Results

Table 1 summarises the pathogens present at each site. Other pathogens, including *Fusarium* spp., for which a PREDICTA B® test has not been developed, could not be quantified but are likely to have been present and possibly played a role in disease development and response. Plant samples will be processed through NGS to detect the presence of *Fusarium* and other species.

Table 3. Initial density of pathogens detected in soil samples from 2020 field sites in the UN/YP/MN regions. Fungi results are reported as pgDNA/g soil. Pratylenchus neglectus are reported as nematodes/g soil.

Region	**Site**	**R. solani AG2.1**	**R. solani AG8**	**P. pinodella**	**M. phaseolina**	**P. neglectus**	**Pythium clade f**	**Pythium clade I**
MN	Eudunda	1	43	279	2	1	3	5
	Farrell Flat	248	48	9	15	1	16	2
	Hart	0	0	342	1	1	19	5
	Pinery	0	101	0	1	3	28	4
	Riverton	0	20	186	2	2	28	13
	Tarlee	2	141	104	1	1	36	4
	Turretfield	36	4	54	75	2	71	1
UN	Booleroo	21	62	2	3	0	36	0
	Warnertown	4	6	89	15	0	46	7
YP	Pt Broughton	0	0	11	89	1	13	5
	Maitland	18	0	3	1	35	21	57

These sites were selected without prior knowledge of disease risk and are representative of the pulse producing areas. Eudunda, Hart, Riverton, Tarlee all had medium-high levels of P. pinodella; Maitland had medium levels of P. neglectus; Pinery, Riverton, Tarlee, Turretfield, Booleroo and Warnertown all had medium levels of Pythium clade F while Maitland had a medium level of Pythium clade I; and Eudunda, Farrell Flat, Pinery, Tarlee and Booleroo had medium -high levels of R. solani AG8. Root disease developed at all sites, however severity varied (Figure 3). For example, at Farrell Flat (both lentil and faba bean), average untreated disease score was less than one – a disease level unlikely to reduce yield. At Maitland (lentil and faba bean), average untreated disease score approached three (Figure 3). At most sites, root disease scores were greater than two across a range of crop types.

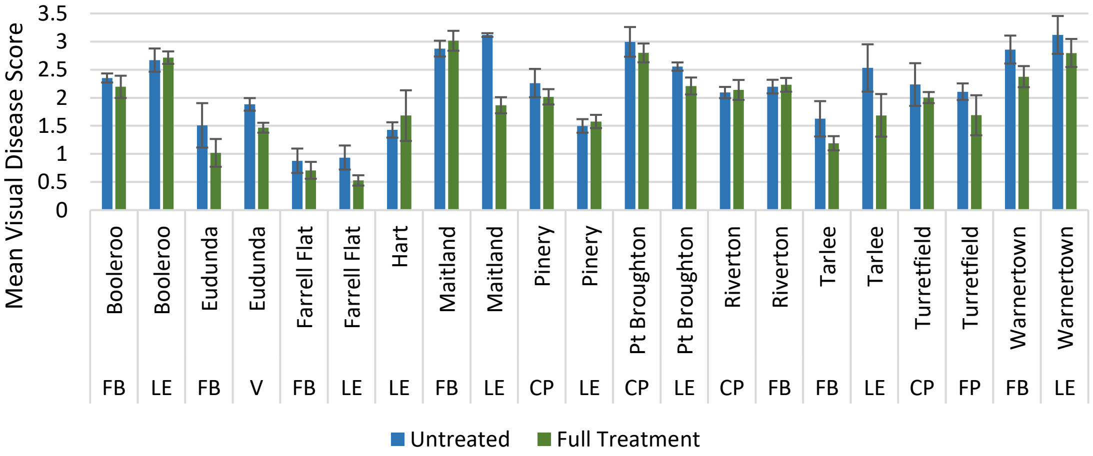

Figure 3. Root disease score of pulses either untreated or treated with a combination of pesticides selected to control fungi, oomycetes and nematodes in disease response trials located in the UN/YP/MN regions in 2020. Crop type is denoted as follows: FB = faba bean, LE = lentil, V = vetch, FP = field pea, CP = chickpea

Full treatment with a combination of pesticides appeared to reduce root disease compared with the untreated control at Maitland (lentil), Tarlee (both lentil and faba bean), Farrell Flat (lentil) and Warnertown (faba bean).

Complete disease control was not achieved at any site, despite the inclusion of a combination of products applied at robust rates. For example, the difference at Tarlee (lentil) was approximately one unit of a 0-5 scale. This indicates that current (unregistered) products are not particularly effective on pulse root diseases under the range of field conditions experienced at sites in 2020.

Despite only partial disease control, yield effects were observed at two lentil and two faba bean sites (Table 2). However, the yield responses to various treatments did not follow the same trend across sites; the untreated control often was not the worst yielding treatment. For example, at Tarlee (lentil) the oomycete control alone increased yield by 0.42 t/ha over the untreated, but the further addition of fungicides appeared to reduce yields – this suggests *Pythium* was likely a constraint in lentil at this site, but also indicates phytotoxic effects of the other chemistry. At Maitland, all fungicide/oomycete treatments increased yield.

The variation in responses suggests the relationship between plant, pathogen and fungicide control options is not simple. However, these results demonstrate that, where a target pathogen is present, even partial control can have yield benefits, indicating that soilborne disease are likely a production constraint. Yield responses of up to 0.62 t/ha were observed at other sites around SA in 2020, generally at sites in the higher rainfall zones such as Bool Lagoon in the south-east of SA.

Table 4. Average yields and standard error (SE) of treatments applied to pulse seed and soil at soilborne disease response sites in MN/UN/YP in 2020. All treatments are currently unregistered and have been coded: O = treatment selected to control oomycetes (Pythium & Phytophthora), F1 = selected to control Rhizoctonia, Phoma etc.., N = selected to control nematodes.

		Treatment					
Crop	**Site**	**Nil**	**O**	**O + F1**	**O + F1 + N**	**SE**	***p-value***
Lentil	Booleroo	1.94	1.75	1.65	1.92	0.28	0.146
	Farrell Flat	1.99	2.06	1.78	2.02	0.11	0.144
	Maitland	2.86	2.99	2.99	3.07	0.10	0.007
	Tarlee	3.11	3.53	2.82	3.15	0.21	<0.001
	Pinery	2.72	2.83	2.71	2.73	0.05	0.062
	Warnertown	2.19	2.27	2.17	2.18	0.07	0.577
	Hart	1.94	1.94	1.91	1.97	0.09	0.511
Faba bean	Booleroo	2.59	2.21	2.32	2.16	0.32	0.931
	Eudunda	3.97	3.89	3.74	3.62	0.09	0.058
	Farrell Flat	4.86	4.94	4.83	5.01	0.10	0.288
	Maitland	4.52	4.47	4.56	4.68	0.11	0.199
	Riverton	4.37	4.48	4.08	4.51	0.14	0.015
	Tarlee	3.59	3.72	3.79	3.58	0.09	<0.001
	Warnertown	2.25	2.30	2.26	2.33	0.05	0.478

Conclusion

Surveys undertaken by this project show root disease is common in Australian pulse crops, including those in the MN/UN/YP. Pathogens are generally present in complex. Some pathogens are very common across grain legume regions and crop types i.e. *P. pinodella, P. neglectus, Pythium* spp., *Fusarium* spp. and *Rhizoctonia solani* AG8. We suspect these have some effects on yield across many crops in many regions, although they are unlikely to pose a threat of complete loss.

Several pathogens were detected including *Aphanomyces euteiches* and *Phytophthora* spp. that caused substantial yield loss in isolated crops. These pathogens are favoured by wet conditions and could cause large losses in above average rainfall seasons.

Yield losses up to 0.62 t/ha yield in faba beans at Bool Lagoon, associated with partial control of moderate-high root disease, is an indication that soilborne diseases can be a significant constraint to pulse yields. Smaller responses such as at Yeelanna indicate that there is likely some small gains even where pathogen loads and environmental conditions are not highly-conducive to disease.

Acknowledgements

We thank collaborators from DPIRD, AgVic, NSW DPI and USQ for their assistance with the national pulse survey. We also thanks staff in SARDI regional offices in Clare, Port Lincoln, Minnipa and Struan for their assistance in sowing the pulse root disease yield response trials, particularly Penny Roberts and Sarah Day of SARDI Clare for their contribution and collaboration.

Canola – will I get an economic response from applying a fungicide?

Steve Marcroft[1], Angela Van de Wouw[2], Susie Sprague[3], Andrew Ware[4], Kurt Lindbeck[5], Andrew Wherret[6], Andrea Hills[7], Nick Perndt[1]

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Key findings

- The canola industry is now more reliant on fungicides, in some regions there is less emphasis on cultural practices to minimise disease.
- The decision to use a fungicide is not clear cut. You must first understand the disease risk profile of your crop.
- Fungicide decisions at seeding time need to be made prior to sowing and therefore prior to any disease scouting.
- Blackleg crown canker results from infection during early seedling growth. Prior to sowing, use the BlacklegCM decision support tool to identify high risk paddocks and explore management strategies to reduce yield loss.
- Early vegetative (4-10 leaf) foliar fungicide application should be based on the risk profile of your crop, after scouting for leaf lesions and the potential yield of the crop.
- Fungicide application for upper canopy infection is separate to the decision-making process for crown canker. Upper canopy infection fungicide application can result in very variable yield returns. You must understand your risk before applying a fungicide.
- Our knowledge on upper canopy infection (UCI) is improving and it is likely that decision making will become more reliable. A UCI App is expected to be released via GRDC investment when we have enough confidence on recommendations to aid decision making.

Will I get an economic return from applying a fungicide to my canola crop?

In recent times new fungicide actives and new timing recommendations have resulted in large yield responses. Many agronomists have reported 20% returns, but many others have also reported no yield returns. In our trials we've achieved up to 49% return but also zero. So how do you know where your crop will sit in 2021?

Obviously predicting a yield return will be very accurate if you know exactly how much disease will occur, but unfortunately the level of crop damage caused by disease is determined by a number of interconnected factors and to complicate it even further other diseases, such as sclerotinia, white leaf spot, powdery mildew and Alternaria, can also influence economic returns.

The key is to identify the risk for an individual crop and then determine the cost of application compared to the cost of potential yield loss. In most years this is relatively easy, for example, low rainfall year is low risk, high rainfall year and high yield potential is very easy to gain an economic advantage from fungicide application. But it is the decile 4 to 7 years where there is lots to be gained or lost from fungicide decisions.

Blackleg crown canker

Do I need a seed treatment and/or fungicide amended fertiliser?

Risk factors:

1. Canola growing region – high canola intensity and high rainfall = high risk. One in four year rotations and 500 m isolation between this year's crop and last year's stubble reduces risk.
2. Variety resistance – varieties rated R-MR or above have very low risk of developing crown cankers. MR will develop cankers but only if grown under high disease severity for example, canola/wheat/canola in high rainfall.
3. Pathogen population – if you've grown the same variety for a number of years and disease severity is increasing then you sow a variety from the same resistance group you will be at a higher risk of crown cankers.
4. Crop germination timing - severe crown canker is most likely to develop when plants are infected during the early seedling stage (cotyledon to 4th leaf). The driving factor for seedling infection is the length of time that the plant is exposed to blackleg infection while in the seedling stage. Therefore, the risk of seedling infection, which leads to crown cankers, is very variable from season to season. For infection to occur blackleg fruiting bodies on the canola stubble must be ripe and ready to release spores. Fruiting bodies typically become ripe approximately three weeks after the break of the season when the stubble has stayed consistently moist. Spores are then released with each rainfall event. Temperature also has a large influence as it will determine the length of time that the plant remains in the vulnerable seedling stage. Once plants progress to the 4th leaf stage they are significantly less vulnerable to crown canker. That is, older plants will still get leaf lesions, but the pathogen is less likely to cause damaging crown cankers as the fungus cannot grow fast enough to get into the crown. Typically, plants sown early in the growing season (April) will develop quickly under warmer conditions and progress rapidly past the vulnerable seedling stage whereas, plants sown later (mid-May) will progress slowly and remain in the vulnerable seedling stage for an extended period.
5. Modern farming system changes – our research has shown that inter-row sowing which enables full stubble retention has influenced spore release timings and spore release quantity. Stubble that remains standing stays drier between rainfall events, it therefore produces less spores early in the season, when seed treatments and fertiliser fungicide are most efficient. Standing stubble can then produce more spores later in the season, these later released spores will not cause crown cankers but may increase severity of upper canopy blackleg. Standing stubble that is knocked down 12 months later can then produce spores early in the second growing season.

If sowing an R rated variety in a one in four-year rotation in mid-April the probability of getting an economic return from a seed treatment or fertiliser-amended fungicide is very low. Sow a MS rated variety in a canola / wheat / canola rotation at the end of May and you will likely get a large return from your fungicide application. The challenge with seed treatments and fertiliser-amended fungicide is that the decision to use these products are made a long time before sowing and therefore you will not know the germination date and therefore the individual season risk. But you will know the risks associated with your canola region, variety blackleg rating and distance to last year's stubble.

Do I need a vegetative foliar fungicide application?

Vegetative foliar fungicides (4-10 leaf) are also designed to protect plants from crown cankers, this application timing will extend the length of protection that you receive from your seed treatment. They are likely to give an economic return under four circumstances.

1. You've done everything wrong and your crop is getting severe disease.
2. You are in a high-risk environment chasing maximum yield and may be growing a variety with slightly inferior disease resistance. For example, the highest yielding variety in your region may be a MR (or you've retained canola seed etc).
3. The pathogen population has changed and your resistant variety has become susceptible. This could also be the case if you retain open pollenated (OP) canola seed each year.
4. The season is very conducive for blackleg. You know from pervious monitoring that your normal variety is resistant in your environment but a wet season and early spore maturity has meant that disease severity is much higher than usual.

The main advantage you have when trying to determine if you will get an economic return from a foliar fungicide is that you can wander into your crop and assess the level of disease before you apply a fungicide.

1. No lesions = low disease risk; fungicides unlikely to give economic return.
2. Infected cotyledons and 1st 3 leaves = high disease risk; fungicides likely to give an economic return.
3. Dying plants from crown canker = extreme disease risk; fungicides likely to give an economic return.

Leaf lesion severity will give an indication to the likelihood of an economic return from a fungicide application. However, you must take into consideration the variety blackleg rating. All varieties that are reliant on quantitative resistance may get the same level of leaf infection. However, an R rated QR variety will not develop crown cankers whereas a MS-S variety may die, a MR variety may get partial crown infection. You also need to take into consideration the seed treatment and fertiliser amended fungicides used as these fungicides will reduce crown canker even on crops with severe leaf lesions. In most cases if you have sown a variety with adequate resistance and used as seed or fertiliser treatment then you will not need a vegetative foliar but monitor your crop and make an in-season decision.

The timing of foliar vegetative fungicide is not critical, 4-6 leaf application will provide the best protection as it will be active as the seed/fertiliser treatments run out of steam. However, by waiting to the 8-10 leaf stage you will still get good efficacy (reduced compared to the 4-6 leaf) but you will have a much better idea of how the season is progressing from a blackleg and yield potential perspective.

We recommend using the BlacklegCM App to help in making blackleg management decisions. BlacklegCM uses your variety and crop management options to predict yield loss and economic returns from fungicide applications. You can do comparisons with changed disease management options, changed varieties and changed fungicide applications. The real power of the app is that it allows you to play with as many different scenarios as you wish, and it will remind you of all the parameters that will cause yield loss for when you are working out the potential risk of your canola crop.

Upper canopy blackleg fungicide application

Blackleg Upper Canopy Infection (UCI) refers to infection of the upper stem, branches, flowers and pods and whilst we are constantly improving our understanding regarding these new symptoms, there is still a very large knowledge gap of how individual varieties react to UCI. Furthermore, our research shows that similar symptoms of UCI can cause very severe economic impact in one season and have no economic impact in another. As such, our recommendations for managing blackleg UCI is constantly evolving.

Should I apply a fungicide for UCI protection?

Currently, there is no way to predict economic return accurately. A GRDC investment is working on improving knowledge including determining timing of infection leading to yield loss, weather parameters associated with yield loss and strategies for screening for genetic resistance.

However, you can still determine if your crop is likely to be a high, moderate or low risk situation.

1. Date to commencement of flowering. Crops that flower earlier in the season are at a higher risk, they will flower in cooler wetter late winter/early spring which is more conducive for blackleg infection.
2. Time from the commencement of flowering to harvest. We hypothesis that the fungus requires a certain amount of time from when it initially infects the plant to when it causes the damage (internal infection) that leads to yield loss. The longer time period from infection to harvest = increased risk of yield loss.

The date to 1st flower and the date from 1st flower to harvest are good predictors of yield loss. This knowledge can in hindsight explain why in some regions/years yield loss can occur whilst in other years yield loss may not occur. Obviously, these key dates change between regions, for example, if two crops flower on August 7 but the mallee crop is mature on October 25 and the western district crop matures on November 25 then there is higher potential for damage to the western district crop.

3. Spring rainfall and temperature. Our preliminary data suggests that UCI given enough time will cause damage to the vascular tissue in the stems and branches resulting in yield loss to the pods. However, similar levels of disease can cause different amounts of yield loss depending on the weather during pod fill. Pods that ripen without moisture stress and during cool weather can tolerate more disease, imagine a partially blocked xylem, on a cool day the plant can still get sufficient moisture, but on a hot day the partially blocked xylem cannot deliver enough moisture.
4. Genetic resistance. This is the missing piece of the puzzle. We do know that effective major gene resistance (Resistance Groups) will stop blackleg and if your variety has effective major gene resistance your crop will not get any UCI. However, it is difficult to determine if you do have effective major gene resistance as it depends on the blackleg population on your farm. The best way to determine major gene resistance is to monitor your crop for leaf lesions. Major gene resistance is effective across all plant parts so if there are no leaf lesions it means that there could be no blackleg present or more likely that your variety has effective major gene resistance.
5. The other resistance is variety quantitative resistance, this is often indicated by the blackleg rating of your variety. Although it is possible for varieties to have a high blackleg rating from major gene but low quantitative resistance. However, if your variety has a R rating then it should either have effective major gene or excellent quantitative resistance. But what does good quantitative resistance mean for UCI control? To be honest the answer is “we don’t know”, but we do know that varieties with good quantitative get the UCI symptoms but we are suspicious that these varieties may then get less damage to the vascular tissue than more susceptible varieties. This could be the same as how varieties react at the seedling stage, that

is, a MR rated variety and a MS variety both get leaf lesions but the MS then develops more crown canker and subsequent yield loss. The reality is that we need to develop a robust blackleg rating system for UCI – we're working on it.

6. Fungicide application timing. Our work has shown a wide window of response times with good results (assuming that you have a damaging level of disease) from 1st flower to 50% bloom. However, we suggest aiming for 30% bloom for a number of reasons. Firstly the 30% bloom stage is as late as you can go and still get good penetration into the canopy, your main aim is to protect the main stem which will have a greater impact on yield compared to individual branches. Secondly the 30% bloom spray will control any initial infections that have already occurred. Thirdly the 30% bloom timing will provide protection for a few weeks into the future, therefore UCI will only start occurring again after the 50% bloom stage, hopefully by then any infections will occur too late to cause significant yield loss. In 2020 we even saw this 30% time provide some protection onto pods but not at all sites and in previous years the 30% timing has not provided pod protection.

7. Pod infection is unlikely to be controlled through fungicide application. Pod infection occurs when there are rainfall events during podding and the fungal spores land directly on the pods and cause disease. We have found that severe pod infection can lead to an additional 20% yield loss. Unfortunately, no fungicides are registered for application during podding due to maximum residue limits (MRL) regulations. Major gene resistance will control pod infection.

What are the steps to determining a UCI spray decision?

1. Leaf lesions – presence of leaf lesions indicates that blackleg is present and that your variety does not have effective major gene resistance. No leaf lesions = no reason to spray.

2. New leaf lesions on upper leaves as the plants are elongating – this observation is not critical but does give an indication that blackleg is active as the crop is coming into the susceptible window. However, a number of wet days at early flower will still be high risk even if there were no lesions on new leaves up to that point. Remember it will take at least 14 days after rainfall to observe the lesions. More lesions = higher blackleg severity.

3. Date of 1st flower and targeted date of harvest - the earlier in the season flowering occurs is higher risk. This date will vary for different regions. Generally, shorter season regions can more safely commence flowering at an earlier date compared to longer season regions. Earlier harvest date results in less time for the fungus to invade the vascular tissue and cause yield loss. Consequently, if you're in a long growing season rainfall region and your crop flowers in early August and is harvested in December you are in a very high risk situation.

4. Yield potential – yield potential is simply an economic driver. A 1% return on a 3 t/ha crop is worth more money than a 1% return on a 1 t/ha crop.

How can I determine if I should have sprayed for UCI?

1. Check for external lesions.

2. Cut branches and stems to check for blackened pith, which is indicative of vascular damage and likely yield loss

3. Observe darkened branches, these branches go dark after vascular damage and are indicative of yield loss.

4. Pod infection will cause yield loss, unfortunately there is nothing that can be done to prevent pod infection.

5. Leave unsprayed strips to check for yield returns.

Which fungicide active should I use?

There are two parts to this question. Firstly, in terms of which active will give better control, few side by side comparisons have been undertaken for blackleg control. But, the GRDC blackleg rating project has undertaken comparisons for the seed treatment fungicides, data suggests that the SDHI fungicides provide protection for a longer period of time compared to the DMI fungicides. Ultimately, crop timing and determining your risk and therefore potential economic return are more important factors when choosing a fungicide.

The second aspect of choosing an active is in regard to managing the risk of fungicide resistance. Resistance towards the DMI fungicides has been detected within ~30% of Australian populations over the past three years whilst no resistance has been detected for the SDHI fungicides. However, excessive use of the SDHI fungicides has the potential to select for fungicide resistance. Therefore, limitations on the number of applications for each fungicide active within a growing season have been developed and can be found at the CropLife website:
https://www.croplife.org.au/resources/programs/resistance-management/canola-blackleg/

Acknowledgements

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GRDC project codes: UOM1904-004RTX, UM00051, CSP00187, MGP1905-001SAX

Useful resources and references

BlacklegCM App for iPad and android tablets:
www.grdc.com.au/resources-and-publications/all-publications/publications/2020/blackleg-management-guide

Canola: the ute guide:
https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-27/canola-the-ute-guide

Marcroft Grains Pathology website: www.marcroftgrainspathology.com.au

Subsoil amelioration – the last year

Stuart Sherriff and Sam Trengove; Trengove Consulting

Key findings

- Deep ripping on soils with subsoil constraints decreased long-term grain yields at one site and had no effect at four others.
- Subsoil amendments were not able to increase long-term grain yields at any site at Bute or Hart.
- Nitrogen recovery of surface or subsoil applied amendments was poor at four of five sites, with the greatest recovery achieved at the site with the least constraints.

Why do the trial?

Subsoil constraints are known to have a large impact on grain yields in the Mid-North of SA. Trials in other regions including south western Victoria have reported large yield responses (up to 60% yield increase in 1st year) from treatments of deep ripping and deep placement of high rates (up to 20 t/ha) of chicken litter. The grain yield response is thought to come from increasing the plant available water holding capacity of these soils by improving the structure of the subsoil. Although the cost associated with implementing these treatments is high, with these reported yield gains it is possible to pay for the treatments in the first season.

How was it done?

Seven randomised complete block design trials with three replicates of the same eight treatments (Table 1) were established in March 2015. The trials were located in three different geographic areas including two near Clare at Hill River, two at Hart and three at Bute. At each location the trials were located on different soil types which are described below. Trial data was only collected from Hill River from 2016 – 2018 and has not been reported here, previous trial reports for individual years containing Hill River data can be found on the Hart website.

Table 1. Treatment list for the 7 subsoil manuring sites established in 2015.

Treatment	Nutrition	Ripping	Placement
1	Nil	No	Nil
2	Nil	Yes	Nil
3	20 t/ha chicken litter	No	Surface
4	20 t/ha chicken litter	Yes	Surface
5	20 t/ha chicken litter	Yes	Subsoil
6	3 t/ha synthetic fertiliser	No	Surface
7	3 t/ha synthetic fertiliser	Yes	Surface
8	3 t/ha synthetic fertiliser	Yes	Subsoil

Sites and soil types

Hart East	Calcareous gradational clay loam Subsoil constraint: High pH and moderate to high ESP below 30 cm
Hart West	Calcareous loam Subsoil constraint: High pH, Boron and ESP below 30 cm
Bute Northwest	Calcareous transitional cracking clay Subsoil constraint: High pH, Boron and ESP below 30 cm
Bute Mid	Calcareous loam Subsoil constraint: High pH, Boron and ESP below 60 cm
Bute Southeast	Grey cracking clay with high exchangeable sodium at depth Subsoil constraint: High pH, Boron and ESP below 30 cm

The initial treatments (Table 1) were established prior to sowing in 2015. Ripping and subsoil treatments were applied with a purpose-built trial machine loaned from Victoria DPI. The machine is capable of ripping to a depth of 600 mm and applying large volumes of product to a depth of 400 mm. Chicken litter was sourced from three separate chicken sheds for ease of freight, the average nutrient content is shown in Table 2. After the treatments were implemented the plots at all sites were levelled using an offset disc. Since 2015 only seed and district practice fertiliser rates have been applied to all plots.

In 2020 the Hart sites were sown with narrow points and press wheels on 250 mm spacing. The Bute sites were sown using a concord seeder on 300 mm spacing with 150 mm sweep points and press wheels.

The rate of chicken litter (20 t/ha) used in these trials was based on the rate being used in south western Victoria where the large yield responses had been observed. To assess if responses to chicken litter were attributed directly to the nutrition in the chicken litter, the 3 t/ha synthetic fertiliser treatment was designed to replicate the level of nutrition that is found in an average analysis of 20 t/ha of chicken litter. This treatment was made up of 800 kg/ha mono-ammonium phosphate (MAP), 704 kg/ha muriate of potash (MoP), 420 kg/ha sulphate of ammonia (SoA) and 1026 kg/ha urea.

Table 2. Average nutrient concentration from three chicken litter sources used in subsoil manuring trials established in 2015.

Nutrient		Nutrient concentration dry weight	Moisture content	Nutrient concentration fresh weight	kg nutrient per tonne fresh weight
N	Nitrogen	3.80%	8%	3.50%	35.0
P	Phosphorus	1.72%		1.58%	15.8
K	Potassium	2.31%		2.13%	21.3
S	Sulphur	0.55%		0.51%	5.1
Zn	Zinc	0.46 g/kg	8%	0.42 g/kg	0.4
Mn	Manganese	0.51 g/kg		0.47 g/kg	0.5
Cu	Copper	0.13 g/ kg		0.12 g/kg	0.1

Cumulative grain yields for six seasons

Over the past six seasons no treatment in these trials has been able to increase grain yields compared to standard management (Figure 1 and 2). Main treatment effects were:

- Deep ripping (T2) decreased long-term grain yields at the Bute NW site and have had no impact at any other site (Figure 1 and 2).
- Chicken litter applied to the soil surface (20 t/ha) as an amendment in 2015 (T3) reduced grain yields compared to the untreated control at all five sites presented in this report.
- Synthetic fertiliser applied at high rates as an amendment (T6) to the soil surface produced long-term grain yields equivalent to the untreated control at four of five sites. This is in contrast with the chicken litter effect.

Subsoil application of both amendments (T5 chicken litter, T8 synthetic fertiliser) have not provided any long-term grain yield improvement at any of the three Bute sites (Figure 1). In the Bute paddock, the NW and SE site have more severe subsoil constraints at shallower depths (from 300 mm), compared with the Mid site (from 600 mm), as described in the soil descriptions. This is also reflected in the site yields over the past six seasons, with grain yields for the NW and SE sites being lower than the Mid site. With the subsoil machinery used placing amendments at ~400 mm, the subsoil amendment application was placed into the constrained subsoil at the NW and SE sites, whereas it was placed ~200 mm above the constrained subsoil at the Mid site.

Long-term grain yield results indicate that the subsoil treatments have tended to reduce yield at the more constrained sites NW and SE. Therefore, these treatments have increased the yield gap between the better and poorer performing soil types.

At the Hart site subsoil application of amendments did not increase grain yields compared to the control treatment. However, they appear to have increased yields compared to surface application. The best example of this is at Hart East (Figure 2) with surface and subsoil placed chicken litter. This is due to yield loss associated with surface application of amendments in lentil in 2016 which was a high rainfall, high biomass and potentially high disease pressure season. It is thought that surface application lead to greater biomass and greater disease in this year resulting in reduced yields. Subsoil application did not produce the same level of early biomass accumulation (data not presented) and subsequent yields were greater compared to surface application.

Over the last six seasons there has been little difference between the chicken litter and synthetic amendment treatments when compared in individual seasons. However, a multi-site analysis over the lifetime of the trials shows there is an advantage of synthetic fertiliser compared to chicken litter (Table 3). The synthetic fertiliser treatments produced 1.22 t/ha and 1.07 t/ha more grain yield for surface applied application with (T7 vs T4) and without ripping (T6 vs T3), respectively. There was no difference when the amendments were placed in the subsoil (T8 vs T5).

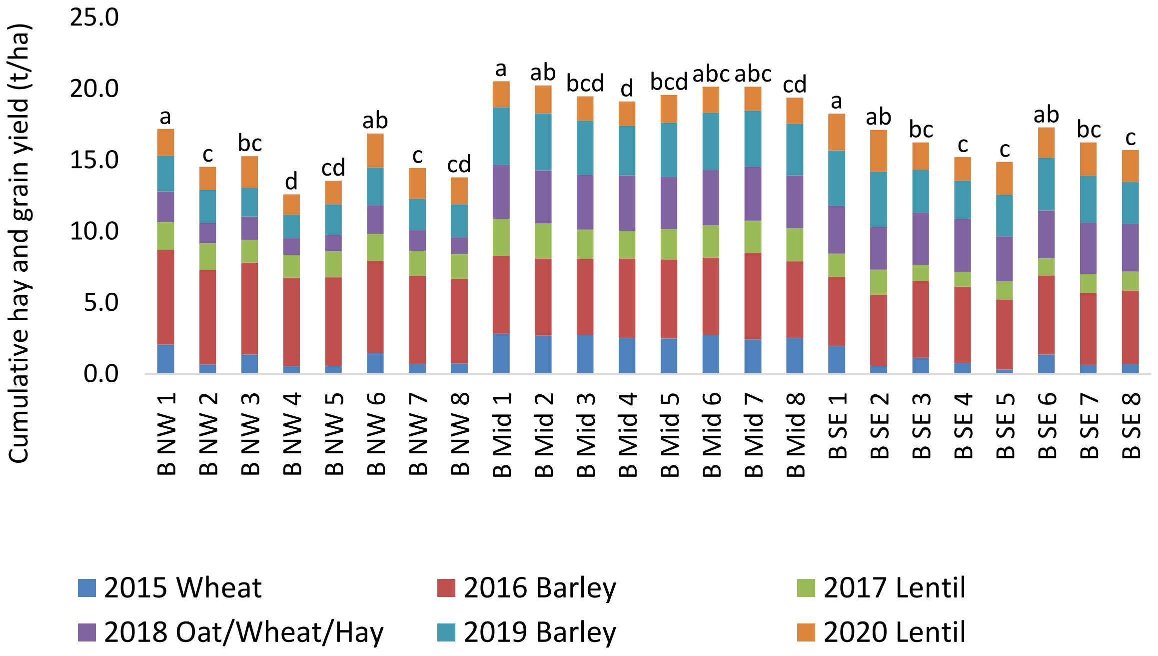

Figure 1. Cumulative hay and grain yield (t/ha) for the Bute North West (B NW), Bute Mid (B Mid) and Bute South East (B SE) sites for 2015 – 2020. Letters denote significant differences for totals at a given site. Treatment number shown in x axis label.

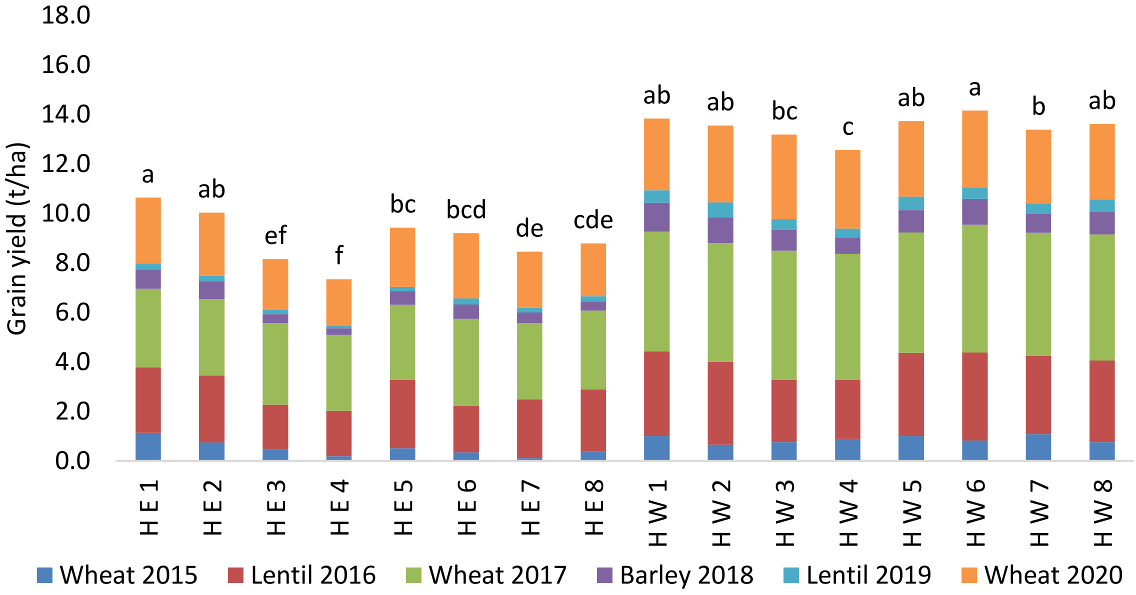

Figure 2. Cumulative grain yield (t/ha) for the Hart East (H E) and Hart West (H W) sites for 2015 – 2020. Letters denote significant differences for totals at a given site. Treatment number shown in x axis label.

Table 3. Total grain production (t/ha) averaged across five sites from 2015 – 2020 at subsoil trials Hart and Bute.

Treatment	**Nutrition**	**Ripping**	**Placement**	**Total grain production (t/ha)**
1	Nil	No	Nil	16.1 ^{a}
2	Nil	Yes	Nil	15.2 ^{bc}
3	20 t/ha chicken litter	No	Surface	14.5 ^{d}
4	20 t/ha chicken litter	Yes	Surface	13.4 ^{e}
5	20 t/ha chicken litter	Yes	Subsoil	14.3 ^{d}
6	3 t/ha synthetic fertiliser	No	Surface	15.6 ^{ab}
7	3 t/ha synthetic fertiliser	Yes	Surface	14.6 ^{cd}
8	3 t/ha synthetic fertiliser	Yes	Subsoil	14.3 ^{d}
LSD (P≤0.05)				*0.7*

Nitrogen (N) removal was calculated using grain yield and protein data for the last six seasons (Figures 3 and 4). At the Bute NW site and Hart East site greater amounts of nitrogen were removed from the surface applied synthetic fertiliser followed by ripping (T7) treatments compared with chicken litter (T4). Low long-term grain yields indicate that the subsoil constraints are greatest at these sites in each paddock. At other sites and treatments (T3 vs T6 and T5 vs T8) the differences were not significant but there was still a general trend of more N being removed from the synthetic amendment treatments.

Of the 700 kg N/ha that was applied in 2015 only a small proportion has been recovered. On average, just 0.8% of chicken litter applied N was recovered compared to 5.2% of synthetic amendment applied N. These poor recovery rates are a reflection of adequate N fertiliser application in the standard fertiliser programs being applied to these paddocks. The highest yielding site (Bute Mid) was the site with the least subsoil constraints and was the only site to consistently remove more N from treatments where the amendments were applied compared to the non-amendment treatments (T1 and T2). For this site 18% of N that was applied in 2015 was recovered over the six years, showing that with less subsoil constraints and higher yield potential a greater level of N was be extracted from the soil. More testing needs to be conducted to establish where the N that has not been recovered has gone.

Note that standard commercial rates of fertiliser have been applied to these trials each year in addition to the amendment rate, total approximate N applied for Bute and Hart was 185 and 168 kg N/ha respectively. Also note that of the six seasons two were legumes where nitrogen fixation would have occurred.

The long-term results from these trials suggest that the greatest gains from high rates of chicken litter or synthetic fertiliser applied as an amendment will come from the best parts of the paddock with higher levels of grain yield and protein being produced in these areas. The process of subsoil amelioration through addition of chicken litter or synthetic fertiliser into the subsoil has not been successful at these sites and if anything, grain yields have declined as a result.

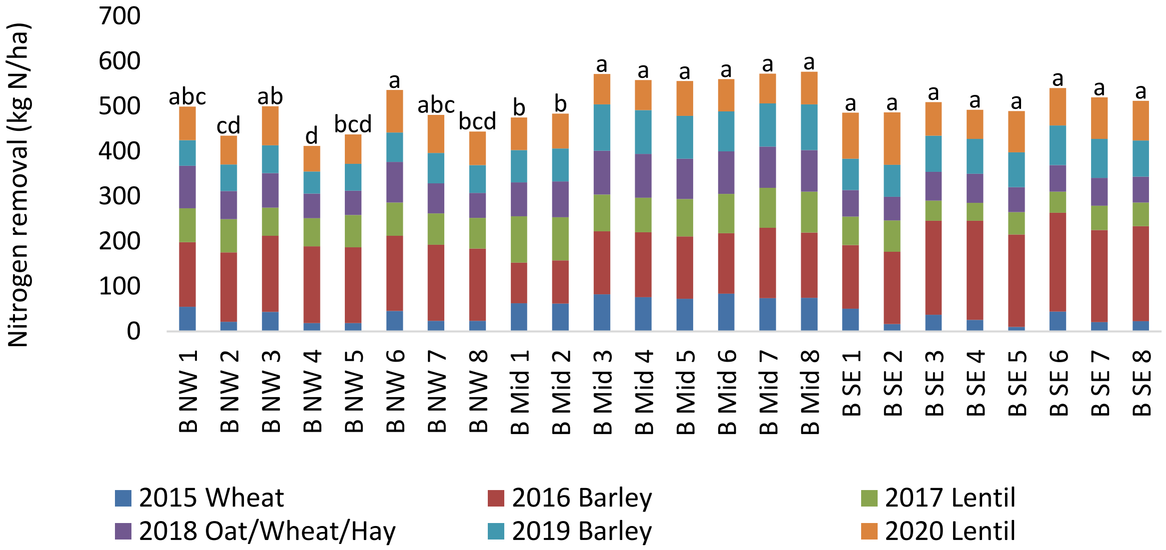

Figure 3. Cumulative N removal for the Bute North West (B NW), Bute Mid (B Mid) and Bute South East (B SE) sites for 2015 – 2020. Letters denote significant differences for totals at a given site.

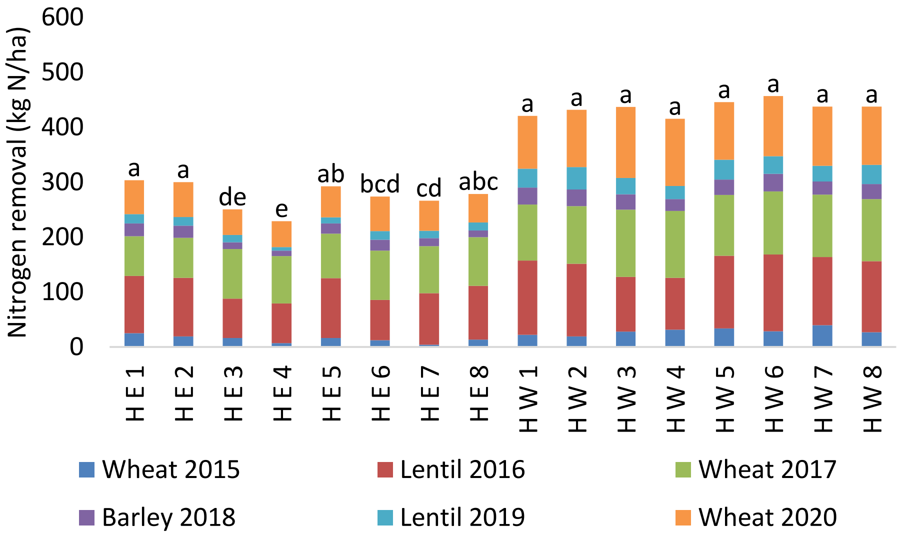

Figure 4. Cumulative N removal for the Hart East (H E) and Hart West (H W) sites for 2015 – 2020. Letters denote significant differences for totals at a given site.

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Improved productivity on sandy soils
- Kybunga case study 2020

Stuart Sherriff and Sam Trengove, Trengove Consulting

Key Findings

- Shallow or deep ripping alone did not provide any grain yield increase, which contrasts with the previous season.
- Deep ripping with chicken litter has provided the greatest cumulative partial gross margin in 2019 and 2020.
- Spading with chicken litter applied increased grain protein by 2.8% compared to the control, whereas deep ripping plus chicken litter did not significantly increase grain protein.
- The addition of chicken litter to deep ripping and spading provided a 9% grain yield increase.

How was it done?

Trial location:	Kybunga (Blyth BOM annual rainfall 404mm, growing season 291mm)		
Plot size:	1.5 m x 20.0 m	**Fertiliser:**	27:12 @ 120 kg/ha
Seeding date:	May 15, 2020		Urea (46:0) @ 100 kg/ha on August 3
Variety:	Spartacus CL barley		

Soil constraints: Low organic carbon, low cation exchange capacity**,** mild water repellence and compaction (anecdotal, not yet measured)

The trial was a randomised complete block design with seven treatments. The trial was located on a sandhill at Kybunga with two replicates across the top of the hill and two replicates on the western slope of the hill. Chicken litter (CL) was applied to the surface of plots prior to the implementation of soil disturbance treatments.

All soil disturbance treatments were implemented on May 13, 2019. Ripping treatments were conducted using a Williamson-Agri Ripper, a bent leg low disturbance ripping machine with four tynes per plot. Ripping depth was either shallow (30 cm) or deep (50 cm). Spading was conducted with a 1.8 m Farmax spading machine operated at 5 km/h to a depth of 30 cm.

Treatments

1	District practice (control)
2	Shallow ripping (30 cm)
3	Deep ripping (50 cm)
4	Spading (30 cm)
5	Deep ripping + spading
6	Deep ripping + chicken litter @ 7.5 t/ha
7	Spading + chicken litter @7.5 t/ha

Crop measurements during the growing season included GreenSeeker NDVI measurements on July 23 and September 3. The trial was harvested for grain yield in November and grain quality was assessed post-harvest.

Results and Discussion

Yield and grain quality

GreenSeeker NDVI on July 23 showed spading, deep rip with CL and spading with CL increased NDVI value over the control (Table 1). The NDVI of spading with CL was 40% compared to the control and higher than all other treatments. GreenSeeker NDVI recorded on September 3 showed all treatments were greater than the control, except for deep rip. Shallow rip and deep rip plus spade increased from the earlier assessment to be greater than the control. Spading plus CL maintained its NDVI advantage over all other treatments and had an NDVI value 60% greater than the control. The addition of ripping with spading did not increase any NDVI readings compared to spading alone. Deep ripping was not greater than the control at both timings. However, shallow ripping was greater than the control and deep ripping on the September 3 GreenSeeker measurement.

Grain yield results show that either shallow or deep ripping alone did not provide an increase in yield (Table 1). This contrasts with the 2019 results in wheat, where both shallow and deep ripping had greater NDVI throughout the season and increased grain yield by 0.97 t/ha (23%). This suggests that these treatments were constrained by something other than compaction in 2020. The addition of CL with deep ripping increased yield by 0.38 t/ha over straight deep rip, indicating the benefit of chicken litter. Spading, rip plus spading, deep rip with CL, and spading with CL all increased grain yield by an average of 0.48 t/ha (17%). Spading with CL was the highest yielding treatment providing a 21% increase in grain yield over the control.

The grain yield benefits from the addition of CL to both deep ripping and spading was relatively consistent from 2019 to 2020. The deep ripping and spading treatments with CL averaged a 12% increase in 2019 and a 9% yield increase in 2020 over deep ripping and spading alone.

Spading with CL was the only treatment to have increased grain protein over the control treatment (Table 2). This increase was also 2.0% higher compared to ripping with CL, indicating that incorporation of the CL was important for nutrient uptake. This is supported by soil nitrogen results from samples taken from 0 – 90 cm depth on April 17, 2020 (Table 1). The spading + CL treatment was the only treatment to have higher deep soil N with an additional 26 kg N/ha compared to the control treatment. The increase in grain yield and protein in this treatment meant there was an additional 73 kg N/ha removed compared to the control treatment. This indicates that more N is likely to have mineralised from the spaded CL during the growing season, or the crop was accessing nitrogen that had leached beyond the depth of sampling.

Grain screenings (4.8%) and retention (76.5%) indicate grain size was smaller for the spading with CL treatments. However this effect was not great enough to change the grain quality classification.

Table 1. Deep soil N (kg N/ha 0 – 90cm April 17th 2020) for selected treatments, GreenSeeker NDVI and grain yield data for the Kybunga trial in 2020.

	Treatment	Deep N (kg/ha) Apr 17 2020	NDVI Jul 23 2020	NDVI Sep 3 2020	Grain yield (t/ha)
1	Control	39	0.325	0.477	2.89
2	Shallow rip		0.353	0.545	3.03
3	Deep rip	41	0.316	0.493	2.93
4	Spade	37	0.387	0.639	3.34
5	Rip + spade		0.356	0.628	3.31
6	Deep rip + CL	45	0.375	0.608	3.31
7	Spade + CL	65	0.455	0.761	3.50
	LSD (P≤0.05)	*15*	*0.035*	*0.038*	*0.34*

Table 2. Grain quality data for the Kybunga low OM trial in 2020.

Treatment		**Protein (%)**	**Test weight (kg/hL)**	**Screenings (%)**	**Retention (%)**
1	Control	13.5	66.9	3.0	83.6
2	Shallow rip	13.7	66.8	2.9	82.2
3	Deep rip	13.1	66.5	2.7	83.4
4	Spade	14.4	66.6	3.4	80.0
5	Rip + spade	14.5	65.2	3.9	78.2
6	Deep rip + CL	14.3	66.3	2.9	82.5
7	Spade + CL	16.3	64.4	4.8	76.5
LSD ($P \leq 0.05$)		*1.0*	*NS*	*1.0*	*NS*

All treatments were classified as BAR1 as per grain quality analysis.

Partial gross margin (PGM)

Despite the significant costs associated with some of these treatments the increased grain yield was achieved on this soil type means that the treatments can be paid for in two seasons. Return on investment ratios from the ripping treatments were greatest due to their lower input costs. However greatest overall returns come from the treatments that received the chicken litter and ripping or spading due to the greater yield gains. Although the cost of spading and chicken litter was high the return on investment was still 1:1.05 and 1:0.64 for deep rip + CL and spade + CL, respectively over two seasons.

Table 3. Cumulative partial gross margin analysis for seasons 2019 and 2020 for the Kybunga trial. Price assumptions include chicken litter $34.5/t, SoA $400/t, wheat ASW (2019) $310/t, wheat H2 (2019) $320/t, barley BAR1 $220/t. Cost of spading in the deep rip plus spading treatment is reduced due to pre-ripping.

Treatment	**Disturbance ($/ha)**	**Chicken litter ($/ha)**	**2019 SoA ($/ha)**	**Total costs ($/ha)**	**Cumulative grain yield (t/ha)**	**Cumulative gross income**	**Cumulative PGM ($/ha)**	**ROI (%)**
Control	$0	$0	$60	$60	7.16	$1,917	$1,857	
Shallow rip	$50	$0	$60	$110	8.09	$2,186	$2,076	144
Deep rip	$70	$0	$60	$130	8.35	$2,271	$2,141	172
Spade	$200	$0	$60	$260	8.57	$2,304	$2,044	49
Rip + spade	$250	$0	$60	$310	8.77	$2,365	$2,055	45
Deep rip + CL	$70	$260	$0	$330	9.33	$2,594	$2,264	105
Spade + CL	$200	$260	$0	$460	9.44	$2,670	$2,210	64

The treatments without CL (T1 – T5) applied have removed on average, 84% of the total N applied over the two years that the trial has been running. Compared to the two CL treatments (T6 – T7), where only an average of 51% of total N applied has been removed. The soil N results from April 2020 indicated large differences in available soil N between the two CL treatments. As the CL in the spaded treatment has been incorporated deeper into the soil profile compared to the ripping treatment it is likely that more has been mineralised. It is not clear where the additional N is in the deep rip treatments, it is possible that it is still on or near the surface in un mineralised CL and will be released over an extended period compared to the spading treatment.

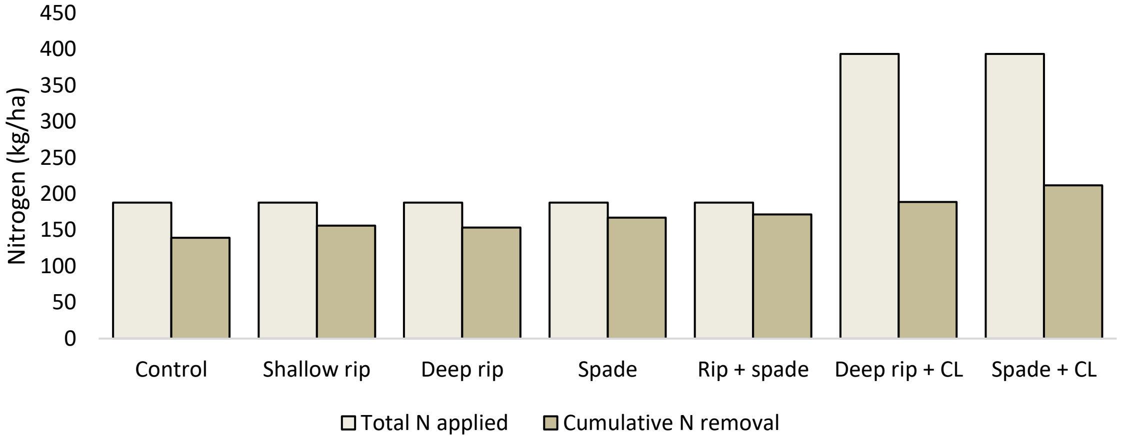

Figure 1. Total N applied through synthetic fertiliser and chicken litter for all treatments and the cumulative N removal through grain removal.

Acknowledgements

Funding for this trial is gratefully acknowledged from GRDC project CSP00203 ‘Increasing production on sandy soils in low and medium rainfall areas of the Southern Region’. Kenton, Tracey and Will Angel are thanked for hosting the trial on their property and assistance with applications of pesticide and fertiliser throughout the season.

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Canola nitrogen management

Brianna Guidera and Sarah Noack; Hart Field-Site Group

Key Findings

- This season, the application of 100 kg N/ha at seeding provided the highest grain yields. Rates above 100 kg N/ha did not result in any yield benefit.
- Nitrogen application rate had a negative effect on oil content decreasing oil on average by 0.03% per kg applied N.
- Grain yield and oil content responses from spilt applications of N were variable in both trial years (2017 and 2020) due to seasonal conditions.

Why do the trial?

Nitrogen (N) management decisions for the best dollar return can vary from year to year and are primarily driven by seasonal conditions and attitude to risk. “How much N should be applied?” and “When should it be applied?” are two of the most challenging questions for growers. One approach to address these questions is to use an N budget, which focuses on target crop yield and grain quality. The aim of the trial was to analyse the outcomes of simple N management strategies (rate and timing) on grain yield and oil content in canola.

How was it done?

Plot size	2.0 m x 10.0 m	**Fertiliser**	DAP (18:20) + 1% Zn + Impact @ 80 kg/ha (14 kg N/ha)
Seeding date	May 5, 2020		In-season application rates of N, supplied as urea, listed in Table 1 (below).
Harvest date	November 4, 2020		
Location	Hart, SA		

The trial was a randomised complete block design using 44Y90 canola, with three replicates of five N treatments. The trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy.

Pre-seeding soil tests were taken on April 24 at depths of 0-10, 10-30 and 30-60 cm. Total available soil N was 53 kg N/ha. In-season Normalised Difference Vegetation Index (NDVI) measurements were taken on each plot to assess leaf greenness and biomass. Crop yield and oil content (%) and 1000 grain weight were measured for all plots. Daily rainfall at the Hart site was also recorded (Figure 1).

Table 5. Seeding and in-season nitrogen treatments

Treatment	Application rates/timings
1	Nil
2	100 kg N/ha @ seeding
3	50 kg N/ha @ seeding + 50 kg N/ha @ rosette
4	50 kg N/ha @ seeding + 50 kg N/ha @ rosette + 100 kg N/ha @ early flowering
5	200 kg N/ha @ early flowering

Rosette: Applied July 10
Early flowering: Applied August 5

Results and discussion

Biomass

Nitrogen management had a variable effect on NDVI during the growing season. Differences in NDVI were only present after the rosette N application (July 10) as measured on July 29 (Figure 2). Canola treated with 100 kg N/ha, both at seeding and across split applications, had the same NDVI response as plots treated with 200 kg N/ha across three split applications. Plots treated with 200 kg N/ha late in the season (early flowering August 5) had a lower NDVI response. This indicated that the crop was able to access the same amount of N from 100 kg/ha or 200 kg/ha this season. Despite Hart receiving above average annual and growing season rainfall this year, May, June and July were well below average and limited N uptake and biomass production early.

The NDVI for all treatments reached a peak in mid-July and then decreased in early August. This decrease in NDVI coincided with low rainfall in the preceding months (Figure 1) which resulted in a lack of N uptake and crop water stress. The NDVI increased again in early August after 28 mm of rainfall was received. At the last assessment the nil treatment had the lowest NDVI value, and the 50 kg N/ha at seeding and 50 kg N/ha at rosette application had the highest NDVI. All other treatments were greater than the nil but, not different to each other.

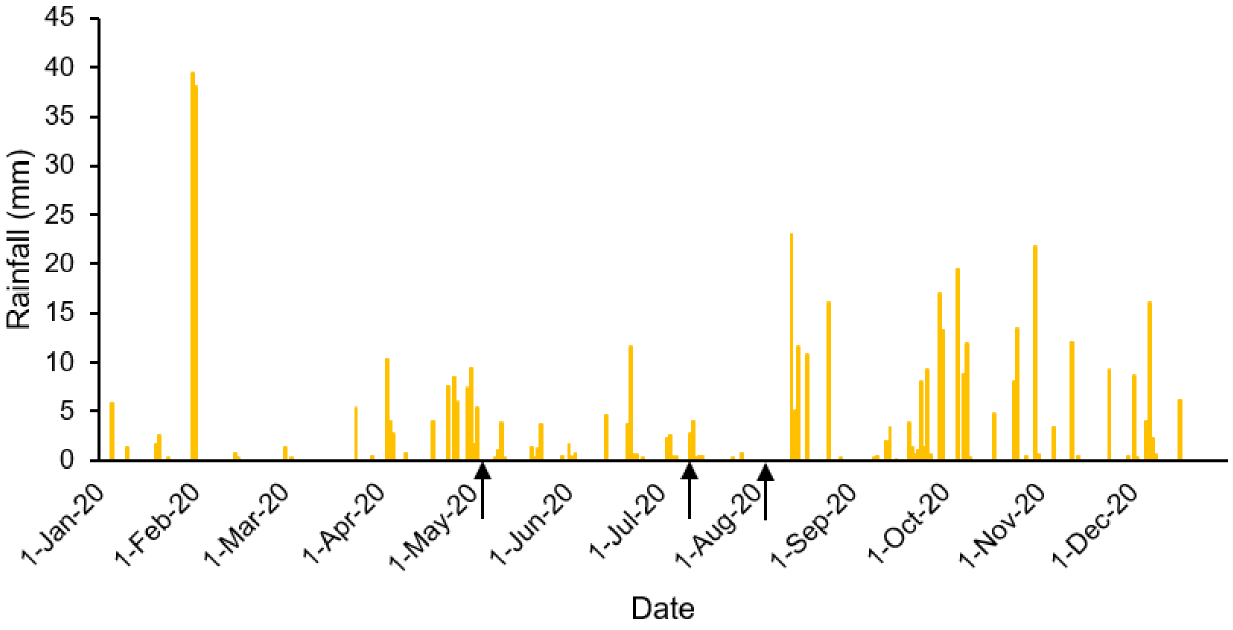

Figure 1. Daily rainfall at Hart in 2020. Black arrows indicate N fertiliser application dates.

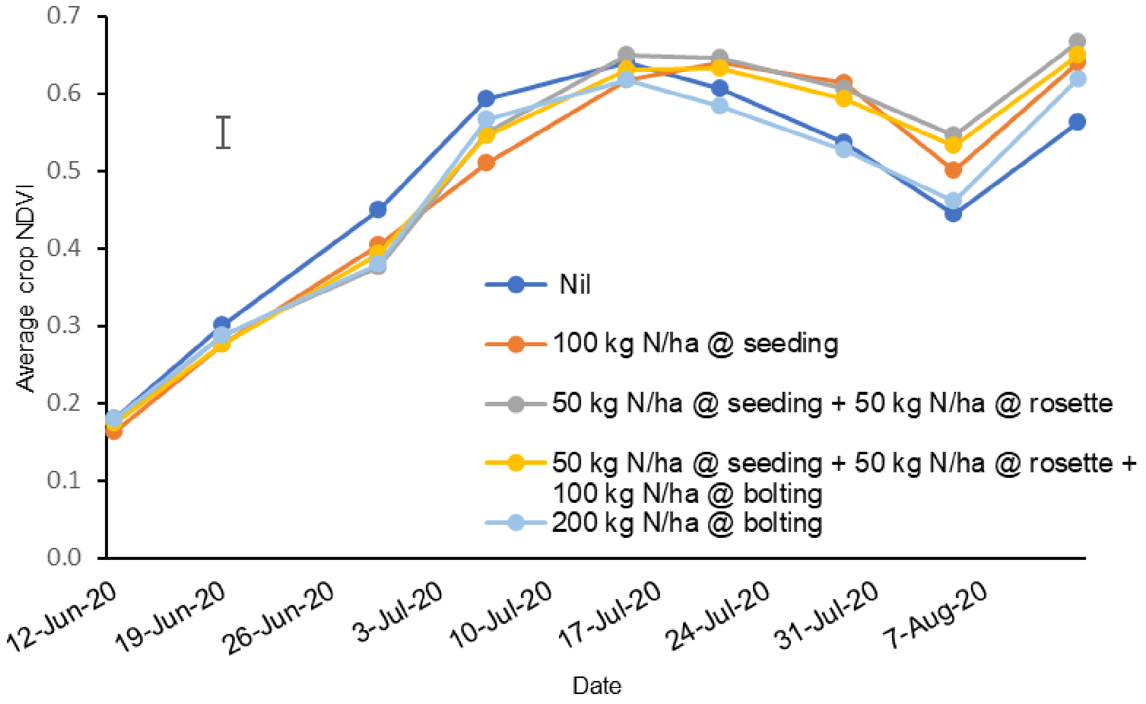

Figure 2. Crop biomass response to N applications at Hart in 2020. LSD (P≤0.05) = 0.04

Grain yield

Applying 100 kg N/ha at seeding was sufficient to produce the highest canola grain yield (Table 2) at Hart in 2020. This treatment on average yielded 0.18 t/ha higher than the nil treatment and was not different to applying 200 kg N/ha at early flowering, or to 200 kg N/ha applied across three split applications. Results from the same trial in 2017 also found applying 100 kg N/ha at seeding produced the highest yield (Table 2). However, it should be noted the late N applications were completed at bolting in 2017 whereas due to lack of rainfall events, applications in 2020 were delayed until early flowering.

In both 2020 and to a larger extent in 2017 there were scenarios where grain yield penalties occurred from delayed in-season N applications. When comparing growing season rainfall (GSR) between the seasons, 2017 was drier than 2020 overall with 191 mm and 336 mm respectively. Despite higher rainfall in 2020 there were limited events which occurred immediately after seeding, rosette and early flowering N applications. Increasingly growers are delaying applying part of their fertiliser program to minimise the risk of bulky crops early and manage seasonal conditions. In this case splitting applications are useful and if crop demand is met growers can still achieve high yields.

Oil content and grain weight

Increasing N application rate had a negative effect on oil content. The nil treatment had the highest oil content, followed by plots treated with 100 kg N/ha (alone or split application) and then plots treated with 200 kg N/ha total (Table 2). Across both seasons the 100 kg N/ha treatments contained oil contents greater than 42% (oil content where a premium is paid). On average oil content was decreased by 0.03% per kg applied N (Figure 3). This N treatment effect is common in low-medium rainfall zones. Previous research has shown oil content may decrease by 0.02 to 0.08 % per kg applied N on average (Seymour et a. 2016; Brennan and Bolland 2007a). However, generally oil content is unaffected by N application timing, though split applications have been associated with reduced oil content in dry conditions (Seymour *et al.*2016). This is consistent with the findings in 2017 and 2020 at Hart where N rate had a bigger impact on oil content compared to N application timing.

Nitrogen rate and application timing had no significant effect on 1000 grain weight, which was 3.74 g on average (Table 2).

Table 6. Canola grain yield (t/ha) and quality results at Hart for 2017 and 2020. All results are presented as the average value within each treatment. Shaded grey values indicate the highest grain yield and oil content.

Nitrogen treatment	Grain yield (t/ha)	Oil content (%)	1000 seed weight (g)
2017 season (GSR 191 mm)			
Nil	1.07^{a}	44.3^{c}	
50 kg N/ha @ seeding + 50 kg N/ha @ rosette	1.31^{b}	42.8^{bc}	
50 kg N/ha @ seeding + 50 kg N/ha @ rosette + 100 kg N/ha @ bolting	1.31^{b}	41.1^{ab}	
100 kg N/ha @ seeding	1.40^{bc}	43.9^{c}	
200 kg N/ha @ bolting	1.52^{c}	38.5^{a}	
LSD (P≤0.05)	***0.2***	***2.7***	
2020 season (GSR 336 mm)			
Nil	0.55^{a}	47.1^{c}	3.8
50 kg N/ha @ seeding + 50 kg N/ha @ rosette	0.55^{a}	43.2^{b}	3.6
50 kg N/ha @ seeding + 50 kg N/ha @ rosette + 100 kg N/ha @ early flowering	0.62^{ab}	41.3^{a}	3.6
100 kg N/ha @ seeding	0.73^{b}	43.2^{b}	3.8
200 kg N/ha @ early flowering	0.77^{b}	41.7^{a}	3.9
LSD (P≤0.05)	***0.15***	***0.70***	*NS*

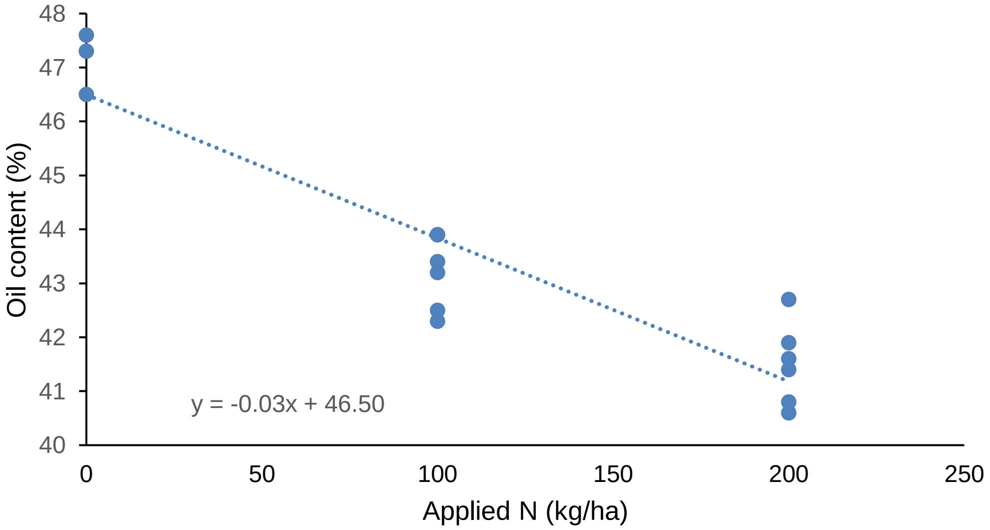

Figure 3. Canola oil content (%) response to total rate of applied N (kg/ha).

Summary

This report gives an example of how N management may affect canola grain yield and quality. The trials were conducted across two differing seasons which included prolong periods of dry which impacted crop N uptake. Overall application of 100 kg N/ha at seeding was sufficient to achieve the right balance between grain yield and oil content in these trials. The outcomes may have been quite different in a wet year. Economic factors such as current grain prices, cost of production and personal attitude to risk need to be accounted for to develop a nitrogen budget to estimate returns.

Acknowledgements

The Hart Field-Site Group would like to thank Pioneer® Seeds for donating the canola seed for the trial.

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Improved phosphorus prescription maps – beyond P replacement

Sam Trengove, Stuart Sherriff & Jordan Bruce; Trengove Consulting and Sean Mason; Agronomy Solutions

Key Findings

- Optimal phosphorus (P) applications for maximising gross margins differ within a paddock and have been linked to varying soil properties.
- Using the spatial data layers, soil pH and in season crop satellite imagery in a combined index has provided good prediction of P response and optimal P fertiliser rates.
- Benefits from targeting P responsive sites with high P rates can be observed in following seasons, indicating a long-term benefit and economic gain from this strategy.

Why do the trial?

The aim of this project is to increase the profitability derived from phosphorus (P) fertiliser applications. This will be achieved through increasing P fertiliser use efficiency by better understanding the spatial variability in P availability, demand and P response.

Map data layers that can infer spatial information on P uptake, soil tie up and response are becoming increasingly available, such as grain yield, soil pH, soil EC and NDVI. However, the best methodology for integrating these data for improving P rate calculations is unknown. The aim of this project is to better understand how these data layers can be integrated to produce variable rate P prescription maps that optimise P rates across variable paddocks.

This was achieved by analysing data layers (yield, soil pH, soil EC, NDVI) to identify the range in likely P response. This information was used to locate a series of P rate trials, in two paddocks in 2019 and three paddocks in 2020 in the Mid-North and Yorke Peninsula regions. The yield responses observed in these trials are being used to determine the relative importance or weighting that each data layer has on the rate calculation and inform the best method for integrating these data layers for calculating optimal P rates.

How was it done?

Predicted P response (low – very high) was estimated through analysis of historical satellite imagery and Veris pH data for five paddocks. Harvest yield maps were also used to check for ranges in grain yield. Based on these estimates, eight sites were selected in 2019 and a further 13 sites were selected in 2020 to cover a range of expected P response. Four sites were chosen in each of the paddocks near Bute in 2019 and 2020, Koolunga (2019) and Brinkworth (2020), and the paddock near Kybunga (2020) had five sites. The sites were chosen to cover the range in expected P response across each of the five paddocks.

An example of the map data layers used is shown in figure 1A and 1B for the 2019 Bute paddock. These data layers have been combined into a P sufficiency index (Figure 2), also being termed pHNNDVI in this report and is simply calculated by dividing soil pH by the normalised NDVI.

- pHNNDVI = soil pH/normalised NDVI

Based on this calculation, paddock zones with high soil pH and low NDVI have a high pHNNDVI value. These areas are predicted to have a higher P response than areas with low soil pH and high NDVI (low pHNNDVI).

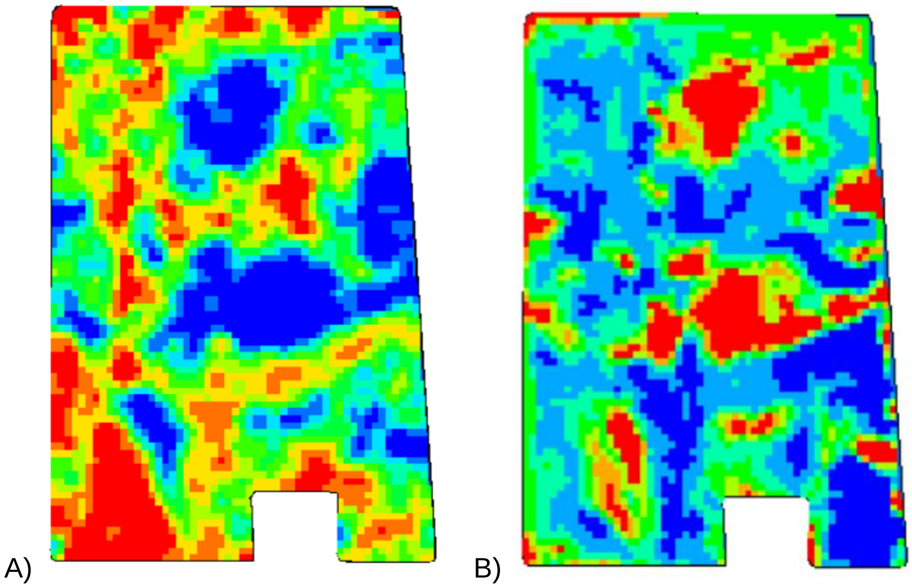

Figure 1. A) Soil pH CaCl2 and B) satellite NDVI for the trial paddock at Bute in 2019, warm colours represent low pH and NDVI values and cool colours represent high values.

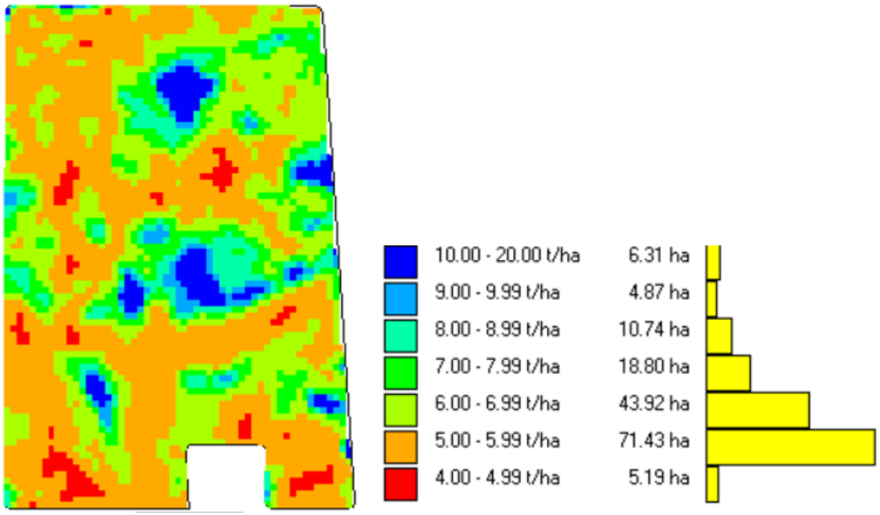

Figure 2. pHnNDVI derived from soil pH and satellite NDVI (shown in Figure 1) for the 2019 Bute trial paddock.

At each of the 21 sites selected, a P response trial was established using knife points and press wheels as a randomised complete block design with three replicates. Treatments included P rates of 0, 5, 10, 20, 30 and 50 kg P/ha (Table 2). Fertiliser was applied using MAP and nitrogen rates were matched between treatments using adjusted rates of urea. An additional treatment of 5 t/ha chicken litter was applied in trials in 2019 and 5 t/ha biosolids was applied to a treatment at Bute and Brinkworth in 2020. The entire paddock at Brinkworth was treated with biosolids at 3.5 t/ha in 2019.

Measurements throughout the season included soil tests (0-10 cm) for P levels (Table 1), Greenseeker NDVI, tissue tests on selected treatments and grain yield and quality. Grain samples were also retained and will be tested for P concentration to calculate P removal.

P rate for optimum grain yield for each site was calculated by generating a response curve (Exponential Rise to Max which generates the equation y = y0+a(1-exp(-b*x))) based on yield data for each site and then predicting the P rate that would achieve 90% of maximum yield. Partial gross margins (PGM) were then calculated from this data.

Table 1. Site descriptions and soil test results for 21 trial sites in five paddocks across NYP and Mid-North. Where descriptions of low-high are used, it is a relative reference compared to the paddock average.

Paddock	**Site**	**Historical NDVI**	**Veris pH**	**Expected P response**	**Numerical expected response**	**DGT P**	**Colwell P**	**PBI**	**pH CaCl2**
Koolunga 2019	**1**	Moderate	Alkaline	**High**	5	12	24	121	7.55
	2	Low	Alkaline	**High**	5	21	35	131	7.58
	3	High	Acid	**Moderate**	4	56	33	51	6.19
	4	Moderate	Neutral	**Low**	1	62	62	77	5.87
Bute 2019	**5**	Mod-High	Acid	**Low**	1	103	27	20	4.94
	6	Moderate	Neutral	**Moderate**	4	106	63	50	5.96
	7	Low	Alkaline	**High**	5	22	20	71	7.67
	8	Low	Alkaline	**High**	5	38	19	51	7.67
Brinkworth 2020	**9**	Low-med	High	**Moderate-high**	3	211	75	62	7.63
	10	Med-high	Moderate	**Low-moderate**	2	110	53	103	6.65
	11	Low	High	**High**	5	65	45	115	7.69
	12	High	Low	**Low**	1	186	94	63	6.22
Bute 2020	**13**	High cereal, med break	low/med	**Low**	1	180	33	23	5.75
	14	Low/high	high	**High**	5	46	38	68	7.82
	15	Medium/Low	medium	**Moderate**	4	107	67	92	6.11
	16	Low	high	**High**	5	68	37	105	7.63
Kybunga 2020	**17**	High	Neutral	**Moderate**	4	86	32	62	7.15
	18	Low	Alkaline	**High**	5	26	25	110	7.78
	19	Medium	Acidic	**Low**	1	142	23	28	6.99
	20	Medium	Alkaline	**High**	5	47	15	58	7.75
	21	Low	Strongly Alkaline	**Very high**	6	21	37	120	7.85

Table 2. Treatment list and application rates of MAP and urea for the 21 P trials in 2019 and 2020, chicken litter at sites in 2019 and biosolids applied at Brinkworth and Bute only in 2020.

Treatment	**P rate (kg/ha)**	**MAP (kg/ha)**	**Urea (kg/ha)**
1	0	0	49.4
2	5	22.7	44.5
3	10	45.5	39.5
4	20	90.9	29.7
5	30	136.4	19.8
6	50	227.3	0.0
7	Chicken litter in 2019 or Biosolids 2020 5t/ha	0	0

Results and Discussion

Table 3 shows expected P response, pHnNDVI value and the site average grain yields to demonstrate the production levels at each site. Site average yields range from 1.02 to 5.09 t/ha and P rate for optimum grain yield ranges from 0 kg P/ha to 55 kg P/ha P. It should be noted that there is no correlation between historical grain yield and P response for these 21 sites.

The relationships derived from the 21 P response trials conducted in 2019 and 2020 show that there is a useful correlation between the derived pHnNDVI and soil P availability measured with DGT (Figure 3). It also shows that in this dataset the pHnNDVI provides an improved correlation with optimum P rate than DGT P, indicating the methodology developed performed better than industry standard soil testing methodology. Both pHnNDVI and DGT P were far superior to Colwell P at these 21 sites (data not shown).

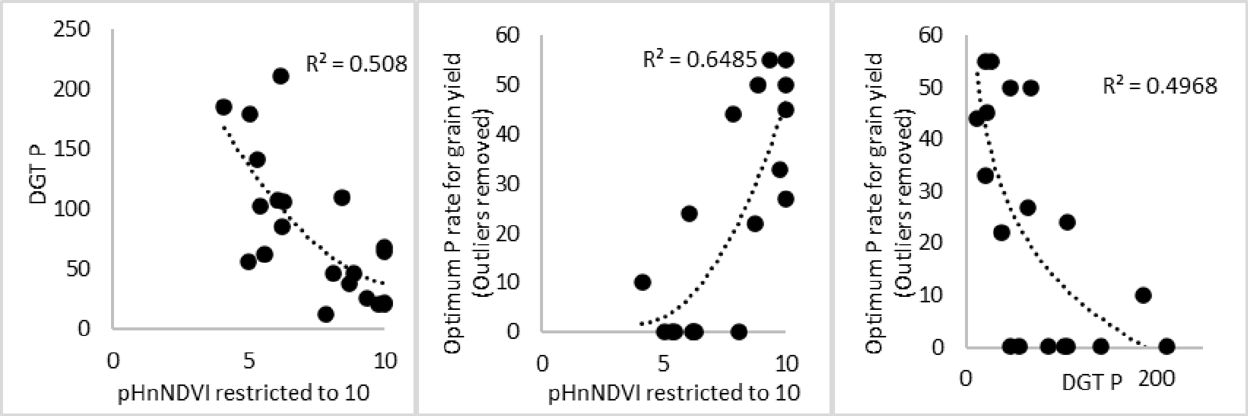

Figure 3: Relationship between pHnNDVI, DGT P and optimum P rate for grain yield derived from 21 P response sites in five paddocks in 2019 and 2020.

Optimal P rates at the P responsive sites increased PGM by up to $79/ha compared with returns from replacement P rates, with an average improvement in PGM of $41/ha. In the five focus paddocks assessed in this project (SAGIT TC119) the area of predicted high P response ranged from 16-40% of paddock area based on the derived P sufficiency index. Based on Trengove Consulting client data it is expected that these paddock areas of high P response would be representative of the region northern YP and western Mid-North where the trials were conducted. This represents a large area where economic gains could be achieved through improved P fertiliser strategies.

Longer-term economic response to P fertiliser is also sensitive to the accumulation or depletion of P over time and the crop response to changing soil P status in subsequent years. Three responsive trial sites established in 2019 at Bute and Koolunga were monitored again in 2020 when they were sown to lentil. Bute sites received 24 kg P/ha in 2020 and Koolunga 15 kg P/ha. At two of these sites lentil yield responses were measured in 2020 to P applied in 2019, with 50 kg P/ha treatments increasing lentil yield by 0.22 t/ha compared with untreated. These longer-term responses strengthen the economic case for higher P rates on responsive soils.

The highly responsive sites are responsive to extremely high P rates, up to 30-50 kg P/ha in many instances. However, these rates of P have not improved crop growth to the extent that these P deficient sites have the same vigour as the low response sites (using NDVI as a measure of vigour). For example, at Bute in 2020 sites 14 and 16 were P deficient and responsive to high rates on P. However, application of 50 kg P/ha at these sites did not increase NDVI to match NDVI of the untreated plots at the P sufficient, low response sites 13 and 15 (Figure 4). In addition, the long-term responses at sites from Bute and Koolunga described above indicate further long-term residual benefits of high P rate application. These results suggest that it is difficult to completely overcome low soil P status and severe P deficiency in a single year with fertiliser alone. It suggests that building soil fertility over time and increasing low soil P status will enable greater yields to be attained than fertiliser P can achieve in a single season.

A similar concept has emerged from hyper yielding trial sites in the high rainfall zone. That is, it is difficult to achieve high yields on low fertility sites where majority of the nutrient supply comes from fertiliser. Sites with high inherent fertility are required to achieve ‘hyper yields’. Similarities are evident with the P responses observed in this project, suggesting that building the baseline soil P status will build yield potential beyond what fertiliser P can attain in a single year.

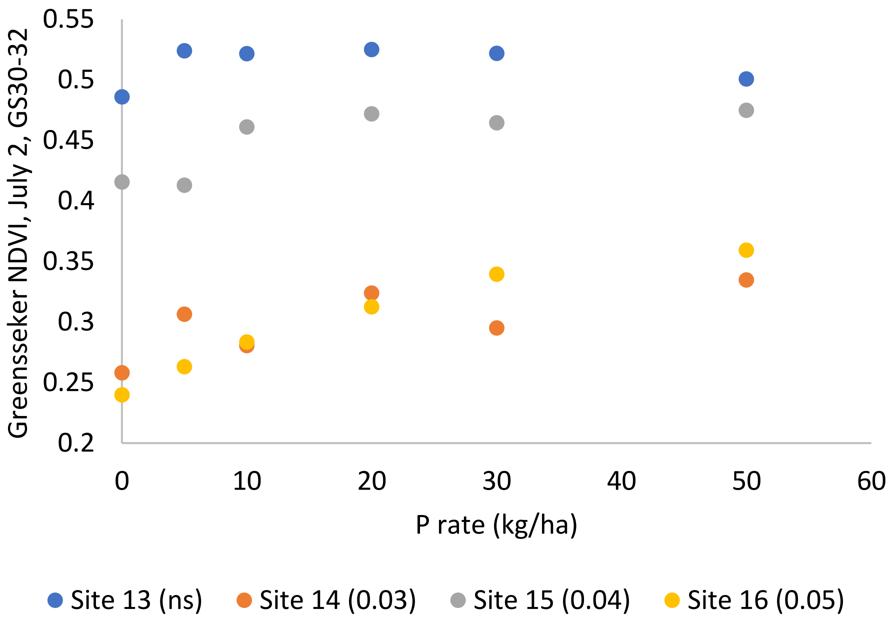

Figure 4. Greenseeker NDVI July 2, 2020 at Site 13 – 16 Bute P rate trials. LSD (P≤0.05) for each site is shown in brackets.

*Table 3. Expected P response, pHnNDVI, site average yield P rate for optimum grain yield and youngest emerge blade tissue P concentration (mg/kg) for P rate trials 2019 and 2020. The significance of grain yield response to P applications of each site is indicated by ** (P≤0.01), * (P≤0.05) and non-significant response (NS).*

Site	**Expected P response**	**pH/ nNDVIi**	**Site average yield (t/ha)**	**Calculated optimum P rate for 90% grain yield (kg/ha)**	**Critical concentration of leaf tissue P met at P rate**	**Grain response to P**
Site 1	High	7.9	2.07	44	50	**
Site 2	High	9.8	2.55	33	Not achieved	**
Site 3	Moderate	5.0	3.11	0	20	NS
Site 4	Low	5.6	2.65	*	10	NS
Site 5	Low	5.4	5.09	0	10	NS
Site 6	Moderate	6.3	4.64	0	0	NS
Site 7	High	10.0	4.08	45	50	**
Site 8	High	8.7	4.92	22	50	**
Site 9	Mod-high	8.4	2.16	50	#	NS
Site 10	Low-mod	6.1	3.27	0*	#	NS
Site 11	High	10.0	2.08	27	#	**
Site 12	Low	4.1	2.57	10	#	*
Site 13	Low	5.0	2.53	*	0	NS
Site 14	High	8.8	2.51	50	Not achieved	**
Site 15	Moderate	6.0	1.14	24	10	*
Site 16	High	10.0	1.02	50	50	**
Site 17	Moderate	6.2	2.34	0	50	NS
Site 18	High	9.3	2.16	55	Not achieved	**
Site 19	Low	5.3	3.80	0	20	NS
Site 20	High	8.1	3.02	0	Not achieved	NS
Site 21	Very high	10.0	2.09	55	Not achieved	**

** unable to predict optimum P rate for 90% yield for low level and non-significant responses*
 # leaf tissue samples not taken at these sites

Conclusions

Yield potential alone is not a good indicator of P requirement in this environment. When the data layers of pH and historical, early NDVI, are combined into a P sufficiency index, or pHnNDVI, the data can be used in parts of the Upper Yorke and Mid-North to predict P response as well as currently available soil tests. Adoption of this method of variable rate P application could lead to improved fertiliser use efficiency, increasing whole paddock grain yield outcomes for a given volume of fertiliser across the landscape. This would be achieved through greater grain yield production on underperforming, alkaline soil types. The advantage of using pH and satellite imagery for this purpose is that they can be measured cost effectively at higher resolution than traditional soil testing or grid sampling. If soil sampling is to be used for P rate recommendations then data from this project suggests that DGT-P should be used in preference to Colwell P in this environment as Colwell P had a poor relationship with optimal P rates in this data set.

It is important to note that this relationship will not fit in all situations and some knowledge of soil chemistry or ground truthing be conducted before decisions are made.

Acknowledgements

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Project No: SAGIT TC219

Long-term comparison of seeding systems

Sarah Noack, Rebekah Allen & Brianna Guidera; Hart Field-Site Group

Key findings

- Available soil nitrogen pre-seeding ranged from 41 to 115 kg N/ha. The high nutrition treatment had accumulated 44 kg N/ha more soil available nitrogen compared to the medium nutrition treatment.
- There was no effect of historic nitrogen application on grain yield. However grain protein was improved in the high compared to medium nutrition treatment (13.4% vs 11.7%).
- Wheat grain yields ranged from 2.3 to 3.0 t/ha. There were grain yield differences among seeder types this season with disc seeder > strategic > no-till.

Why do the trial?

The Hart cropping systems is unique, running since 2000, the trial provides SA grain growers with information on the long-term effects of cropping systems (a combination of seeders, tillage and stubble management) and nitrogen fertiliser regime. There continues to be industry interest in disc seeders due to their ability to retain heavy stubble, minimise soil disturbance, increased seeding speed and seed depth uniformity. To date the trial has shown no one seeding system or nutrition regime is consistently higher in grain yield, quality or gross margin.

The trial aims to compare the performance of three seeding systems and two nitrogen (N) strategies. This is a rotation trial (Figure 1) to assess the long-term effects of seeding systems and higher fertiliser input systems on soil fertility, crop growth and grain yield and quality.

How was it done?

Plot size	44 m x 13 m	**Fertiliser**	MAP (10:22) at seeding @ 50 kg/ha
Seeding date	May 27 - Disc May 29 - No-till and Strategic	**Medium nutrition**	Urea (46:0) @ 70 kg/ha on Aug 10
Variety	Scepter Wheat @ 100 kg/ha	**High nutrition**	Urea (46:0) @ 70 kg/ha on Aug 10 Easy N (42.5:0) @ 80 L/ha on Sept 11
Harvest date	December 9, 2020		
Location	Hart, SA		

The trial was a randomised complete block design with three replicates, containing three tillage/seeding treatments and two N treatments. Wheat stubble was uniformly managed across the trial area coming into 2020. The trial was managed with the application of pesticides to ensure a weed, insect and disease-free canopy.

2000	2001	2002	2003	2004	2005	2006	2007
Sloop barley	ATR-Hyden canola TT	Janz wheat	Yitpi wheat	Sloop barley	Kaspa peas	Kalka durum	Janz wheat

2008	2009	2010	2011	2012	2013	2014	2015
Janz wheat	Flagship barley	Clearfield canola	Correll wheat	Gunyah peas	Cobra wheat	Commander barley	44Y89 (CL) canola

2016	2017	2018	2019	2020
Scepter wheat	Scepter wheat	Wharton field pea	Sheriff CL wheat	Scepter Wheat

Figure 1. Crop history of the long-term cropping systems trial at Hart 2000 – 2020.

The disc, strategic and no-till treatments were sown using local growers Tom Robinson, Michael Jaeschke and Matt Dare’s seeding equipment, respectively.

Seeding treatments:

Disc – sown into standing stripper front stubble with John Deere 1890 single discs at 152 mm (6”) row spacing, closer wheels and press wheels.

Strategic – worked up pre-seeding, sown with 100 mm (4”) wide points at 200 mm (8”) row spacing with finger harrows.

No-till – sown into standing stubble in one pass with a Flexicoil 5000 drill, 16 mm knife points with 254 mm (9”) row spacing and press wheels.

Nutrition treatments:

Medium – starter fertiliser plus one in-season N application (refer to previous page)

High – starter fertiliser plus two in-season N applications (refer to previous page)

All plots were assessed for soil available N (0-20, 20-40, 40-60 and 60-80 cm) at the start of May, 2020. Plant establishment was assessed by counting 4 x 1 m sections of row and NDVI in each plot on July 6 and August 22, 2020. All plots were assessed for grain yield at harvest. All data was analysed using ANOVA in Genstat.

Results and discussion

Soil available nitrogen

Soil available N was measured in autumn (following wheat in 2019) and ranged between 41 kg N/ha to 115 kg N/ha (Figure 2). The high nutrition treatment had accumulated 44 kg N/ha more, averaging 91 kg N/ha for the high and 47 kg N/ha for the medium treatment. This difference indicates there was higher amounts of N carried over from the high treatment compared to the medium under dry 2019 seasonal conditions.

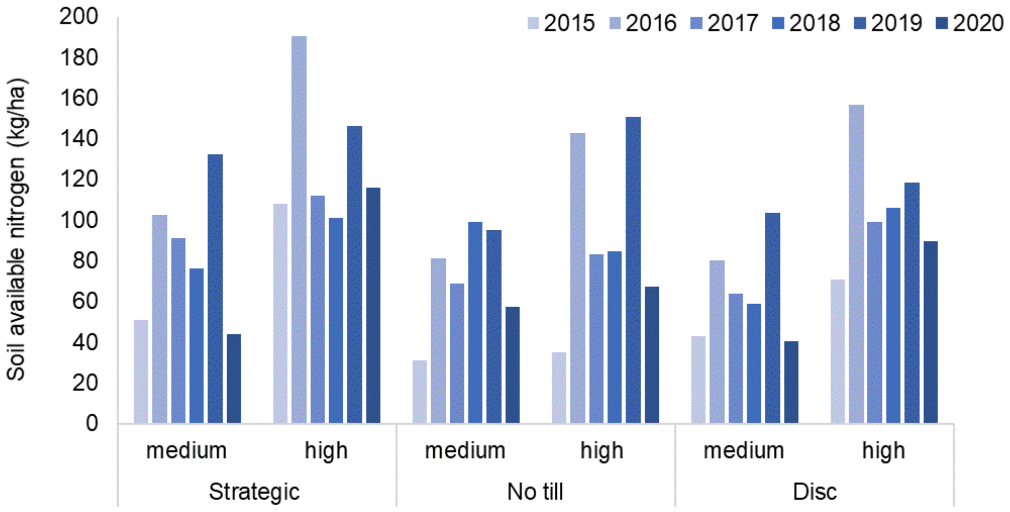


Figure 2. Soil available nitrogen (kg N/ha) pre-seeding for Hart long-term seeding systems trial from 2015 – 2020.

Plant establishment and NDVI

This season plant establishment was higher (271 plants/m^2) in the disc sown treatments compared to the no-till and strategic treatments (187 and 194 plant/m^2). The target plant density of the wheat seed source was 220 plants/m^2. This higher plant number translated to a higher NDVI (0.20 compared to 0.16) at the early July assessment. After six weeks this NDVI difference disappeared with all seeding systems averaging 0.41.

Historic and current nutrition regime had no effect on plant establishment or NDVI this season. At the July and August assessments soil moisture and rainfall at Hart had been low, resulting in similar N uptake in all treatments.

Grain yield and quality

Wheat grain yields across the trial ranged from 2.3 to 3.0 t/ha (Table 1). The dry winter combined with later seeding dates (late May - early June) reduced yield potential. The disc seeder provided the highest yields at 3.0 t/ha followed by the strategic and no-till seeders at 2.6 t/ha and 2.3 t/ha respectively. In the last five seasons (Table 1), all years have resulted in grain yield differences among the seeding systems. In seasons where yield differences were observed, generally the no-till and disc alone or together outperformed the strategic treatment. However, across the last 20 years of research one of the main outcomes from this trial has been a positive one for growers, in that there is no one seeding systems that gives consistently higher yields.

Grain quality values for screenings and test weight were not affected by seeding system or nutrition treatment (data not shown). The trial average screening level was less than 1.0% and test weights averaged 82 kg/hL. This lack of difference in grain quality among the seeder and nutrition treatments is consistent across the history of the trial.

Grain protein levels were high as a result of carry-over soil available N pre-seeding (Figure 2) and the accumulation of 44 kg N/ha more under the high nutrition treatment. It is not surprising that this translated to protein differences between the medium 11.7% (H2 classification) and high 13.4% (H1 classification) nutrition treatments.

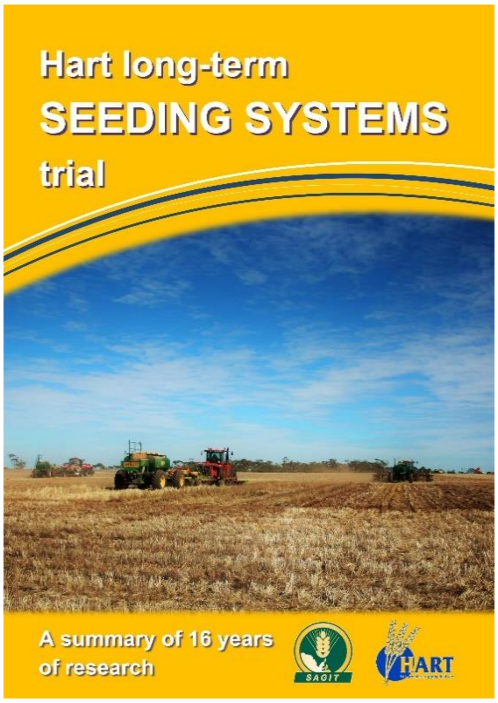
Table 1. Grain yield (t/ha) for all seeder and nutrition treatments for the past five seasons.

Seeder type	**Fertiliser strategy**	**2016 Wheat**	**2017 Wheat**	**2018 Field pea**	**2019 Wheat**	**2020 Wheat**	
		Grain yield (t/ha)					Protein (%)
Strategic	Medium	4.8	4.8	0.8	1.3	2.6	11.7
	High	5.9	5.9	0.7	1.2	2.7	13.6
No Till	Medium	4.2	4.2	0.9	0.9	2.3	13.1
	High	5.8	5.8	1.0	1.1	2.4	13.9
Disc	Medium	5.0	5.0	0.7	1.3	3.0	10.3
	High	5.9	5.9	0.7	1.3	3.0	12.9
LSD nutrition (P≤0.05)				*NS*	*NS*	*NS*	
LSD seeder (P≤0.05)				*0.2*	*0.1*	*0.2*	
LSD seeder x nutrition (P≤0.05)		*0.3*	*0.3*	*NS*	*NS*	*NS*	*0.7*

Read the full summary of 16 years of results on the Hart website:
http://www.hartfieldsite.org.au/pages/trials-results/hart-long-term-seeding-systems-trial.php

Acknowledgements

The HFSG thank the South Australians Grains Industry Trust (SAGIT) for providing funding to support this research (H119). They also thank all the growers and SARDI Clare who assisted with trial seeding, spraying and harvesting.



Hart Grower Guides

Download the full '**Hart long-term SEEDING SYSTEMS trial**' booklet on our website (look for Resources / Grower Guides in the main menu).

You'll find other Grower Guides too:

- Ten tips for early sown wheat
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- Soil Organic Matters – can soil carbon be increased through stubble retention
- Nitrogen management in wheat – why are nitrous oxide emissions an issue

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The agronomic value of precision planting technologies with winter grain crops

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Key findings

- Precision planting improved the uniformity of crop stands and often allowed reductions in plant density without loss of yield.
- Potential benefits will be greatest in crops with high seed input costs.
- Grain yield responses to precision planting have been variable in project trials to date and suggests adoption of the technology may not be warranted based on crop yield response alone.
- Precise and smart seeding technology is evolving rapidly with air-seeder based transitional options becoming available, which may allow a more practical and cost-effective pathway to greater planting precision.

Background

Precision planting technologies are designed to place seed at a consistent depth and interplant distance within a row to promote uniform emergence and to minimise interplant competition. The ability to precisely locate a single seed in the seeding row is referred to as singulation. Precision planters first appeared in the post-war era as a technology to improve yield in maize and they have been used extensively since then in a wide range of summer crops where expensive and high vigour hybrid seeds are planted at relatively low plant populations.

The recent interest in using precision planting technology with winter crops, especially in hybrid canola, has been prompted by a desire to reduce the costs of using hybrid seeds and has been reported that even placement of seeds improves yields at low plant densities, which would allow significant reductions in seeding rates. For example, field trials in Canada (Yang *et al.* 2014) reported yields with equally spaced canola plants were up to 20% and 32% higher compared to uneven spacing at low and high yielding sites, respectively. More recent work in WA in canola and lupin have indicated that even spacing, minimising interplant competition, may allow a reduction of sowing rates below current recommended rates, with predicted savings of $24/ha in seed of hybrid canola (Harries *et al.* 2019).

While these results are encouraging, there has been no systematic assessment of the value of precision planting technology in winter crop production for small grain crops in Australia. The aim of the current project is to assess the value of precision planting in canola and a number of pulse crops in the southern and western regions. The project has three main components:

(i) a paddock survey of establishment in a number of crops in 2018 and 2019 in the southern and western regions to assess the variation in seedling emergence and seedling depth and to examine what factors may contribute to this variation.

(ii) a series of small-scale and large-scale trials comparing conventional sowing (either a cone seeder or an air-seeder) with precision planting and,

(iii) a qualitative survey of current users of precision planters for winter grain crops.

This paper focusses on the results of the field trials and the experiences of growers using precision planters. The results of the crop survey have been reported previously (McDonald *et al.* 2020).

Method

A series of small plot trials was conducted between 2018 and 2020 using a purpose-built 6-row seeder that could sow seeds as a conventional cone seeder or as a precision planter. The precision planting units used in Victoria and South Australia were commercial row units supplied by Spot-on-Ag, in Boort Victoria (see Table 4). The trial at Merredin in 2019 used a small plot seeder operated by WA DPIRD with the capacity for singulation as well as conventional sowing. Both plot seeders used disc seeding systems, except in 2018 when cone seeding could only be done with a tyned seeding system. Details of the trials are given in Table 1.

Table 1. Details of the small plot trials conducted between 2018 and 2020.

Year	Site	Crop	
2018, 2019	Birchip Hart	Canola Lentil	Seeding method (Conventional, Precision) Plant density (6) Row spacing (23 cm, 30 cm)
2019	Roseworthy	Canola	Seeding method (Conventional, Precision) Plant density (5)
		Faba bean	Seeding method (Conventional, Precision) Seed treatment (Graded, Ungraded) Plant density
2019	Merredin	Lupin Canola	Seeding method (Conventional, Precision) Plant density (4)
2020	Horsham	Canola	Seeding method (Conventional, Precision) Plant density (4)
		Faba bean	Seeding method (Conventional, Precision) Row spacing (23 cm, 46 cm) Plant density (4)
2020	Hart	Canola Chickpea Wheat	Seeder type (Conventional, Precision) Plant density (4)

Large scale trials were also conducted with canola and faba bean near Skipton in western Victoria using a Väderstad airseeder (Seedhawk model in 2018; Rapid model in 2019) and a Väderstad precision planter (Tempo). Each trial compared the responses to row spacing (25 cm *vs* 50 cm) and sowing rate (recommended *vs* half-recommended) and were sown in plots 150 m long.

In all trials, seedling emergence at 5 weeks after seeding, interplant distance at seedling emergence, NDVI, biomass production at flowering or peak biomass, grain yield and yield components were measured. All trials were replicated and randomised and were designed either as split plot or as complete factorial trials with between 4 and 6 replicates. The uniformity of seed placement within the rows was assessed by the coefficient of variation (CV) of the interplant distance.

Results and discussion

Plot trials

The emergence rate of the trials varied considerably (Tables 2, 3). In the canola trials there were both increases and reductions in seedling establishment with precision planting (Table 2). However there was a consistent improvement in the uniformity of the interplant spacing with a 20-40% reduction in the CV for interplant distance.

In most trials there was no significant difference in the yields between the two seeders, with significant differences being measured in two of the nine trials; in both cases precision planting improved yields.

*Table 2. Summary of the effects of conventional and precision seeding on crop establishment, the uniformity of plant spacing and grain yield in canola. The trial at Skipton used commercial seeding and planting equipment in large plots and the remaining experiment used a small plot seeder. The significance of the difference between the precision planter and the conventional seeder is indicated: *** - P≤0.001; ** - P≤0.001; * - P≤0.05; NS = not significant.*

Site and year	**Conventional sowing**			**Precision planter**		
	Crop establish-ment (%)	*Interplant distance CV (%)*	*Grain yield (t/ha)*	*Crop establish-ment (%)*	*Interplant distance CV (%)*	*Grain yield (t/ha)*
Hart 2018	90	101	1.38	65***	77***	1.39 ^{NS}
Birchip 2018	64	103	0.35	59 ^{NS}	80***	0.37 ^{NS}
Hart 2019	67	99	0.54	64^{NS}	72***	0.61*
Birchip 2019	105	103	2.15	82**	66***	2.21 ^{NS}
Roseworthy 2019	51	89	0.98	68***	61***	0.98 ^{NS}
Merredin, 2019	88	-	0.34	69***	-	0.39 ^{NS}
Skipton 2019	102	85	2.64	76***	78^{NS}	2.68 ^{NS}
Hart 2020	48	94	1.01	52^{NS}	59*	1.06 ^{NS}
Rupanyap, 2020	100	99	3.40	83^{NS}	73***	3.62*

Crop establishment in the pulses were generally higher than in canola, but as with canola, there was no consistent effect of precision planting on establishment and crop uniformity was improved substantially (Table 3).

Precision planting improved grain yield by 18% or 22% in faba bean and significant increases of 10% (lupin) and 14% (lentil) were also measured. The results for canola and pulses indicated that despite variable effects on establishment, precision planting resulted in yields equivalent to or higher than those achieved with conventional sowing.

*Table 3. Summary of the effects of conventional and precision seeding on crop establishment, the uniformity of plant spacing and grain yield in pulse crops. The trials at Skipton used commercial seeding equipment in large plots and the remaining experiment used a small plot seeder. The significance of the difference between the precision planter and the conventional seeder is indicated: *** - P≤0.001; ** - P≤0.001; * - P≤0.05; NS = not significant.*

Crop	**Site and year**	**Conventional sowing**			**Precision planter**		
		Crop establish-ment (%)	*Interplant distance CV (%)*	*Grain yield (t/ha)*	*Crop establish-ment (%)*	*Interplant distance CV (%)*	*Grain yield (t/ha)*
Faba bean	Skipton, 2018	125	84	1.33	115*	34***	1.57*
	Skipton, 2019	129	86	3.95	124^{NS}	41***	3.91^{NS}
	Roseworthy, 2019	86	81	2.23	72**	39***	2.25^{NS}
	Rupanyap, 2020	69	104	4.56	89**	66***	5.57**
Lentil	Hart, 2018	101	-	1.21	77*	-	1.38*
	Birchip, 2018	97	102	0.91	106^{NS}	63***	0.88^{NS}
	Hart, 2019	59	95	2.55	50**	70***	2.43^{NS}
	Birchip, 2019	114	99	0.69	81***	73***	0.64^{NS}
Lupin	Merredin 2019	105		0.70	94^{NS}		0.77*
Chickpea	Hart, 2020	64	89	0.99	60^{NS}	58***	1.10**

The relationships between grain yield and established plant number were examined because of the variable effects of precision planting on both plant number and yield. Among all the trials, three types of responses were evident (Figure 1, 2): no difference in the response to plant density between the conventional and precision planting, a consistent yield advantage of precision planting over a range of plant densities and a greater ability to maintain yields at low density by precision planting.

A consequence of the latter two responses is that precision planting would allow a reduction in plant density with little or no yield penalty. Similar relationships were reported by Harries *et al.* (2019) in comparisons between unevenly spaced and evenly spaced plantings (Figure 3), suggesting the responses observed in the current trials were associated with differences in the uniformity in plant spacing within the crop. The potential economic benefit of this is the saving on seed costs from producing the same yield with fewer plants/m^2 and little yield penalty. However, the responses to precision planting varied among experiments and it is still unclear what the main factors that influence the response are.

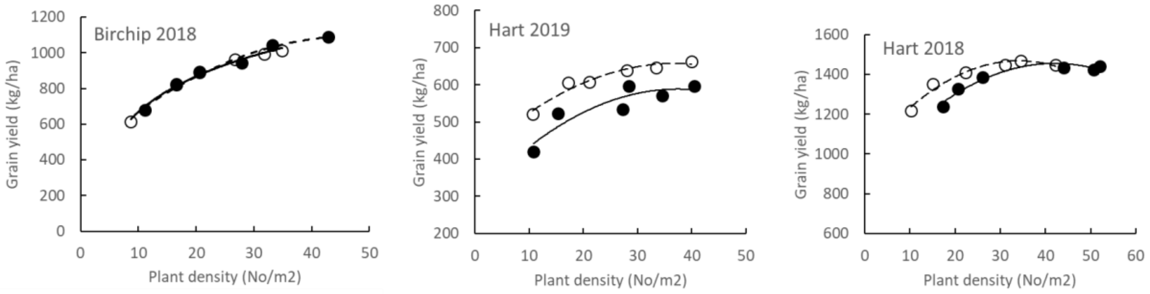

Figure 1. The relationships between the established number of plants/m^2 and the yield of canola sown either with a conventional cone seeder (●) or a precision planter (○) at three sites.

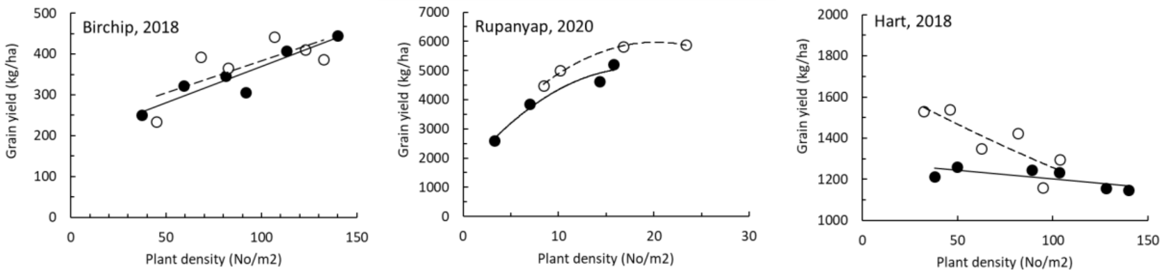

Figure 2. The relationships between the established number of plants/m² and the yield of pulse crops sown either with a conventional cone seeder (●) or a precision planter (○). The crops were lentil (Birchip 2018, Hart 2018) and faba bean (Rupanyap 2020).

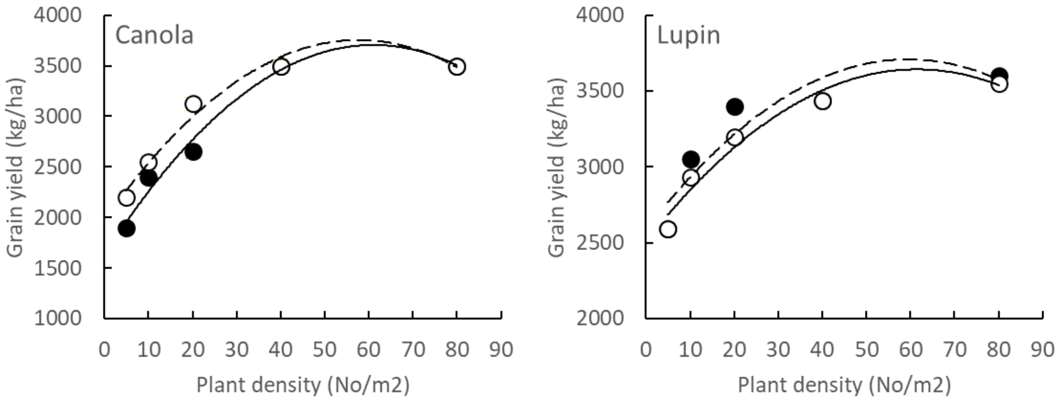

Figure 3. The response to plant density in canola and lupin by plants that were unevenly spaced (●) or evenly spaced (○) in trials in Western Australia (after Harries et al. 2019).

Field survey: precision planters vs air seeders

The paddock survey on crop establishment included four paddocks of two growers currently using precision planters, which allowed a limited comparison of commercial performance relative to conventional air-seeders. One grower was from the southern region and one from the western region. There was no consistent difference in crop establishment between paddocks sown with precision planters and conventional seeders (data not shown). In comparison with canola crops sown using conventional seeders, three of the four paddocks sown with a precision planter had lower-than-average variation in plant numbers and seedling depth, but there were also several paddocks sown with airseeders that showed similar or greater uniformity in plant number and seedling depth. These results suggest that while precision planters increase the ability to improve the uniformity of crops stands, there are still substantial gains that can be achieved using conventional air-seeder equipment and good results can also be achieved through careful settings and operations, and with adoption of ‘precision seeding systems’.

The project also evaluated the impact of precision planter settings on performance, highlighting in particular the rapid negative impacts of high planting speed and sub-optimal vacuum levels on seed singulation quality. Figure 4 shows an example of a calibration with field peas on the coefficient of variation output by the sensor-based monitoring system. The data, which correlated very well with weight-based seed rate calibration, show good to excellent singulation quality (%CV≤15) at 3 km/h and very satisfactory quality (15≤%CV≤30) at 6 km/h with sufficient vacuum level (> 18 “ H_2O). Performance at 9 km/h was sub-optimal with the 21-slot disc used, while a 35-slot disc could slow down the disc rotation by 40% and align the 9km/h performance between that of the original 3 and 6 km/h.

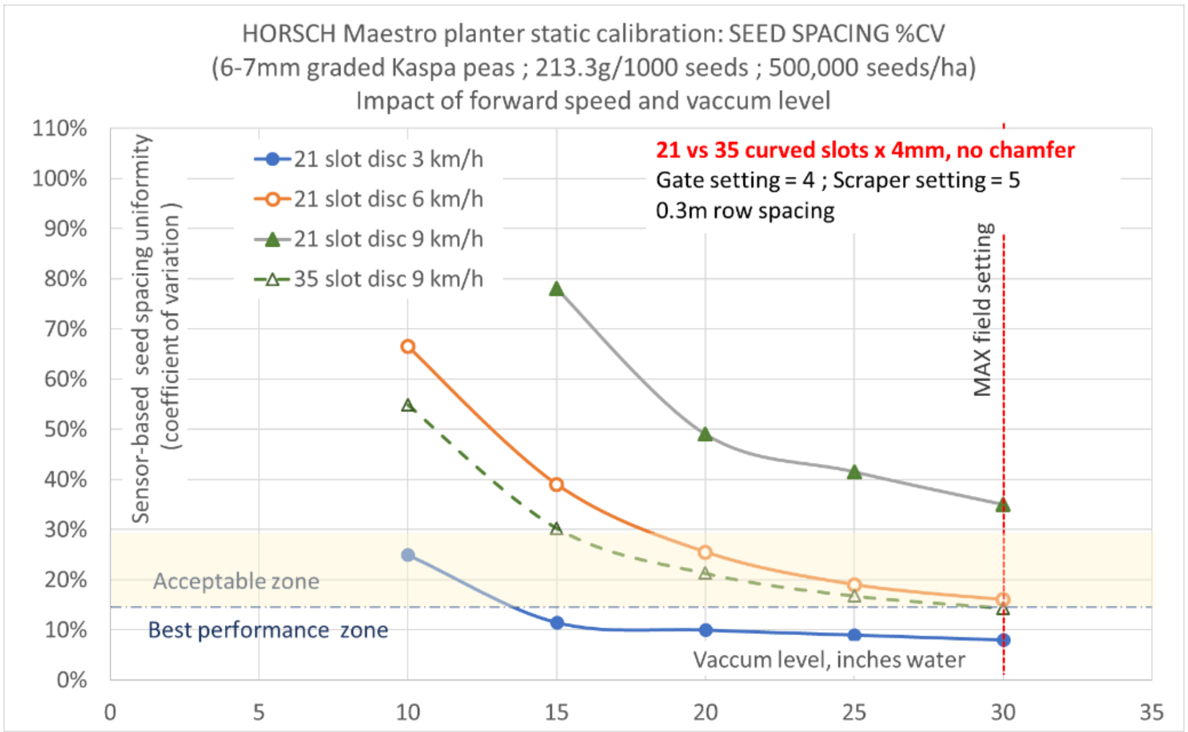

Figure 4. The impact of singulation vacuum setting and planting speed on the coefficient of variation (CV) of inter-seed spacing, with two disc plate designs.

Current developments in precision planting technology

There is a wide range of precision planter technologies commercially available, increasingly trending towards 'Intelligent Planting', using hi-tech sensor-based real-time monitoring and automation. Precision planter technology is increasingly catering for winter grain crops, including:

- improved singulation with winter grain dedicated plates and meter accessories,
- control systems suited to linear seed rate of winter grain crops,
- narrower row spacings within the 190-380 mm range,
- central commodity (bulk fill) system for broadacre applications, and
- liquid and/or granular fertiliser banding options.

To improve the versatility of singulation planters, downgrading to 'bulk metering' disc plates can be done selectively with crops where singulation may be unreliable, to ensure accurate bulk seed rate is still achieved (e.g. Great Plains Ag. *Yield-Pro HDP planters*).

Intermediate technologies also exist to improve the uniformity of seed distribution across seeding rows, such as single-row metering rollers where row-to-row variation can be 50% less than with centralised air-seeding (PAMI, 2019). Seed singulation row-kits are also emerging as optional features on broadacre disc seeding machines – which can be selected on a paddock-by-paddock basis. This integration of singulation kits onto air-seeders combines the flexibility of fertiliser placement and separation options available with air-seeding systems. Their integration with tyne-based seeding systems presents specific challenges and to date has been limited to prototypes, while limited tyne-disc hybrid systems are now commercially available. Developments of these intermediate technologies in the future could increase the versatility of precision planting in winter cropping systems in a range of soil conditions, but their mainstream adoption will rely on them being practical, cost-effective, and not affecting the timeliness of sowing within a cropping program.

Conclusions

Precision planting trials conducted over the last 3 years demonstrated an improved uniformity of crops stand and resulted in grain yields equivalent to or better than those achieved with conventional sowing. In a number of cases, plant density could be reduced with precision planting without a yield penalty, allowing a reduction in seed costs. However, the magnitude of the effect varied considerably, and further work is required to understand the main environmental and management factors that determine the agronomic benefits of precision planting. In dedicated calibration evaluation, planter performance was shown to be easily affected by suboptimal planter settings and operation.

A small number of growers using precision planting technology for winter grain crops in the southern and western regions have struggled with lack of technical support and information and with trying to adapt old technology to winter cropping. Nevertheless, some have experienced sizeable benefits with specific crops and are optimistic that gains in productivity and profitability can be achieved by more uniform seed placement along the row. Commercial precision planters increasingly cater for winter grain crops planting, use smart technology to monitor and automate adjustments on-the-go, while singulation kits are now slowly appearing as an additional feature of air-seeders for use on selected crops. The mainstream adoption of precision planters will require their use to not only be cost-effective but also practical, versatile and not significantly reduce seeding timeliness.

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Hart 2020

Getting The Crop In seminar - just before the pandemic hit

Our 2020 trial site

Soil testing

The Hart team

Notes