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Front cover photo taken by Sandy Kimber at Hart on September 14th (the day before the 2015 Hart Field Day).
With thanks to Sandy Kimber, Sarah Noack and Gabrielle Hall for other photos used within this publication.

Interpreting data

Interpretation of statistical data from the trials

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 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 2 treatments are different, and so in some cases a non-significant result may still be useful.

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Acknowledgements

The success of the Hart Field-Site Group 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 their knowledge and experience through to land and equipment for conducting trials.

Peter Baker
Andrew & Peter Cornwell
Robert & Dennis Dall
Matt Dare
Trevor & Kathy Fischer
Leigh Fuller
Simon Honner
Peter Hooper
Grant & Craig Jaeschke
Michael Jaeschke
Jim Maitland
Peter & Lyell McEwin
Todd McPharlin
David Michael
Stuart Sherriff
Damien Sommerville
Ian Sparks
Alex Stockman
Sam Trengove
Tom & Ashley Robinson
Robert & Glenn Wandel
Mark Williams
Justin & Bradley Wundke

We would also like to thank various organisations for the provision of seed and/or products that are trialed in the 2015 research program.

ADAMA
Agbyte
AgriCrop
Australian Grain Technologies
AvantAgri
BASF
Bayer Crop Science
Crop Care
Dow AgroSciences
GrowGreen
Heritage Seed
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InterGrain
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Nufarm, Pioneer Seeds
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Hart events in 2016

Hart 2015 season and rainfall chart

The 2015 season started with good opening rains which enabled a number of early sowing trials to be sown in mid-March (Table 1). Consistent rainfall in April was in line with the long-term average (Figure 1) however, in May, June and July we observed well below average rainfall with only 19, 21 and 29 mm respectively. Much needed rainfall occurred in August (66 mm) and September (32 mm) however minor frost damage at the trial site occurred in early and late August (greater damage was observed in neighbouring districts). Care should be taken when interpreting variety and time of sowing trials due to differences in varietal maturities and therefore frost incidence this season.

The season came to a quick end as we experienced below average rainfall and a run of days where temperature increased to 30-35°C in early October. Similar to 2014 it was another warm dry finish to the season. Overall the 2015 growing season rainfall was 230 mm and annual was 353 mm, well below the long-term avenge of 300 mm and 400 mm, respectively.

Table 1. Hart rainfall chart 2015

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st			2.0					14.2				
2nd						2.4		5.6	6.0			
3rd								1.4	11.4		23.8	
4th	1.4							3.8			23.6	
5th					6.0			3.2			0.2	
6th				17.0				4.0				
7th							0.6					2.6
8th	3.4	0.6					0.2					
9th	14.6					1.0			13.6			
10th	23.6						0.4		0.6			
11th	7.4						5.4					
12th							2.2	15.4				
13th	17.2						0.8	1.6				
14th							2.2	0.2				
15th						0.4	3.0		0.6			
16th							0.8	0.2				
17th						8.4	1.0			0.4		
18th						3.2	0.8					
19th				18.0	13.0							
20th						1.2				0.6		
21st	1.0									2.6		
22nd							7.6					
23rd			0.2			0.6	0.2					
24th						1.6	0.4	16.0				
25th				25.0		1.4					0.8	
26th			1.0				1.6					
27th							1.0					
28th						0.2	0.8					
29th												
30th												
31st												
Monthly total	68.6	0.6	3.2	60.0	19.0	20.4	29.0	65.6	32.2	3.6	48.4	2.6
Running total	68.6	69.2	72.4	132.4	151.4	171.8	200.8	266.4	298.6	302.2	350.6	353.2

Total annual rainfall		Growing season (Apr-Oct)	
Long-term average	400 mm	Long-term average	305 mm
2013	377 mm	2013	303 mm
2014	426 mm	2014	280 mm
2015	353 mm	2015	230 mm

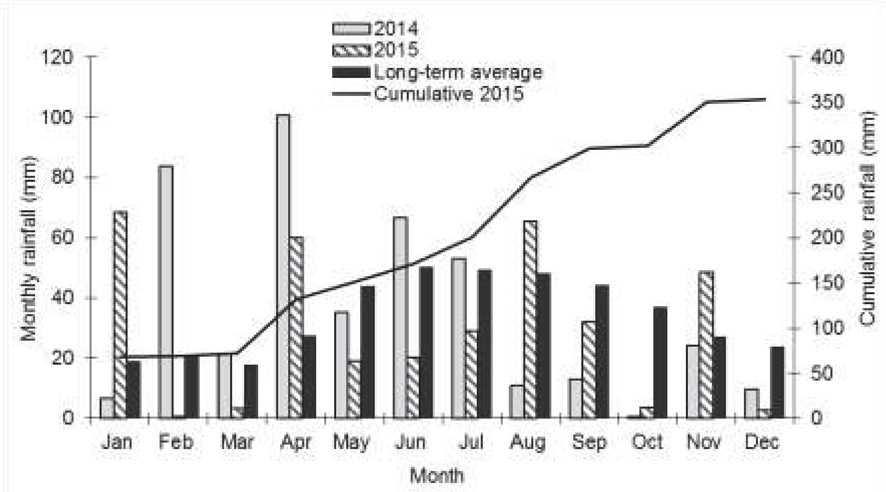

Figure 1. Hart rainfall graph for 2014, 2015 and long-term average.

Hart trial site - soil analysis

Soil physical and chemical properties for the 2015 Hart trial site. Sampled on 14th April, 2015.

	Sampling depth (cm)				
	0-15	15-30	30 - 60	60 - 90	Total profile
Texture					sandy loam - loam
Gravel %	5	5	5	5	
Available Nitrogen kg N/ha					45
Phosphorus Colwell mg/Kg	31	14	17	11	
Potassium Colwell mg/Kg	275	158	167	176	
Sulphur mg/Kg	2.5	2.3	5.5	26.5	
Organic Carbon %	1.0	0.8	0.6	0.3	
Conductivity dS/m	0.2	0.2	0.3	0.4	
pH Level ($CaCl_2$) pH	7.1	7.6	7.8	8	

Predicta B - on row samples, no added stubble (sampled 16/04/2015)

- Take-all – low/medium risk
- Crown rot (*F. pseudograminearum*) – high risk
- Yellow leaf spot (test under development) – present
- Common root rot – low risk
- Pythium clade f – present
- Root lesion nematode (*Pratylenchus neglectus*) – low risk (6 nematodes/g of soil)
- Root lesion nematode (*P. thornei*) – low risk (1 nematode/g of soil)
- Black spot of peas – medium risk

The following were not detected

- Cereal cyst nematode
- Take – all (oat)
- Rhizoctonia bare patch
- Root lesion nematodes (P. penetrans, P. teres)
- Phytophthora root rot (Phytophthora medicaginis)
- Eyespot
- Crown rot caused by Fusarium culmorum

Comparison of wheat varieties

Sarah Noack, Hart Field-Site Group

Key Findings

- Scepter, Scout, Phantom and Cosmick were the highest yielding commercially available AH varieties at Hart in 2015, yielding between 4.48 and 4.71 t/ha.
- Trojan was the highest yielding APW variety at 4.84 t/ha.
- Test weight and screening levels across the trial averaged 80.5 kg/hL and 2.3%.

Why do the trial?

To compare the performance of new wheat varieties and lines against the current industry standards.

How was it done?

Plot size	1.75 m x 10 m	**Fertiliser**	DAP (18:20) + Zn 2% @ 100 kg/ha
Seeding date	6th May 2015		UAN (42:0) @ 95 L/ha, 8th July
			UAN (42:0) @ 48 L/ha, 11th Aug

The trial was a randomised complete block design with 3 replicates and 21 varieties. Fungicides and herbicides were applied as necessary to keep the crop canopy free of disease (ie. stripe rust) and weeds. All plots had the edge rows removed prior to harvest and were assessed for grain yield, protein, test weight and screenings with a 2.0 mm screen.

Results and discussion

Wheat grain yields ranged from 2.19 t/ha for Hatchet CL Plus up to 4.84 t/ha for Trojan (Table 1), with an average site yield of 4.27 t/ha. During the season it was evident that earlier maturing varieties had been impacted by frost and this should be taken into account when interpreting the results. The highest yielding varieties were Trojan, Scepter and Scout, closely followed by Phantom, LPB111727, Cosmick, LPB111728, Cutlass, Cobra and Estoc, all yielding above 4.40 t/ha. The long-term variety yield data shows Trojan and Emu Rock also performed well over a range of seasons yielding 108% of the trial averages. Although not in the top yielding varieties at Hart in 2015, both Mace and Corack also have high mean yields of 109% and 107%, respectively.

Wheat grain proteins were generally low (less than 10.5%) across the trial. Those varieties able to achieve levels for Hard 1 or 2 classification were Hatchet CL Plus, Axe and Wallup. This result relates to yield dilution effects (lower yield = higher protein). A larger number of varieties met the protein level for APW (minimum 10.5%) inducing Gladius, AGT Katana, Emu Rock and Mace.

Grain test weights across the trial averaged 80.5 kg/hL and all varieties exceeded 76 kg/hL, the minimum required for maximum grade (Table 1). Screening levels at the site averaged 2.3% and all varieties fell below the maximum level of 5% for Hard and APW classification.

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) of wheat varieties at Hart in 2015. Mean grain yield (% of trial average) of Hart wheat variety trials (2010-2015) and number of trials.

Quality	Variety	**Grain yield** t/ha	% of site average	**Protein** %	% of site average	**Test Weight** kg/hL	% of site average	**Screenings** %	% of site average	**Mean yield** 2010-2015	No. of trials
AH	Axe	3.81	89	12.0	113	79.1	98	1.8	78	104	6
	Cobra	4.45	104	10.3	97	79.1	98	2.4	103	104	4
	Cosmick	4.48	105	9.4	89	81.1	101	4.5	193	105	2
	Emu Rock	4.29	100	10.8	101	80.5	100	3.4	147	108	5
	Gladius	4.15	97	11.5	108	80.0	99	2.4	103	100	6
	Grenade CL Plus	4.37	102	10.0	94	80.7	100	2.0	87	97	4
	Hatchet CL Plus	2.19	51	16.8	158	77.6	96	1.3	54	79	3
	AGT Katana	4.34	102	10.8	102	82.4	102	2.2	95	104	6
	Kord CL Plus	4.16	97	10.4	98	80.2	100	4.4	189	96	5
	Mace	4.27	100	10.6	100	80.4	100	1.4	58	109	6
	Phantom	4.59	107	9.6	90	80.6	100	2.3	101	101	5
	Scepter (RAC2182)	4.71	110	9.1	86	81.1	101	2.8	120	-	
	Scout	4.68	110	10.0	94	82.8	103	1.8	77	106	6
	Shield	4.39	103	10.2	96	79.9	99	3.3	140	100	4
	Wallup	4.06	95	11.7	110	77.1	96	1.3	55	97	4
	H1 receival standard			*>13.0*		*>76.0*		*<5.0*			
APW	Cutlass	4.45	104	9.4	89	81.5	101	2.2	96	-	
	Corack	4.07	95	10.4	98	80.8	100	1.8	77	107	5
	Estoc	4.43	104	10.4	98	82.4	102	2.0	85	100	6
	Trojan	4.84	113	9.8	92	81.1	101	2.1	91	108	3
	APW1 receival standard			*>10.5*		*>76.0*		*<5.0*			
Unclassified	LPB111727	4.53	106	10.2	96	81.1	101	2.0	84	-	
	LPB111728	4.47	105	9.7	92	80.7	100	1.6	69	-	
	Site Average	4.27	100	10.6	100	80.5	100	2.3	100		
	LSD (P≤0.001)	0.24		0.84		1.89		0.6			

- first included at Hart in 2015

Comparison of barley varieties

Sarah Noack, Hart Field-Site Group

Key Findings

- Fathom, Keel, Hindmarsh and Fleet were the highest yielding feed barley varieties at Hart averaging 4.8 t/ha.
- La Trobe, Charger and SouthernStar were the highest yielding commercially available malt varieties averaging 4.6 t/ha.
- Compass (pending malt classification) also yielded similar at 4.85 t/ha.

Why do the trial?

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

How was it done?

Plot size	1.75 m x 10 m	**Fertiliser**	DAP (18:20) + Zn 2% @ 100 kg/ha
Seeding date	6th May 2015		UAN (42:0) @ 95 L/ha, 8th July
			UAN (42:0) @ 48 L/ha, 11th August

The trial was a randomised complete block design with 3 replicates and 21 varieties. Fungicides and herbicides were applied as necessary to keep the crop canopy free of disease (ie. net blotch) and weeds. All plots had the edge rows removed prior to harvest and were assessed for grain yield, protein, test weight, screenings with a 2.2 mm screen and retention with a 2.5 mm screen.

Results and discussion

Fathom, Keel, Hindmarsh and Fleet were the highest yielding feed barley varieties at Hart in 2015, ranging from 4.7-4.9 t/ha (Table 1). The site average yield across all feed varieties was 4.6 t/ha. The lowest yielding feed variety was Oxford at 3.93 t/ha. The long-term yield data reflects the trends seen for feed varieties at Hart in 2015.

The highest yielding malt varieties were La Trobe, Charger, SouthernStar, Bass and Schooner ranging from 4.4-4.7 t/ha. Compass and Spartacus, currently pending malt accreditation were also high yielding at 4.85 t/ha and 4.65 t/ha. The average yield across all malt varieties at Hart was 4.24 t/ha. Both La Trobe and Compass are also high yield in the long-term yield results (Table 1).

Grain protein for all malt barley varieties averaged 11.8% across the trial. All malting varieties except Admiral, Schooner and Westminster fell between the allowable protein range of 9-12% for malt 1 and 2 classification.

A number of malting varieties fell below the minimum test weight specification of 65 kg/hL including, Charger, Commander, Navigator, Westminster and Admiral. The only feed varieties to fall below the minimum test weight specification for F1 feed barley of 62.5 kg/hL (Table 1) were Oxford and Fleet.

Screening levels across the trial averaged 12.5%. Consistent with previous seasons Oxford produced higher screenings of 42.8% followed by Buloke (23.8%), Scope (20.1%) and Westminster (20.0%).

Retention levels across the trial were low. For the commercially available malt varieties, Bass was the only variety to exceed the minimum retention level for malt 2 (>62%). As reported in previous years Compass had a high retention percentage of 79.2% to meet malt 1 standard.

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL), screenings and retention (%) of barley varieties at Hart 2015. Mean grain yield (% of trial average) of Hart barley variety trials (2010-2015) and number of trials.

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	Mean yield 2010-2015	No. of trials
Feed	Fathom	4.91	112	11.4	98	65.3	100	6.9	55	68.4	137	115	5
	Fleet	4.69	107	11.8	101	60.2	92	8.5	68	52.2	104	111	6
	Hindmarsh	4.74	108	11.4	98	68.4	104	14.6	117	48.4	97	110	6
	Keel	4.88	112	11.6	100	70.5	108	4.7	37	80.9	162	109	6
	Maritime	4.17	95	12.0	104	66.8	102	4.4	35	78.8	158	94	6
	Oxford	3.93	90	12.1	104	62.2	95	42.8	342	5.9	12	95	6
	F1 receival standard			*NA*		*>62.5*		*<15*		*NA*			
Malting	Admiral	3.64	83	13.1	113	59.1	90	15.1	120	32.6	65	-	
	Bass	4.40	101	11.7	101	67.3	103	3.0	24	67.5	135	99	4
	Buloke	4.22	96	11.5	99	65.0	99	23.8	191	40.3	81	102	6
	Charger	4.59	105	11.3	98	64.2	98	12.3	99	53.4	107	103	3
	Commander	4.36	100	11.8	101	63.5	97	16.7	134	48.8	98	107	6
	GrangeR	4.09	93	11.2	97	66.1	101	6.2	49	44.7	89	93	5
	La Trobe	4.70	107	11.3	97	68.4	104	14.8	118	40.1	80	108	4
	Navigator	4.03	92	11.8	102	62.5	95	8.7	70	33.8	68	103	6
	Schooner	4.37	100	12.2	105	68.7	105	5.7	46	58.8	117	94	6
	Scope	4.32	99	11.3	98	66.0	101	20.1	161	29.6	59	99	6
	SouthernStar	4.50	103	11.3	97	70.4	108	9.1	73	54.8	110	-	
	Westminster	3.61	83	12.7	110	63.4	97	20.0	160	22.9	46	85	5
	Malt 1 receival standard			*9-12%*		*>65.0*		*<7.0*		*>70.0*			
Unclassified	EB1401	4.29	98	10.6	91	61.1	93	8.6	69	57.7	115	-	
Pending malt accreditation	Compass	4.85	111	10.9	94	65.6	100	4.0	32	79.2	158	107	6
	Spartacus CL (IGB1334T)	4.65	106	10.8	93	70.8	108	12.4	99	51.7	103	-	
	Site Average	4.38	100	11.6	100	65.5	100	12.5	100	50.0	100		
	LSD (P≤0.05)	0.35		1.0		1.7		3.2		11.5			

- first included at Hart in 2015

Comparison of durum varieties

Sarah Noack, Hart Field-Site Group

Key findings

- The average grain yield for all durum varieties was 3.07 t/ha, with only 0.34 t/ha between all seven varieties trialed.
- Test weight values were high and only two varieties (Hyperno and Yawa) exceeded the minimum 5% screenings level at Hart in 2015.

Why do the trial?

To compare the performance of new durum varieties and lines against current industry standards.

How was it done?

Plot size	1.75 m x 10 m	**Fertiliser**	DAP (18:20) + Zn 2% @ 100 kg/ha
Seeding date	6th May 2015		UAN (42:0) @ 87 L/ha, 8th July
			UAN (42:0) @ 43 L/ha, 11th Aug

The trial was a randomised complete block design with 3 replicates and 7 varieties. Fungicides and herbicides were applied as necessary to keep the crop canopy free of disease and weeds.

All plots were assessed for grain yield, protein, test weight and screenings with a 2.0 mm screen.

Results and discussion

Durum grain yields ranged from 2.88 t/ha to 3.22 t/ha, with a site average yield of 3.07 t/ha (Table 1). The highest yielding varieties were DBA-Aurora, Yawa, Tjilkuri and Caparoi. Grain protein levels were not high enough for DR1 (>13%), however all varieties were higher than 11.5% required for DR2 delivery.

All varieties were above the minimum test weight value of 76 kg/hL. Similar to 2014, Caparoi had the highest test weight followed by Tamaroi. Screening levels across the trial were low and the only varieties to exceed 5% screenings were Hyperno and Yawa.

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) for durum varieties at Hart, 2015.

Variety	Grain yield t/ha	% of site average	Protein %	% of site average	Test Weight kg/hL	% of site average	Screenings %	% of site average
Caparoi	3.03	99	12.2	103	79.7	102	1.8	46
Tamaroi	2.88	94	11.8	100	78.9	101	2.1	55
Saintly	2.98	97	11.9	101	77.9	100	2.3	58
Hyperno	3.01	98	11.8	100	76.9	98	7.5	195
DBA-Aurora	3.22	105	11.4	97	77.4	99	2.7	69
Tjilkuri	3.11	102	12.2	103	77.9	100	3.9	101
Yawa	3.22	105	11.5	97	77.9	100	6.8	176
Site Average	**3.07**	**100**	**11.8**	**100**	**78.1**	**100**	**3.9**	**100**
LSD ($P \leq 0.05$)	0.21		0.4		1.2		1.2	

Understanding canola variety development to improve yields

Andrew Ware and Christine Walela, SARDI

Key findings

- The 2015 season was cooler than 2014 which affected how canola varieties developed and grain yields.
- Early sowing presents a good opportunity to improve canola water use efficiency and yields but variety selection is important.

Why do the trial?

The 2015 season formed the second year of field trials conducted at a number of locations across South Australia, investigating options to increase canola profitability and reduce production risk with tactical agronomy advice underpinned by physiological insights. In this project SARDI is working in conjunction with CSIRO and NSW DPI to undertake physiological and agronomic research from southern QLD to the Eyre Peninsula.

Research conducted by John Kirkegaard and Mike Robertson, CSIRO, that concluded in 2005 found water use efficiency in canola was typically maximised through early sowing. However, this research was conducted prior to the release of many of the modern hybrid varieties available today. The research also didn't explore the effect of canola yield and development when sowing time is pushed into even earlier sowing windows that are now possible with modern farming practices.

In both 2014 and 2015 trial sites were established at three sites in South Australia (Yeelanna, LEP, Hart, Mid North and Lameroo, Mallee). In each year a range of high yielding canola varieties were planted at multiple sowing times, starting from mid-April. A range of development stages were recorded throughout the season as well as grain yield. The results aim to improve the water use efficiency of canola, through early sowing and correct variety selection. It will also provide researchers with information on how canola develops in different environments so that further improvements to yield can be exploited.

How was it done?

Plot size	2.0 m x 10.0 m	**Fertiliser**	100 kg/ha DAP (18:20) @ sowing + 150 kg/ha N post emergent
Seeding dates	14th April 2015 30th April 2015 15th May 2015		

The trial was randomised block design (with times of sowing blocked together) and measurements included: pre-sowing nitrogen, soil moisture, flowering dates, hand harvested yields, grain oil.

Results and discussion

Comparisons between 2014 and 2015

Similar trials have been conducted on the Hart field site in 2014 and 2015, where sowing dates were within a day of each other in each year and the majority of the varieties were the same. This allows for comparisons between seasons and provides some insights into the drivers of development in several of the varieties.

Figure 1 shows the cumulative average daily temperature for Snowtown from 15 April (selected as it has longer term data). The cumulative daily temperature is the daily maximum temperature plus the daily minimum temperature divided by two, with each temperature from 15 April added together to provide a cumulative total. This shows that the temperatures observed in 2014 were considerably warmer than the average figure and in 2015 temperatures were slightly cooler than average.

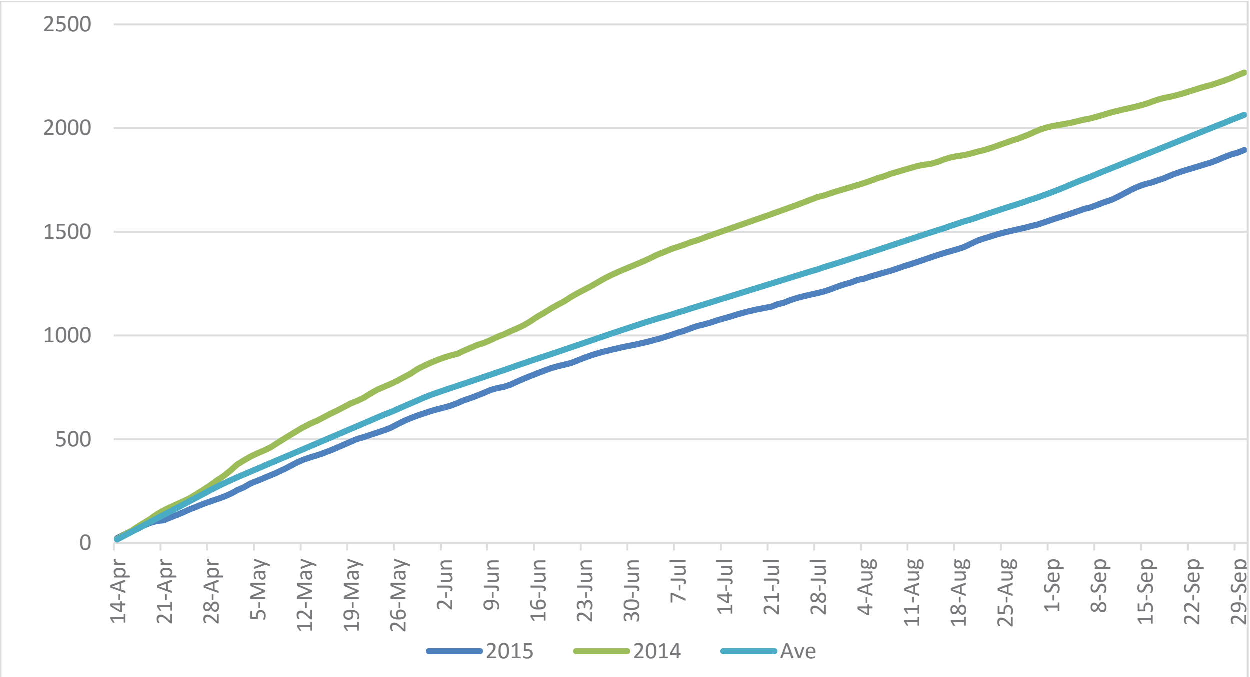

Figure 1. Cumulative average daily temperature for Snowtown (long term average, 2014 and 2015)

The effect of temperature on flowering date and subsequently yield for two varieties in 2014 and 2015 is shown in Table 1. Both varieties, Hyola 575CL and Pioneer 45Y88CL flowered two weeks earlier in ToS 1 (mid-April) in the warmer conditions of 2014 compared with 2015. However, Pioneer 45Y88CL flowered over two weeks later than Hyola 575CL in the first time of sowing 2014. The grain yield of Hyola 575CL from ToS 1 compared to ToS 2 (1 May) in 2014 showed a 0.57 t/ha yield advantage from delaying sowing by two weeks in this variety, but no advantage from either sowing date with Pioneer 45Y88CL. This indicates that thermal time (or cumulative temperature) is a factor in the development of both varieties, but plays a more important role in Hyola 575CL, as when planted early (mid-April), can race through its development and flower too early resulting in a yield penalty. This effect was stronger in warmer 2014 than 2015, but is still a risk if deciding to plant early. The 50% flowering date for all varieties and ToS trialed in 2015 are presented in Table 2.

Table 1. 50% flowering dates and yield of two selected canola varieties at Hart, 2014 and 2015.

		ToS1		ToS2		ToS3	
Hart		2014	2015	2014	2015	2014	2015
Flowering Date	Hyola 575	29-Jun	16-Jul	2-Aug	10-Aug	31-Aug	25-Aug
	45Y88CL	16-Jul	4-Aug	17-Aug	17-Aug	4-Sep	31-Aug
Yield (t/ha)	Hyola 575	1.49	2.31	2.06	2.4	2.05	1.75
	45Y88CL	1.98	2.54	1.96	2.16	1.89	1.76

2015 Yield and Flowering Date

Hand harvest yields are presented (Figure 2) as birds caused significant damage to some plots that made plot harvested yields unrepresentative. This may have inflated the grain yields, but relative differences should be consistent. The variety 44Y89CL in time of sowing 1 had too much bird damage for yields to be displayed here.

Grain yields show that in 2015 most varieties benefited from planting in mid-April, with these treatments having the highest yields. The exception to this was the early maturing variety ATR Stingray and Hyola 575CL.

Table 2. 50% flowering dates of nine varieties sown at different sowing dates at Hart in 2015.

	14-Apr	30-Apr	15-May
44Y89CL	23-Jul	10-Aug	25-Aug
45Y88CL	4-Aug	17-Aug	31-Aug
Archer	10-Aug	20-Aug	4-Sep
ATR_Gem	18-Jul	14-Aug	28-Aug
ATR_Stingray	7-Jul	4-Aug	20-Aug
AV_Garnet	31-Jul	14-Aug	28-Aug
Hyola_559TT	20-Jul	10-Aug	25-Aug
Hyola_575CL	16-Jul	10-Aug	25-Aug
Hyola_750TT	4-Aug	17-Aug	31-Aug

Canola flowering at Hart

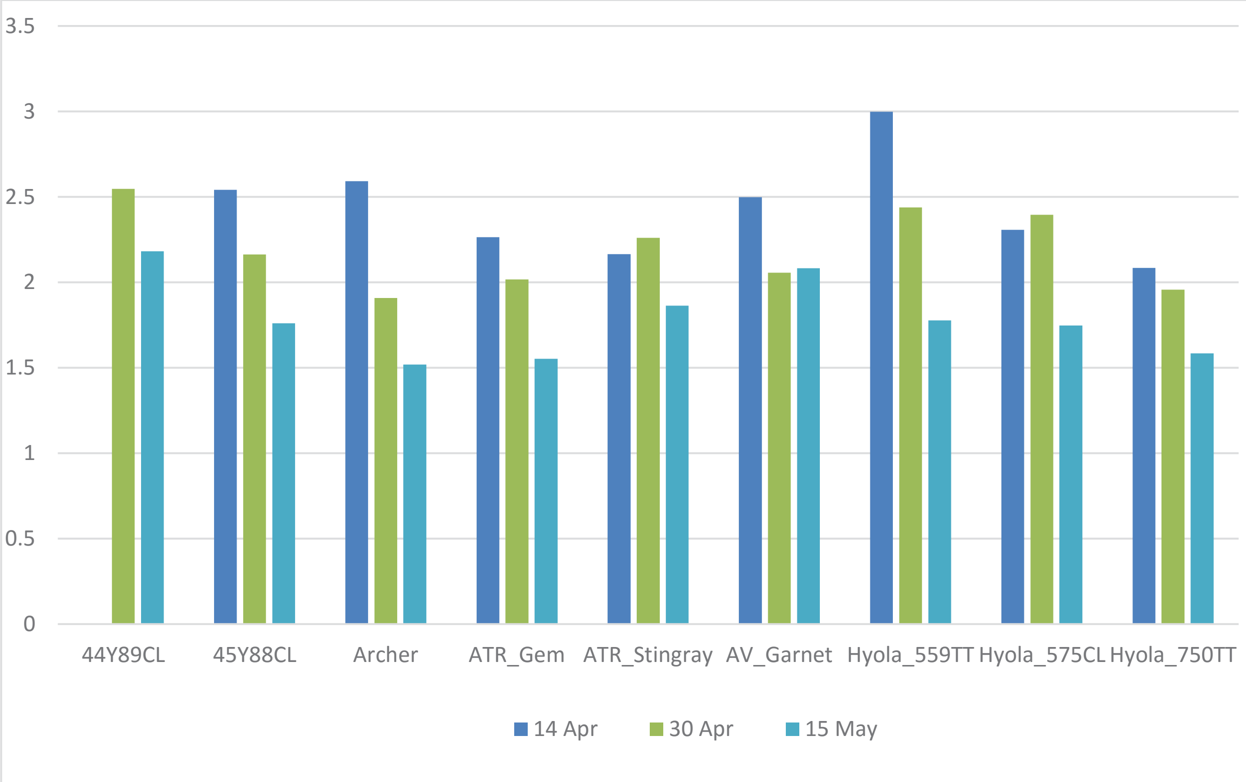

Figure 2: Hand harvest grain yields (t/ha) from Hart, 2015 (lsd P=0.05%: 0.31t/ha).

Summary / implications

Two years of field trial data at the Hart field site has shown early sowing can offer an opportunity to maximise canola yields and water use efficiency. Sowing early may also offer other benefits to the farming system by taking the pressure off of the peak sowing window for wheat. Selection of the correct variety is important for this to be realised. Varieties that have their development largely affected by cumulative temperature such as ATR Stingray and Hyola 575CL may not be suitable for planting in mid-April in the Hart environment. Early sowing of canola must take into consideration the risk of pests and diseases that it may have and these should be carefully managed.

Acknowledgements

This work is funded by GRDC Optimised Canola Agronomy Project: CPS00187

The Clare SARDI New Variety group, particularly John Nairn and Henk Venter for their assistance in managing the trial.

The Hart Field Site Group for hosting the trial.

Project leader: John Kirkegaard, CSIRO Agriculture, Canberra.

Optimising cultivar and time of sowing in wheat

Sarah Noack and Peter Hooper, Hart Field-Site Group
James Hunt, CSIRO Agriculture

Key Findings

- Despite damage from frosts, the highest wheat yield in this trial came from Trojan sown in late April at Hart.
- Based on two years of trial data across SA, Trojan complements Mace in a cropping program and allows growers to sow earlier and achieve higher yields (0.7 t/ha) than could be achieved with Mace alone.
- Across nine trials in SA (2014 and 2015) there was an average yield penalty of 28 kg/ha per day for every day sowing is delayed past the end of the first week of May.

Why do the trial?

The majority of our current wheat varieties need to be sown in the first half of May to flower during the optimal period for grain yield. Recent research in southern NSW has shown they have well adapted winter and slow maturing spring cultivars that when sown in mid-late April will out-yield fast maturing cultivars sown in May. However, the same cannot be said for SA where no cultivar x ToS options have been shown to out-yield Mace sown in its optimal window.

Currently options for growers in SA who wish to sow early are not well known. The aim of this trial was to investigate time of sowing for individual wheat cultivars with different maturities.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 2% Zn @ 100 kg/ha @ seeding
Seeding date	ToS 1 – 10th April ToS 2 – 30th April ToS 3 – 15th May		Urea @ 70 kg/ha split application @ GS30 and GS32 for each ToS

The trial was a split block design with three replicates, five bread wheat and one durum wheat cultivar (Table 1). Fungicides were applied as necessary to keep the crop canopy free of disease (ie. stripe rust). Crop growth stages were recorded between 12th of June and 8th of October to identify the flowering time for each treatment. All plots were assessed for grain yield, protein, test weight and screenings with a 2.0 mm screen.

Table 1. Wheat cultivars and their maturity used in this experiment

Variety	Maturity	Comments
Cobra	Fast maturing (moderate vernalisation, weak photoperiod)	High yielding AH quality variety similar maturity to Mace
EGA_Wedgetail	Mid-maturing winter (strong vernalisation, moderate photoperiod)	The early sowing and dual purpose standard in SNSW and an excellent grain-only option. May be too slow in most of SA, only has APW quality and can be quite intolerant of problems associated with alkaline soils (CCN, boron, aluminium)
Emu Rock	Very fast maturing (weak vernalisation, weak photoperiod)	High yielding AH quality variety suited to a broad range of environments in SA
Mace	Fast-maturing spring (moderate vernalisation, weak photoperiod)	No introduction necessary! SA main-season benchmark and in the trial as a control from a mid-late May sowing
Trojan	Mid-fast maturing spring (weak vernalisation, moderate photoperiod)	Has demonstrated good adaption to SA and has an unusual photoperiod gene which may allow it to be sown in late April and flower at the optimal period
DBA-Aurora		Released in 2014 this variety has shown a good disease resistance profile, improved grain size and grass weed competitiveness

Results and discussion

The area around Hart is not generally considered a frost prone district however, in both seasons of this trial frost damage has been evident in some treatments (variety and ToS dependent).

Trojan sown on 30th of April was the highest yielding treatment, out yielding Mace sown at the same time by 0.5 t/ha (Table 2). This result is similar to 2014 and reflects the results seen in a number of experiments across SA at Minnipa, Cummins, Pt Germein and Tarlee (Figure 1).

The optimal flowering time to maximise grain yield in the Hart area is considered to be mid-September. The optimal flowering time is a product of temperature, radiation, water availability and frost and heat risk. The highest yielding treatment Trojan sown at ToS 1 and ToS 2 was at mid-flowering or start of flowering growth stage, respectively at the optimal flowering time (Figure 2).

Cultivars Mace, Cobra and Emu Rock all yielded highest when sown on 30th April (ToS 2). At this ToS Mace and Cobra were mid-flowering at the optimal time (Figure 2). Emu Rock had almost finished flowering by the first week of September however, at the later ToS it was likely to have been impacted by heat stress in early October (>35°C for 3 days), reducing grain yield.

Slow maturing cultivars such as Wedgetail have shown poor adaptation across SA. In 2015 at Hart, Wedgetail sown early matched the yield of Mace sown in its optimal window. The growth stage assessments show Wedgetail sown on 10th April was able to reach flowering in mid-late September.

Protein did not vary across ToS however, there were significant differences between cultivars (Table 2). Similarly, there was no significant difference in test weight and all varieties were above 76 kg/hL the minimum required for maximum grade. Screening levels across the trial were generally low with all varieties below 5% (maximum level for maximum grade). Higher screening levels were measured in Emu Rock, which can be attribute to frost damage and also in DBA-Aurora.

Table 2. Grain yield and quality for all wheat varieties trialed at Hart, 2015.

	Yield (t/ha)			Protein (%)		
	10th April	30th April	15th May	10th April	30th April	15th May
Wedgetail	3.5	3.4	2.7	11.0	12.6	11.5
Trojan	3.7	4.0	3.4	10.0	10.3	11.0
Mace	2.9	3.5	3.5	11.2	9.8	10.1
DBA-Aurora	1.6	3.0	2.5	11.2	11.6	12.1
Emu Rock	3.1	3.4	3.1	12.6	11.7	11.9
Cobra	3.2	3.6	3.1	12.6	13.3	11.1
LSD (P≤0.005)	0.3			ns		
	Test weight (kg/hL)			Screenings (%)		
	10th April	30th April	15th May	10th April	30th April	15th May
Wedgetail	79.6	78.8	79.0	3.2	1.7	1.6
Trojan	79.3	80.1	78.6	2.0	2.0	3.5
Mace	79.3	80.0	80.4	1.3	1.6	2.6
DBA-Aurora	78.8	77.6	77.7	1.8	4.5	4.5
Emu Rock	78.3	79.8	78.2	4.8	4.5	2.4
Cobra	77.5	77.1	80.3	1.4	2.9	2.4
LSD (P≤0.005)	ns			1.6		

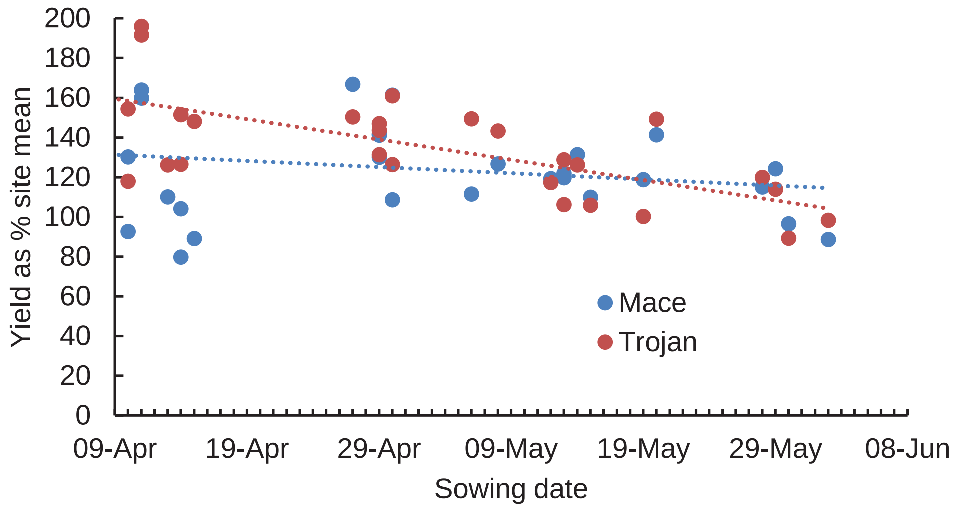

Figure 1. Mean yield (% of site mean) of Mace and Trojan at nine SA sites across 2014 and 2015 seasons (Minnipa 14 & 15, Cummins 14 & 15, Pt Germein 14 & 15, Hart 14 & 15, Tarlee 14). Linear regression for both Mace and Trojan are significant (P≤0.001) and are significantly different from each other in gradient (P=0.045) and intercept (P=0.025).

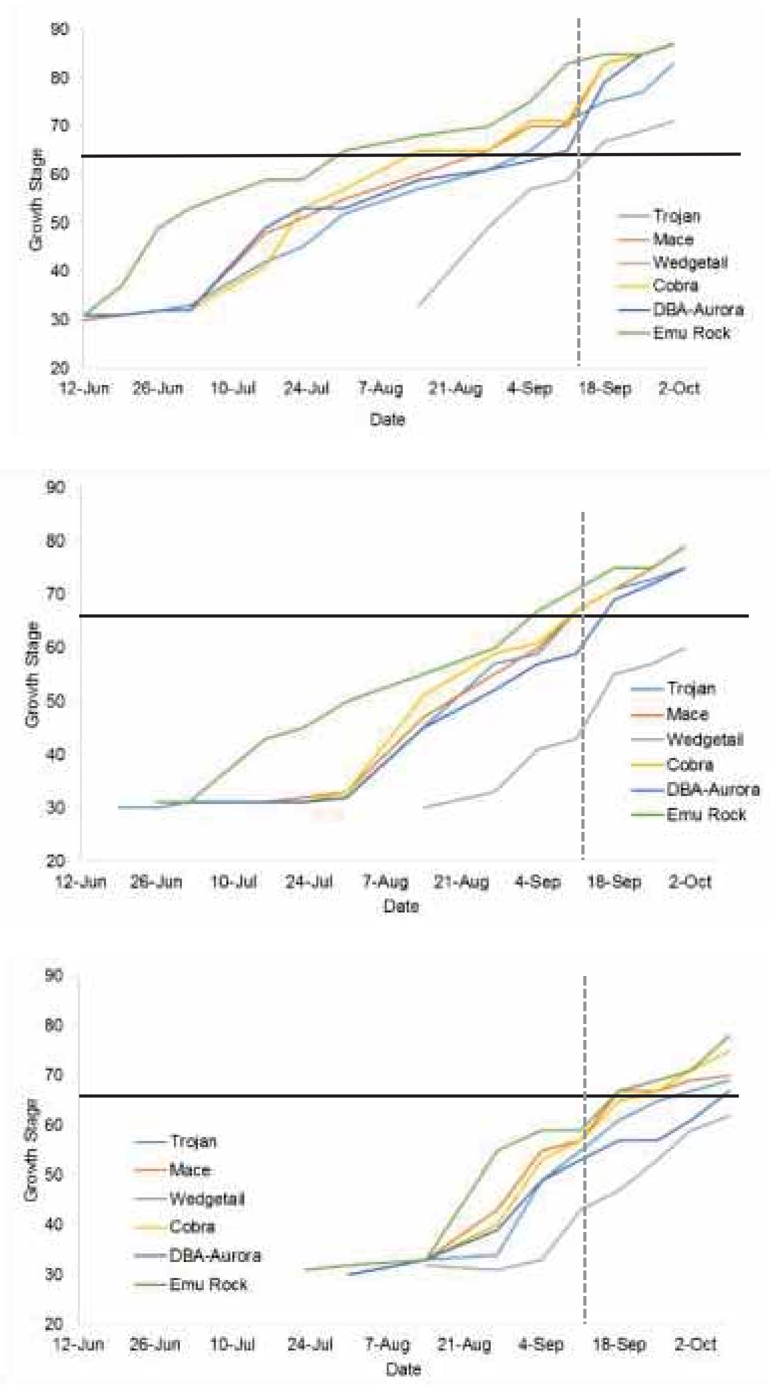

Figure 2. Growth stage assessment for all varieties and times of sowing 10th April (top), 30th April (middle) and 15th May (bottom) between 12th of June and 8th of October at Hart, 2015. The horizontal black line represents mid-flowering (GS65) and the vertical dashed line displays optimal flowering time (approximately 15th September).

Implications

Trials across multiple environments in SA over the past two years have shown that yields decline at a rate of 28 kg/ha per day once sowing extends past the end of the first week in May. In order to maximise average yields, growers should aim to finish seeding wheat by mid-May. Growers with longer wheat sowing programs will require multiple cultivars of different development types in order to allow them to start early enough. An example of how this might be achieved is presented in Table 3. In years with a late break where seed bed moisture isn't available to establish slow developing cultivars in their optimal window, yields will be maximised by dry sowing only a fast developing cultivar (e.g. Mace or equivalent) starting from the opening of its optimal window.

Table 3. An example of how slow developing cultivars and early sowing can be used to maximise farm wheat yield depending on the duration of wheat sowing program. In years where there is no seed bed moisture available and sowing starts 'dry', yield will be maximised by planting Mace (or equivalent fast developing cultivar) from 1 May onward.

Duration of wheat sowing program	Cultivars (or equivalent maturity types) required to maximise average yield	Sowing window if seed bed moisture available
10 days or less	Mace	5-15 May
10-20 days	Trojan, Mace	25 April-15 May
20-25 days	Cutlass, Trojan, Mace	20 April-15 May
25 days or more	Wedgetail, Cutlass, Trojan, Mace	10 April-15 May

Remember early sown crops require different management in order to get the most out of them;

- Don't dry-sow slow developing varieties (EGA Wedgetail, Cutlass), they will flower too late if not established early. There needs to be seed-bed moisture and ideally some stored soil water to get them through to winter.
- If growing winter wheat (EGA Wedgetail) and not grazing defer N inputs until after GS30, stem elongation.
- Pick clean paddocks – winter wheat is not competitive with ryegrass and common root diseases are exacerbated by early sowing.
- Protect against diseases associated with early sowing – barley yellow dwarf virus (imidicloprid on seed backed up with in-crop insecticides at the start of tillering if aphid pressure high), *Zymoseptoria tritici* in some areas (flutriafol on fertiliser and timely foliar epoxyconazole applications at GS30 & GS39). Many slow developing cultivars also have poor resistance to stripe rust (flutriafol on fertiliser and timely foliar fungicide application at GS39, flag leaf emerged).

Acknowledgements

The Hart Field-Site Group acknowledges the CSIRO contribution to this research funded by GRDC project CSP00178.

Variety and agronomic performance of faba beans in medium and high rainfall zones in SA

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[1]SARDI Clare, [2]University of Adelaide

Key findings

- Seasonal conditions had an overriding influence on crop performance and bean yields in 2015.
- Early sowing benefited yields in less favourable low/medium rainfall environments where biomass production was lower.
- Sowing densities above the recommended rates of 24 plants/m^2 led to high increases in biomass production at flowering time however, had no effect on final grain yield.
- Seed size was small in 2015, adjust seeding rates accordingly to maintain optimum plant populations for 2016.

Why do the trial?

The faba bean time of sowing trials form part of the five year project; 'DAV000113, Expanding the use of pulses in the southern region, 2010 -2015', a Southern Pulse Agronomy Project funded by GRDC and being implemented by SARDI in conjunction with DEDJTR Victoria and DPI NSW.

Early sowing of faba beans is a widely adopted strategy to establish crops early if rains are timely, potentially increasing yields. A frequent run of dry springs has also necessitated growers to adapt early sowing as a way of managing heat and moisture stress. Previous research by SARDI has however shown that early sowing is beneficial in the less favourable low/medium rainfall areas. In high rainfall areas the benefits from early sowing have been less definitive as early sown crops often result in high levels of vegetative growth, resulting in poor light penetration, flower retention and pod set along with increased disease pressure which may have adverse effect on yields.

The release of new faba bean varieties such as PBA Samira and PBA Zahra which have improved agronomic and disease traits offer opportunities for growers to have high and profitable yields in the high yielding environments. Our aim was to improve our understanding of faba bean varietal response to early time of sowing in both low/medium and high biomass production environments.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	MAP (10:22) + ZN 2% @ 100 kg/ha
Seeding date	*Hart* 14th April, 7th May, 27th May *Tarlee* 17th April, 7th May, 25th May		

Sowing date by variety trials were conducted at two sites: Hart and Tarlee, representing medium and high rainfall areas respectively. The trial was designed as a split plot randomised complete block design with sowing date as the main plot and faba bean varieties as the sub-plots replicated thrice. Six faba bean varieties, Farah, AF09167 (new early flowering line under evaluation), PBA Zahra (AF05095-1), PBA Rana, Nura, and PBA Samira were sown at the above three sowing dates at both sites.

A sowing density by timing trial using faba bean variety PBA Samira, was also conducted at Tarlee. The trial was similarly designed as a split plot, randomised complete block design with sowing date as the main plot and sowing densities as the sub-plots replicated thrice. PBA Samira was sown under six densities of 12, 16, 20, 24, 28 and 32 plants/m^2 at the three sowing timings above.

The faba beans were direct drilled with narrow points using a plot cone seeder on 22.5 cm (9 inches) row spacing at a depth of 5 cm. Early control to prevent disease establishment was maintained by applying, 145 ml/ha Tebuconazole + 2.3 L/ha Chlorothalonil during the vegetative stage, 2 L/ha Chlorothalonil + 500 ml/ha Carbendazim at pre flowering/canopy closure and further foliar fungicides were applied as required in line with district practice. A number of plant and seed measurements were undertaken at different stages including at; a) pre flowering- plant establishment, NDVI, b) flowering – day to first flower, plant height, biomass cuts, c) maturity & harvest – plant height, yield and d) post-harvest – seed weight (g/100 seed).

Results and discussion

Review of seasonal conditions, 2015

The growing seasonal rainfall (GSR) (April-October) of 228 mm at Hart and 329 mm at Tarlee was below the long term average GSR of 313 and 398 mm for the two respective sites. Above average winter rainfall in the early growing months favoured high crop establishment and vigour and presented conditions for crops to develop high biomass canopies during the latter part of winter. Little disease pressure occurred in the trials due to regular applications of foliar fungicides.

At both sites, varieties sown in mid-April flowered (day to first flower) during the middle of winter, while those sown during early-May and late-May flowered during late winter and early spring (Table 1). The time of flowering varied between varieties and across sowing dates however these differences remained consistent across the two sites. Farah and AF09167 were the earliest flowering varieties at each time of sowing, and flowered at similar dates (within 4 days of each other) and generally around 10 days in front of all other varieties. PBA Rana and Nura flowered at similar times and were often similar to PBA Samira. PBA Zahra flowered between PBA Rana/Nura and PBA Samira.

Crops received low spring rainfall and severe ‘heat shock’ in early October where maximum temperatures were in excess of 35^{o}C for several days, leading to a quick ‘hay off’ of the high biomass that had been set earlier in the season. The combination of high temperatures and low stored soil moisture during the critical reproductive period (late flowering and pod filling) had a huge impact on bean yields across many districts in SA.

Table 1. 50% flowering dates recorded for six faba bean varieties sown at three different dates at Hart and Tarlee, 2015.

	Time of sowing- Hart 2015			Time of sowing - Tarlee 2015		
Variety	**14-Apr**	**6-May**	**27-May**	**15-Apr**	**7-May**	**25-May**
Farah	3-Jul	4-Aug	25-Aug	9-Jul	10-Aug	28-Aug
AFO9167	7-Jul	2-Aug	28-Aug	9-Jul	10-Aug	28-Aug
PBA Zahra	14-Jul	12-Aug	5-Sep	20-Jul	18-Aug	4-Sep
PBA Rana	16-Jul	14-Aug	4-Sep	23-Jul	20-Aug	4-Sep
Nura	16-Jul	14-Aug	4-Sep	23-Jul	20-Aug	4-Sep
PBA Samira	20-Jul	14-Aug	5-Sep	23-Jul	20-Aug	8-Sep

Biomass production

Biomass production measured as dry matter weight (t/ha) was assessed early in the season at the day of first flower for each variety across sowing dates. The Tarlee trial produced the highest amounts of biomass ranging between 2.1 and 2.5 t/ha. There were only small differences in the amount of biomass produced at flowering across all varieties and sowing dates (Figure 1). The season at Tarlee presented better conditions enabling higher biomass levels compared to those at Hart. At Hart, early sown beans produced higher amounts of biomass compared to the two late sowings which produced similar amounts of biomass to each other.

Varieties differed in the amount of biomass production at the flowering stage but this depended on the site. PBA Zahra and PBA Samira produced similar or higher amounts of biomass compared to other varieties at Tarlee. The two early flowering varieties, Farah and AF09167 had low biomass levels at this site. At Hart however, AF09167, was associated with the highest biomass levels compared to all varieties which performed similarly (Figure 2).

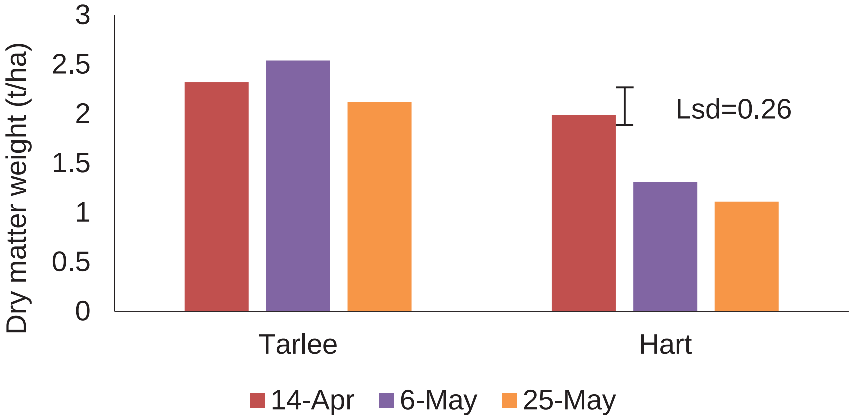

Figure 1. Dry matter production (t/ha) at commencement of flowering averaged across six faba bean varieties sown at three different sowing dates at Tarlee and Hart, 2015.

A sowing density by seeding time trial was also conducted at Tarlee with PBA Samira. In this trial seeding density had a significant effect on biomass production which increased as sowing density increased outside the currently recommended rate of 24 plants/m^2. An increase in sowing density from 24 to 32 plants/m^2 produced an extra 1 t/ha (Figure 2).

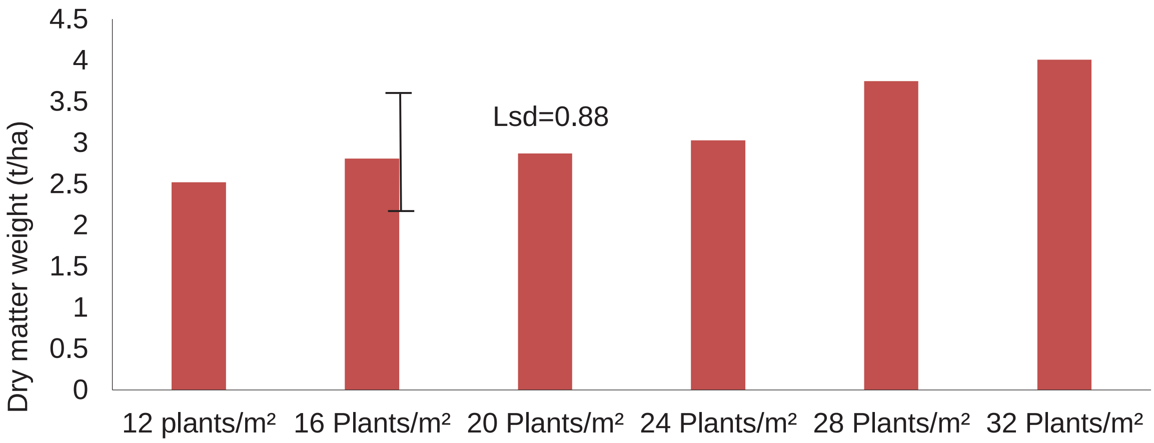

Figure 2. Dry matter production (t/ha) of PBA Samira at commencement of flowering under six different sowing densities (12-32 plants/m^2) averaged across three sowing timings at Tarlee, 2015.

Grain yield

Faba bean yields in many areas of SA in 2015 were lower than normal, despite the large biomass that had been set through the season. Sowing early in mid-April was beneficial at Hart compared to sowing in early-May with a further drop in yield in the latest sowing (Figure 3). However, at Tarlee the least benefit was achieved from sowing early compared to the two later sowings, which performed similarly to each other. It is worth noting that variable levels of pod loss occurred particularly at the early time of sowing at Tarlee due to strong wind events in late November which reduced grain yields to some extent.

Averaged across sites and sowing timings, the variety that was most responsive to early sowing in 2015 was the early flowering and maturing breeding line AF09167 (Table 2). This was followed by PBA Rana which also responded to early sowing. PBA Samira and PBA Zahra yielded similarly over the three sowing times and generally the same as Nura and Farah.

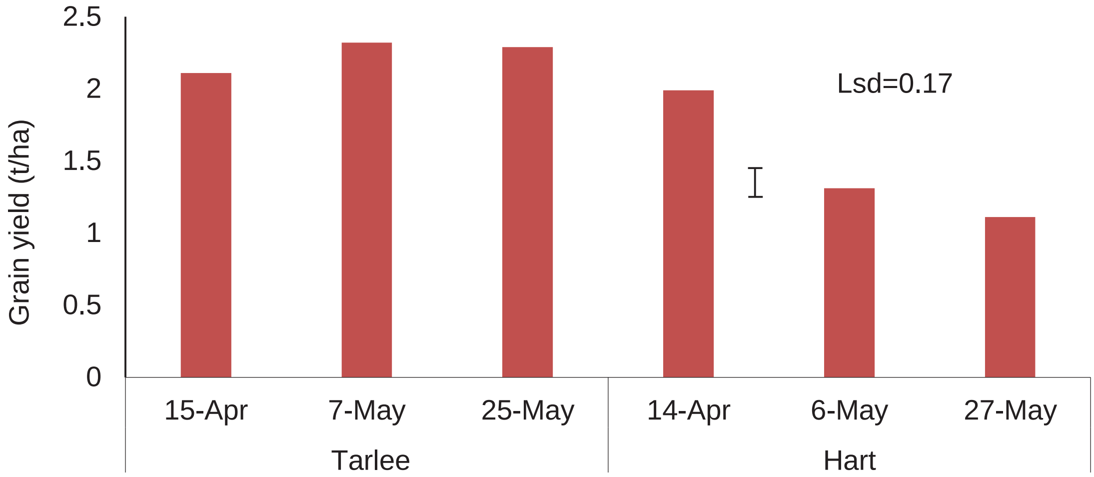

Figure 3. Grain yield (t/ha) averaged across six faba bean varieties sown at three different sowing dates at Tarlee and Hart, 2015.

Table 2. Grain yield (t/ha) of six faba bean varieties sown at three different timings at Hart and Tarlee in 2015.

	Time of sowing (ToS)		
Variety	ToS 1*	ToS 2*	ToS 3*
PBA Zahra	1.81	1.85	1.87
AF09167	2.74	1.95	1.62
Farah	2.05	1.86	1.75
Nura	1.84	1.90	1.70
PBA Rana	1.96	1.42	1.39
PBA Samira	1.92	1.90	1.89
LSD= 0.258			

* Hart TOS 1 = 14 April; TOS 2 = 06 May; TOS 3 = 27 May
* Tarlee TOS 1 = 15 April; TOS 2 = 17 May; TOS 3 = 25 May

Results from the sowing density by timing trial in PBA Samira at Tarlee found there was no grain yield response to any plant density treatment (12 – 32 plants per sq. m) across all three timings. This was despite the large differences in biomass production that had been found at flowering between the recommended 24 and 32 plants/m^2. Faba bean seed size achieved under the dry spring conditions of 2015 was considerably smaller (approximately 10%) when compared to the five year average in SA. Therefore, to achieve the recommended plant populations in 2016, seeding rates will need to be adjusted accordingly.

Summary / implications

Long term analysis (2006-2015) of faba bean sowing date trials has generally found a flat or no grain yield response to sowing date in higher rainfall areas such as Tarlee. However, within individual year's grain yield has shown positive, negative or no response to sowing timings and this has been variety responsive due to varying seasonal conditions and yield limiting factors. This pattern was reflected this season where early sown faba beans did not result in a yield increase over later sowing dates nor lead to a decrease in yields at Tarlee regardless of variety or plant density. The lack of response however, seems to be a more common occurrence in higher rainfall areas where biomass production is high and harvest index (grain yield to biomass ratio) is often significantly reduced when sown early.

There is a positive relationship between early sowing and yield in less favourable or moisture limited environments such as Hart and therefore this practice should be maintained to optimise yields. Long term faba bean yields (2008 – 2015) from National Variety Trial and Pulse Breeding Australia trial programs have shown that the two new varieties, PBA Zahra and PBA Samira have consistently produced higher yields compared to other varieties across SA. PBA Zahra, had a yield advantage of more than 5% over older varieties such as Fiesta VF, Farah, Nura and Fiord. PBA Samira was the second highest yielding variety yielding more than 5% over Nura. Although the yield potential of both varieties is more optimised in high yielding environments, their performance was comparable to other varieties under severe heat and moisture stress conditions experienced in 2015.The new line which is currently under evaluation, AF09167, was highly responsive to the early sowing across the two sites and could also offer opportunities for high yields under such tough finishing conditions.

Agronomic management such as varying sowing density did not have any effect on bean yield this season. In high rainfall environments, an increase in sowing density outside of the recommended 24 plants/m^2 led to an increase in biomass production at flowering and despite no effect on grain yield. This increase may be detrimental in years with more favourable finishes.

Acknowledgement

Funding for this work was provided through GRDC project DAV00113 and their support is greatly appreciated. We also acknowledge the support of research colleagues from SARDI team at Clare. Much gratitude also goes to the land owners/managers of the different farms where the trial sites were located.

Hart Field Day 2015

Rotational benefits following different field pea cultivars

Elizabeth Farquharson, Ross Ballard, Nigel Charman, SARDI

Key findings

- Canola growth and grain yield was better following PBA Percy, than after PBA Hayman or Kaspa.
- Pea shoots contained 23, 17 and 13 kg fixed N/t DM, for PBA Percy, Kaspa and PBA Hayman, respectively.
- PBA Percy produced less dry matter, but increased available soil N and used less water.
- Pea roots and nodules of PBA Hayman were estimated to have contributed 37 kg/ha to the available soil N pool of 107 kg/ha (0-60 cm soil depth) in the 6 month period following peas.

Why do the trial?

Field pea cultivars vary in their N_2-fixation. On average, fixed N in the above ground herbage (shoots) has been found to range from 78 kg/ha for Kaspa to 95 kg/ha for PBA Percy at maximum dry matter production (mid pod fill). This trial sought to improve our understanding of below ground nitrogen contributions in the year following peas and to what extent different pea cultivars affect the performance of the following crop (canola).

How was it done?

The trial was conducted over two years, where pea cultivars were grown in year 1 and the plots over sown with canola in year 2.

Year 1 (2014)

Plot size	1.4 m x 12 m	**Fertiliser**	80 kg/ha MAP (10:22) + 2% Zinc
Seeding date	28th May 2014		

The trial was arranged in split-plot design with three replications (Figure. 1). Main plot treatments were fallow or sown to one of the field pea cultivars; PBA Percy (hereafter Percy), Kaspa or PBA Hayman (hereafter Hayman) to achieve a seedling density of 50 plants/m^2. Peas were grown to maximum dry matter production (mid pod fill), then cut at ground level. Sub-plots comprised retention or removal of the above-ground material including all shoots and pods (hereafter referred to as shoots). Retained shoots (mimicking an unincorporated green manure) were pegged down on the surface of plots until April 2015.

Bay	Row	Cultivar	Treatment
1	1	Kaspa	Shoots Removed
	2	Kaspa	Shoots Retained
	3	Percy	Shoots Removed
	4	Percy	Shoots Retained
	5	Fallow	n/a
	6	Fallow	n/a
	7	Hayman	Shoots Removed
(a)	8	Hayman	Shoots Retained

Figure 1. (a) Schematic of the trial design for replicate 1 and (b) an example of plots following retention (left) or removal (right) of the pea shoots at maximum dry matter.

The fallow treatment was included to provide an estimate of background N mineralisation at the site.

- Shoot material was removed so that changes in available soil N in addition to those in the fallow treatment could be attributed to the roots and nodules remaining in the soil.
- Where shoots were retained on the plots we would expect mineralisation from both the roots and shoots to contribute to increased soil N levels.

Available soil N was measured in all treatments at depths 0-10 cm, 11-30 cm and 31-60 cm on 1st May and again for the Fallow and Hayman treatments on 28th November. Ten plant shoots were sampled from each plot at mid pod fill (27th Aug. for Percy, 14th Oct. for Kaspa and 28th Oct. for Hayman) and combined with earlier pea density measurements to estimate shoot dry matter (DM). Shoots were also used to determine N concentration (%N), proportion of N derived from fixation and total N_2 fixed.

Year 2 (2015)

Available soil N and soil moisture content was measured in all treatments at depths 0-10 cm, 11-30 cm and 31-60 cm on 16th April 2015.

Pea shoot residues that remained on 'retained' sub-plots were removed in April to avoid any confounding effects to the subsequent canola crop (e.g. pests and disease, sowing issues). The amount of dry matter, N concentration (%N) and total N content of the removed residues was determined. The trial was sown with 44Y89 canola on 15th May, with no addition of N fertiliser (only 100 kg/ha triple super phosphate at seeding). Growth of the canola crop was monitored through the season. Ten plants were removed from each plot near maximum dry matter production (13th August) and combined with earlier density measurements to estimate shoot dry matter (DM). Shoots were also used to determine % N and total N content. Plots were machine harvested on 16th November and seed yield determined.

Results and discussion

Year 1.

Percy was the fastest maturing cultivar and produced 4.5 t DM/ha up until maximum dry matter (max DM) when the shoots were cut at ground level (Figure. 2). This compared to 5.2 t DM/ha for Kaspa and 6.5 t DM/ha for Hayman. The shoot N concentration at max DM was significantly higher for Percy (2.46%) than for the other cultivars (2.1% for Kapsa and 1.55% Hayman). Percy also fixed a higher percentage of N (93%) than Kaspa (80%) and Hayman (85%). This resulted in the shoots containing 23, 17 and 13 kg fixed N/t DM, for Percy, Kaspa and Hayman, respectively.

Overall, total N in the above ground DM was not significantly different between cultivars, averaging 107 kg/ha.

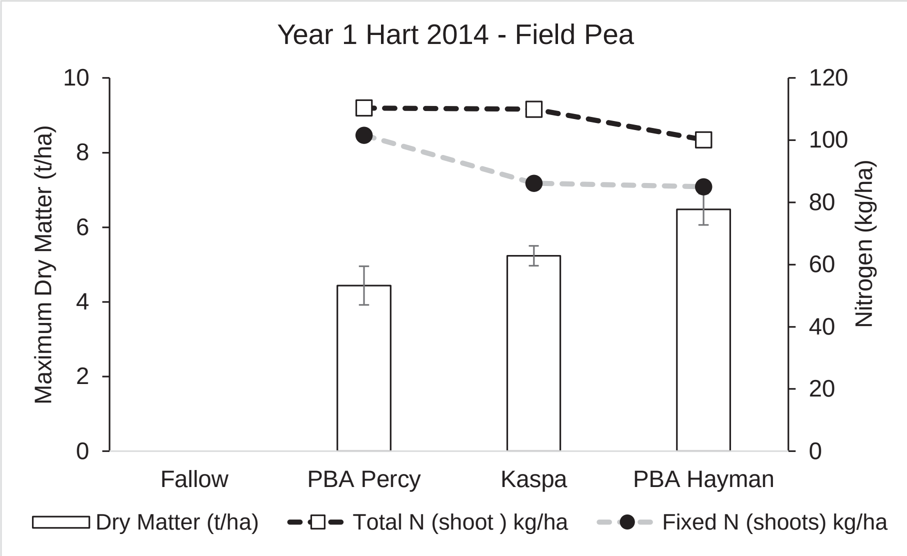

Figure 2. Above ground (shoots and pods) dry matter production, total N and total fixed N at mid pod fill of PBA Percy, Kaspa and PBA Hayman field pea grown at Hart in 2014.

Year 2.

Approximately half the pea residues in the retained treatments remained on the surface of sub-plots in April 2015. The amount of residue was similar for each of the cultivars and on average contained 53 kg N/ha (about half of what was produced in 2014).

Canola sown in the 2014 fallow treatment produced most DM, total crop N (shoots and pods) and seed yield (Figures. 3 & 4). There were significant differences following different pea cultivars. Canola after Percy produced more DM, total crop N and seed yield compared to the Kaspa and Hayman treatments. There were no significant differences between the DM removed and DM retained treatments.

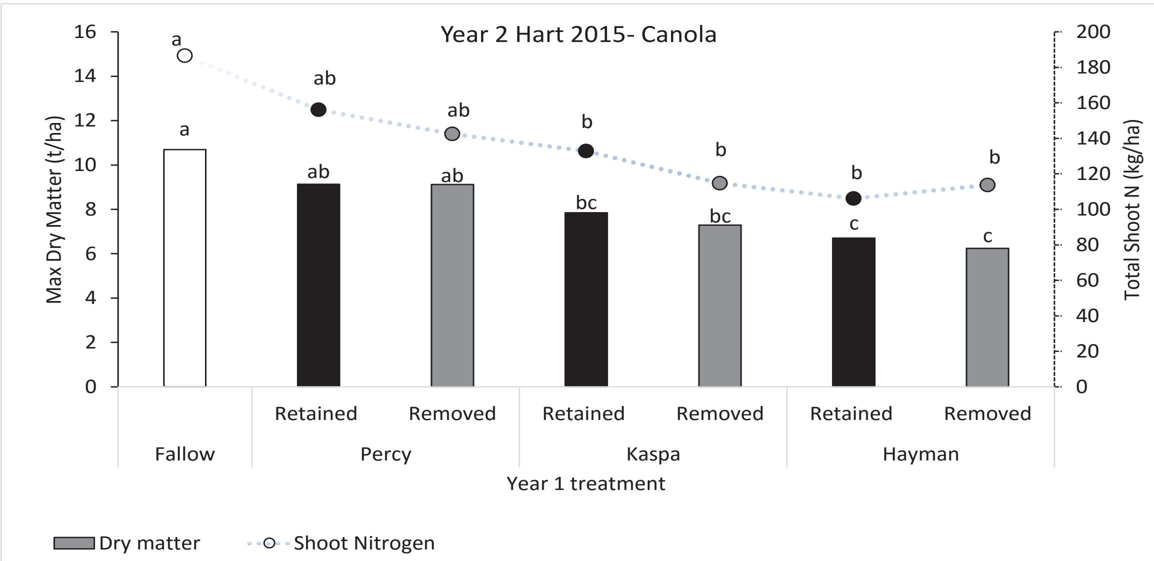

Figure 3. Max dry matter and total N (shoots and pods) of canola in 2015 following treatments from 2014 pea trial (fallow or retained vs removed dry matter of PBA Percy, Kaspa, PBA Hayman). Different letters between treatments (for each parameter) indicate mean values are significantly different (P<0.05).

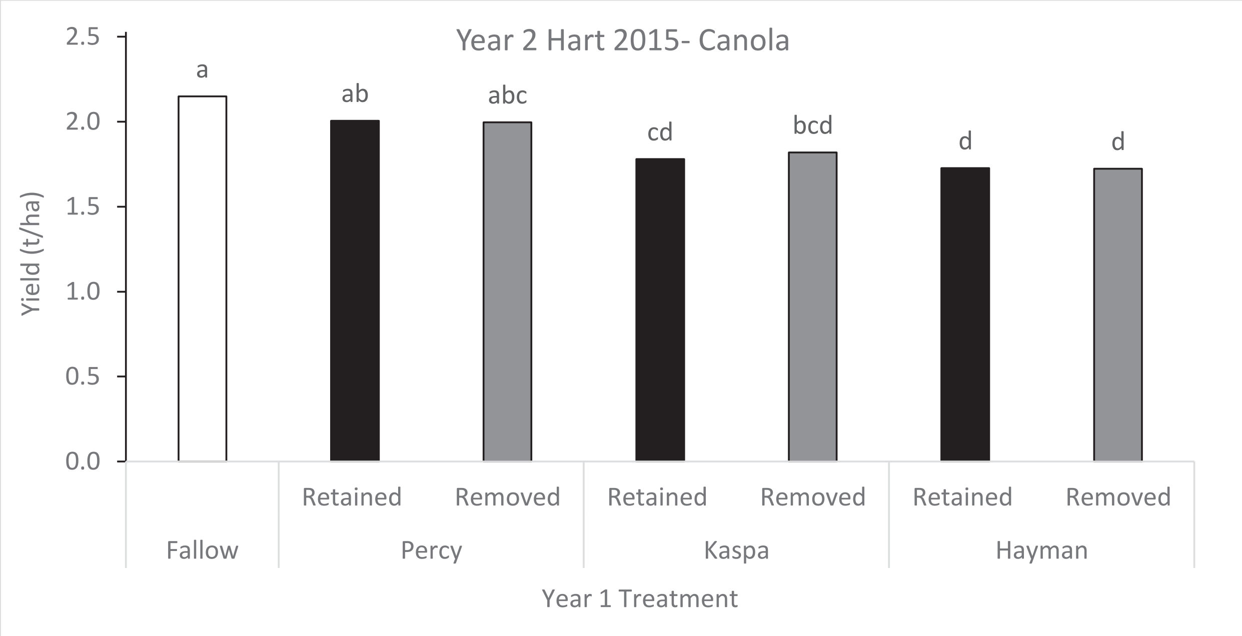

Figure 4. Seed yield of canola in 2015 following treatments from 2014 pea trial (fallow or retained vs removed dry matter of PBA Percy, Kaspa, PBA Hayman). Different letters between treatments (for each parameter) indicate mean values are significantly different (P<0.05).

Soil N and Water Budget

All trial plots had similar levels of available soil N before sowing peas, approximately 20 kg/ha in the 0-10 cm soil zone, 49 kg/ha (11-30 cm) and 62 kg/ha (31-60 cm), a total of 131 kg/ha (0-60 cm).

By the end of the 2014 growing season (November) available soil N (to 60 cm depth) had increased in the fallow treatments to 144 kg/ha, but decreased under Hayman to 61 kg/ha. Compared to N levels at the start of the season, this was an increase of 28 kg under fallow and a decrease of 68 kg/ha under Hayman. The peas had used some available soil N for growth.

At the start of the 2015 season (April) available N (to 60 cm depth) had increased marginally under fallow treatments (from 144 to 152 kg/ha) and to a greater extent (from 61 to 110 kg/ha) under the pea treatments. Where shoots had been retained on the plots there was 117 kg available N, compared to 104 where shoots were removed, but the mean values were not significantly different. Therefore, the average of the retained and removed treatments is presented from here on.

A more detailed examination of the plant available soil N (April 2015) with soil depth is shown in Figure 5. All pea treatments had a similar total available N in the top 0-10cm (30 kg N/ha), but less than the fallow, which had 49 kg/ha. Available N increased at 11-30 cm depth under all pea treatments, the greatest being under Percy (46 kg/ha) and least under Hayman (34 kg/ha). Fallow treatments again had the highest available N (56 kg/ha) at this depth. Fallow and Hayman had similar available N at the 31-60 cm depth (45 kg/ha), with slightly lower amounts under Percy and Kaspa (40 and 37 kg/ha respectively).

Over-summer mineralisation of the pea roots and nodules from PBA Hayman is estimated to have contributed 37 kg/ha to the available soil N pool (106 kg/ha, 0-60 cm) measured in April 2015.

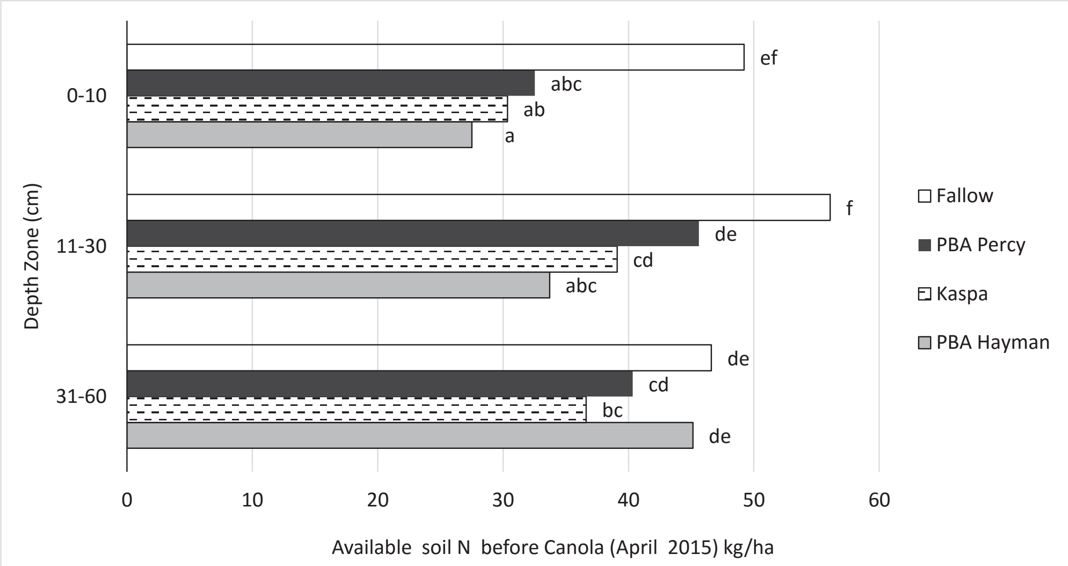

Figure 5. Available soil N before canola (April 2015) at three soil depths (0-10cm, 11-30 cm, 31-60cm) under treatments from 2014 pea trial (fallow, PBA Percy, Kaspa, PBA Hayman). Different letters between treatments (for each parameter) indicate mean values are significantly different (P<0.05).

Retaining or removing the pea shoots did not significantly affect plant available water (PAW) within the 0-60 cm soil zone, when estimated in April 2015 from gravimetric water content measurements (data not shown). However, there were significant effects of pea cultivar and fallow (Figure 6). Fallow treatments had more PAW in the 11-30 cm zone. Similarly, the deficit in PAW was lowest under fallow in the 31-60 cm zone. In this zone, the PAW deficit was also less under Percy than Hayman, probably because the Hayman grew for longer and extracted more water at depth.

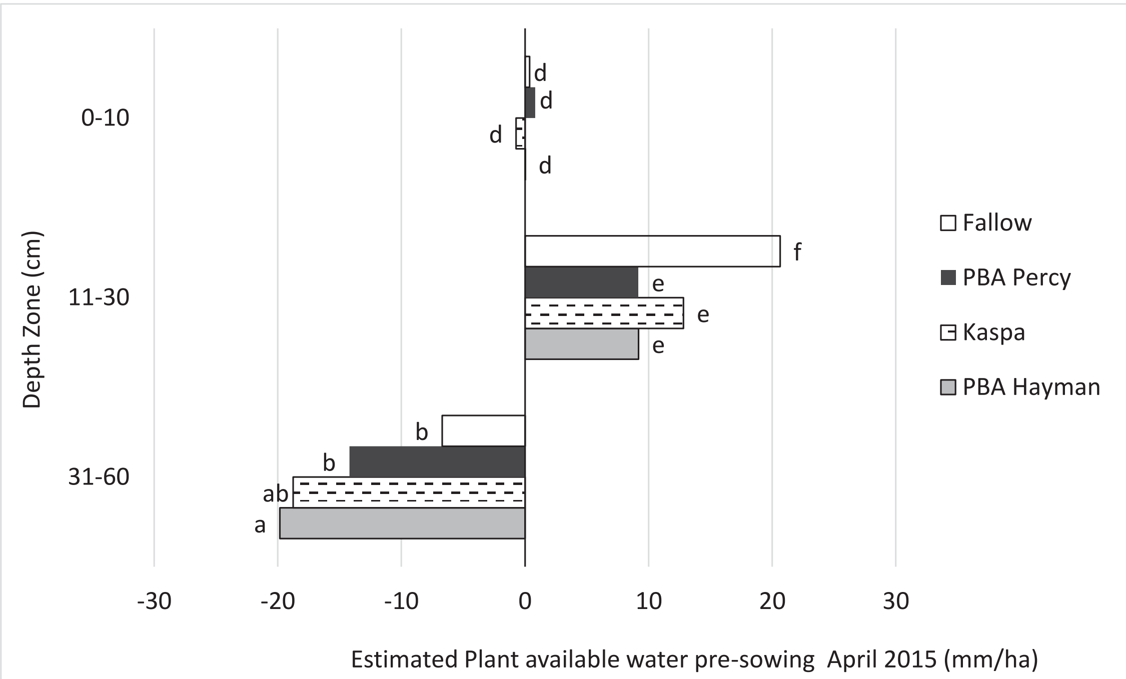

Figure 6. Estimated plant available water before sowing (April 2015) at three soil depths (0-10cm, 11-30 cm, 31-60cm) under treatments from 2014 pea trial (fallow, PBA Percy, Kaspa, PBA Hayman). Different letters between treatments (for each parameter) indicate mean values are significantly different (P<0.05).

Summary & implications

- Pea cultivars differed in their dry matter production, with Hayman greater than Kaspa which in turn was greater than Percy, at mid pod fill. However, because the cultivars with higher DM had lower shoot N concentrations, their overall accumulation of shoot N was similar.
- Cultivar had a small effect on the total amount of available soil N for the subsequent canola crop. Pea cultivar also had a significant effect on the distribution of N in the profile, with significantly more N available in the 11-30 cm zone following Percy (46 kg/ha) compared to Hayman (34 kg/ha).
- Over-summer mineralisation of the pea roots and nodules from Hayman is estimated to have contributed 37 kg/ha to the available soil N pool (107 kg/ha, 0-60cm) measured in April 2015.
- Where shoots had been retained on the plots, there was 117 kg/ha available soil N, compared to 104 where shoots were removed. Since about half the retained residues did not break down over summer, the full potential contribution from shoots was not realised. At least 53 kg of shoot N was not returned to the soil.
- Canola had the highest dry matter, above ground N and seed yield following the fallow treatment from year 1. This is almost certainly the result of the increased PAW and available soil N following the fallow.
- Canola dry matter and yield after pea was highest after Percy which used the least water and left the most available soil N.
- Additional N benefits from the peas are expected to accrue for at least another year, as N continues to be mineralised from pea residues remaining in the soil.

Acknowledgements

The trial was sown and managed by the New Variety Agronomy Group (SARDI, Clare). Funding was provided through GRDC project Optimising Nitrogen Fixation – Southern Region (DAS 00128).

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Getting The Crop In seminar 2015

Wheat yield and its components in response to early sowing and nitrogen fertiliser rate

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Key findings

- Early sowing increased grain yields in all of the wheat varieties trialed, however, the size of the increase was dependent on the variety.
- Nitrogen application increased grain yield in the early sown treatments and increased grain protein especially in late sown crops.

Why do the trial?

Nitrogen (N) management remains one of the most important and risky decisions for farmers in South Australia. Decisions need to be made about both the timing and the quantity of N fertiliser. New practices such as early sowing and the use of new wheat varieties are likely to alter crops N fertiliser needs and farmers will need to adjust their N management accordingly.

Early sowing is receiving more attention as it has the potential to increase yields in years and locations with low frost risk. Nitrogen management has to be adjusted to capture the higher yield potential and maintain grain protein of early-sown crops. Porker and Wheeler (2014) found that in some barley varieties, if sown early, delaying N application could increase protein content without yield penalty. However, if sown later, delayed N application still increased protein but also resulted in a significant yield penalty. For other varieties they found that earlier N application was preferred. These findings suggest that nitrogen management has to account for both sowing time and variety. Therefore, there is an emergent need to refine N management for specific wheat varieties and in relation to sowing time to maximise yield, grain protein, N use efficiency and thus reduce financial risk.

The results presented here are part of a larger three year GRDC project to develop a benchmark (a nitrogen dilution curve) which will be used to accurately determine crops' N status. Our final aim of this trial is to determine how a crops' N status changes in relation to early sowing and variety. At time of this publication, the nitrogen dilution curve which is needed to determine crop N status is still under development. However, we present our preliminary results of the effects of sowing time, N application and variety on biomass, yield and yield components.

How was it done?

Plot size:	1.75 m x 10.0 m
Seeding dates:	30th of April and 26th of May 2015
Seeding rate:	210 plants / m2
Fertiliser (urea N):	0 kg N/ha 60 kg N/ha split between seeding and beginning of tillering (GS20)
Initial mineral soil N:	30th of April: 89 kg N/ha
(0-100 cm soil layer)	26th of May: 123 kg N/ha
Wheat varieties:	Mace, Axe, Scout, Trojan, Spitfire and Cobra.

Methods

The trial had a randomised block design with 2 sowing dates, 6 wheat varieties, 2 N rates and 3 replicates. Soil samples were taken the day before, or on the day of sowing for each sowing date. Soil was sampled up to 1 metre deep in 20 cm layers and analysed for initial soil moisture and N content.

Biomass was sampled in two rows of 50 cm at anthesis and 2 rows of 1 metre at maturity. The biomass was oven dried at 60°C and weighed. The samples taken at anthesis were analysed for total shoot N. The samples taken at maturity were separated into ears and remaining shoot. The remaining shoot was analysed for N content and the ears were used for determination of yield and yield components: 1000-grain weight, number of ears per m2, harvest index (i.e. grain weight / total biomass), screenings and protein content.

Effects of variety, sowing date and N fertiliser rate on biomass, yield and yield components was statistically tested using three-way-ANOVA at a 5% significance level.

Results and Discussion

Grain yield and protein

Grain yield was affected by variety, sowing time and N application, with some interactive effects (Figure 1). Yield differed among varieties, with lowest yields for Axe and Spitfire (2.4 t/ha average of all treatments) and highest yields for Trojan (3.1 t/ha), Mace and Scout (2.9 t/ha).

Overall, early sowing increased yield, however the increase was larger for some varieties than others. For example, Trojan and Spitfire (under the 60 kg N/ha treatment) increased by 1.6 and 1.0 t/ha respectively, while Axe and Mace only increased yield by 0.2 and 0.3 t/ha respectively under the same N fertiliser rate. This can partly be attributed to the difference in cultivar maturities. Axe (early maturing) and Mace (mid - early maturing) are both earlier maturing than Trojan and Spitfire which are mid - long season maturing varieties and can thus make use of a longer season, especially when sown early.

Nitrogen application only increased yields in the early sowing treatment (Figure 1). In the late sowing treatment, N application did not increase yield. In contrast, grain protein increased with N fertiliser, but the increase was larger in the late sown treatment (3.9%, averaged for all varieties) than in the early sown treatment (1.4%, Figure 2).

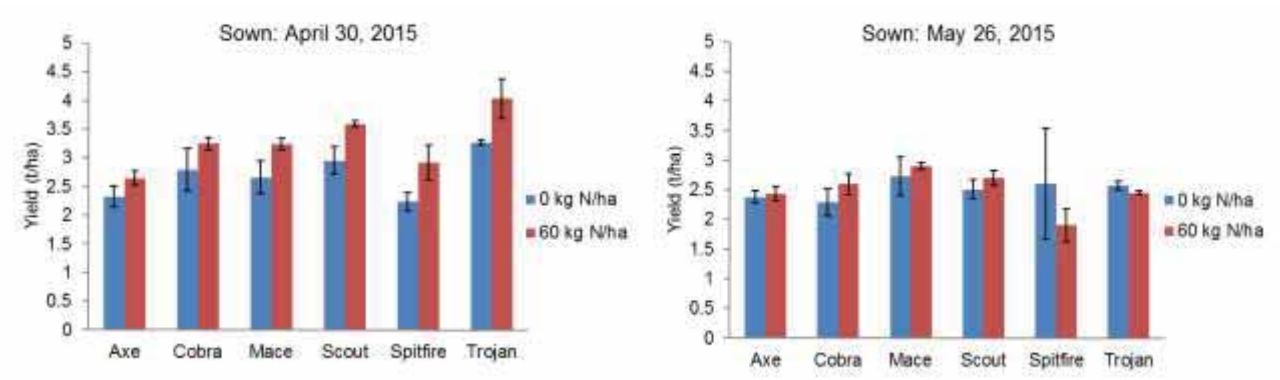

Figure 1. Effect of N fertiliser on yield for early (April 30) and late (May 26) sowing. Error bars represent 2 standard errors.

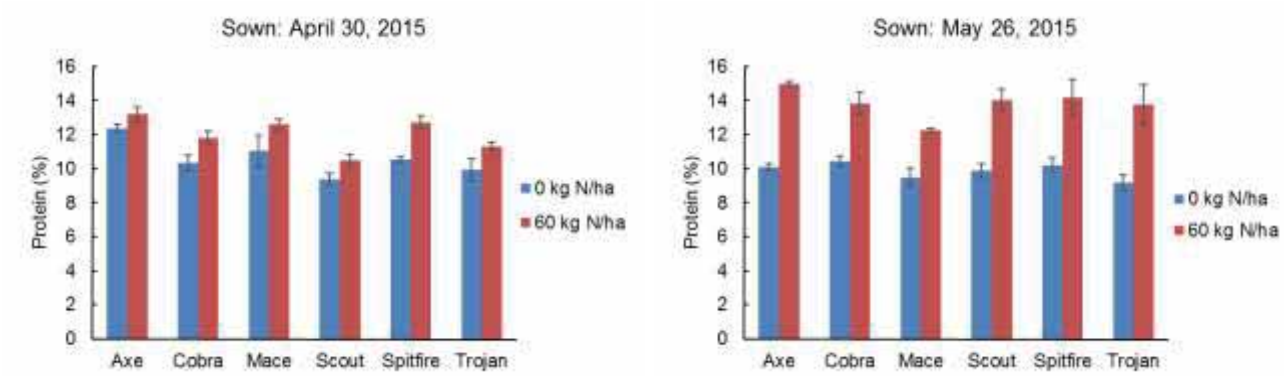

Figure 2. Effect of N fertiliser on grain protein for early (April 30) and late (May 26) sowing. Error bars represent 2 standard errors.

Yield components

Biomass and the number of ears per m^2 (i.e. tillering) increased with N fertiliser at both early and late sowing times. However, 1000-grain weight decreased and screenings increased with N fertiliser in late-sown crops (Table 1). In other words, N fertiliser increased the number of ears per m^2, but in the late sown crop, because of the shorter growing season, there was likely not enough time to fill the additional grain, resulting in higher screenings, lower 1000-grain weight and no yield increase. The smaller grain size in the late sown, 60 N treatment, increased the concentration of protein in the grain, which is commonly observed.

Table 1. Biomass at anthesis, harvest index, screenings, 1000-grain weight and number of ears per m^2, per sowing time and N treatment.

	Biomass at anthesis (t/ha)		Harvest Index		Screenings (%)		1000 grain weight (g)		# ears /m^2	
Early sowing										
	0 N*	**60 N**	**0 N**	**60 N**	**0 N**	**60 N**	**0 N**	**60 N**	**0 N**	**60 N**
Axe	4.34^{a}	5.28	0.38^{c}	0.40^{ab}	0.20	0.44	38.49^{b}	37.34	248	281
Cobra	4.47^{a}	5.06	0.43^{abc}	0.46^{a}	0.18	0.53	40.77^{ab}	36.99	223	276
Mace	4.61^{a}	4.96	0.40^{abc}	0.40^{ab}	0.11	0.28	42.49^{a}	40.90	231	288
Scout	4.00^{a}	5.25	0.44^{ab}	0.46^{ab}	0.10	0.20	41.71^{ab}	39.77	246	276
Spitfire	3.11^{b}	4.89	0.39^{bc}	0.38^{b}	0.17	0.66	43.97^{a}	41.36	230	305
Trojan	4.58^{a}	5.48	0.45^{a}	0.46^{a}	0.06	0.77	42.89^{a}	37.79	268	304
Late sowing										
	0 N	**60 N**	**0 N**	**60 N**	**0 N**	**60 N**	**0 N**	**60 N**	**0 N**	**60 N**
Axe	3.42	4.84^{ab}	0.43	0.39^{ab}	0.33	4.92	36.66^{a}	28.81^{ab}	252	305
Cobra	4.05	5.50^{ab}	0.44	0.39^{ab}	0.91	13.83	31.17^{b}	25.69^{b}	219	285
Mace	4.19	5.52^{a}	0.45	0.42^{a}	3.37	24.30	34.28^{ab}	28.11^{ab}	221	268
Scout	4.95	5.75^{a}	0.40	0.38^{ab}	10.29	19.74	33.84^{ab}	26.74^{ab}	247	271
Spitfire	3.51	4.38^{b}	0.51	0.32^{b}	3.91	17.51	36.69^{a}	30.65^{a}	229	293
Trojan	3.71	5.76^{a}	0.42	0.38^{ab}	0.31	14.76	36.49^{ab}	29.10^{ab}	212	262

*N rate in kg N/ha

Conclusions

In general, for the varieties trialed, early sowing (in absence of frost) increased grain yield. Nitrogen application increased the number of ears per m^2. In the early sowing treatment, this resulted in significantly higher yields compared with the 0 N treatment. However, in the late sown treatment, the season was too short to fill all grains which resulted in no yield increase, higher screenings, lower 1000-grain weight and higher grain protein, compared with the 0 N treatment.

Acknowledgements

The authors thank GRDC for project funding (project DAS00147) and Hart staff for managing the trial.

References

Porker and Wheeler (2014) *Getting the best from barley agronomy*. GRDC Update papers 2014: https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Getting-the-best-from-barley-agronomy-and-management.

Special guest speaker, Dr Heather Bray delivers her lunch time address at the 2015 Hart Field Day

Management strategies for improved productivity and reduced nitrous oxide emissions

Sarah Noack and Peter Hooper, Hart Field-Site Group
Nick Poole, Michael Straight and Tracey Wylie, Foundation for Arable Research Australia
Sam Trengove and Stuart Sherriff, Precision Agriculture Australia

Key findings

- The nitrogen application strategy that maximised grain yield was not always the same strategy to minimise nitrous oxide (N_2O) emissions.
- While nitrogen applied at GS31 maximised wheat yield following field pea it produced 10 times higher emissions compared to the same application at seeding.
- The pattern and concentration of N_2O emissions were similar for wheat following field pea or canola.

Why do the trial?

Nitrous oxide (N_2O) is a greenhouse gas, primarily produced from agricultural activities such as fertilisation and breakdown of livestock waste. Recent research has shown there are a range of reduction strategies that may benefit growers both environmentally and economically. The objectives of this trial were to measure and demonstrate on-farm strategies that can reduce nitrous oxide by trialling four key practices:

- Use of legumes in the cropping rotation.
- Application of nitrogen fertiliser at key stem elongation growth stages.
- The use of precision farming tools to better measure N mineralisation.
- Use of nitrification inhibitors.

Soils also release dinitrogen (N_2) gas through denitrification however, we cannot measure this as dinitrogen is naturally occurring in the Earth's atmosphere. There is a strong relationship between nitrous oxide emissions and denitrification. In general dinitrogen releases can be 20-30 times greater than N lost from nitrous oxide, though the exact relationship between the two gases depends on the soil water content.

How was it done?

Plot size	9.0 m x 16.5 m	**Fertiliser**	Urea/DAP (22:15) @ 81 kg /ha at seeding (18 kg N/ha). All in-season N applications as specified by treatments below.
Seeding date	3rd May 2015		
Crop	Mace wheat		

The trial was a factorial design with four replicates, two previous crop histories (canola or field pea) and six nitrogen treatments. In 2014 the canola and field pea blocks were sown adjacent to each other on similar soil and using identical management (with the exception of N).

In 2015 the trial was sown with Mace wheat. Six nitrogen treatments were applied as incorporated by sowing (IBS) on 3rd May, start of stem elongation (GS30) on 9th July, first node (GS31) on 16th July, second node (GS32) on 31st July or mid-booting (GS45) on 28th August as follows;

1) Nil nitrogen applied
2) 40 kg N/ha applied as urea at first node (GS31) of the wheat crop
3) 80 kg N/ha applied as urea at first node (GS31) of the wheat crop
4) 80 kg N/ha as urea IBS
5) 80 kg N/ha applied as Entec urea (nitrification inhibitor) at first node (GS31) of the wheat crop
6) Real Time Tactical Treatment - determined using a Greenseeker® to measure crop canopy greenness. The rate for the ex-canola ground was 53 kg N/ha as urea split across GS30, GS32 and GS45. The rate for the ex-field pea ground was 43 kg N/ha as urea split across GS32 and GS45.

Soil assessments
A number of measurements were taken throughout the season including nitrous oxide monitoring in treatments 1 (nil), 3 (80 kg N/ha at GS31) and 4 (80 kg N/ha IBS). Sampling occurred once per week during the growing season and twice per week after seeding and the GS31 nitrogen applications for three weeks. Soil nitrogen was assessed in the canola and field pea blocks prior to seeding (16th April) and in-season at GS32 (20th July) at depths 0-30 cm and 30-60 cm.

Crop structure assessments
Fixed marker points were used for crop structure assessments, 2 markers x 1 m each side per plot. Plant establishment, tiller and head number were all assessed at these fixed marker points. Dry matter and nitrogen content were sampled at GS30 and GS31 for treatments 1 and 4 only and GS32, GS39, GS65 and GS99 for all treatments. Two metres of row were collected at two points in each plot, weighed, subsampled, oven dried at 60°C for 72 hours and dry matter (t/ha) calculated.

Grain yield and quality
The trial was harvested on the 2nd December 2015. All plots were assessed for grain yield, protein, test weight and screenings (<2.0 mm screen).

Results and discussion

Soil nitrogen status
Prior to seeding the block following field pea contained 10 kg of available soil N/ha more compared to the block following canola (Table 1). The use of legume crops such as field peas generally leave higher residual levels of soil nitrogen and the expectation was the legume ground will release more available nitrogen in-season and require less nitrogen fertiliser compared to the canola treatments.

In-season the nil and 80 kg N/ha applied IBS treatment were assessed for available soil nitrogen. For the plots following canola, the soil nitrogen reserves had been run down to 7 kg N/ha where nil was applied, compared to 26 kg N/ha where 80 kg N/ha had been applied at seeding (Table 1). In contrast to this the plots following legume for both the nil and 80 kg N/ha both contained 25 kg N/ha, indicating the ability of the nil legume treatment to mineralise more nitrogen in season compared to the canola treatment.

Table 1. Available soil nitrogen (kg N/ha) for ex-field pea and ex-canola ground sampled pre-seeding (16 April) and in-season (20th July), 2015.

Previous crop	Sampling depth (cm)	Pre-seeding	In-season	
		Nil N	Nil N	80 kg N/ha IBS
		Available soil N kg/ha		
Field pea	0-30	27.8	13.7	9.8
	30-60	10.5	10.6	15.4
	Total	**38.4**	**24.3**	**25.2**
Canola	0-30	22.0	1.1	20.7
	30-60	7.6	6.1	4.8
	Total	**29.5**	**7.2**	**25.5**

Crop structure

Plant establishment and tiller number were similar for wheat following field pea or canola, averaging 173 plants/m^2 and 305 tillers/m^2 (Figure 1). In 2014 however, all crop structure assessments were higher for wheat following a legume. Head number was also similar for wheat following field pea and canola at 241 and 231 heads/m^2, respectively. This is not surprising given the difference in yield potential between the seasons with 70 mm less growing season rainfall (25% of long-term average) in 2015.

There was no difference in plant population, tiller number or head number for any of the nitrogen rates and application timings. This result is similar to those obtained in 2014.

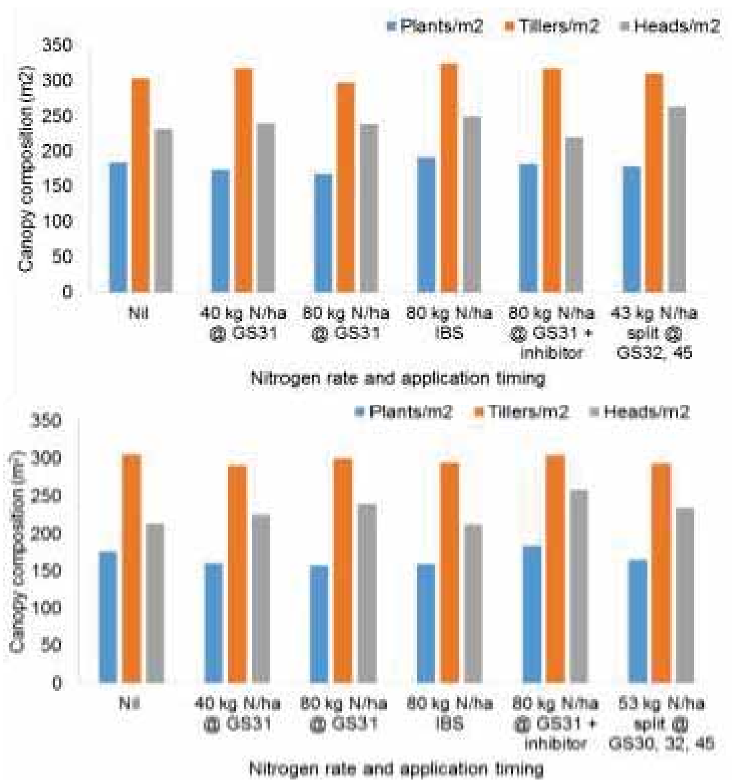

Figure 1. Plant, tiller and final head number/m^2 for Mace wheat following field pea (top) and canola (bottom) for all nitrogen treatments. No significant difference in nitrogen rate or application timing for any canopy structure assessments.

Dry matter production for all nitrogen rates and applications were similar across all sampling dates (data not shown). Nitrogen uptake in the wheat crop was consistent across all N rates and application timings (Table 2). By mid-flowering (GS65) nitrogen uptake was higher where rates of 80 kg N/ha were applied for wheat after canola.

Grain yield and quality

The highest yields in wheat following canola or field peas were measured where 80 kg N/ha was applied at GS31 with or without a nitrification inhibitor and the tactical N treatments (Table 3). In addition to this for the wheat following field peas the 40 kg N/ha applied at GS31 was also high yielding, however protein content was lower compared with the higher nitrogen rates. Application of 80 kg N/ha at seeding was also high yielding however, protein levels were lower. These results are consistent with previous nitrogen research trials which have shown applications of nitrogen prior to stem elongation can be seen as building the foundation of yield and have little or no effect on protein. Later applications can be used to maintain or increase protein, but have little effect on yield.

There was no difference in test weight or 1000 grain weight (data not shown, the average for wheat following canola 34.2 and field pea 38.9 g/1000 grains) for any of the nitrogen rates or application timings (Table 3). Small differences were measured in screenings, however the majority of the treatments were below 5% (requirement for maximum grade).

Table 2. Wheat nitrogen uptake in biomass (kg N/ha) following field pea or canola at various growth stages. Where present, different letters denote significant differences (P≤0.05) within the same timing and previous crop.

Previous crop	Treatment	GS30	GS32	GS39	GS65	GS99
		kg N/ha				
Canola	Nil	21	29	44	46[c]	92
	40 kg N/ha @ GS31	24	33	47	61[bc]	73
	80 kg N/ha @ GS31		38	44	75[ab]	115
	80 kg N/ha IBS		34	52	66[ab]	95
	80 kg N/ha @ GS31 + inhibitor		37	54	84[a]	106
	53 kg N/ha split @ GS30, 32, 45		31	50	63[bc]	103
	LSD (P≤0.05)	ns	ns	ns	20	ns
Field pea	Nil	40	52	66	83	61
	40 kg N/ha @ GS31	42	48	73	86	67
	80 kg N/ha @ GS31		50	79	104	77
	80 kg N/ha IBS		53	80	91	66
	80 kg N/ha @ GS31 + inhibitor		51	78	94	96
	43 kg N/ha split @ GS32, 45		51	76	98	71
	LSD (P≤0.05)	ns	ns	ns	ns	ns

Table 3. Summary of grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) for Mace wheat sown following field pea and canola for all nitrogen rates. Where present, different letters denote significant differences (P≤0.05) within the same timing and previous crop.

Previous crop	Nitrogen rate	Grain yield t/ha	Protein %	Test weight kg/hL	Screenings %
Canola	Nil	2.76^{c}	11.6^{c}	77.4	2.1^{c}
	40 kg @ GS31	3.05^{b}	12.2^{bc}	76.6	3.2^{bc}
	80 kg @ GS31	3.10^{ab}	13.2^{ab}	74.1	4.8^{ab}
	80 kg @ IBS	3.05^{b}	12.3^{bc}	77.2	2.9^{bc}
	80 kg @ GS31 + inhibitor	3.30^{a}	13.6^{a}	74.6	5.8^{a}
	53 kg split @ GS30, 32, 45	3.19^{ab}	12.4^{abc}	75.8	3.8^{bc}
	LSD (P≤0.05)	0.24	1.25	ns	2.0
Field pea	Nil	3.85^{c}	11.4^{c}	79.7	1.3
	40 kg @ GS31	4.31^{ab}	12.1^{b}	78.7	1.8
	80 kg @ GS31	4.40^{a}	13.0^{a}	78.0	1.8
	80 kg @ IBS	4.15^{b}	12.4^{ab}	79.5	1.4
	80 kg @ GS31 + inhibitor	4.21^{ab}	13.0^{a}	78.9	1.7
	43 kg split @ GS32, 45	4.13^{b}	12.8^{a}	78.9	1.4
	LSD (P≤0.05)	0.25	0.62	ns	ns

Nitrous oxide emissions

Nitrous oxide emissions were 10-30 times higher when nitrogen was applied at GS31 compared to seeding (Table 4, Figure 2). Applying nitrogen at seeding did not result in emission values higher than the background soil level (nil). This is in contrast to 2014 where highest emissions were observed from nitrogen applications at seeding. The difference in emissions between the two seasons can be attributed to the distribution and amount of growing season rainfall and soil conditions (eg moisture and temperature).

Previous crop	Treatment	g N_2O-N/ ha/ season
Canola	Nil	201
	80 kg/ha GS31	3071
	80 kg/ha IBS	178
Field pea	Nil	103
	80 kg/ha GS31	3300
	80 kg/ha IBS	378

Table 4. Total nitrous oxide emissions (May 4th – December 2nd) for nil, 80 kg N/ha IBS or applied at GS31 for wheat sown after field pea and canola at Hart, 2015.

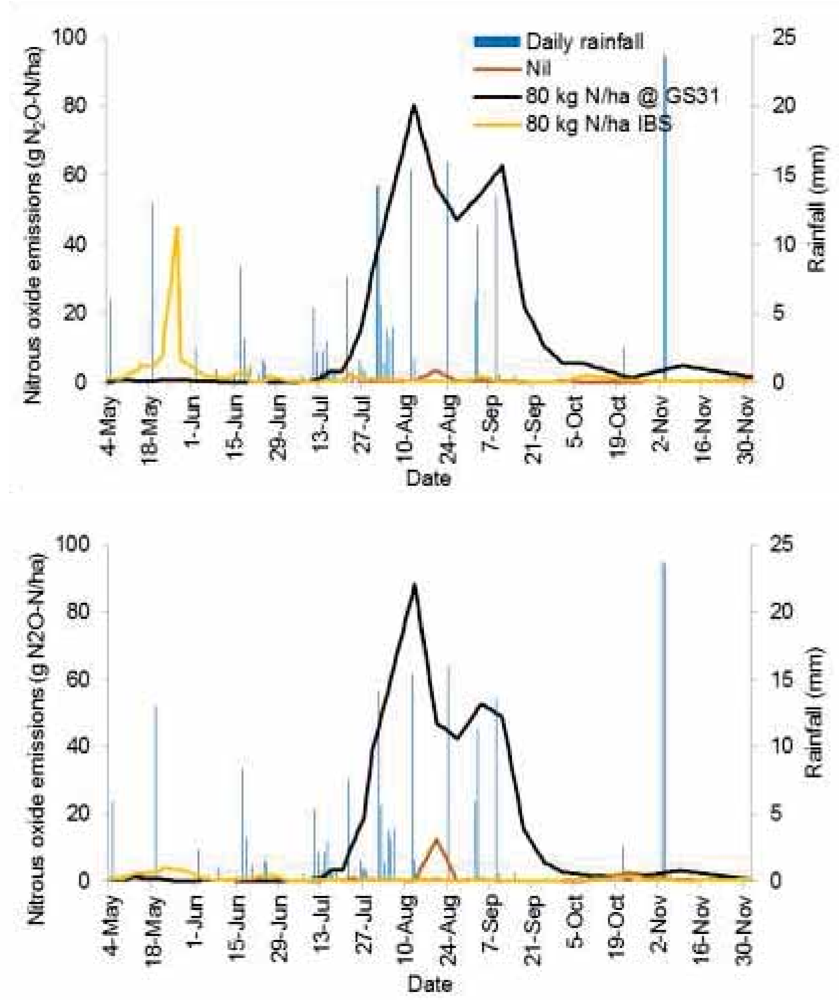

Figure 2. Nitrous oxide emissions (g N_20/ha) for the period of 4th May – 2nd December for nitrogen fertiliser × crop history treatments for wheat following (left) field pea and (right) canola at Hart, 2015.

The 2015 season at Hart, started with an opening break of 60 mm in April followed by below average rainfall in May, June and July totalling 68 mm (Figure 2). In this same period in 2014 the trial received 155 mm and corresponded to the highest emission period. After the GS31 nitrogen application in 2015 (July 16th) the site received 66 mm in August and a sharp increase was seen in N_2O emissions from this treatment. Daily emission values remained high (60-80 g N_2O-N/ha/day) until early September when the soil dried out from the lack of further spring rainfall. During August and September there were also times where the average daily soil temperature was 2-3°C higher compared to 2014 (Figure 3) contributing to higher emissions.

Despite a small increase in emissions for the IBS treatments in late May this treatment did not vary compared to nil applied, indicating the crop and/or soil microorganisms tied the available nitrogen up in other forms.

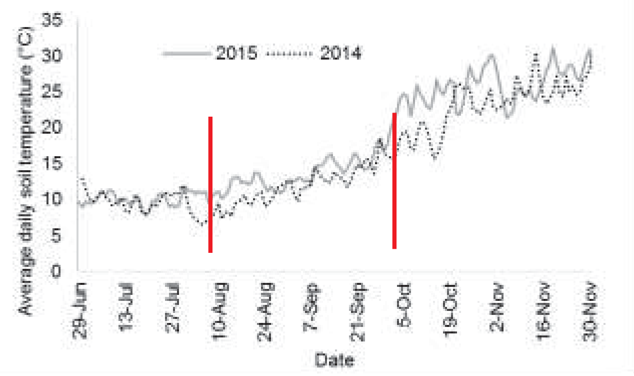

Figure 3. Average daily soil temperature (°C) at 10 cm in 2014 and 2015. The red bars indicate the start and end of the high N_2O emission period in 2015.

Summary

Results from this season have shown that the nitrogen application strategy that maximised yield was not always the same strategy that minimised N_2O emissions. For wheat following field peas nitrogen applied at GS31 maximised yield, but also produced the highest N_2O emissions. However, for wheat following canola, application of nitrogen at seeding resulted in both a high yield and low nitrous oxide emissions.

Acknowledgements

The authors acknowledge the department of Agriculture for funding this research project as part of Action on The Ground (AOTGR2-0015). We also gratefully acknowledge Rob Wandel for hosting and managing the trial on his property.

Managing stubble and fertiliser to increase soil carbon

Sarah Noack, Hart Field-Site Group
Harm van Rees, Cropfacts Pty Ltd and Jeff Baldock, CSIRO

Key Findings

- The addition of extra nutrients and stubble management (removed, incorporated or intact) did not affect grain yield or soil carbon stocks after three years of trial work.

Why do the trial?

Soil organic matter (SOM) consists of organic material derived from living organisms (plant, animal or microorganism) and is made up of three different fractions (POC- Particulate Organic Carbon, HOC – Humus, and ROC – Resistant). Only the ROC (mainly charcoal) and HOC (humus) fractions, which make up 20-80% of the total SOM, are regarded as permanent (slow to breakdown) in soil. Soil organic matter has a number of functions in soil (van Rees, 2013) including improved soil structure, release of available N and increasing plant available water storage. In recent discussions of Soil Organic Carbon (SOC) accounting programs farmers may benefit financially for sequestering atmospheric C (CO_2).

Analysis of nutrients in a series of Australian and international soils suggested that soil carbon stocks can potentially be increased if sufficient nutrients are applied (Kirkby et al. 2011). That is, the addition of N, P and S enabled the soil micro-organisms to break down the C rich residues from previous crops into SOM. The aim of this trial was to add normal, as required to optimise yield potential, and extra amounts of nutrients (N, P and S) to different stubble managements (intact, incorporated and removed) to see if SOM levels could be increased.

How was it done?

Plot size	2.7 m x 10.0 m	**Fertiliser**	Normal nutrition DAP + Zn 2% @ 100 kg/ha at seeding Extra nutrition DAP + Zn 2% @ 135 kg/ha, SOA @ 10 kg/ha and urea (46:0) @ 21 kg/ha at seeding UAN (42:0) @ 87 L/ha, 11th August all plots
Seeding date	5th June 2015		

Crop rotation

2012	2013	2014	2015
Gladius wheat	Fathom barley	Wallup wheat	44Y89 CL Canola

The trial was a randomised complete block design with three stubble managements (standing, worked and removed), two fertiliser rates (normal and extra) and four replicates. The trial was established at Hart in 2012 and the same treatments were overlayed in 2013, 2014 and 2015 with a crop rotation of barley, wheat, barley and canola, respectively. Fertiliser was applied according to the yield potential as generated by Yield Prophet® (normal nutrition). The high nutrient rate was the normal rate plus additional nutrients (N, P and S) required for the breakdown of 1.6 t/ha stubble from the previous barley crop (Kirkby et al. 2011).

Soil samples were collected for SOC analysis and bulk density (undisturbed ring method) to a depth of 0-10 and 10-30 cm at the start of the trial (autumn 2012) and after three seasons (autumn 2015).

Results and discussion

Grain yield

Across four seasons of trial work there was no difference in grain yield (Table 1) or quality (data not shown) for stubble management or the application of additional nutrients, analysed as an interaction or alone. From an agronomic view there was no yield or quality benefit in adding more N, P and S to aid stubble decomposition.

Table 1. Grain yield (t/ha) for all stubble and nutrition treatments trial from 2012-2015 at Hart.

		Grain yield t/ha			
Stubble	Nutrition	2012 barley	2013 wheat	2014 barley	2015 canola
Removed	High	2.05	5.89	4.02	0.71
	Normal	1.83	5.95	4.00	0.68
Intact	High	1.77	6.00	4.27	0.67
	Normal	1.69	5.82	3.91	0.65
Incorporate	High	1.76	5.88	4.14	0.69
	Normal	1.87	5.86	3.96	0.67
	LSD (P≤0.05)	ns	ns	ns	ns

Soil carbon

After three years of implementing different stubble and nutrient management strategies, soil C content (%) at Hart ranged between 1.5 and 1.8% for the topsoil (0-10cm) and 0.8 and 1.3% for the subsoil (10-30cm). There was no significant difference in SOC content between the 2012 and 2015 measurements (Figure 1).

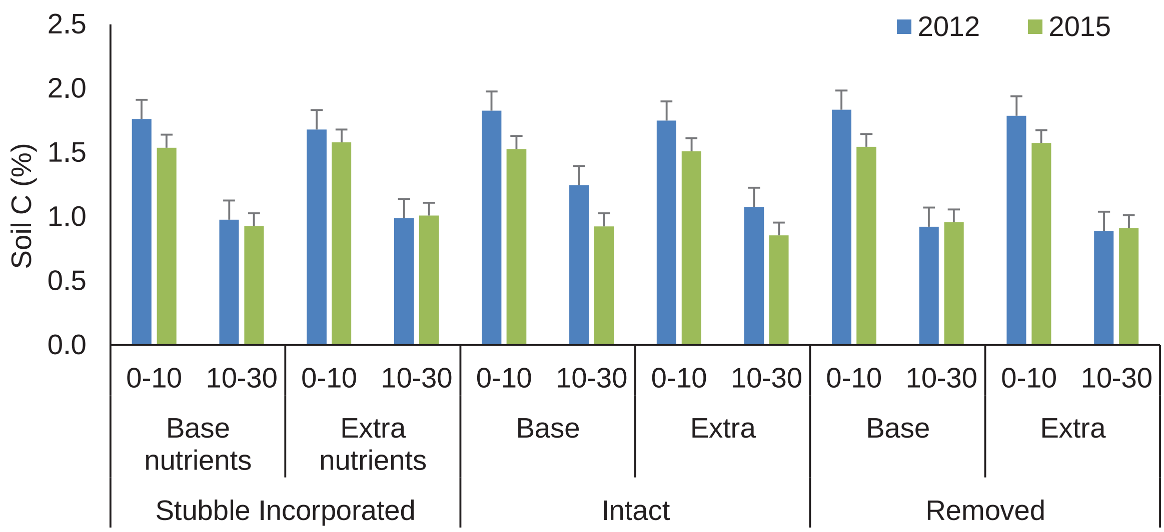

Figure 1. Soil organic carbon content (%) for the top and subsoil after three years of stubble and nutrient application treatments.

To measure the change in the amount of soil C over time, the soil mass per unit volume of soil has to be taken into account – in other words the amount of soil C is reported for a defined soil mass (ESM, Equivalent Soil Mass). The concept of ESM compensates for variations in the way samples were collected and also allows for variations in soil bulk density, resulting from different tillage practices.

Soil C stocks at Hart ranged from 35 to 40 t C/ha (Figure 2). However, there was no significant difference between 2012 and 2015 in soil C stocks between stubble management or nutrition treatments.

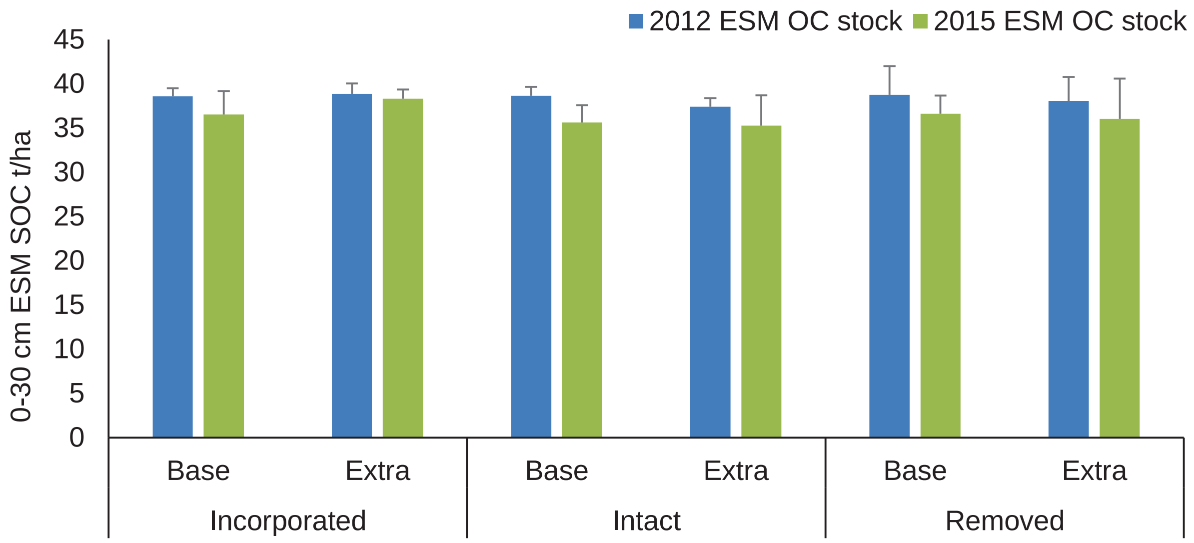

Figure 2. Soil Equivalent Soil Mass C stocks (t C/ha) in in 2012 (start of the trial) and 2015 after three years of stubble and nutrient application treatments at Hart.

The same result applied to the other seven trial sites located in SE Australia – there were no significant increases in SOC stocks at any of the sites. This work shows that increasing soil C stocks is a long-term process, and three years was not long enough to measure significant changes with the practices selected. This is consistent with a recent review indicating the largest gains in soil C stock were seen 5 to 10 years after adoption or change in practice (Sanderman et al. 2009). They also reported that improved management of cropland (eg. no-till or stubble retention) resulted, on average, in a relative gain in SOC of 0.2-0.3 t C/ha/year compared with conventional management across a range of Australian soils. The Hart trial will be re-measured again on the completion of the 2016 season after five years of trial work.

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Ripping and subsoil placement of chicken litter and fertiliser

Stuart Sherriff and Sam Trengove, Trengove Consulting

Key findings

- The nil treatment produced the highest grain yield at all sites.
- Deep ripping treatments reduced early crop vigour and grain yield at all sites, however at the Clare sites the effect on crop vigour was less.
- Subsoil manuring produced higher grain yields than surface manuring at 4 of 5 harvested sites.

Why do the trial?

Subsoil constraints are known to reduce grain yields in the Mid North of SA. Trials in other regions including SW Vic have reported large yield responses (up to 60% yield increase in the 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 attributed to the improvement in sub soil structure which increases the plant available water holding capacity of these soils.

Currently there is limited adoption of subsoil manuring due to access to chicken litter and specialised equipment to deep rip and place the litter. Although the cost associated with implementing these treatments is high, if significant yield gains can be made it has been possible to pay for the treatment in the first season at many of the Victorian sites.

How was it done?

Plot size	2.5 m x 12.0 m	**Base fertiliser**	Clare: 80 kg/ha 32:10 kg/ha IBS, 160 kg/ha post emergent urea Hart: 110 kg/ha 22:14 kg/ha IBS Bute: 80 kg/ha DAP IBS NW & SE 70 kg/ha post emergent urea Mid 140 kg/ha Post emergent urea
Seeding date	Clare: 6th May Hart: 3rd June Bute: 3rd June		

Seven randomised complete block design trials with three replicates of the same eight treatments were established in March 2015. The trials were located in three different geographic areas including two at Clare, two at Hart and three at Bute. At each location the trials were located on different soil types which are described below.

Soil types

Hart east	Calcareous gradational clay loam High pH and moderate to high exchangeable sodium percentage (ESP) below 30 cm
Hart west	Calcareous loam High pH, Boron and ESP below 30 cm
Bute northwest	Calcareous transitional cracking clay High pH, Boron and ESP below 30 cm
Bute mid	Calcareous loam High pH, Boron and ESP below 60 cm
Bute southwest	Grey cracking clay with high exchangeable sodium at depth High pH, Boron and ESP below 30 cm
Clare east	Black cracking clay
Clare west	Loam over red clay Moderate ESP below 60 cm and moderate Boron below 90cm
Bute sand hill	Sand over sandy clay loam Low exchangeable cation capacity

The 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 3 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. The trials at Clare were sown using a commercial parallelogram knifepoint and press wheel seeder on 250 mm spacing. The Hart west trial was sown using a John Deere 1980 single disc at 152 mm (6") row spacing, closer wheels and press wheels. The Hart east trial was sown using narrow points at 225 mm (9") row spacing. The Bute trials were initially sown using a Concord on 300 mm spacing with 150 mm sweep points and press wheels, however due to poor establishment in deep ripped treatments these trials were re-sown using a 6 row plot seeder with narrow points and press wheels on 225 mm spacing.

Commercial rates of seeding fertiliser, post emergent urea and pesticides were applied by the growers in their standard paddock operations to provide adequate nutrition and crop protection for the control treatments.

The rate of chicken litter (20 t/ha) was used in these trials based on trials from south western Victoria. To assess if the results are coming directly from the nutrition in the chicken litter the fertiliser treatment was added at rates to match the nutrition (N, P, K, S) in the average analysis of the chick litter. This treatment is 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 and will be referred to as 'matched fertiliser' throughout the article.

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	Matched fertiliser (NPKS)	No	Surface
7	Matched fertiliser (NPKS)	Yes	Surface
8	Matched fertiliser (NPKS)	Yes	Subsoil

Table 2. Average nutrient concentration from the 3 sources used in Hart subsoil manuring trials 2015.

Nutrient		Nutrient concentration dry weight	Moisture content	Nutrient concentration fresh weight	Kg nutrient per tonne fresh weight
N	Nitrogen	3.8 %		3.50 %	35.0
P	Phosphorus	1.72 %	8%	1.58 %	15.8
K	Potassium	2.31 %		2.13 %	21.3
S	Sulfur	0.55 %		0.51 %	5.1
Zn	Zinc	0.46 g/kg		0.42 g/kg	0.4
Mn	Manganese	0.51 g/kg	8%	0.47 g/kg	0.5
Cu	Copper	0.13 g/kg		0.12 g/kg	0.1

Assessments including segmented soil tests to 120 cm, plant establishment, Greenseeker NDVI, grain yield and grain quality were conducted and results analysed using Genstat ANOVA. In selected plots at the Bute NE and Bute SE sites the plant counts were conducted in an area of the plot not affected by poor emergence, the same area of the plot was used for all other measurements including NDVI and harvest. Some plots, including all from treatment five were not harvested due to whole of plot having very poor emergence at Bute. These areas were later re-sown by hand to fill in the gaps. The Clare trials were unable to be harvested due to fire damage.

Results and discussion

Crop establishment was measured on selected treatments and the responses varied among sites. At the Hart east site the nil treatment had the best establishment (162 plants/m^2) with all other treatments being similar (average 118 plants/m^2). Fertiliser toxicity from the surface applied matched fertiliser treatment reduced emergence at the Hart west site to 82 plants/m^2. No significant difference was observed at the Bute Mid and SE treatments with average values of 164 and 141 plants/m^2 respectively. The effects at the Clare sites were only marginal with emergence values ranging from 201 and 212 plants/m^2.

No significant NDVI response was measured at the Hart east site. At the Hart west site the NDVI of plots treated with 20 t/ha chicken litter placed on the surface had the highest values (average 0.57), 190% of the nil and all other treatments were similar (Table 3). At the three Bute sites, treatments that received either 20 t/ha of chicken litter on the surface or the matched fertiliser treatment applied to the surface and not ripped produced the highest NDVI at the time of measurement. This indicates that although deep ripping did not reduce plant numbers it did reduce early vigour, which supports visual observations that were made throughout the season. The 20 t/ha of chicken litter on the surface and the matched fertiliser treatments also produced high values at the Clare sites, however, at Clare the impact of ripping was not as great.

Table 3. NDVI values from Greenseeker measurements at Hart and Bute (15th August 2015) and Clare (29th July 2015) subsoil manuring trials.

Treatment	Nutrition	Ripping	Placement	Greenseeker NDVI						
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE	Clare East	Clare West
1	Nil	No	Nil	0.59	0.30	0.74	0.69	0.66	0.75	0.85
2	Nil	Yes	Nil	0.64	0.31	0.62	0.69	0.34	0.74	0.81
3	20 t/ha chicken litter	No	Surface	0.58	0.54	0.86	0.87	0.80	0.88	0.89
4	20 t/ha chicken litter	Yes	Surface	0.57	0.60	0.70	0.85	0.59	0.85	0.88
5	20 t/ha chicken litter	Yes	Subsoil	0.66	0.30	0.55	0.67	0.24	0.73	0.81
6	MAP, MoP, SoA, Urea	No	Surface	0.54	0.25	0.86	0.86	0.85	0.86	0.88
7	MAP, MoP, SoA, Urea	Yes	Surface	0.54	0.30	0.70	0.76	0.30	0.82	0.85
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.69	0.32	0.57	0.74	0.36	0.76	0.83
LSD (P≤0.05)				ns	0.09	0.08	0.09	0.16	0.05	0.02

The nil treatment produced the highest grain yields at all of the Hart and Bute sites ranging from 1.14 t/ha at Hart east to 2.82 t/ha at the Bute mid site (Table 4). The second highest yielding treatments at four sites were 20 t/ha chicken litter or matched fertiliser applied to the surface with no ripping.

Ripping had a strong negative impact on grain yield. At all five sites it reduced grain yield when comparing against the same levels of nutrition. In the nil, 20 t/ha chicken litter and the matched fertiliser treatment grain yield was reduced by of 42%, 55% and 42% respectively across the five sites by including ripping.

By comparing the same level of nutrition placed in the subsoil to that on the surface, the data shows that grain yield for the subsoil treatments is always greater or equal to that for the surface applied treatments. The average yield gain across the five sites is 0.14 t/ha for putting nutrition into the subsoil. Grain yield was similar at each site for chicken litter and the matched fertiliser treatments. There was no consistent difference between the chicken litter and matched fertiliser when comparing within the same level of placement. The average across all sites was within 0.01 t/ha for both surface and subsoil applications.

The Bute mid site produced the highest grain yields of all sites with an average of 2.62 t/ha. However, there was no significant response to treatment at this site.

Table 4. Grain yield (t/ha) from Hart and Bute subsoil manuring trials 2015. Bute SE treatment 5 not harvested due to poor establishment.

Treatment	Nutrition	Ripping	Placement	Grain yield (t/ha)				
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE
1	Nil	No	Nil	1.14	1.28	2.07	2.82	1.97
2	Nil	Yes	Nil	0.74	0.86	0.66	2.70	0.61
3	20 t/ha chicken litter	No	Surface	0.45	0.94	1.38	2.72	1.13
4	20 t/ha chicken litter	Yes	Surface	0.19	0.56	0.55	2.52	0.77
5	20 t/ha chicken litter	Yes	Subsoil	0.52	0.73	0.56	2.50	*
6	MAP, MoP, SoA, Urea	No	Surface	0.35	1.20	1.49	2.71	1.36
7	MAP, MoP, SoA, Urea	Yes	Surface	0.11	0.67	0.70	2.44	0.74
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.40	0.75	0.75	2.53	0.87
LSD (P≤0.05)				0.21	0.27	0.36	ns	0.36

Grain protein varied greatly across treatments at all sites (Table 5). Not surprisingly there was generally an inverse relationship where, as grain yield increased protein was reduced. Therefore, the lowest proteins came from treatments with no chicken litter or matched fertiliser (average 13.6% for all sites). Ripping in the absence of nutrition treatments decreased yield and therefore protein increased to an average of 16.1% for all sites in the absence of chicken litter or matched fertiliser. Across all sites, subsoil applications of chicken litter or matched fertiliser compared to surface applications of the same treatment reduced protein by an average of 0.8% and 0.5% respectively (this difference was not significant when sites were analysed individually).

Table 5. Grain protein (%) from Hart and Bute subsoil manuring trials 2015. Bute SE treatment 5 not harvested due to poor establishment. Hart east treatments 4 and 7 did not produce a sufficient sample for quality testing.

Treatment	Nutrition	Ripping	Placement	Grain protein (%)				
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE
1	Nil	No	Nil	12.6	12.9	15.2	12.7	14.7
2	Nil	Yes	Nil	15.3	17.0	18.3	13.1	17.0
3	20 t/ha chicken litter	No	Surface	20.5	21.2	18.0	17.4	18.6
4	20 t/ha chicken litter	Yes	Surface	*	20.2	19.4	17.3	19.0
5	20 t/ha chicken litter	Yes	Subsoil	18.2	19.0	19.1	16.6	*
6	MAP, MoP, SoA, Urea	No	Surface	20.5	20.0	17.8	17.7	18.4
7	MAP, MoP, SoA, Urea	Yes	Surface	*	20.8	19.0	17.4	18.2
8	MAP, MoP, SoA, Urea	Yes	Subsoil	19.0	19.9	18.7	16.9	18.0
LSD ($P \leq 0.05$)				3.0	2.0	1.0	1.0	1.3

All test weight values were greater than 71 kg/hL. The highest values came from the higher yielding Bute mid site with an average of 80.4 kg/hL.

Screenings values were generally high, with the nil treatments producing values from 5.5% at Bute SE to 8.2% at Bute mid (Table 6). The highest values were recorded at the Hart west site with surface applied applications of 20 t/ha chicken litter with an average of 33.3%. Of the three grain quality parameters the screenings value is what determined the receival grade for each treatment, AUH2 was the maximum grade achieved for all treatment and site combinations.

Table 6. Grain screenings (% < 2.0mm) from Hart and Bute subsoil manuring trials 2015. Bute SE treatment 5 not harvested due to poor establishment. Hart east treatments 4 and 7 did not produce a sufficient sample for quality testing.

Treatment	Nutrition	Ripping	Placement	Grain screenings (%<2.0mm)				
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE
1	Nil	No	Nil	6.2	7.0	7.9	8.2	5.5
2	Nil	Yes	Nil	11.6	14.0	15.9	6.9	16.8
3	20 t/ha chicken litter	No	Surface	20.3	31.9	9.1	13.0	11.9
4	20 t/ha chicken litter	Yes	Surface	*	34.7	16.8	7.4	17.7
5	20 t/ha chicken litter	Yes	Subsoil	26.0	16.2	15.9	9.0	*
6	MAP, MoP, SoA, Urea	No	Surface	19.6	13.2	12.4	16.5	12.2
7	MAP, MoP, SoA, Urea	Yes	Surface	*	20.6	16.2	13.8	13.2
8	MAP, MoP, SoA, Urea	Yes	Subsoil	26.7	20.2	13.4	7.9	23.3
LSD ($P \leq 0.05$)				2.9	6.9	4.3	4.3	8.9

Summary / implications

Subsoil manuring has led to significant yield gains in high rainfall areas, particularly south western Victoria. These results were not replicated in the first year of trials in the Mid North and growers should be cautious before implementing such strategies in this region. The results from the Hart and Bute sites are partly due to poor establishment from dry conditions at the time of sowing in combination with the difficulty of producing a suitable seedbed with good seed to soil contact in deep ripped treatments.

The results highlight the importance of timely sowing and good establishment, particularly in seasons with a dry and hot finish. Trials where sowing was delayed were lower yielding than the adjacent commercial crop sown earlier.

Issues related to cloddy soil and crop establishment in deep ripped treatments are not expected to be on-going as the large clods are broken down overtime. All treatments in the seven trials are expected to continue to influence grain yield and quality for a number of years and will continue to be monitored and harvested in the coming seasons.

Acknowledgements

The authors would like to acknowledge the financial support of GRDC (TRE0002) and Northern and Yorke Natural Resource Management. Thank you to David Woodard for assistance with the Bute site selection and Renick Peries for the loan of the subsoil manure ripper. Also thankyou to all of the growers involved for assisting with machinery, chicken litter and provision of land for trials.

These photos (above) were taken at the trial on Matt Dare's property on March 23rd 2015.

Reassessing the value of phosphorous replacement strategies on fixing soils

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Key findings

- Economic gains can be made by applying higher than typical replacement P rates on soils with the ability to fix applications of P.
- Highest gross margins are obtained by growing the most suitable variety for your region assuming P nutrition is corrected.

Why do the trial?

The aim of this project is to quantify the economic benefit to farmers of:

- applying high application rates of phosphorus (P) on moderate buffering soils (phosphorus buffering index PBI) across a range of sites with different yield potentials.
- comparing three-four common wheat and barley varieties to assess their Phosphorus Use Efficiency (PUE).

Phosphorus deficiency still occurs in several regions across SA with major yield limitations occurring due to inadequate applications of P. Low soil P test values are commonly associated with soils that have moderate to high P buffering indices (> PBI 100) implying that replacement P programs may not be sufficiently accounting for the low fertiliser recoveries, thereby generating inadequate P replacement rates. In some cases, application rates > 40 kg P/ha might be required to maximise yields, a fertiliser rate that under some circumstances might not be the most economic if yields are low. Identifying these sites and assessing under which circumstances (yield potential, fertiliser prices) high rates of P are economically-viable will add vital information to the grains industry.

Wheat and barley varieties may vary in their responsiveness to P either by having root traits that increase access to soil P or by more efficient use of the P taken up by the crop. In combination with different yield potentials external P requirements and phosphorus use efficiency (PUE) could vary. Identifying varieties that have greater PUE in deficient soil is of great interest to many farmers in S.A. due to the relatively low P levels driven by moderate to high P fixing soils in several regions.

How was it done?

Plot size	1.8 m x 5.0 m	**Fertiliser**	P as MAP (10:22) @ 0, 5, 10, 20, 30 and 50 kg P/ha. Urea was used to balance N inputs so each treatment had an application of 22 kg N/ha applied at sowing.
Seeding date	2nd June 2015		

The trial location was at Pinery on a red calcareous (~10% $CaCO_3$) soil. Four wheat (Cobra, Corack, Mace and Trojan) and four barley varieties (Commander, Compass, Fathom and La Trobe) were sown at each P treatment, and replicated 4 times. Soil sampling (0-10 cm) occurred soon after sowing to obtain P availability measures across the trial (Table 1). Growth responses of each variety to applied P was assessed at the start of stem elongation, GS30 (data not shown) by NDVI and at maturity. Response of each variety to applied P was expressed as phosphorus use efficiency (PUE %) which = Yield (control, 0P)/Yield (maximum) x 100. Optimal P rates required to maximise yields were also calculated together with gross margins (GM), calculated by subtracting fertiliser cost off the income made in grain yield at each P rate. Prices used were as follows (PIRSA Gross Margin guide 2016) – wheat \$260/t, barley \$260/t and MAP \$700/t.

Table 1. Soil test results for Pinery, 2015.

Crop		PBI	Colwell P (mg/kg)	DGT P (μg/L)
Barley	mean	135	28	17
Wheat	mean	135	31	14
Barley	minimum	128	23	11
	maximum	143	45	26
Wheat	minimum	129	21	8
	maximum	140	49	28

Interpretation: Critical Colwell P (mg/kg) for this site is 32 mg/kg based on PBI value. Colwell P values for both the barley and wheat trials were slightly deficient. DGT values indicate moderate deficiency with values well below the critical value of 52 μg/L.

Results and discussion

Grain yield

Wheat and barley yield penalties occurred when P was not applied at this site. Significant responses to P applications occurred for both wheat and barley (Table 2 and 3). There were also significant differences between the yields of wheat and barley varieties but no interaction between variety and P rate. This means that any differences in terms of PUE between the varieties was too small to assess.

In wheat, Corack and Mace performed well as did Compass, Fathom and La Trobe all yielded better than Commander. Optimal P rates were high for all wheat varieties (>50 kg P/ha) and greater than the highest P rate applied in this trial. For barley optimal P rates ranged from 22 to 50 kg P/ha. This high P requirement was caused by the high P fixing ability of this soil type and potentially later sowing time. The later sowing time may have caused the poor relatively performance of Trojan which is a longer maturing variety compared to the other wheat varieties sown.

Table 2. Wheat grain yield (t/ha), PUE (%) and optimal P (kg P/ha) for all varieties trialed at Pinery, 2015.

Variety	Yield (Control) t/ha	Maximum yield t/ha	PUE %	Optimal P kg/ha
Cobra	2.19	2.99	73	>50
Corack	2.66	3.58	74	>50
Mace	2.45	3.35	73	>50
Trojan	2.50	2.81	89	>50
Mean	*2.45*	*3.29*	*74*	*>50*

Treatment	P value	Least significant difference (LSD)
Variety	< 0.001	0.14 (t/ha)
P rate	< 0.001	0.17 (t/ha)
Variety x P rate	ns > 0.05	

Table 3. Barley grain yield (t/ha), PUE (%) and optimal P (kg P/ha) for all varieties trialed at Pinery, 2015.

Variety	Yield (Control) t/ha	Maximum yield t/ha	PUE %	Optimal P kg/ha
Commander	2.40	3.20	75	22
Compass	2.82	3.88	73	50
Fathom	2.78	3.68	76	46
La Trobe	2.94	3.95	74	44
Mean	*2.73*	*3.69*	*74*	*46*

Treatment	P value	Least significant difference (LSD)
Variety	< 0.001	0.182 (t/ha)
P rate	< 0.001	0.223 (t/ha)
Variety x P rate	ns > 0.05	

Gross margins (GM)

The calculated GM for each variety revealed that yield increases between varieties was the main driver of increased GM and was relatively independent of optimal P rates (Figure 1 and 2). Corack returned the greatest GM out of the wheat varieties trialed, while it was hard to differentiate between Compass, Fathom and La Trobe barley varieties. In general, the economic P rate where GM was maximised was lower than the P rate required to maximise yields overall. This indicates that on this soil type due to the lower efficiency of applied P, yield increments towards the higher part of the response curve are not great enough to generate income greater than the cost of extra P applied.

The GM curves also highlights the importance of determining economic P rates as considerable reductions in GM can occur with too low or too high P application rates. Economic P rates determined from this trial are considerably greater than P replacement rates based on 3 to 4 t/ha yields which would be 9-12 kg P/ha. To test if higher P rates are economical in your specific soil type, the authors suggest using P rich strips which consist of a P rate at least double typical replacement.

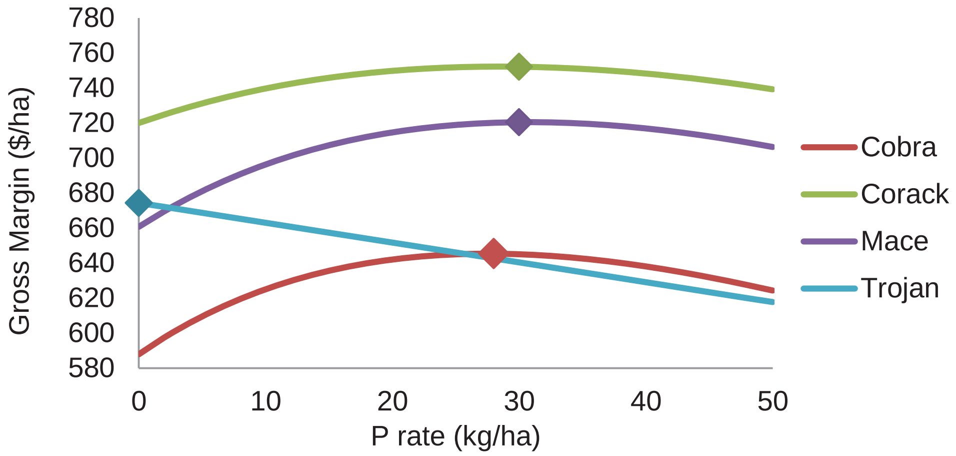


Figure 1. Gross margin curves for different P application rates in wheat. Data points on the curves indicate maximum GM at the associated P rate.

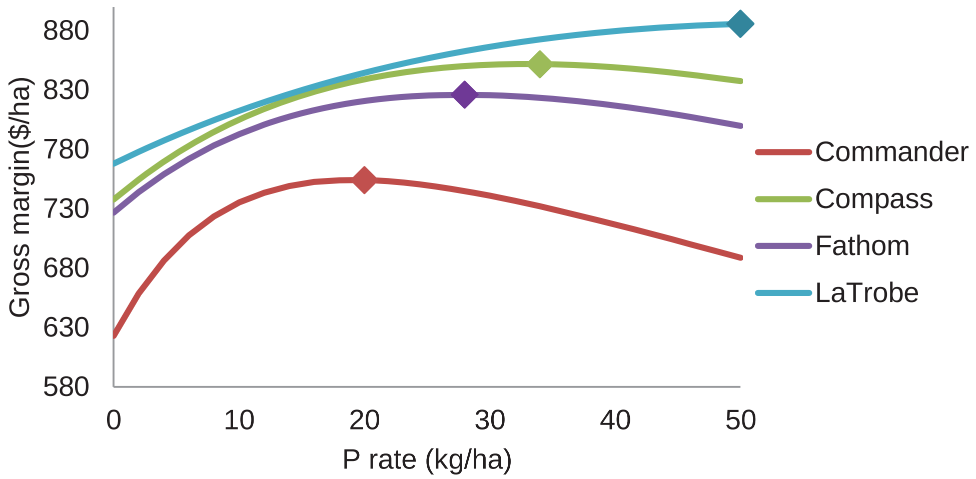


Figure 2. Gross margin curves for different P application rates in barley. Data points on the curves indicate maximum GM at the associated P rate.

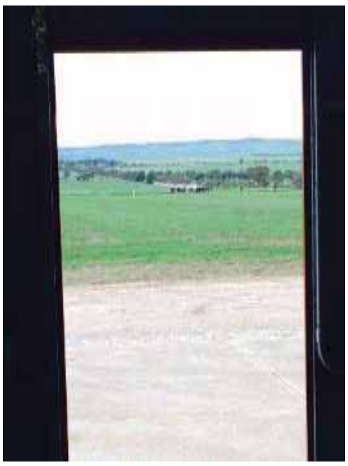
Summary / implications

- Benefits in yield through choosing the most appropriate variety for a particular region outweighs any potential savings through choosing a variety based on higher PUE.
- Overcoming P deficiency on prone soil types (moderate – high PBI) with high P rates will not be the most economical management option but defining economic P rates is important as they are considerably higher than typical replacement rates.
- The use of farmer strip type trials where P rates are adjusted accordingly. That is P rich strips which consist a P rate at least double typical replacement rates to determine if high P rates are economical in your specific soil type.

Acknowledgements

The authors thank SAGIT for the financial assistance that supports this research (project code UA1201).

Seeding at Hart 2015
(above)



Hart Winter Walk 2015
(above, below and left)

Hart Field Day 2015

Early or delayed sowing for improved ryegrass control?

Sarah Noack and Peter Hooper, Hart Field-Site Group
Chris Preston and Sam Kleemann, University of Adelaide

Key findings

- The early break to the 2015 season meant soil moisture and rainfall conditions were similar between ToS 1 and 2 and there was little variation in annual ryegrass control among pre-emergent herbicides tested.
- Grain yield and quality were not affected by pre-emergent herbicide however, there was a 0.7 t/ha yield penalty for the later ToS.
- Over two seasons of research ryegrass seed set was greater when sowing was delayed.

Why do the trial?

A ryegrass management trial at Hart in 2008 showed the best additional management strategy to herbicide application was delaying sowing by 7 days. Delayed sowing reduced ryegrass numbers by 55% for all herbicide treatments. However, this often results in lower crop yield and reduced subsequent crop weed competition.

Since then, the introduction of new residual herbicides has reduced the reliance on post emergent selective grass sprays and provided an improved option for dry sowing. Anecdotal grower evidence would suggest that dry or early sown crops and using adequate rates of residual pre-emergent herbicide provides similar levels of ryegrass control. The aim of this trial was to investigate the effect of early or delayed sowing on reduction of ryegrass numbers in combination with different pre-emergent herbicides.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 2% Zn @ 100 kg/ha
Seeding date	TOS 1: 30th April 2015 TOS 2: 27th May 2015		
Crop	Estoc wheat @ 80 kg/ha		

To ensure even annual ryegrass establishment across the trial site annual ryegrass seed was broadcast at 25 kg/ha in 2014, prior to seeding. Again prior to seeding in 2015 an additional 5 kg/ha annual ryegrass seed was spread ahead of seeding & tickled in with a shallow pass with the seeder prior to herbicide application. The ryegrass used was previously harvested from commercial paddocks and had medium resistance to trifluralin. A standard knife-point press wheel system was used to sow the trial on 22.5 cm (9") row spacings.

The trial was a split block design with one wheat variety, two times of sowing and six pre-emergent herbicides:

1. Nil
2. IBS Boxer Gold 2.5 L/ha
3. IBS Sakura 118 g/ha
4. IBS trifluralin 1.5 L/ha + triallate 1.6 L/ha
5. IBS Sakura 118 g/ha + IBS triallate 2.0 L/ha
6. IBS Boxer Gold 2.0 L/ha + PS (crop 2-3 leaf) Boxer Gold 1.5 L/ha

Pre-sowing herbicides were applied within an hour of sowing & incorporated by sowing (IBS). The post-sowing herbicides were applied on the 27th May (ToS 1) and 29th June (ToS 2) at the 2-3 crop leaf growth stage. Assessment of annual ryegrass plant number per square metre was made for 10th July and head number per square metre on 16th October for both ToS.

Results and discussion

Grain yield was higher for the early time of sowing by 0.7 t/ha (Table 1). Protein was higher in the later time of sowing which can be attributed to yield dilution effects (lower yield = higher protein). Pre-emergent herbicide treatments did not affect final grain yield or quality.

Table 1. Summary of wheat grain yield, protein, test weight and screenings for 30th April and 27th May time of sowing.

Time of sowing	Grain yield t/ha	Protein %	Test weight kg/hL	Screenings %
30th April	2.2	9.4	81.1	1.7
27th May	1.5	12.3	78.5	12.1
LSD (P≤0.05)	0.1	0.8	0.8	1.4

The moist soil conditions in late April meant a good germination of ryegrass had occurred prior ToS 1 (Figure 1). The knockdown herbicide controlled the initial germination and the plots were sown into good moisture following 25 mm of rainfall. This was followed by 5.6 mm ten days after sowing (Figure 1). Conditions prior to the second ToS were similar with 23.4 mm falling eight days prior and 0.2 mm in the week after sowing. The early ryegrass control and optimum sowing conditions were not those initially anticipated (ie. dry sowing), however by early August there were still more than 20 ryegrass plants per square metre (Table 2).

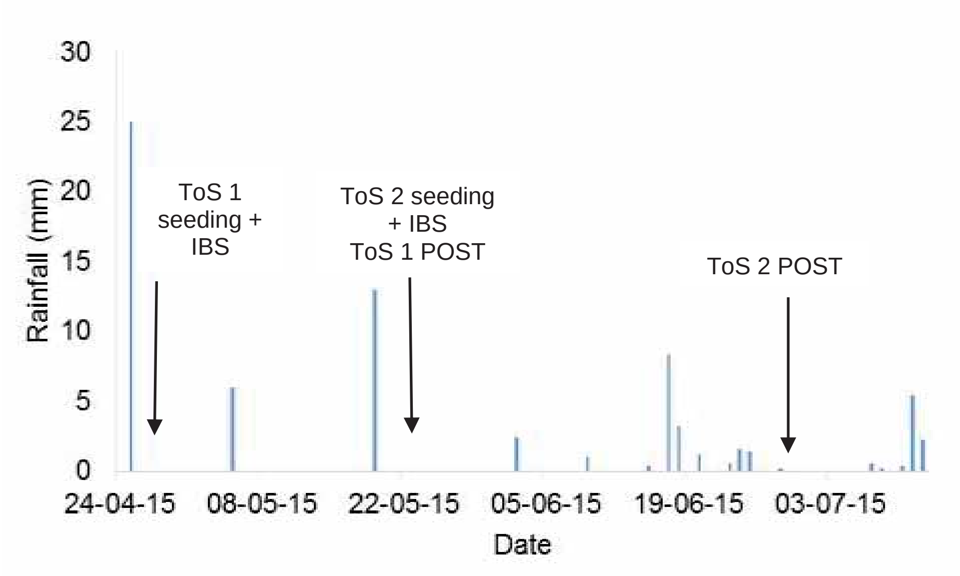


Figure 1. Rainfall from 24th of April through 10th of July at Hart with seeding and herbicide applications indicated in relation to rainfall.

Similarities in starting soil moisture and rainfall following the herbicide applications mean the pre-emergent herbicides behaved similarly across both times of sowing. Early plant counts showed all pre-emergent herbicides reduced annual ryegrass number compared to the nil for both times of sowing (Table 2).

The final head count followed similar trend to the early plant count. All treatments had reduced the number of heads to less than 25% compared to the nil. Overall the final head number was not significantly different between the two times of sowing. However, similar to 2014 there appeared to a greater number of heads/m^2 in ToS 2. As reflected in the grain yield, ToS 2 produced a smaller and less competitive wheat crop.

Table 2. Effect of different pre-emergent herbicides on annual ryegrass plants (plants per metre squared) and head density (heads per metre squared) at Hart, 2015.

	Plant count/m^2		Head count/m^2	
	ToS 1	ToS 2	ToS 1	ToS 2
Nil	18	6	45	44
IBS Boxer Gold	3	1	5	9
IBS Sakura	1	2	3	13
Trifluralin + triallate	2	2	6	14
IBS Sakura + IBS triallate	0	1	0	15
IBS Boxer Gold + POST Boxer Gold	1	2	8	9
LSD (P≤0.05) Herbicide	5.3		12.3	

Acknowledgements

The financial assistance of GRDC to undertake this research is gratefully acknowledged.

Managing clethodim resistant ryegrass without oaten hay

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Key findings

- The decline in ryegrass has been greater after field peas.
- The high intensity herbicide strategy was the most effective option in both rotations.

Background

An increasing number of paddocks in the Mid North of South Australia contain clethodim (ie Select®) resistant annual ryegrass. Managing herbicide resistant ryegrass can come at a great expense and requires an approach which uses chemical and non-chemical strategies.

Crop rotation is important to the overall success of long-term ryegrass management. Oaten hay is a popular and profitable option for growers to reduce ryegrass numbers. However, there are a number of crop rotation options available to best suit individual growers in terms of success and profitability. In addition to crop selection different herbicide strategies can be used to provide successful ryegrass control.

Aim: To conduct a multi-year trial to determine the effects of crop sequence and low, medium and high intensity management strategies to reduce clethodim-resistant ryegrass.

Materials & methods

In year 1 of the study (2013) ryegrass seed with low-medium level resistance to clethodim (ie Select®) and Factor® (ai butroxydim) was hand broadcast and lightly incorporated across the site for the purpose of establishing a seedbank. Resistance screening of the Hart population against a known susceptible population (SLR4) confirmed resistance to both clethodim (10-fold more resistant) and Factor (2-fold more resistant).

Soil core samples (10 cm diameter) were taken across the trial site in April of 2014 and 2015 to determine the ryegrass seedbank. Soil samples were transferred to shallow trays and germinating ryegrass assessed at regular intervals. Seedbank was determined based on the total number of ryegrass seedlings to germinate, and the total area sampled (i.e. core area (πr^2) x number of cores sampled (n=120, 2014; n=162, 2015) and converted to a unit area (ie seeds/m^2). The starting seedbank in April 2014 was determined to be ~1138 ryegrass seeds/m^2.

The first cropping phase of two 3-yr rotations (peas/wheat/barley and canola/wheat/barley) of field peas and canola was established in 2014. Wheat was planted in 2015 (Mace at 80 kg/ha), and will be followed by barley this season (2016). A standard knife-point press wheel system was used to sow the trials on 22.5 cm (9") row spacings. Fertiliser rates were undertaken as per district practice. Ryegrass management strategies of low (MS1), medium (MS2) and high intensity (MS3) were imposed in each cropping sequence phase and are presented in detail in Table 1.

The trial design is a split-plot; with crop sequence assigned to main-plots and management strategies to sub-plots with 3 replicates. Pre-sowing herbicides were incorporated by sowing within a few hours of application, while post-emergent Boxer Gold® was applied to ryegrass at the 1-2 leaf growth stage. Assessments included ryegrass control (reduction in plant density, seed set and seedbank), crop yield and grain quality (protein, test weight and screenings).

Table 1. Management strategies used in long-term ryegrass trial at Hart in 2014 (canola & field peas) and 2015 (wheat).

Management strategy (MS)	Crop sequence Canola_2014	Field peas_2014	Wheat_2015
Low intensity (MS1)	Trifluralin (1.6 L/ha) pre Clethodim (0.5 L/ha) post	Trifluralin (1.6 L/ha) pre Clethodim (0.7 L/ha) post	Sakura (0.118 kg/ha) pre
Medium intensity (MS2)	Triallate (2 L/ha) + propyzamide (1 L/ha) pre	Triallate (2 L/ha) + propyzamide (1 L/ha) + trifluralin (1.6 L/ha) pre Clethodim (0.7 L/ha) post Paraquat crop-top	Sakura (0.118 kg/ha) + triallate (2 L/ha) pre
High intensity (MS3)	Propyzamide (1 L/ha) pre Clethodim (0.5 L/ha) post Weedmaster DST crop-top	Triallate (2 L/ha) + propyzamide (1 L/ha) + trifluralin (1.6 L/ha) pre Clethodim (0.7 L/ha) + Factor (0.18 kg/ha) post Paraquat crop-top	Sakura (0.118 kg/ha) pre Boxer Gold (2.5 L/ha) post

Results and discussion

In response to the three different management strategies (MS) imposed in year 1 (2014), ryegrass seedbank declined following both field peas (54-83%) and canola (27-55%; Table 1). Where excellent ryegrass control was obtained in field peas with pre-sowing propyzamide + triallate and followed by grass selective herbicides (ie clethodim & Factor) and crop-top, the decline was greatest for MS2 (78%) and MS3 (83%). In contrast, the reduction was much smaller following canola, particularly in MS1 (27%). Control in this treatment was initially poor with trifluralin, which placed greater reliance on clethodim, to which the population has some resistance.

Even though there was no ryegrass seed set under MS2 and MS3 in field peas ryegrass was still present prior to sowing wheat in 2015, from the persistent fraction of the seedbank (~15%). Fortunately, this level of persistence is relatively low in comparison to other weed species, however ryegrass is a prolific seed producer and only a few escapes are required to replenish the seedbank.

In this study, crop-topping with paraquat in field peas (MS2 & MS3) and glyphosate in canola (MS3) appeared to provide some additional seed set control and reduction in the seedbank. Performance of crop-topping can however be quite variable both in terms of ryegrass seed control and crop safety. To avoid excessive yield loss in this study, crop-topping was delayed until grain moisture content of field peas was less than 30% and when 20% of canola seeds had changed colour. Such unavoidable delays can often compromise seed set control.

Table 2. Impact of crop sequence and management strategy (MS1-3) on reduction of Group A resistant ryegrass at Hart in 2015. Detailed description of management strategies and herbicides are presented in Table 1. Canola and field peas were sown in 2014 and wheat in 2015. The initial ryegrass seedbank was ~1138 ryegrass seeds/m^2.

Crop sequence	Management strategy (MS)	% reduction in ryegrass seedbank from 2014 to 2015	Ryegrass	
			(plants/m^2)	(heads/m^2)
Field peas/wheat	1	54	3b	8ab
	2	78	3b	3a
	3	83	1a	2a
Canola/wheat	1	27	22d	42c
	2	38	3b	19b
	3	55	8c	10ab
LSD (P=0.05)†			1.8*	13.6*
Crop sequence (CS)			*	*
MS			*	**

†Represents the significance of the interaction between crop sequence x MS.
*, *P<0.05*; **, *P<0.01*.

Differences in density and seed production of ryegrass were evident in wheat, the result of both cropping sequence and MS (Table 2). Even though pre-sowing herbicides were effective in wheat (MS1-3), ryegrass was generally more prevalent in canola/wheat cropping sequence. A carryon effect of poor initial control in canola with trifluralin and clethodim, and absence of preventative seed set measures (i.e. crop-top). Wheat following canola had greater seed production (10-42 heads/m^2) relative to wheat after field peas (<8 heads/m^2). The ineffectiveness of canola/wheat crop sequence to contain ryegrass and prevent seed set could lead to a rapid build-up in weed infestation in the following barley phase. However, the full impact of MS and cropping sequence on ryegrass seedbank won't be fully known until sampling is undertaken in April of this year (2016).

Although there were significant differences in ryegrass control between MS treatments (Table 2), this had little effect on the grain yield of wheat (P=0.05). This is not entirely surprising given ryegrass in its own right is a relatively weak competitor, with higher numbers (>100 plants/m^2) required to produce measurable yield losses. Given the effectiveness of MS to maintain this population at low levels, the competitive influence of ryegrass would have been negligible.

When the results were combined for all MS and presented as the mean of cropping sequence (Table 3), differences in wheat yield and quality (% protein) between the two crop sequences were significant (P<0.05). Wheat grain yield and protein was on average higher following field peas (3.32 t/ha; 11.9 % protein) than canola (2.69 t/ha; 10.3% protein), presumably because of increased availability of nitrogen and water.

Table 3. Impact of crop sequence on grain yield and quality of wheat at Hart in 2015. Because management strategy effect on wheat yield and quality was non-significant data were combined over low, medium and high intensity treatments (MS1-3) and presented as the mean of crop sequence.

Crop sequence	Wheat yield (t/ha)	Grain protein (%)	Test_wt (kg/hL)	% screenings (≤2 mm)
Field peas/wheat	3.32	11.9	77.9	5.7
Canola/wheat	2.69	10.3	78.8	3.7
LSD (P=0.05)	0.144**	0.49**	ns	ns

**, *P<0.01*; ns, not significant.

Conclusion

A three year field trial was initiated at Hart to identify alternate MS and crop sequences to hay, for management of Group A resistant ryegrass. Results from the trial thus far have shown that following crop phases of field peas and canola, where effective MS were imposed on ryegrass, the seedbank was reduced (27-88%). The decline was greater after field peas (78-88%) where more effective pre- and post-sowing herbicide mixtures were used (i.e. pre-sowing propyzamide + triallate followed by clethodim + Factor) and importantly followed by late crop-top for seed set control. In contrast, the standard grower practice of trifluralin and clethodim in canola was the least effective option, resulting in the smallest seedbank decline (27%). Even though pre-sowing herbicides were effective in the following wheat crop, ryegrass appeared more prevalent in MS1 treatment after canola, producing more seed to replenish the seedbank. Ineffectiveness to contain ryegrass may lead to a large rebound in weed infestation in the following barley phase. Consequently, maintaining ryegrass seedbanks at low levels is critical, given its prolific seed production, competitiveness, and propensity at high densities to rapidly evolve resistance to different mode-of-action herbicides.

Acknowledgements

The financial assistance of GRDC and the collaboration of Hart Field-Site Group staff are gratefully acknowledged. We also thank staff from SARDI and Malinee Thongmee (UA) for providing technical assistance.

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Harvest weed seed control – narrow windrow burning paddock case studies

Sam Kleemann[1], Sarah Noack[2], Peter Hooper[2], Gurjeet Gill[1] & Chris Preston[1]
School of Agriculture, Food & Wine, The University of Adelaide[1], Hart Field-Site Group[2]

Key findings

- Narrow windrow burning can be an effective tactic against ryegrass provided:
    1) weed seeds are captured and concentrated at swathing & harvest
    2) the burn heat and duration are enough to kill weed seeds.
- Annual ryegrass control in canola was more variable than last season with 37-86% control of the seed captured and concentration in the windrow. Higher control (86-93%) was achieved for wheat residues concentrated into narrow windrows.

Background

Narrow windrow burning is a practice being adopted by growers across the Mid North to assist in the management of herbicide resistant ryegrass. It is a simple and low cost approach, which involves concentrating chaff and straw residues into a 50-100 cm windrow. If implemented correctly, this technique can provide high levels of ryegrass seed control (>95%). Research from Western Australia (Walsh & Newman 2007) has shown that a minimum temperature of 400°C is required for at least 10 seconds to kill ryegrass seed. To achieve this, appropriate conditions (temperature, wind speeds, humidity etc.) and fuel load is required.

The aim of this study was to assess the effectiveness of narrow windrow burning practices in the Mid North as a late weed seed control tactic against ryegrass in canola and wheat.

How was it done?

The study involved sampling several field sites of canola (n=5) and wheat (n=2) in the Mid North of SA where growers had concentrated stubble and chaff residues at harvest into narrow windrows for burning. Prior the windrows being burnt, stubble cutting height and windrow width (cm) were determined. Information was also collected to include: variety, swath & harvest date, herbicide management, swath width and burn date.

A 5 m section of chaff was protected from burning by removing a small section of windrow at either end to represent an unburnt area. After the narrow windrows were burnt, 10 soil samples (7 cm diameter core x depth 10 cm) were taken from four replicates per site in the following three locations:

1) Burnt section of windrow (centre & edge of windrow)
2) Sample within 5 m on the unburnt section
3) Inter-row

These 10 soil samples were combined to make one bulk sample per treatment. The soil samples were then transferred to shallow trays and germinating ryegrass assessed at regular intervals. Census of ryegrass ceased when no new seedlings emerged over a 3-week period. Ryegrass seed number was determined by the total number of ryegrass seedlings to germinate, and the total area sampled. Sampling from the inter-row (i.e. area between windrows) was undertaken to provide an estimate of the amount of ryegrass seed accumulation in the narrow windrow.

Table 1. Cutting height of canola and wheat stubble, and estimated ryegrass accumulation into narrow windrows at field sites across the Mid North of SA.

Crop phase (Site)		Stubble cutting height (cm)	Estimated ryegrass accumulation
Canola			
	NWB_01	30	Low
	NWB_02	44	Low
	NWB_03	50	Low
	NWB_06	27	High
	NWB_07	50	High
Wheat			
	NWB_04	11	High
	NWB_05	21	Low

Low = less than 8-fold increase in ryegrass in windrow compared to the inter-row.

Results and discussion

The effectiveness of narrow windrow burning is governed by the amount of weed seed captured by swathing or harvest. Often collection of ryegrass seed is better compared to other weed species. (eg. brome grass, barley grass & wild oats) which have a tendency to shed seeds early, well before harvest. However, ryegrass seed capture can be compromised, particularly with lodging (more difficult to feed into the machine front) or delays to swathing and harvest, by which time much of the ryegrass seed has shed onto the soil surface.

The capture and accumulation of ryegrass seed in narrow windrows appeared to be far more variable this season than last. Of the 7 sites assessed, only at 3 sites (2 canola, 1 wheat) was sufficient seed concentrated (>8-fold increase) into the windrow (Table 1). Stubble cutting height or timing of swathing/harvest (data not shown) did not consistently influence seed capture. This is in contrast to results from last season, where there appeared to be a direct correlation between cutting height and the amount of seed captured. There are a number of factors which effect the height and maturity of ryegrass in the crop canopy (eg. crop competition, lodging). The results from this season highlights the need to look at the position and maturity of ryegrass before swathing, otherwise a lot of time can be placed on burning windrows which have low levels of seed.

Table 2. Ryegrass (seeds/m^2 & % control) following burning of canola and wheat residue concentrated into narrow windrows at field sites across the Mid North of SA.

Crop phase (Site)		Windrow treatment			*Ryegrass control (captured seed only)
		Unburnt	Burnt centre	Burnt edge	
		ryegrass seeds (no./m^2)			(%)
Canola					
	NWB_01	546	221	279	54
	NWB_02	857	312	611	47
	NWB_03	1344	927	766	37
	NWB_06	36225	5897	4858	86
	NWB_07	63274	21563	-	66
Wheat					
	NWB_04	63227	6408	11080	86
	NWB_05	9041	253	961	93

*Percent control across entire windrow (i.e. average of burnt centre & burnt edge).

Of the ryegrass seed captured and concentrated into narrow windrows in canola, only at 1 of the 5 sites was a high level of seed control achieved (86%; Table 2). Control was variable in canola (37-86%) indicating that temperatures at the soil surface during burning were generally insufficient and did not reach the required 400°C for at least 10 seconds to kill seeds (Walsh & Newman 2007). This was much lower than the levels observed in 2014 where control was greater than 90%. In contrast, burning was far more effective on ryegrass (86-93% control) in wheat, which can be attributed to the higher fuel loads (40 versus 20 t/ha).

Often overlooked is the amount of seed left behind after burning, creating concentrated strips of ryegrass (Figure 1) on the edge of burnt rows. This was clearly evident in a number of paddocks sampled in this study where even though 80% of seed had been killed in the middle of the windrow a large amount of viable seed remained in the windrow (>5000 seed/m^2) or on the windrow edge (>10,000 seeds/m^2; Table 2.). Achieving effective control in these areas can be difficult and often lead to high weed infestations if not managed correctly. Generally, these sites occurred where growers had waited for fire ban to end (rather than gaining a permit) and burnt at the beginning of May after many areas received >20 mm rainfall. There was insufficient time for the windrow to dry before seeding and these moist conditions led to a poorer quality burns.

Figure 1. Ryegrass germination (>1000 plants/m^2) on the unburnt edge of a narrow windrow of canola.

Photo (above): Soil cores from paddock surveys are spread in trays and germinating ryegrass plants counted over six weeks.

There are other disadvantages to narrow windrow burning which can include unburnt residue and associated trash flow issues at sowing, risk of burning the entire field leading to increased erosion (less of a problem with narrow than conventional windrows), redistribution of nutrients such as potassium in windrow area, and loss of important nutrients such as nitrogen and sulphur lost in smoke.

Summary / implications

Narrow windrow burning can be an effective tactic for late seed set control of ryegrass provided weeds seeds can be captured and concentrated into narrow windrow at swathing or harvest. Cutting lower and earlier before the seeds have had a chance to shed is likely to improve collection. However, concentrating seeds in a narrow windrow does not automatically guarantee control; equally important is to ensure that a hot and long burn is attained to provide best chance of killing most ryegrass seed.

Acknowledgments

The financial assistance of GRDC is gratefully acknowledged. We also wish thank Malinee Thongmee (UA) for providing technical assistance and all eight growers for allowing us to sample their paddocks.

References

Walsh, M. and Newman, P. (2007) Burning narrow windrows for weed seed destruction. Field Crops Research 104, 24-30

Photo (left): Narrow windrow burning in wheat case study.

Photo (left): Narrow windrow burning in canola.

Legume and oilseed herbicide tolerance

Key findings

- In the post emergent treatments, a range of herbicides produced very good control of all oilseed and legume crops included.

Why do the trial?

To compare the tolerance of legume and canola 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) + 2% Zn @ 80-100 kg/ha
Seeding date	26th and 27th May 2015		

Thirteen strips of canola, pasture, vetch, chickpea, faba bean, field pea and lentils were sown. Fifty herbicide treatments were applied across all 13 crops at different timings.

The timings were:

Post seeding pre-emergent (PSPE)	2nd June
Early post emergent (3-4 node)	17th July
Post emergent (5-6 node)	29th July
Late post emergent (8 node)	18th August

Treatments were visually assessed and scored for herbicide effects on the 1st of September (Table 1).

Crop damage ratings were:

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

Results

Many of the herbicides are not registered for the crops that have been sprayed. It is important to check the herbicide label before following strategies used in this demonstration. Herbicide effects can vary between seasons and depend on soil and weather conditions at time of application.

In 2015, a number of the herbicide treatments produced different crop tolerance affects compared to other seasons and care should be taken when interpreting these results.

Majority of the post sowing pre-emergent (PSPE) herbicide applications in 2015 had no effect on crop growth compared to the nil. Terbyne gave a moderate effect on beans, even at the registered rate.

In 2013, Broadstrike was one of the safest herbicides at the 3rd node stage, but in 2015 and 2014 produced severe effects to both vetch varieties (RM4 and Volga) and Frontier clover and Wilpena Sulla. Simazine caused greater damage on the chickpeas and lentils compared to 2014. At this timing, metribuzin was also more damaging to both lentil varieties. Treatments containing Brodal Options were safer on Gunyah peas compared to 2015, along with Raptor on beans.

In the post emergent treatments a range of herbicides produced very good control of all the oilseed and legume crops. These included Ecopar, Carfentrazone, Conclude, Paradigm, Precept, Velocity, Flight, Triathlon and Banvel M. Ecopar was safer on field peas in 2015, but this result would not normally be expected. Adding Metribuzin to carfentrazone did not generally improve the control of volunteer legumes, apart from Hurricane lentils and Frontier balansa clover.

Vortex is a new entry from Adama and is a broadleaf herbicide for cereals. It consists of 6.25g/L of Florasulam and 300g/L 2,4,D LV Ester and the recommended application rate is 820mls/ha plus Uptake oil at 0.5%.

In the 8 node treatments Gunyah peas were a standout by tolerating MCPA sodium and amine, and a low rate of 2,4-D ester. A low rate of 2,4-D ester on both vetch varieties (RM4 and Volga) and Genesis090 chickpea resulted in more damage than would normally be expected.

Table 1. Crop damage ratings for legume and oilseed herbicide tolerance trial at Hart 2015.

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

				Pasture			Lentil		Vetch		C/pea	Pea	Bean	Canola		
				Angel	Frontier	Wilpena Sulla	Jumbo 2	Hurricane	Volga	RM 4	Genesis 090	Gunya	Nura	Diamond	Gem	44Y89
Number	Timing	Treatment	**Rate kg/ha**	10	15	15	55	45	45	45	80	100	140	5	5	5
1		NIL		1	1	1	1	1	1	1	1	1	1	1	1	1
2		Propyzamide (900 g/kg)	550 g	1	1	1	1	1	1	1	1	1	1	1	1	1
3		Diuron (900 g/kg)	550 g	3	5	5	1	1	1	1	1	1	1	3	3	3
4		Simazine (600 g/L)	850 g	5	6	5	1	1	1	1	1	1	1	2	1	3
5		Simazine (600 g/L)	1275 g	5	6	5	2	3	2	1	3	1	1	3	1	5
6		Diuron (900 g/L) + Simazine (600 g/L)	410 g /410 g	4	6	5	1	1	1	2	2	1	1	2	1	1
7		Metribuzin (750 g/kg)	280 g	4	6	3	2	2	2	2	1	1	1	5	2	6
8	**PSPE 2/6/15**	Metribuzin (750 g/kg)	420 g	4	6	4	2	2	3	2	1	1	2	6	3	6
9		Terbyne (875 g/kg)	1000 g	5	6	5	2	2	1	1	1	1	3	5	2	5
10		Terbyne (875 g/kg)	1500 g	6	6	6	4	4	2	2	2	2	3	5	3	6
11		Spinnaker	100g	2	6	6	5	2	3	4	4	3	4	6	6	2
12		Spinnaker + Simazine	40 g/850 g	4	6	6	4	3	4	4	2	2	3	6	6	4
13		Balance	100 g	6	6	6	6	6	6	5	1	5	5	6	6	6
14		Balance + Simazine	100 g /830 g	6	6	6	6	6	6	5	1	5	5	6	6	6
15		NIL		1	1	1	1	1	1	1	1	1	1	1	1	1
16		Simazine (600 g/L)	850 g	4	6	1	3	2	2	2	3	1	1	1	1	1
17		Metribuzin (750 g/kg)	280 g	5	6	1	4	4	5	4	5	2	3	4	2	5
18	**3-4 Node 17/7/15**	Broadstrike + wetter	25 g/0.2%	1	4	4	4	2	5	3	1	2	5	5	5	1
19		Brodal Options	150 mL	3	4	5	2	1	2	3	4	1	4	2	2	2
20		Brodal Options + MCPA Amine	150 mL/150 mL	3	4	5	3	3	4	4	4	1	5	4	4	4
21		Spinnaker + wetter	70 g/0.2%	1	3	4	5	1	3	4	4	2	3	6	6	2
22		Raptor + wetter	45 g/0.2%	2	5	4	5	1	3	4	5	2	1	6	6	3
23		NIL		1	1	1	1	1	1	1	1	1	1	1	1	1
24		Logran + wetter	10 g/0.1%	1	6	5	5	4	6	6	6	5	6	6	6	2
25		Ally + wetter	7 g/0.1%	5	6	6	5	5	6	5	6	5	6	6	6	2
26		Eclipse SC + wetter	50 mL/0.5%	5	6	4	5	4	6	5	5	5	6	5	5	2
27		Ecopar + MCPA Amine	400 mL/500 mL	2	1	4	4	4	5	5	5	1	5	5	5	5
28		Carfentrazone + MCPA Amine	100 mL/500 mL	3	4	4	5	5	5	5	6	4	4	5	5	5
29		Conclude + Uptake	700 mL/0.5%	5	6	6	6	5	6	6	6	5	6	6	6	5
30		Paradigm + Uptake	25 g/0.5%	5	6	6	6	5	6	6	6	5	6	6	6	5
31		Precept + Hasten	750 mL/1%	5	5	5	6	6	6	5	5	5	5	6	6	6
32	**5-6 Node 29/7/15**	Velocity + Hasten	670 mL/1%	6	6	6	6	6	6	6	6	6	6	6	6	6
33		Flight EC	720 mL	4	4	6	5	5	5	5	6	1	6	6	6	6
34		Triathlon	1000 mL	3	5	6	5	5	5	5	6	2	5	6	6	6
35		Banvel M	1000 mL	5	5	5	6	6	6	6	6	5	6	5	5	5
36		Intervix + Hasten	600 mL/1%	1	6	5	5	1	5	5	6	5	5	6	6	1
37		Hussar OD + wetter	100 mL/0.25%	5	6	6	6	5	6	6	6	6	6	6	6	4
38		Crusader + wetter	500 mL/0.25%	4	6	5	6	5	6	6	6	6	6	6	6	2
39		Atlantis OD + Hasten	330 mL/0.5%	5	5	5	5	1	6	6	6	5	5	6	6	1
40		Atrazine + Hasten	833 g/1%	6	6	5	6	6	6	5	6	5	3	5	1	5
41		Lontrel 600	150 mL	6	6	6	6	6	6	6	6	5	6	1	1	1
42		NIL		1	1	1	1	1	1	1	1	1	1	1	1	1
43	*18-08-15*	Vortex + Uptake	820 mL/0.5%	4	6	6	6	6	6	6	6	5	6	6	6	6
44		MCPA Sodium (250 g/L)	700 mL	3	3	1	4	4	5	5	4	1	5	2	4	4
45		MCPA Amine (750 g/L)	350 mL	2	3	4	4	5	5	5	5	2	5	4	4	4
46		Amicide Advance 700	1200 mL	3	3	4	5	5	5	5	5	5	5	4	5	5
47	**8 Node 18/8/15**	2,4-D Ester (680 g/L)	70 mL	1	1	1	1	1	4	4	4	1	1	1	1	1
48		Sprayseed	2000 mL	5	5	5	6	6	5	5	6	6	5	6	6	6
49		Gramoxone	1000 mL	5	5	5	5	5	5	5	5	5	5	6	6	6
50		Glyphosate	1000 mL	6	6	5	5	5	5	5	5	5	4	6	6	6

Assessment of alternative fungicides for improved blackspot control in field peas

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Key Findings:

- The optimum agronomic sowing window for field pea coincided with high blackspot in many districts of South Australia in 2015.
- Under such high disease risk situations, growers in low rainfall areas may be best suited to choose alternative break crop options to field pea to avoid significant yield losses through delayed sowing or disease infection.
- Experimental fungicide treatments with greater efficacy than mancozeb showed improved blackspot control and significant yield increases over the nil and mancozeb treatments in 2015. Further assessment and application approval is still required.

Why do the trial?

Blackspot or ascochyta blight, remains one of the most economically important diseases in field peas often resulting in significant yield losses either directly through infection or indirectly through delaying sowing time to minimise infection. The use of fungicides to control blackspot disease can be an important component of disease management and also assist in maintaining yield potential through enabling agronomically acceptable sowing times. Research in the Mid North of SA has shown that a fungicide application strategy, using P-Pickel T® and two foliar mancozeb applications (9 node and early flowering) at 2 kg/ha suppresses blackspot and is generally economical in crops yielding 1.5 t/ha or greater. The aim of this project was to test the efficacy of a range of experimental (unregistered) foliar fungicides against the above strategy in controlling blackspot in field pea in three major production areas of South Australia.

How was it done?

Plot size	2.0 m x 10.0 m	**Fertiliser**	MAP (10:22) + Zn (2%) @ 90 kg/ha
Seeding date	Hart – 30th April Minnipa - 1st May Pinery – 7th May		

Field pea blackspot fungicide management trials were conducted at three sites Hart and Pinery, which represented medium rainfall zones and Minnipa which represented low rainfall zone. Trials were designed as Randomized Complete Block Design (RCBD), replicated three times with eight fungicide treatments and a nil treatment. Fungicide treatments and application timings are presented in Table 1. The dual purpose (grain/forage) field pea type PBA Coogee was sown at 55 plants/m^2 at all sites due to its increased biomass production, lodging and blackspot susceptibility over Kaspa. The plot sizes were 10 m by 2.0 m with six rows sown on 30 cm (12 inch) spacings. Trial sowing dates were as shown above. The Hart sowing date corresponded to a medium blackspot risk sowing window while Pinery and Minnipa sowing dates were within high blackspot risk sowing windows as forecasted by the Blackspot Manager, DAFWA Crop Disease Forecasts, May 2015.

Table 1. Foliar fungicide treatments and application timings

Treatment	Timing
Nil	
PPT*	
Mancozeb_PPT	8 weeks after sowing (WAS) and early flowering
Chlorothalonil_ PPT	Fortnightly in front of rain events from 8 WAS
Fluid_Flutriafol	seeding
Fluid_Uniform	seeding
Aviator Xpro _PPT	8 WAS and early flowering
Amistar Xtra_PPT	8 WAS and early flowering
Cabrio_PPT	8 WAS and early flowering

*PPT = P-Pickle T® seed treatment @ 200 ml/100 kg seed (360g/L Thiram & 200g/L Thiabendazole) #All treatments were treated with Apron® (350 g/L Matalaxyl-M) seed dressing to control downy mildew
***Some of the fungicide treatments in this research contain unregistered fungicides, application rates and timings and were undertaken for experimental purposes only.*

Blackspot disease was assessed visually at 9 to 10 node (early bud development) and the mid - late flowering stage. Assessment at 9 to 10 node was done as percentage blackspot severity per plot while the final assessment was conducted on five individual plants selected at random from the centre of each plot and scored for the number of girdled nodes. A disease index (DI) was further developed from these scores. Only data from the 9-10 node rating has been presented in this report.

Results and discussion

Low summer rainfall followed by high rainfall during the month of April led to relatively late release of blackspot spores in 2015 and all trials were sown into medium or high risk disease situations. The wet winter climatic conditions favoured plant growth and disease progression, and black spot infection was apparent at all sites. The Minnipa trial was spread with infected pea stubble from the previous year post sowing but prior to emergence and disease onset occurred earlier at this site. The interaction between fungicide treatment and site was significant for blackspot disease infection as measured by percentage plot disease severity at the 9-10 node stage (Table 2). Minnipa had the highest level of disease infection and it was thought that the timing of the first foliar fungicide spray occurred too late for effective control at this site. Similar levels of infection were observed at Hart and Pinery. The fluid injection Uniform and PPT treatments showed similar levels of disease infection to the nil at all sites. Disease severity levels were lower in the mancozeb and fluid flutrifol when compared with the nil, however this reduction in the mancozeb treatment was only significant at Hart. Fortnightly Chlorothalonil treatments reduced disease infection over the nil at Hart and Minnipa but not at Pinery while the Amistar® Xtra treatment reduced infection levels at Hart and Pinery but not at Minnipa. The Cabrio® and Aviator® Xpro treatments showed the highest level of disease reduction over the nil. Further, Cabrio® was also improved over mancozeb at Hart and Aviator® Xpro improved over mancozeb at Hart and Pinery. At Hart, Aviator® Xpro showed an improved level of blackspot control over all other treatments.

Grain yields of field peas at all sites were reduced greatly by a very hot and windy day on October 4th which led to rapid maturity and dry down. There was no site by fungicide treatment effect for grain yield. The Hart and Minnipa sites had similar grain yields (1.6 t/ha) and Pinery was lower yielding (1.2 t/ha). Grain yields showed a very similar response to the mid-flowering disease index scores (data not shown) with similar responses obtained in the nil, mancozeb, PPT and fluid treatments. All these treatments had both a higher disease index score and a lower grain yield than the remaining four treatments (Figure 1).

Table 2. Blackspot severity assessed at 9 to 10 node as percentage plot severity PBA Coogee under different fungicide treatments at Hart, Pinery and Minnipa, 2015.

Treatment	Hart		Minnipa		Pinery	
Nil	23.7	a.....	36.6	a...	21.1	a....
Amistar Xtra_PPT	5.8	....e.	29.7	abc.	13.1	.bcd.
Aviator Xpro _PPT	3.6	.....f	19.1	..cd	7.9	....e
Cabrio_PPT	6.8	...de.	21.1	.bcd	12.2	..cde
Chlorothalonil_PPT	9.3	..cd..	17.1	...d	14.4	abcd.
Fluid_Flutriafol	15.0	.b....	22.9	.bcd	10.4	...de
Fluid_Uniform	28.0	a.....	30.0	ab..	19.6	ab...
Mancozeb_PPT	12.2	.bc...	29.7	abc.	16.5	abc..
PPT	28.2	a.....	26.2	abcd	18.2	abc..
Site mean	11.8		25.1		14.2	

*log base 10 back transformed data; letters indicate significance within a site only

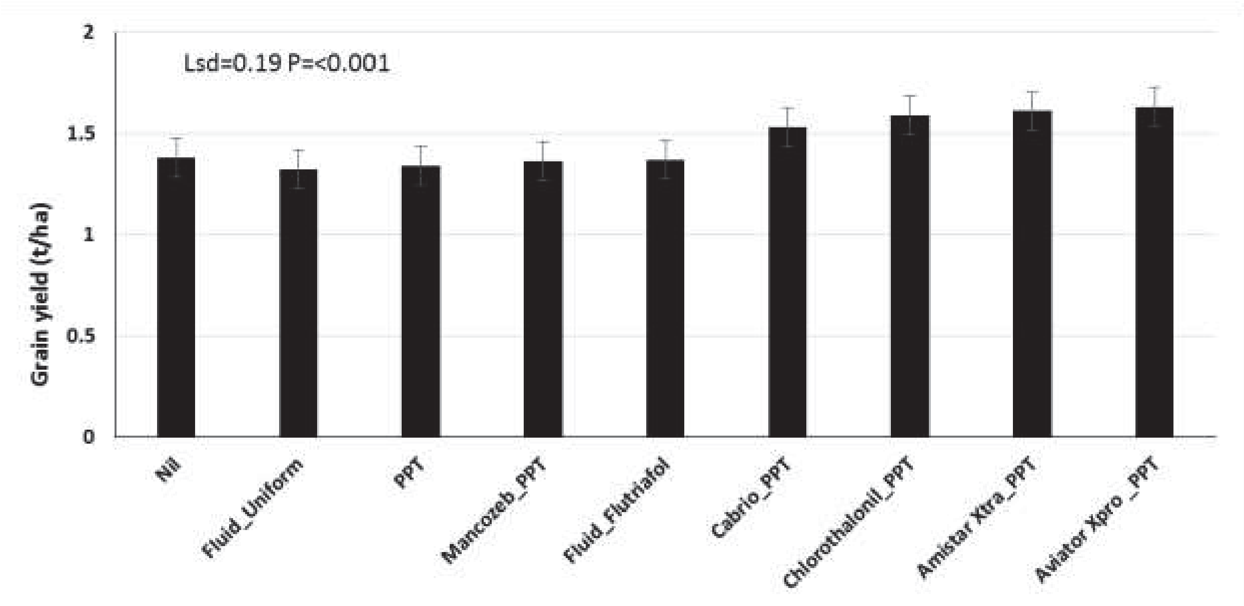

Figure 1. Mean yield (t/ha) of field pea (PBA Coogee) under different fungicide treatments averaged across three field sites, 2015.
***Some of the fungicide treatments in this research contain unregistered fungicides, application rates and timings and were undertaken for experimental purposes only. The results within this document do not constitute a recommendation for that particular use by the author or author's organisation.*

Several experimental fungicides in field pea were effective in both reducing blackspot levels below and increasing grain yields above that achieved in the nil and mancozeb treatments at multiple field sites in SA in 2015. Disease progression and grain yield were both reduced by dry and hot spring conditions in early October at all sites and further evaluation is warranted in years and environments with more favourable spring conditions. Earlier application timings than the eight week treatment used in these experiments may also be warranted along with additional 'spring' treatments in longer more favourable seasons.

Summary / implications

Weather patterns experienced early in 2015 resulted in growers in many districts being advised by DAFWA's Blackspot Manager Prediction model to delay sowing of field peas in SA. This timing was often out of alignment with optimal sowing times based on best agronomic practice for some districts. Growers in these districts had to decide whether to choose an alternative crop, sow field peas into high blackspot-risk situations, or delay sowing date past the optimal window for successful production. Under these circumstances, growers could also revise their blackspot management strategy and consider recommended fungicide applications to manage this disease. If going against the Blackspot Manager recommendations, and choosing to sow into periods where a high risk of blackspot spore showers are predicted in your region, growers should consider an alternative break crop to field pea. However, if field peas are preferred it is important to consider the following to reduce the risk of blackspot outbreaks:

- Apply P-Pickle T seed treatment (PPT) to seed prior to sowing and follow up with current recommended fungicide strategies of two applications of mancozeb, one at 8-weeks after sowing and one early flowering.
- Select paddocks with no history of field pea, or paddocks with a long break period from field pea and history of a low incidence of blackspot.
- Avoid close proximity to previous field pea stubbles, particularly downstream to prevailing wind direction.
- Delay sowing as long as possible.

A number of industry support groups have reported the economic benefit of using fungicide in controlling blackspot in field pea. Results in 2015 showed the current fungicide application strategy, using PPT and two mancozeb applications, suppressed blackspot at most sites, but previous yield benefits reported from this treatment were not realised due to the dry spring experienced in 2015. However, new fungicide actives and formulations being evaluated showed significant increases in efficacy for controlling blackspot compared to both untreated plots and those treated with mancozeb. Furthermore, a significant yield benefit (approx. 15%) were also identified in these treatments this year. Further trials are planned in 2016 to explore these results.

Acknowledgement

Funding for this work was provided through GRDC project DAV00113 (Southern Pulse Agronomy) and their support is greatly appreciated. We also acknowledge the support of research colleagues from the SARDI teams at Clare and Minnipa. Much gratitude also goes to the land owners/managers of the different farms where the trial sites were located and to Rob Griffith Bayer CropScience Pty Ltd for providing Aviator Xpro.

New fungicide options in barley

Sarah Noack and Peter Hooper, Hart Field-Site Group
Nick Poole, Foundation for Arable Research Australia

Key Findings:

- Disease pressure in the trial was low however, there were measurable differences in SFNB and scald for all treatments compared to the control.
- Systiva (seed treatment) provided similar control compared to all in-season applied foliar fungicides.

Why do the trial?

In previous seasons net form net blotch (NFNB) and spot form net blotch (SFNB) have been difficult to control on some barley varieties. Changes in net blotch strains overcoming cultivar resistance, larger plantings of susceptible cultivars and earlier times of sowing have all helped to elevate the importance of controlling these diseases.

Recently, BASF introduced the SDHI fluxapyroxad fungicide as the seed treatment Systiva® for the control of both NFNB and SFNB. Research has shown this product has the potential to replace the first fungicide timing (generally GS30-31) as this seed treatment has systemic activity and good persistence on foliar disease.

The aim of this trial was to demonstrate newly available fungicide products in comparison to existing standards.

How was it done?

Plot size	1.75 m x 8.0 m	**Fertiliser**	DAP (18:20) + Zn 2% @ 100 kg/ha
Seeding date	27th May 2015		

Charger barley was the cultivar selected for this trial (VS and SVS for net form and spot form net blotch respectively) and was sown into a stubble from Commander barley in 2014. The trial was a randomised complete block design with 3 replicates and 10 fungicide treatments (Table 1). Herbicides were applied as necessary to keep the crop canopy free of weeds. All plots were assessed for SFNB infection (October 1st 2015) and selected plots for leaf scald (September 25th 2015).

Table 1. Summary of all fungicide treatment including product name, active ingredient, group and barley growth stage when applied.

	Product and rate	Active ingredient / Group*	Growth stage
1	Nil		
2	Systiva @ 150 mL/100 kg seed	Fluxapyroxad (group 7)	Seeding
3	Systiva @ 150 mL/100 kg seed + Tilt foliar application 0.5 L/ha	Fluxapyroxad (group 7) + propiconazole (group 3)	Seeding + GS49
4	Tilt foliar application 0.5 L/ha	Propiconazole (group 3)	GS31
5	Tilt foliar application 0.5 L/ha	Propiconazole (group 3)	GS31 + GS49
6	Tazer Xpert 1.0 L/ha	Azoxystrobin (group 11)	GS31
7	Experimental 750 mL/ha	-	GS31
8	Prosaro 150 mL/ha	Prothioconazole (group 3) + tebuconazole (group 3)	GS31 + GS49
9	Amistar 400 mL/ha	Azoxystrobin (group 11)	GS31
10	Radial 500 mL/ha	Azoxystrobin (group 11) + epoxiconazole (group 3)	GS31

**FRAC group code list*

Results and discussion

The disease pressure in the trial was low due to lack of rainfall and low crop canopy humidity. The number of SFNB lesions were still however, greatest in the nil (Table 2). There were minor variations among the remaining fungicide treatments. The results show that 127 days after sowing the level of infection in the Systiva alone treatment was similar to all foliar applied treatments.

Table 2. Number of SFNB lesions present on the F, F-1 and F-2 leaves on 1st October, 2015.

Treatment	No. of lesions
1. Nil	6.2
2. Systiva 150 ml/ 100 kg seed	3.7
3. Systiva 150 ml/100 kg seed + Tilt 0.5 L/ha @ GS31	3.1
4. Tilt 0.5 L/ha @ GS31	3.7
5. Tilt 0.5 L/ha @ GS31 + GS49	3.9
6. Tazer Xpert 1.0 L/ha @ GS31	4.5
7. Experimental	3.8
8. Prosaro 150 mL/ha @ GS31 + GS49	2.4
9. Amistar 400 mL/ha @ GS31	3.4
10. Radial 500 mL/ha @ GS31	4.2
Mean	3.9
LSD (P≤0.05)	1.3

Selected treatments were also assessed for scald infection. There was a reduction of the number of large scald foci and incidence on the flag leaf for all fungicide treatments assessed 121 days after sowing (Table 3).

Table 3. Scald infection (%) and hotspot incidence assessed on 25th of September at Hart.

	Incidence of scald on leaf layer			Hotspot incidence*	
Treatments	Flag	Flag-1	Flag-2	Large	Small
1. Nil	20.0[a]	40.0	33.3	4.3[a]	0.3
2. Systiva @ 150 mL/100 kg seed	3.3[b]	36.7	23.3	0.3[b]	1.0
5. Tilt 0.5 L/ha @ GS31 + GS49	0.0[b]	13.3	13.3	0.3[b]	1.3
8. Prosaro 150 mL/ha @ GS31 + GS49	0.0[b]	6.7	40.0	0.7[b]	1.3
Mean	5.8	24.2	27.5	1.4	1.0
LSD ($P \leq 0.05$)	10	ns	ns	2.8	ns

**Large hotspot >10 infected leaves, small hotspot < 10 infected leaves.*

Long term cropping systems trial

Sarah Noack, Hart Field-Site Group

Key findings

- There was no significant difference between seeding systems or level of nutrition on grain yield or oil content.
- Soil available N was the same for all seeding systems pre-seeding however, the no till treat had released more available soil N.
- In-season more available N was measured in the high nutrition treatment compared to the medium.

Why do the trial?

To compare the performance of three seeding systems and two nitrogen strategies. This is a rotation trial to assess the longer 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	35 m x 13 m	**Fertiliser**	DAP/Urea (22:14:00:05) + 0.8% Zn at seeding @ 100 kg/ha
Seeding date	3rd June 2015	**Medium nutrition**	UAN (42:0) @ 87 L/ha on 11th Aug
Variety	44Y89 (CL) canola @ 5 kg/ha	**High nutrition**	UAN (42:0) @ 87 L/ha on 11th Aug and 87 L/ha on 16th Sept

The trial was a randomised complete block design with three replicates, containing three tillage/seeding treatments and two nitrogen (N) treatments. In addition to this in 2014 all disc treatments were harvested using a stripper front. Both the no-till and strategic stubble height were harvested at 15 cm (Figure 2). The disc, strategic and no-till treatments were sown using local growers Tom Robinson, Michael Jaeschke and Matt Dare's seeding equipment, respectively.

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

2000	2001	2002	2003	2004	2005	2006	2007
Sloop barley	Canola	Janz wheat	Yitpi wheat	Sloop barley	Kaspa peas	Kalka durum	JNZ wheat

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

Seeding treatments:

Disc – sown into standing stripper front stubble with John Deere 1980 single disc 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 (district practice).
High – starter fertiliser plus two in-season N applications.

All plots were assessed for soil available N (0-20, 20-40, 40-60 and 60-80 cm) on the 15th of April. Plant establishment was assessed by counting 4 x 1 m sections of row across each plot on 26th of June (crop growth stage cotyledon). In season soil N was assessed on 19th of August (crop growth stage bud visible-first flowers). All plots were assessed for grain yield and oil content at harvest (16th November).

Results and discussion

Soil available N to a depth of 80 cm was measured in autumn and ranged between 33 kg N/ha (no-till) and 80 kg N/ha (strategic). The high nutrition treatment had not accumulated more available N compared to the medium treatment.

Pre-seeding the no-till treatment had mineralised more available N, while in season there was no difference between seeding systems. At the time of sampling all plots had received 60 kg N/ha (that is, high N rate had not been applied). The average difference between the two nutrition rates was 43 kg N/ha. This increase in available N can be attributed to the long-term addition of higher N levels in these plots, building up organic N levels and mineralising more available N in-season.

Table 1. Available soil nitrogen (kg/ha) pre-seeding and in season and plant emergence (plants/m^2) for seeding treatments in 2015.

Seeding system	Nutiriton	Available soil N 15th April	Available soil N 19th August	Emergence
		kg N/ha	kg N/ha	plants/m^2
Strategic	Medium	51	130	56
	High	108	208	70
Disc	Medium	43	130	57
	High	71	169	68
No-till	Medium	31	157	78
	High	35	169	83
LSD (P≤0.05)				
Tillage		35	ns	22
Nutrition		ns	30	ns
Seeder × Nutrition		ns	ns	ns

Crop emergence was highest for the strategic and disc seeding systems 84 and 71 plants per square metre, respectively (Figure 2). The no-till treatment had the lowest crop establishment with 51 plants per square metre.

Figure 2. (L-R) 44Y89 (CL) canola sown with a disc seeder into stripper front stubble, no-till treatment and strategic tillage treatment taken on 18th August, 2015.

Seeding treatment did not affect the grain yield of 44Y89 canola, averaging 0.55 t/ha (Table 2.). The canola yields were not reflective of the district given the late sowing date to coincide all seeding equipment. Similarly, there was no difference in oil content, averaging 35.8% across the trial.

Table 2. Grain yield (t/ha) and oil content (%) for nutrition and seeding treatments in 2015. There was no significant interaction (P≤0.05) between seeding system and nutrition.

Seeding system	Nutiriton	Yield t/ha	Oil content %
Strategic	Medium	0.56	35.6
	High	0.61	35.1
Disc	Medium	0.53	36.2
	High	0.54	35.6
No-till	Medium	0.55	36.4
	High	0.51	35.7
LSD (P≤0.05)			
Seeder × Nutrition		ns	ns

Acknowledgements

The HFSG thank the South Australians Grains Industry Trust (SAGIT) for providing funding to support this research (H0113). We also thank all the growers who assisted with trial seeding, spraying and harvesting. Thanks to Pete McEwin and Stuart McIntosh for donating seed for the trial.

Influence of seeding systems and stubble management on pre-emergent herbicides

Sam Kleemann[1], Sarah Noack[2], Gurjeet Gill[1] and Peter Hooper[2]
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Key findings

- Pre-emergent herbicides can cause crop damage. Separation of the herbicide from crop seed is essential for crop safety, which is more easily achieved in knife-point & press wheel seeding systems but considerably more difficult with low soil disturbance single discs.
- Crop stubble can intercept & bind pre-emergent herbicides, which affects crop safety & herbicide efficacy. Low solubility herbicides such as trifluralin have a tendency to bind strongly to crop residues, which reduces the potential for crop damage but also limits its ability to provide effective weed control in situations with heavy stubble load.
- Choose the right herbicide for the job – not all pre-emergent herbicides behave the same so follow label recommendations closely.

Why do the trial?

Over the last two decades seeding equipment used by the growers has changed considerably, which can greatly affect weed control and crop safety of pre-emergent herbicides. The behaviour of pre-emergent herbicides can be influenced by soil type, the amount of soil disturbance, the level of incorporation, the position of weed seeds in the soil and the amount crop stubble present.

Given that most pre-emergent herbicides can cause some crop damage, herbicide safety at sowing is often obtained by creating '**positional selectivity**'. This is achieved by creating physical separation between the crop seed and herbicide. Achieving this separation involves the seeding system displacing and throwing herbicide treated soil into the inter-row to create a low herbicide environment in which crop seed can safely germinate. This objective is more easily achieved by tined seeding systems fitted with knife-points which can aggressively engage the soil than low disturbance discs.

The aim of this study was to evaluate the effect of crop stubble management and seeding system on pre-emergent herbicide behaviour and crop safety.

How was it done?

Plot size	10.0 m x 12.0 m	**Fertiliser**	DAP/urea (22:14) @ 100 kg/ha at seeding Urea/SOA (33:00:00:11) @ 100 kg/ha 21st June Urea (46:00) @ 80 kg/ha 31st July
Seeding date	3rd June 2015		
Seeding rate	100 kg/ha Mace wheat		

To assess the impact of seeding systems & crop stubble on pre-emergence herbicides, a large field trial using commercial scale machinery was established at Hart during 2014 harvest. This involved establishing four different crop stubble treatments summarised in table 1.

Table 1. Summary of wheat stubble treatments in 2015.

Stubble treatment
Baled – stubble cut with stripper front, slashed (9 cm high) and removed
Short – stubble retained cut to height of 15 cm
Medium – stubble retained and cut to height of 30 cm
Tall – stubble retained and cut using stripper front, height 80 cm

Each stubble treatment was split at sowing between a standard knife-point press wheel system on 25 cm (10") row spacings and a John Deere single disc (JD) on 15 cm (6") row spacings. Pre-emergent (pre-seeding) herbicide treatments were applied perpendicular to the direction of sowing and included:

1. Trifluralin (1.5 L/ha) + triallate (1.6 L/ha) IBS
2. Sakura (118 g/ha) IBS
3. Boxer Gold (2.5 L/ha) IBS
4. Boxer Gold (1.0 L/ha) + triallate (1.6 L/ha) IBS + Boxer Gold (1.5 L/ha) POST

The trial design is a modified split-split plot; with crop stubble treatments assigned to main-plots, seeding systems to sub-plots and pre-emergent herbicides to sub-sub-plots with 3 replicates. Pre-emergent herbicides were applied within a few hours of sowing in the incorporated by sowing (IBS) treatment, while post-emergent (POST) Boxer Gold was applied when the wheat had reached 1-3 leaf growth stage (29/6/15). All herbicides were applied in 100 L/ha water volume.

Stubble height was assessed prior to seeding by removing 4 x 1 m cuts per plot. Plant establishment was assessed by counting 4 x 1 m sections of row across each plot. All plots were assessed for grain yield, protein, test weight and screenings.

Results and discussion

Crop establishment

Wheat seedling establishment was significantly affected by the interaction between herbicides and seeding system (Figure 1). Trifluralin plus triallate significantly reduced wheat emergence under the JD single disc (<50%) but not under the knife-point system (Figure 1; 175 plants/m^2). Incorporated by sowing and split applications (IBS & POST) of Boxer Gold also reduced wheat emergence under single disc, however the damage was minor (15-25%) relative to trifluralin plus triallate (Figure 2). In contrast, no crop damage was observed in Sakura plots. These results are consistent with the findings of several field trials undertaken over the last 5 years at Roseworthy, which have shown Sakura to be the safest herbicide option for use in discs.

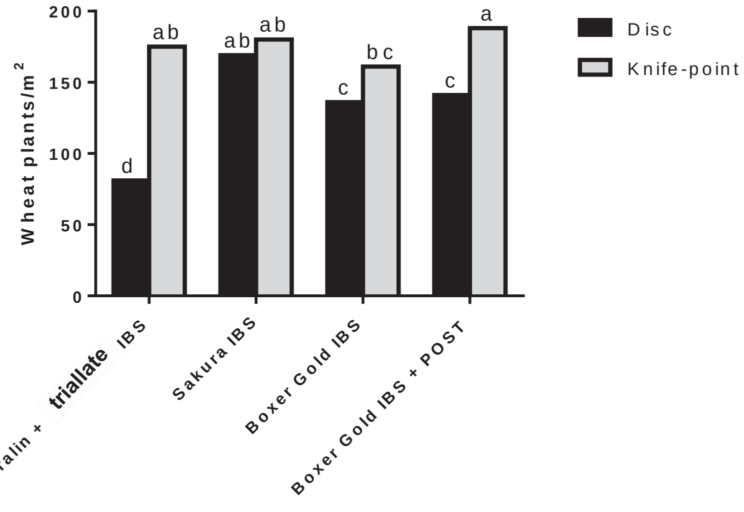

Figure 1. Effect of pre-emergence herbicides on wheat establishment (plants/m^2) in JD single disc and standard knife-point press wheel system. Bars with different letters represent the significance ($P \leq 0.05$) of the interaction between seeding system & herbicide.

The higher soil disturbance knife-point system has been previously shown to create enough soil throw to remove herbicide treated soil out of the furrow. The single disc however appears to leave most of the herbicide treated soil in the furrow, where it is in close proximity to crop seed. Previous research (Kleemann et al. 2014) has also shown that crop damage from pre-emergent herbicides can be reduced by fitting residue managers in front of the single disc modules. The residue managers appeared to remove some herbicide treated soil from the furrow, which in turn would have reduced crop damage from the pre-emergence herbicides. Similar crop safety has been observed with triple discs, whereby the leading coulters act in the same manner to remove herbicide ahead of the disc openers (Kleemann et al. 2012). In this study at Hart, the single disc system was not fitted with any residue manager and this may be the reason for poor wheat establishment in trifluralin plus triallate.

Figure 2. Trifluralin + triallate sown with (left) JD disc and (middle) knife point press wheel and (right) Sakura sown with JD disc.

Even though there were large differences between crop stubble treatments in height (15 cm *Vs*. 80 cm) and ground cover, herbicide × seeding system interaction was non-significant (Table 2). There was, however, a trend for greater crop damage in the disc system with trifluralin plus triallate in the short stubble (49 plants/m^2) than in the long-stubble treatment. This is not surprising, given the tall stripper front stubble would have intercepted a much greater amount of herbicide, resulting in less herbicide reaching the soil surface to cause crop damage.

Table 2. Effect of stubble height on plant establishment (plants/m^2) for JD single disc and standard knife-point press wheel system. No significant difference (P≤0.05) in crop establishment for stubble treatment or seeding systems.

	Baled	Short	Medium	Stripped
Disc	138	115	130	144
Knife-point	162	191	175	
LSD (P≤0.05)		ns		

Grain yield

The differences measured in crop establishment did not translate to reductions in grain yield for any seeder by herbicide combination. Grain yields ranged from 1.35 – 1.54 t/ha, averaging 1.45 t/ha across the trial (Table 3). Similarly, there was no interaction between seeder and stubble height. However, there was an effect of stubble height on its own (Figure 3), with the short stubble treatment yielding highest. As previously mentioned there was noticeable crop damage in the short stubble treatment during establishment. We suspect the lower plant number effected plant tillering (increased tiller number to form more heads or reduced tiller number and more heads filled well) increasing grain yield relative to the other stubble treatments.

Table 3. Effect of pre-emergence herbicides on wheat grain yield (t/ha) for JD single disc and standard knife-point press wheel system.

	Trifluralin + triallate IBS	Sakura IBS	Boxer Gold IBS	Boxer Gold IBS + POST
Disc	1.35	1.54	1.52	1.48
Knife-point	1.40	1.45	1.45	1.38
LSD (P≤0.05)		ns		

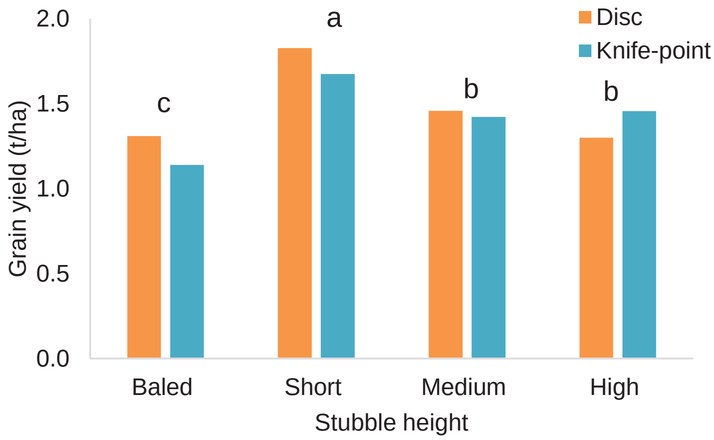

Figure 3. Effect of stubble height and seeder (JD single disc and standard knife-point press wheel) on grain yield (t/ha) at Hart, 2015. Different letters indicate significant difference (P≤0.05) between stubble treatment means (LSD = 0.15).

Summary / implications

This field trial has shown that irrespective of stubble management, wheat crops can be seriously damaged by the use of trifluralin and triallate in single disc systems. In contrast, Sakura caused no damage to wheat establishment and appears to be the safest option for use in wheat in single disc systems. Although, Boxer Gold caused a minor reduction in wheat plant density in the single disc, wheat can often compensate by producing more tillers and ears per plant to maintain grain yield.

Acknowledgements

The financial assistance of SAGIT (South Australian Grain Industry Trust) is gratefully acknowledged (H113). We also wish to thank Matt Dare, Tom Robinson and Pete McEwin for their assistance in trial preparation and implementation, and field staff from SARDI (Clare office) for providing technical support.

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Yield Prophet® performance in 2015

Sarah Noack, Hart Field-Site Group

Key findings

- Yield prophet closely predicted a final grain yield of 4.2 t/ha for Mace wheat at Hart.
- The lack of in-season rainfall in June and July meant the difference between 20% and 80% of years was only 1.5 – 2 t/ha during this time.

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 and soil nitrogen 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	1st May 2015	**Fertiliser**	30 kg N/ha 1st May 30 kg N/ha 21st July
Variety	Mace wheat @ 180 plants per square metre		

Yield Prophet® simulations were run throughout the season to track the progress of wheat growth stages and changes in grain yield predictions.

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.

Results

At the first simulation, 5th June 2015 Yield Prophet® predicted that Mace wheat sown on the 1st May would yield 5.2 t/ha in 50% of years (Figure 1). After below average rainfall in June it is not surprising that this yield prediction dropped to 4.1 t/ha on 1st July simulation. This yield prediction was closely maintained up until the end of October.

The Yield Prophet® simulation on the 28th September for grain yield, given an average (50%) finish to the season, was 4.2 t/ha, only 0.2 t/ha above the finish for 80% of years. The actual grain yield for Mace wheat sown on the 6th May at Hart in 2015 closely aligned with the predication at 4.3 t/ha.

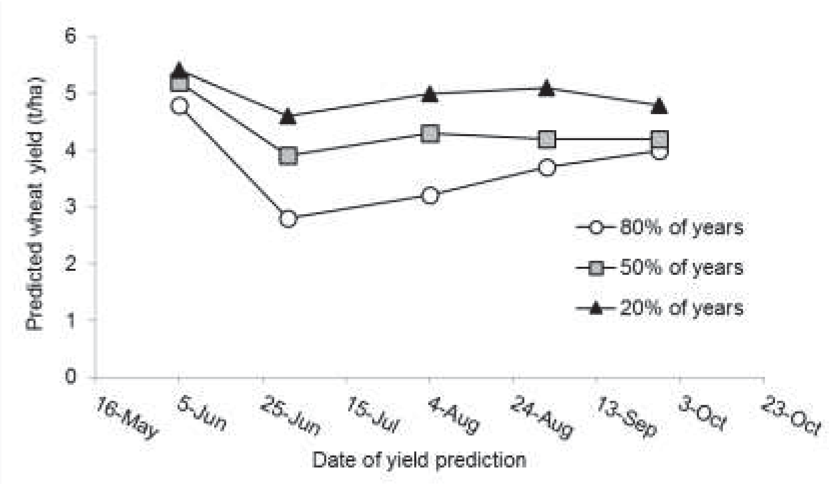


Figure 1. Yield Prophet® predictions from 5th June to the 28th September for Mace wheat sown on the 1st May, 2015. 80%, 50% and 20% represent the chance of reaching the corresponding yield at the date of the simulation.

Plant available water (PAW) (0-90 cm) when the first simulation was run at the beginning of June was 52 mm (Figure 2). This was 46 mm less stored moisture compared to the same time in 2014. Plant available water remained steady across June and July as any rainfall received was used by the crop and not available for storage. From early August the bucket increased to 70 mm and was maintained at this level until early September. With no additional rain after the end of September the PAW decreased. As seen in 2014, the 2015 season favoured earlier districts. Additional rainfall in many of the later districts was required to finish the season and reduce screening levels, although generally grain yield and quality were good in areas unaffected by frost damage.

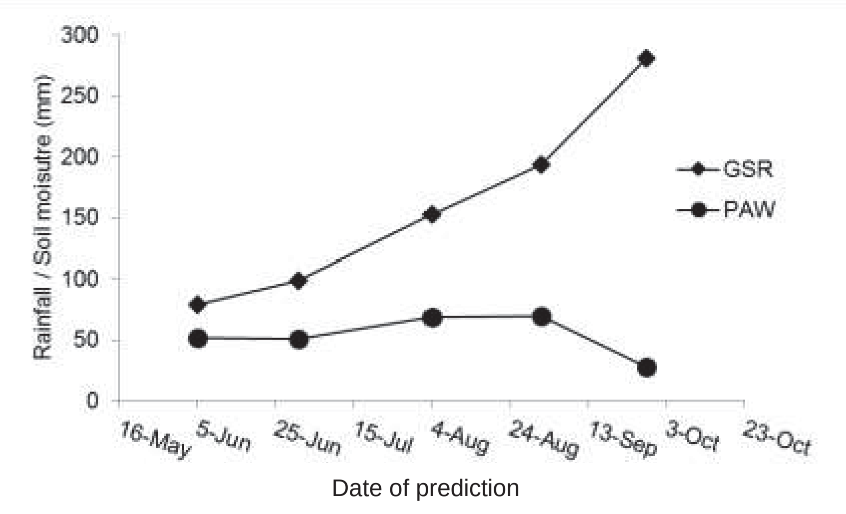


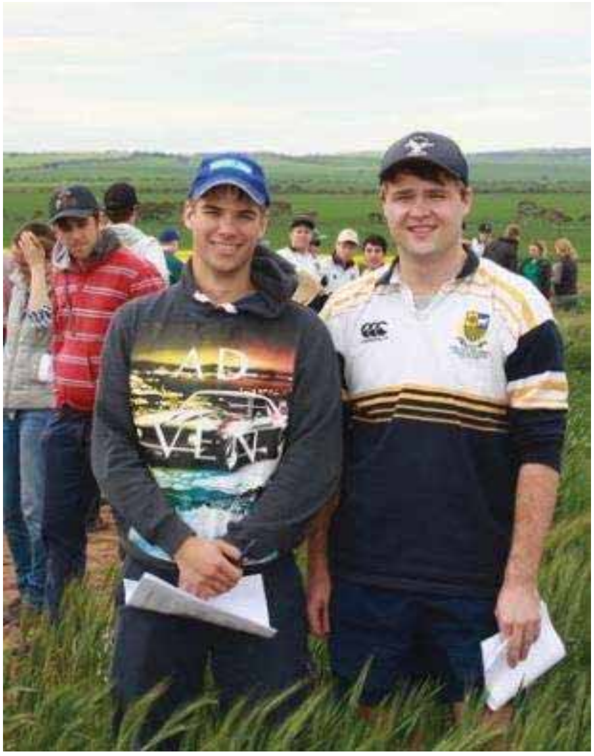
Figure 2. Predicted plant available water (PAW) and recorded cumulative growing season rainfall from 19th of June to 13th of October at Hart in 2015.

Spring Twilight Walk 2015






University students linking theory with practice at Hart



"It's vitally important for our third year students, who will be working in the industry next year, to visit a site like Hart to look at some of the leading questions farmers need addressed through research."

Dr Gurjeet Gill, University of Adelaide

20th August 2015

Notes

Notes

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