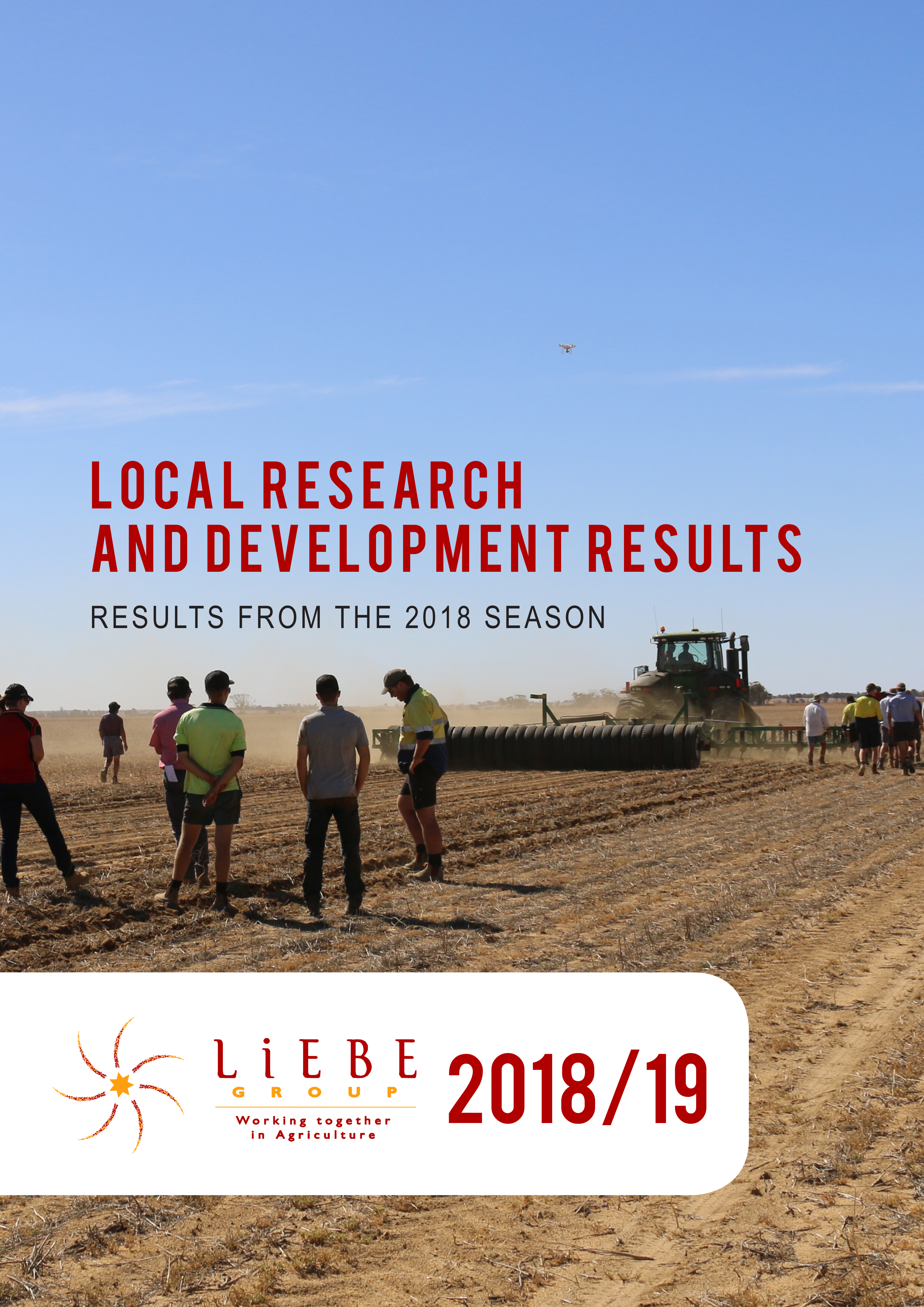

LOCAL RESEARCH AND DEVELOPMENT RESULTS

RESULTS FROM THE 2018 SEASON

LiEBE GROUP

Working together in Agriculture

2018/19

Dear Liebe Group Members and Supporters,

It is with much anticipation that we present to you the Liebe Group Local Research and Development Results Book for 2018. This book contains results from research trials and demonstrations conducted in the Liebe region from the 2018 season.

2018 was a fantastic season for many members in the Liebe Group region and saw great results coming from trials throughout the district. I would like to congratulate the Liebe Group staff team on successfully managing our geographically vast trial program in 2018 and ensuring the group can continue to deliver locally relevant research and extension activities for our members. Many thanks also to the McCreery family and Kalannie locals who contributed to a successful Main Trial Site and Spring Field Day.

All of our partners and supporters play a vital role in ensuring the continued success of the Liebe Group. We acknowledge the invaluable support we receive from the Grains Research and Development Corporation (GRDC), the Department of Primary Industries and Regional Development (DPIRD), The Farm Weekly, the Shire of Dalwallinu, the Central Wheatbelt Biosecurity Association and the Grower Group Alliance. We would also like thank our Diamond Partners Rabobank, RSM, CSBP, CBH Group and AFGRI Equipment as well as our gold and silver partners.

We are looking forward to a number of events in 2019 including:

Crop Updates and Trials Review Day on Wednesday 6th March, supported by GRDC
Women's Field Day on Thursday 20th June
Post Seeding Field Walk, Wednesday 24th July and Spring Field Day Thursday 12th September at the Keamy's Property, Watheroo; and,
The new monthly AgChat series which kick started in February

The results from this book should be interpreted with caution and decisions should not be based on one season of data. Please contact the Liebe Office if you have any further queries and we encourage you to get in touch with our research partners if you would like further information on a given trial.

We wish you all the best for a successful 2019 season and look forward to working with all you throughout the year.

Kind regards,

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Danielle Hipwell	Administration Officer	admin@liebegroup.org.au
Alana Hartley	Research and Development Coordinator	research@liebegroup.org.au
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Cover Image: Deep Ripper Demonstration Day at the 2018 Main Trial Site, Kalannie.

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LIEBE GROUP COMMITTEES 2018

The Liebe Group would like to recognise the support and contribution of the Liebe Group Management, Finance, Women's and Research and Development Committees of 2018 to the work outlined in this publication.

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Ross Fitzsimons (President)
Alex Keamy (Vice President)
Gary Butcher
Simon Metcalf
Brad McIlroy
Boyd Carter
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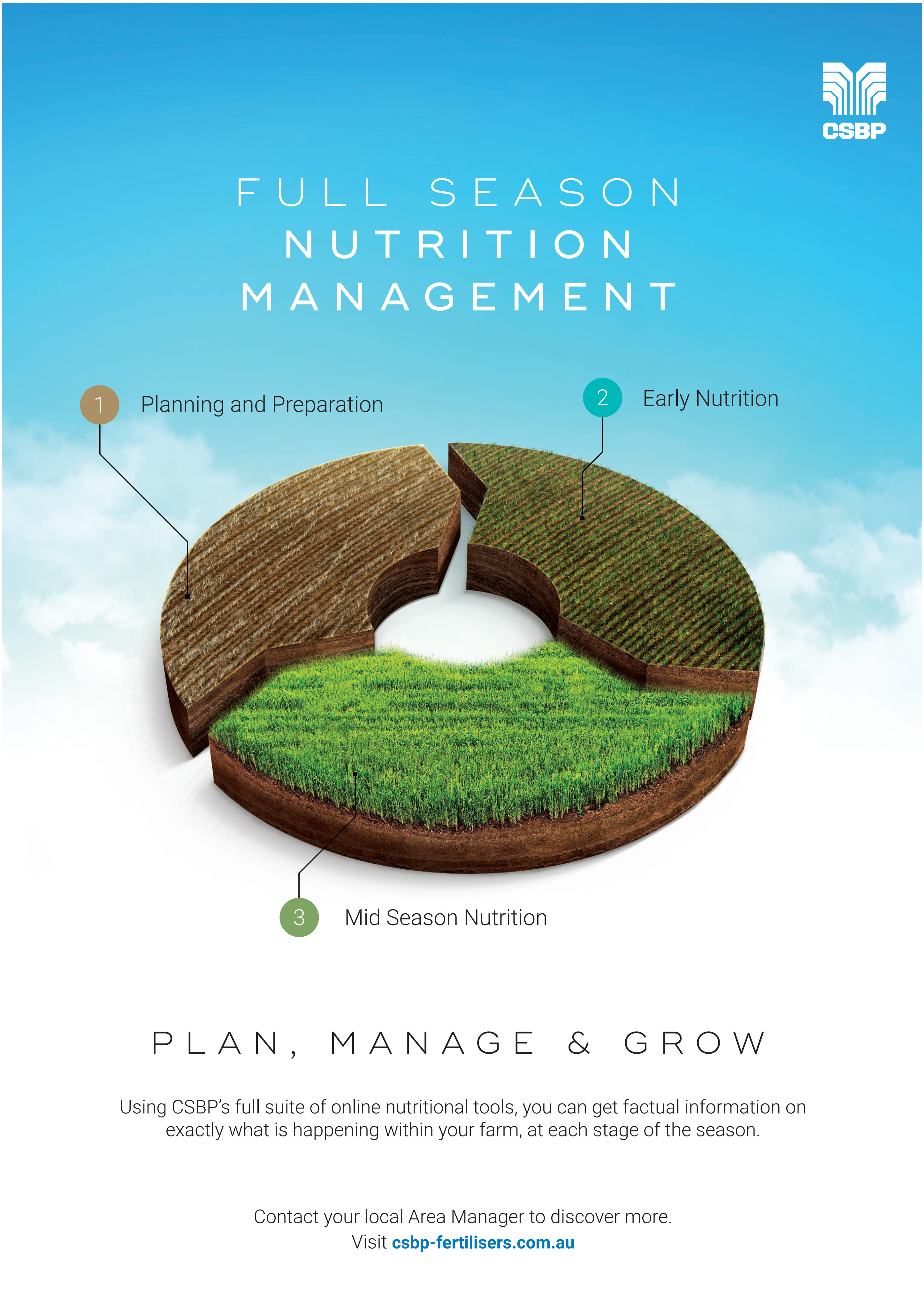
LOCAL RESEARCH & DEVELOPMENT RESULTS

Index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UNDERSTANDING TRIAL RESULTS AND STATISTICS

We have tried to present all trial results in one format throughout this results book. However, due to differences in trial designs, this isn't always possible. The following explanations and definitions should provide you with sufficient statistical understanding to get the most from the trial results.

Mean
The results of replicated trials are often presented as the average (or mean) of all replicates for each treatment. Statistics are used to determine if the difference between means is a result of treatment (e.g. different chemicals) or natural variability (e.g. soil type)

Significant Difference
In nearly all trial work there will be some difference between treatments, e.g. one rate of fertiliser will result in a higher yield than another. Statistics are used to determine if the difference is a result of treatment or some other factor (e.g. soil type). If there is a significant difference then there is a very strong chance the difference in yield is due to treatments, not some other factor. The level of significance can also play a role, this is denoted with a P value. If it says P<0.05% there is a greater than 95% probability that a difference is a result of treatment and not some other factor.

The LSD Test
To determine if there is a significant difference between two or more treatments, a least significant difference (LSD) is often used. If there is a significant difference between two treatments, their difference will be greater than the LSD. For example when comparing the yield of five wheat varieties (Table 1), the difference in yield between variety 4 and 5 is greater than 0.6 t/ha (LSD), therefore it can be said there is a significant difference. This means its is 95% (P=0.05) certain that the difference in yield is a result of variety not soil type or some other factor. Whilst there is a difference in yield between variety 1 and 2, it is less than 0.6 t/ha, therefore the difference is unable to be determined as a result of variety; it may be due to subtle soil type change or other external factors. Letters are often used to indicate which varieties are significantly different, using the LSD value (Table 1), so in this example, there is no significant different between varieties 1, 2 and 3, whereas varieties 4 and 5 are significantly different to each other and the rest of the varieties. Where the LSD result reads as 'NS' this represents that the values are not significantly different from each other.

Table 1: Yield of five wheat varieties

Treatment	Yield (t/ha)
Variety 1	2.1[a]
Variety 2	2.2[a]
Variety 3	2.0[a]
Variety 4	2.9[b]
Variety 5	1.3[c]
P value	<0.001
LSD (P=0.05)	0.6
CV (%)	9.4

The Coefficient of Variation (CV%)

The CV measures the amount of variation in the data. A low CV means less background noise or variations. Having less variation means there is more confidence in the trial results. Having high variation could mean that factors other than the one being testes are influencing the result (e.g. soil type), and if the same trial was recreated at your place, results may be different. Generally a CV of 5-10% (up to ~15%) is considered acceptable for wheat yields in field trials; some measurements would expect a higher CV, and some lower.

Non-replicated Demonstrations

This book presents the results from a range of non-replicated demonstrations. In this case we cannot say for certain if the difference in yield or quality is the result of treatment or some other factor e.g. soil type or old wheel tracks. Whilst the results from demonstrations are important, they need to be interpreted careful as they are not statistical.

Nearest Neighbour Control

Some demonstrations will indicate a nearest neighbour control. In unreplicated research, often a control treatment will be included throughout the trial so a better decision can be made regarding treatment performance. This is helpful in situation where there may be a fertility gradient in the trial paddock hence it would be better to compare treatments against the nearest neighbour control rather than against other varieties. This would give a more accurate indication of treatment performance.

2018 season overview

Steve Sawyer, R&D Committee Chair

Welcome to the 2019 season. Last season was rewarding for many of us and it was also a great year to step into the role of R&D Chair. Starting a little later into the season, I would like to thank the R&D committee for their efforts in getting the 2018 trials season underway, by sharing their production priorities with our industry partners and researchers.

2018 has certainly been a busy year, not just on farm but also in the Liebe office. The staff moved from the small office located in the shire building, to the fantastic facility taking pride on the main street of town. On top of this, they have engaged with many of our members from across the region, which now expands seven shires, and implemented research projects across all three port zones our region encompasses.

The season began with the annual Crop Updates, which took on a new agenda for the first time. This event combined the annual Trials Review Day and Crop Updates in to one major event. Members and industry reviewed trial results from the 2017 research season, while also engaging in presentations on global markets, farm planning after a dry season, learning more about harvest weed seed management and the seed destructor technology, and succession planning from Nuffield scholar James Dempster.

The Main Trial Site, located at the McCreery family's property, showcased research to those members throughout our eastern districts, capturing an audience close to 200 people at the Spring Field Day. The Main Trial Site was a showcase of research from partners and funded research projects, and is a testament to the ongoing effort by the industry to improve on farm productivity. Many thanks must be extended to the Liebe Group Management and partners for supporting the establishment of a canola variety trial at the Main Trial Site, due to the absence of a canola NVT in that region. The McCreery's also raised the stakes for 'best Spring Field Day prop' with the ultimate IBC challenge – The Liebe Bar. We appreciate all the efforts of our partners, R&D committee members, the wider membership and the Kalannie community for supporting this great day.

On top of the events, the R&D committee have also been busy supporting staff in the development of new research ideas, which have been compiled into a number of project applications and proposals for the National Landcare Program and GRDC. On top of this, 12 funded project sites spanning a 200 km radius, and the coordination and delivery of 14 trials at the Main Trial Site, has kept our R&D Coordinator extremely busy. Invested projects throughout the Liebe region include;

	Title	Location	Host	Status
1	GRDC RCSN: Management of nutrition on ameliorated non-wetting soils of the Geraldton Port Zone	Eneabba Marchagee	Rohan Broun Clint Hunt	Completed
2	GRDC: "Ripper Gauge"	Dalwallinu Kalannie	Carlshausen family McCreery family	Ongoing (2019-2020)
3	GRDC: Profitable legumes for the Western Region	Carnamah Dalwallinu Kalannie Koorda	Scott Bowman Ian & Ainsley Hyde McCreery family Nathan Brooks	Ongoing (2019)
4	GRDC RCSN: Benefits of foliar micronutrients on cereals in a low rainfall zone.	Sampling surveys with a total of 25 farmers from throughout the area		Ongoing (2019)
5	GRDC: Crop establishment – survey of plant establishment and demonstration of precision seeding equipment	Paddock surveys with 7 Liebe members	Demonstration site hosted by the McCreery family in Kalannie	Ongoing (2019-2021)
6	Liebe Group Practice for Profit	Dalwallinu	Mills family	Completed
7	GRDC: Subsoil Constraints (DPIRD & GRDC)	West Wubin	Barnes family	Completed

Much of the project work the Liebe Group does is a result of the ideas that are generated from the R&D Committee. As a grower driven group, we do also encourage our members to share their production challenges, and ideas to solve them, with the committee so that future research is both locally relevant and timely.

Looking back on 2018, personally, and I am sure others might agree, that there has been much learnt. After a dry 2017, many started the season more tentatively than usual. Once the rain came in late May, we then found out what other challenges 2018 was going to throw at us.

Limited weed germination in 2017 coupled with dry sowing in 2018 saw the crop and the weeds all come up together on the first rain, giving rise to large hectares of unclean paddocks, particularly those paddocks that had been cultivated. Good winter rain also challenged our logistics management – meaning, getting across the ground to spray the weeds at the correct stage was an uphill battle thus; not all the weeds were sprayed at the right time, and we still had significant weed burden at the end of the season. This will definitely be something to keep in mind when planning for the 2019 season.

Livestock owners will be looking to increase stock numbers after having destocked in 2017 and continuing to be conservative with numbers in 2018, due to the late germination of feed. From a weed management perspective livestock will add significant diversity to the weed management strategy where weed burdens were experienced in 2018. Greater grazing capacity of grass weeds and manipulation of pastures will hopefully see 2019 tidy up a few paddocks ready for 2020!

2018 also had its rewards: Good yields, strong prices, win-falls from wheat crops sown on 2017 sprayed out canola paddocks, and a renewed confidence to reinvest the success of 2018 into a successful 2019 season.

CEREAL RESEARCH RESULTS

Wheat National Variety Trial - Buntine

Peter Bird, National Variety Trials, GRDC West

Key Messages

- With AH classification, varieties Vixen, Devil and Scepter were the three highest yielding varieties. Kinsei and Zen were the two highest yielding Noodle varieties. These 5 varieties were all significantly higher yielding than Mace. In the Clearfield segment, Razor CL Plus yielded more than Chief CL Plus in this trial.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term multi environment (MET data) on the NVT online website is a reliable source of data for variety decisions.

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district "best practice" window and located on a typical soil type for the area.

Trial Details

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Grey yellow sand
Soil pH ($CaCl_2$)	0-10 cm:5.7 10-60 cm: 4.6
EC (dS/m)	0-10 cm:0.1 10-60 cm: 0.0
Paddock rotation:	2014 wheat; 2015 wheat; 2016 canola
Sowing date	Dry sown 15/05/2018, effective sowing date 25/05/18
Sowing rate	180 seeds/m2
Fertiliser	15/05/2018: Gusto Gold 120 kg/ha, Urea 50 kg/ha 15/07/2018: UAN 120 L/ha
Herbicides, insecticides & fungicides	15/05/2018: 400 mL/ha Uniform (applied on fertilizer), 150 mL/100 kg Systiva (applied on seed) 15/05/2018: 118 g/ha Sakura, 2 L/ha Trifluralin, 250 g/ha Diuron, 75 g/ha Lontrel Advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 21/07/2018: 1.5 L/ha Boxer Gold 28/06/2018: 700 mL/ha Velocity 18/07/2018: 500mL/ha Aviator Xpro 06/09/18: 150 mL/ha Prosaro
Growing season rainfall	254 mm

Results

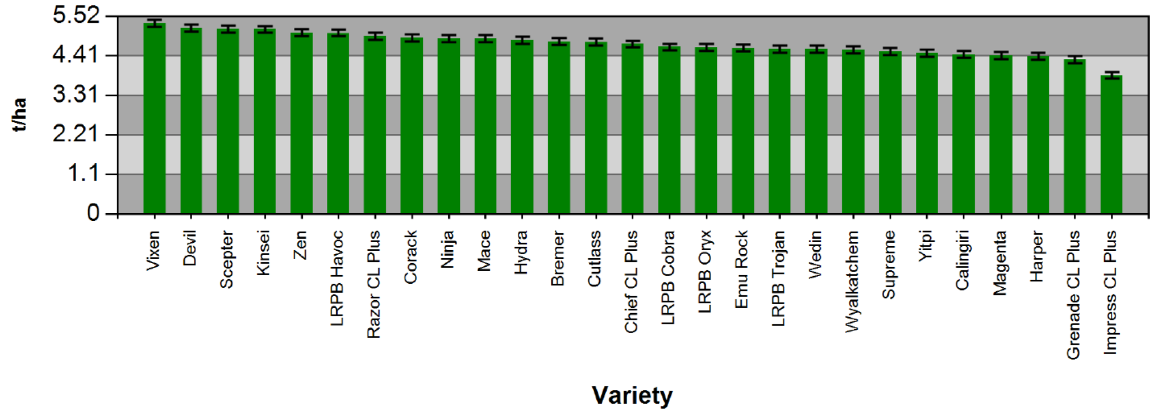

Figure 1: Yield comparison of wheat varieties sown in Buntine, 2018

Table 1: Wheat yield analysis and grain quality, Buntine, 2018

Treatment	Yield 2018 (t/ha)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (<2.0mm sieve)
Vixen	5.32	76.44	9.81	1.65
Devil	5.18	76.57	9.88	2.08
Scepter	5.16	76.75	9.57	2.53
Kinsei	5.15	76	9.46	4.33
Zen	5.06	78.78	9.91	1.18
LRPB Havoc	5.05	77.3	10.79	1.98
Razor CL Plus	4.96	75.91	9.62	2.44
Corack	4.91	78.58	10.93	0.79
Ninja	4.9	77.39	10.17	3.18
Mace	4.89	75.94	9.91	2.68
Hydra	4.85	77.81	10.13	3.42
Bremer	4.8	79.8	10.22	2.39
Cutlass	4.8	80.71	9.47	1.72
Chief CL Plus	4.74	78.65	10.27	1.94
LRPB Cobra	4.66	76.05	10.78	1.84
LRPB Oryx	4.64	77.21	10.28	2.2
Emu Rock	4.63	78.79	10.1	2.79
LRPB Trojan	4.6	78.12	10.49	3.69
Wedin	4.6	74.56	10.17	1.86
Wyalkatchem	4.58	76.77	10.74	1.35
Supreme	4.53	77.99	10.15	1.54
Yitpi	4.48	78.96	10.35	2.57
Calingiri	4.45	76.24	10.41	2.11
Magenta	4.42	75.55	11.22	5.55
Harper	4.4	76.83	10.59	3.96
Grenade CL Plus	4.31	74.98	10.89	2
Impress CL Plus	3.87	76.15	12.93	0.81
LSD	*0.19*	*n.a.*	*n.a.*	*n.a.*
CV (%)	*2.32*	*n.a.*	*n.a.*	*n.a.*
P value	*<0.001*	*n.a.*	*n.a.*	*n.a.*

Comments

The trial was successful with a significant variety effect and low CV. The 2018 season did not have earlier sowing opportunities – the trial was sown dry and emerged from rainfall on the 25th May. Good winter rainfall and warm conditions allowed the crop to grow well. September was very dry, but the good sandy soil allowed access to soil moisture until October rain helped to finish the crop. The result was very good yields, low to average protein and low screenings. Grain quality measurements are not replicated, so should be viewed with caution.

For results of all NVT trials for 2018, and long term MET data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements

Thanks to property owner, Mike Dodd for providing the site for the NVT and Living Farm for conducting the trial to a high standard. Participating seed companies, GRDC and the NVT program coordinators.

Contact

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0436 681 822

Wheat National Variety Trial - Kalannie

Peter Bird, National Variety Trials, GRDC West

Key Messages

- Scepter and Devil were the two highest yielding varieties and yielded significantly more than other varieties in the trial. Kinsei was the highest yielding Noodle variety. In the Clearfield segment Chief CL Plus yielded more than Razor CL plus in this trial.
- While grain protein was generally lower than ideal, hectolitre weights were very good, and screenings very low. Grain quality measurements are not replicated, so should be viewed with caution.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term multi environment (MET) data on the NVT online website is a reliable source of data for variety decisions.

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district "best practice" window and located on a typical soil type for the area.

Trial Details

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Yellow grey sand
Soil pH ($CaCl_2$)	0-10 cm:5.2 10-60 cm: 4.2
EC (dS/m)	0-10 cm:0.3 10-60 cm: 0.0
Paddock rotation:	2015 unknown; 2016 unknown; 2017 chemical fallow
Sowing date	04/06/2018
Sowing rate	140 seeds/m2
Fertiliser	04/06/2018: Gusto Gold 120 kg/ha, Urea 50 kg/ha 21/07/2018: UAN 80 L/ha 24/08/2018: UAN 40 L/ha 30/08/1018: UAN 30L/ha
Herbicides, insecticides & fungicides	04/06/2018: 400 mL/ha Uniform (applied on fertilizer), 150 mL/100 kg Systiva (applied on seed) 04/06/2018: 2L/ha Paraquat + Diquat, 118 g/ha Sakura, 2 L/ha Trifluralin, 250 g/ha Diuron, 75 g/ha Lontrel Advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 18/06/2018: 2 L/ha Boxer Gold 25/06/2018: 800 mL/ha Velocity 19/07/2018: 400mL/ha Aviator Xpro, 30 g/ha Transform 24/08/18: 150 mL/ha Prosaro
Growing season rainfall	223 mm

Results

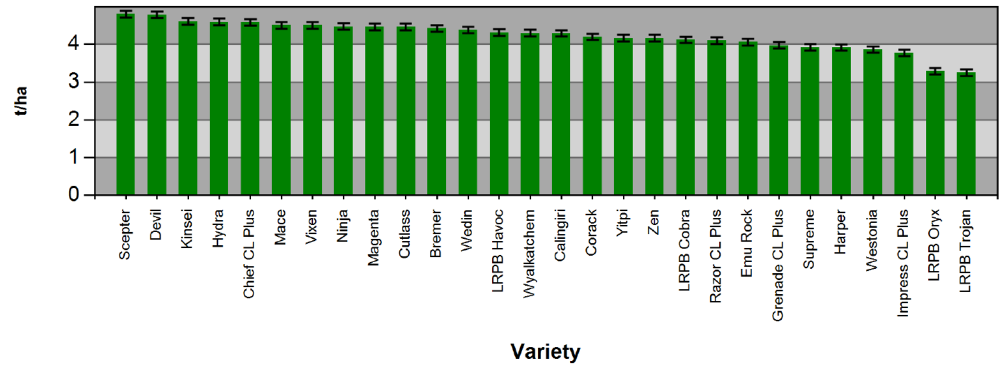

Figure 1: Yield comparison of wheat varieties sown in Kalannie, 2018

Table 1: Wheat yield and grain quality, Kalannie, 2018

Treatment	Yield 2018 (t/ha)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (<2.0mm sieve)
Scepter	4.79	82.82	9.39	1.75
Devil	4.77	81.61	9.01	1.06
Kinsei	4.6	81.8	8.81	0.92
Chief CL Plus	4.58	82.3	9.49	0.96
Hydra	4.58	82.42	9.9	1.76
Mace	4.49	80.51	9.58	1.71
Vixen	4.49	80.38	10.38	0.98
Ninja	4.46	81.5	9.49	2.43
Cutlass	4.45	81.67	9.6	0.75
Magenta	4.45	83.19	9.9	0.81
Bremer	4.42	83.81	10.2	0.62
Wedin	4.37	80.31	9.49	0.62
LRPB Havoc	4.3	83.83	9.88	0.91
Wyalkatchem	4.29	81.75	10.37	0.8
Calingiri	4.28	82.6	9.81	0.63
Corack	4.19	81.56	9.99	0.7
Yitpi	4.15	83.03	10.27	1.12
Zen	4.15	82.3	9.68	0.43
LRPB Cobra	4.11	80.15	10.67	1.02
Razor CL Plus	4.09	82.02	9.78	1.53
Emu Rock	4.05	81.99	10.78	1.71
Grenade CL Plus	3.96	80.66	10.39	0.86
Harper	3.9	82.35	10.67	1.35
Supreme	3.9	81.42	9.78	1.01
Westonia	3.85	80.76	10.46	1.05
Impress CL Plus	3.76	80.86	11.06	1.05
LRPB Oryx	3.28	79.83	10.3	1.69
LRPB Trojan	3.24	84.18	10.68	0.77
LSD	*0.17*	*n.a.*	*n.a.*	*n.a.*
CV (%)	*2.31*	*n.a.*	*n.a.*	*n.a.*
P value	*<0.001*	*n.a.*	*n.a.*	*n.a.*

Comments
The trial was successful with a significant variety effect and low CV. The opening rains for the 2018 season were on the 25th May. This trial was sown on the 4th June to allow a 10 day timing difference to the early break wheat trial. Even with the delayed sowing, the trial yielded very well, with high hectolitre weight and low screenings. Good winter rainfall and warm conditions allowed the crop to grow well. September was very dry, but the good sandy soil allowed access to soil moisture until October rain helped to finish the crop. Grain quality measurements are not replicated, so should be viewed with caution.

For results of all NVT trials for 2018, and long term multi environment data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements
Thanks to the McCreery family for providing the site, the Liebe Group for hosting the trial at the main field day site and Living Farm for conducting the trial to a high standard. Participating seed companies, GRDC and the NVT program coordinators.

Contact
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Wheat National Variety Trial - Miling

Peter Bird, National Variety Trials, GRDC West

Key Messages

- Zen was the highest yielding variety in this trial at 4.82 T/ha, significantly higher than the next highest noodle variety Kinsei at 4.67 T/ha. The hard varieties Havoc, Vixen and Devil were not significantly different from each other, at 4.81, 4.75 and 4.68 T/ha respectively. In the Clearfield segment, Razor CL Plus out-yielded Chief CL Plus in this trial.
- Screenings were high across varieties in this trial. Zen, Vixen and Impress CL Plus were the only varieties to achieve screenings less than 5%. Grain quality measurements are not replicated, so should be viewed with caution.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term multi environment (MET) data on the NVT online website is a reliable source of data for variety decisions.

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district “best practice” window and located on a typical soil type for the area.

Trial Details

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Light grey sandy loam
Soil pH ($CaCl_2$)	0-10 cm:6.6 10-60 cm: 4.4
EC (dS/m)	0-10 cm:0.1 10-60 cm: 0.0
Paddock rotation:	2015 unknown; 2016 unknown; 2017 canola
Sowing date	26/05/2018
Sowing rate	180 seeds/m2
Fertiliser	26/05/2017: Gusto Gold 120 kg/ha, Urea 50 kg/ha 10/07/2017: UAN 120 L/ha 28/08/2017: UAN 50 L/ha
Herbicides, insecticides & fungicides	15/05/2018: 400 mL/ha Uniform (applied on fertilizer), 150 mL/100 kg Systiva (applied on seed) 15/05/2018: 2 L/ha Glyphosate 570, 118 g/ha Sakura, 2 L/ha Trifluralin, 250 g/ha Diuron, 75 g/ha Lontrel Advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 21/06/2018: 1.5 L/ha Boxer Gold 28/06/2018: 670 mL/ha Velocity 02/08/2018: 700mL/ha Velocity, 300 mL/ha Prosaro, 50 g/ha Transform
Growing season rainfall	355 mm

Results

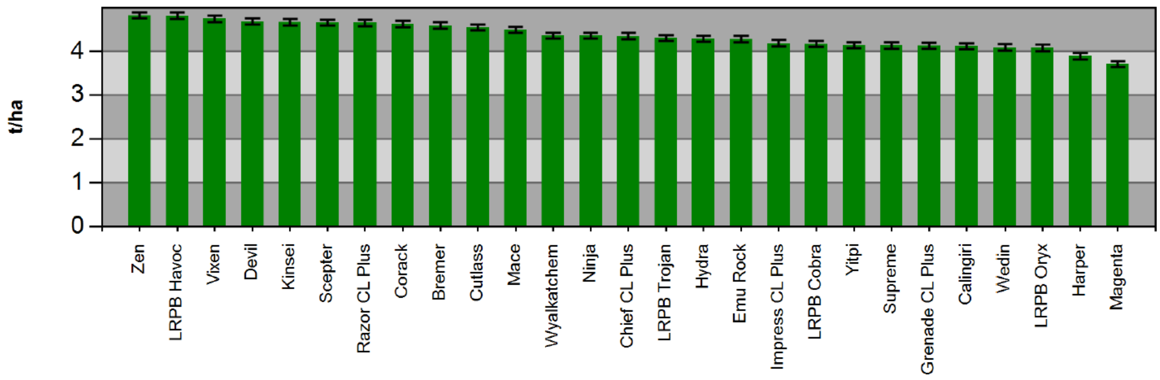

Figure 1: Yield comparison of wheat varieties sown in Miling, 2018

Table 1: Wheat yield and grain quality, Miling, 2018

Treatment	Yield 2018 (t/ha)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (<2.0mm sieve)
Zen	4.82	76.92	11.54	3.65
LRPB Havoc	4.81	74.66	12.34	7.8
Vixen	4.75	74.2	12.14	4.04
Devil	4.68	73.88	12.1	10.28
Kinsei	4.67	75.17	11.34	12.43
Scepter	4.66	73.62	11.77	9.43
Razor CL Plus	4.65	73.43	12.27	10.64
Corack	4.63	74.96	12.43	5.65
Bremer	4.59	79.32	11.93	6.26
Cutlass	4.55	78.39	11.81	7.46
Mace	4.49	72.86	12.57	15.36
Ninja	4.36	73.58	12.54	10.82
Wyalkatchem	4.36	74.3	12.96	7.3
Chief CL Plus	4.35	76.47	12.14	5.45
LRPB Trojan	4.3	76.81	11.82	14.15
Hydra	4.29	73.33	12.37	14.95
Emu Rock	4.28	75.38	13.24	8.71
Impress CL Plus	4.19	74.03	13.49	1.88
LRPB Cobra	4.17	71.36	13.14	11.63
Supreme	4.14	75.35	11.95	6.44
Yitpi	4.14	78.35	11.99	8.7
Grenade CL Plus	4.13	73.6	12.89	7.19
Calingiri	4.11	74.12	12.3	7.25
Wedin	4.09	73.34	11.46	5.84
LRPB Oryx	4.08	74.36	12.05	11.5
Harper	3.89	75.81	12.89	20.02
Magenta	3.71	72.89	13.55	12.23
LSD	0.14	n.a.	n.a.	n.a.
CV (%)	1.9	n.a.	n.a.	n.a.
P value	<0.001	n.a.	n.a.	n.a.

Comments

The trial was successful with a significant variety effect and low CV. This trial was sown the day after the opening rains, on the 26th May. Very good winter rainfall and warm conditions allowed the crop to grow exceptionally well. September was very dry, and the very high biomass produced from the good rainfall, soil fertility and applied Nitrogen caused the plants to produce high biomass. September was very dry and the result was a tight finish for this site. As a result, protein is good, but hectolitre weights are low and screenings are high across the trial. Grain quality measurements are not replicated, so should be viewed with caution.

Variety rankings in this trial may be different from other trials in the region, possibly due to the very tight finish at this site.

For results of all NVT trials for 2018, and long term multi environment data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements

Thanks to David McLagan for providing the site and Living Farm for conducting the trial to a very high standard. Participating seed companies, GRDC and the NVT program coordinators.

Contact

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Barley National Variety Trial - Buntine

Peter Bird, National Variety Trials, GRDC West

Key Messages
- The feed variety Rosalind yielded 6.00T/ha, significantly higher than other varieties in the trial.
- Protein and screenings were on the high side – reflecting good fertility, high biomass and a somewhat tight finish to the season. The only variety to make malting specs was Compass at 5.68T/ha, however grain quality data is not replicated so should be viewed with caution.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term multi environment (MET) data on the NVT online website is a reliable source of data for variety decisions.

Aim
The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background
The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district "best practice" window and located on a typical soil type for the area.

Trial Details

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Grey yellow sand
Soil pH ($CaCl_2$)	0-10 cm:5.7 10-60 cm: 4.6
EC (dS/m)	0-10 cm:0.1 10-60 cm: 0.0
Paddock rotation:	2015 unknown; 2016 unknown; 2017 canola
Sowing date	Sown dry 15/05/18, effective sowing date 25/05/18
Sowing rate	150 seeds/m2
Fertiliser	15/05/2018: Gusto Gold 120 kg/ha, Urea 50 kg/ha 10/07/2018: UAN 80 L/ha
Herbicides, insecticides & fungicides	15/05/2018: 400 mL/ha Uniform (applied on fertilizer), 150 mL/100 kg Systiva (applied on seed) 15/05/2018: 2 L/ha Trifluralin, 1.6 L/ha Tri-allate /ha, 250 g/ha Diuron, 75 g/ha Lontrel Advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 21/06/2018: 1.5L /ha Boxer Gold 28/06/2018: 700 mL/ha Velocity 18/07/2018: 500 mL/ha Aviator Xpro 02/08/2018: 50 g/ha Transform 06/09/2018: 150mL Prosaro
Growing season rainfall	254 mm

Results

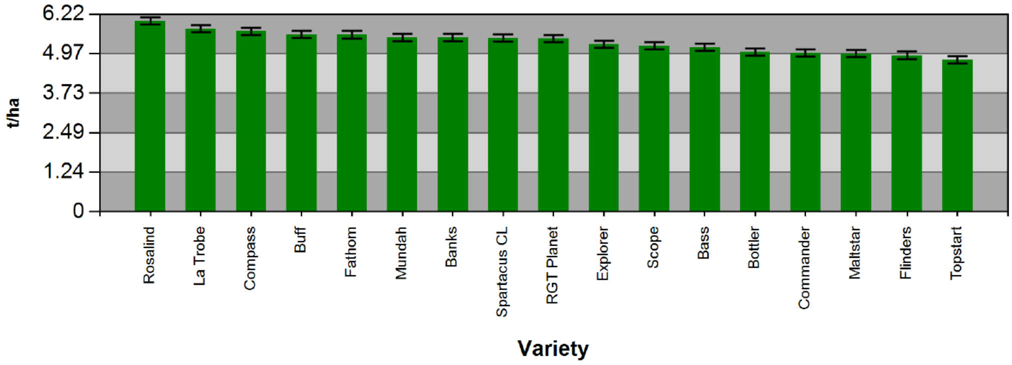

Figure 1: Yield comparison of barley varieties sown in Buntine, 2018

Table 1: Barley yield and grain quality, Buntine, 2018

Treatment	Yield 2018 (t/ha)	Hectolitre Weight (kg/hL)	Grain Brightness (Colour)	Protein (%)	Screenings (<2.5mm sieve)
Rosalind	6	69.18	58.5	11.3	23.61
La Trobe	5.76	69.69	60.1	11.65	32.7
Compass	5.68	67.32	61.3	10.99	12.82
Buff	5.58	65.38		12.96	36.65
Fathom	5.57	66.82		14.6	29.9
Mundah	5.49	64.91	58.5	11.97	19.59
Banks	5.48	68.2	58.6	12.2	35.68
Spartacus CL	5.46	70.68	59.8	11.76	28.13
RGT Planet	5.44	60.02	59.9	11.64	54.05
Explorer	5.27	60.62	59.4	11.74	43.59
Scope	5.22	66.49	59.6	12.07	47.57
Bass	5.17	68.58	59.7	12.75	36.27
Bottler	5.02	64.23	61.8	12.07	55.79
Commander	4.99	66.74	59.8	10.96	36.59
Maltstar	4.98	63.13	62	12.07	64.06
Flinders	4.92	68.45	59.8	12.28	40.39
Topstart	4.79	64.48	60.7	12.15	59.23
LSD	0.23	n.a.	n.a.	n.a.	n.a.
CV (%)	2.62	n.a.	n.a.	n.a.	n.a.
P value	<0.001	n.a.	n.a.	n.a.	n.a.

Comments

The trial was successful with a significant variety effect and low CV. The 2018 season did not have earlier sowing opportunities – the trial was sown dry and emerged from rainfall on the 25th May. Good winter rainfall and warm conditions allowed the crop to grow well. September was very dry, but the good sandy soil allowed access to soil moisture until October rain helped to finish the crop. The result was very good yields, good protein but screenings on the high side. Grain quality measurements are not replicated, so should be viewed with caution. For results of all NVT trials for 2018, and long term multi environment data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements

Thanks to property owner, Mike Dodd for providing the site for the NVT and Living Farm for conducting the trial to a high standard. Participating seed companies, GRDC and the NVT program coordinators.

Contact

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Barley National Variety Trial - Kalannie

Peter Bird, National Variety Trials, GRDC West

Key Messages

- Buff was the outstanding variety in this trial, yielding more than 1t/ha higher than any other variety. This is likely due to the acid subsoil at this site of pH4.2. Buff is marketed as an acid soil tolerant variety.
- None of the potential malting varieties in the trial achieved Malt 1 standards, due either to protein or screenings being too high. Grain quality measurements are not replicated, so these measurements should be viewed with caution.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term multi environment (MET) data on the NVT online website is a reliable source of data for variety decisions.

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district “best practice” window and located on a typical soil type for the area.

Trial Details

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Yellow grey sand
Soil pH ($CaCl_2$)	0-10 cm:5.2 10-60 cm: 4.2
EC (dS/m)	0-10 cm:0.3 10-60 cm: 0.0
Paddock rotation:	2013 unknown; 2016 unknown; 2017 chemical fallow
Sowing date	Sown dry 20/05/2018, effective seeding date 25/05/2018
Sowing rate	150 seeds/m2
Fertiliser	20/05/2018: Gusto Gold 120 kg/ha, Urea 50 kg/ha 21/07/2018: UAN 80 L/ha 24/08/2018: UAN 60 L/ha 30/08/2018: UA 30 L/ha
Herbicides, insecticides & fungicides	20/05/2018: 400 mL/ha Uniform (applied on fertilizer), 150 mL/100 kg Systiva (applied on seed) 20/05/2018: 2 L/ha Glyphosate 570, 2 L/ha Trifluralin, 1.6 L/ha Tri-allate /ha, 250 g/ha Diuron, 75 g/ha Lontrel Advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 18/06/2018: 2 L /ha Boxer Gold 25/06/2018: 800 mL/ha Velocity 19/07/2018: 400 mL/ha Aviator Xpro, 30 g/ha Transform 24/08/2018:150 mL/ha Prosaro,
Growing season rainfall	216.5 mm

Results

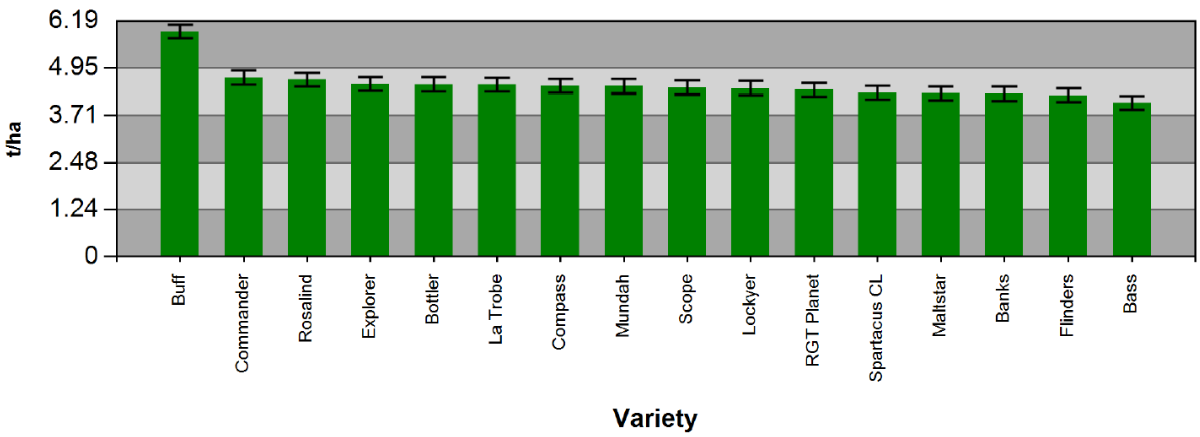

Figure 1: Yield comparison of barley varieties sown in Kalannie, 2018

Table 1: Barley yield and grain quality, Kalannie, 2018

Treatment	Yield 2018 (t/ha)	Hectolitre Weight (kg/hL)	Grain Brightness (Colour)	Protein (%)	Screenings (<2.5mm sieve)
Buff	5.91	70.26	61.6	10.98	9.57
Commander	4.7	66.39	61.4	12	20.73
Rosalind	4.64	70.69	59.1	12.87	13.39
Explorer	4.53	66.96	59.4	13.54	19.98
Bottler	4.52	70.39	60.9	13.21	29.36
La Trobe	4.51	71.9	60.6	13.1	26.23
Compass	4.48	69.53	61.6	12.54	18.97
Mundah	4.48	65.57	59	12.65	11.3
Scope	4.44	69.52	58.9	13.86	20.59
Lockyer	4.42	67.48	61.2	13.19	24.68
RGT Planet	4.38	69.87	60.8	12.1	23.16
Spartacus CL	4.3	72.04	61.5	14.1	18.78
Maltstar	4.29	69.24	62.9	12.1	38.8
Banks	4.28	69.87	59.5	12.87	29.88
Flinders	4.24	70.89	60.9	13.19	15.69
Bass	4.04	72.37	59.9	14.32	8.6
LSD	0.36	n.a.	n.a.	n.a.	n.a.
CV (%)	4.75	n.a.	n.a.	n.a.	n.a.
P value	<0.001	n.a.	n.a.	n.a.	n.a.

Comments

The trial was successful with a significant variety effect and low CV. The 2018 season did not have earlier sowing opportunities – the trial was sown dry and emerged from rainfall on the 25th May. Good winter rainfall and warm conditions allowed the crop to grow well. September was very dry, but the good sandy soil allowed access to soil moisture until October rain helped to finish the crop. The result was very good yields, high protein but screenings on the high side. Grain quality measurements are not replicated, so should be viewed with caution.

For results of all NVT trials for 2018, and long term multi environment data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements

Thanks to the McCreery family for providing the site, the Liebe Group for hosting the trial at the main field day site and Living Farm for conducting the trial to a high standard. Participating seed companies, GRDC and the NVT program coordinators.

Contact

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Barley National Variety Trial - Miling

Peter Bird, National Variety Trials, GRDC West

Key Messages

- Rosalind was the highest yielding variety in the trial, yielding significantly more than any other variety in the trial.
- This trial produced very high biomass in winter, but the dry September resulted in high screenings. Compass was the only variety in the trial to achieve screenings less than 20%. Grain quality measurements are not replicated, so this data should be viewed with caution.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term multi environment (MET) data on the NVT online website is a reliable source of data for variety decisions.

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district "best practice" window and located on a typical soil type for the area.

Trial Details

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Light grey sandy loam
Soil pH ($CaCl_2$)	0-10 cm: 6.6 10-60 cm: 4.4
EC (dS/m)	0-10 cm:0.1 10-60 cm: 0.0
Paddock rotation:	2015 unknown; 2016 unknown; 2017 canola
Sowing date	26/05/2018
Sowing rate	150 seeds/m2
Fertiliser	26/05/2018: Gusto Gold 120 kg/ha, Urea 50 kg/ha 10/07/2018: UAN 80 L/ha 28/08/2018: UAN 30 L/ha
Herbicides, insecticides & fungicides	26/05/2018: 400 mL/ha Uniform (applied on fertilizer), 150 mL/100 kg Systiva (applied on seed) 26/05/2018: 2 L/ha Glyphosate 570, 2 L/ha Trifluralin, 1.6 L/ha Tri-allate /ha, 250 g/ha Diuron, 75 g/ha Lontrel Advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 21/06/2018: 1.5L /ha Boxer Gold 28/06/2018: 700 mL/ha Velocity 02/08/2018: 700 mL/ha Velocity, 300 mL/ha Prosaro, 50 g/ha Transform
Growing season rainfall	355 mm

Results

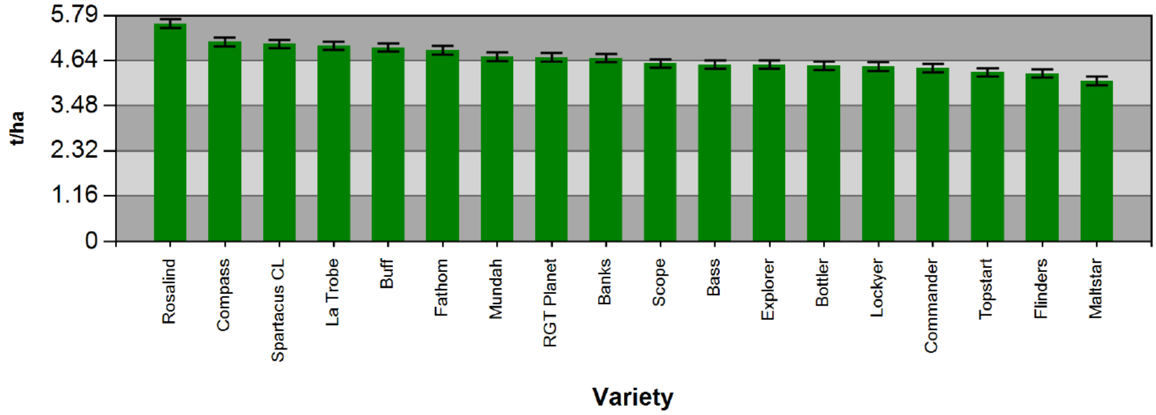

Figure 1: Yield comparison of barley varieties sown in Miling, 2018

Table 1: Barley yield and grain quality, Miling, 2018

Treatment	Yield 2018 (t/ha)	Hectolitre Weight (kg/hL)	Grain Brightness (Colour)	Protein (%)	Screenings (<2.5mm sieve)
Rosalind	5.59	67.66	53.7	13.22	43.45
Compass	5.12	65.81	59.6	13.02	18.85
Spartacus CL	5.06	66.33	57.1	14.13	60.65
La Trobe	5.02	69.18	58.2	13.25	54.52
Buff	4.97	65.27	56.9	14.18	52.62
Fathom	4.9	65.27	55.6	14.32	41.86
Mundah	4.74	65.92	54.4	13.91	27.67
RGT Planet	4.72	64.83	56	12.79	43.68
Banks	4.7	68.97	55.5	14.13	45.05
Scope	4.56	66.26	55.7	14.99	55.67
Bass	4.53	69.66	55.8	14.57	27.24
Explorer	4.53	60.42	62.1	15.34	60.74
Bottler	4.5	64.96	56.1	14.68	62.49
Lockyer	4.48	66.01	57	15.01	49.92
Commander	4.44	65.21	56.4	14.66	55.55
Topstart	4.33	64.91	56.7	14.88	69.39
Flinders	4.3	67.44	56.8	15.1	48.73
Maltstar	4.11	64.04	57.4	14.21	69.7
LSD	0.22	n.a.	n.a.	n.a.	n.a.
CV (%)	2.84	n.a.	n.a.	n.a.	n.a.
P value	<0.001	n.a.	n.a.	n.a.	n.a.

Comments

The trial was successful with a significant variety effect and low CV. This trial was sown the day after the opening rains, on the 26th May. Very good winter rainfall and warm conditions allowed the crop to grow exceptionally well. September was very dry, and the very high biomass produced from the good rainfall, soil fertility and applied Nitrogen caused the plants to produce high biomass. September was very dry and the result was a tight finish for this site. As a result, protein is high, and screenings very high across the trial. Grain quality measurements are not replicated, so should be viewed with caution.

For results of all NVT trials for 2018, and long term multi environment data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements

Thanks to David McLagan for providing the site and Living Farm for conducting the trial to a very high standard. Participating seed companies, GRDC and the NVT program coordinators.

Contact

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Practice for Profit Trial

Alana Hartley, Research & Development Coordinator, Liebe Group

Key Messages

- Yield was significantly higher under high input treatments (+0.3 t/ha) and significantly higher following volunteer pasture rotation (2016) compared to Field Peas or Canola (+0.4 t/ha).
- Protein was significantly higher under high inputs and following Field Peas (2016) but significantly lower following wheat.

Aim

The purpose of this trial is to investigate the interactions of crop rotation and input rates on the long term yield, quality and profitability of the farming systems in the Dalwallinu region.

Background

Historically the Liebe Group Practice for Profit trials were conducted on different sites each year, resulting in data and information varying according to rainfall and soil type. In 2011 a long-term site on the Mills property, east of Dalwallinu, was set up where the Liebe Group have investigated rotation practices and economic impact of input systems on overall enterprise profitability.

The following rotations and break crops have been investigated over eight consecutive years: continuous wheat, wheat on canola, wheat on fallow and wheat on field peas. High and low inputs were applied to mimic production systems seeking to either maximise crop yield potential, taking seasonal conditions into account, or to produce a crop at the lowest possible cost, irrespective of seasonal conditions. The high cost of production strategy puts more pressure on farm finances and increases the risk to the business, so the purpose of this trial was to see which of these management strategies generated the highest profit. We also explored whether the high cost strategy generated sufficient returns to compensate for the higher risk.

The rotational history is shown in Table 1. High and low input treatments were not applied in 2011 but began in 2012. In 2013 the set rotation was not able to be planted due to a timing mismatch between rain and trial contractors resulting in the soil being too dry for the small trial seeding machinery to negotiate and the whole site was fallowed. Input costs associated with spray topping for fallow management has been included in the economic analysis. Low and high input wheat was planted in 2014 and 2015. 2016 saw the trial in its second rotational phase of wheat, field peas, canola and fallow. Unlike 2011, in 2016 all rotation inputs were adjusted for high and low treatments.

Table 1: Practice for Profit trial, rotation history.

Treatment	2011	2012	2013	2014	2015	2016	2017	2018
1	Wheat	Wheat	Fallow	Wheat	Wheat	Wheat	Wheat	Wheat
2	Wheat	Wheat	Fallow	Wheat	Wheat	Wheat	Wheat	Wheat
3	Canola	Wheat	Fallow	Wheat	Wheat	Canola	Wheat	Wheat
4	Canola	Wheat	Fallow	Wheat	Wheat	Canola	Wheat	Wheat
5	Fallow	Wheat	Fallow	Wheat	Wheat	Fallow	Wheat	Wheat
6	Fallow	Wheat	Fallow	Wheat	Wheat	Fallow	Wheat	Wheat
7	Field Peas	Wheat	Fallow	Wheat	Wheat	Field Peas	Wheat	Wheat
8	Field Peas	Wheat	Fallow	Wheat	Wheat	Field Peas	Wheat	Wheat

In 2017, the site entered its seventh consecutive season and returned to a wheat rotation. Inputs were adjusted to reflect grower standard practice for high and low input farming systems.

It is important to note that both high and low inputs of this trial are considered on a seasonal basis. The soil nutrition levels are tested annually and fertiliser rates adjusted accordingly with high input treatments reviewed midseason. Soil results are not reported here as all nutrients; Nitrogen, Potassium, Phosphorus and Sulphur, were adequate.

Trial Details

Property	Wenballa Farm, East Dalwallinu
Plot size & replication	8.8m x 12m x 3 replications
Soil type	Loamy clay
Soil pH ($CaCl_2$)	0-10cm: 5.1 10-20cm: 7.1 20-40cm: 7.5
EC (dS/m)	0-10cm: 0.112
Sowing date	30/05/2018
Seeding rate	60 kg/ha
Paddock rotation	See Table 1
Fertiliser	See Table 2
Herbicides, Fungicides & Insecticides	10/05/2017: **High** – 400 ml/ha Flutriafol (500 g/L) in-furrow, Boxer Gold 2 L/ha + Trifluralin 2 L/ha, Sprayseed 2 L/ha, Velocity 1 L/ha, LVE 440 ml/ha, MSO 1% **Low** – Trifluralin 2 L/ha, Sprayseed 2 L/ha Jaguar 1 L/ha, LVE 440 ml/ha
Growing season rainfall	300 mm

Table 2: 2018 Practice for Profit input rates.

Treatment	2018 Rotation	Variety	Input	Agstar Extra (kg/ha)	Urea (kg/ha)	Flexi-N 6 WAS (L/ha)	Urea Z 32 (kg/ha)
1	Wheat low	Mace	Low	40	40	0	
2	Wheat high	Mace	High	70	40	50	20
3	Wheat low	Mace	Low	50	40	0	
4	Wheat high	Mace	High	70	40	50	20
5	Wheat low	Mace	Low	50	40	0	
6	Wheat high	Mace	High	70	40	50	20
7	Wheat low	Mace	Low	50	40	0	
8	Wheat high	Mace	High	70	40	50	20

Post emergent nitrogen at late tillering-early stem elongation was applied on 7th August as urea rather than Flexi N, due to wet conditions making the clay soil type inaccessible to vehicles for liquid spraying.

Results and Discussion

Table 3 summarises the average soil pH and organic carbon (OC%) collected prior to seeding from 2012 to 2018. Most treatments show a noticeable decline of 1.5 units in soil pH in the top 0-10 cm of the profile. Organic carbon has improved by 0.46% over the lifetime of the trial, and is likely due to the retention of stubbles post-harvest since the beginning of the trial in 2011.

Table 3: Average organic carbon (OC) and pH ($CaCl_2$) across all high and low input treatments taken from 2012-2018.

Year	Depth (cm)	Average pH ($CaCl_2$)	Average OC (%)
March 2012	0-10	6.6	0.66
	10-20	7.3	0.60
	20-30	8.0	0.42
July 2013	0-10	5.3	0.89
	10-20	7.1	0.48
	20-30	7.9	0.33
March 2014	0-10	5.7	0.89
	10-20	7.1	0.56
	20-30	7.5	0.51
November 2015	0-10	5.7	0.80
	10-20	6.9	0.52
	20-30	7.4	0.42
April 2016	0-10	5.4	0.83
March 2017	0-10	5.1	0.92
March 2018	0-10	5.1	1.12

Note: 2013 was a chemical fallow across all plots.

An analysis of restricted maximum likelihood (REML) was conducted due to an imbalance in the data set caused by a seeding error that was experienced in 2017.

There was a significant effect on wheat yield for the impact of previous crop type ($p<0.1$), Table 5, and input level ($p<0.05$), Table 6, while the interaction was not significant. Yields following the 2016 rotation of fallow were significantly higher than after canola (0.4 t/ha) or field peas (0.5 t/ha). Input alone also had a significant impact on yield, where high input yielded 0.3 t/ha greater than low input plots. These significant yield impacts will be reflected in the economic analysis.

Table 5: Impact of previous crop on 2018 wheat yield and all other variables.

Previous Crop/stubble	2018 Wheat Yield	Protein (%)	Hectolitre (g/hL)	Screenings (%)	Grade
Wheat	3.07	8.43	82.02	1.28	ASW1
Canola	2.82	10.2	81.29	1.35	APW2
Fallow	3.19	11.68	80.66	2.10	H2
Field Peas	2.74	10.9	81.86	2.78	APW1
P (crop)	*0.069*	*0.001*	*0.569*	0.003	

There was a significant effect on protein for both previous crop ($p=0.001$) and input level ($p<0.05$), while the interaction was not significant. Wheat protein was 0.78% higher after a 2016 than after field peas and 1.48% higher after canola. The fallow system therefore allowed the crop to grow in 'softer' conditions. A lower hectolitre weight suggests that grain size was bigger. This also indicates why grain protein is higher than the other crop systems. This created a significant difference in payment grades across each treatments and has an influence on economic return, Table 8.

Neither crop type or input affected on hectolitre weight or screenings significantly.

Table 6: Impact of High and Low inputs on 2018 wheat yield and all other variables

Treatment	2018 Wheat Yield	Protein (%)	Hectolitre (g/hL)	Screenings (%)	Grade
High	3.12	10.57a	81.54	2.31	APW1
Low	2.79	9.67b	81.38	1.45	ASW1
LSD (P=0.05)	*0.2628*	*0.8319*	*NS*	*0.002*	
P value (input)	*0.019*	*0.037*	*0.843*	*0.283*	

However there was a signficant interaction between input level and previous crop type on screenings ($p<0.05$, Table 7).Screenings were significantly higher for high inputs following either field peas or fallow. Screenings for these combinations were 3.6% and 2.92% respectively, while other treatment combinations averaged 1.4%..

Table 7: Effect of crop type and input interaction on screenings

	Screenings %	
Previous Crop/Input	**High**	**Low**
Canola	1.47	1.23
Field Peas	3.60	1.98
Fallow	2.92	1.27
Wheat	1.25	1.32
P value	0.018	

Economic Analysis

Two sets of analyses have been conducted on yield results from the 2018 harvest data; gross margin analysis by treatment (Table 8) and analysis of operating profit over the past eight years of the trial (Table 9). The highest gross margin return was achieved by treatment eight, high input wheat on field pea (2016), at $907/ha. The high yield coupled with strong protein, resulted in this rotation taking advantage of mineralised N from the 2016 pea rotation and achieving H2 grade for protein. Another strong performing treatment, treatment 6, yielded a gross margin return at $700/ha. Despite falling short of treatment eight by $207/ha, these gross margins suggest the additional inputs coupled with the rotational benefit of a legume or fallow is beneficial to future wheat crops.

After investigating the effects of crop rotation and input levels for the past eight seasons, the analysis of operating profit as depicted in Table 9, begins to show how the system affects long term profitability.

The simplest system, which was the continuous 'wheat low', only having a gross margin return of $605/ha in 2018 (Table 8), remained the most profitable rotation which returned $99/ha as operating profit at a 19% margin over the past eight seasons. It has remained profitable over this time due to it being the lowest risk system. However the analysis does not recognise the potential risk that a low input system places on the long term management and profitability. Where fewer inputs are applied, growers increase the risk of exposing their crop and the future farming system to greater weed pressure, disease and lower yields and reduced quality, as experienced in the 2018 season. Increasing inputs to manage risk of weed burden, onset of disease and additional nutrition inputs to improve quality can be beneficial in a season seeking a high yield potential however, the extra investment of the high input continuous wheat saw a -8% return. While yields were good and operating profit over the past eight years remains high at an average of $99/ha, quality suggested that the low input wheat system is running out of nitrogen, and is unlikely to generate favourable yields in the next above average season.

Table 8: 2018 season gross margin analysis by treatment

		Variable Costs									
Treatment #	**Seed Rate**	**Seed Costs**	**Input Costs**	**CBH Costs**	**Crop insurance (1%)**	**Total Variable Costs**	**Yield**	**Grade**	**Grain Price**	**Income**	**GM ($/ha)**
1	60	$18.0	254.47	104.31	9.92	386.70	2.90	ASW1	342	991.80	605.10
2	60	$18.0	367.34	116.18	11.05	512.57	3.23	ASW1	342	1104.66	592.09
3	60	$18.0	254.47	98.92	9.41	380.79	2.75	ASW1	342	940.50	559.71
4	60	$18.0	367.34	103.95	10.90	500.19	2.89	APW1	377	1089.53	589.34
5	60	$18.0	254.47	112.23	10.67	395.37	3.12	ASW1	342	1067.04	671.67
6	60	$18.0	367.34	118.34	12.40	516.08	3.29	APW1	377	1240.33	724.25
7	60	$18.0	254.47	73.38	8.08	353.93	2.04	H2	396	807.84	453.91
8	60	$18.0	367.34	117.98	12.99	516.31	3.28	H2	396	1298.88	782.57

Grain prices (Glencore Grain Kwinana Port Zone Bid sheet January 2019): H2 - $396, APW1 - $377, APW2 - $353, ASW1 - $342, AGP1 - $340

*Variable Costs only include seed, fertiliser, chemical and CBH costs and crop insurance at 1% of income

Gross margin analysis provides a snap shot of a single season's economic performance but does not take in to account the impact of production performance and rotation over time. The analysis of operating profit given in Table 9 analyses average income margins over the eight years and assesses the impact of average full costs (average input costs plus other costs, including fixed and variable costs not captured in operations costs) on total operating profit ($/ha).

Table 9: Economic Analysis as Operating Profit ($/ha) over 8 year lifetime of the trial

								Simple Low Risk	*Lowest Cost*	*Highest Cost*
Treatment	**Average Income**	***Average Full Costs**	**Operating Profit**	**Full Cost as % Income**	**Profit Margin**	**Extra Investment**	**Return on the Extra Investment**	**Comparison to Wheat Low**	**Comparison to Fallow Low**	**Comparison to Wheat High**
Wheat low	532	434	99	81%	19%			0	104	6
Wheat high	602	509	93	85%	15%	76	-8%	-6	98	0
Canola low	477	407	70	85%	15%			-28	76	-22
Canola high	563	475	88	84%	16%	68	26%	-11	94	-5
Chemical fallow low	358	364	-6	102%	-2%			-104	0	-98
Chemical fallow high	403	425	-21	105%	-5%	61	-26%	-120	-16	-114
Field Peas low	418	404	13	97%	3%			-85	19	-79
Field Peas high	522	474	48	91%	9%	70	49%	-51	53	-45

*Other costs include fixed costs of $154 plus $25 for variable cost not accounted for which equals $179. These costs have been taken from the Farmanco Profit Series for the medium rainfall zone over the years in the analysis.

The next best performing system was the high input wheat on high input canola rotation. This is due to the improved weed management strategy and the higher gross return previous canola crops have provided the system. After eight years, the rotation appears to respond well to the extra investment of such a high cost crop rotation; with a 26% return on extra investment under the high input canola treatment. Compared to the high input wheat system, high input canola system still does not perform as well, although only behind slightly at -5%.

The lowest cost system was the chemical fallow, which appears attractive to growers where gross margin returns in 2018, due to higher yields, were $671/ha and $724/ha for both low and high inputs (Table 8). However, under this rotation there were only four seasons out of seven that were in crop and provided this system an income. This reduced the actual gross margin over the eight years to just $194/ha and $176/ha for low and high respectively (Appendix A Table 1). This rotation has been has not been able to produce a big enough margin in dollars per hectare to cover the fixed costs or extra investment associated with its management however the management of the farming enterprise sees a reduction operational demand; allowing for operational inputs be put into those cropped paddocks in a timely manner.

Comments
All treatments performed well in 2018, after a growing season rainfall of 300 mm. After eight years of consecutive analysis of yield and economic return at this site, the continuous wheat rotation remains the most consistent in its financial returns.

As noted in the economic analysis, the level of risk a grower can sustain when adopting a low input farming system may become evident in future years of this trial. Careful observation and measurement of weed and disease pressure will further support the initial objective of the High versus Low input analysis, to determine if and when a particular system may show signs of 'breaking'.

This long term trial has now concluded its final season.

Acknowledgements
Thank you to the Mills family for their continued support in hosting this trial site for the last eight years. Thank you to Angus McAlpine, CSBP, for trial design and nutrition support and, Rob Sands and David Cameron of Farmanco for trial design support and economic analysis. Thanks must also be extended to the field research team at the DPIRD Wongan Hills research station for site management.

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Peer review:: Roger Lawes, CSIRO and Bob French, DPIRD

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Appendix A:

Table 1: Cumulative Gross Margin by treatment

Treatment	Average Income	*Average Input Costs	Average Margin	Cost as % Income	Margin as % Income	Extra Investment	Return on the Extra Investment	Comparison to Wheat Low	Comparison to Pasture Low	Comparison to Wheat High
								Simple Low Risk, Highest Margin	*Lowest Cost*	*Highest Cost*
Wheat low	532	234	299	44%	56%			0	104	28
Wheat high	602	312	270	52%	45%	79	-36%	-28	76	0
Canola low	477	207	290	43%	61%			-9	95	19
Canola high	563	278	285	49%	51%	71	-6%	-14	91	15
Chemical fallow low	358	164	194	46%	54%			-104	0	-76
Chemical fallow high	403	228	176	56%	44%	64	-29%	-123	-19	-94
Field Peas low	418	204	263	49%	63%			-35	69	-7
Field Peas high	522	277	213	53%	41%	73	-68%	-85	19	-57

Do alternative dwarfing genes improve the performance of deep sown wheat?

Dr Bob French, Senior Research Officer, DPIRD Merredin

Key Messages

- Sowing deep (> 100mm) compared to shallow (~ 60mm) reduced wheat establishment by 6-72% depending on the genotype.
- Among current widely grown cultivars, longer coleoptile cultivars Magenta and Cutlass established better when sown deep than Mace, Emu Rock, or Scepter, which have shorter coleoptiles.
- Lines with a range of coleoptile lengths derived by backcrossing with the old tall cultivar Halberd generally established better than current commercial cultivars but coleoptile length was not the only factor influencing establishment.
- Deep sowing reduced grain yield less than crop establishment, and some genotypes showed greater ability to compensate for poor establishment.
- Systematic seed depth variation within plots made further analysis of yield data unreliable.

Aim

To characterise the impact of genetically determined differences in coleoptile length on wheat response to deep seeding.

Background

Growers often want to seed wheat deeper than normal to access soil containing sufficient moisture to support germination, especially early in the growing season when evaporation rates are high and rainfall events infrequent. The likelihood of increasingly variable May rainfall in Western Australian (WA) agricultural areas, and the desire to use April rain more efficiently, mean this is likely to become more common.

Sowing deeper than 80mm delays and usually reduces the extent of wheat establishment, and often reduces grain yield, compared to sowing at 40 to 50mm under ideal conditions. Strategies to improve establishment of deep sown wheat should therefore improve the reliability of wheat production on WA farms. One of the constraints is the length of coleoptiles, which are the protective structures growing from germinating seeds to the soil surface where young leaves emerge. If coleoptiles are too short to reach the soil surface young leaves will have to push through soil to reach it and may experience stress from mechanical impedance and any soil applied herbicides.

Most modern Australian wheat cultivars contain the dwarfing genes *Rht1* or *Rht2*, which shorten the coleoptile compared to the older tall cultivars common before 1980. There are alternative dwarfing genes that do not shorten coleoptiles and should allow retention of the agronomic advantages of semi-dwarf wheats while enabling deeper sowing.

CSIRO has developed backcross populations with a range of these genes in a background of the widely adapted Australian tall cultivar Halberd, which has no dwarfing genes. We tested how a range of lines from these populations respond to very deep sowing, while also benchmarking against widely adapted commercial cultivars known to differ in coleoptile length.

Trial Details

Property	Liebe Group Main Trial Site, McCreery's Property, Cottage Road, Kalannie
Plot size & replication	10m x 1.54m x 3 replications
Soil type	Sandy loam
Soil pH (caCl2)	0 - 10cm: 5.3 10 - 20cm: 4.4 20 - 30cm: 4.2
EC (dS/m)	0 - 10cm: 0.088 10 - 20cm: 0.043 20 - 30cm: 0.036
Paddock rotation	2013: wheat 2014: wheat 2015: volunteer pasture 2016: wheat 2017: canola/chemical fallow
Sowing date	07/06/2018
Sowing rate **Sowing depth**	49 to 60 kg/ha calculated to give 120 plants/m 40 to 100mm
Fertiliser	07/06/2018: 80 kg/ha Agras (at seeding) 19/07/2018: 50 L/ha Flexi-N
Herbicides, Insecticides & fungicides	07/06/2018: 1 L/ha Sprayseed 250 + 2 L/ha Triflur X 30/07/2018: 670 mL/ha Velocity + 1% Mso
Growing Season Rainfall	216.5mm (April - October)

Results

Genotypes used

Eighteen wheat genotypes with different dwarfing genes (Table 1) were sown at target depths of 40 mm and 100 mm into moist soil. Table 1 also shows coleoptile lengths measured in a separate experiment and thousand seed weights of the seed used in this trial.

Table 1: Coleoptile lengths and thousand seed weights of genotypes used in this trial. Coleoptile length was measured under controlled conditions in 2017, and thousand seed weight was measured on seed used in this trial. Coleoptile length of Magenta was not measured; it usually has slightly longer coleoptiles than Mace, and similar to Cutlass. All H_ lines were derived from Halberd backcrosses and are at least 99% genetically identical, except for the dwarfing genes.

Genotype	Dwarfing gene	Coleoptile length (mm)	Thousand seed weight (g)	Genotype	Dwarfing gene	Coleoptile length (mm)	Thousand grain weight (g)
Halberd	None	139	38.9	H_141	*Rht8_2*	142	40.0
H_9	*Rht5*	157	37.5	H_150	*Rht_13*	153	37.2
H_10	*Rht5*	147	37.8	H_153	*Rht_13*	151	37.5
H-67	*Rht8_1*	153	38.7	H_H+3	*Rht3*	95	33.2
H_86	*Rht8_1*	141	40.6	Cutlass	*Rht1*	107	42.3
H_110	*Rht2*	115	34.8	Emu Rock	*Rht1*	89	43.8
H_117	*Rht1*	124	34.3	Mace	*Rht1*	95	41.2
H_119	*Rht1*	114	36.4	Magenta	*Rht1*	-	36.5
H_121	*Rht1*	119	33.0	Scepter	*Rht1*	72	41.7

Depths achieved

Seed depth varied considerably within each depth treatment due to soil throw from rear seeder tines onto seed rows placed by the front tines. We therefore distinguished two row classes which were monitored separately in each treatment. Class one consisted of even numbered rows counting from the plot edge with average measured seed depth of 63mm and 72mm respectively in the shallow and deep treatments, and class two was comprised of the odd numbered rows with average measured seed depth of 79 and 109 mm respectively in the shallow and deep treatments. There was therefore little contrast in depth between class one rows in the deep treatment and class two rows in the shallow treatment, but otherwise there was good depth contrast between treatments.

Crop emergence

Figure 1 compares crop emergence between class one rows (63mm) in the shallow treatment and class two rows in the deep treatment (109mm). Emergence was faster in all genotypes when sown shallow, and final emergence numbers were also greater when sown shallow in all genotypes except Halberd and H_117. Emergence from deep sowing as a percentage of shallow sowing ranged from 28% for Emu Rock to 94% for H_117, and was generally lower in commercial cultivars than backcross lines (Table 2). Among the backcross lines substituting alternative dwarfing genes for Rht1 did not improve emergence from deep sowing, contrary to findings in similar trials at Merredin and Mullewa in 2016 and at Merredin in 2018 (French et al. 2017). However commercial cultivars with longer coleoptiles (Cutlass and Magenta) did emerge better from depth than those with short coleoptiles, especially Emu Rock and Scepter.

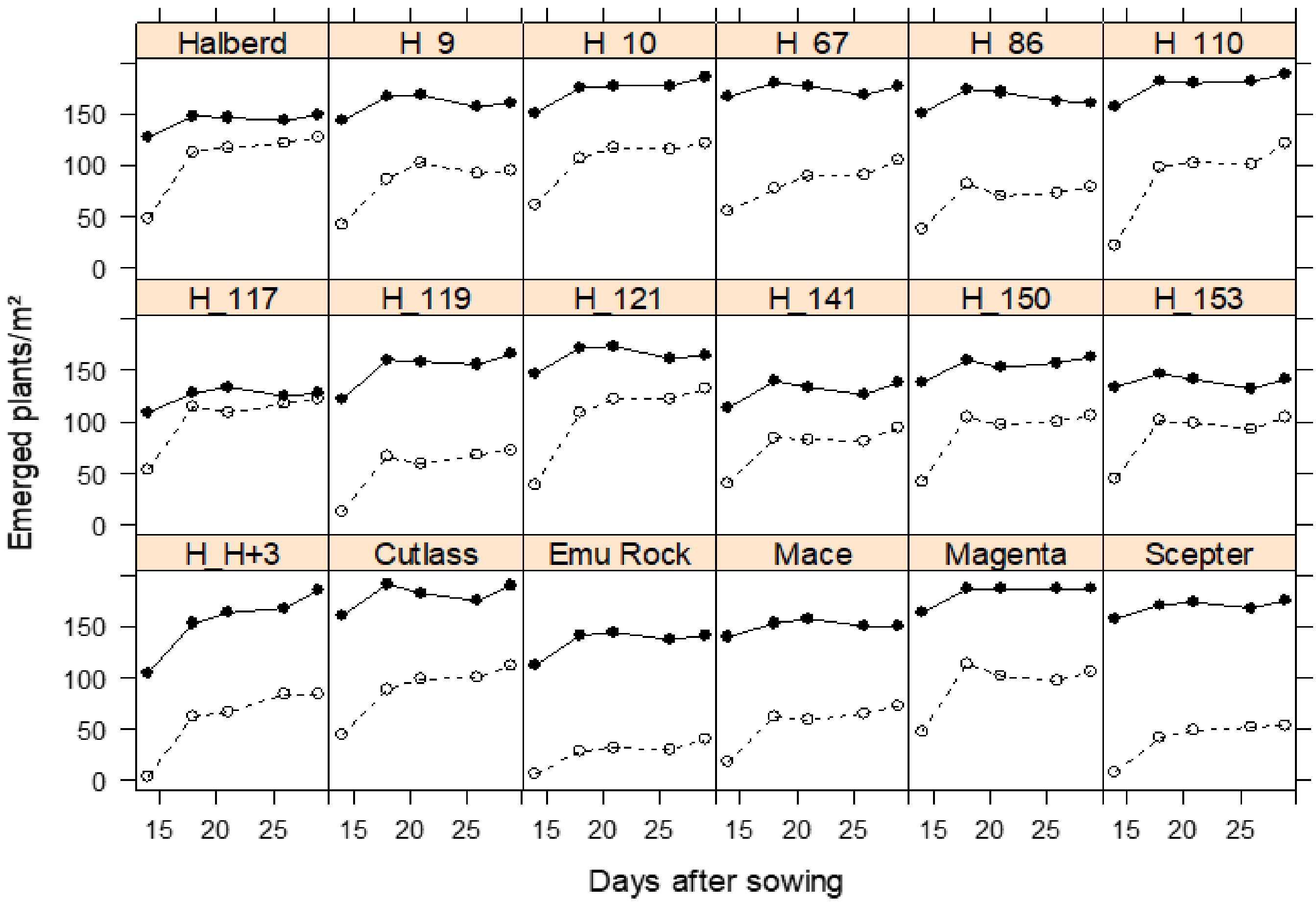

Figure 1: Emergence patterns of 18 wheat genotypes with different dwarfing genes sown ~63mm deep (solid lines) or ~109mm deep (dashed lines).

Table 2: Ratio of emergence 29 days after sowing of 18 wheat genotypes sown ~109mm deep to that when sown ~63mm deep.

Genotype	Emergence ratio	Genotype	Emergence ration	Genotype	Emergence ratio
Halberd	0.851	H_117	0.945	H-H+3	0.451
H_9	0.594	H_119	0.439	Cutlass	0.590
H_10	0.652	H_121	0.801	Emu Rock	0.279
H-67	0.600	H_141	0.683	Mace	0.483
H_86	0.488	H_150	0.648	Magenta	0.571
H_110	0.642	H_153	0.739	Scepter	0.303

Grain yield and quality
Deep sowing reduced grain yield by up to 31% (Table 3). This was unrelated to reductions in establishment, and potentially reflects differing ability among genotypes to compensate for low density, as well as variability introduced by depth variation between rows within the same treatment. Deep sowing did not affect grain protein or small grain screenings.

Comments
Sowing wheat deeper than 100mm reduced crop establishment compared to sowing at 60mm by up to 70%, but some genotypes were far less affected than others. These generally had longer coleoptiles than the most affected genotypes, but factors other than coleoptile length were also important, as some of the better performing genotypes did not have particularly long coleoptiles. This is consistent with previous seed depth trials at Wubin and Buntine (French 2014, French 2015). Deep sowing also reduced grain yield but variation in seed depth within plots made it difficult to interpret these data.

Table 3: Effect of sowing depth on grain yield of 18 wheat genotypes at Kalannie 2018. Figures followed by the same letter in the superscript are not significantly different.

Genotype	Grain yield (kg/ha)		Genotype	Grain yield (kg/ha)	
	Deep	Shallow		Deep	Shallow
Halberd	1685^{hijk}	2000^{abcdefgh}	H_141	1589^{jkl}	1808^{eghij}
H_9	1918^{cdefghi}	1897^{cdefghi}	H_150	1630^{ijk}	1877^{cdeghij}
H_10	1986^{abcdefghi}	1918^{cdefghij}	H_153	1617^{ijk}	1808^{eghij}
H_67	1493^{k}	1781^{fghijk}	H_H+3	973^{n}	1397^{im}
H_86	1151^{mn}	1562^{jkl}	Cutlass	1849^{dfghj}	2260^{ab}
H_110	1712^{hijk}	1836^{defghij}	Emu Rock	1603^{ijkl}	2137^{abcd}
H_117	1986^{acbdefgh}	2110^{abcde}	Mace	1781^{fghijk}	1973^{bcde}
H_119	1781^{fghijk}	1959^{bcdefgh}	Magenta	2069^{abcdef}	2192^{abc}
H_121	1740^{ghijk}	2041^{abcdefg}	Scepter	1918^{cdefgh}	2301^{a}
Genotype P < 0.001 Depth P < 0.001					
Genotype x Depth *P = 0.321* Genotype x Depth *LSD = 319*					

Halberd backcross lines generally showed less establishment reduction than current widely grown cultivars indicating there is potential to improve the ability of wheat to emerge from sowing deeper than 100mm. The alternative dwarfing genes tested in this work have been made available to Australian plant breeders to use in their crossing programs so this material will become more widely available in due course. In the meantime there are exploitable differences in current commercial cultivars with short-coleoptile cultivars such as Emu Rock and Scepter showing greater establishment reduction than long coleoptile cultivars such as Magenta and Cutlass which would therefore be more suitable for deep sowing to chase moisture.

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CANOLA & PULSES RESEARCH RESULTS

Hybrid Canola in the WA Lower Rainfall Regions

Alana Hartley, Research & Development Coordinator, Liebe Group

Key messages

- Hybrid canola in low rainfall Agzones has shown good potential in National Variety Trials and commercial trials, giving growers confidence that higher financial returns per hectare (than OP varieties) is achievable.
- Hybrid canola varieties deliver improved stress tolerance along with enhanced plant establishment and early vigour. Each of these hybrid traits has been observed to also assist with improved weed control from better crop competition
- OP varieties such as Bonito still perform consistently in the medium to low rainfall zones, with high oil providing good economic returns.
- Hybrid varieties that have a negative return on investment in 2018 in this region are unlikely to provide an economic return in future seasons.

Aim

To demonstrate the relative profitability and observed weed competition effectiveness of hybrid canola versus Open Pollinated Triazine Tolerant (OP TT) canola in the low rainfall zone.

Background

There is little data comparing hybrid and open pollinated canola varieties in the Kalannie region because variety trials have historically been situated further west, in higher rainfall environments. While the adoption of hybrid canola has been rapid through many growing regions of WA it has been limited throughout the low rainfall regions. The uptake of hybrid Roundup Ready® (RR) and Triazine Tolerant (TT) canola has been somewhat delayed in many eastern low rainfall areas of WA due to the perceived risks of growing a hybrid canola (with higher seed input costs there is a risk of not achieving positive economic returns).

The use of open pollinated TT canola varieties is common throughout the Kalannie region due to the ability to retain low cost seed. Conversely adoption of hybrid TT varieties has been limited by seed costs and the marginal growing conditions often experienced in this area, which increase the risk of low economic return.

This canola variety trial demonstrated both the economic and agronomic impacts of adopting hybrid canola varieties compared to the widely grown OP TT varieties.

The comparison of hybrid varieties to OP investigated the following;

- If hybrid varieties gave higher financial returns per hectare in trials and commercial crops;
- If hybrid varieties exhibited higher stress tolerance with improved establishment; and,
- If hybrid varieties have improved weed control (from better crop competition).

Trial Details

Property	Liebe Group Main Trial Site, McCreery's Property, Cottage Road, Kalannie
Plot size & replication	10m x 1.54m x 3 replications
Soil type	Loamy sand
Soil pH (caCl2)	0 - 10cm: 5.1 10 - 20cm: 4.2 20 - 30cm: 4.2
Paddock rotation	2015: volunteer pasture 2016: wheat 2017: canola/fallow
Sowing date	07/05/2018
Sowing rate	As per protocol
Fertiliser	07/05/2018: Landmark K-Start 65 kg/ha, Urea 40 kg/ha 27/06/2018: UAN + Sulphur 50 L/ha
Herbicides, Insecticides & fungicides	07/05/2018: Atrazine 1.1 kg/ha (TT only), Alphacypermethrin 0.2 L/ha, Chlorpyrifos 0.2 L/ha, Sprayseed 2 L/ha, 1.5 L/ha Trifluralin 20/06/2018: Atrazine 1.1 kg/ha, MSO 1% (TT only) 20/06/2018: Roundup Ready® 0.9 kg/ha 05/07/2018: Roundup Ready® 0.9 kg/ha 05/07/2018: Clethodim 0.5 L/ha, MSO 1%
Growing Season Rainfall	216.5mm (April - October)

Variety Treatments

Entry	TT Treatments	RR Treatments
1	ATR Bonito	InVigor R 3520
2	ATR Stingray	Hyola® 404RR
3	InVigor T 4510	Hyola® 506RR
4	InVigor T 3510	M36416
5	Hyola® 350TT	RR81589
6	Hyola® 559TT	
7	Hyola® 580CT	

Trial Layout

Buffer Row	Row 1	Row 2	Row 3	Row 4	Row 5	Row6
TT Buffer	Bonito	InVigor T4510	Hyola® 350TT	Stingray	TT Buffer	TT Buffer
TT Buffer	CHYB2124TT	Hyola® 580CT	Hyola® 559TT Filler	Hyola® 559TT	TT Buffer	TT Buffer
TT Buffer	InVigor T4510	CHYB2124TT	Bonito	Hyola® 559TT Filler	TT Buffer	TT Buffer
TT Buffer	Hyola® 559TT	Stingray	Hyola® 580CT	Hyola® 350TT	TT Buffer	TT Buffer
TT Buffer	Hyola® 350TT	Hyola® 559TT Filler	Hyola® 559TT	CHYB2124TT	TT Buffer	TT Buffer
TT Buffer	Hyola® 580CT	Bonito	Stingray	InVigor T4510	TT Buffer	TT Buffer

Row 7	Row 8	Row 9	Row 10	Row 11	Buffer
RR Buffer	RR Buffer	Hyola® 506RR	InVigor R 3520	Hyola® 404RR	RR Buffer
RR Buffer	RR Buffer	M36416	Hyola® 404RR Filler	RR81589	RR Buffer
RR Buffer	RR Buffer	Hyola® 404RR	Hyola® 506RR	M36416	RR Buffer
RR Buffer	RR Buffer	InVigor R 3520	RR81589	Hyola® 404RR Filler	RR Buffer
RR Buffer	RR Buffer	Hyola® 404RR Filler	Hyola® 404RR	Hyola® 506RR	RR Buffer
RR Buffer	RR Buffer	RR81589	M36416	InVigor R 3520	RR Buffer

← N

Results/comments

Rainfall at the Kalannie Main Trial Site was slightly higher than average (203 mm), with the site receiving 216 mm growing season rainfall (April-October). All varieties were planted on 7th May and opening rains were not received until 24th May. This meant that germination of the trial was late, with crop emerging in cooler and shorter days than had it germinated after seeding in early May. Plant densities ranged between 35-70 plants/m^2 except for the Invigor T3510, which had an average density of 26 plants/m^2. These plant densities however, are still above the recommended range of 20-25 plants/m^2 in this rainfall zone with some varieties being densely populated. Crop competition saw plant numbers plateau at 26-35 plants/m^2 at rosette stage.

Seasonal conditions at the site in Kalannie were favourable after the late start, with 216 mm GSR. Site yield ranged from 1.6 to 2.2 t/ha with all varieties across both the Triazine Tolerant and Roundup Ready technologies performing well.

Harvest results

Average yield and oil has been analysed across all varieties demonstrated in this trial.

Triazine Tolerant – Open Pollenated (OP) and Hybrid

Table 1: Triazine Tolerant (TT) Open Pollenated (OP) and Hybrid yield and oil harvest results.

Variety	Average Yield (t/ha)	Average Oil (%)
ATR Bonito	1.705[a]	47.87[d]
ATR Stingray	1.691[a]	45.97[c]
Hyola® 350 TT	1.745[a]	46.00[c]
Hyola® 559 TT	2.185[b]	47.46[d]
Hyola® 580 CT	1.583[a]	43.80[a]
InVigor T3510	1.948[ab]	44.67[b]
InVigor T4510	1.823[a]	45.23b[c]
L.s.d.	*0.3688*	0.745
P value	*0.038*	<0.001

**Results followed with a different letter indicates a significant difference between varieties*

There was a significant difference in the yield of the TT varieties with some of the hybrids out-performing the OP's; Hyola 559TT yielded 2.18 t/ha and InVigor T3510 1.95 t/ha, both significantly higher than the other hybrid and OP TT varieties.

The open pollinated variety ATRBonito had a significantly higher oil content at 47.87% compared to all other varieties. Of the hybrid varieties, Hyola 559TT also yielded a significantly higher oil content at 47.46%. With canola receiving a financial bonus for oil content over 42%, the high oil of these two varieties was reflected in the economic analysis.

The hybrid dual herbicide tolerant variety Hyola 580 CT (Clearfield and triazine tolerant) was significantly lower yielding and had lower oil content than all other varieties tested at this site.

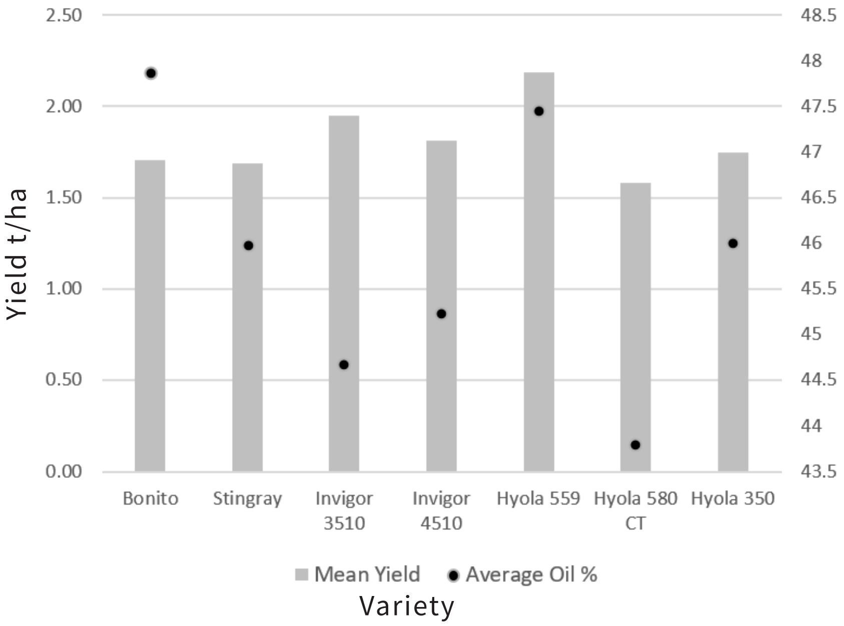

Figure 1: Yield and Oil of OP and Hybrid TT varieties at Kalannie, 2018

Roundup Ready

Roundup Ready® canola varieties have performed consistently across the medium rainfall areas of the Western Australian Wheatbelt. With high yields, oil, ability to control hard to kill weeds, and economic gains, making the adoption of RR varieties an attractive option for the cropping rotation. Open pollinated RR varieties were released but have now been superseded by the hybrids. Consequently all Roundup Ready® varieties used are hybrids.

In the low rainfall regions, cost of hybrid seed is a limiting factor to adoption. For weed control purposes, growers from these regions are keen to adopt the Roundup Ready® technology however wish to see the economic gains that can be made before deciding to adopt. Where RR technology has been adopted, it is considered another tool for integrated weed management (IWM) in combination with the OP TT varieties.

Table 2: Roundup Ready® yield and oil harvest results.

Variety	Average Yield (t/ha)	Average Oil (%)
Hyola® 404	2.198	48.50[c]
Hyola® 506	2.246	48.13[bc]
RR81589	2.403	48.27[bc]
M36416	2.110	48.00[b]
InVigor R 3520	1.921	46.03[a]
L.s.d.	*NS*	0.4737
P value	*0.334*	<0.001

**Those results followed by a different letter are significantly different. No significant difference (NS)*

Harvest results of the Roundup Ready® varieties saw no significant difference in yield. Oil did differ however, with varieties such as Hyola 404RR having significantly higher oil (48.5%) compared to InVigor R 3520, which yielded the lowest oil content (46.03%) of all the RR varieties demonstrated at this site. All varieties were above 42% and are therefore eligible for the oil bonus.

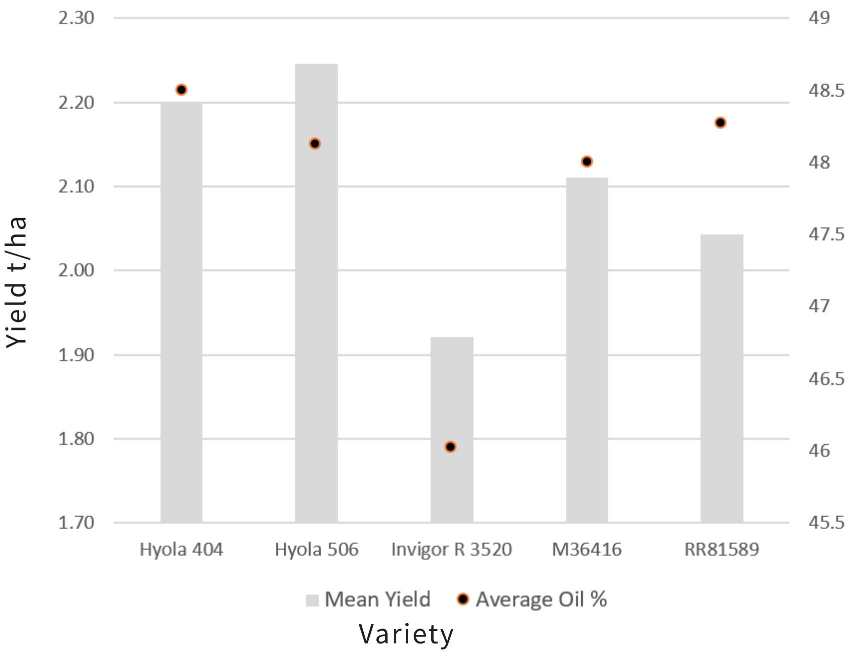

Figure 2: Roundup Ready Yield and Oil at Kalannie, 2018

Economic analysis

Three types of analysis have been conducted to determine the economic value of each canola variety and technology demonstrated in this trial – gross margin return, operating profit and return on investment (ROI %).

Grain prices used in this analysis are $548/t for CAG1 (GM-canola) and $592/t for CAN1 (non-GM) as of 12th November 2018 (Glencore Grain). All varieties achieved a CAG1 or CAN1 grade when tested for quality, using CBH quality standards. Oil bonus is calculated at $8.64/t clean grain using the CBH canola calculator. Variable costs included seed cost, CBH fees and production costs. No other variable costs have been included.

Gross margin (GM) return (Figure 3) identified hybrid TT variety Hyola 559TT as the top performing variety at this site in 2018, with a GM/ha return of $1,040/ha. Hyola 559TT emerged $271.73/ha ahead of the next highest grossing variety InVigor T3510, and $65.80/t ahead of the highest grossing Roundup Ready® variety Hyola 506RR at $974/ha.

The lowest gross returns gained by a TT variety was Hyola 580 CT at $591.73/ha and the lowest gross return from the RR varieties being InVigor R3520 at $784.08/ha.

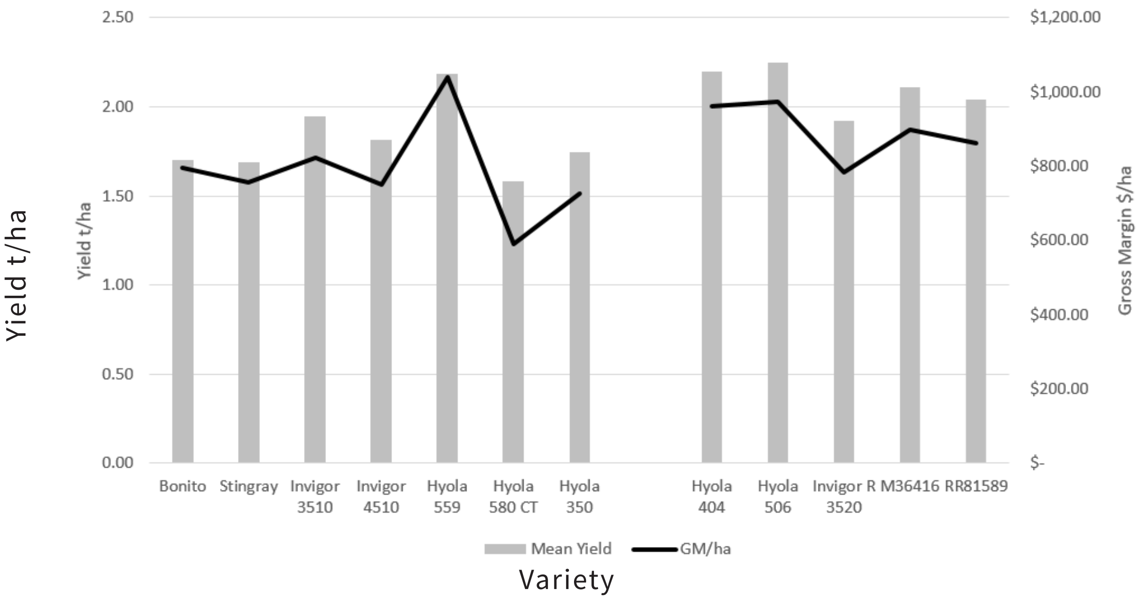

Figure 3: Representation of yield and gross margin by variety, 2018

To accurately reflect the profitability of the canola technologies trialled at Kalannie, a calculation of operating profit (income – full costs) and ROI has been conducted (Table 3). Full costs include total variable costs plus other fixed costs calculated at an average of $200/ha. The ROI is a reflection of the total production cost in comparison to the income that crop made. As noted in Figure 4 there were some varieties that had a negative ROI, making those varieties unprofitable at Kalannie in the 2018 season.

Table 3: Operating Profit and return on investment for each trialled variety

	Variety	Average Income	* Average Full Costs	Operating Profit	Full Cost as % Income	Profit Margin	Return on Investment (%)
TT	Bonito	$1,907.34	$502.01	$595.33	45.75%	54.25%	18.59%
	Stingray	$1,060.10	$502.97	$557.13	47.45%	52.55%	10.77%
	InVigor 3510	$1,198.94	$576.57	$622.37	48.09%	51.91%	7.94%
	InVigor 4510	$1,124.64	$573.57	$551.07	51.00%	49.00%	-3.92%
	Hyola® 559	$1,398.27	$558.17	$840.10	39.92%	60.08%	50.51%
	Hyola® 580 CT	$962.05	$570.32	$391.73	59.28%	40.72%	-31.31%
	Hyola® 350	$1,094.48	$567.55	$526.93	51.86%	48.14%	-7.16%
RR	Hyola® 404	$1,320.97	$560.44	$760.53	42.43%	57.57%	35.70%
	Hyola® 506	$1,342.64	$568.34	$774.30	42.33%	57.67%	36.24%
	InVigor R 3520	$1,115.71	$531.64	$584.08	47.65%	52.35%	9.86%
	M36416	$1,258.49	$560.44	$698.05	44.53%	55.47%	24.55%
	RR81589	$1,222.61	$560.44	$662.17	45.84%	54.16%	18.15%

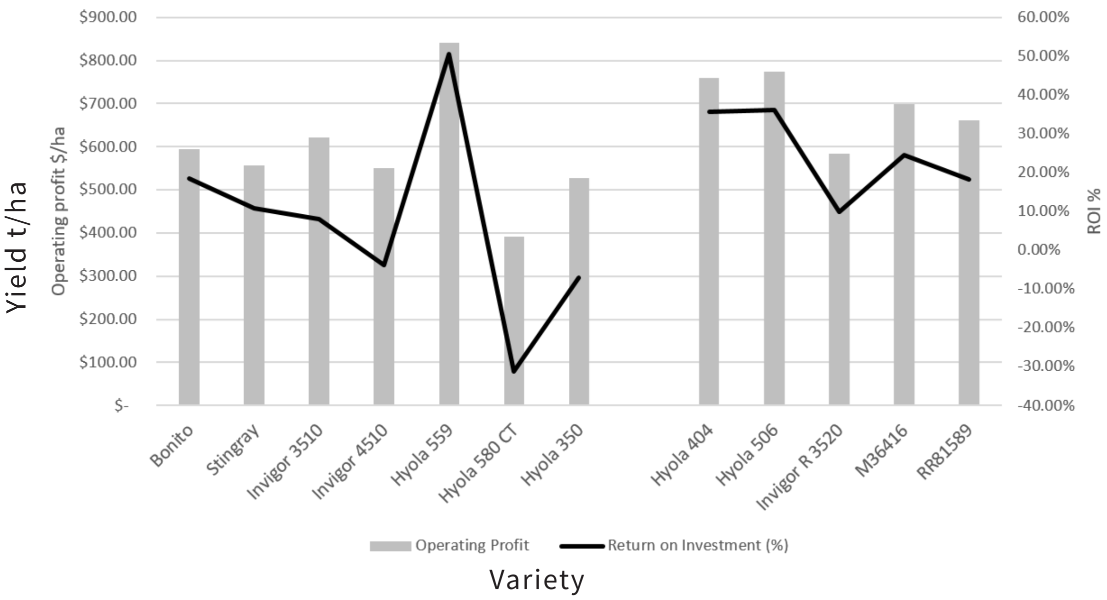

Figure 4: Operating profit and associated Return on Investment (ROI%) of tested varieties

Triazine Tolerant (TT) hybrid variety Hyola 559TT was the most profitable variety at this site, with an operating profit of $840/ha and ROI over 50%. This was closely followed by RR varieties Hyola 506RR at $774.30/ha and ROI 36.24% and, Hyola 404RR at $760.53/ha and ROI 35.7%.

Open pollinated TT variety ATRBonito may not have yielded as high as its hybrid counterparts however due to the low cost in retaining seed, and strong oil content attracting a high oil bonus, this variety saw the next highest ROI after Hyola 559TT, at 18.59% when compared to all other TT varieties trialled at this site.

Short season hybrid Hyola 350TT had a moderate operating profit of $526/ha however due to the additional cost of seed, lower yield and oil, ROI was -7.16%. Dual herbicide tolerant variety Hyola 580 CT had the lowest operating profit of the TT varieties and also experienced an ROI of -31.31%.

Roundup Ready® variety InVigor R 3520 yielded low operating profit of $584/ha; $78 - 176/ha less compared to all other RR varieties, which also reflected in a low ROI. While a positive return was still gained, ROI was low at 9.86%.

Comments

Hybrid canola varieties can be considered profitable in the low rainfall regions such as Kalannie, particularly the Hyola 559TT, Hyola 506RR and Hyola 404RR varieties. Due to a longer period of growing season rainfall and mild conditions, shorter season hybrids and OP's such as the 3 series hybrids (Hyola 350TT, Invigor T3510 and Invigor R3520) and Stingray, were not favoured.

Consistent rainfall was the key driver of yield in this season and results of varieties tested may or may not be replicated in subsequent seasons, or where seasonal conditions are below average. When selecting a variety that is suitable for your growing region, refer to the Canola Variety Sowing Guide (DPIRD, 2018).

Acknowledgements

This trial was initiated through the interest of the Liebe Group R&D committee and their desire to see canola variety performance at the 2018 Liebe Group Main Trial Site in Kalannie. Thank you to the Liebe Group for supporting this trial. Many thanks to Advanta Seeds and BASF Seeds (previously Bayer Seeds) for contributing to this trial and providing canola varieties for demonstration at this site.

Statistical analysis for this trial was conducted by the Department of Primary Industries and Regional Development (DPIRD) and, economic analysis reviewed by Farmanco.

Thank you to the McCreery family for providing the site for this trial and the ongoing support throughout the season.

Reviewed by: Martin Harries, DPIRD

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Lentil Variety Trial - Dalwallinu

Mark Seymour, Senior Research Officer, DPIRD

Key Messages

- Lentils are well suited to the heavier soils of Dalwallinu and current varieties produced yields up to 1.95 t/ha in 2018.
- Over the longer term PBA Hallmark XT has outperformed PBA Hurricane XT and growers interested in IMI tolerant lentils are encouraged to try this variety on their farm.
- Medic pasture can be a significant weed in lentils and are difficult to manage in-crop. Growers should identify paddocks with a low pasture base.

Aim

To identify suitable lentil varieties for Western Australian farming systems.

Background

Lentils are rapidly expanding in the Esperance region and have been identified as having a fit elsewhere in Western Australia (WA). The Department of Primary Industries and Regional Development (DPIRD) run a small NVT style program to identify suitable varieties for WA conditions and provide supporting information for newly released varieties. In this series DPIRD were testing 10 released varieties and 20 unreleased genotypes (data not shown here) sown in April in key locations in WA.

Trial Details

Property	Ian and Ainsley Hyde, Bell Road, Dalwallinu
Plot size & replication	1.8 x 10 x 3
Soil type	Red-brown clay loam
Soil pH ($CaCl_2$)	0-10cm: 6.5 10-20cm: 7.4 20-30cm: 8.1
EC (dS/m)	0-10cm: 0.280 10-20cm: 0.194 20-30cm: 0.355
Paddock rotation:	2018: Field Peas 2017: Barley 2016: Wheat
Sowing date	24/04/2018
Sowing rate	Variety dependent: Target 100 p/m^2
Fertiliser	Banded 100 Kg/ha Superphosphate treated with Hi load Gold @200 mL/ha
Herbicides, insecticides & fungicides	24/04/2018: IBS 1.0 kg/ha Terbyne Xtreme (875 g terbuthylazine/kg) + 1 L/ha Treflan, 20/06/2018: 25 g/ha Broadstrike 19/07/2018: 100 mL/ha Brodal + 100mL/ha metribuzin (salvage to control medic – minimal crop damage), 10/09/2018: 1 L/ha Select + Hasten, 25th October 3 L/ha Reglone
Growing season rainfall	300 mm (April - October)

Results

At Dalwallinu in 2018 lentil growth and yields were excellent. Overall, all varieties averaged 5 t/ha of dry matter and average seed yields across all varieties was 1.6 t/ha. Thus lentils produced an economic yield and will also provide good levels of nitrogen for following cereal crops.

No released variety yielded higher than the industry standard variety PBA Bolt (Table 1) at the Dalwallinu site. One of the breeding lines (data not shown) did out yield PBA Bolt at Dalwallinu in 2018.

Table 1: Lentil variety trial, Dalwallinu

Variety	Yield (t/ha)	% of Bolt	50% flowering	1000seed weight (g)
PBA Hallmark XT (CIPAL1422)	1.95 gh	123	1-Sep	41 hi
NUGGET	1.41 abcd	89	31-Aug	40 ghi
PBA ACE	1.63 abcdefgh	103	28-Aug	43 jk
PBA BLITZ	1.54 abcdef	97	24-Aug	48 m
PBA BOLT	1.58 abcdefg	100	27-Aug	41 ghi
PBA FLASH	1.30 ab	82	3-Sep	47
PBA GREENFIELD	1.49 abcde	94	1-Sep	51 n
PBA HERALD XT	1.56 abcdefg	99	4-Sep	30 a
PBA HURRICANE XT	1.68 bcdefgh	106	1-Sep	34 b
PBA JUMBO2	1.76 cdefgh	111	27-Aug	48 m
Mean	1639	104		40
P value	0.02			<0.001
LSD	386.4	24		2

Values followed by the same letter are not significantly different
*Statistics have been conducted on all varieties tested at the site however, only results from released varieties are shown here.

The new variety PBA Hallmark XT (tested as CIPAL1422) nearly produced significantly higher yields than PBA Bolt and PBA Hurricane XT. Over the last five years, PBA Hallmark XT appears to be a more reliable variety than PBA Hurricane XT (Figure 1) and produces medium sized seed compared to PBA Hurricane XT's smaller seed (Table 1 and Figure 2). In southern areas, PBA Hallmark XT has been observed to handle cooler conditions slightly better than PBA Hurricane XT, and the plots are more even in terms of plant establishment and biomass production.

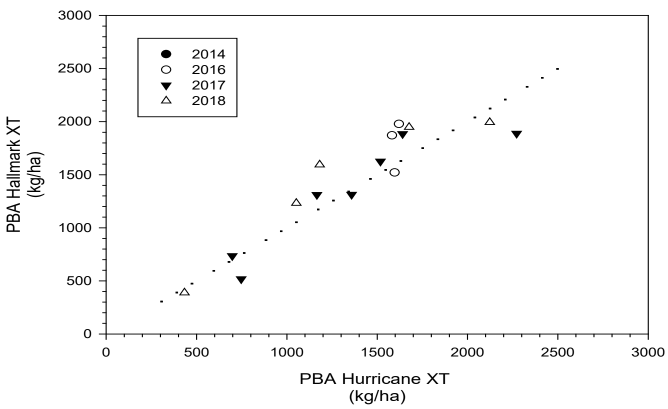

Figure 1: Seed yield comparison between PBA Hurricane XT and PBA Hallmark XT in experiments conducted by DPIRD and Pulse Breeding Australia (PBA) in WA from 2014 to 2018. Dashed line indicates 1:1.

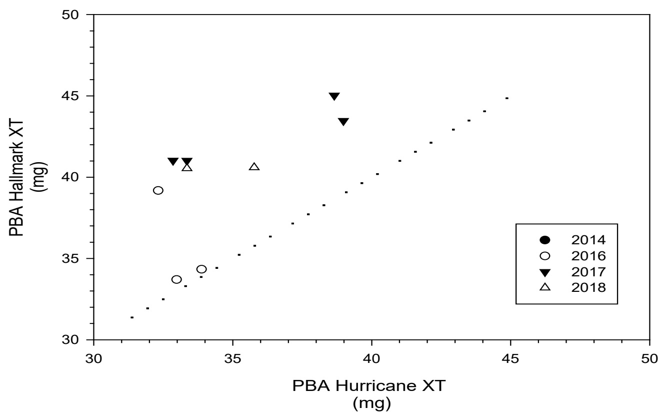

Figure 2: Seed size (mg) comparison between PBA Hurricane XT and PBA Hallmark XT in experiments conducted by DPIRD and PBA in WA from 2014 to 2018. Dashed line indicates 1:1.

Comments

Crop growth was excellent all year with significant falls, experienced throughout the growing season, April-October. The site had a well-established medic base which residual herbicides and Broadstrike were unable to control. Management of the site was adjusted to include an application of an unregistered mix of Brodal and Metribuzin, which suppressed the medic for the rest of the season and had minimal effect on the lentils.

The trial demonstrates the good fit lentils have for heavier soils in the Dalwallinu region. Lentils produced good yields and excellent biomass; resulting in an economic yield in the year of the lentil crop and should provide elevated levels of soil nitrogen for following cereals in 2019.

For other reports related to this trial see National Variety Trial (NVT) online or visit GRDC's on-farm trial web site at https://www.farmtrials.com.au

Acknowledgements

This trial is one of a series conducted throughout WA as part of the GRDC/DPIRD co-funded project "Tactical Break Crop Agronomy in Western Australia". Pulse Breeding Australia (PBA) provided seed for experiments. Thanks to the Wongan Hills TSU for trial management and Liebe Group for their continued support in providing trial sites. Salzar Rahman and Pam Burgess provided technical assistance to ensure all treatments and measurements occurred in a timely and accurate fashion

Peer review:: Martin Harries, DPIRD

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Can we extend the sowing window of canola: Wongan Hills

Martin Harries, Research Officer, DPIRD

Key messages

- Yields were impressive; 1.9t/ha from April 26 and 2.2t/ha from May 17
- Mid-season maturity varieties showed the greatest plasticity in plant development across sowing dates and may be a good option over a wide sowing/establishment period.
- Short season hybrids may enable the sowing window to be extended later with reduced risk.
- APSIM flowering dates were close to observed dates.

Aim

To investigate yield and phenology of canola cultivars when sown in March to provide better advice to agronomists and growers about best varieties to use and safe sowing and flowering windows.

Background

There is considerable interest in sowing canola early to maximise yield and minimise the risk of missing a sowing opportunity. For the past 120 years, since the release of Federation wheat, plant breeding programs of all crop species have focused on increasingly short season varieties with high harvest index (Pugsley, 1983). More recently longer wheat genotypes are being explored (Hunt, 2017), because these may be better adapted to earlier sowing. The same needs to occur with broadleaf species by testing current varieties at a wide range of sowing dates and comparing these to diverse phenotypes.

The trial tested ten Triazine Tolerant (TT) canola varieties sown at four dates as described in the trial details.

Trial Details

Property	Wongan Hills Research Station		
Plot size & replication	10m x 2m x 4 replications		
Soil type	Sand over loam		
Soil pH ($CaCl_2$)	0-10cm: 6.0	10-20cm: 5.8	20-30cm: 6.1
EC (dS/m)	0-10cm: 0.088	10-20cm: 0.035	20-30cm: 0.036
Paddock rotation:	2017 wheat		
Sowing dates	15/3/18 (TOS1), 5/4/18 (TOS2), 26/4/18 (TOS3) & 15/5/18 (TOS4)		
Varieties	CBTelfer (V.Early), ATR Stingray (Early), ATR Bonito (Early/mid), ATR Wahoo (Late), Hyola 350TT(V.early) Bayer InVigor T4510 (Early), Pioneer 44TO2 (Early), Hyola 559TT (Mid), SF Ignite (Mid/late), DG 670TT (Late), Hyola 725RT (Late).		
Sowing rate	Various; target = 40 plants/m2 and 65% field establishment (FE).		
Irrigation	Total growing season rainfall plus irrigation was 295, 286, 289 and 300mm for TOS 1, 2, 3 and 4 respectively.		
Fertiliser	50 units N, 7 units of S and 11 units of P to all sowing times		
Herbicides, insecticides & fungicides	Chemical pest control applications of Prosaro®, Pirimor®, Dimethoate, Affirm® as required.		
Annual rainfall	359mm		

Results

Establishment and growth

Overall plant establishment was on target at 40 plants/m2 and 65% field establishment (FE). In early June there was a large difference in growth, measured as green area, between the sowing times (*P* <0.001). Time of sowing 1 and 2 had more green area than sowing times 3 and 4. There was considerable difference between varieties but this was not statistically significant.

Biomass at maturity increased at later sowing times and was significantly different between sowing times 1 & 2 and 3 & 4 (Table 1). The final biomass cuts included seed and as such the bird damage that occurred within TOS 1 & 2 will have affected these results. Even so there were clear varietal differences (*P* <0.001) and a variety by sowing time interaction (*P* <0.001). It is notable that the early season hybrids were able to produce large amounts of biomass which indicates that they are quite plastic in their growth habit.

Table 1. Plant biomass at maturity (g/m^2). TOS 1 sampled 19/9, TOS 2 & 3 26/9, TOS 4 (10/10)

			Biomass (g/m^2)		
Variety	**TOS 1**	**TOS 2**	**TOS 3**	**TOS 4**	**Var Av**
Hyola 350TT		455	664	802	640
Pioneer 44TO2	460	618	581	779	610
ATR Bonito	304	366	627	693	497
DG 670TT	435	543	779	702	615
Hyola 559TT	469	468	604	825	591
Hyola 725RT	625	656	638	769	672
InVigor T4510	376	430	694	792	573
SF Ignite	533	541	625	796	624
ATR Stingray	365	401	657	618	510
CB Telfer	585	462	624	612	571
ATR Wahoo	543	666	645	619	618
TOS Av	469	510	649	728	
P value (TOS)			<0.05		
Lsd			120		
P value (Variety)			<0.001		
Lsd			68		
P value (TOS x Variety interaction)			<0.001		
Lsd			154		

Development

Flowering on the main stem was measured from the same 20 plants per plot throughout the experiment. Later sowing had the effect of reducing the differences in flowering time of the varieties, as would be expected to occur in response to reduced growing period. As with all trials in this series the recently released early season hybrids including, Hyola 350TT, InVigor T4510 and Pioneer 44TO2 all flowered earlier than Hyola 559TT. APSIM predictions of flowering date were close to the observed dates.

The duration of flowering of the whole plant was estimated by rating the percentage bloom from whole plots. Flowering duration from TOS 1 ranged across varieties from 100 to 74 days. This compared to 46 to 52 days for TOS 4. Hence later sowing had the effect of reducing the whole plant flowering duration and reducing the difference in flowering duration between varieties. The mid-season varieties had the greatest plasticity of plant development across sowing times, with up to 51 days difference in flowering duration between TOS 1 and 4 (Table 2).

Table 2. Whole plot ratings of bloom, dates at first and last 10% of bloom and duration between these dates.

	TOS 1			TOS 2			TOS 3			TOS 4			
Variety	First 10%	Last 10%	Days	First 10%	Last 10%	Days	First 10%	Last 10%	Days	First 10%	Last 10%	Days	Days difference TOS 1 to TOS 4
ATR Stingray	14/5	10/8	88	10/6	22/8	73	15/7	19/9	66	3/8	22/9	50	38
Hyola 350TT				8/6	24/8	77	12/7	17/9	67	1/8	22/9	52	
InVigor T4510	16/5	9/8	85	8/6	5/9	89	22/7	19/9	59	9/8	24/9	46	39
ATR Bonito	17/5	8/8	83	15/6	30/8	76	20/7	15/9	57	8/8	24/9	47	36
Pioneer 44TO2	26/5	26/8	92	21/6	12/9	83	20/7	17/9	59	7/8	25/9	49	43
Hyola 559TT	24/5	25/8	93	24/6	13/9	81	25/7	19/9	56	8/8	27/9	50	43
DG 670TT	30/5	25/8	87	4/7	5/9	63	28/7	22/9	56	12/8	1/10	50	37
SF Ignite	7/6	15/9	100	4/7	16/9	74	26/7	22/9	58	14/8	2/10	49	51
Hyola 725RT	22/6	16/9	86	10/7	25/9	77	28/7	27/9	61	15/8	4/10	50	36
ATR Wahoo	25/6	7/9	74	10/7	25/9	77	12/8	23/9	42	20/8	5/10	46	28

Note: CBTelfer not reported as bird damage affected flowering duration &, Hyola 350TT not available for TOS 1.

Yield and quality

Yield and quality data is presented from TOS 3 and 4 only because of bird damage to earlier sown treatments.

The overall average yield of the trial was 2.04 t/ha. Averaged across all varieties TOS 3 yielded 1940 kg/ha and TOS 4, 2146 kg/ha. The higher yield from sowing in May compared to April was most likely due to mild spring conditions, however the difference was not statistically significant. There was a variety response with CBTelfer, ATR Wahoo and Hyola 725RT yielding less than all of the other varieties; these varieties are the extremes of short (CBTelfer) and long (ATR Wahoo & Hyola 725RT) season types included in the trial. All varieties except Hyola 725RT yielded more from the later sowing date (TOS 4) and there was no variety by sowing time interaction (Figure 1).

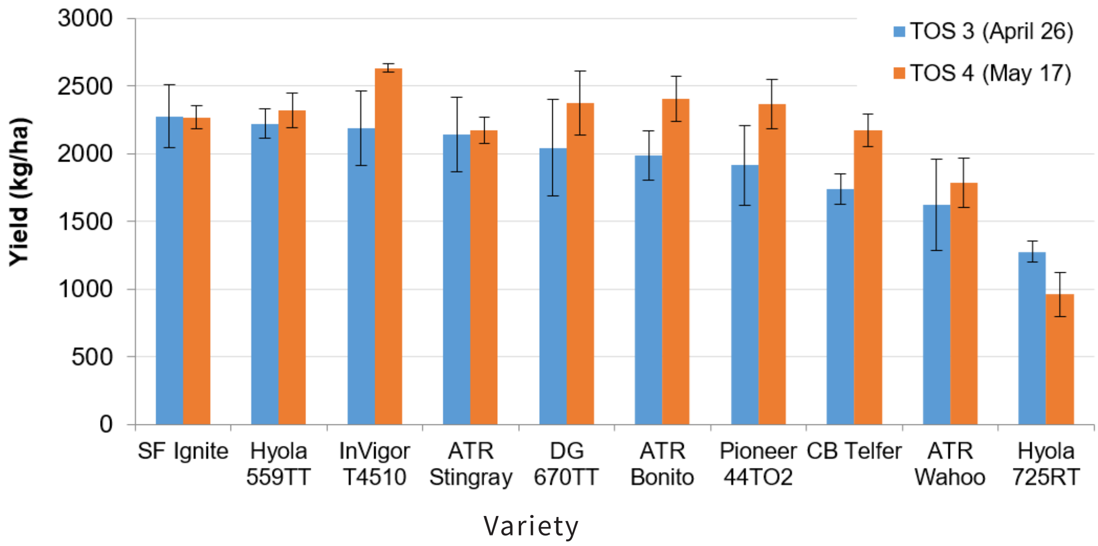

Figure 1. Seed yield of 10 canola cultivars canola cultivars from time of sowing 3 (April 26) and 4 (May 17) at Wongan Hills in 2018. Note: Hyola 350TT not reported due to bird damage.

Time of sowing did not affect seed oil or seed size but variety affected both (Table 2). Seed oil concentration of varieties ranged from 47.1 to 44.4%, this represents a $21/tonne difference between varieties (Table 3).

Table 3. Seed oil concentration (%) and 1000 seed weight (g).

	Seed oil (%)			1000 seed weight		
Variety	TOS 3	TOS 4	Var Av.	TOS 3	TOS 4	Var Av.
Hyola 350TT	44.5	44.2	44.3	3.9	3.5	3.7
Pioneer 44TO2	45.5	44.5	45.0	3.5	3.2	3.3
ATR Bonito	47.6	46.6	47.1	3.7	3.1	3.4
DG 670TT	44.9	44.1	44.5	3.2	3.0	3.1
Hyola 559TT	47.4	45.2	46.3	3.7	3.3	3.5
Hyola 725TT	46.9	44.8	45.8	3.5	3.5	3.5
InVigor T4510	45.4	44.7	45.1	3.4	3.1	3.2
SF Ignite	44.6	44.1	44.4	3.1	3.0	3.1
ATR Stingray	46.7	44.3	45.5	3.0	2.6	2.8
CB Telfer	46.7	45.1	45.9	3.4	3.2	3.3
ATR Wahoo	45.3	43.7	44.5	3.3	3.4	3.4
TOS average	46.0	44.7		3.4	3.2	
P value (TOS)		NS			NS	
Lsd						
P value (variety)		<0.001			<0.001	
Lsd		1.07			0.1827	
P value (interaction)		NS			NS	

Comments

There are a wide range of maturity types within existing canola cultivars. The mid-season maturity varieties showed the greatest plasticity in plant development across the sowing dates and may be a good option over a wide sowing period. Short season hybrids produced substantial biomass from later sowing dates and may enable the sowing window to be extended later with reduced risk. Both of these traits would be particularly useful in dry sowing situations when emergence date is unknown. The Department of Primary Industries and Regional Development will run this experiment again in 2019 and use bird netting to ensure yield results are obtained from early sowing dates.

Acknowledgements

Thanks to Salzar Rahman for measurements and Shari Dougall and the Wongan Hills Department of Primary Industries and Regional Development (DPIRD) Research Station for managing this trial. This DPIRD project is supported through investment by GRDC DAW00227.

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Peer review:: Andrew Blake, Department of Primary Industries and Regional Development

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Department of Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Canola (Roundup Ready and Triazine Tolerant) National Variety Trial - Buntine

Peter Bird, National Variety Trials, GRDC West

Key Messages

- DG 408 was the top yielding variety in the RR trial, however 4 varieties significantly out-yielded the older, well established variety Hyola 404.
- Invigor T 4510 topped the TT trial, with 5 hybrid varieties significantly out-yielding Bonito, the highest yielding OP variety.
- Although the season break – 25th May – was later than ideal for canola, the trial yielded very well and allowed different maturity groups to yield well.
- Grower decision on variety choice for 2018 should not purely be based on this trial, but include data from across the region and over a number of years. The NVT long term MET data on the NVT online website is a reliable source of data for variety decisions.

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops compared to the current commercial varieties grown in the area. The aim is to have two years of data when a variety is released.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition.

All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season, but is typically done within an average district "best practice" window and located on a typical soil type for the area.

Trial Details - RR

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Grey yellow sand
Soil pH ($CaCl_2$)	0-10 cm:6.1 10-60 cm: 4.9
EC (dS/m)	0-10 cm:0.1 10-60 cm: 0.0
Paddock rotation:	2015 unknown; 2016 unknown; 2017 wheat
Sowing date	Dry sown 30/04/18, effective sowing date 25/05/18
Sowing rate	40 seeds/m2
Fertiliser	30/04/2018: Gusto Gold 120 kg/ha, Urea 100 kg/ha 10/07/2018: UAN 120 L/ha 08/08/2018: UAN 40 L/ha
Herbicides, insecticides & fungicides	30/04/2018: 400 mL/ha Flutriafol (applied on fertilizer) 30/04/2018: 2 L/ha Paraquat + Diquat, 1 L/ha Propyzamide, 75 g/ha Lontrel advanced, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 11/06/18: 400 mL/ha Prosaro 15/06/18: 900 g/ha Roundup Ready, 50 g/ha Transform 04/07/18: 900 g/ha Roundup Ready 08/08/18: 650 mL/ha Aviator Xpro, 50 g/ha Transform 06/09/18: 450 mL/ha Prosaro, 300 mL/ha Affirm, 550 g/ha Pirimicarb 30/10/18: 2L/ha Diquat
Growing season rainfall	254 mm

Results

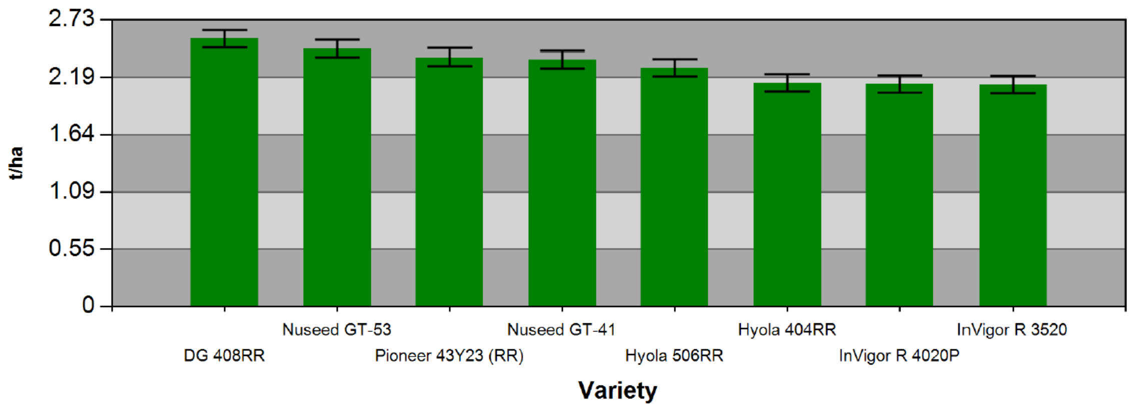

Figure 1: Yield comparison of RR canola varieties sown in Buntine, 2018

Table 1: Canola yield and oil, RR, Buntine, 2018

Treatment	Yield 2018 (t/ha)	Oil @ 6% Moisture (%)
DG 408RR	2.55	51.1
Nuseed GT-53	2.46	47.2
Pioneer 43Y23 (RR)	2.38	47.5
Nuseed GT-41	2.35	49.0
Hyola 506RR	2.28	48.6
Hyola 404RR	2.14	48.8
InVigor R 3520	2.12	48.1
InVigor R 4020P	2.12	46.9
LSD	*0.17*	*n.a.*
CV (%)	*4.43*	*n.a.*
P value	*<0.001*	*n.a.*

Trial Details - TT

Plot size & replication	10 m x 1.52 m x 3 replicates
Soil type	Grey yellow sand
Soil pH ($CaCl_2$)	0-10 cm: 6.1 10-60 cm: 4.9
EC (dS/m)	0-10 cm: 0.1 10-60 cm: 0.0
Paddock rotation:	2015 unknown; 2016 unknown; 2017 wheat
Sowing date	Dry sown 30/04/18, effective sowing date 25/05/18
Sowing rate	40 seeds/m2
Fertiliser	30/04/2018: Gusto Gold 120 kg/ha, Urea 100 kg/ha 10/07/2018: UAN 120 L/ha 08/08/2018: UAN 40 L/ha
Herbicides, insecticides & fungicides	30/04/2018: 400 mL/ha Flutriafol (applied on fertilizer) 30/04/2018: 2 L/ha Paraquat + Diquat, 1 L/ha Propyzamide, 75 g/ha Lontrel advanced, 1.1 kg/ha Atrazine, 1 L/ha Chlorpyrifos, 200 mL/ha Bifenthrin 11/06/18: 400 mL/ha Prosaro 25/06/18: 1.1 kg/ha Atrazine, 500 mL/ha Clethodim, 100 mL/ha Haloxyfop 12/07/18: 500 mL/ha Clethodim, 100 mL/ha Haloxyfop 08/08/18: 650 mL/ha Aviator Xpro, 50 g/ha Transform 06/09/18: 150 mL/ha Prosaro, 300 mL/ha Affirm, 50 g/ha Transform 30/10/18: 2L/ha Diquat
Growing season rainfall	254 mm

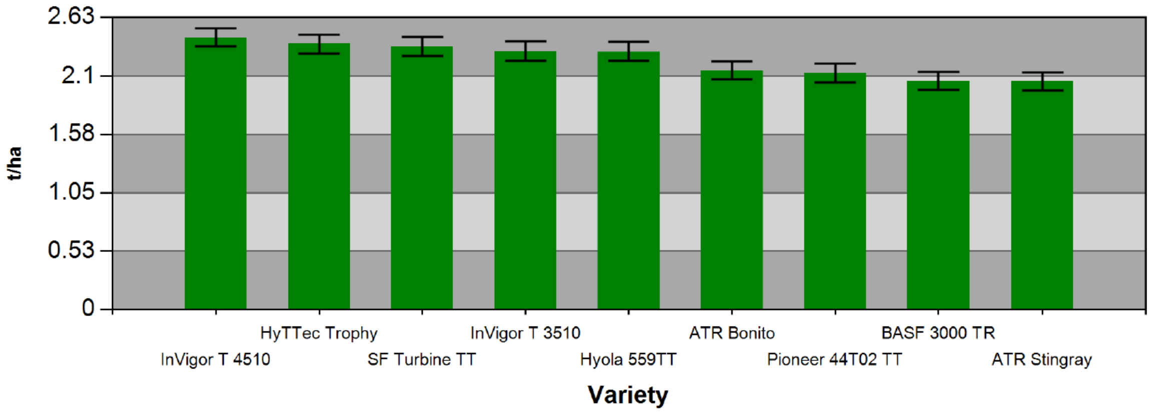

Figure 2: Yield comparison of TT canola varieties sown in Buntine, 2018

Table 2: TT Canola yield and oil, Buntine, 2018

Treatment	Yield 2018 (t/ha)	Oil @ 6% Moisture (%)
InVigor T 4510	2.45	46.3
HyTTec Trophy	2.39	47.6
SF Turbine TT	2.37	47.1
Hyola 559TT	2.33	48.3
InVigor T 3510	2.33	45.2
ATR Bonito	2.16	49.1
Pioneer 44T02 TT	2.13	47.8
ATR Stingray	2.06	47.5
BASF 3000 TR	2.06	46.0
LSD	*0.17*	*n.a.*
CV (%)	*4.46*	*n.a.*
P value	*<0.001*	*n.a.*

Comments

The trials were successful with significant variety effects and low CV's. The 2018 season did not have early sowing opportunities – the trial was sown dry and emerged from rainfall on the 25th May. Good winter rainfall and warm conditions allowed the crop to grow well. September was very dry, but the good sandy soil allowed access to soil moisture until October rain helped to finish the crop. The result was good yields and high oil contents. Oil measurements are not replicated, so should be viewed with caution.

For results of all NVT trials for 2018, and long term multi environment data, please visit the National Variety Trials online website, www.nvtonline.com.au

Acknowledgements

Thanks to property owner, Mike Dodd for providing the site for the NVT and Living Farm for conducting the trial to a high standard. Participating seed companies, GRDC and the NVT program coordinators.

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Demonstration of profitable legumes in the Western region - Carnamah

Alana Hartley, Research & Development Coordinator, Liebe Group

Key points

- Chickpea yield can be impacted by harvesting the crop too soon – before it is fully ripe.
- Field peas were a highly profitable legume option
- Where soil type permits, lentils have a good economic fit in the Carnamah region

Aim

To investigate the suitability and profitability of alternative legume crops in the Western Region.

Background

Previous research has suggested that most legume and pulse crops are best suited to fine textured soils of neutral to alkaline pH. While attempts to grow legumes and pulses in regions where the soil classification does not meet previously noted criteria has been varied in its success in the past, Western Australian growers have limited adoption of such crop types. This is in part due to suitability of soil type, competition against weeds and weed control options, yield, market access and overall profitability of legume crops.

Each site within this two year GRDC funded project, aims to demonstrate how, and if, certain grain legumes are suitable for the farming systems of each region in which the project will be implemented. The sites cover a vast range of soil types, rainfall zones and farming systems (cropping and mixed farming).

At the Carnamah Legume Demonstration site, three legumes were compared to canola, which is the current break crop option of choice in the area. Chickpeas, field peas and lentils aim to provide a profitable alternative to canola.

Trial Details

Trial location	Ian and Scott Bowman, Back Inering Rd, Carnamah	
Plot size & replication	19.02 m x 750m x 2 replications	
Soil type	Duplex	
Soil pH ($CaCl_2$)	0-10cm: 6.2 10-20cm: 6.2 20-30cm: 6.9	
Paddock rotation:	2015: Wheat 2016: Wheat 2017: Wheat	
Sowing date	24/05/18	
Sowing rate	Striker chickpeas: 80 kg/ha Gunya field peas: 80 kg/ha Hurricane lentils: 40 kg/ha Bonito canola: 3 kg/ha	
Fertiliser	Agflow Extra 65 kg/ha, ALOSCA 10 kg/ha (Group F, E & N)	
Herbicides, Insecticides & Fungicides		
(Pre-emergent)	Propyzamide 550 g/ha (whole site)	
	Field Peas & Chickpeas Terbyne 1 kg/ha Metribuzin 150 g/ha Spinnaker 50 g/ha (PSPE)	**Lentils** Diuron 500 g/ha Metribuzin 150 g/ha Spinnaker 50 g/ha (PSPE)
(Post emergent) **13/06/2018**	Chlorpyrifos 350 ml/ha (whole site)	
12/07/2018	Clethodim 500 ml/ha, Targa 150 ml/ha, 0.5% Uptake (whole site)	
22/08/2018	Aviator XPro 300 ml/ha (whole site)	
Growing Season Rainfall	240 mm	

Treatments

Plot	Rep	Treatment No.	Treatment
1	1	C	Canola
2	1	1	Lentils
3	1	2	Chickpeas
4	1	3	Field Peas
5	2	1	Lentils
6	2	2	Chickpeas
7	2	3	Field Peas
8	2	C	Canola

Trial Layout

Canola (Grower Crop) Plot 1	Lentils	**Lentils** Plot 2	**Chickpeas** Plot 3	**Field peas** Plot 4	**Lentils** Plot 5	Lentils	**Chickpeas** Plot 6	**Field peas** Plot 7	**Canola** Plot 8	Canola (Buffer)

Results

Soil analysis

Soil analysis was conducted at the beginning of the project, to measure base line nutrients. Further soil testing will be conducted after the legume phase, to determine the change in N status from the baseline results.

Table 1: Baseline soil nutrition status, Carnamah, February 2018.

Site	Depth	pH	PBI	Col P	Col K	KCl S	NO3N	NH4N	EC	OC
	0-10	6.1	40.4	36	407	52.1	33	5	0.210	1.03
	10-20	7.5	77.5	11	314	22.9	10	< 1	0.445	0.40
Carnamah	**20-30**	8.1	87.7	4	292	44.4	4	< 1	0.490	0.34
	30-40	8.4		3	322		3	< 1	0.716	
	40-50	8.2		3	278		1	< 1	0.624	

PreDicta B was conducted prior to the trial being sown, to determine the disease profile and risk at the beginning of the project. The results indicated that there was a low presence of disease at the site. PreDicta B will conducted again prior to next season and entering into the wheat phase, to determine if the legume crops have had an impact on the disease profile.

Table 2: PreDicta B Soil borne disease rating

Test	Result
Cereal Cyst Nematode (CCN)	Nil
Take All (Wheat & Oat race)	1.1
Rhizoctonia solani	0.7
F. pseudograminaerum (test 1)	Nil
F. pseudograminaerum (test 2)	1.7
Pyrenophora tritici-repentis (YLS)	2.9
Bipolaris	0.3
Pythium	1.0
Macrophomina phaseolina (collar rot/stem rot)	2.0

Disease detection rating

Low
Medium
High

Plant and weed establishment

Weeds were managed differently across each of the crop types demonstrated at the site. Specific herbicides were used to ensure adequate weed control without yield penalty due to crop herbicide safety. Where adoption of legumes in the past has been limited due to a lack of weed control options, herbicide and crop rotation management strategies now allow for legumes, such as those demonstrated, to be grown without an undue risk of a yield limiting weed burden.

Due to the sowing rates, ideal plant densities of each crop type and adequate pre-emergent herbicide control, there was no significant difference between plant and weed numbers.

Table 3: Crop plant and weed establishment counts, June 2018

Crop Type	Average plant establishment/m2	Average weed count/m2
Canola	61	6
Chickpeas	41	7
Field Peas	42	2
Lentils	101	7
P value	0.079	0.50
lsd	54.9	NS

The site was managed effectively with a herbicide regime suitable to each crop type. This meant that weeds did not influence crop establishment or yield.

Harvest results

Harvested yield varied across replicates, within and between crop types (Figure 1). There was a significant difference observed in yield of chickpeas and lentils between Rep one and two. This was due to poorer establishment observed in Rep two of the trial site. Although initial plant counts did not indicate any significant difference, site variability was a potential contributor to the variation in harvested yield.

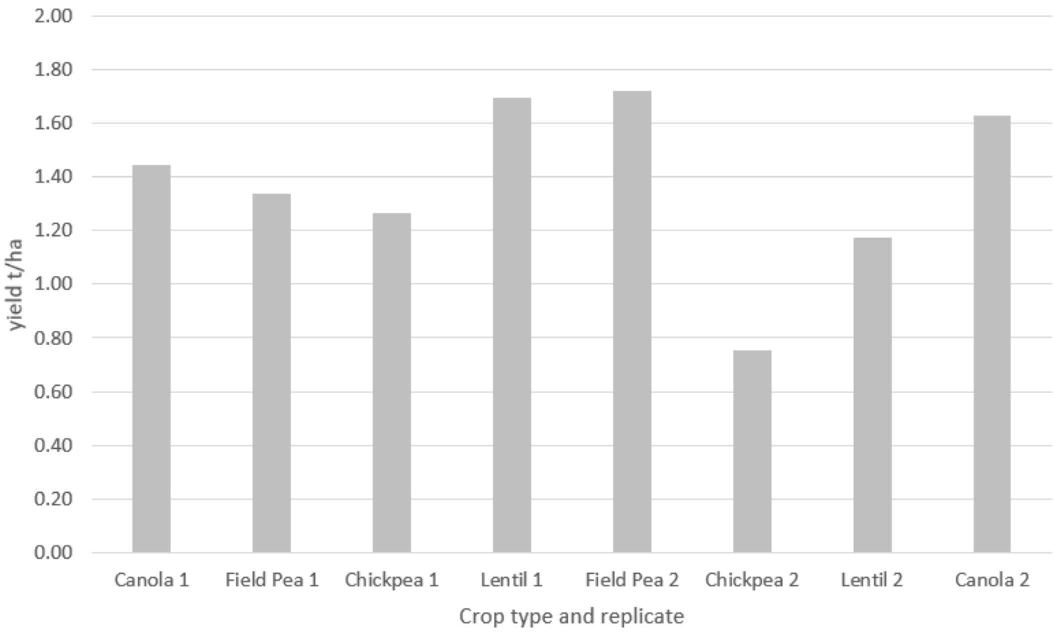

Figure 1: Crop yield (t/ha) by replicate

Site average yields by crop type showed little difference between canola, field peas and lentils. Chickpeas were the poorest performing crop type at that site, with Rep two lowering the average yield to 1.01 t/ha (Figure 2). This was due to the timing of harvest, where chickpeas are often the last crop to be harvested. As such the chickpeas were harvested too early and not all grain was being collected by the harvester. Grain loss was evident in the chaff which was exiting the rear of the harvester.

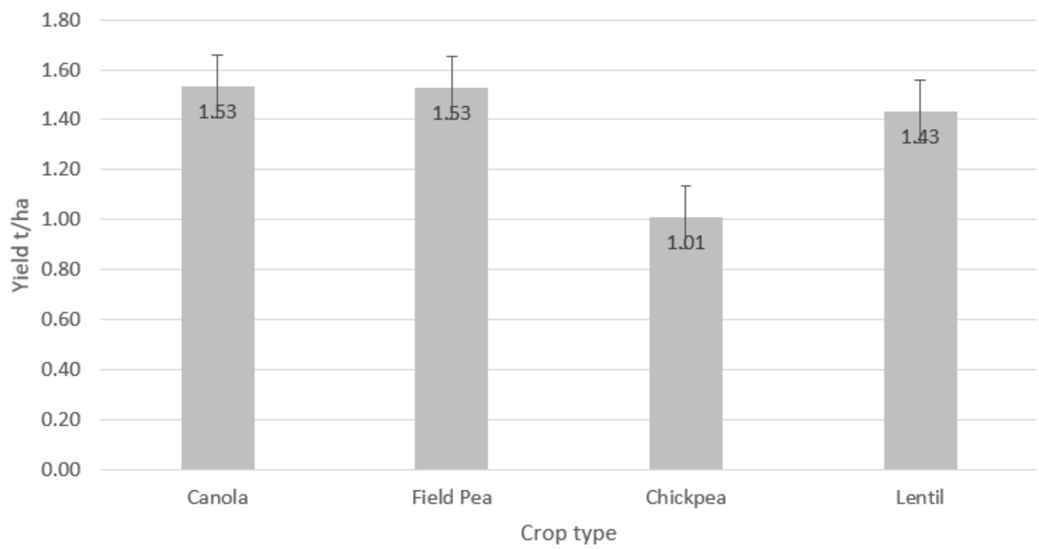

Figure 2: Average yield (t/ha) by crop type (combined yield data for both replicates)

Economic analysis

Assessment of enterprise profitability was conducted on a single seasons results, across each replicate, with the combined economic performance reported in Appendix A. Figure 3 summarises operating profit as earnings before interest and tax (EBIT). Good yields from both canola and field peas, coupled with strong prices at $592 and $600/t FIS respectively, saw these crops standout as the most profitable break crop option in the 2018/19 season. When compared to canola, field peas were a highly profitable legume option for this region, earning a combined operating profit of $359/ha.

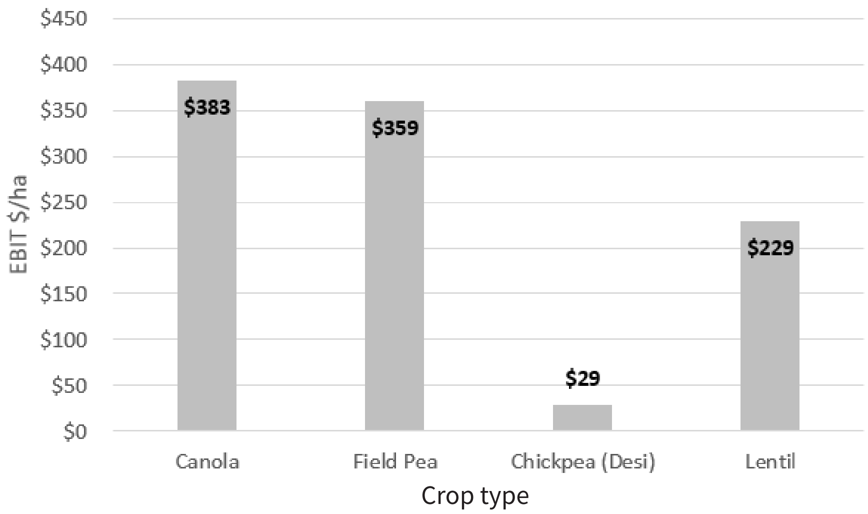

Figure 3: Combined Enterprise Operating Profit (EBIT) per hectare

Lentils were the next best performing legume crop in this demonstration with an operating profit of $229/ha. Operating profit for this crop was impacted by a discounted grain price of $500/t, which was considerably lower than the other enterprises in this analysis. With variable operating costs $37-89/ha lower than the other crops demonstrated, without the effect of price discounting on grain, lentils have good economic potential in this growing region.

Chickpeas were the least profitable crop type; suffering from low yields and high variable operating costs compared to the other enterprises in the analysis, only yielding an operating profit of $29/ha.

Comments

Adequate control of weeds and sufficient plant densities resulted in a clean, competitive crop at the Carnamah site. Canola remains a high earning crop that commonly forms part of a crop rotation in many farming enterprises. Robust agronomy packages and prices of the legume types demonstrated by this project, means crops such as field peas and lentils have potential suitability in the Carnamah region.

The need to harvest chickpeas early to match the logistics of harvest of the trial compromised the results for the chickpea treatments. Use of established management practices for the harvesting of chickpeas is required to reduce the incidence of yield loss at harvest time.

The ranking of each species on profitability should be viewed in light of the highly variable price of pulses from year to year.

Acknowledgements

The Liebe Group would like to thank the Bowman family for hosting this trial site and for the time and effort they have contributed to the management of the demonstration. The economic analysis for this project has been conducted by Ben Curtis and Stacey Bell of Farmanco. This project has been made possible through the GRDC investment: Demonstration of legumes for reliable profitability in the Western Region. Project Code: LIE1802-003SAX

Peer review: Alan Meldrum, Grain Growers

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Appendix A:

Enterprise Analysis Crop – Combined Replicates

Carnamah					
Crop Enterprise		**Canola**	**Field Pea**	**Chickpea Desi**	**Lentil**
Yield	t/ha	1.53	1.53	1.01	1.43
Average Grain Price (FIS)	$/t	$592	$600	$600	$500
Income	**$/ha**	**$908**	**$916**	**$605**	**$717**
Variable Operating Costs	**$/ha**	$	$	$	$
Seed, Treatment & EPR's	$46	$2	$61	$100	$21
Grain Freight (Up Country)	$32	$35	$35	$23	$33
Grain Handling Charges	$20	$24	$22	$15	$21
Crop Contract	$35	$35	$35	$35	$35
Other Crop Costs & Crop Ins	$22	$22	$22	$22	$22
Wages Gross	$28	$28	$28	$28	$28
R&M Mach./Plant/Vehicle	$42	$42	$42	$42	$42
Fuel & Oil	$27	$27	$27	$27	$27
Fertiliser, Lime & Gypsum	$86	$135	$70	$70	$70
Pesticide	$66	$42	$82	$82	$56
Variable Operating Costs	$	$392	$424	$444	$355
Variable Operating Costs	**$/ha**	**$392**	**$424**	**$444**	**$355**
Operating Gross Margin	$	$516	$492	$162	$362
Operating Gross Margin	**$/ha**	**$516**	**$492**	**$162**	**$362**
Fixed Operating Costs	$	$133	$133	$133	$133
Fixed Operating Costs	**$/ha**	**$133**	**$133**	**$133**	**$133**
Total Operating Costs	$	$525	$557	$577	$488
Total Operating Costs	**$/ha**	**$525**	**$557**	**$577**	**$488**
Operating Profit (BIT)	$	$383	$359	$29	$229
Operating Profit (BIT)	**$/ha**	**$383**	**$359**	**$29**	**$229**
Finance Costs	$	$36	$36	$36	$36
Earnings Before Tax (EBT)	**$**	**$347**	**$323**	**-$7**	**$193**
Earnings Before Tax (EBT)	**$/ha**	**$347**	**$323**	**-$7**	**$193**

Demonstration of profitable legumes in the Western Region - Dalwallinu

Alana Hartley, Research & Development Coordinator, Liebe Group

Key Messages

- Adequate pre and post emergent weed control is critical for maintaining yield potential and quality of grain legume crops.
- Canola remains the most profitable non-cereal crop type demonstrated at this site in 2018.
- Where vetch grain is not harvested and sold as feed, consideration of this legume crop type for its grazing value may be advantageous for a mixed farming system.

Aim

To investigate the suitability and profitability of alternative legume crops in the Western Region.

Background

Previous research has suggested that most legume and pulse crops are best suited to fine textured soils of neutral to alkaline pH. While attempts to grow legumes and pulses has had varied success in the past on un-preferred soil types, Western Australian growers therefore have limited adoption of such crop types. This is in part due to suitability of soil type, weed competition and weed control options, yield, market access and overall profitability of legume crops.

Each site within this two year GRDC funded project, aims to demonstrate how and if certain grain legumes are suitable for the farming systems of each region in which the project will be implemented. The sites will cover a vast range of soil types, rainfall zones and farming systems (cropping and mixed farming).

At the Dalwallinu Legume Demonstration site three legumes were compared to canola, which is the current break crop option of choice in the area. Chickpeas, field peas and vetch aim to provide a profitable alternative to canola.

Trial Details

Trial location	Ian and Ainsley Hyde, Bell Rd, Dalwallinu			
Plot size & replication	18.28 m x 300m x 2 replications			
Soil type	Heavy red loam			
Soil pH ($CaCl_2$)	0-10cm: 6.1	10-20cm: 6.8	20-30cm: 7.7	
Paddock rotation:	2015: Wheat	2016: Wheat	2017: Barley	
Sowing date	Canola, Vetch, Chickpeas 25/05/2018, Field Peas 11/06/2018			
Sowing rate	Striker chickpeas: 90 kg/ha Twilight field peas: 100 kg/ha Volga vetch: 40 kg/ha Bonito canola: 3 kg/ha			
Fertiliser	22/05/2018: NPK CZ 60kg/ha (canola, vetch, chickpeas) 11/06/2018: Double-Phos 60 kg/ha (field peas)			
Herbicides, Insecticides & Fungicides	**Canola**	**Chickpeas**	**Field Peas**	**Vetch**
(Pre-emergent)	Trifluralin 2 L/ha Simazine 1.1 kg/ha Chlorpyrifos 200 ml/ha	Trifluralin 2 L/ha Simazine 1.1 kg/ha Chlorpyrifos 200 ml/ha	Metribuzin 150 g/ha Diuron 600 g/ha Glyphosate 520 1.5 L/ha Chlorpyrifos 150 ml/ha	Trifluralin 2 L/ha Simazine 1.1 kg/ha Chlorpyrifos 200 ml/ha
(Post emergent)	13/06/2018: Atrazine 1.05 kg/ha Enhance 0.5%	18/07/2018: Clethodim 360 330 ml/ha Verdict 520 50 ml/ha Chlorpyrifos 250 ml/ha Hasten 1%	18/07/2018: Clethodim 360 330 ml/ha Verdict 520 50 ml/ha Chlorpyrifos 250 ml/ha Hasten 1%	18/07/2018: Clethodim 360 330 ml/ha Verdict 520 50 ml/ha Chlorpyrifos 250 ml/ha Hasten 1%
Growing Season Rainfall	300 mm			

Treatments

Plot	Rep	Treatment No.	Treatment
1	1	1	Chickpeas
2	1	C	Canola
3	1	2	Field peas
4	1	3	Vetch
5	2	C	Canola
6	2	2	Field peas
7	2	1	Chickpeas
8	2	3	Vetch

Trial Layout

Grower Crop Field peas	Chickpeas	Canola	Field Peas	Vetch	Canola	Field peas	Chickpeas	Vetch	**Grower Crop** Field peas

---North boundary fence---

Results

Soil analysis

Soil analysis was conducted at the beginning of the project, to measure base line nutrients. Further soil testing will be conducted prior to seeding 2019, to determine the change in N status from the baseline results.

Table 1: Baseline soil nutrition status, Dalwallinu, February 2018.

Site	Depth	pH	PBI	Col P	Col K	KCl S	NO3N	NH4N	EC	OC
Dalwallinu	0-10	5.7	80.4	37	430	16.6	51	6	0.182	1.30
	10-20	7.4	157.3	9	258	4.8	9	1	0.047	0.90
	20-30	7.7	204.8	7	118	3.4	4	1	0.069	0.50
	30-40	7.7		5	94		4	2	0.133	
	40-50	8.3		3	96		2	1	0.179	

PreDicta B was conducted prior to the trial being sown, to determine the disease profile and risk at the beginning of the project. The results indicated that there was a low presence of disease at the site. PreDicta B will conducted again prior to next season and entering into the wheat phase, to determine if the legume crops have had an impact on the disease profile.

Table 2: PreDicta B Soil borne disease rating

Test	Result
Cereal Cyst Nematode (CCN)	Nil
Take All (Wheat & Oat race)	0.9
Rhizoctonia solani	1.1
F. pseudograminaerum (test 1)	3.4
F. pseudograminaerum (test 2)	Nil
Pyrenophora tritici-repentis (YLS)	1.3
Bipolaris	0.8
Pythium	1.4
Macrophomina phaseolina (collar rot/stem rot)	2.0

Disease detection rating

Disease detection rating
Low
Medium
High

Plant and weed counts

Weeds and plant counts were taken at establishment (four weeks after sowing) and again at late establishment, when the legume crops were at branching. There were no significant differences in plant numbers between crop types as shown in Table 3. A log transformation of weed counts suggest that there was some influence of weeds on crop establishment, however this was not highly significant. Counts were not taken for field peas, as they had only just been sown at the time the establishment counts were taken.

Table 3: Crop plant and weed establishment counts, June 2018

Crop type	Average plant/m^2	Log weeds/m^2
Canola	61	3.62
Chickpeas	60	2.33
Field Peas	Not sown at time of counts	
Vetch	50	2.51
P value	0.292	0.098
Lsd	NS	NS

Late plant and weed counts (Table 4), showed no significant difference between crop type, and weed counts by crop type. There was however a significant difference between weeds in the canola plots compared to other crop types demonstrated. Canola had the lowest average weed counts of all crop types, due to crop competition and shading of weeds and the addition of a post emergent herbicide.

Only a grass selective was applied to the legume crops, meaning broadleaf weeds and some grass weed survivors and late germinations remained uncontrolled, thus having some influence over the reduction in plant numbers from early establishment to late counts. Weed burden also has an influence on crop yield.

Table 4: In crop plant and weed counts, August 2018

Crop type	Average plant/m2	Average weeds/m2
Canola	37	5
Chickpeas	41	38
Field Peas	41	54
Vetch	38	25
P value	0.982	0.247
Lsd	NS	NS

Harvest yield

This demonstration was harvested using grower equipment, with yield being measured by weigh trailer. Crop yield by replicate (Figure 1) illustrates a downward trend in yield from replicate one to replicate two. This is due to a slight soil type change across the site at depth; where Rep two had a sandy texture and marginally lower pH to Rep one.

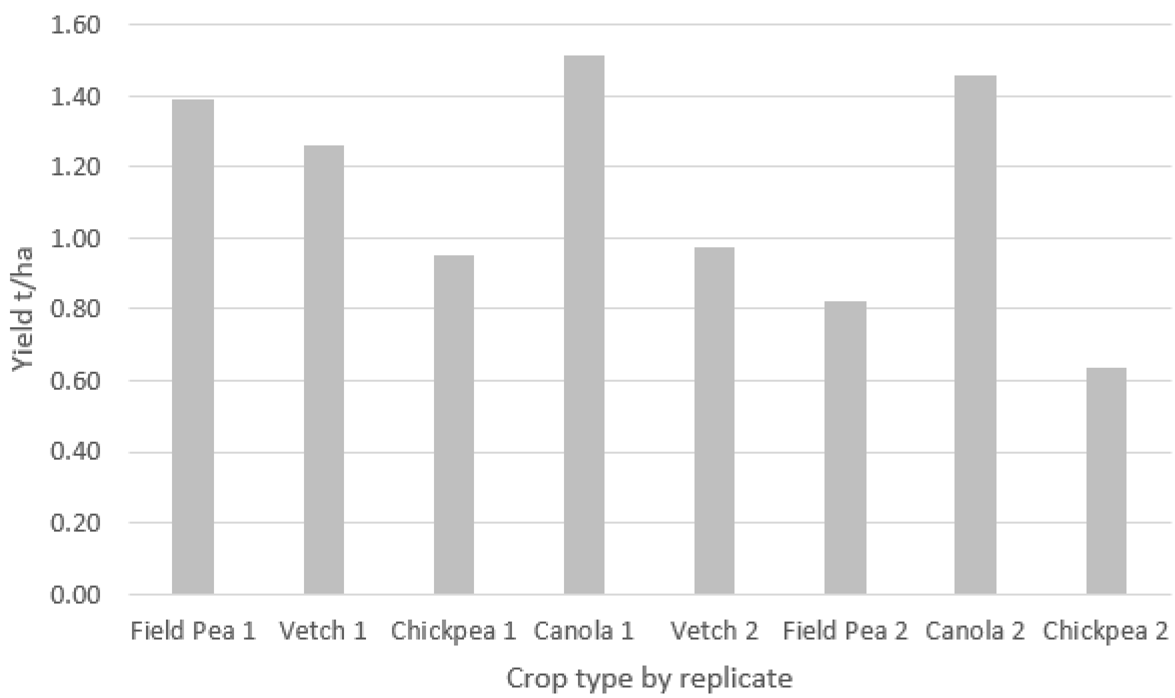

Figure 1: Crop yield (t/ha) by replicate

Canola was the only crop type in this demonstration that was not influenced by spatial variation in soil and weed burden. This is because canola is a more competitive crop, with cabbaging canola competed for sunlight and nutrients by shading germinating weeds. All other crop types were heavily influenced by the presence of broadleaf weeds such as double gee, turnip, capeweed, thistles and grasses. Hence reaffirming the need to adequately manage weeds both pre and post emergent. Chickpeas were the most influenced by weed burden.

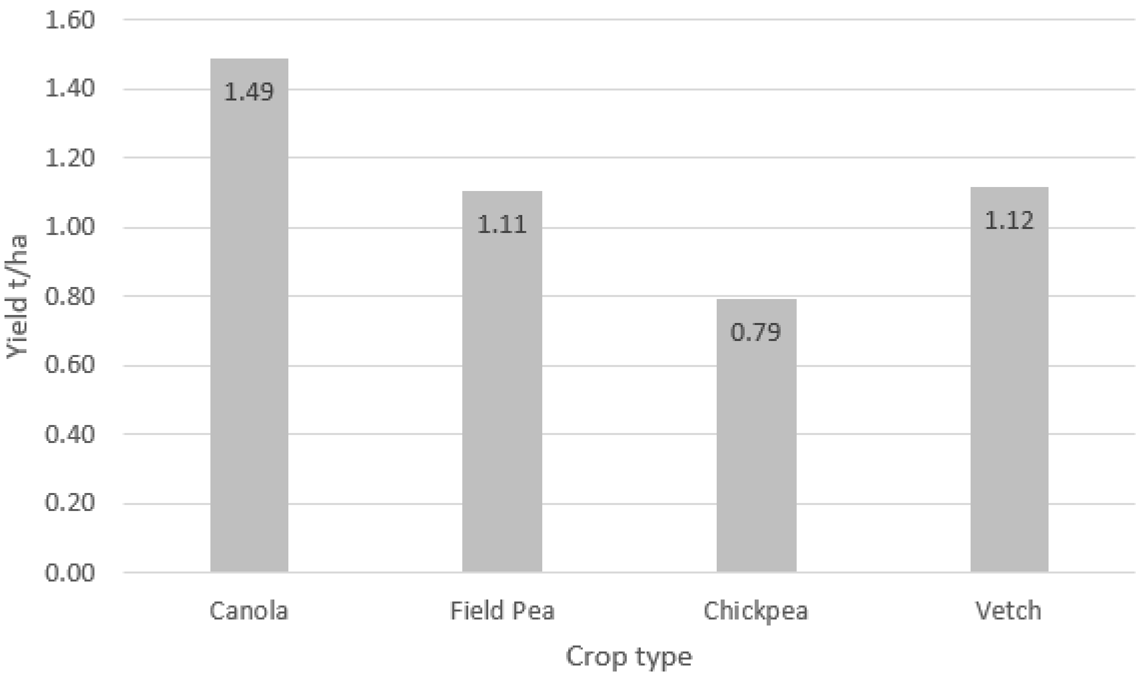

Figure 2: Combined average yield (t/ha) by crop type

Combined average yields (Figure 2), indicate that canola remains the most competitive break crop option at this site however, given sufficient post emergent weed control, field peas and vetch have a potential fit as a legume option for a farming system in this region.

Economic analysis

Assessment of enterprise profitability was conducted on a single season results, across each replicate, with the combined economic performance reported in Appendix A. Figure 3 summarises operating profit as earnings before interest and tax (EBIT). The value of nitrogen or updated disease status has not been factored into this analysis but will be adjusted for the wheat phase in 2019.

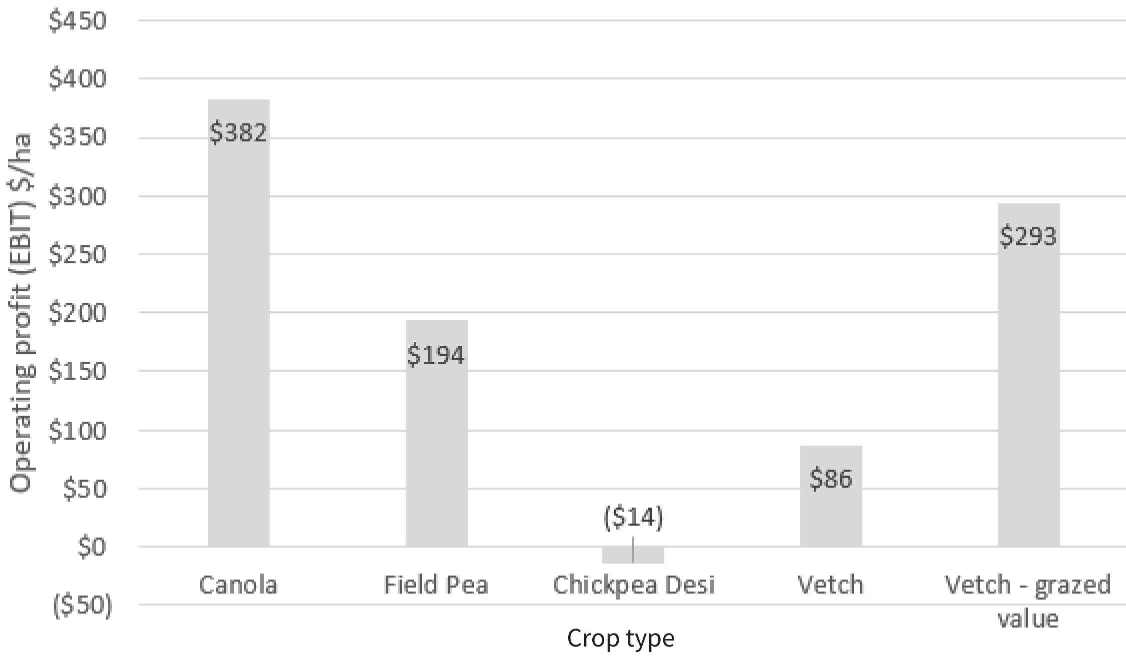

Figure 3: Combined enterprise operating profit (EBIT) $/ha, 2018

The highest earning crop demonstrated by this project was canola, with an operating profit of $382/ha. Field peas also yielded a positive operating profit at $194/ha but was not as profitable compared to canola due to the lower yield. Chickpeas were affected by poor yields and quality due to weed burden, resulting in a loss of $14/ha. The grain value of vetch achieved a modest $86/ha operating profit.

Vetch is a legume pasture species and will often be grazed, brown manured or cut for forage hay. The variety demonstrated at Dalwallinu, Volga, is a multi-purpose variety where livestock producers can maximise their returns from grazing both crop biomass and grain. A grazing value has been calculated in appendix A. The following assumptions have been made;

- 1 DSE consumes 1kg dry matter (DM) per day
- At the end of grazing there is budgeted to be 1000kg DM/ha remaining in order to retain enough cover to avoid paddock damage.
- In this example this means of the 3000kgs grown, 2000kg would be consumed. Of this 2000kg consumed lamb and wool production has been calculated and represents income.
- It is assumed that there would be single bearing ewes on this paddock as well which would turn off a lamb as well as a fleece.
- Sale price of sheep is $122 (average price for Medium Rainfall Farmanco clients as shown in the Farmanco Profit Series)
- Average wool cut is 5.39kg/hd, average price is $10.57/kg (average price and kg for Medium Rainfall Farmanco clients as shown in the Farmanco Profit Series)
- The dry matter figure is only a visual assessment and information taken from this analysis be considered with caution.

For livestock producers considering a legume species in the rotation, the Dalwallinu demonstration site indicated that grazed vetch provides significant economic advantage to both lamb and wool enterprises with a calculated operating profit of $293/ha.

Comments

To successfully grow a legume crop in a rotation, suitable agronomic and management practices must be considered. Adequate pre and post emergent of weeds in pulse crops is required to limit the impact on yield and quality; matching crop soil requirements with soil type and; consideration of harvesting equipment and settings to avoid yield losses add to the planning and success of a legume crop.

Canola remains a highly profitable non-cereal crop option within a rotation after the 2018 season at Dalwallinu. Where soil type permits, field peas have an economic fit within the farming system. Further work is required to determine the suitability of chickpeas in a rotation. While vetch performed well, the ability to control the weed burden must be considered prior to planting. The grazing value may also be considered, beyond the value of grain, for this crop type, where stock are a part of the farm program as the yield potential of vetch is much lower than for the other legumes.

Acknowledgements

Liebe Group would like to thank the Hyde family for hosting this trial site and for the time and effort they have contributed to the management of the demonstration. The economic analysis for this project has been conducted by Ben Curtis and Stacey Bell of Farmanco. This project has been made possible through the GRDC investment: Demonstration of legumes for reliable profitability in the Western Region.
Project Code: LIE1802-003SAX

Peer Review: Alan Meldrum, Grain Growers

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Appendix A

Dalwallinu						
Crop Enterprise		**Canola**	**Field Pea**	**Chickpea Desi**	**Vetch**	**Vetch - Grazing Value**
Yield	t/ha	1.49	1.11	0.79	1.12	3.00
Carrying Capacity for 150 days	DSE					13.33
Annualised carrying capcity	DSE					5.48
Average Grain Price (FIS)	$/t	$582	$600	$600	$500	
Income	**$/ha**	**$865**	**$664**	**$476**	**$558**	**$758**
Variable Operating Costs	**$/ha**	$	$	$	$	
Seed, Treatment & EPR’s	$53	$2	$61	$91	$61	$61
Grain Freight (Up Country)	$26	$34	$25	$18	$29	
Grain Handling Charges	$16	$23	$16	$11	$16	
Crop Contract	$35	$35	$35	$35	$35	$35
Other Crop Costs & Crop Ins	$22	$22	$22	$22	$22	$22
Wages Gross	$28	$28	$28	$28	$28	$28
R&M Mach./Plant/Vehicle	$42	$42	$42	$42	$42	$42
Fuel & Oil	$27	$27	$27	$27	$27	$27
Fertiliser, Lime & Gypsum	$60	$104	$45	$45	$45	$45
Pesticide	$35	$32	$36	$38	$35	$35
Variable Operating Costs	$	$349	$337	$358	$339	$295
Variable Operating Costs	**$/ha**	**$349**	**$337**	**$358**	**$339**	**$295**
Operating Gross Margin	$	$515	$327	$119	$219	$463
Operating Gross Margin	**$/ha**	**$515**	**$327**	**$119**	**$219**	**$463**
Fixed Operating Costs	$	$133	$133	$133	$133	$170
Fixed Operating Costs	**$/ha**	**$133**	**$133**	**$133**	**$133**	**$170**
Total Operating Costs	$	$482	$470	$491	$472	$465
Total Operating Costs	**$/ha**	**$482**	**$470**	**$491**	**$472**	**$465**
Operating Profit (BIT)	$	$382	$194	-$372	-$253	$293
Operating Profit (BIT)	**$/ha**	**$382**	**$194**	**-$14**	**$86**	**$293**
Finance Costs	$	$36	$36	$36	$36	$56
Earnings Before Tax (EBT)	**$**	**$346**	**$158**	**-$50**	**-$289**	$237
Earnings Before Tax (EBT)	**$/ha**	**$346**	**$158**	**-$50**	**$50**	**$237**

Demonstration of profitable legumes in the Western Region - Kalannie

Alana Hartley, Research & Development Coordinator, Liebe Group

Key points

- Preparation of paddocks is key to the success of legume crops such as chickpeas and field peas. Control of weeds prior to sowing is crucial and, rolling to level the seed bed post seeding improves the ability to harvest such crop types.
- Field peas and chickpeas are more susceptible to frost damage compared to canola or lupins.
- Canola remains a highly profitable non-cereal crop in Kalannie in 2018.

Aim

Demonstrate the profitability of alternative grain legume crops across the Western Region

Background

Previous research has suggested that most legume and pulse crops are best suited to fine textured soils of neutral to alkaline pH. While attempts to grow legumes and pulses in regions where the soil classification does not meet previously noted criteria has been varied in its success in the past, Western Australian growers have limited adoption of such crop types. This is in part due to suitability of soil type, competition against weeds and weed control options, yield, market access and overall profitability of legume crops.

Each site within this two year GRDC funded project, aims to demonstrate how, and if, certain grain legumes are suitable for the farming systems of each region in which the project will be implemented. The sites cover a vast range of soil types, rainfall zones and farming systems (cropping and mixed farming).

At the Kalannie Legume Demonstration site three legumes are being compared to canola, which is the current break crop option of choice in the area. Chickpeas, field peas and lupins aim to provide a profitable alternative to canola.

Trial Details

Trial location	McCreery Rd, McCreery property, Kalannie
Plot size & replication	12m x 200m x 2 replications
Soil type	Duplex – red loam over sand
Soil pH ($CaCl_2$)	0-10cm: 5.3 10-20cm: 6.1 20-30cm: 7.6
Paddock rotation:	2015: Canola 2016: Wheat 2017: Oats
Sowing date	03/05/2018
Sowing rate	Canola (snapper): 8 kg/ha Chickpea (Striker): 67 kg/ha Field pea (Twilight): 69 kg/ha Lupins (Jurien): 82 kg/ha
Fertiliser	03/05/2018: K-Till Extra 70 kg/ha 18/07/2018: Flexi N 70 L/ha
Herbicides, Insecticides & Fungicides	Simazine 1.1 kg/ha, Trifluralin 2 L/ha, Chlorpyrifos 0.2 L/ha (whole site)
(Post emergent)	
Chickpeas	Broadstrike 12 g/ha, Factor 180 g/ha + 1% MSO, Veritas 0.5 L/ha
Field peas & lupins	Brodal 150 ml/ha, Metribuzin 100 g/ha Factor 180 g/ha + 1% MSO
Canola	Atrazine 1.1 kg/ha, Clethodim 0.5 L/ha, Factor 80 g/ha + 1% MSO
Growing Season Rainfall	216 mm

Treatments

Plot	Rep	Treatment No.	Treatment
1	1	1	Lupins
2	1	C	Canola
3	1	2	Chickpeas
4	1	3	Field Peas
5	2	C	Canola
6	2	2	Chickpeas
7	2	1	Lupins
8	2	3	Field Peas

*Calibration issues were experienced during seeding, causing seeding rates to be applied incorrectly. Intended rates for crops were as follows: Canola – 3.5 kg/ha, Chickpeas 90 kg/ha, Field peas 100 kg/ha.

Trial Layout

Grower Crop Canola	Chickpeas	Canola	Field Peas	Lupins	Canola	Field peas	Chickpeas	Lupins	**Grower Crop** Canola

Results

Soil analysis

Soil analysis was conducted at the beginning of the project, to measure base line nutrients. Further soil testing will be conducted prior to seeding 2019, to determine the change in N status from the baseline results. Over all benefits of additional N and a disease break, due to the legume phase, will be measured as the improved wheat yield and quality compared to the control (canola treatment).

Site	Depth	Col P	Col K	KCl S	O C	pH H2O	pH Ca Cl2	EC	PBI	NO3N	NH4N	Ca Cl2 Al
Kalannie	0-10	27	159	35.9	0.68	6.0	5.3	0.234	19.0	18	4	
	10-20	19	88	6.3	0.35	6.8	6.1	0.112	15.4	5	1	
	20-30	6	140	11.1	0.24	8.6	7.6	0.199	22.6	4	< 1	
	30-40	5	233			9.0	7.9	0.306		3	< 1	0.23
	40-50	4	264			9.2	8.2	0.589		4	< 1	0.34

PreDicta B was conducted prior to the trial being sown, to determine the disease profile and risk at the beginning of the project (Table 1). PreDicta B will be conducted again prior to next season and entering into the wheat phase, to determine if the legume crops have reduced the disease profile. No foliar fungicide was applied at this site early in the season due to the low disease pressure. A late application was applied to chickpeas only upon the presence of a low level of grey mould. Chickpeas were purchased pre-treated with Thiam fungicide.

PreDicta B results

Table 1: PreDicta B disease ratings - March 2018

Test	Result
CCN	0
Stem nematode	0
Take all	1.3
Gga	0
Rhizoctonia solani	0.7
Crown rot	0
Bipolaris	2.0
Pythium	1.0
Eyespot	0
P. neglectus (Nematodes)	0.1
Macrophomina phaseolina (collar/stem rot)	1.7
Phoma rabiei (chickpea aschochyta)	0

Disease detection rating

Low
Medium
High

Many other PreDicta B tests were conducted other than those listed, however, they all returned a result of zero or below detectable, and have not been listed in this article.

Plant and weed Counts

Canola establishment was significantly higher than the ideal range for an Open Pollinated (OP) TT variety at 170 plants/m^2 (ideal range: 30-40 plants/m^2 in a low rainfall zone). This was due to the seeding calibration error that was experienced at the time of sowing the demonstration.

Lupins were effected by poor germinating seed, resulting in significantly low plant counts compared to other crop types demonstrated. Ideal plant density for lupins is 45 plants/m^2. This improved slightly in by the late establishment counts (Table 3) in August.

Table 2: Establishment and weed counts – June 2018

Crop type	Average plants/m2	Average weeds/m2
Canola	170	19
Chickpeas	40	22
Field Peas	45	54
Lupins	18	27
P value	0.054	0.600
Lsd	104.3	NS

Field peas were also affected by the calibration error at seeding however establishment counts were within the ideal range of 40-50 plants/m^2. Seeding rates of 90-100 kg/ha of varieties such as Gunyah or Twilight, should achieve this target density. Plant density is important for field peas due to the structure of the crop canopy. These erect crop types use nearby plants as support, to avoid early lodging. Failure to meet target densities increases the risk of lodging creating difficulties at harvest and, reduces the crops competitiveness against weeds.

Chickpeas were slow to establish and were affected by the post emergent Broadstrike herbicide application, however, plants recovered and meet the target plant density range of 25-50 plants/m^2. The erect crop canopy, improved lodging resistance and decreased pod shattering is expected to assist with harvest-ability of this crop type.

There were no significant differences in weed counts during early establishment, although pre-emergent herbicides did not control weeds in the field peas as well as other crop types.

Post emergent applications of herbicides did control some weeds, with counts showing a significant reduction in weed populations at the time of late counts (Table 3). Weed control in the chickpeas was not as strong, due to the limited herbicide options for controlling broadleaf weeds, resulting in weed numbers significantly higher than the other crop types. Weed burden also caused a significant reduction in crop plant numbers, as shown in Table 3.

Table 3: Late plant and weed counts - August 2018

Crop type	Average plants/m2	Average weeds/m2
Canola	93	0
Chickpeas	15	16
Field Peas	41	3
Lupins	30	4
P value	0.046	0.008
Lsd	98.1	5.2

A late germination of weeds had significant consequences on final yield Figure 1, as limited herbicide options and crop stage did not permit a late post emergent application to control the late emerging weed population.

A mild frost event on the 9th of September had an impact on final yield, particularly for the field peas and chickpeas; where fully developed seed were frost damaged and shrivelled. A plot harvester was bought in to harvest 20 m ‘plots’ from each field pea replicate, to gain a more accurate yield from the site.

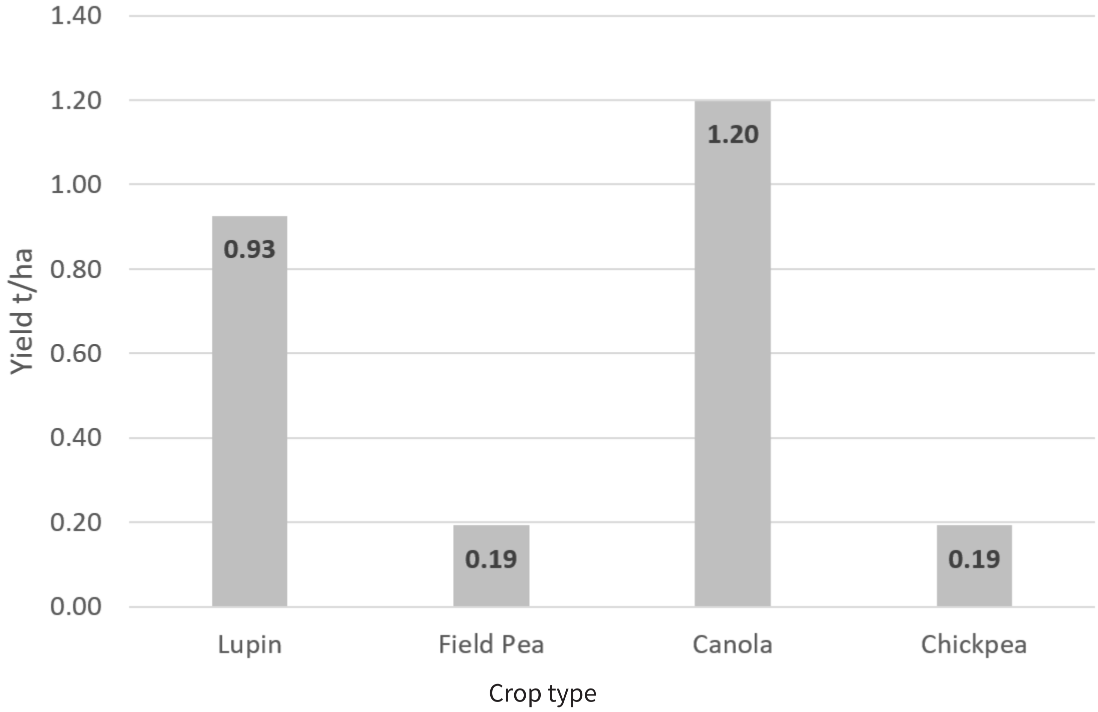

Figure 1: Average yield (t/ha) by crop type at the Kalannie Legume Demonstration Site

Due to the frost effected crop, yield has not been represented by plot and replicate in this report. Combined average yield by crop type in Figure 1, represents both replicates in the demonstration. Despite a seeding error and frost, both canola and lupins yielded well at 1.2 t/ha and 0.93 t/ha respectively. Field peas were significantly effected by frost whist the chickpeas were effected by frost and weed competition.

Economic analysis

Assessment of enterprise profitability was conducted on a single seasons results, across each replicate, with the combined economic performance reported in Appendix A. Figure 2 summarises operating profit as earnings before interest and tax (EBIT).

Variable input costs were similar across all legume crop types except canola, whose inputs were approximately $26/ha greater (appendix A). This did not have any significant effect on overall profitability, where canola was a standout, having an operating profit of $330/ha.

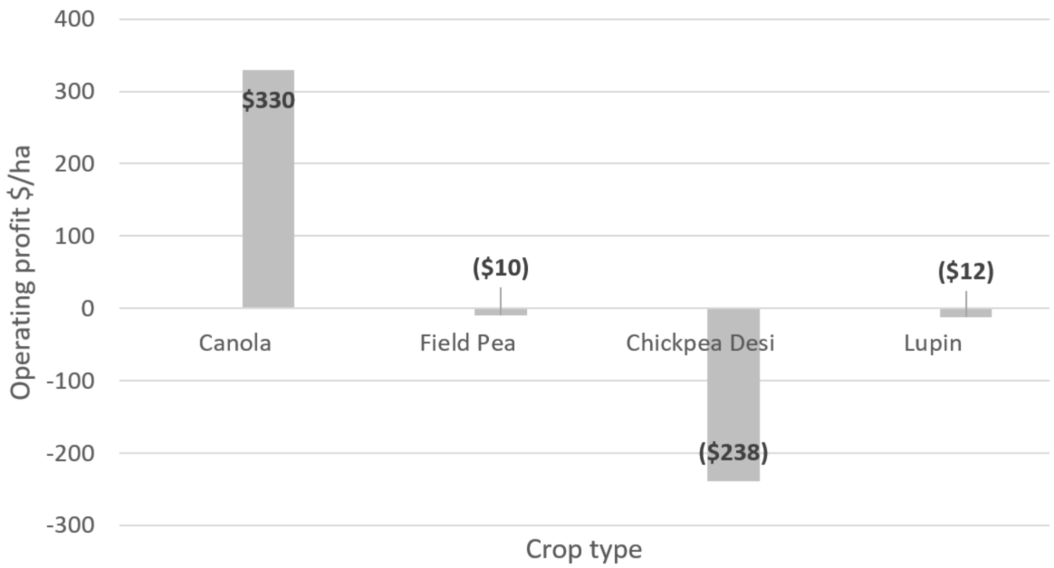

Figure 2: Operating profit (EBIT) per hectare, 2018

Weed burden, frost damage and poor quality seed resulted in negative operating profits for all legumes demonstrated.

Comments

Field peas and chickpeas suffered significant yield losses from frost. Adequate pre and post emergent control of weeds is also required to limit the impact of weed burden on yield and quality of legume crops. The weed burden at this site would have compromised the legume yields regardless of the affects of frost.

The alkaline pH of the site would also have restricted the yield potential of lupin. The comparative performance of the legume species to canola cannot be adequately assessed due to these factors.

Acknowledgements

The Liebe Group would like to thank the McCreery family for hosting this project over the next two seasons and their contribution of time, seed and fertiliser for the trial. Thank you also to the Nixon family for supplying the field pea seed for this demonstration.

Thank you to AFGRI equipment, Dalwallinu, for the supply of machinery to enable this demonstration to be sown.

Thank you to the Tactical Break Crop researchers at the Department of Primary Industries and Regional Development (DPIRD) for the agronomic support and advice for each of the crop types demonstrated at this site. Extended thanks to the team at the Wongan Hills Research Station who provided their services for harvesting the field peas at this site.

The economic analysis for this project has been conducted by Ben Curtis and Stacey Bell of Farmanco. This project has been made possible through the GRDC investment: Demonstration of legumes for reliable profitability in the Western Region. Project Code: LIE1802-003SAX

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Appendix A

Enterprise Analysis by crop – combined replicates

Kalannie					
Crop Enterprise		**Canola**	**Field Pea**	**Chickpea**	**Lupin**
Yield	t/ha	1.20	0.57	0.19	0.93
Average Grain Price (FIS)	$/t	$592	$600	$600	$370
Income	**$/ha**	**$710**	**$343**	**$116**	**$343**
Variable Operating Costs	**$/ha**	$	$	$	$
Seed, Treatment & EPR's	$36	$5	$42	$68	$30
Grain Freight (Up Country)	$17	$28	$13	$4	$21
Grain Handling Charges	$10	$19	$8	$3	$10
Crop Contract	$21	$21	$21	$21	$21
Other Crop Costs & Crop Ins	$15	$15	$15	$15	$15
Wages Gross	$15	$15	$15	$15	$15
R&M Mach./Plant/Vehicle	$32	$32	$32	$32	$32
Fuel & Oil	$22	$22	$22	$22	$22
Fertiliser, Lime & Gypsum	$60	$101	$47	$47	$47
Pesticide	$59	$50	$64	$54	$68
Variable Operating Costs	$	$307	$280	$281	$281
Variable Operating Costs	**$/ha**	**$307**	**$280**	**$281**	**$281**
Operating Gross Margin	$	$403	$63	-$165	$61
Operating Gross Margin	**$/ha**	**$403**	**$63**	**-$165**	**$61**
Fixed Operating Costs	$	$73	$73	$73	$73
Fixed Operating Costs	**$/ha**	**$73**	**$73**	**$73**	**$73**
Total Operating Costs	$	$380	$353	$354	$354
Total Operating Costs	**$/ha**	**$380**	**$353**	**$354**	**$354**
Operating Profit (BIT)	$	$330	-$10	-$238	-$12
Operating Profit (BIT)	**$/ha**	**$330**	**-$10**	**-$238**	**-$12**
Finance Costs	$	$24	$24	$24	$24
Earnings Before Tax (EBT)	**$**	**$306**	**-$34**	**-$262**	**-$36**
Earnings Before Tax (EBT)	**$/ha**	**$306**	**-$34**	**-$262**	**-$36**

Demonstration of profitable legumes in the Western Region - Koorda

Alana Hartley, Research & Development Coordinator, Liebe Group

Key Messages

- Significant weed burdens can impact yield of legume crops considerably if not controlled well with rotation or pre and post emergent herbicide options.
- Without control of weeds, soil borne diseases can be carried from legume phase into the cereal phase.

Aim

To investigate the suitability and profitability of alternative legume crops in the Western Region.

Background

Previous research has suggested that most legume and pulse crops are best suited to fine textured soils of neutral to alkaline pH. While attempts to grow legumes and pulses in regions where the soil classification does not meet previously noted criteria has been varied in its success in the past, Western Australian growers have limited adoption of such crop types. This is in part due to suitability of soil type, competition against weeds and weed control options, yield, market access and overall profitability of such crops.

Each site within this two year GRDC funded project, aims to demonstrate how and if certain grain legumes are suitable for the farming systems of each region in which the project will be implemented. The sites will cover a vast range of soil types, rainfall zones and farming systems (cropping and mixed farming).

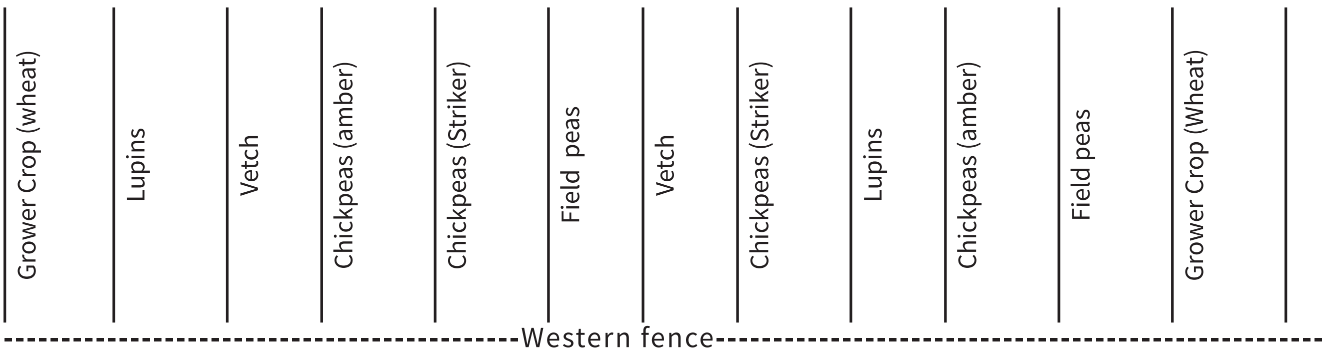
At the Koorda Legume Demonstration site three legumes are being compared to lupins, which is the current break crop option of choice in the area. Chickpeas, field peas and vetch aim to provide a profitable alternative to lupins.

Trial Details

Trial location	Nathan Brooks, Remnant Rd, Koorda
Plot size & replication	18.28 m x 300m x 2 replications
Soil type	Red-brown loamy sand
Soil pH ($CaCl_2$)	0-10cm: 5.5 10-20cm: 7.2 20-30cm: 7.7
Growing season rain	214 mm (taken from Koorda weather station)
Paddock rotation:	2015: Wheat 2016: Wheat 2017: Wheat
Sowing date	14/05/2018
Sowing rate	Chickpeas (Striker): 90 kg/ha Chickpeas (Amber): 90 kg/ha Field peas (Gunyah): 100 kg/ha Vetch (Volga): 40 kg/ha Lupins (Mandelup): 80 kg/ha
Fertiliser	14/05/2018: Agstar 50 kg/ha
Herbicides, Insecticides & Fungicides	
(Pre-emergent)	14/05/2018: Trifluralin 2 L/ha Simazine 1.1 kg/ha Chlorpyrifos 400 ml/ha
(Post emergent)	19/07/2018 Clethodim 360 250 ml/ha Hasten 1%
Growing Season Rainfall	236 mm

Trial Layout

Plot	Rep	Treatment No.	Treatment
1	1	1	Lupins
2	1	4	Vetch
3	1	5	Chickpeas (Amber)
4	1	2	Chickpeas (Striker)
5	1	3	Field Peas
6	2	4	Vetch
7	2	2	Chickpeas (Striker)
8	2	1	Lupins
9	2	5	Chickpeas (Amber)
10	2	3	Field Peas



Results

Soil analysis was conducted at the beginning of the project, to measure base line nutrients. Further soil testing will be conducted after the legume phase, to determine the change in N status from the baseline results.

Table 1: Baseline soil nutrition, March 2018

Site	Depth	pH	PBI	Col P	Col K	KCl S	NO3N	NH4N	EC	OC
Koorda	0-10	5.8	61.2	45	666	37.4	46	4	0.222	0.89
	10-20	7.6	97.1	17	635	20.2	20	1	0.190	0.86
	20-30	7.8	184.0	6	481	42.6	13	< 1	0.256	1.23
	30-40	7.7		4	329		11	< 1	0.390	
	40-50	8.6		3	335		13	< 1	0.534	

PreDicta B was conducted prior to the trial being sown, to determine the disease profile and risk at the beginning of the project. The results indicated that there was a low presence of disease at the site. PreDicta B will be conducted again prior to next season and entering into the wheat phase, to determine if the legume crops have had an impact on the disease profile.

Table 2: PreDicta B Soil borne disease rating

Test	Result
Cereal Cist Nematode (CCN)	Nil
Take All (Wheat & Oat race)	0.9
Rhizoctonia solani	1.4
F. pseudograminaerum (test 1)	3.2
F. pseudograminaerum (test 2)	Nil
Pyrenophora tritici-repentis (YLS)	0.6
Bipolaris	1.7
Pythium	1.4
Pratylenchus neglectus	1.1
Macrophomina phaseolina (collar rot/stem rot)	2.0

Disease detection rating

Low
Medium
High

Plant Establishment Counts

Early establishment counts taken in June, Table 3, showed no significant difference in plant numbers for each crop type. At the time of establishment, the site was free of weed burden.

Table 3: Plant establishment counts, June 2018

Crop type	Average plants/m^2
Chickpeas (Striker)	26
Chickpeas (Amber)	32
Field Peas (Gunyah)	33
Lupins (Mandelup)	42
Vetch (Volga)	39
P value	0.389
Lsd	NS

Late application of post emergent grass selective herbicide and no broadleaf herbicide application influenced plant and weed counts, taken at late branching crop stage in August. Crop plant numbers remained relatively unchanged compared to establishment counts in Table 3. Weed burden was significant across the site. All treatments were affected by weeds, thus no significant difference was observed (Table 4) between crop types in their competitiveness or control.

Table 4: Crop plant and weed counts, August 2018

Crop type	Average plants/m^2	Average weeds/m2
Chickpeas (Striker)	35	60
Chickpeas (Amber)	33	64
Field Peas (Gunyah)	39	47
Lupins (Mandelup)	39	86
Vetch (Volga)	41	63
P value	0.955	0.233
Lsd	NS	NS

Harvest results

Harvest results were heavily influenced by the presence of an uncontrolled annual ryegrass weed burden. Competition for moisture and nutrients and two mild frost events in August and September effected flowering and seed development. As such, yields were significantly below expectations in a season where rainfall was adequate. The best yielding crop, given the circumstances was field peas (figure 1) as the crop was competitive early and had lower weed burden (table 4) than the other less competitive crop types demonstrated.

The impact on weeds, although not significantly different between crops at this site (due to the uniformity of the burden), reinforces the need for careful selection of paddocks, herbicide weed control options and future rotation management.

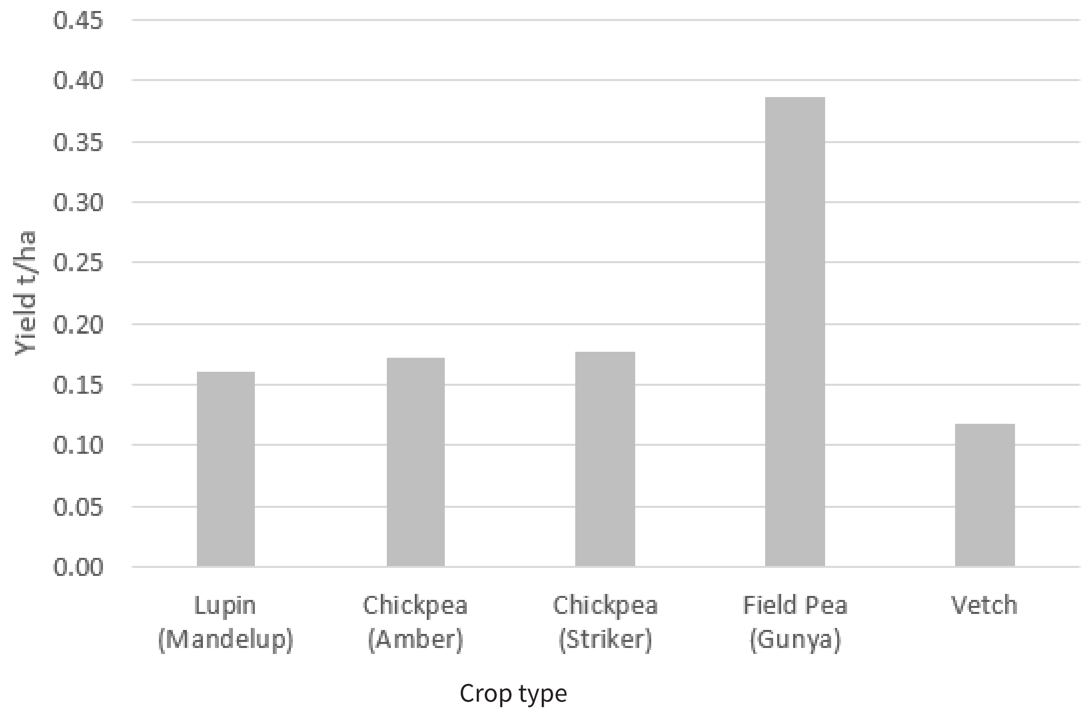


Figure 1: Average yield (t/ha) by crop type at the Koorda Legume Demonstration Site

Economic Analysis

Assessment of enterprise profitability was conducted on a single seasons results, across each replicate, with the combined economic performance reported in Appendix A. Figure 2 summarises operating profit as earnings before interest and tax (EBIT).

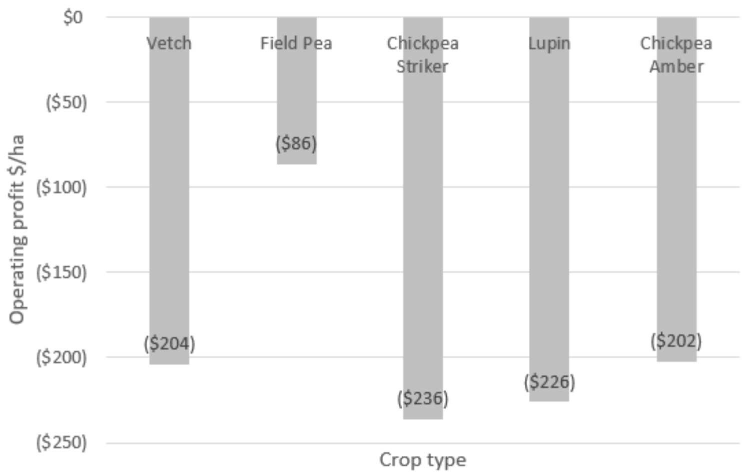


Figure 2: Combined Enterprise Operating Profit (EBIT)

The economic analysis uses standard grain quality standards to apply a value to each crop type grown at the site. No crop yielded an economic return.

Comments

Late germinating ryegrass and capeweed became a significant issue at this site in 2018, impacting highly on yield and quality of grain samples collected from each treatment. As such, adequate herbicide management plans to manage future weed burdens during the cereal phase of this project will be critical.

Early crop stand and biomass was good, suggesting potential for setting nitrogen in the soil. This will be measured with soil testing in 2019, coupled with measurement of wheat yield and quality.
Weeds are also a carrier of many soil borne diseases. PreDicta B will also be carried out across individual treatments to measure the presence of soil borne diseases after the legume phase.
The heavy weed burden, resulting in poor yields for all species, precludes useful recommendations for the best choice of legume species for this soil type using data from this demonstration.

Peer Review: Alan Meldrum, Grain Growers

Acknowledgements

Liebe Group would like to thank Nathan Brooks and his family for hosting this trial site and for the time and effort they have contributed to the management of the demonstration.

The group would also like to acknowledge the contribution of the Farmanco Agronomists and Consultants who have assisted our site hosts in the management of these sites and the facilitation of the Crop Sequencing workshops, which are being delivered across each of the port zones in 2018 and 2019. The economic analysis for this project has been conducted by Ben Curtis and Stacey Bell of Farmanco.

This project has been made possible through the GRDC investment: Demonstration of legumes for reliable profitability in the Western Region. Project Code: LIE1802-003SAX

Contact

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Appendix A

Economic analysis by crop – combined replicates

Koorda						
Crop Enterprise		Vetch	Field Pea	Chickpea Striker	Lupin	Chickpea Amber
Yield	t/ha	0.12	0.39	0.18	0.16	0.17
Average Grain Price (FIS)	$/t	$500	$600	$600	$370	$600
Income	**$/ha**	**$59**	**$232**	**$106**	**$60**	**$103**
Variable Operating Costs	**$/ha**	$	$	$	$	$
Seed, Treatment & EPR's	$51	$21	$60	$91	$31	$55
Grain Freight (Up Country)	$5	$3	$9	$4	$4	$4
Grain Handling Charges	$3	$1	$6	$3	$2	$2
Crop Contract	$21	$21	$21	$21	$21	$21
Other Crop Costs & Crop Ins	$15	$15	$15	$15	$15	$15
Wages Gross	$15	$15	$15	$15	$15	$15
R&M Mach./Plant/Vehicle	$32	$32	$32	$32	$32	$32
Fuel & Oil	$22	$22	$22	$22	$22	$22
Fertiliser, Lime & Gypsum	$32	$32	$32	$32	$32	$32
Pesticide	$34	$28	$35	$35	$39	$35
Variable Operating Costs	$	$190	$245	$269	$213	$233
Variable Operating Costs	**$/ha**	**$190**	**$245**	**$269**	**$213**	**$233**
Operating Gross Margin	$	-$131	-$13	-$163	-$153	-$129
Operating Gross Margin	**$/ha**	**-$131**	**-$13**	**-$163**	**-$153**	**-$129**
Fixed Operating Costs	$	$73	$73	$73	$73	$73
Fixed Operating Costs	**$/ha**	**$73**	**$73**	**$73**	**$73**	**$73**
Total Operating Costs	$	$263	$318	$342	$286	$306
Total Operating Costs	**$/ha**	**$263**	**$318**	**$342**	**$286**	**$306**
Operating Profit (BIT)	$	-$204	-$86	-$236	-$226	-$202
Operating Profit (BIT)	**$/ha**	**-$204**	**-$86**	**-$236**	**-$226**	**-$202**
Finance Costs	$	$24	$24	$24	$24	$24
Earnings Before Tax (EBT)	**$**	**-$228**	**-$110**	**-$260**	**-$250**	**-$226**
Earnings Before Tax (EBT)	**$/ha**	**-$228**	**-$110**	**-$260**	**-$250**	**-$226**

WEEDS RESEARCH RESULTS

Summer Weed Control

Clare Johnston, Agronomist, Elders Scholz Rural

Key messages

- Application timing is important to ensure complete control of button grass.
- Spray actively growing button grass prior to it reaching 4cm in diameter. Rain following application may be enough for it to regrow, however, seed set will be drastically reduced.
- A double knock strategy improved brownout.

Aim

To determine the effect of different herbicide options on control of summer weeds, particularly button grass.

Background

Summer weed control is vital for ensuring optimum gross margins in broadacre agriculture. Uncontrolled they deplete soil moisture and nutrients, reducing the yield potential of the subsequent crop. Summer weeds also act as a green bridge for crop pests and disease. Button grass (Dactyloctenium radulans) is a native species found throughout Australia. It is a common summer weed species which has spread and become more of an issue in the Liebe region in recent years.

Trial Details

Property	Liebe Group Main Trial Site, McCreery's Property, Cottage Road, Kalannie
Plot size & replication	11m x 2m x 3 replications
Soil type	Sandy loam
Soil pH (caCl2)	0 - 10cm: 5.6 10 - 20cm: 5.0 20 - 30cm: 4.9
EC (dS/m)	0 - 10cm: 0.101 10 - 20cm: 0.055 20 - 30cm: 0.055
Paddock rotation	2015: Pasture 2016: Pasture 2017: Pasture 2018: Wheat
Herbicides	9/2/2018: As per protocol. 6.30-7.30am, 21^{o}C, RH 71%, delta T 3 13/3/2018: Paraquat treatments. 6.15-6.30am, 22.8^{o}C, RH 53%, delta T 5.8
Growing Season Rainfall	216.5mm (April - October)

Treatments

No.	Treatment	Approx. $/Ha
	Carrier = 90 L/ha water	
1	Control	
2	1.5 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion	$7.50
3	3 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion	$13.45
4	4.5 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion	$19.40
5	1.18 L/ha Roundup Ultramax + 1% AMS + 0.5% Companion	$9.80
6	2.36 L/ha Roundup Ultramax + 1% AMS + 0.5% Companion	$17.90
7 (11)	1 L/ha Ester 680 + 1.5 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion *Fb. 1 L/ha Paraquat 250 + 0.5% Hasten*	$14.80 +$6
8 (12)	1 L/ha Ester 680 + 3 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion *Fb. 2 L/ha Paraquat 250 + 0.5% Hasten*	$20.75 +$11
9	128 mL/ha Triclopyr 750 + 1 L/ha Ester 680 + 1.5 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion	$17
10	128 mL/ha Triclopyr 750 + 1 L/ha Ester 680 + 3 L/ha Glyphosate 450 + 1% AMS + 0.5% Companion	$22.95

Results

Brownout of treatments showed a clear rate response to glyphosate (Figure 1). The addition of Ester 680 and triclopyr was expected to have some antagonism however observations showed that this was not the case. The double knock application of paraquat 32 days after initial treatments showed an increase in brownout. If planning a double knock strategy, it is recommended to apply closer to the first application time for optimum efficiency. Generally, the second application should be applied before symptoms from the first application are evident (Cameron, J. 2014).

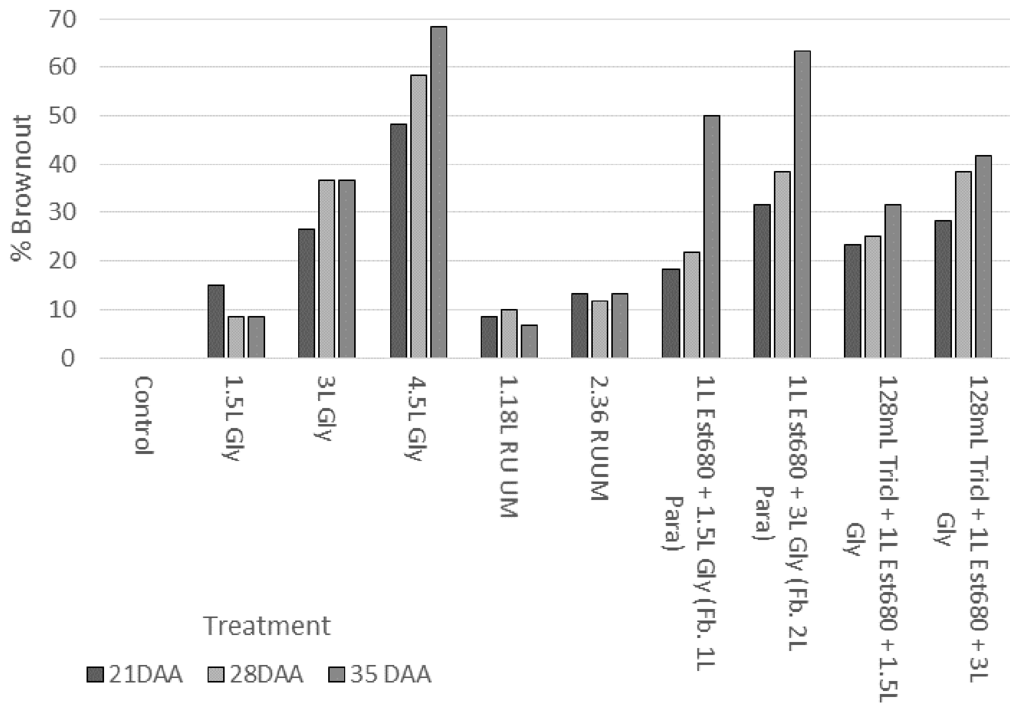

Figure 1: Brownout of treatments at 21, 28 and 35 days after application. *Indicates treatments 11 & 12 - following paraquat applications.

Comments

After 73mm of rain on the 12th January the trial site was covered in healthy looking button grass when it was sprayed on the 9th February. Apart from this major event, the site only received 0.6mm two days prior to spraying and 1mm on the 24th February. This meant that while the button grass looked healthy, it was not actively growing. Under stress, anecdotal evidence has shown the button grass is able to shut down and wait for moisture before pushing out new roots and shoots.

Soil moisture samples were taken on the 22nd March to compare the control to treatment 4 (4L/ha glyphosate) which showed the best brownout. While there was a trend of higher soil moisture in treatment 4, this was not statistically significant. The lack of rainfall following application meant that the quicker brownout of the button grass was not enough to significantly impact soil moisture. Differences would be expected if rainfall followed application. Also as a result of no significant difference in soil moisture, there were no visual differences between germination and vigour of the following crop. Once the season broke the crop received regular rainfall events resulting in no water stress during establishment.

Figure 2 below shows the size of button grass at the time of spraying. In evaluating the control it was observed that button grass smaller than approximately 4cm was controlled while larger ones were able to reshoot when moisture became available.

Unfortunately the Roundup Ultra Max source for this trial was not in specification and therefore resulted in a poor result at both rates. This is contrary to results found by other research in which Roundup Ultra Max performed better than glyphosate 450.

To follow on from these results Elders Scholz Rural will be redesigning this trial to run in 2019 incorporating feedback from attendees at the field days.

Figure 2: At the time of spraying, larger button grass already had a seed emerged which would be ideal to spray at an earlier stage for better control.

Acknowledgements

Thank you to the McCreery family and the Liebe Group for hosting this trial at the 2019 Main Trial Site.

Reference

Cameron, J. and Storrie, A. (eds). (2014). Summer fallow weed management in the southern and western grains regions of Australia – a reference for grain growers and advisers. GRDC publication, Australia

Peer reviewed: Dave Scholz, Elders Scholz Rural

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Investigation into the crop safety effects of summer fallow applied herbicides on winter cereal crops

Michael Macpherson, National Technical Manager, Imtrade Australia

Key points

- There is minimal robust information available on the effect of summer fallow herbicides for plant-backs to winter cereals grown in the lower rainfall zones and in sandy, acidic soils.
- Changing weed profiles over summer has led to interest in alternate chemistries.
- Some summer fallow chemistries appear to significantly reduce crop biomass.

Aim

To investigate the plant-back window for a number of summer fallow herbicide options when applied under lower rainfall conditions in sandy, acidic soils.

Background

Changing summer weed profiles across the northern and central WA wheatbelt are challenging the ability of currently utilised actives to provide adequate fallow control. As there appears to be a shift in the timing of rainfall events, growers are beginning to focus on methods to better manage soil moisture profiles, which has led to more attention being given to summer fallow weed management.

Alternative herbicidal options are being considered for use on these weed profiles, with traditional glyphosate + 2,4 D/Triclopyr brews not providing adequate control in some situations. By looking at alternative herbicides, consideration needs to be made to plant-back windows to winter crops. There are a number of potential options that are being considered/used where the plant-back periods for northern WA growing areas is not well defined. A number of these alternative options (Phenoxys, Sulfonureas etc.) can carry lengthy residuals in certain soil and rainfall situations. This trial was established to begin looking at some of the potential options for safety to following crops.

Trial details

Location	Liebe Group Main Trial Site, McCreery property, Kalannie
Plot size & replication	12 treatments x 3 replications. Plot size 10 x 2m
Soil type	Sandy loam
pH	0-10 cm: 6.2
Paddock rotation:	Pasture 2015-17
Sowing date	31/05/2018
Sowing rate	40 kg/ha Havoc wheat
Fertiliser	Seeding: 70 kg/ha Ktill extra, Post: 60 units N
Herbicides, Insecticides & Fungicides	Fallow: 31/1/2018 3 L/ha Glyphosate 540 Pre-em: Glyphosate + Diuron + Trifluralin + Alpha-cypermethrin Post: 20/7/2018 400 mL/ha 2,4-D LVE, 800mL/ha Jaguar, 80g/ha lontrel
Growing Season Rainfall	216.5 mm (April - October)

Treatments

	Product	Active	Rate (mL/ha)
1	Untreated Control	--	--
2	Rally 300	Clopyralid	150
3	Rally 300	Clopyralid	300
4	Frenzy 750	Sulfosulfuron (Monza)	25g
5	Haloxyfop 900	Haloxyfop	180
6	LV Ester 680	2-4,D Ester	800
7	LV Ester 680	2-4,D Ester	1200
8	Hurricane Ultimate 750	Triclopyr	60
9	Hurricane Ultimate 750	Triclopyr	100
10	Metsulfuron 600	Metsulfuron (Ally)	7g
11	Picker	Picloram + Triclopyr	300
12	Commander 75-D	Picloram + 2,4-D	1000

Trial Layout

The trial was conducted in accordance with the principles of ANOVA, incorporating a Randomised Complete Block Design (RCBD) with 12 treatments and 3 replications, totalling 36 plots.

Plot size is 10 meters long by 2 meters wide.

There were four application timings with the same treatment list and randomisation. Applications were made as per Table 1.

Table 1: Application timing

Application No.	**1**	**2**	**3**	**4**
Application timing	121 DBS	86 DBS	57 DBS	0 DBS
Date	31 Jan 2018	6 Mar 2018	3 Apr 2018	31 May 2018

DBS = Days Before Sowing

The trial site was kept free of weeds (Button grass, Tarvine) by regular application of Glyphosate only. The reason for keeping the site weed free was to prevent any effects of treatment efficacy on weeds creating uncontrolled variation in the site via weed effects (moisture removal, allelopathy etc) which have the potential to mask direct plant-back issues.

Results

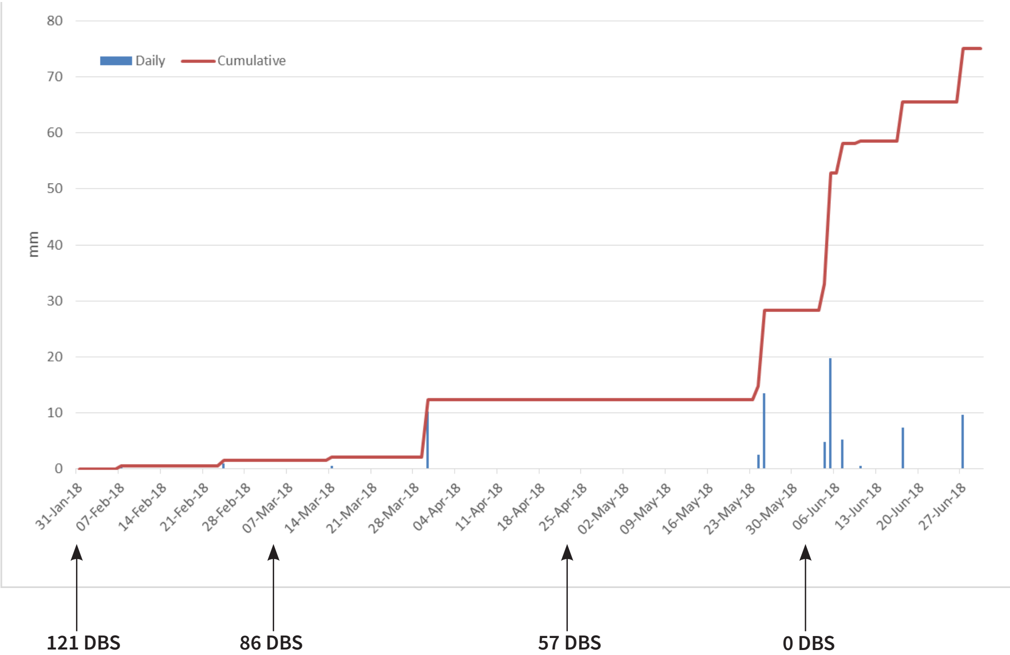

Figure 1: Cumulative and daily rainfall for the trial site from trial commencement to 30th June 2018

Table 2: Comparison of treatment means. Mean number of germinated wheat cv. Havoc seedlings.

No.	Treatment	Application rate	121DBS 33DAS	86DBS 33DAS	57DBS 33DAS	0DBS 33DAS
		(g/ha)	*3/07/2018*	*3/07/2018*	*3/07/2018*	*3/07/2018*
1	Untreated	0	84.2	85.9	83.8[ab]	99.6[ab]
2	Rally	150	88.8	97.6	78.8[b]	101.6[a]
3	Rally	300	91.7	96.6	77.8[bc]	92.3[ab]
4	Frenzy	25	91.7	100.0	82.9[ab]	88.9[b]
5	Haloxyfop	180	86.8	100.8	71.6[c]	59.0[c]
6	LV Ester	800	85.6	97.9	84.4[ab]	88.2[b]
7	LV Ester	1200	87.4	95.7	78.9[b]	99.0[ab]
8	Hurricane Ultimate	60	86.7	100.0	79.9[b]	100.1[ab]
9	Hurricane Ultimate	100	96.0	102.7	80.9[ab]	99.4[ab]
10	Metsulfuron	7	87.9	100.2	87.9[a]	99.6[ab]
11	Picker	300	87.1	92.7	83.8[ab]	98.1[ab]
12	Commander	1000	86.0	100.6	82.1[ab]	92.2[ab]
		P value	0.499	0.382	0.016	<0.001
		LSD	ns	ns	7.15	12.49

ns - no statistical significance at $p < 0.05$
Means within the same cell with a letter in common are not significantly different (P>0.05)

Table 3: Comparison of treatment means. Mean Biomass percentage of wheat cv. Havoc treated 121 Days Before Sowing

			121 DBS		
No.	Treatment	Application rate	33 DAS	54 DAS	88 DAS
		(g/ha)	*3/07/2018*	*24/07/2018*	*27/08/2018*
1	Untreated	0	100	100.0	100.0
2	Rally	150	100	98.3	100.0
3	Rally	300	100	96.7	96.7
4	Frenzy	25	100	95.0	96.7
5	Haloxyfop	180	100	93.3	95.0
6	LV Ester	800	100	100.0	100.0
7	LV Ester	1200	100	100.0	100.0
8	Hurricane Ultimate	60	100	100.0	100.0
9	Hurricane Ultimate	100	100	100.0	100.0
10	Metsulfuron	7	100	100.0	100.0
11	Picker	300	100	100.0	100.0
12	Commander	1000	100	100.0	100.0
		P value	1	0.219	0.189
		LSD	ns	ns	ns

ns - no statistical significance at p <0.05
Means within the same cell with a letter in common are not significantly different (P>0.05)

Table 4: Comparison of treatment means. Mean Biomass percentage of wheat cv. Havoc treated 86 Days Before Sowing

			86 DBS		
No.	Treatment	Application rate (g/ha)	33 DAS *3/07/2018*	54 DAS *24/07/2018*	88 DAS *27/08/2018*
1	Untreated	0	100.0	100.0	100.0a
2	Rally	150	100.0	100.0	100.0a
3	Rally	300	100.0	100.0	100.0a
4	Frenzy	25	100.0	100.0	100.0a
5	Haloxyfop	180	100.0	96.7	98.3ab
6	LV Ester	800	100.0	100.0	100.0a
7	LV Ester	1200	100.0	100.0	100.0a
8	Hurricane Ultimate	60	100.0	100.0	100.0a
9	Hurricane Ultimate	100	100.0	100.0	100.0a
10	Metsulfuron	7	100.0	96.7	96.7b
11	Picker	300	100.0	100.0	100.0a
12	Commander	1000	100.0	100.0	100.0a
		P value	1	0.477	0.037
		LSD	ns	ns	1.95

ns - no statistical significance at p <0.05
Means within the same cell with a letter in common are not significantly different (P>0.05)

Table 5: Comparison of treatment means. Mean Biomass percentage of wheat cv. Havoc treated 57 Days Before Sowing

			57 DBS		
No.	**Treatment**	**Application rate**	**33 DAS**	**54 DAS**	**88 DAS**
		(g/ha)	*3/07/2018*	*24/07/2018*	*27/08/2018*
1	Untreated	0	100	100.0a	100.0a
2	Rally	150	100	100.0a	100.0a
3	Rally	300	100	100.0a	100.0a
4	Frenzy	25	100	88.3b	96.7a
5	Haloxyfop	180	100	70.0d	85.0b
6	LV Ester	800	100	100.0a	100.0a
7	LV Ester	1200	100	100.0a	100.0a
8	Hurricane Ultimate	60	100	100.0a	100.0a
9	Hurricane Ultimate	100	100	100.0a	100.0a
10	Metsulfuron	7	100	80.0c	86.7b
11	Picker	300	100	100.0a	100.0a
12	Commander	1000	100	98.3a	98.3a
		P value	1	<0.001	<0.001
		LSD	ns	2.04	4.15

ns - no statistical significance at p <0.05
Means within the same cell with a letter in common are not significantly different (P>0.05)

Table 6: Comparison of treatment means. Mean Biomass percentage of wheat cv. Havoc treated 0 Days Before Sowing

			0 DBS		
No.	**Treatment**	**Application rate**	**33 DAS**	**54 DAS**	**88 DAS**
		(g/ha)	*3/07/2018*	*24/07/2018*	*27/08/2018*
1	Untreated	0	100a	100.0a	100.0a
2	Rally	150	100a	100.0a	100.0a
3	Rally	300	100a	100.0a	100.0a
4	Frenzy	25	100a	89.0b	95.0b
5	Haloxyfop	180	50b	41.7d	68.3d
6	LV Ester	800	100a	100.0a	100.0a
7	LV Ester	1200	100a	100.0a	100.0a
8	Hurricane Ultimate	60	100a	100.0a	100.0a
9	Hurricane Ultimate	100	100a	100.0a	100.0a
10	Metsulfuron	7	100a	73.3c	88.3c
11	Picker	300	100a	100.0a	100.0a
12	Commander	1000	100a	96.7a	96.7ab
		P value	<0.001	<0.001	<0.001
		LSD	6.56	3.71	3.43

Means within the same cell with a letter in common are not significantly different (P>0.05)

Table 7: Comparison of treatment means. Harvest data of wheat cv. Havoc treated 57 Days Before Sowing

			57 DBS				
No.	**Treatment**	**Application rate**	***Yield***	***Protein***	***Hectolitre***	***Whitehead***	***Screenings***
		(/ha)	*t/ha*	%	%	%	%
1	Untreated	0	2.14	10.0	82.9	1.47	2.06
2	Rally	150	2.03	10.0	83.1	0.30	0.88
3	Rally	300	2.10	10.0	83.5	0.36	0.74
4	Frenzy	25	1.91	8.83	83.5	0.30	1.33
5	Haloxyfop	180	1.86	7.0	82.6	0.30	1.38
6	LV Ester	800	1.91	10.0	83.1	0.47	0.89
7	LV Ester	1200	2.05	10.0	82.0	0.38	0.86
8	Hurricane Ultimate	60	1.93	10.0	82.6	0.30	0.80
9	Hurricane Ultimate	100	2.00	10.0	81.6	0.35	0.95
10	Metsulfuron	7	1.87	8.0	83.7	0.40	0.84
11	Picker	300	1.85	10.0	83.3	0.27	0.90
12	Commander	1000	1.75	9.83	83.0	0.26	0.86
		P value	0.395	0.472	0.371	0.523	0.348
		LSD	ns	ns	ns	ns	ns

ns - no statistical significance at $p < 0.05$

The rainfall for the site over the summer post application of the treatments was not high (Figure 1), with roughly 25mm received post application of 121 and 86 days before sowing (DBS) treatments and 15mm for the 57 DBS treatment. This amount of rainfall is generally considered inadequate to break down/dissipate most problematic herbicide actives.

When applied well in advance of seeding (121 – 86 DBS), none of the treatments appear to have affected the germination of wheat. However the application of Haloxyfop at timings closer to seeding (57 – 0 DBS) have significantly reduced the germination of wheat compared to the untreated control (Table 2).

When assessed by visual biomass percentage, a number of treatments have affected the vigour of wheat. Interestingly, most treatments did not show any effect on biomass until 54 days post sowing, which when applied to a whole paddock situation may lead to misdiagnosis of the cause of the thin crop/poorly performing crop. Some of the biomass reductions may not even be noticeable at all in a large scale situation without untreated areas for comparison.

The biomass results indicate;

- Haloxyfop caused significant biomass reduction when applied 57 days before seeding or directly in front of the seeder bar. (Tables 5 & 6)
- Frenzy (Monza) caused significant biomass reductions when applied up to 57 days before seeding. (Tables 5 & 6)
- Metsulfuron (Ally) caused significant biomass reductions when applied out to 86 days before seeding. (Tables 4, 5 & 6)

Interestingly, the yield data (only taken from the 57 DBS timing, Table 7) indicated that the visual reduction in biomass has not influenced the final yield or the quality of the harvested samples. With the soft finish that the trial site received this season, it appears that the wheat has been able to compensate for the early-mid season biomass reductions. If the season was a more typical finish for this location, or an early cut-off, it would be expected that compensation may not occur. Visually at harvest, the 0 DBS timing was still significantly affected.

Peer Review: Clare Johnston, Elders Scholz Rural

Acknowledgements
Thanks to the Liebe Group and the McCreery family for hosting the trial at the Liebe Group Main Trial Site and, for seeding and assisting with site maintenance.

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Demonstration of the efficacy and host crop safety of various pre-emergent herbicides in wheat

Michael Macpherson, National Technical Manager, Imtrade Australia

Key points

- Pre-emergent herbicides have different characteristics which provide different outcomes dependant on the prevailing environmental conditions.
- Number of new blended active ingredient products available for ryegrass control in cereals.
- All pre-emergent herbicides provided good control of annual ryegrass at this location under the prevailing weather conditions.

Aim

To demonstrate and investigate the efficacy of various pre-emergent herbicide options for the control of annual ryegrass (ARG) in wheat.

Background

Ryegrass is a serious problem in most Australian broad-acre cropping systems. Increasing issues with resistance make it important for growers to have cost effective herbicide strategies that provide adequate control. With an increasing number of options available, making the right choices can be difficult. Balancing efficacy against cost, in combination with environmental conditions is imperative for optimizing outcomes. Imtrade Australia, in collaboration with the Liebe Group, has implemented a number of pre-emergent herbicide trials over the last four years to provide local information for growers. This trial is designed to directly represent local management strategies, with the trial being sown with the host grower's seeding equipment and fertiliser.

Trial details

Trial location	Liebe Group Main Trial Site, McCreery Property, Kalannie
Plot size & replication	12 treatments x 3 replications. Plot size 10 x 2m
Soil type	Sandy loam
pH	3-10 cm: 6.2
Paddock rotation:	Pasture 2015-17
Sowing date	31/05/2018
Sowing rate	40 kg/ha Havoc wheat
Fertiliser	Seeding: 70 kg/ha Ktill extra, Post: 60 units N
Herbicides, Insecticides & Fungicides	Pre-em: 2 L/ha Glyphosate 450 Post: 20/7/2018 400 mL/ha 2,4-D LVE, 800mL/ha Jaguar, 80g/ha lontrel
Growing season rainfall	216.5 mm (April - October)

Treatments

	Treatment	Rate (L/ha)
1	Untreated Control	--
2	Trifluralin 480	2
3	Arcade	3
4	Boxer Gold	2.5
5	Arcade + Trifluralin 480	3 + 1
6	Imtrade Bolta Duo	3
7	Imtrade Diablo Duo	3
8	Imtrade Jetti Duo	1.8
9	Sakura	118g
10	Exp 1	3.6
11	Trifluralin (Pre) + (Post) Boxer Gold	2 Pre + 2.5 Post
12	Exp 2 (post)	0.55 Post

Trial Layout

The trial was conducted in accordance with the principles of ANOVA, incorporating a Randomised Complete Block Design (RCBD) with 12 treatments and 3 replications, totalling 36 plots.

1	2	3	4	5	6	7	8	9	10	11	12	buffer	10	6	4	9	1	5	8	12	7	2	11	3	buffer	7	5	11	3	6	10	2	9	4	1	12	8
Replicate 1													Replicate 2													Replicate 3											

Results

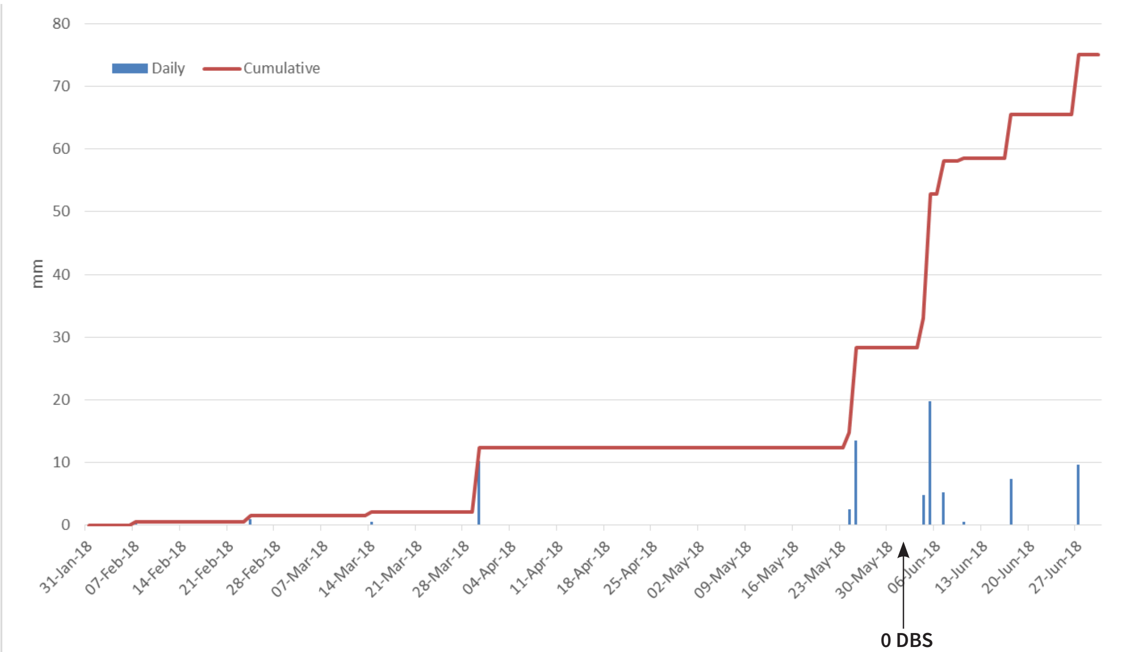

Figure 1: Cumulative and daily rainfall for the trial site from 31 Jan 2018 to 30 Jun 2018

Cumulative rainfall at the trial site. Note the pre and post seeding rainfall, which provided good conditions for crop and weed germination, allowing for optimal herbicidal efficacy.

Table 1: Comparison of treatment means. Mean number of annual ryegrass plants per m^2

No.	Treatment	Application rate *(g/ha)*	54 DAT *24-Jul-18*	89 DAT *27-Aug-18*
1	Untreated	0	44.7c	36.3c
2	Trilfularalin 480	2	3.3a	3.3a
3	Arcade	3	2.7a	4.0a
4	Boxer Gold	2.5	3.0a	2.0a
5	Arcade + Trifluralin 480	3+1	3.3a	3.0a
6	Imtrade Bolta Duo	3	1.7a	2.3a
7	Imtrade Diablo Duo	3	1.0a	3.7a
8	Imtrade Jetti Duo	1.8	3.3a	2.3a
9	Sakura	118g	2.0a	2.3a
10	Exp1	3.6	1.7a	2.3a
11	Trifluralin (Pre) + Boxer Gold (Post)	2 pre + 2.5 Post	2.3a	1.3a
12	Exp2 (post)	0.55	29.7b	14.0b
		P value	<0.001	<0.001
		LSD	8.94	5.71

Means within the same cell with a letter in common are not significantly different (P>0.05)
DAT – Days after Treatment

Annual ryegrass (ARG) counts were taken at 54 days after treatment (DAT) and at 89 DAT, to quantify the efficacy of each pre-emergent herbicide. Table 1 shows that all pre-emergent herbicides controlled emerging weeds well compared to the untreated control. Similarly ARG counts at 89 DAT remained relatively unchanged, with weed numbers being low compared to that of the untreated control.

Conclusion

2018 provided good seasonal conditions for optimal herbicide efficacy at this location. Adequate rainfall was received within 21 days of the trial being sown (Figure 1) to allow for weed germination to coincide with the activation of the herbicides. Good seeding conditions and low stubble/organic matter at sowing allowed for excellent incorporation of the actives.

The data clearly demonstrates the efficacy of pre-emergent herbicides on annual rye grass (ARG), with all pre-emergent treatments providing excellent control on this low-moderate population. The post emergent Boxer Gold treatment was not really required at this site this season as the pre-emergent trifluralin provided good up-front control with very few survivors, however was applied for demonstration purposes.

Peer Review: Clare Johnston, Elders Scholz Rural

Acknowledgements

Thanks to the Liebe Group and the McCreery Family for hosting this trial at the Liebe Group Main Trial Site and, for seeding and assisting with maintenance of the site.

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DISEASES & PESTS RESEARCH RESULTS

Yield loss from crown rot of wheat, barley and oat varieties at two sowing dates - National Crown Rot Program, Wongan Hills, 2018

Daniel Huberli, Plant Pathologist, DPIRD, and Clayton Forknall, Senior Biometrician, Qld Department of Agriculture and Fisheries

Key Messages

- No significant yield losses to applied crown rot inoculum were measured in the milling oat varieties considered, while wheat and barley varieties showed up to 24% and 11% yield losses, respectively.
- While sowing date affected the grain yield of some wheat and barley varieties, the oat varieties considered showed no significant response to sowing date in this experiment.
- The application of crown rot inoculum reduced the yield of all crop types in both sowing dates, with the magnitude of losses exacerbated with delayed planting.
- To minimise the level of yield loss from crown rot, determine the levels of inoculum present prior to sowing and if required, choose a wheat or barley variety that has lower yield loss to crown rot if sowing back into cereal.

Aim

1. Determine the relative yield loss to crown rot of wheat, barley and oat varieties.
2. Determine if earlier sowing (1 May) will change the level of yield loss to crown rot compared with later sowing (28 May).

Background

Crown rot, caused by the stubble-borne fungus *Fusarium pseudograminearum*, is a significant limitation to grain production in Western Australia, particularly in low to medium rainfall areas and in regions with limited break crop options from cereals. Nationally, management strategies to minimise yield losses due to the disease include rotation with non-host canola or pulse break crops, inter-row sowing, cereal variety choice and sowing at the earliest recommended window, along with controlling grass weeds both in break crop and over summer fallow periods.

The relative yield loss from crown rot of wheat and barley varieties was identified previously in inoculated trials sown in late May in Merredin and Wongan Hills during 2014 to 2016, (Hüberli et al. 2017). For barley, Litmus and Spartacus had the lowest yield loss (8-11%) from crown rot, while Bass had the highest yield loss (28%). For wheat, Emu Rock and Scepter had the lowest yield loss (10-13%) and Justica CL the highest (31%). In inoculated oat variety trials sown late May during 2016 to 2017 in Pingelly, Muresk and Merredin, there were no differences in yield loss to crown rot among the seven milling varieties tested, with a 4% average yield loss across all varieties (Hüberli et al. 2018). There were some differences in incidence and severity of infection post-harvest. Mitika had the lowest level of disease, while Yallara had the highest level. A selection of the barley, wheat and oat varieties demonstrating high and low yield losses to crown rot in these previous experiments were trialled at Wongan Hills Research Station in 2018 under inoculated and uninoculated conditions and sown at two sowing dates. This aimed to determine the potential variation in the relative yield loss of the different crop types and varieties across the sowing dates.

Trial Details

Property	DPIRD Wongan Hills Research Station, Wongan Hills
Plot size & replication	10m x 1.54m x 3 replications
Soil type	Loamy sand
Soil pH ($CaCl_2$)	0-10cm: 6.7
EC (dS/m)	0-10cm: 0.083
Paddock rotation:	2015 pasture, 2016 pasture, 2017 pasture
Sowing date	TOS1: 01/05/2018 into 20mm irrigated soil previous day TOS2: 28/05/2018 into moist soil
Sowing rate	150 plants/m^2 for wheat (Emu Rock, Justica CL and Scepter) and barley (Bass, Litmus and Spartacus CL) 240 plants/m^2 for milling oats (Kojonup, Mitika and Yallara)
Treatments	Two rates of crown rot inoculum were applied at sowing (0 and 2.0 g/m row) using sterile wheat (Mace) seed colonised with *Fusarium pseudograminearum*
Fertiliser	01/05/2018 (TOS1) or 28/05/2018 (TOS2): 80 kg/ha Macropro Plus 26/06/2018 (TOS1) or 18/07/2018 (TOS2): 50 L/ha Flexi-N
Herbicides, insecticides & fungicides	08/02/2018 (whole trial): 100 mL/ha Garlon, 500 mL/ha Ester, 1.8 L/ha Roundup Ultramax 01/05/2018 (TOS1) or 28/05/2018 (TOS2): 1 kg/ha Terbyne Xtreme, 1.5 L/ha Triflur X, 2 L/ha Sprayseed 250, 200 mL/ha Alpha-Scud, 200 mL/ha Chlorpyrifos 21/06/2018: 2 L/ha Precept (TOS1) or 85 mL/ha Dimethoate (TOS2) 05/07/2018 (TOS2): 1.5 L/ha Precept 17/07/2018 (whole trial): 500 mL/ha Propiconazole
Growing Season Rainfall	341mm (May - October); TOS1 recieved from 20mm on 30/04/2018

Results

Crown rot reduced grain yield significantly at both times of sowing (Figure 1), however the magnitude of yield losses varied. In the second time of sowing, which displayed a greater average yield than the first time of sowing the yield loss due to added crown rot inoculum was 10% compared to 5% in the first time of sowing.

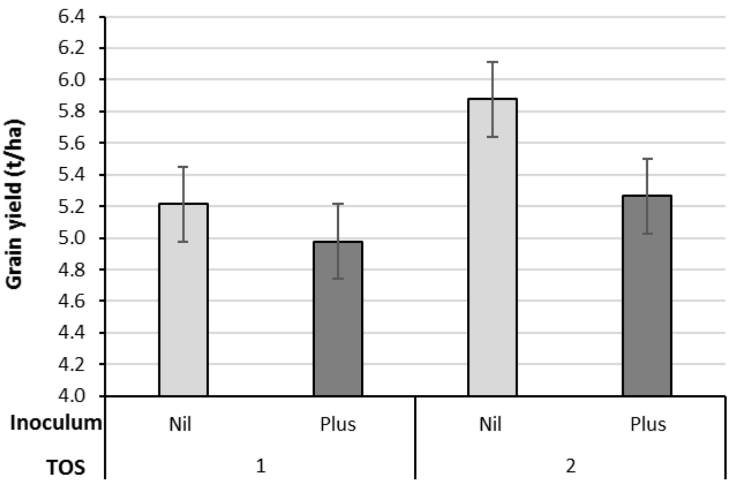
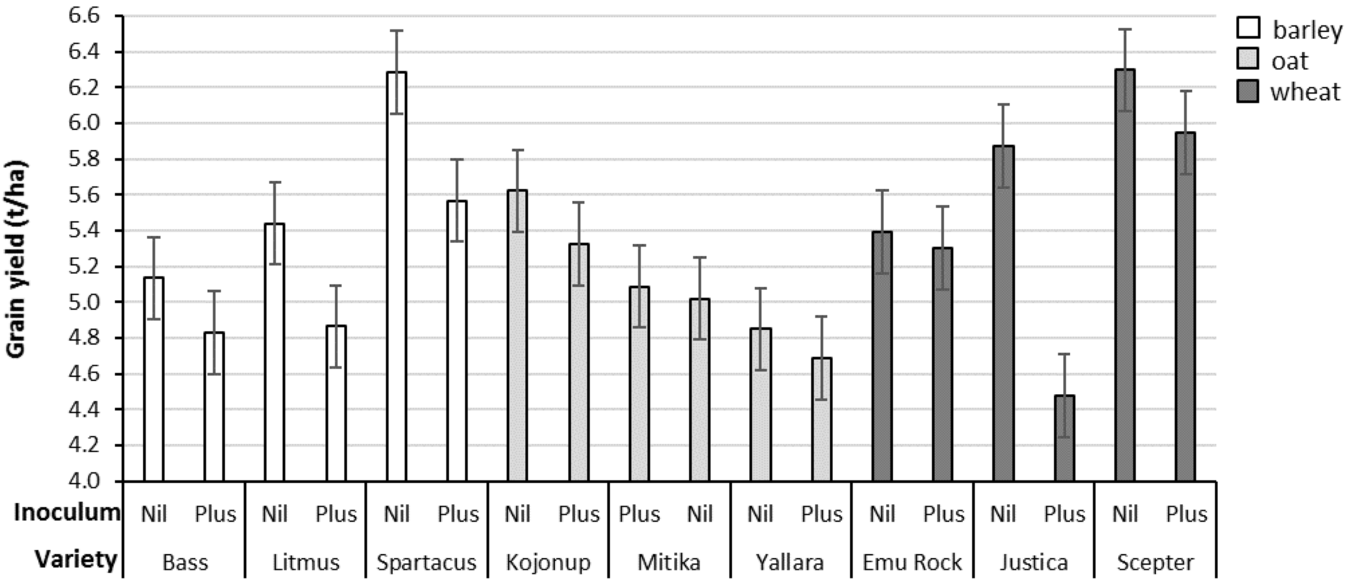


Figure 1: Average grain yield (+/- standard error of the mean) for all cereals in nil and plus crown rot inoculum plots sown on either 1 May 2018 (TOS1) or 28 May 2018 (TOS2) at Wongan Hills Research Station. LSDs for comparison of crown rot inoculum within the same TOS = 0.19 t/ha and between TOS = 0.68 t/ha.

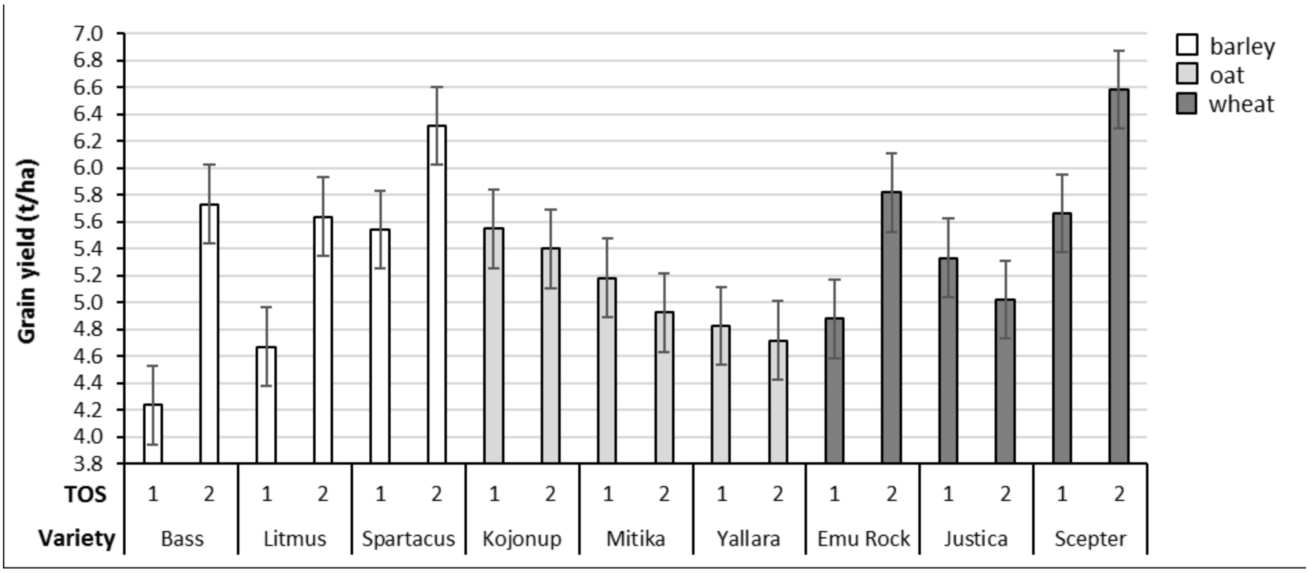
Two barley varieties (Litmus and Spartacus) and one wheat variety (Justica CL) demonstrated significant yield losses to applied crown rot inoculum, while there were no significant yield losses measured between the oat varieties (Figure 2). Yield losses for Litmus and Spartacus were 11% and for Justica CL yield loss was 24%. Spartacus, Scepter and Emu Rock yielded significantly better than other tested varieties in plots with added crown rot inoculum (Figure 2).

Two of the barley varieties (Bass and Litmus) and two of the wheat varieties (Emu Rock and Scepter) yielded better at the second time of sowing when compared to the first (Figure 3). There was no significant effect of sowing time on yield for all three oat varieties. Whitehead assessments of wheat and barley plots determined that there were no or very few whiteheads expressed at the first time of sowing (data not shown). At the second time of sowing there were very large and significant number of whiteheads for Justica CL of 22% /m row compared to the other crop varieties which had 4-7% with the exception of Emu Rock which had no expression of whiteheads. No whiteheads were observed in



the oat varieties.

Figure 2: Average grain yield (+/- standard error of the mean) for barley, oat and wheat varieties in nil and plus crown rot inoculum plots at Wongan Hills Research Station in 2018. LSDs for comparison of crown inoculum levels within the same variety = 0.41 t/ha, between varieties within the same crop type = 0.44 t/ha, and across



varieties and crop types = 0.49 t/ha.

Figure 3: Average grain yield (+/- standard error of the mean) for barley, oat and wheat varieties sown on either 1 May 2018 (TOS1) or 28 May 2018 (TOS2) at Wongan Hills Research Station. LSDs for comparison of varieties within the same crop type within the same TOS = 0.48 t/ha, varieties across crop types within the same TOS = 0.57 t/ha, and varieties of the same or different crop types between TOS = 0.85 t/ha.

Stem browning to assess the level of crown rot infection and grain quality measurements including screenings and protein have not been completed at this stage.

Comments

The results from this trial show the potential detrimental effect of crown rot inoculum at sowing on the yield of some wheat and barley varieties, demonstrating the role variety choice can play, if considering these cereal types, to maximise grain yield in the presence of crown rot. However, these effects were not witnessed in the milling oat varieties considered, with no significant difference in yield observed. In this trial, the best yielding varieties with added crown rot inoculum were Spartacus, Scepter and Emu Rock. While Spartacus was the best yielding barley variety, it did suffer larger yield losses than Bass, however, due to its greater yield potential, it was still able to out-perform other varieties in the presence of crown rot inoculum. In trials during 2014 to 2016 at this site, both Spartacus and Litmus had the smallest yield losses to added crown rot inoculum. It is possible that the lower pH (<5.0) in the soil in 2014-2016 may have given Litmus, an acid soil tolerant barley variety, a competitive edge over the other barley varieties tested in the experiments.

The reduced yields, irrespective of crown rot, recorded for the first time of sowing when compared to the second time of sowing are most likely a result of late rainfall at the experimental location. As expected for their maturity class, the earlier maturity varieties, Emu Rock, Scepter and Litmus yielded significantly better at the second time of sowing (end of May) with the exception of Bass, an intermediate maturity variety. While time of sowing influenced the yield of Emu Rock and Scepter, there was no evidence that the effect of crown rot on yield varied across the sowing times for these varieties or any of the other varieties, but rather both Emu Rock and Scepter were subject to yield losses of similar magnitude. Interestingly, Justica CL, a mid to late maturing variety, did not demonstrate significant yield decline at the second sowing time which is outside of its recommended planting window. Justica CL did however, have a similar level of yield loss to added crown rot inoculum at both sowing dates. The late start to the season may have influenced these interactions and so further work plans to investigate the impact of time of sowing on crown rot infection and associated yield loss.

While the oat varieties considered did not display significant yield losses to crown rot, oats are not a break crop for the disease. Previous trials have shown that inoculum levels at the start of the second year following wheat and oats were equivalent (Hüberli et al. 2018). The best option to reduce medium to high inoculum levels is a two year rotation with non-cereal break crops (canola or pulses). But if a cereal must be grown then choose milling oats, followed by barley or wheat to limit the yield losses incurred to crown rot. If sowing barley or wheat into paddocks infected with crown rot, choose a variety that has lower yield losses to crown rot and sow within the recommended planting window for that variety to potentially reduce the effect of moisture stress on disease expression during grain filling.

Acknowledgements
Technical support from Miriam Connor and Kris Gajda. Department of Primary Industries and Regional Development (DPIRD) Research Support Unit at Wongan Hills sowed, managed and harvested the trial. This research was a co-investment by DPIRD and GRDC (DAN00175, National crown rot epidemiology and management program).

Further Reading

Hüberli, D., Gajda, K., Connor, M. and Van Burgel, A. (2018) Are oats an effective break crop for crown rot? In: Proceedings of the 10th Australasian Soilborne Disease Symposium, 4 - 8 September, Adelaide, Australia. http://researchrepository.murdoch.edu.au/id/eprint/41956/

Hüberli, D., Gajda, K., Connor, M. and Van Burgel, A. (2017) Choosing the best yielding wheat and barley variety under high crown rot. In: 2017 Grains Research Updates, Perth, Western Australia, 27 - 28 February. http://researchrepository.murdoch.edu.au/id/eprint/35682/

Peer review:: Steven Simpfendorfer, NSW DPI

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GOVERNMENT OF WESTERN AUSTRALIA Department of Primary Industries and Regional Development

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Queensland Government

SAGI Statistics for the Australian Grains Industry National | North | West | South

Grain yield in wheat at different crown rot inoculum levels - Wongan Hills, 2018

Daniel Huberli, Plant Pathologist, DPIRD; Clayton Forknall, Senior Biometrician, Qld Department of Agriculture and Fisheries; and Steven Simpfendorfer, Senior Research Scientist, NSW Department of Primary Industries

Key Messages

- Yield loss from crown rot is related to the inoculum level present at sowing, with up to 13% yield loss in wheat recorded with the highest inoculum levels at Wongan Hills in 2018.
- Wheat varieties have different responses to crown rot with a 0.34 t/ha penalty in grain yield between the least and most impacted variety in this trial in 2018.
- To minimise the level of yield loss from crown rot, determine the levels of inoculum present prior to sowing and if required, choose a wheat or barley variety that has lower yield loss to crown rot if sowing back into cereal.

Aim

Determine the impact of increasing levels of crown rot inoculum at sowing on grain yield of different wheat varieties.

Background

Crown rot, caused by the stubble-borne fungus *Fusarium pseudograminearum*, has a significant impact on grain yield in Western Australia, particularly in seasons where rainfall is limiting during grain filling. The fungus can survive for multiple years in cereal stubble and inoculum levels can build up over several years under intensive cereal cropping and stubble retention practices. Grass weeds can also be a significant host of the crown rot fungus. In the central agro-ecological zone a recent soil survey (2015-2017) at sowing identified that 34% of 972 paddocks had a detectable level of crown rot inoculum and 15% were at a medium to high level. Inoculum levels present at sowing along with climatic conditions during spring determine the extent of loss in grain yield associated with crown rot infection.

Wheat varieties respond differently and vary in the level of yield loss to crown rot. In inoculated trials at Wongan Hills Research Station (2014 - 2016) there was a 20% difference in yield loss between the least and most impacted variety (Hüberli et al. 2017). In the three years, Emu Rock had no more than 10% yield loss while Mace had 19-23%, and Justica CL, the most impacted, suffered 23-29% losses. Scepter was included in the 2016 trial and had 8% yield loss to crown rot, while Emu Rock had no yield loss and Mace had 19%. Therefore, variety choice can have an impact on grain yield in paddocks with high levels of crown rot inoculum.

Assessing paddocks visually for crown rot can be deceptive if only whiteheads are considered as the level of expression of this symptom is governed by the amount of moisture stress during grain filling. Additionally, whiteheads can be a symptom of other issues including take-all or frost. Pulling up plants or stubble and assessing stem bases for browning distinctive of crown rot infection, once the outer-leaf sheaths are pulled back, is the best approach. A PREDICTA B test prior to sowing will also determine the level of crown rot inoculum present in paddocks to guide management decisions.

Trial Details

Property	DPIRD Wongan Hills Research Station, Wongan Hills
Plot size & replication	10m x 1.54m x 3 replications
Soil type	Loamy sand
Soil pH ($CaCl_2$)	0-10cm: 6.1
EC (dS/m)	0-10cm: 0.107
Paddock rotation:	2017 canola. No crown rot detected by PREDICTA B prior to sowing.
Sowing date	3/07/2018 (resown trial after first trial failed due to herbicide damage)
Sowing rate	150 plants/m^2
Wheat varieties	Variety / Crown rot resistance rating[A]: Emu Rock – MSS; Kunjin – MSS; Mace – S; Scepter – S; Westonia – S [A] Crown rot resistance reaction: MSS – moderately susceptible to susceptible, and S – susceptible
Treatments	Six rates of crown rot inoculum were applied at sowing (0, 0.25, 0.5, 1.0, 2.0 and 4.0 g/m row) using sterile wheat (Mace) seed colonised with *Fusarium pseudograminearum*
Fertiliser	03/07/2018: 80 kg/ha Macropro Plus
Herbicideswww, insecticides & fungicides	08/02/2018: 100 mL/ha Garlon, 500 mL/ha Ester, 1.8 L/ha Roundup Ultramax 03/07/2018: 2 L/ha Triflur X, 2 L/ha Sprayseed 250, 200 mL/ha Alpha-Scud, 200 mL/ha Chlorpyrifos 27/08/2018: 670 mL/ha Velocity
Growing Season Rainfall	265 mm (July to October 2018) includes 20 mm irrigation on 4/10/2018

Variety	Crown rot resistance rating[A]
Emu Rock	MSS
Kunjin	MSS
Mace	S
Scepter	S
Westonia	S

Results

There was a significant interaction (*P* = 0.06) between wheat variety and the applied rate of crown rot inoculum. Grain yield declined with increasing rates of crown rot inoculum applied at sowing for all varieties (Table 1). At 4.0 g/m row of applied crown rot inoculum the extent of yield loss varied between 8 to 13% for the varieties considered, when compared to the treatment where no inoculum was applied. At 1.0 g/m applied inoculum, only Kunjin and Mace had no significant level of yield loss, while Emu Rock, Scepter and Westonia had yield losses of 6 to 9%. Overall, Mace was the lowest yielding variety at both 2.0 and 4.0 g/m row inoculum rates, while Kunjin was the highest yielding at the 4.0 g/m row rate.

Stem browning to assess the level of crown rot infection and grain quality measurements including screenings and protein are still to be assessed.

Table 1. Effect of increasing rates of crown rot inoculum applied at sowing on grain yield (t/ha; percentage yield loss relative to the untreated control in parenthesis) of five wheat varieties at Wongan Hills Research Station during 2018. Variety x inoculum interaction is significant at 6% level.

	Applied crown rot inoculum (g/m row) at sowing					
Variety	**0**	**0.25**	**0.5**	**1.0**	**2.0**	**4.0**
Emu Rock	2.37	2.31 (ns)	2.25 (5)*	2.16 (9)*	2.11 (11)*	2.07 (13)*
Kunjin	2.47	2.41 (ns)	2.31 (6)*	2.37 (ns)	2.13 (13)*	2.27 (8)*
Mace	2.22	2.24 (ns)	2.22 (ns)	2.17 (ns)	1.96 (12)*	1.93 (13)*
Scepter	2.35	2.27 (ns)	2.20 (6)*	2.20 (6)*	2.19 (7)*	2.12 (10)*
Westonia	2.38	2.34 (ns)	2.28 (ns)	2.16 (9)*	2.11 (11)*	2.14 (10)*
P Value						
Var. x Inoculum			0.055			
LSD						
Var. x Inoculum			0.11			

* Significant yield loss relative to the untreated within that variety (%).
ns = Not significant.

Comments

The results demonstrate the detrimental effect of increasing crown rot inoculum levels at sowing on wheat yield. They also show that variety choice can be important in getting the best grain yield in the presence of crown rot, although differences between varieties in this trial were not as large as in previous seasons. It should be noted that the late sowing date is likely to have impacted on the response of all varieties. A later sowing date can push the grain filling window of varieties into a part of the growing season where they are more at risk from moisture stress, which can also exacerbate yield losses due to crown rot. However, the irrigation and rainfall events during October of over 40mm may have minimised this effect given that yield losses were low (8-13% at 4.0 g/m row) compared to previous years' trials at this site where losses of up to 29% were recorded at the lower rate of 2.0 g/m row of applied crown rot inoculum (Hüberli et al. 2017). Emu Rock out-yielded Mace in this trial at the two highest inoculum rates, but it did not perform as well as in previous years of experimentation conducted at this site. Nonetheless choosing Mace over any of the other varieties in the presence of higher levels of crown rot inoculum cost between 0.15 to 0.34 t/ha in grain yield.

The wheat or barley choice in the presence of crown rot when sown late May are provided as relative yield loss levels in the current WA sowing guides (see reference section for website link). The levels of yield loss reported were determined in inoculated trials conducted between 2014 and 2016 at the Wongan Hills and Merredin Research Stations.

Crown rot is difficult to manage because the causal fungus can persist in cereal and grass weed residues for 2-3 years, inoculum build up is favoured by the adoption of stubble retention systems, there are only moderate levels of genetic resistance available, and there are no in-crop fungicide options. Therefore, management practices must be in place at sowing to reduce impact on yield. First and foremost, it is important to consider the level of crown rot inoculum present to avoid high yield losses in susceptible wheat varieties. Crown rot levels can be determined visually (see GRDC Tips and Tactics Crown Rot Western Region) or by using PREDICTA B. Consider a two year rotation with non-cereal break crops (canola or pulses) when crown rot inoculum levels are medium to high. If cereals must be grown then choose milling oats, followed by barley, followed by wheat. Oats suffer little yield loss to crown rot (Huberli et al. 2018), while barley and wheat can be heavily impacted (Huberli et al. 2017). Despite oats suffering less yield loss to crown rot, they are not break crops for crown rot as the inoculum load in following year was at the same level as wheat (Huberli et al. 2017). If sowing barley or wheat into paddocks infected with crown rot, choose a variety that has lower yield losses to crown rot and sow within the earliest possible part of the recommended planting window to potentially reduce the effect of moisture stress on disease expression during grain filling.

Acknowledgements

Technical support from Miriam Connor and Kris Gajda. Department of Primary Industries and Regional Development (DPRID) Research Support Unit at Wongan Hills sowed, managed and harvested the trial. This research was a co-investment by DPIRD and GRDC (DAW00245, Yield loss response curve for host resistance to leaf, crown and root diseases in wheat and barley project).

Further Reading

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Hüberli, D., Gajda, K., Connor, M. and Van Burgel, A. (2017) Choosing the best yielding wheat and barley variety under high crown rot. In: 2017 Grains Research Updates, Perth, Western Australia, 27 - 28 February. http://researchrepository.murdoch.edu.au/id/eprint/35682/

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Peer review:: Kylie Chambers, DPIRD

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Management of Crown Rot and Rhizoctonia in Mace wheat using soil and seed-applied fungicides

Matt Willis, Customer Advisory Representative, Bayer Crop Science

Key points

- Crown rot and rhizoctonia are yield limiting soil borne pathogens that are becoming more common with the increase in intensive cereal rotations across the WA Wheatbelt.
- The use of effective seed and/or in-furrow fungicides is one strategy to reduce the impact of seed and soil borne pathogens on crop competition and yield.
- EverGol® Energy is a newly registered cereal seed treatment available to growers for the 2019 season. It is registered for the control of smuts, bunts and fusarium head blight, and the suppression of rhizoctonia, crown rot, white grain disorder and pythium.

Aim

To demonstrate the symptoms and impact of crown rot, flag smut and rhizoctonia on grain yield and compare the level of control/suppression possible with of a range of seed and in-furrow treatments in wheat.

Background

Crown rot is a fungal disease of cereals caused by *Fusarium pseudograminearum* or *F. culmorum* (less common) that can impact grain yield and quality, and increase screenings. Common symptoms can include damping off at establishment under wet conditions but are generally observed as whiteheads in crop. Whiteheads from crown rot result in shrivelled or no grain and golden brown discolouration of crowns caused by hyphal growth in the plant which becomes more pronounced from mid to late grain-filling. Intensive cereal rotations without non-cereal break crops and stubble retention practices can increase inoculum in the soil but it is the climatic conditions during spring that determines the level of yield loss associated with crown rot infection.

Rhizoctonia root rot caused by *Rhizoctonia solani* (AG8) reduces growth and yield of cereals and other crops; losses can exceed 50%. Affected crops cannot access water and soil nutrients efficiently due to root pruning. Distinct bare patches occur when seminal roots are attacked within 3-5 weeks of sowing, and areas of uneven growth occur when crown roots are affected during the cooler months. Risks are higher in intensive cereal rotations and when using minimum soil disturbance practices. The use of sulfonylurea herbicides such as Monza®, Ally® or Glean® may increase the effects of the pathogen on developing cereals.

Flag smut is a parasitic fungus that infects wheat and produces streaks of soot-like spores on the flag leaf. This causes the leaf to become curled and distorted, and heads are rarely produced on these tillers. Flag smut spores can be transmitted via soil or externally on contaminated seed.

Trial Details

Property name	Liebe Group Main Trial Site, McCreery property, Kalannie	Mingenew Irwin Group, Mitchell property, Mingenew
Plot size & replication	12 m x 2.5 m x 3 replications	12 m x 2.5 m x 3 replications
Soil type	Loamy sand	Moderate red loam
Soil pH ($CaCl_2$)	0-10 cm: 5.5 10-20 cm: 4.9 20-30 cm: 4.4	0-10 cm: 6.3
EC (dS/m)	0-10 cm: 0.227 10-20 cm: 0.067 20-30 cm: 0.045	0-10 cm: 0.088
Paddock history:	2017: canola/fallow, 2016: wheat, 2015: volunteer pasture, 2014: wheat	2017: wheat
Sowing date	02/06/2018	29/05/2018
Sowing rate	80 kg/ha Mace wheat treated as per treatment list	80 kg/ha Mace wheat treated as per treatment list
Inoculum rate	1.5 g of millet seed inoculated with *F. pseudograminearum* or *R. solani* per meter row	1.5 g of millet seed inoculated with *F. pseudograminearum* per meter row
Fertiliser	02/06/18: 100 kg/ha Gusto Gold® (drilled), 50 kg/ha urea (top dressed) 14/07/18: 60 kg/ha urea	29/05/18: 80 kg/ha MAPTE (drilled), 90 kg/ha urea (top dressed)
Herbicides, insecticides & fungicides	02/06/18: 118 g/ha Sakura® + 25 g/ha Monza + 2 L/ha Spray.Seed® + 1 L/ha Lorsban® 06/07/18: 1 L/ha Velocity® + 500 mL/ha MCPA LVE + 400 mL/ha alpha cypermethrin + 1% Kwickin®	29/05/18: 118 g/ha Sakura® + 25 g/ha Monza 23/06/18 3 L/ha Arcade® + 12 mL/ha Trojan® 23/06/18: 670 mL/ha Velocity + + 1% Hasten®
Growing season rainfall	216.5 mm	261.4 mm 1 May to 31st August

Treatments

Table 1: Trial treatments, cost $/ha and inoculated pathogen

	Seed Treatment / In-furrow Treatment	Variable cost per hectare (80 kg/ha seeding rate)	Inoculum type
1	Untreated – no-inoculum	-	Nil
2	Untreated	-	Rhizoctonia
3	130 mL/100 kg EverGol® Energy (ST)	$5.67	Rhizoctonia
4	260 mL/100 kg EverGol Energy (ST)	$11.34	Rhizoctonia
5	180 mL/100 kg Vibrance (ST)	$5.24	Rhizoctonia
6	360 mL/100 kg Vibrance (ST)	$10.48	Rhizoctonia
7	320 mL/100 kg Rancona Dimension (ST)	$9.98	Rhizoctonia
8	150 mL/100 kg Systiva (ST)	$25.08	Rhizoctonia
9	400 mL/100 kg Pontiac (ST)	$8.64	Rhizoctonia
10	130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	$16.57	Rhizoctonia
11	180 mL/100 kg Vibrance (ST) + 300 mL/ha Uniform (IF)	$24.14	Rhizoctonia
12	Untreated	-	Crown rot
13	150 mL/100 kg Baytan T (ST)	$2.63	Crown rot
14	130 mL/100 kg EverGol Energy (ST)	$5.67	Crown rot
15	260 mL/100 kg EverGol Energy (ST)	$11.34	Crown rot
16	320 mL/100 kg Rancona Dimension (ST)	$ 9.98	Crown rot
17	130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	$ 16.57	Crown rot

(Note: all treatments except Pontiac were also treated with 120 mL/100 kg Gaucho Red to ensure all treatments had the same rate of imidacloprid.)

Results

The Kalannie site was established on a failed canola crop in 2017 with excellent weed control, and benefits of stored moisture and residual nutrition in the soil that assisted the growth of the crop.

A PREDICTA B soil test was conducted at this site in March 2018 and no rhizoctonia or crown rot was detected. To ensure a presence of these pathogens in this trial, plots were inoculated with either *R. solani* or *F. pseudograminearum* using infected sterile millet seed sown at 1.5 g/m row. The site was re-tested in August to determine how successful this process was; a high level of 1158 (pg DNA/g soil) was detected for *R. solani* AG8, and a low level of 4.88 (pg DNA/g soil) was detected for *F. pseudograminearum*.

The wheat seed sown was tested at the Department of Primary Industries and Regional Development (DPIRD) DDLS plant pathology laboratory for smuts, with a flag smut level of between 12,990-13,200 spores per 50 g sample detected.

Due to the low level of crown rot established in the Liebe Group Kalannie trial site, data from this and a similar trial at the Mingenew-Irwin Group (MIG) have been used in this report to demonstrate the comparative efficacy of treatments in a trial with symptoms of crown rot expression. The MIG site was on a moderate red loam with a medium level of 274.27 (pg DNA/g soil) was detected for *F. pseudograminearum* from the mid-season PREDICTA B test in the MIG trial, and unlike at the Liebe trial, whitehead symptoms were visible at the end of the season.

Following a very dry autumn at both trial sites, the first significant rains of the season fell on the 24^{th} of May. This trial was then sown into good soil moisture on the 2^{nd} of June following 16mm of rain. Regular rainfall events throughout June, July and August meant that the crop was rarely stressed, although a dry September negatively impacted grain-filling. The conditions in the Liebe trial were not worst case for either pathogen but have still provided enough pressure for comparison of rhizoctonia activity and the inclusion of the MIG trial allows for comparison against crown rot.

Rhizoctonia

At 17 days after seeding (DAS) based on crop establishment counts in the Liebe Group trial there was no significant difference ($P \leq 0.05$) in crop establishment between treatments inoculated with rhizoctonia (Table 1). Pontiac recorded the lowest crop emergence count. Older generation triazoles like flutriafol or Baytan can affect emergence due to shortening of the coleoptile resulting in a reduction in the crop's ability to grow away from the rhizoctonia inoculum.

Based on NDVI biomass measures at 102 DAS all EverGol Energy treatments and the Vibrance + Uniform treatment recorded comparable emergence to the non-inoculated untreated in the trial despite being inoculated with rhizoctonia.

All inoculated treatments recorded a grain yield significantly ahead of Pontiac in this trial (Table 4). The untreated non-inoculated yield was significantly different to all treatments highlighting the impact of rhizoctonia.

Both of the split on seed and infurrow treatments (EverGol Energy ST + IF or Vibrance ST + Uniform IF) recorded a comparable yield and $ROI/ha. Previous SARDI and Bayer trial results have recorded a benefit of splitting the chemistry across the rhizosphere to better protect both crown and seminal roots.

Table 2: Biomass reduction ratings, crop establishment counts 17 days after sowing (DAS), and NDVI assessments (79 and 102 DAS) for plots inoculated with rhizoctonia at the Liebe site.

Assessment Date	20/06/2018				21/08/2018			13/09/2018		
Days After Seeding	17 DAS				79 DAS			102 DAS		
Seed Treatment / In-furrow Treatment	**% Biomass Reduction**	**Crop plants/m^2**		**% UTC[1]**	**NDVI[2]**		**% UTC**	**NDVI**		**% UTC**
Untreated - no inoculum	0	168.7	-	100	0.704	ab	100	0.729	a	100
Untreated	13	169.1	-	100	0.669	bcd	95	0.719	ab	99
130 mL/100 kg EverGol Energy	11	165.3	-	98	0.662	bcd	94	0.691	abc	95
260 mL/100 kg EverGol Energy	5	177.9	-	106	0.683	bc	97	0.715	ab	98
180 mL/100 kg Vibrance	13	174.5	-	103	0.631	cd	90	0.680	bc	93
360 mL/100 kg Vibrance	9	169.1	-	100	0.638	cd	91	0.681	bc	93
320 mL/100 kg Rancona Dimension	15	177.9	-	105	0.617	d	88	0.661	c	91
150 mL/100 kg Systiva	13	169.6	-	101	0.619	d	88	0.655	c	90
400 mL/100 kg Pontiac	15	154.6	-	92	0.612	d	87	0.651	c	89
130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	8	173.0	-	103	0.743	a	106	0.720	ab	99
180 mL/100 kg Vibrance (ST) + 300 mL/ha Uniform (IF)	5	165.7	-	98	0.714	ab	101	0.729	a	100
LSD P=.05		27.42			0.054			0.039		
Standard Deviation		16.1			0.032			0.023		
CV		9.49			4.76			3.26		

[1] UTC =

[2] *Means followed by same letter do not significantly differ (Duncan's New Multiple Range at 5% significance level).*
Note untreated not inoculated was not sown with either rhizoctonia treated millet.

Table 3: Biomass reduction ratings, crop establishment counts 17 days after sowing (DAS), and NDVI assessments (79 and 102 DAS) for plots inoculated with crown rot at the Liebe site.

Assessment Date	20/06/2018				21/08/2018			13/09/2018		
Days After Seeding	17 DAS				79 DAA			102 DAA		
Seed Treatment / In-furrow Treatment	**% Biomass Reduction**	**Crop plants/m^2**		**% UTC**	**NDVI**		**% UTC**	**NDVI**		**% UTC**
Untreated – no inoculum	0	168.7	-	100	0.704	b	100	0.729	-	100
Untreated	18	152.1	-	90.2	0.718	ab	102	0.733	-	100
150 mL/100 kg Baytan-T	11	163.2	-	96.7	0.734	ab	104	0.736	-	101
130 mL/100 kg EverGol Energy	6	148.6	-	88.1	0.736	ab	105	0.732	-	100
260 mL/100 kg EverGol Energy	8	166.7	-	98.8	0.736	ab	105	0.744	-	102
320 mL/100 kg Rancona Dimension	12	161.4	-	95.7	0.746	ab	106	0.745	-	102
130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	7	157.0	-	93.1	0.750	a	106	0.754	-	103
LSD P=.05		24.9			0.039			0.022		
Standard Deviation		14.97			0.021			0.012		
CV		9.03			2.91			1.65		

[2] *Means followed by same letter do not significantly differ (Duncan's New Multiple Range at 5% significance level).*
Note untreated not inoculated was not sown with crown rot treated millet.

All inoculated treatments recorded a grain yield significantly ahead of Pontiac in this trial (Table 4). The untreated non-inoculated yield was significantly different to all treatments highlighting the impact of rhizoctonia.

Both of the split on seed and infurrow treatments (EverGol Energy ST + IF or Vibrance ST + Uniform IF) recorded a comparable yield and $ROI/ha. Previous SARDI and Bayer trial results have recorded a benefit of splitting the chemistry across the rhizosphere to better protect both crown and seminal roots.

Table 4: Yield and gross margin results for plots inoculated with rhizoctonia at the Liebe site.

Seed Treatment / In-furrow Treatment	Yield (t/ha)		% UTC	% Protein	% Moisture	Hectolitre weight (kg/hL)	Screenings % (<2.5mm screen)	Grade	Gross ($/ha)	ROI relative to Pontiac ($/ha)
Untreated - no inoculum	3.57	a	100	9.2	9.4	82.3	3.5	ASW1	$ 1,213.60	n/a
Untreated	3.25	bc	91.1	8.7	9.5	82.9	3.6	ASW1	$ 1,105.00	n/a
130 mL/100 kg EverGol Energy	3.24	bc	90.9	9.4	9.4	83.9	2.4	ASW1	$ 1,102.65	+$ 165.90
260 mL/100 kg EverGol Energy	3.20	bc	89.7	9.4	9.2	83.3	2.8	ASW1	$ 1,088.48	+$ 146.05
180 mL/100 kg Vibrance	3.06	bc	85.8	10.0	9.4	83.8	2.5	APW2	$ 1,053.50	+$ 117.17
360 mL/100 kg Vibrance	3.15	bc	88.1	9.9	9.3	83.9	2.1	ASW1	$ 1,069.57	+$ 128.00
320 mL/100 kg Rancona Dimension	3.08	bc	86.4	10.1	9.3	83.6	2.7	APW2	$ 1,060.66	+$ 119.59
150 mL/100 kg Systiva	3.04	c	85.2	9.7	9.4	82.4	2.9	ASW1	$ 1,034.18	+$ 78.01
400 mL/100 kg Pontiac	2.76	d	77.4	9.9	9.4	82.9	3.1	ASW1	$ 939.73	$ -
130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	3.29	bc	87.8	9.4	9.5	82.8	2.6	ASW1	$ 1,117.75	+$ 170.10
180 mL/100 kg Vibrance (ST) + 300 mL/ha Uniform (IF)	3.31	b	92.8	9.3	9.3	84.6	2.5	ASW1	$ 1,126.25	+$ 171.02
LSD P=.05	0.2304		ASW1 delivered Kwinana 10/12/18				$ 340.00			
Standard Deviation	0.13527		APW2 delivered Kwinana 10/12/18				$ 344.00			
CV	4.26									

[1] *Means followed by same letter do not significantly differ (Duncan's New Multiple Range at 5% significance level).*

Note: Grain quality was only determined from the second replicate at this site. Treatment prices can be found in the Treatment List.

Crown rot

All treatments recorded comparable grain yield in this trial due to the failure for the crown rot inoculum to express given the seasonal conditions (Table 5).

EverGol Energy at the 130 mL/100kg rate and Baytan are not registered for crown rot. Always refer to the most recent product label.

The highest $ROI/ha ($57.47 above Baytan) was recorded from the combination of 130 mL/ 100kg EverGol Energy applied on seed followed by the liquid banded 200 mL/ha of EverGol Energy.

Table 5: Yield and gross margin results for plots inoculated with crown rot at the Liebe site.

Seed Treatment / In-furrow Treatment	Yield (t/ha)		% UTC	Protein %	Moisture	Hectolitre weight (kg/hL)	Screenings % (<2.5mm screen)	Grade	Gross ($/ha)	ROI relative to Baytan ($/ha)
Untreated	3.57	-	100	9.2	9.4	82.3	3.5	ASW1	$ 1,213.80	n/a
Untreated	3.42	-	95.9	8.9	9.3	82.8	3.0	ASW1	$ 1,162.80	n/a
150 mL/100 kg Baytan-T (ST)	3.46	-	96.9	9.4	9.3	81.8	2.8	ASW1	$ 1,176.40	$ -
130 mL/100 kg EverGol Energy (ST)	3.46	-	96.9	8.9	9.3	83.2	2.6	ASW1	$ 1,176.40	-$ 3.03
260 mL/100 kg EverGol Energy (ST)	3.6	-	100.8	9.5	9.3	81.5	2.9	ASW1	$ 1,224.00	+$ 38.90
320 mL/100 kg Rancona Dimension (ST)	3.58	-	100.2	9.3	9.3	93.2	3.0	ASW1	$ 1,217.20	+$ 33.45
130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	3.67	-	102.7	9.1	9.6	82.6	3.3	ASW1	$ 1,247.80	+$ 57.47
LSD P=.05	0.38			ASW1 delivered Kwinana 10/12/18			$ 340.00			
Standard Deviation	0.209									
CV	5.90									

[1] *Means followed by same letter do not significantly differ (Duncan's New Multiple Range at 5% significance level).*

Note: Grain quality was only determined from the second replicate at this site. Treatment prices can be found in the Treatment List.

At 9 days after sowing Baytan appeared the most aggressive at reducing emergence based on a biomass reduction (Table 6).

The untreated inoculated plots had 9.7% whiteheads. Although not significant the highest level of whitehead control was recorded from 260 mL/ 100 kg EverGol Energy with a 74% reduction in white head expression compared to the untreated inoculated plots. All treatments apart from Baytan recorded ≥52% reduction in whiteheads with a rate response evident in the EverGol Energy rates. The addition of Aviator Xpro as a foliar fungicide application did not add reduce whiteheads any further than the EverGol Energy (260 mL/100 kg) seed treatment alone.

Table 6: Biomass reduction ratings 9 days after sowing (DAS), crop establishment counts and NDVI assessment results for plots inoculated with crown rot at the Mingenew-Irwin Group site.

	Assessment Date	07/06/2018	19/06/2018			05/10/2018	
	Days After Seeding	9 DAS	21 DAS			129 DAS	
Seed Treatment / In-furrow Treatment	**Foliar (Z31)**	**Biomass Reduction %**	**Biomass Reduction %**	**Crop plants/ m^2**	**% UTC**	**% White heads**	**% Control**
Untreated – non-inoculated	500 mL/ha Tilt	0	0	157.5 a	100	0.551	n/a
Untreated	500 mL/ha Tilt	35	27	90.4 d	57.4	9.741	0
150 mL/100 kg Baytan-T (ST)	500 mL/ha Tilt	85	33	109.8 cd	69.8	7.496	23
130 mL/100 kg EverGol Energy (ST)	500 mL/ha Tilt	8	9	127.3 abc	80.9	4.671	52
260 mL/100 kg EverGol Energy (ST)	500 mL/ha Tilt	15	3	158.0 a	100.3	2.526	74
320 mL/100 kg Rancona Dimension (ST)	500 mL/ha Tilt	15	3	134.6 abc	85.5	4.308	56
130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	500 mL/ha Tilt	17	7	123.0 bc	78.1	3.918	60
260 mL/100 kg EverGol Energy (ST)	300 mL/ha Aviator Xpro	15	8	151.6 ab	96.3	3.542	64
			LSD P=.05	29.65		0.38	
			Standard Deviation	16.93		0.209	
			CV	12.87		5.9	

[1] *Means followed by same letter do not significantly differ (Duncan's New Multiple Range at 5% significance level).*
Note: Results from this MIG trial were used to compare the treatments under crown rot pressure which did not express in the Liebe trial site despite inoculation.

All treatments significantly improved grain yield compared to the untreated inoculated (Table 7).

The two 260 mL/ 100 kg EverGol Energy treatments and Rancona Dimension met AUH2 grain quality specifications due to reduced screenings.

The highest $ROI/ha in this MIG crown rot trial was recorded from EverGol Energy followed by a foliar of Aviator Xpro $701.92 compared to with Tilt foliar fungicide $607.81.
There was some Septoria nodorum present in the trial and visually the Aviator Xpro treated plots were lower in disease which may have contributed to additional grain fill.

Table 7: Yield and gross margin results for plots inoculated with crown rot at the Mingenew-Irwin Group site. Note that the top treatment was not inoculated. Grain quality was only determined from the second replicate at this site. Treatment prices can be found in Treatment List.

Seed Treatment / In-furrow Treatment	Foliar (Z31)	Yield (t/ha)		% UTC	Screen-ings % (<2.5mm screen)	Hectolitre weight (kg/hL)	Protein %	Grade	Gross / ha	ROI relative to Baytan ($/ha)
Untreated – non-inoculated	500 mL/ha Tilt	3.58	ab	100	11.4	74.3	12.9	FED1	$ 966.60	n/a
Untreated	500 mL/ha Tilt	1.96	e	55	11.4	73.6	13.0	FED1	$ 529.20	n/a
150 mL/100 kg Baytan-T (ST)	500 mL/ha Tilt	2.54	d	71	13.5	70.3	14.3	FED1	$ 685.80	$ -
130 mL/100 kg EverGol Energy (ST)	500 mL/ha Tilt	3.00	c	84	13.0	73.5	13.5	FED1	$ 810.00	+$ 121.17
260 mL/100 kg EverGol Energy (ST)	500 mL/ha Tilt	3.41	b	95	8.1	73.2	13.3	AUH2	$ 1,282.16	+$ 587.66
320 mL/100 kg Rancona Dimension (ST)	500 mL/ha Tilt	3.46	ab	97	9.9	73.3	12.9	AUH2	$ 1,300.96	+$ 607.81
130 mL/100 kg EverGol Energy (ST) + 200 mL/ha EverGol Energy (IF)	500 mL/ha Tilt	3.71	ab	104	10.6	73.2	13.2	FED1	$ 1,001.70	+$ 301.97
260 mL/100 kg EverGol Energy (ST)	300 mL/ha Aviator Xpro	3.74	a	105	7.2	76.3	12.0	AUH2	$ 1,406.24	+$ 701.92
	LSD P=.05	0.279								
	Standard Deviation	0.157			FED1 delivered Geraldton 10/12/18			$270.00		
	CV	4.97			AUH2 delivered Geraldton 10/12/18			$376.00		

[1] *Means followed by same letter do not significantly differ (Duncan's New Multiple Range at 5% significance level).* Note: Grain quality was only determined from the second replicate at this site. Treatment prices can be found in Treatment List.

Comments

Crop establishment

The potential from early generation triazoles (i.e. Baytan, flutriafol) for shortening of the coleoptile was evident in the lower crop establishment values in both the Liebe Group and MIG trials under disease expression. This highlights the importance to get the crop up and out of the ground to reduce the potential impact of soil borne diseases like rhizoctonia, crown rot and pythium.

Rhizoctonia

Comparison of the seed treatments inoculated with rhizoctonia in the Liebe Group trial recorded the lowest crop emergence and yield from Pontiac (containing flutriafol).

Vibrance at the 180 and 360 mL/100 kg rates and Rancona Dimension recorded a slightly lower $ROI/ha than EverGol Energy. Systiva and Pontiac both recorded lower yields than EverGol Energy, Vibrance and Rancona Dimension when inoculated with rhizoctonia.

Crown rot

In the MIG crown rot trial EverGol Energy 260 mL/100 kg and Rancona Dimension recorded comparable yield and $ROI/ha. Both EverGol Energy split application and EverGol Energy 260 mL plus Aviator Xpro as a foliar both recorded higher yield than EverGol Energy 260 mL with Tilt foliar. The use of Baytan which is not registered for crown rot suppression recorded significantly lower yield than the registered treatments (EverGol Energy or Rancona Dimension) for crown rot.

EverGol Energy overview

EverGol Energy with newer generation chemistry consistently recorded good plant establishment, disease suppression and yield across both the Liebe Group and Mingenew Irwin Group trials and was superior to the untreated when inoculated with either rhizoctonia or crown rot highlighting its crop safety and broad disease activity.

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Peer review: Rick Horbury – Customer Advisory Manager (Bayer) and Daniel Huberli, Plant Pathologist, Department of Primary Industries and Regional Development

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NUTRITION RESEARCH RESULTS

Fertiliser N x P x K rate comparison

Angus McAlpine, Central Midlands District Agronomist, CSBP

Key Messages

- Nitrogen (N) was the key driver to increase crop yield by an average of 1.72 t/ha and protein by 2.04%
- Yield responses were up to 0.34 t/ha to the higher rates of applied Phosphorus (P) and Potassium (K), however protein yield indicated no statistical difference.
- Crop water use efficiency was maximised at 17.8 kg/mm (Calculation at end of report) with the highest Nitrogen (N) rate of 114 kg/ha (Treatment 7)

Aim

To investigate which rates of three key nutrients, Nitrogen (N), Phosphorous (P) and Potassium (K), will result in achieving the maximum gross margins.

Background

It is important as a farming business to focus on maximising crop gross margins in any given season. Achieving the maximum gross margin (GM) will depend on how much return you are getting for every dollar invested. Soil and plant testing can provide us with the key information needed to make these fertiliser investment decisions. Applying the right nutrient at the right rate to maximise that return on investment will help achieve that goal of maximising gross margins. Planning for which nutrients will be required in any season will help growers ensure that they do not over apply or under apply fertiliser, which both result in reduced gross margins.

Trial Details

Property	Liebe Group Main Trial Site, McCreery property, Kalannie
Plot size & replication	20m x 2.5m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	See Soil Analysis Below
EC (dS/m)	See Soil Analysis Below
Paddock rotation:	2016 pasture, 2017 pasture
Sowing date	22/05/2018
Sowing rate	58 kg/ha Sceptre wheat
Fertiliser	See Treatments Table 29/6/2018 Tillering Flexi-N, 22/7/2018 Stem Elongation Flexi-N
Herbicides, insecticides & fungicides	22/5/2018 2.5 L/ha Trifluralin, 300 ml/ha Lorsban, 1% Response 29/6/2018 850 ml/ha Velocity, 31/7/2018 400 ml/ha Prosaro
Growing season rainfall	216.5mm (April - October)

Soil Analysis

Table 1: Soil analysis results

Depth (cm)	pH	EC	OC	Nit N	Amm N	P	PBI	K	S	Ex Ca	Ex Mg	Ex K	Ex Na	eCEC	Al
0-10	5.3	0.68	0.8	19	8	25	28.8	130	34	3.3	0.9	0.31	1.99	7	0.4
10-20	4.5	0.10	0.8	4	1	14	41.5	74	19						2.7
20-30	4.2	0.11	0.4	4	1	3	60.6	61	35						5.8
30-40	4.1	0.15	0.3	3	<1	2	59.3	49	46						7.6

DTPA Cu: 0.46 mg/kg; DTPA Zn: 0.33 mg/kg

Results
Favourable growing conditions in season and a soft finish resulted in exceptional crop yields. Yield results in Table 2 indicate that nitrogen increased grain yields significantly by an average of 1.72 t/ha and protein by 2.04%, from applications of up to 255 L/ha of Flexi-N (treatments 10 and 4). However to gauge overall crop response protein yield (which is simply yield times grain protein percent) must be considered. This will help determine the total nitrogen recovery and response. This is important when investigating whether the crop utilised nitrogen efficiently and achieved maximum yield potential. Grain screenings were not statistically significant across the treatments and ranged from 2.6% to 1.7%.

Table 2: The effect of fertiliser rates on wheat yield and grain quality.

	Banded	Banded	Tillering	Stem Elongation				Yield	Protein	Protein Yield	Hl Wt
Trt	(kg/ha)	(L/ha)	(L/ha)	(L/ha)	N	P	K	(t/ha)	(%)	(kg/ha)	(kg/hL)
1	Nil	-	-	-	-	-	-	2.09^{f}	7.37^{de}	149^{d}	77^{c}
2	40 Agstar Extra	-	-	-	6	6	-	2.29^{f}	7.47^{de}	181^{c}	78^{bc}
3	40 Agstar Extra	55 Flexi-N	50 Flexi-N	-	50	6	-	3.31^{d}	7.90^{cd}	266^{b}	78^{bc}
4	40 Agstar Extra	55 Flexi-N	100 Flexi-N	100 Flexi-N	113	6	-	4.13^{bc}	9.84^{a}	399^{a}	80^{a}
5	80 Agstar Extra	-	-	-	11	11	-	2.65^{e}	7.71^{cde}	203^{c}	77^{c}
6	80 Agstar Extra	43 Flexi-N	50 Flexi-N	-	51	11	-	3.59^{d}	7.83^{cd}	277^{b}	78^{bc}
7	80 Agstar Extra	43 Flexi-N	100 Flexi-N	100 Flexi-N	114	11	-	4.45^{a}	9.33^{ab}	401^{a}	80^{a}
8	61 K-Till Max	-	-	-	6	6	9	2.37^{ef}	7.54^{cde}	179^{cd}	78^{bc}
9	61 K-Till Max	55 Flexi-N	50 Flexi-N	-	50	6	9	3.33^{d}	8.10^{c}	263^{b}	78^{bc}
10	61 K-Till Max	55 Flexi-N	100 Flexi-N	100 Flexi-N	113	6	9	3.93^{c}	9.78^{ab}	397^{a}	80^{a}
11	121 K-Till Max	-	-	-	12	11	18	2.64^{e}	7.16^{e}	186^{c}	78^{bc}
12	121 K-Till Max	43 Flexi-N	50 Flexi-N	-	51	11	18	3.50^{d}	7.87^{cd}	284^{b}	79^{ab}
13	121 K-Till Max	43 Flexi-N	100 Flexi-N	100 Flexi-N	114	11	18	4.30^{ab}	9.09^{b}	389^{a}	79^{ab}
	Prob (=0.05)				**LSD**			0.26	0.63	30	1.59

When comparing the protein yields in this trial, it showed no statistical difference from the increased phosphorus rates of 6 kg/ha to 11 kg/ha including both the K-Till Max treatments. This therefore indicates that 6 kg/ha of phosphorus applied at seeding along with strong background levels was enough to meet crop requirements. This was also supported in the tissue tests taken at late tillering. Given the site had sufficient background levels of potassium it was not surprising that the additional potassium did not provide any significant yield or protein response.

Water use efficiency increased on average from 9.9 kg/mm with the compound only treatments to 13.7 kg/mm with the 93 – 105 L/ha of Flexi-N. The highest average water use efficiency of 16.8 kg/mm was achieved with the 243 – 255 L/ha of Flexi-N. See appendix A for water use efficiency calculation rates.

Economic Analysis
Gross Margin (GM) in Table 3 are calculated on crop yield times grain price less fertiliser costs only. Crop yield and maximum gross margins of $1229/ha were realised with Treatment 7 by applications of 11 kg/ha of phosphorus and 114 kg/ha of nitrogen (Table 3).

Table 3: Gross Income analysis by treatment

Trt	Banded (kg/ha)	Banded (L/ha)	Tillering (L/ha)	Stem Elongation (L/ha)	N	P	K	Yield (t/ha)	Protein (%)	Protein Yield (kg/ha)	Fertiliser Cost $/ha	Grain Income $/ha	GM $/ha
1	Nil	-	-	-	-	-	-	2.09^{f}	7.37^{de}	149^{d}	0	679	679
2	40 Agstar Extra	-	-	-	6	6	-	2.29^{f}	7.47^{de}	181^{c}	30	744	714
3	40 Agstar Extra	55 Flexi-N	50 Flexi-N	-	50	6	-	3.31^{d}	7.90^{cd}	266^{b}	98	1076	978
4	40 Agstar Extra	55 Flexi-N	100 Flexi-N	100 Flexi-N	113	6	-	4.13^{bc}	9.84^{a}	399^{a}	195	1342	1148
5	80 Agstar Extra	-	-	-	11	11	-	2.65^{e}	7.71^{cde}	203^{c}	60	861	801
6	80 Agstar Extra	43 Flexi-N	50 Flexi-N	-	51	11	-	3.59^{d}	7.83^{cd}	277^{b}	120	1167	1047
7	80 Agstar Extra	43 Flexi-N	100 Flexi-N	100 Flexi-N	114	11	-	4.45^{a}	9.33^{ab}	401^{a}	217	1446	1229
8	61 K-Till Max	-	-	-	6	6	9	2.37^{ef}	7.54^{cde}	179^{cd}	49	770	721
9	61 K-Till Max	55 Flexi-N	50 Flexi-N	-	50	6	9	3.33^{d}	8.10^{c}	263^{b}	117	1082	966
10	61 K-Till Max	55 Flexi-N	100 Flexi-N	100 Flexi-N	113	6	9	3.93^{c}	9.78^{ab}	397^{a}	213	1277	1064
11	121 K-Till Max	-	-	-	12	11	18	2.64^{e}	7.16^{e}	186^{c}	97	858	761
12	121 K-Till Max	43 Flexi-N	50 Flexi-N	-	51	11	18	3.50^{d}	7.87^{cd}	284^{b}	157	1138	981
13	121 K-Till Max	43 Flexi-N	100 Flexi-N	100 Flexi-N	114	11	18	4.30^{ab}	9.09^{b}	389^{a}	254	1398	1144
	Prob (=0.05)						**LSD**	0.26	0.63	30			

Note: Assuming ASW wheat @ $325/t. Fertiliser costs based off list price January 2019 ex Kwinana

Comments

The trial demonstrates that it is important to monitor soils and plant test crops to have enough information on hand to plan for and make good economic fertiliser decisions. In order to maximise gross margins nutrient applications should be aligned to crop demand. Utilising the tools available, coupled with expert in season observations, growers can estimate yield potential and crop demand for nutrients.

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Appendix A: Water Use Efficiency Calculation

Summer Fallow Rainfall (Nov-Mar) = A (mm)
Growing Season Rainfall (Apr-Oct) = B (mm)
(A x 0.25) + B = Total Season Rainfall
Total Season Rainfall / Wheat Yield (kg/ha) = Water Use Efficiency (Kg/mm)

'Yardstick" demonstrations for the Western Region - Kalannie

Richard Devlin, Managing Director, Living Farm Pty Ltd

Key Messages
- 2018 = Decile 6 season cumulative. July-October = decile 10.
- Season responsive to fertiliser rate.
- Canola yielded higher than expected, given late start.
- Poor quality barley with high screenings.

Aim
The primary aim of the 'Yardstick' project is to conduct a series of agronomic demonstrations in wheat, barley and canola that will assist growers in making crop type (wheat, barley or canola), varietal and nitrogen decisions.

Background
As identified by growers through various GRDC RCSN open forums, tight budgets and variable seasons have resulted in a desire to revisit standard fertiliser practices, crop types and varieties.

As such the Yardstick trials have several aims:
1. What crop type gives the best economic return? Wheat, barley or canola?
2. Do different varieties respond differently to different nutrition packages?
3. To cross reference with the National Variety Trials, which generally have higher levels of fertiliser applied due to their aim of identifying the highest yielding germplasm, free from nutritional or budgetary constraints

Reflecting the initial protocol developed by growers in the low rainfall zone of the central wheatbelt, in this initial year fertiliser rates have remained low.

In this trial two rates of phosphorus are tested - either 0 Units (representing a decile 0 season, similar to what was experienced in this area in 2017) or 5 units. There are 3 rates of nitrogen applied- 0 units, 10, 30 or 50 (the latter being split). Two varieties of canola, wheat and barley are included in this trial.

In this initial year a basic but robust trial design has been implemented - and it is expected that with the learnings from this trial in 2018 combined with RCSN input that a more district specific program will be implemented for the remaining two years of this study.

All three trials (wheat, barley and canola) were dry sown on the 20th May with the first significant rainfall on May 26th.

Trial Details

Property	McCreery property, Cottage Road, Kalannie
Plot size & replication	10 x 1.75 x 3 replicates
Soil type	Loamy sand
Soil pH ($CaCl_2$)	0-10cm: 5.9 10-20cm: 5.3 20-30cm: 5.3
EC (dS/m)	0-10cm: 0.300 10-20cm: 0.0
Paddock rotation:	2015: Volunteer pasture 2016: Wheat 2017: Canola/Fallow
Sowing date	20/05/2018
Sowing rate	Canola aim 40 plants/m^2, Wheat aim 140 plants/m^2, Barley aim 150 plants/m^2
Fertiliser	See Treatment Details
Herbicides, insecticides & fungicides	**Wheat Pre-emergent:** 118 g/ha Sakura, 2 L/ha trifluralin, 250 g/ha diuron, 75 mL/ha Lontrel Advanced **Barley Pre-emergent:** 2 L/ha trifluralin, 1.6 L/ha Avadex, 250 g/ha diuron, 75 mL/ha Lontrel Advanced **Canola Pre-emergent:** 1 L/ha propyzamide, 1.1 kg/ha atrazine, 200 mL/ha bifenthrin, 75 mL/ha Lontrel Advanced **Wheat Post-emergent** 800 mL/ha Velocity 400 mL/ha Aviator Xpro **Barley Post-emergent** 800 mL/ha Velocity 400 mL/ha Aviator Xpro **Canola Post emergent** 1.1 kg/ha atrazine, 500 mL/ha clethodim 600 mL/ha Aviator Xpro (Blackleg spray - due to trial being located on failed canola crop)
Growing season rainfall	216.5 mm

Results

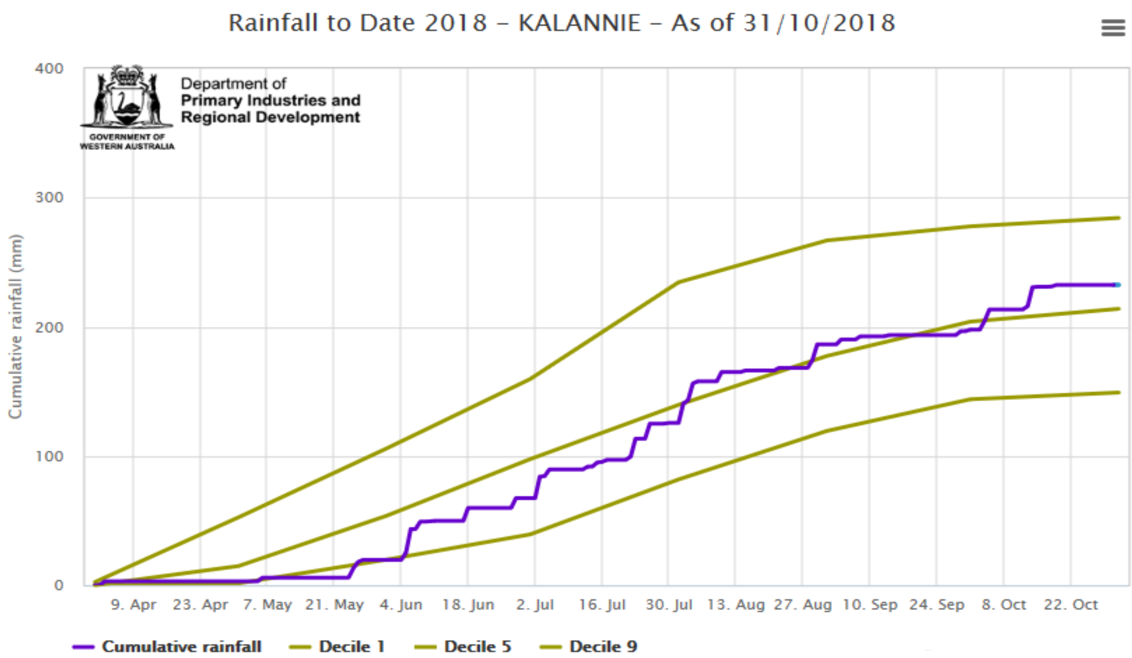

Figure 1: Cumulative growing season rainfall for Kalannie (2018).Source: DPRID rainfall tool.

Wheat

Table 1: Crop establishment (plants/m^2) wheat.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Scepter	114	105	110	108	*109*
Trojan	112	115	111	111	*112*
Means	*113*	*110*	*111*	*109*	
	P (variety)= NS			*l.s.d (P<0.05) = n.a.*	
	P (Decile) = NS			*l.s.d (P<0.05) = n.a.*	
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) = n.a.*	

- No difference in establishment between the varieties at any nutrition package (Decile).

Table 2: Yield (t/ha) wheat.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Scepter	2.34	2.66	2.86	3.08	*2.74*
Trojan	1.19	1.52	1.39	1.57	*1.42*
Means	*1.77*	*2.09*	*2.13*	*2.33*	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*0.14*
	P (Decile) <0.001			*l.s.d (P<0.05) =*	*0.198*
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) =*	*n.a*

- Scepter significantly out-yielded Trojan - to be expected given the late start to the season.
- Rate response to increasing rates of nitrogen: this was particularly evident in the Scepter plots.

Table 3: Protein (%) wheat.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Scepter	9.2	9.6	10.1	10.0	*9.9*
Trojan	10.4	10.6	12.1	13.2	*11.6*
Means	9.8	10.1	11.1	12.0	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*0.22*
	P (Decile) <0.001			*l.s.d (P<0.05) =*	*0.32*
	*P (Variety*Decile) = 0.002*			*l.s.d (P<0.05) =*	*0.45*

- Protein response to nitrogen - with increasing rates of nitrogen we saw increasing levels of protein.
- Decile 6 was the only treatment to receive post emergent nitrogen, which did not have a significant effect in Scepter.
- Varietal differences in protein. Proteins are lower on Scepter than Trojan: but remember, Scepter yielded significantly higher so protein dilution is to be expected.

Table 4: Hectolitre weight (kg/hL) wheat.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Scepter	80.5	81.1	80.4	80.0	*80.5*
Trojan	83.3	82.5	81.5	81.9	*82.3*
Means	*81.9*	*81.8*	*81.0*	*80.9*	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*0.73*
	P (Decile) = NS			*l.s.d (P<0.05) =*	*n.a*
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) =*	*n.a*

- Only varietal difference in hectoliter weights.
- Nitrogen had no effect on hectoliter weights.

Table 5: Screenings (%) wheat.

	Decile 0	Decile 3	Decile 6	Play Season	*Means*
Scepter	2.0	1.4	1.7	1.5	*1.7*
Trojan	1.4	1.3	1.8	1.9	*1.6*
Means	*1.7*	*1.4*	*1.8*	*1.7*	
	P (variety)= = NS			*l.s.d (P<0.05) = n.a.*	
	P (Decile) = NS			*l.s.d (P<0.05) = n.a.*	
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) = n.a.*	

- No effect from nutrition on screenings.
- No difference in screenings between varieties. Given the low yields of Trojan it might have been expected that we may see screenings - but lack of high amounts of post-em nitrogen possibly saved Trojan from screenings.

Barley

Table 6: Crop establishment (plants/m^2) barley.

	Decile 0	Decile 3	Decile 6	Play Season	Means
LaTrobe	113	107	113	107	*110*
Bass	114	107	108	111	*110*
Means	*114*	*107*	*111*	*109*	
	P (variety)= =NS			*l.s.d (P<0.05) =*	*n.a*
	P (Decile) =NS			*l.s.d (P<0.05) =*	*n.a*
	*P (Variety*Decile) =NS*			*l.s.d (P<0.05) =*	*n.a*

- No difference in establishment between the varieties at any nutrition package.

Table 7: Yield (t/ha) barley.

	Decile 0	Decile 3	Decile 6	Play Season	Means
LaTrobe	1.88	2.30	2.33	2.25	*2.19*
Bass	1.51	1.64	1.71	1.84	*1.68*
Means	*1.70*	*1.97*	*2.02*	*2.05*	
	P (variety)= P <0.001			*l.s.d (P<0.05) =*	*0.169*
	P (Decile) =0.03			*l.s.d (P<0.05) =*	*0.239*
	*P (Variety*Decile) =NS*			*l.s.d (P<0.05) =*	*n.a*

- LaTrobe significantly out-yielded Bass, regardless of nutritional package. To be expected given LaTrobe is a quicker variety than Bass.
- Rate response to increasing fertiliser observed in Bass, but not in the higher yielding LaTrobe.

Table 8: Protein (%) barley.

	Decile 0	Decile 3	Decile 6	Play Season	Means
LaTrobe	9.6	12.6	12.7	13.7	*12.2*
Bass	11.3	12.1	13.5	12.7	*12.4*
Means	*10.5*	*12.4*	*13.1*	*13.2*	
	P (variety)= =			*l.s.d (P<0.05) =*	*1.26*
	P (Decile) =0.02			*l.s.d (P<0.05) =*	*1.78*
	*P (Variety*Decile) =NS*			*l.s.d (P<0.05) =*	*n.a*

- High proteins in all but the lowest fertiliser (Decile 0) treatment for LaTrobe.
- Generally increasing proteins with increasing fertiliser.
- Mixed results here - normally we would expect Bass to have higher proteins than LaTrobe, but the results vary. Remarkably high proteins achieved given the low fertiliser rates.

Table 9: Hectolitre weight (kg/hL) barley.

	Decile 0	Decile 3	Decile 6	Play Season	Means
LaTrobe	65.3	64.9	64.9	64.3	*64.9*
Bass	61.0	57.6	61.0	58.7	*59.6*
Means	*63.1*	*61.2*	*63.0*	*61.5*	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*n.a*
	P (Decile) = NS			*l.s.d (P<0.05) =*	*n.a*
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) =*	*n.a*

- No statistically significant differences in hectoliter weights between the varieties.
- No statistically significant differences in hectoliter weights between the fertiliser treatments.

Table 10: <2.2 mm screenings (%) barley.

	Decile 0	Decile 3	Decile 6	Play Season	Means
LaTrobe	4.2	5.4	4.6	5.1	*4.8*
Bass	3.1	2.8	3.7	2.8	*3.1*
Means	*3.7*	*4.1*	*4.1*	*4.0*	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*0.409*
	P (Decile) =NS			*l.s.d (P<0.05) =*	*n.a*
	*P (Variety*Decile) =0.020*			*l.s.d (P<0.05) =*	*0.818*

- Significantly higher small screenings in Latrobe than Bass.

Table 11: 2.2-2.5 mm screenings (%) barley.

	Decile 0	Decile 3	Decile 6	Play Season	Means
LaTrobe	37.6	48.0	46.0	51.7	*45.8*
Bass	23.3	25.1	31.0	30.1	*27.4*
Means	*30.4*	*36.6*	*38.6*	*40.9*	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*2.449*
	P (Decile) <0.001			*l.s.d (P<0.05) =*	*3.463*
	*P (Variety*Decile) =0.04*			*l.s.d (P<0.05) =*	*4.898*

- Generally increasing screenings with increasing fertiliser rate.
- Less screenings in Bass than in Latrobe: this is to be expected with Bass being a variety that is known for its plump grain.

Canola

Table 12: Crop establishment (plants/m^2) canola.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Hyola 559	47	49	47	47	*48*
InVigor T4510	46	48	43	45	*46*
Means	*47*	*48*	*45*	*46*	
	P (variety)= = NS			*l.s.d (P<0.05) =*	*n.a*
	P (Decile) = NS			*l.s.d (P<0.05) =*	*n.a*
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) =*	*n.a*

- No difference in establishment between the varieties at any nutrition packages (Deciles).

Table 13: Yield (t/ha) canola.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Hyola 559	1.35	1.43	1.51	1.62	1.48
InVigor T4510	1.16	1.34	1.37	1.50	1.34
Means	1.25	1.39	1.44	1.56	
	P (variety)= = 0.001			*l.s.d (P<0.05) =*	*0.073*
	P (Decile) <0.001			*l.s.d (P<0.05) =*	*0.103*
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) =*	*n.a*

- Significantly higher yields in Hyola 559TT than InVigorT4510 in this trial.
- Both varieties showed a significant rate response to fertiliser (Decile).
- Excellent yield achieved by these varieties under comparatively low fertiliser rates and given the late break to the season.

Table 14: Oil (%) canola.

	Decile 0	Decile 3	Decile 6	Play Season	Means
Hyola 559	47.3	47.3	47.3	46.3	*47.1*
InVigor T4510	46.5	45.5	44.9	44.8	*45.4*
Means	*46.9*	*46.4*	*46.1*	*45.6*	
	P (variety)= <0.001			*l.s.d (P<0.05) =*	*0.41*
	P (Decile) = 0.002			*l.s.d (P<0.05) =*	*0.58*
	*P (Variety*Decile) = NS*			*l.s.d (P<0.05) =*	*n.a*

- Higher oil content in Hyola 559TT than InVigorT4510 in this trial.
- Response to fertiliser (decile). Results show decreased oil content with increasing fertiliser rate.

Comments

These trials were designed to evaluate the differences between wheat, barley and canola under differing fertiliser regimes, as denoted by seasonal deciles. Cumulative growing season rainfall in 2018 finished as decile 6 however remained below decile 5 until after tillering - May = decile 1-2, June = decile 3-4, July = decile 5-6, August-October = decile 5-7. Cumulative rainfall from July-October = Decile 10.

Even the top rates of fertiliser were generally lower than what many used in 2018, however previous “Yardstick” trial work has shown the varieties performance is generally independent of fertiliser regime’ i.e. a good variety is still a good variety regardless of whether it receives little or a lot of fertiliser.

These trials largely support this, with the differences observed being mainly due to the maturity length of the varieties rather than any particular variety having superior fertiliser use efficiency. This was particularly apparent as these trials were deliberately set up with two different maturity length varieties, with the quicker maturing line almost always out-yielding the longer line.

As might be expected from a season like 2018, in all crop types we saw an increase in yield with increasing fertiliser rate. In fact the rate response curve suggests that some yield had been forfeited from lack of nitrogen even in the top rate (the play-the-season).

When comparing crop types (i.e. which crop is better?) it’s hard to compare: the better varieties in each crop type are all quite comparable if you were to look at a gross $ return/ha. Two things that should be noted are firstly, the canola was probably higher yielding than might have been expected for such a late start and for what was across all deciles a fairly conservative fertiliser regime. The second point of note was the poor quality of the barley, with extremely high plump grain screenings in both varieties.

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Management of nutrition after rotary cultivation of a non-wetting soil in the Geraldton Port Zone - Eneabba

Alana Hartley, Research & Development Coordinator, Liebe Group, Stephen Davies, Soil Scientist and Project Manager, DPIRD, and James Easton, Senior Agronomist, CSBP

Key Messages
- Cultivation will often see improved yields in the first two seasons, particularly on lighter soils.
- The 2018 season saw 409 mm of growing season rainfall (GSR) resulting in a significant response to nitrogen (N) and a response to a residual high potassium (K) applied in 2017.
- In soils deficient in K (below 40-50mg/kg) at 0-10 cm, application of higher rates of top dressed K to take advantage of the residual benefits across seasons could be considered.

Aim
To determine the impact of N and K supply on yield and quality, on ameliorated non-wetting soils in the Geraldton Port Zone.
To determine the most effective way to apply nutrients (granular, banded, top dressed or liquid) on non-wetting soils after amelioration, in the Geraldton Port Zone.

Background
Water repellence is a significant constraint to production in Western Australian broadacre farming systems. It is estimated that 6.9 million hectares are considered at moderate risk of water repellence, and further 3.3 million hectares are high risk, based on the area of coarse sandy topsoils with low clay content (van Gool, 2008). In the Geraldton Port Zone, approximately 52% of the arable soils are at moderate to high risk of water repellence (van Gool, 2008).

Water repellent soils are defined by having slow permeability to water, characterised by uneven wetting of soils, water run-off and pooling and/or, flow through the soil via preferential pathways, leaving the surrounding soil dry (Roper et al. 2015).

Over the years, farmers have adopted many practices to mitigate soil water repellence, with various levels of success. These include; furrow sowing, use of surfactants, addition of clay and, more recently, deep cultivation through complete or partial inversion of the soil by mouldboard plough, rotary spader or one-way disc plough, which have been successful in mitigating water repellence issues (Davies, Scanlan & Best, 2011; Roper et al. 2015).

These strategic deep tillage practices that mitigate soil water repellence can alter crop nutrition; including nutrient availability and distribution through the soil profile. Physio-chemical aspects of the soil profile are also disturbed and will influence root growth and biological activity (Robson & Taylor, cited in Vu et al. 2009). The implication of the redistribution of the organic matter and nutrient rich topsoil from the use of cultivation equipment varies for each nutrient. Both spading and mouldboard ploughing are likely to increase N mineralisation however, the distribution of other nutrients highlights the need to conduct soil testing post cultivation to understand the new soil profile (Davies, Scanlan & Best, 2011).

To investigate the impact of cultivation has to the management of nutrients post amelioration, three sites were selected across the Geraldton Port Zone; Eneabba, Marchagee and Irwin. In 2017, the project team chose to select two nutrients, K and N which were applied in various forms; granular, banded, top-dressed and liquid. It was also agreed that, to avoid the initial flush of nutrients after the first year of cultivation, that selected sites would have been ameliorated a minimum of two years prior to implementing the trial. In season rainfall in 2017 was considerably lower than average (265 mm), resulting in no significant differences between treatments. As a result, a second season of research was established to further investigate nutrition management on these ameliorated non-wetting soils. The trial design for the 2018 season was modified to examine the effects of K and N, and the residual value of K, on an ameliorated non-wetting soil.

The Eneabba site was established on white non-wetting sand over gravel, which had been rotary spaded in 2015 to ameliorate the non-wetting soil surface.

Trial Details

Property	Rohan Broun, Eneabba
Plot size & replication	1.54 m x 20 m x 4 replications
Soil type	White sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 6.0 10-20cm: 6.0 20-30cm: 5.8
EC (dS/m)	0-10cm: 0.085
Sowing date	18/04/2018
Seeding rate	1.8 kg/ha (DG 540 RR canola)
Paddock rotation	2015: Wheat 2016: Wheat 2017: Wheat 2018: Canola (RR)
Amelioration	2015: Rotary Spaded
Fertiliser	See Table 1
Herbicides, Fungicides & Insecticides	18/04/2018: Flexi N and compound fertiliser as per treatment schedule, 200 ml/ha Lorsban, 200 ml/ha Dominex Duo. 08/06/2018: 900 g/ha Roundup Ready 3/07/2018: 05/07/2018: 900 g/ha Roundup Ready 2/08/2018: Flexi N top up as per treatment schedule 24/08/2018: 500 kg/ha gypsum 27/09/2018: 750 ml/ha Lorsban, 500 ml/ha Dominex Duo.
Growing season rainfall (GSR)	409 mm

Trial Layout

The initial trial design included a combination of N and K rates ranging from nil to very high. Poor seasonal conditions in 2017 led to harvest results providing no significant difference between treatments. As such, the trial was extended into 2018 with treatment modifications. The final implemented treatments can be found in Table 1 where treatment nine (9) has been modified to reflect grower standard practice of not applying additional top dressed K rather, it utilises the high K rate that had been applied in the previous season (2017). This is now reflected as Residual High K.

Table 1: Implemented nutrient treatments for 2018

	Treatment	Banded (L/ha)	Banded (kg/ha)	Rosette (L/ha)	Budding (L/ha)	N	P	K
1	Std N No K	50 Flexi N	85 Agstar Extra	80 Flexi N		70	12	0
2	Std N Std K	50 Flexi N	100 K-Till Extra	80 Flexi N		70	12	11
3	Liquid K	117 Flexi NK	85 Agstar Extra	80 Flexi N		70	12	11
4	Std N High K	50 Flexi N	100 K-Till Extra/28 MoP	80 Flexi N		70	12	25
5	No N		62 Big Phos/51 MoP			0	12	25
6	Low N	50 Flexi N	100 K-Till Extra/28 MoP			31	12	25
7	High N	50 Flexi N	100 K-Till Extra/28 MoP	80 Flexi N	71 Flexi N	100	12	25
8	High N No K	50 Flexi N	85 Agstar Extra	80 Flexi N	71 Flexi N	100	12	0
9*	Residual High K	50 Flexi N	85 Agstar Extra	80 Flexi N		70	12	0

*200 kg MoP was applied in 2017 with the residual K from this treatment being carried over to 2018.

Results and Discussion

In 2018, the Eneabba site received 409mm of GSR, with consistent falls received between May and October. Early soil tests were taken prior to sowing from treatments 1 and 9. These treatments represent soil with nil K applied compared to residual application of high K rate (Table 2 and 3).

Results have been averaged across all four replicates of the trial site however, Rep 1 did indicate slightly higher N, phosphorous (P) and K levels due to the higher gravel and clay content at that end of the site.

Background soil N status was low and with significant growing season rainfall in 2018, the site showed visual responses to N. Potassium (K) levels under treatment 9 were somewhat higher than in treatment 1 however, soil Colwell K is still below adequate levels and suggests the site would be responsive to K. Water penetration testing was also conducted at the beginning of the project in 2017, to determine the effectiveness of the cultivation treatment removing the non-wetting layer. This has not changed from one season to the next.

Table 2: Soil test results Treatment 1 (Standard N, No K) Eneabba, 26th March 2018

Depth	pH ($CaCl_2$)	OC%	EC	NO_3 N	NH_4 N	Col P	Col K	PBI	MED	WDPT (secs)
0-10 cm	6.2	0.57	0.072	19	1	9.5	20	7.5	0	6.8
10-20 cm	5.9	0.69	0.039	11	1	10	17	8.6		
20-30 cm	5.6	0.42	0.022	6	1	12.5	15	8.6		
30-40 cm	4.9						24			
40-50 cm	5.0						24			

Table 3: Soil test results Treatment 9 (Residual High K) Eneabba, 26th March 2018.

Depth	pH ($CaCl_2$)	OC%	EC	NO_3 N	NH_4 N	Col P	Col K	PBI	MED	WDPT (secs)
0-10 cm	6.2	0.57	0.072	14	1	10	34	7.5	0	6.8
10-20 cm	6.1	0.69	0.039	9	<1	8	30	8.6		
20-30 cm	5.4	0.42	0.022	3	1	12	18	8.6		
30-40 cm	4.9						19			
40-50 cm	5.0						25			

Organic Carbon percent (OC% - determined by Walkley-Black method), Electrical Conductivity ds/m^2 (EC), Nitrate nitrogen (NO_3 N), Ammonium nitrogen (NH_4 N), Colwell Phosphorus (Col P), Colwell potassium (Col K), Phosphorus Buffering Index (PBI), molarity of ethanol droplet test (MED), water droplet penetration time (WDPT)

An analysis of Restricted Maximum Likelihood (REML) was conducted for yield on three of the four replicates in the trial. Replicate four was excluded due to poor establishment and wind damage.

The REML analysis accounts for the yield trend across the site and adjusts the means accordingly resulting in a better ability to distinguish between treatment effects.

Table 4 indicates canola grain yield had a clear response to N, with the high N treatments (100 kg N) achieving significantly higher yields than treatments with lower N rates. Canola grain yield was generally not responsive to K, except for the residual K treatment, which has significantly higher K than the other treatments, at the same standard level (70kg) of N. Despite this the residual K treatment yield was equivalent to the treatments with the highest N levels (treatments 7 and 8), irrespective of K-level applied, further reinforcing the N responsiveness of this site.

Table 4: Impact of fertiliser management strategy on 2018 Canola yield

REML Analysis – 3 reps				
Treatment	**Description**	**Yield**	**N**	**K**
1	Std N No K	1.06 ab	70	0
2	Std N Std K	1.14 bc	70	11
3	Liquid K	1.06 ab	70	11
4	Std N High K	1.11 ab	70	25
5	No N	0.91 a	0	25
6	Low N	0.93 ab	31	25
7	High N	1.32 cd	100	25
8	High N No K	1.32 cd	100	0
9	Residual High K	1.36 cd	70	Residual
l.s.d (p<0.1)		0.21		
P. value		*0.028*		

Means followed by a different letter are significantly different.

An analysis of variance (ANOVA) was conducted to examine the main effect of N only (Table 5). This found that the high N rate was significantly higher yielding than any of the lower N treatments, and the standard N in turn was also significantly higher than no N.

Table 5: Grain yield response to N rate (ANOVA)

Nitrogen rate (kg/ha)	Average yield (t/ha)
0	1.08^{a}
31	1.20^{ab}
70	1.40^{b}
100	1.62^{c}

Analysis of oil was conducted using ANOVA, including all four replicates in the trial. High N treatments were significantly higher yielding of oil (Table 6) compared to treatments 5 and 6. While there was no significant difference between those treatments with ‘standard N’ and, treatments 5 and 6.

Table 6: Impact of fertiliser management strategy on 2018 Canola oil % (ranked lowest to highest)

Treatment	Description	Oil %	N	K
1	Standard N, No K	44.7 ab	70	0
2	Std N, Std K	45.4 abc	70	11
3	Liquid K	44.4 a	70	11
4	Std N, High K	45.6 bc	70	25
5	No N	44.6 ab	0	25
6	Low N	44.4 a	31	25
7	High N	46.0 c	100	25
8	High N, No K	45.7 bc	100	0
9	Residual High K	44.9 abc	70	Residual
	l.s.d.	*1.169*		
	P. Value (<0.05)	*0.055*		

Economic analysis

A gross margin analysis has been conducted to investigate the profitability of the nutrition packages applied in this trial. Treatment 2 (standard N, standard K) has been used as the grower standard practice (GSP) cost base for this analysis.

Table 7: Gross margin analysis by treatment

	Treatment	Banded (L/ha)	Banded (kg/ha)	Rosette (L/ha)	Budding (L/ha)	N	P	K	Yield (t/ha)	Oil (%)	Gross Re-turn ($/ha)	Trt. Cost ($/ha)	GM ($/ha)	Diff. cf. Trt. 2 $/t (GSP)
1	Std N No K	50 Flexi N	85 Agstar Extra	80 Flexi N		70	12	0	1.06	44.7	574	158	416	-30
2	Std N Std K	50 Flexi N	100 K-Till Extra	80 Flexi N		70	12	11	1.14	45.4	621	175	447	-
3	Liquid K	117 Flexi NK	85 Agstar Extra	80 Flexi N		70	12	11	1.06	44.4	571	183	388	-59
4	Std N High K	50 Flexi N	100 K-Till Extra/28 MoP	80 Flexi N		70	12	25	1.11	45.6	610	193	417	-30
5	No N		62 Big Phos/51 MoP			0	12	25	0.91	44.6	489	71	418	-29
6	Low N	50 Flexi N	100 K-Till Extra/28 MoP			31	12	25	0.93	44.4	503	136	367	-80
7	High N	50 Flexi N	100 K-Till Extra/28 MoP	80 Flexi N	71 Flexi N	100	12	25	1.32	46	729	243	487	40
8	High N No K	54 Flexi N	85 Agstar Extra	80 Flexi N	71 Flexi N	100	12	0	1.33	45.7	718	211	508	61
9	Residual High K	54 Flexi N	85 Agstar Extra	80 Flexi N		70	12	Res.	1.36	44.9	739	291	448	1

Grain prices use for GM analysis: $520/t GM Canola plus oil bonus $8.64 per tonne clean grain.

Treatments 7 and 8 had strong gross margin returns at $487 and $508/ha (Table 7). When compared to GSP, this was an improvement of $40/t for treatment and $61/t for treatment 8. The additional investment for nitrogen at budding, coupled with adequate growing season rainfall, saw a strong response to N but no additional benefit from K in these two treatments. The additional investment in K from the residual top dressed treatment (treatment 9) only yielded an extra $1/ha above the GSP of treatment 2. This suggests that, while the yield improvements from the residual K treatment were significant, financially the additional investment would be considered uneconomical as the returns from such an application may not be realised every season.

Comments

Eneabba reflects a sand over gravel and clay profile response, where spading has mixed heavier soil (gravel and clay) through the profile and potentially improved root access to this deeper subsoil. Soil testing indicates this clay gravel layer does hold somewhat more potassium than the sandy soil above. This coupled with the reduced crop demand for K from a late emerging crop and dry finish could explain why there was not a strong response to K at this site.

While seasonal rainfall provided adequate conditions to produce an N response at this site, the lack of K response, except where MoP was top dressed in 2017, suggests that current management practices for N and K are sufficient for driving yield and oil. Such responses however, reinforce the continued need for growers to have a greater understanding of their soil profile, to depth, using existing tools such as soil sampling and analysis, to ensure fertiliser decisions meet crop demand as influenced by soil type, nutrient supply and yield potential.

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Management of nutrition on a mould-boarded non-wetting soil in the Geraldton Port Zone - Marchagee

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Key Messages

- A high application of potassium (K), 25 kg/ha and standard nitrogen (N) rates, 70 kg/ha improved wheat yield and grain quality up to 0.47 t/ha on mould boarded deep sand.
- In the presence of adequate potassium (> 40-50 mg/kg), in favourable seasons, wheat can respond to the application of N) fertiliser, resulting in high yield and protein. Where K is limited, returns from N are likely to be poor.
- The results indicate that a higher rate of K than banding 11 kg/ha K can lead to a significant increase in yield and profitability.

Aim

1. To quantify the impact of nitrogen and potassium fertiliser on wheat yield and quality, after mouldboard ploughing non-wetting soils in the Geraldton Port Zone.
2. To determine the most effective way to apply nutrients (granular, banded, top dressed or liquid) on non-wetting soils after amelioration, in the Geraldton Port Zone.

Background

Water repellence is a significant constraint to production in Western Australian broadacre farming systems. It is estimated that 6.9 million hectares are considered at moderate risk of water repellence, with a further 3.3 million hectares at high risk, based on the area of coarse sandy topsoils with low clay content (van Gool 2008). In the Geraldton Port Zone, approximately 52% of the arable soils are at moderate to high risk of water repellence (van Gool 2008).

Water repellent soils are characterised by having slow and uneven water infiltration, water run-off and ponding and ‘bypass’ flow through the soil via preferential pathways, leaving the surrounding soil dry (Roper et al. 2015).

Over the years, farmers have adopted many practices to mitigate soil water repellence, with various levels of success. These include furrow sowing, surfactant application, addition of clay and more recently, deep cultivation through complete or partial inversion of the soil by mouldboard plough, rotary spading or one-way disc plough, which has been successful in mitigating water repellence issues (Davies, Scanlan & Best 2011; Roper et al. 2015).

These strategic deep tillage practices that mitigate soil water repellence can alter crop nutrition; including nutrient availability and distribution through the soil profile. Physio-chemical aspects of the soil profile are also disturbed and will influence root growth and biological activity (Robson & Taylor, cited in Vu et al. 2009). The implication of the redistribution of the organic matter and nutrient rich topsoil from the use of cultivation equipment varies for each nutrient. Both spading and mouldboard ploughing are likely to increase N mineralisation however, the distribution of other nutrients highlights the need to conduct soil testing post cultivation to understand the new soil profile (Davies, Scanlan & Best 2011).

To investigate the impact of cultivation has on the management of nutrients post amelioration, three sites were selected across the Geraldton Port Zone; Eneabba, Marchagee and Irwin. In 2017, the project team chose to select two nutrients, K and N which were applied in various forms; granular, banded, top-dressed and liquid. It was also agreed that, to avoid the initial flush of nutrients after the first year of cultivation, that selected sites would have been ameliorated a minimum of two years prior to implementing the trial.

2017 saw a lower than average rainfall for the Marchagee trial site, only receiving 171 mm for the growing season. As a result, there was limited significant difference in yield on all treatments except where liquid K was applied. As such, the project has continued for a second season, investigating the management of N and K in its various forms (liquid, granular, top dressesed or banded). The trial design for the 2018 season focussed on the placement and effects of K on an ameliorated non-wetting soil.

The Marchagee site was established at Clint Hunt's property east of Marchagee, on deep yellow sand, which had been mouldboard ploughed in 2014 to ameliorate the non-wetting soil surface.

Trial Details

Property	Clint Hunt, Hunt Partners, Marchagee
Plot size & replication	1.54 m x 20 m x 4 replications
Soil type	Deep yellow sand
Soil pH ($CaCl_2$)	0-10cm: 5.3 10-20cm: 5.6 20-30cm: 4.6
EC (dS/m)	0-10cm: 0.023
Sowing date	18/05/2018
Seeding rate	Scepter 70 kg/ha
Paddock rotation	2015: Wheat 2016: Canola 2017: Wheat 2018: Wheat
Amelioration	2014: Mouldboard ploughed
Fertiliser	As per treatment schedule
Herbicides, Fungicides & Insecticides	18/05/2018: 200 ml/ha Lorsban, 200 ml/ha Dominex Duo, 1.5 L/ha Trifluralin, 118 g/ha Sakura
Growing season rainfall (GSR)	218 mm

Trial Layout

The initial trial design included a combination of rates for both N (0, 31, 70, 100 kg N/ha) and K (0, 11, 25, 99 kg K/ha) and application times. Treatment nine has been modified to investigate the residual value of a high rate of muriate of potash (MoP) applied the year before. This is now reflected as residual very high K.

Table 2 Implemented trial design

Treatment		Banded (L/ha)	Banded (kg/ha)	Z23 (L/ha)	Z32 (L/ha)	N	P (kg/ha)	K
1	Std N No K	50 Flexi N	85 Agstar Extra	83 Flexi N		70	12	0
2	Std N Std K	50 Flexi N	100 K-Till Extra	83 Flexi N		70	12	11
3	Liquid K	117 Flexi NK	85 Agstar Extra	83 Flexi N		70	12	11
4	Std N High K	50 Flexi N	100 K-Till Extra/28 MoP	83 Flexi N		70	12	25
5	No N		62 Big Phos/51 MoP			0	12	25
6	Low N	50 Flexi N	100 K-Till Extra/28 MoP			31	12	25
7	High N	50 Flexi N	100 K-Till Extra/28 MoP	83 Flexi N	71 Flexi N	100	12	25
8	High N No K	54 Flexi N	85 Agstar Extra	83 Flexi N	71 Flexi N	100	12	0
9	Residual Very High K	54 Flexi N	85 Agstar Extra	83 Flexi N		70	12	99

Results and Discussion

In 2018, the Marchagee site received 218 mm growing season rainfall (GSR). Early soil tests were taken from treatment 1 (Table 3) and treatment 9 (Table 4) prior to sowing. Being a deep yellow sand, with K levels well below adequate (40-50 mg/kg) it was expected that this site would be responsive to K fertiliser in 2018.

Water droplet penetration testing (WDPT) and molarity of ethanol droplet test (MED) was also conducted at the beginning of the project to determine the effectiveness of the cultivation treatment in removing the non-wetting layer at the surface, to ensure that non-wetting did not impact on the treatments being applied.

Table 3: Soil test results Treatment 1, Marchagee, 19th March 2018

Depth	pH ($CaCl_2$)	OC%	EC	NO_3 N	NH_4 N	Col P	Col K	PBI	MED	WDPT (secs)
0-10 cm	5.3	0.58	0.047	18	2	21	28	11.5	0	0
10-20 cm	4.9	0.55	0.028	9	< 1	19	22	12.9		
20-30 cm	4.5	0.32	0.017	3	< 1	17	24	10.5		
30-40 cm	4.7					12	27			
40-50 cm	4.7					4	23			

Table 4: Soil test results Treatment 9, Marchagee 19th March 2018

Depth	pH ($CaCl_2$)	OC%	EC	NO_3 N	NH_4 N	Col P	Col K	PBI	MED	WDPT (secs)
0-10 cm	5.2	0.53	0.044	15	1	25	68	9.4	0	0
10-20 cm	5.2	0.55	0.030	11	< 1	17	22	11.9		
20-30 cm	4.6	0.30	0.017	4	< 1	15	18	8.6		
30-40 cm	4.4					12	19			
40-50 cm	4.6					4	18			

Organic Carbon percent (OC% - determined by Walkley-Black method), Electrical Conductivity ds/m (EC), Nitrate nitrogen (NO_3 N), Ammonium nitrogen (NH_4 N), Colwell Phosphorus (Col P), Colwell potassium (Col K), Phosphorus Buffering Index (PBI), molarity of ethanol droplet test (MED), water droplet penetration time (WDPT)

Due to the below average GSR that was received in 2017 (117 mm), 2018 soil tests from treatment 9 indicate that there has been little to no movement of the top dressed MoP from the 0-10 cm layer. Presumably much of the K would have been available for the crop in 2018.

Wheat yield and protein were analysed at harvest in Table 5. Treatment 2 has been used at a grower standard practice (GSP) control, to compare the response of other treatments. The site was responsive to the application of K, particularly where K had been banded at seeding. This was observed at all rates of K, where there was a 10% improvement in yield from treatment 1 to treatment 2, 25% yield improvement from treatment 1 to treatment 4 and, a 28% yield improvement under treatment 9. Treatment 3, Liquid K fertiliser, did not provide any benefits to yield, under the management practices being investigated.

Using the modified French and Schultz yield potential calculator, 74mm summer rain (January – March) and the 218mm GSR gave a wheat yield potential of 2.8 t/ha but, this goes down to 1.4 t/ha with the dry finish and low plant densities so, 1.3-1.9 t/ha achieved at this site was reasonable. With a better September, higher yields would have driven greater demand for N and K. There was a limited response to N for yield at this site.

Table 5: Impact of fertiliser management strategy on 2018 wheat protein (lowest to highest)

	Treatment	Yield	Protein %	Hectolitre	Screenings %	Grade	N (kg/ha)	K (kg/ha)
1	Std N, No K	1.34 a	11.9 de	75.0 ab	4.5 bc	H2	70	0
2	Std N, Std K	1.68 de	11.0 cd	76.5 abc	2.6 a	APW1	70	11
3	Liquid K	1.32 a	13.3 fg	75.6 abc	5.4c	AUH2	70	11
4	Std N, High K	1.81 ef	10.9 c	76.8 bc	2.3 a	APW1	70	25
5	No N	1.50 bc	8.1 a	77.5 bc	3.4 ab	ASW1	0	25
6	Low N	1.60 cd	9.5 b	78.1 c	2.7 a	ASW1	31	25
7	High N	1.86 f	12.5 ef	76.4 abc	2.8 a	H2	100	25
8	High N, No K	1.36 ab	13.9 g	73.6 a	5.4 c	AUH2	100	0
9	Residual Very High K	1.72 def	11.0 cd	78.4 c	2.8 a	APW1	70	Residual
	l.s.d	0.159	0.9	3	1.2			
	P value	<0.001	<0.001	<0.06	<0.001			

Means followed by a different letter are significantly different

A significant response to N was observed when analysing grain quality; particularly grain protein. This was noticeable under treatments 4, 5, and 6, with increasing N and constant K rate.

A 0.34 t/ha yield response to K was observed in treatments 1, 2 and 9, where N rate remained constant and K increased from 0 kg/ha K, 11 kg/ha K to the high residual K. While treatment 1 did have a higher protein, resulting in an economic gain, moving from APW1 to H2 grade, as noted in table 5, yield was low. The yield response to treatments with 25 units of K, diluted grain protein.

Grain protein results indicate that treatments with 70 or more units of N, had adequate protein (>10.5%) for APW1, H2 and H1 grades. However, high N without adequate K resulted in high screenings and lower hectolitre weight, sufficient to downgrade grain to AUH2.

There were no differences between treatments in any of the plant tissue testing results, indicating adequate uptake of nutrients in the presence of soil moisture.

Economic analysis

A basic gross margin (GM) analysis was conducted (Table 7) to determine the return from each treatment compared to Treatment, which has been used as the grower standard practice (GSP) cost base for this analysis.

With a significant response to N at this site, the highest yielding treatment, treatment 7 had the highest gross margin return at $486/ha. This was a $40/ha financial improvement from Treatment 2, justifying both the extra investment in N and K.

Where there was a significant response to K in treatments 1, 2 and 9, there was a loss of $103/ha compared to treatment 2 due to the significant capital investment in K applied in the 2017 season.

Table 7: Gross margin analysis by treatment

	Treatment	Banded (L/ha)	Banded (kg/ha)	Z23 (L/ha)	Z32 (L/ha)	N	P	K	Yield (t/ha)	Grade	Gross Return ($/ha)	Trt. Cost ($/ha)	GM ($/ha)	Var. Trt 2 (GSP)
1	Std N No K	54 Flexi N	85 Agstar Extra	83 Flexi N		70	12	0	1.34	H2	522	162	360	-86
2	Std N Std K	50 Flexi N	100 K-Till Extra	83 Flexi N		70	12	11	1.68	APW1	621	175	446	
3	Liquid K	117 Flexi NK	85 Agstar Extra	83 Flexi N		70	12	11	1.32	AUH2	488	183	305	-141
4	Std N High K	50 Flexi N	100 K-Till Extra/28 MoP	83 Flexi N		70	12	25	1.81	APW1	669	193	476	32
5	No N		62 Big Phos/51 MoP			0	12	25	1.50	ASW1	510	71	439	-7
6	Low N	50 Flexi N	100 K-Till Extra/28 MoP			31	12	25	1.60	ASW1	544	136	408	-38
7	High N	50 Flexi N	100 K-Till Extra/28 MoP	83 Flexi N	71 Flexi N	100	12	25	1.86	H2	725	239	486	40
8	High N No K	54 Flexi N	85 Agstar Extra	83 Flexi N	71 Flexi N	100	12	0	1.36	AUH2	503	213	290	-156
9	Residual Very High K	54 Flexi N	85 Agstar Extra	83 Flexi N		70	12	99	1.72	APW1	636	293	343	-103

Grain prices used for GM analysis: APW1 - $370, H2 +20, AUH2 + $0, ASW1 -$30.

Response to potassium, in the economic analysis, indicates the higher rate of K (25kg/ha) was a key factor for profitability in contrast to N. There was little difference between the standard N and high N rates. This suggests that where K is present, in a season where spring rainfall was limited in September, a conservative N strategy was still successful.

Comments

On deep sands adequate K is essential for achieving grain yield however the results also indicate that N levels need to be maintained to ensure adequate grain protein. High N with inadequate K resulted in low yield, high protein and high screenings and poorer gross margin. Higher grain yields as a result of earlier sowing or more September rainfall would have increased crop demand and the importance of N for driving yield. Highest gross margins were achieved in treatments that combined high K (25kg banded at seeding) with some N.

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SOIL HEALTH RESEARCH RESULTS

The role of local lime sources and cultivation in improving profitability on acid sandplain

Caroline Peek, Senior Development Officer, DPIRD Merredin

Key Messages

- There was a yield response to cultivation in 2017 and 2018.
- There was a yield response to the application of local lime sources when combined with cultivation in 2017 but not in 2018.
- The local alternative carbonate sources performed as well or better than the lime sand in 2017.
- There was no response to the application of gypsum in 2018.
- Several local lime sources were most effective at increasing pH in the top 15cm.
- The offset discs created the most even pH profile in the top 15cm.
- Local alternative carbonate sources tested have a high percentage of very fine particles.

Aim

To investigate the effectiveness of local lime sources and their interaction with cultivation and deep ripping on alleviating subsoil acidity and compaction.

Background

Sandplain soils common in the eastern Wheatbelt are often naturally low in pH and high in aluminium, and cropping continues to acidify these soils. With the use of heavy agricultural machinery, some of these soils are also prone to subsoil compaction. The continued application over time of a neutralising source such as limesand has been shown to improve and maintain the productivity of these soils. Many farmers in the eastern Wheatbelt find the transport cost of coastal lime sand to be prohibitive at the rates required.

Low rainfall may limit the movement of lime into the subsoil, adding to grower concerns about the time it will take to achieve a return on their lime investment. This may be improved by using finer material and mechanical incorporation. Growers are interested in identifying, extracting and applying local lime (carbonate) sources.

Trial Details

Property	Nixon family, Kalannie
Plot size & replication	6m x 1.8m x 3 replications
Soil type	Acid sandy earth
Soil pH ($CaCl_2$)	0-10cm: 4.6-5.0 10-80cm: 4.0-4.3
Paddock rotation:	2017: Wheat
Sowing date	20/05/2018
Sowing rate	50 kg/ha Scepter wheat
Fertiliser	20/05/2018 50kg/ha Agstar 15/06/2018 40kg/ha Urea August 30L/ha FlexiN
Growing season rainfall	190mm

Treatments

Cultivation treatments

The trial has four methods of cultivation including offset discs, nil cultivation, deep rip to 50cm and deep rip with inclusion plates to 45cm. The site had moderate compaction (Figure 1) and the roots start meeting resistance below 10cm. Above 2500Kpa severe constraints to root growth occur.

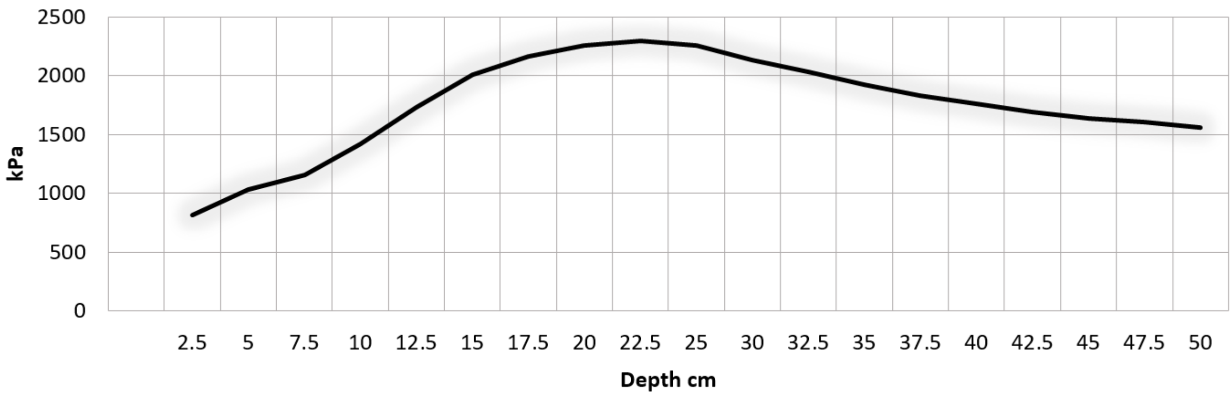

Figure 1: Initial compaction profile of the trial site measure with a penetrometer

Ameliorant treatments

The Nixon family at Kalannie identified a local lime source on an area of morrel soil. The subsoil is extracted and the larger rocks screened out (**morrel subsoil treatment**). The rocks have a higher neutralising value so they were finely crushed and screened over a 2.00mm sieve by Watheroo Dolomite for the trial (**crushed rock treatment**). An unprocessed bulk morrel soil sample from another paddock with no rocks was used as a source (**bulk soil treatment**). **Lime sand** was the standard comparison. Table 1 shows the ameliorants and rates applied. The rates were based on the ENV calculated by the WA calculator to be the equivalent of 2 or 4t/ha of limesand. The local lime sources were applied in 2017. In 2018 plots were split and 2t/ha **gypsum** was applied to the morrel subsoil 5.5t/ha and 11t/ha and nil plots.

The ENV (Table 1) was calculated using the Soil Quality 2017 "Lime Benefit Calculator" (WA calculator). It was also calculated using a method based on research by Scott *et al* (NSW Agriculture lime comparison calculator 2003). Both calculators discount NV based on particle size distribution. The NSW calculator starts discounting at a particle size greater than 0.075mm where the WA calculator starts discounting at greater than 0.5mm. The NSW version results in a comparatively heavier discounting of the limesand compared to the alternative carbonate sources, which have a higher % of very fine material. The morrel soil carbonate sources often contain large particles that slake in water so the wet sieve analysis is more accurate in determining particle size.

Table 1: Neutralising values (NV) and effective neutralising values (ENV) of the ameliorants and rates spread in 2017 and 2018

Ameliorants applied 2017	Application rate t/ha	Ameliorants applied 2018	Wet sieve ENV% (WA calculator)	Wet sieve ENV% (NSW calculator)	Total NV%
Lime sand	4		87	42	88
Morrel subsoil	5.5 and 11	+-Gypsum 2t/ha	32	28	45
Crushed Rock	4.5 and 9		43	33	72
Bulk soil	30		13	10	13
Nil		+- Gypsum 2t/ha			

Results

Soil pH results in 2018

All plots were soil tested to 50cm in March 2018. The pH results for the ameliorants averaged across the four cultivation treatments show that the morrel subsoil applied at 11 t/ha and the Bulk soil applied at 30t/ha had significantly higher pH readings down to at least 15cm (Figure 2). There were no differences below 20cm.

The cultivation with offset discs averaged across all ameliorants showed a more even pH profile down to 15 cm, which would be expected with the mixing of the ameliorants through the profile. (Figure 3). The inclusion plate furrow also shows higher pH down the profile compared to samples taken from between the furrows. Crop growth was visually stronger in the inclusion furrows in both 2017 and 2018 than between the furrows, which would indicate that there was a better soil environment in the furrows.

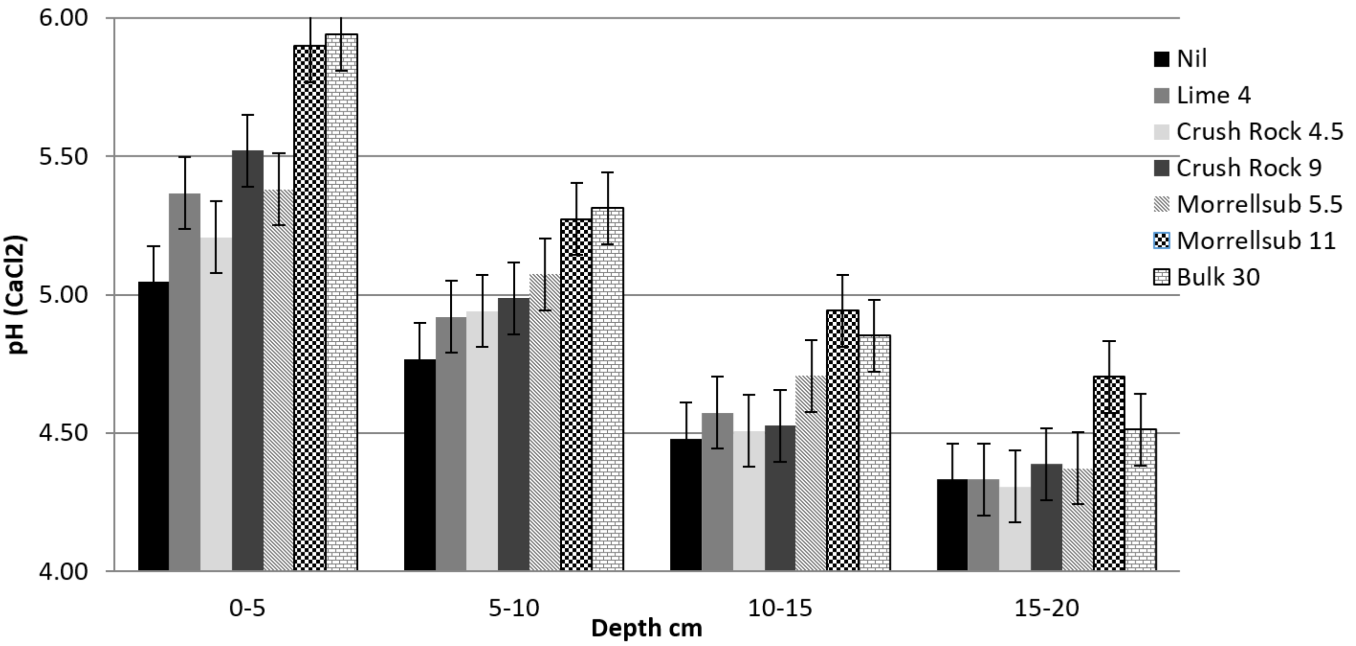

Figure 2: pH profile of each ameliorant averaged across all cultivation treatments

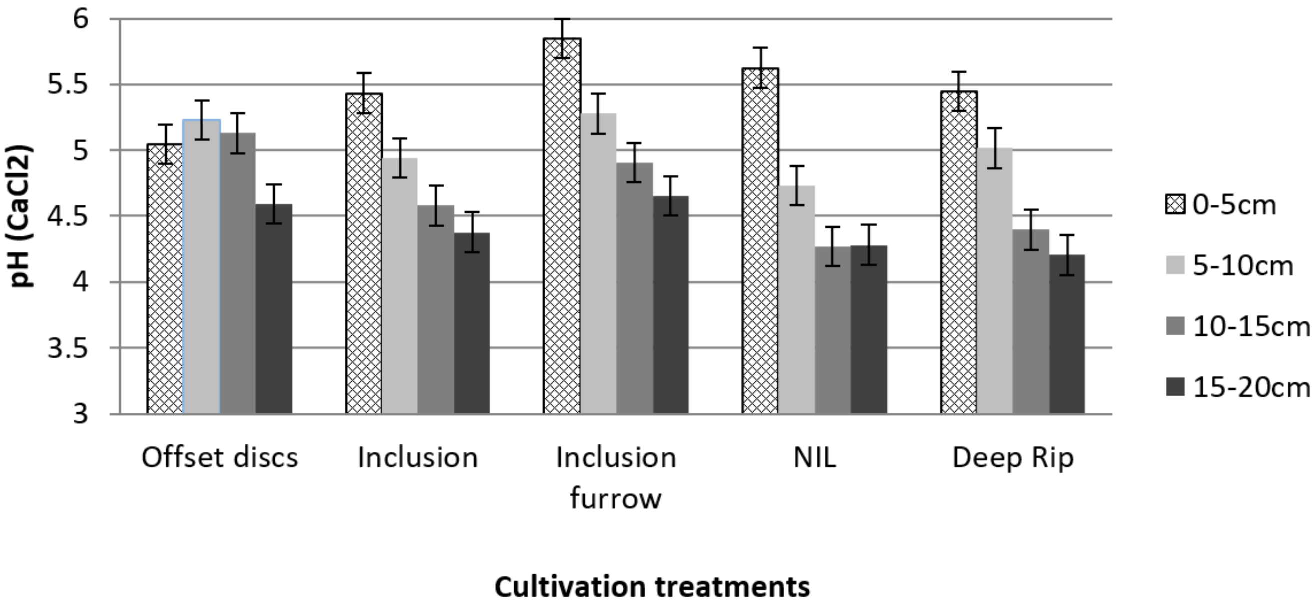

Figure 3: pH profile of each cultivation treatment averaged across all ameliorant treatments

Potassium

Good levels of total potassium have been measured in morrel sources. When the same sources are tested for Colwell K, which measures the plant available K in solution, the levels drop considerably (Table 2). More information on the implications of these findings is being followed up with mineralogy testing. It is likely that it will play a minor role in the economics of using morrel sources.

Table 2: Total Potassium (K) versus Colwell K from morrel sources

Total% K	Total kg/tonne	Colwell K (mg/kg)	Colwell K (%k)	Colwell K (kg/tonne)
0.34	3.5	332	0.032	0.35
1.41	14	482	0.048	0.48
0.78	7.8	626	0.063	0.63
1.2	12.9	388	0.039	0.39

Cultivation response

In 2018 deep ripping and offset discs increased yield by 221 kg/ha compared to the nil (Figure 4). In 2017 the response to cultivation was bigger (592 734 kg/ha) but the 2018 crop enjoyed better winter rainfall and less moisture limitations (Table 3).

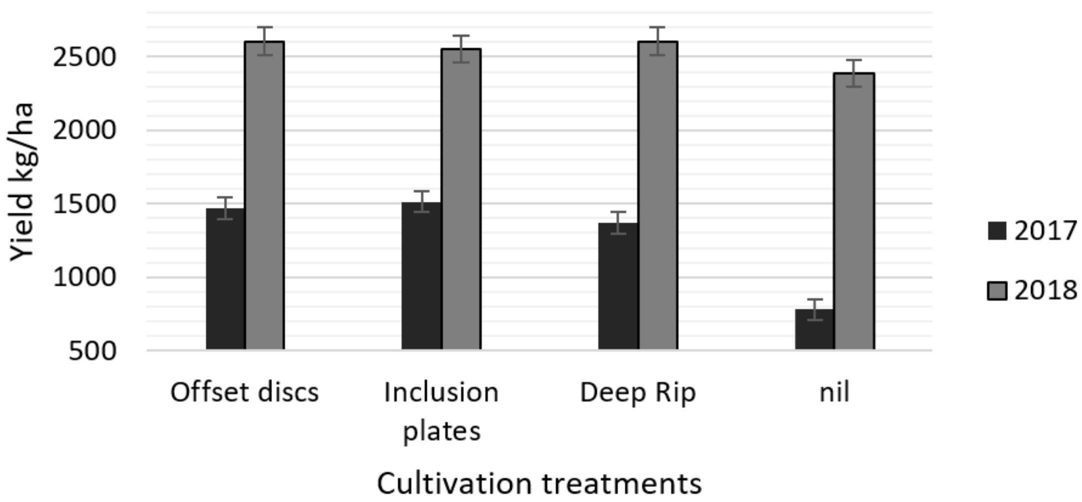

Figure 4: Grain yield response to cultivation in 2017 and 2018 (lsd P=0.05)

Table 3: Rainfall distribution in 2017 and 2018

	2017 (mm)	2018 (mm)
January-March	92	95
April-July	33	125
August -September	78	65

Total dry matter cuts at harvest show that nil cultivation had significantly lower biomass than the cultivation treatments (Figure 5). Tiller counts at harvest followed a similar trend. NDVI measurements taken through the year showed that by late August the nil cultivation treatment had a significantly lower NDVI. It was surprising that the grain yield differences were not greater. Seasonal conditions were good but September was relatively dry which may have influenced the result. Initial analysis indicates grain size was good across all treatments.

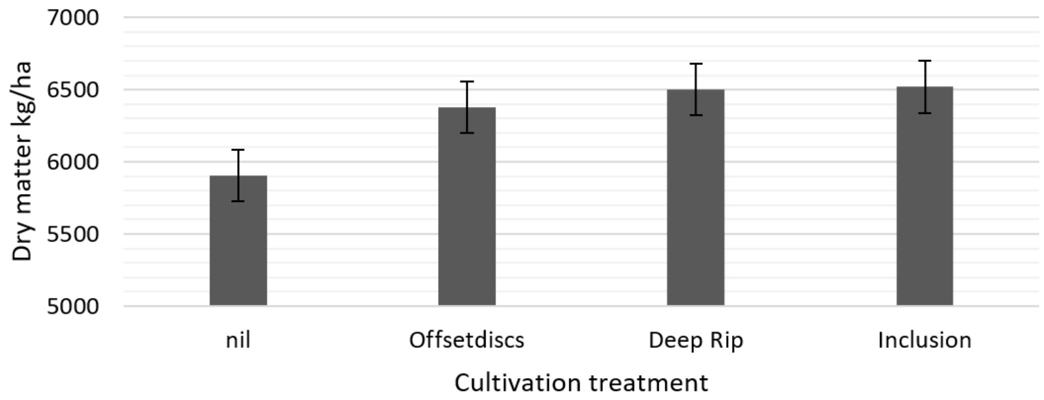

Figure 5: Total dry matter biomass cuts taken at harvest 2018 (lsd P=0.05)

Amelioration Responses

In 2017 there was a response to amelioration when cultivation was applied and the local lime sources were significantly higher yielding than where no ameliorant was applied (Figure 6) but we did not see that response in 2018 (Figure 7).

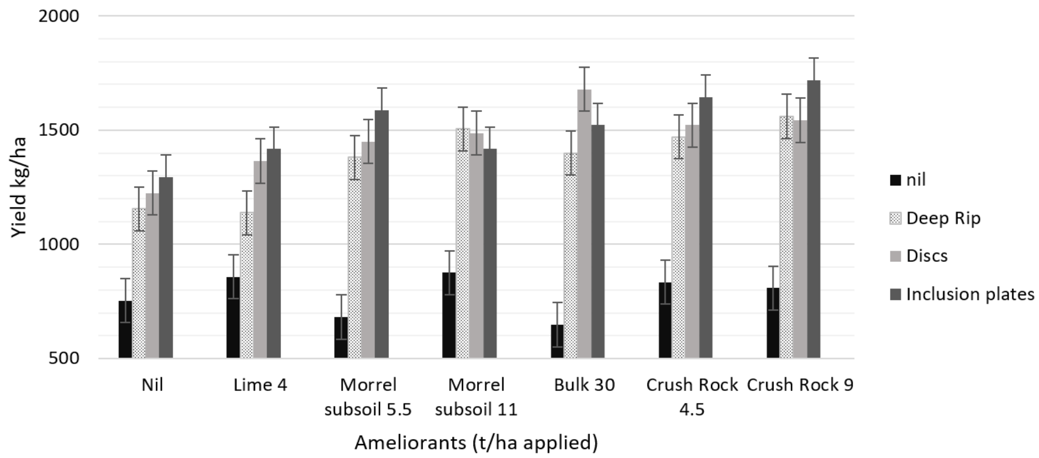

Figure 6: Grain yield response to amelioration and cultivation 2017 (lsd P=0.05)

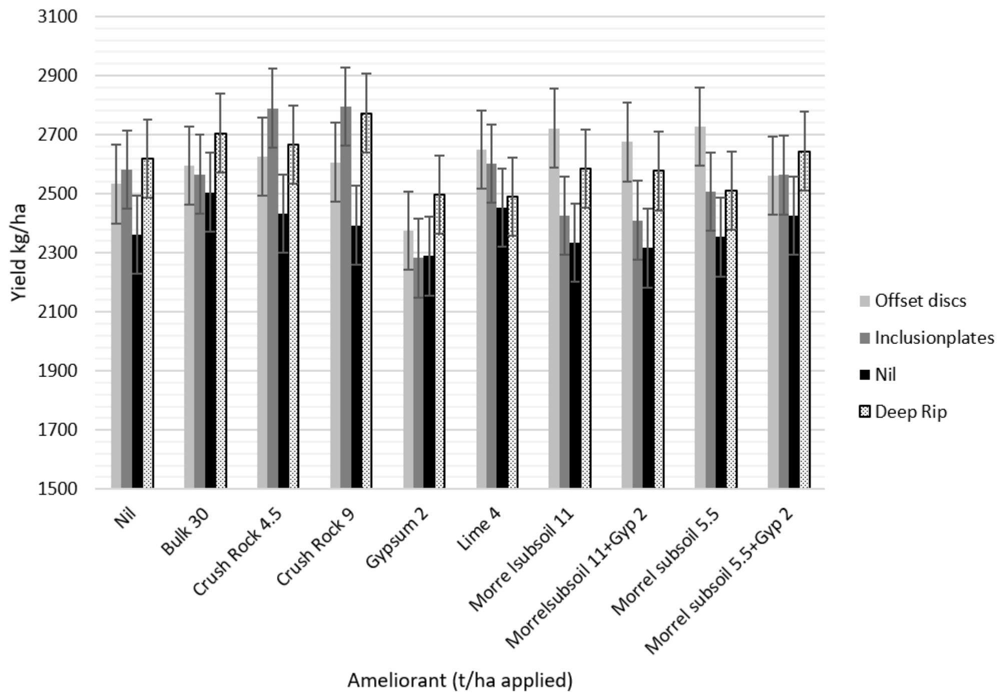

Figure 7: Grain yield response to amelioration and cultivation 2018 (lsd P=0.05)

Tissue test results

Tissue tests were taken on 23 July 2018 and nutrients were adequate across all treatments. Molybdenum levels were depressed by the addition of gypsum (Table 3) although still in the adequate range. This interaction has been observed in other work (Geoff Anderson pers comm.).

Table 3: Tissue test results for Molybdenum (youngest fully expanded leaf)

Ameliorant	Mo ug/kg
Bulk 30t/ha	327 a
Morrel subsoil 11t/ha	291.5 a
Lime 4t/ha	278.8 a
Crush Rock 4.5t/ha	275.3 b
Crush Rock 9t/ha	255.6 b
Morrel subsoil 5.5t/ha	238.5 b
Morrel subsoil 11+Gypsum 2t/ha	178.3 c
Nil	172.9 c
Morrel subsoil 5.5+Gypsum 2t/ha	143.3 c
Gypsum 2t/ha	75.7 d

Results followed by the same letter do not significantly differ from each other (P= 0.05)

Local lime source survey

A number of potential on-farm carbonate sources from across the eastern Wheatbelt have been analysed by wet sieve. The samples all have a high percentage (%) of very fine particles in the 0-0.075mm range (Table 5). This could be important to consider in the eastern Wheatbelt as fine particles react more quickly given their larger surface area. They have a range of neutralising values but in all sources the highest neutralising value is always in the larger particles (+2.00mm).

Table 5: The wet sieve particle size distribution % for a range of eastern Wheatbelt on-farm carbonate sources and Limesand also showing the NV% for the very fine particle size (0-0.075mm) and the coarse particle size (+2.00mm). Limesand is highlighted in grey.

Wet sieve particles size %								
+2.00mm	NV%	-2mm +1mm	-1mm +0.5mm	-0.5mm +0.25mm	-0.25mm +0.075mm	0 - 0.075mm	NV%	Total NV%
*12	82	21	15	12	12	19	63	72
*14	81	7	9	10	12	41	55	45
31	67	4	9	7	12	38	35	37
18	68	1	5	5	6	64	34	35
13	61	7	10	10	12	49	26	27
23	68	5	9	7	9	45	11	26
8	57	6	11	8	12	56	14	16
*4	55	10	19	9	4	41	16	13
5	62	5	8	7	8	66	9	12
0		0	2.8	51.8	44.6	0.9	79.4	89

*Kalannie trial sources

Comments

There were big responses to cultivation in 2017 but this effect was reduced in the improved soil moisture conditions of 2018. Offset discs performed as well as the deep rip treatments in both seasons. There was a significant response to ameliorants when cultivation was applied in 2017 but not in 2018. The pH profile under several local lime sources treatments has improved significantly compared to Lime sand. The finer particle sizes with their increased surface area of the local sources would suggest that a faster reaction time could be expected which is key to low rainfall amelioration. Length of time of this effectiveness would need to be monitored by a regular soil testing program. Calculating effective rates based on NV and ENV will be a key component of the economic analysis when comparing a local carbonate source to lime sand from the coast. The use of the NSW based calculator that values the fine particles more highly is possibly the better choice. Cultivation with the offset discs had also incorporated the ameliorants more evenly down the profile to 15cms. Cultivation to aid incorporation is recommended when liming. Local sources with large slaking particles may benefit from a good rainfall event before cultivation to ensure a better distribution of fine particles through the soil. Wet sieve analysis is also the preferred method of analysing particles size of materials that slake. In 2019 it is planned to sow canola. Canola is more sensitive to soil acidity and it is also a valuable crop to be able to include in a sandplain rotation. Faster amelioration of soil acidity would be very beneficial such as to allow for the inclusion of canola in the rotation.

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Deep soil re-engineering to optimise grain yield under low rainfall conditions

Gaus Azam, Chris Gazey and Richard Bowles, DPIRD

Key Messages

- Wheat grain yield was doubled and water use efficiency (WUE) was as high as 24 kg/mm due to deep amelioration of soil compaction and acidity in the low rainfall region of WA.
- Deep incorporation of lime increased soil pH by more than a unit and decreased Al concentration to below toxic levels within two months of lime application.
- Wheat plants produced root systems 60-65cm deep with deep amelioration of compaction and acidity compared to 20-25cm deep for the untreated control. Deeper roots allowed plants to extract soil water and nutrients from deeper soil horizons and avoid moisture stress, in absence of sufficient rainfall, during the grain filling stage.

Aim

The trial was conducted in a paddock near Kalannie, Western Australia, where a wheat crop was grown in small plots under no soil constraints (to an approximate depth of 45cm) to quantify the yield potential and WUE of wheat on an ameliorated acidic sandplain.

Background

More than 70% of topsoil samples and almost 50% of subsurface (10-20 and 20-30cm) layer samples collected from the WA wheatbelt were below the minimum recommended pH targets of 5.5 and 4.8 (Gazey et al., 2013). These soils are acidic due to the historic contribution of the leguminous native plants and/or due to intensive use of ammonium based fertilisers and export of food and fibre from the farm. Conventional application of surface applied agricultural lime to treat acidic soil takes many years to improve soil pH deeper in the soil profile (Li et al., 2019) and increase crop yield (Whitten, 2002). While grain yield increases occur, the number of years that elapse before yield improves, and economic benefit is realised, is a barrier for many growers. Therefore, growers are looking for more rapid methods to correct subsurface soil acidity.

A large proportion of acidic sandplain is also compacted (van Gool 2011). Literature suggests that physical incorporation of lime through tillage operations to an acidic soil could be the most effective way of improving soil pH while reducing soil compaction (Davies 2014). Scanlan et al (2014) suggested that if an efficient tillage operation is used to mix to the depth where the soil pH constraint occurs, then an immediate payback on lime and cultivation is possible. However, currently used soil amelioration practices (e.g. deep ripping, liming) are found to partially remediate soil acidity and compaction. Such soil renovation generates variable crop yield responses as we observed from various long-term field trials (Davies 2018).

In paddocks where multiple soil constrains such as compaction and subsoil acidity are present, most crop roots are confined within 20-30cm of the surface. With such shallow roots a large proportion of growing season rainfall quickly drains away beyond the root zone. The aim of this filed trial was to test whether ‘Re-engineering’ (deep tillage and lime incorporation) soils profile with multiple constraints can significantly improve rooting depth of grain crop towards optimising water use efficiency (WUE) and grain yield.

Trial Details

Trial location	Nixon property, Kalannie
Plot size & replication	3m x 2m x 2 replications
Soil type	Acidic (Wodjil) sand
Soil pH ($CaCl_2$)	0–10cm: 4.4 10–20cm: 3.9 20–30cm: 3.9
Paddock rotation:	2017 wheat, 2018 wheat
Sowing date	10 May 2018 (1 June 2018 re-sown)
Sowing rate	60 kg/ha Mace wheat
Fertiliser	11 May 2018 (MAP 37 kg/ha, SOP 10 kg/ha); 29 May 2018 (Urea 57 kg/ha)
Herbicides, Insecticides & Fungicides	10 May 2018 (Pre-sowing: Triflur 2 L/ha, Sprayseed 250 2 L/ha, Sakura 118 g/ha); 11 July 2018 (Post-emergence: Velocity 670 mL/ha, MSO 1%)

Treatments

T0	Control	zero grading, zero lime
T 1	Excavation + 0 t/ha lime	Grade 10cm, then 10–30cm, keep soils from each layer separately, rotary hoe 30–45cm without spreading lime; back-fill the plots layer-by-layer without adding any lime.
T 2	Excavation + 1.5 t/ha lime	Grade 10cm, then 10–30cm, keep soils from each layer separately, rotary hoe 30–45cm without spreading lime; back-fill the plots without adding any lime to the 10–30cm subsoil; back-fill topsoil (0–10cm) and incorporate 1.5 t/ha lime with a manually operated rotary hoe.
T 3	Excavation + 4.5 t/ha lime	Grade 10cm, then 10–30cm, keep soils from each layer separately, rotary hoe 30–45cm without spreading lime; back-fill 10–30cm and incorporate 3.0 t/ha lime with a rotary hoe; back-fill topsoil (0–10 cm) and incorporate 1.5 t/ha lime with a rotary hoe.
T 4	Excavation + 6 t/ha lime	Grade 10cm, then 10–30cm, keep soils from each layer separately, incorporate 1.5 t/ha lime with a rotary hoe to 30–45cm; back-fill 10–30cm and incorporate 3.0 t/ha lime with a rotary hoe and back-fill topsoil (0–10 cm) and incorporate 1.5 t/ha lime with a rotary hoe.

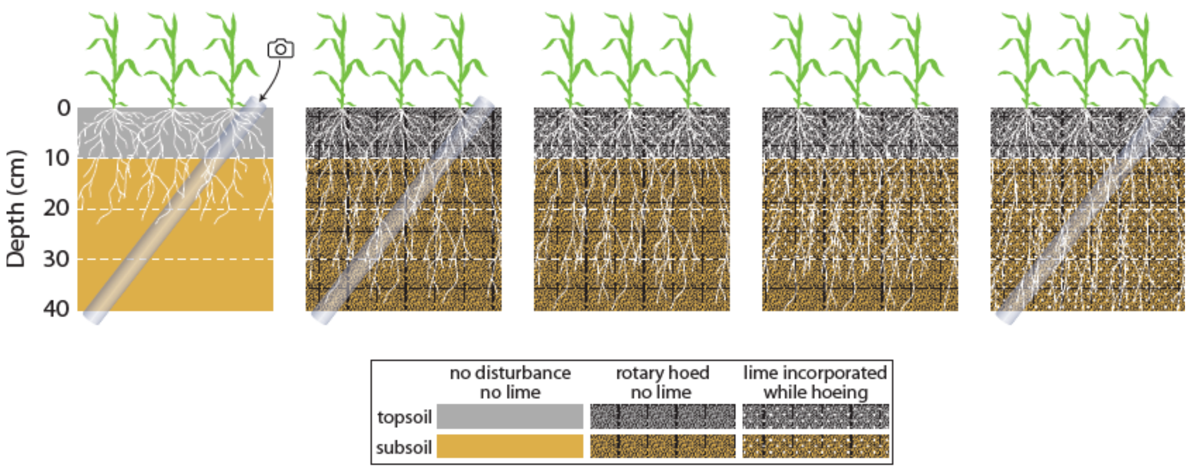

Figure 1: A schematic diagram of the four amelioration treatments and the control.

Results

Rainfall and temperature in 2018

Season 2018 began with average rainfall but the rainfall in spring, especially the month of September, was well below average (7mm, figure. 2a). The total rainfall for the shortened growing season (May-September) was 187 mm. There were only two days with negative air temperature and these were not low enough to cause crop damage (figure. 2b).

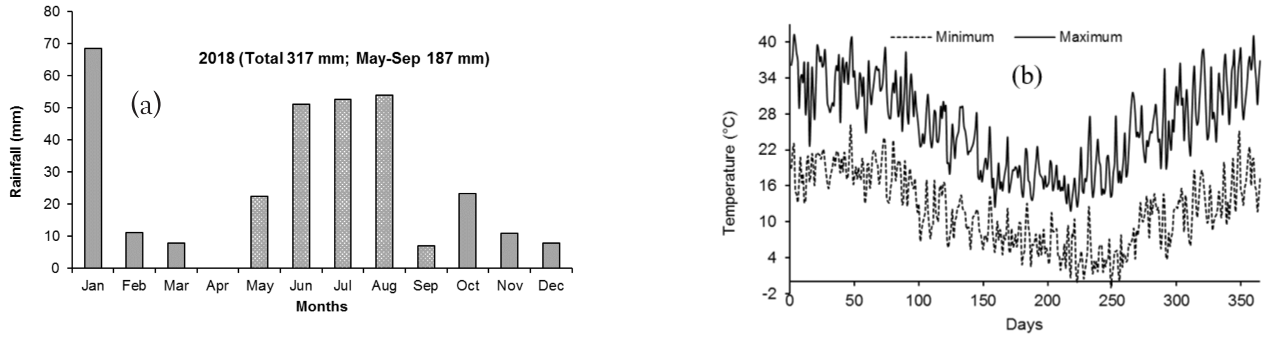

Figure 2: (a) Monthly total rainfall, and (b) daily minimum and maximum temperatures at the trial site in 2018.

Soil excavation completely removed compaction to the depth of excavation (Fig. 3a). Lime incorporation lifted soil pH of the treated soil horizons well above the minimum recommended pH_{Ca} of 5.5 in the surface and 4.8 in the subsurface (Fig. 3b). Liming also decreased total Al from a very toxic range (18-27 mg/kg in the control subsoil) to a non-toxic level of <5 mg/kg (Fig. 3c).

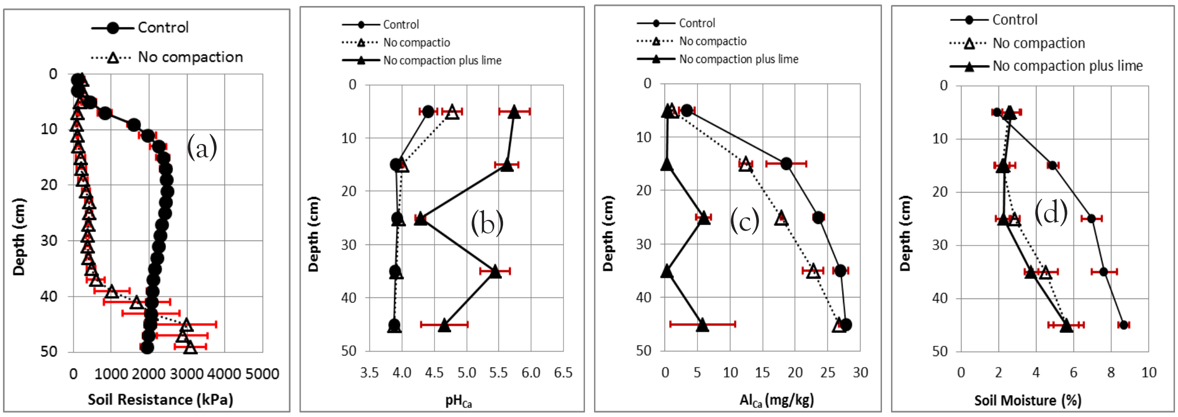

Figure 3: (a) Soil strength on 18 May, (b) Soil pH_{Ca} on 08 August, (c) Soil aluminium on 08 August, and (d) Soil moisture on 23 August.

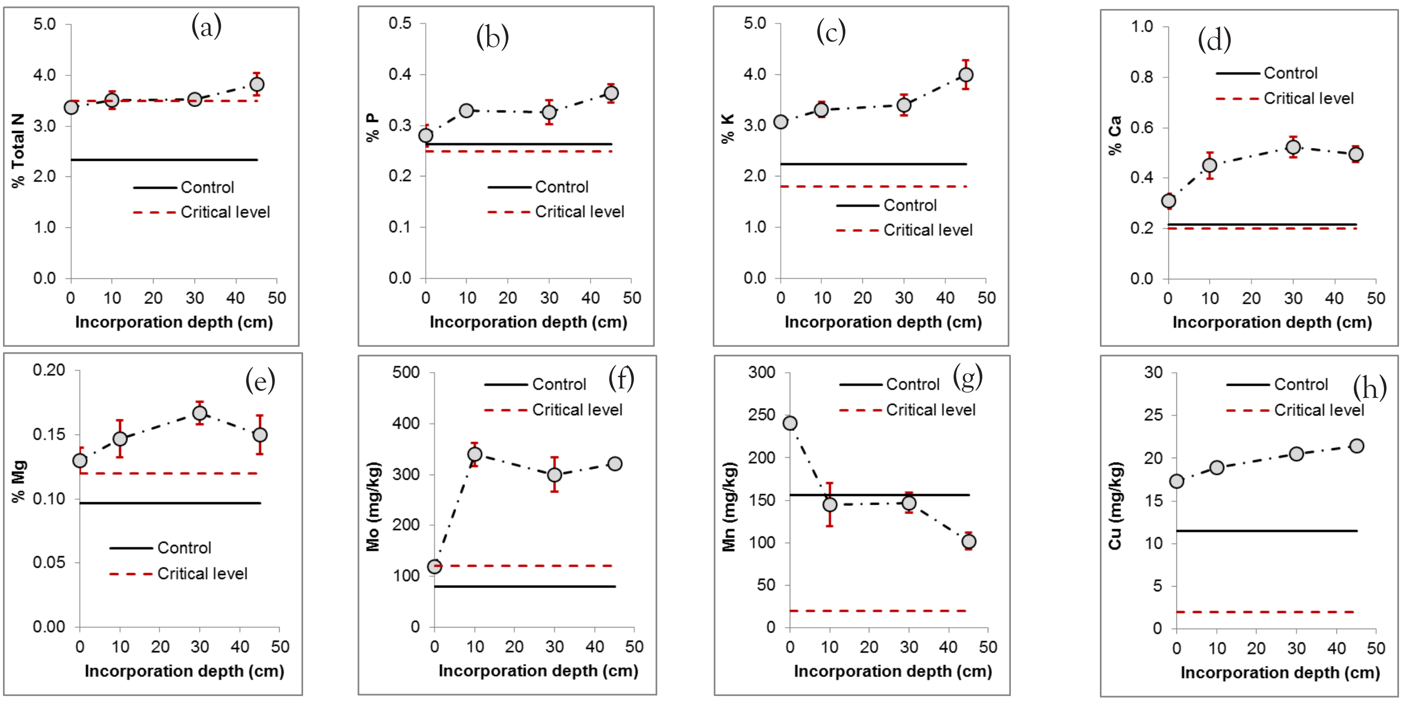

Figure 4: Concentration of (a) total N, (b) P, (c) K, (d) Ca, (e) Mg, (f) Mo, (g) Mn and (h) Cu in wheat tissue at tillering. Incorporation depths, on X-axis, correspond to T1 (0 t lime and incorporation only), T2 (1.5 t lime incorporated to 10cm depth), T3 (4.5 t lime incorporated to 30cm depth) and T4 (6 t lime incorporated to around 45cm depth). Vertical bars represent ± standard error of the mean nutrient concentration.

Due to the above improvement in soil chemistry and physics, there was significant improvement in root growth. Root growth was restricted to within 20-25cm depth for the unameliorated control. For treatments T1-T4 wheat roots grew up to 60-65cm depth, where lime was incorporated at depths (T3 and T4), there were more fine roots and roots hairs in the deeper horizons. The wheat crop growing on ameliorated soil profiles was found to extract more water (Fig. 3d) and nutrients (Fig. 4). In the untreated control plots a large proportion of the soil water remained unused (Fig. 3d).

Liming significantly increased N, P, K, Ca, Mg, Mo and Cu concentration in wheat tissue at tillering stage. Lime and incorporation had some negative effect on Mn and Zn concentration in wheat tissue, but their concentrations were still higher than the critical levels.

Plant biomass production in the ameliorated soil profiles was doubled (Fig. 5a). This improvement in biomass production did not affect the grain filling (i.e., harvest index was not different, Fig. 5c) despite having a dry month of September (Fig. 2a). Ultimately, wheat grain was more than double in the deep lime incorporated treatment compared to the untreated control (Fig. 5b). Incorporation of 6 t/ha lime to 0-45cm depth was significant better than the incorporation of 1.5 t/ha lime to 0-10cm soil. T1 (removal of compaction only) also increased grain yield by 70% compared to the untreated control. WUE was also doubled (24 kg/mm) compared to the untreated control (11 kg/mm). These improvements in plant growth, grain yield and WUE strongly correlated with depth of amelioration of in soil acidity and compaction.

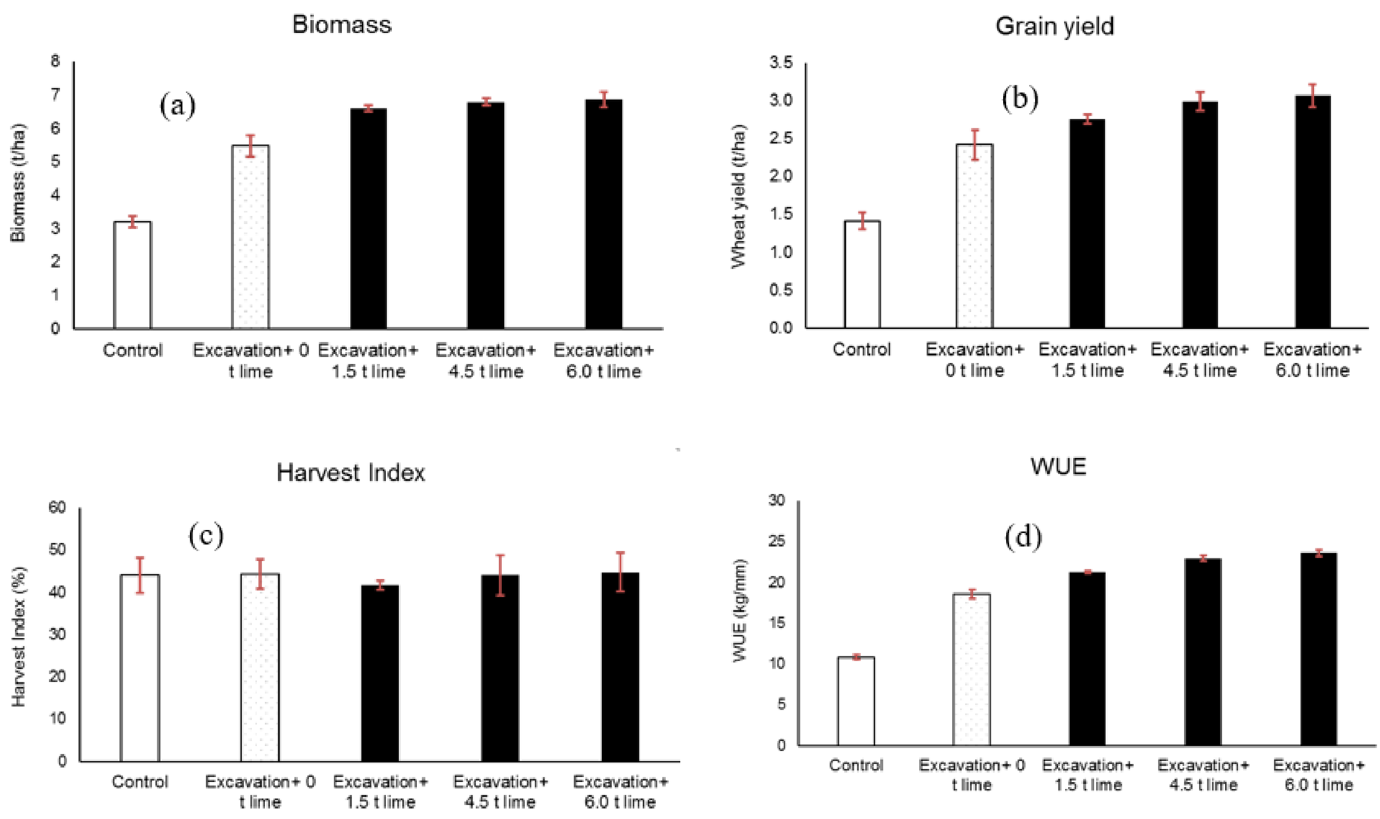

Figure 5: Improvement in wheat (a) biomass, (b) grain yield, (c) harvest index and, (d) water use efficiency in 2018 due deep incorporation of lime. Vertical bars represent ± standard error of the mean values of the respected parameters. Scales on Y-axes are different due to differences in response of different parameters.

Comments

Our results suggest that deep incorporation of lime increased soil pH by more than a unit within two months of lime application. This improvement in soil pH also decreased Al concentration to a completely non-toxic level. Complete removal of compaction (by grading and back-filling) and lime incorporation produced deep root systems (with fine roots and root hairs), which allowed plants to extract soil water and nutrients from deeper soil horizons (Scanlan et al., 2014). With the above improvement in soil chemistry as well as water and nutrient uptake, plants growth was improved significantly. In addition, plants growing in ameliorated plots were not susceptible to the dry finish of the season 2018.

This trial demonstrated that deep amelioration of soil compaction and acidity could double the wheat grain yield, which exceeded the modelled yield potentials for the low rainfall region of WA, reported in van Gool (2001) and Lawes et al. (2018). The WUE of the wheat crop was as high as 24 kg/mm rainfall, which surpassed the expectation of the local grower. Data will be collected from the trial in 2019 and 2020 to quantify the longevity of the benefits. Although it is currently difficult to replicate these soil amelioration treatments to a farmer's scale practice, the findings from this trial will benchmark the maximum grain yield potential at the site.

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Combined application of lime and gypsum boost grain yield in acidic soil

Gaus Azam, Chris Gazey and Mario D'Antuono, DPIRD

Key Messages

- Liming, with or without incorporation, significantly increased wheat grain yield from the first year of the trial. This is due to the increase in soil pH and hence a decrease in aluminium (Al) toxicity. Higher soil pH, due to liming, improved uptake of major macronutrients but decreased Zn and Mn.
- Gypsum also improved grain yield; but not by improving soil pH or reducing total Al concentration. Gypsum greatly increased the ionic strength of soil throughout the profile which might have reduced the relative activity of Al. Gypsum provided an extra amount of S, Ca and micronutrients.
- The application of lime and gypsum together had a greater synergistic effect to improve grain yield than the application of either individually. This can be explained because lime increased soil pH and hence decreased total amount of Al in soil solution. Gypsum likely altered toxic Al into non-toxic forms and leached deeper in the soil. Combined application of lime and gypsum also had a synergistic effect, improving the uptake of most macronutrients.

Aim

The trial was conducted in a paddock near Kalannie, Western Australia, where a wheat crop was grown in small plots to evaluate the interactive effect of lime and gypsum application, with or without incorporation, on subsoil acidity, Al toxicity and grain yield.

Background

Subsurface soil acidity (low pH) is a widespread phenomenon in the Mediterranean climatic region of south Western Australia (Gazey et al., 2014). At low soil pH the toxic forms of aluminium (Al) increase and significantly limit root growth and crop yield (Kopittke et al., 2015). Incorporation of agricultural lime to an acidic soil can increase soil pH which reduces the level of the toxic forms of Al. However, lime is usually applied at the surface soil and it can take several years to increase subsurface soil pH (Li et al., 2019).

Previous work suggests that physical incorporation of lime in the subsurface soil increases the rate of change of subsurface soil pH (Scanlan et al., 2017). However, physical incorporation using tillage equipment makes the liming process expensive for many growers. Another suggested method for quick amelioration of acidic subsoil is the application of gypsum on the soil surface. Surface applied gypsum rapidly moves into the subsoil and may reduce toxic forms of Al, as well as supplying additional calcium (Ca) and sulphur (S) where it is deficient (Sumner et al.,1986). The addition of extra Ca may play a role in reducing Al activity by increasing electrical conductivity (EC) and ionic strength (Is) of the soils (McLay et al., 1994b; Rengel, 1992). McLay et al. (1994a) reported an initial, large increase in wheat grain yield, due to gypsum application, in the eastern wheatbelt of Western Australia (WA). However, there was a negative effect of gypsum on grain yield after the second year of the trial. Treatment with gypsum alone produced inconsistent results in improving crop yield in acidic soil (Smith et al., 1994). Therefore, there is confusion amongst growers in adopting gypsum application as part of management strategies for acidic soils. There is also a large gap in understanding the underlying mechanism of how gypsum brings beneficial chemical changes in soils (Zoca and Penn, 2017).

Trial Details

Trial location	Nixon property, Kalannie
Plot size & replication	20m x 1.8m x 3 replications
Soil type	Acidic (Wadjil) sand
Soil pH ($CaCl_2$)	0-10cm: 4.4 10-20cm: 3.9 20-30cm: 3.9
Paddock rotation:	e.g. 2017 wheat, 2018 wheat
Sowing date	10/05/2018 (04/06/2018 re-sown)
Sowing rate	60 kg/ha Mace wheat
Fertiliser	11/05/2018 (MAP 37 kg/ha, SOP 10 kg/ha); 29/05/2018 (Urea 57 kg)
Herbicides, Insecticides & Fungicides	10/05/2018 (Pre-sowing: Triflur 2 L/ha, Sprayseed 250 2 L/ha, Sakura 118 g/ha); 11/07/2018 (Post-emergence: Velocity 670 ml/ha, MSO 1%)

Treatments

	4 rates of lime x 4 rates of gypsum x with/without cultivation
Lime rates:	0, 2, 4 and 6 t/ha
Gypsum rates:	0, 1, 2 and 3 t/ha
Cultivation:	No cultivation and one-way ploughing (OWP) to 20 cm depth

Results

Rainfall in 2017 and 2018

The two growing seasons were contrasting in terms of rainfall for sowing and finishing the crop (Fig. 1a). Season 2017 had a dry start but finished with average rainfall for the district. In contrast, 2018 started with greater than average rainfall but received well below average rainfall in the month of September. In 2017, the growing months (May-September) received only 124 mm rainfall compared to 187 mm for the same months in 2018. There were only two days with negative air temperature in both years and these were not low enough to cause crop damage (Fig. 2b).

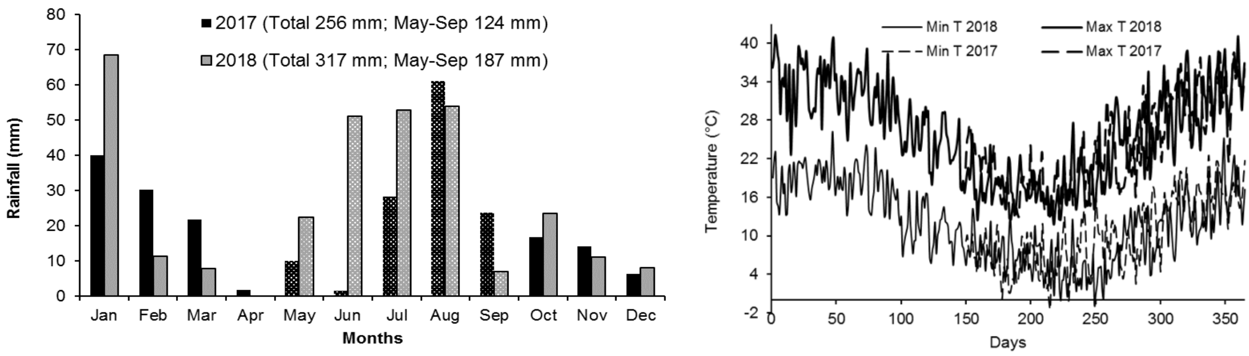

Figure 1: (a) Monthly total rainfall, and (b) daily minimum and maximum temperatures at the trial site during 2017 and 2018.

Grain yield

There was a large difference between the overall trial wheat yield for 2017 (0.95 t/ha) and 2018 (1.85 t/ha) primarily due the differences in rainfall during crop growing months. An extra 64 mm rainfall in 2018 produced an extra 0.9 t/ha wheat crop compared to 2017 season. The interaction of tillage x lime rate x gypsum rate was not significant in either growing season (Fig. 2). The interaction of lime rate x gypsum rate was significant in 2017 (P=0.040) with a polynomial contrast, but it was not significant in season 2018. The main effect of tillage was significant in 2017 (P=0.078), but not significant in season 2018. The main effect of lime was significant in both 2017 (P ≤0.001) and 2018 (P ≤0.001). The grain yield increase in response to lime rate was significant in 2017 but not in 2018. The main effect of gypsum was also significant in both 2017 (P=0.087) and 2018 (P=0.054). However, yield responses to gypsum rate were not significant in either season as 1 t/ha gypsum was optimal for the wheat grain yield.

Overall there was a 13% increase in wheat grain yield from lime treated plots over the control (ripping only) in 2017 (Fig. 2c and 2d). Gypsum did not increase crop yield as much (average 5% increase in yield). In general, combined application of lime and gypsum increased yield more than either ameliorant alone. For example, application of 6 t/ha of lime with 3 t/ha of gypsum without incorporation produced 30% more grain (1.04 t/ha) than the control (0.79 t/ha). Whereas 6 t/ha lime alone increased yield to 0.99 t/ha and 3 t/ha gypsum increased yield to 0.85 t/ha. Similarly to 2017, there was an average 12% increase in wheat grain yield from lime treated plots over the control (ripping only) in 2018 (Fig. 2a and 2b). Overall application of gypsum had an 11% yield benefit over the control. As with 2017, the combined application of lime and gypsum increased yield by more than the application of lime or gypsum individually. Incorporation of 6 t/ha lime plus 3 t/ha gypsum produced 23% more grain (2.05 t/ha) than the control (1.66 t/ha). Whereas 6 t/ha lime alone increased yield to 1.86 t/ha and 3 t/ha gypsum increased yield to 1.82 t/ha.

The wheat grain yield was positively correlated with the number of tillers or heads per unit area, plant biomass yield and the size of the wheat head. However, no such relationship was found between the grain yield and plant emergence count nor the NDVI reading (collected at tillering stage). Lime and gypsum treatments did not affect any grain quality parameters in 2017 however, there was a significant increase in wheat protein due to incorporation in 2017. Wheat grain from the incorporated plots had 12.4% protein compared to 10.9% in non-incorporated plots.

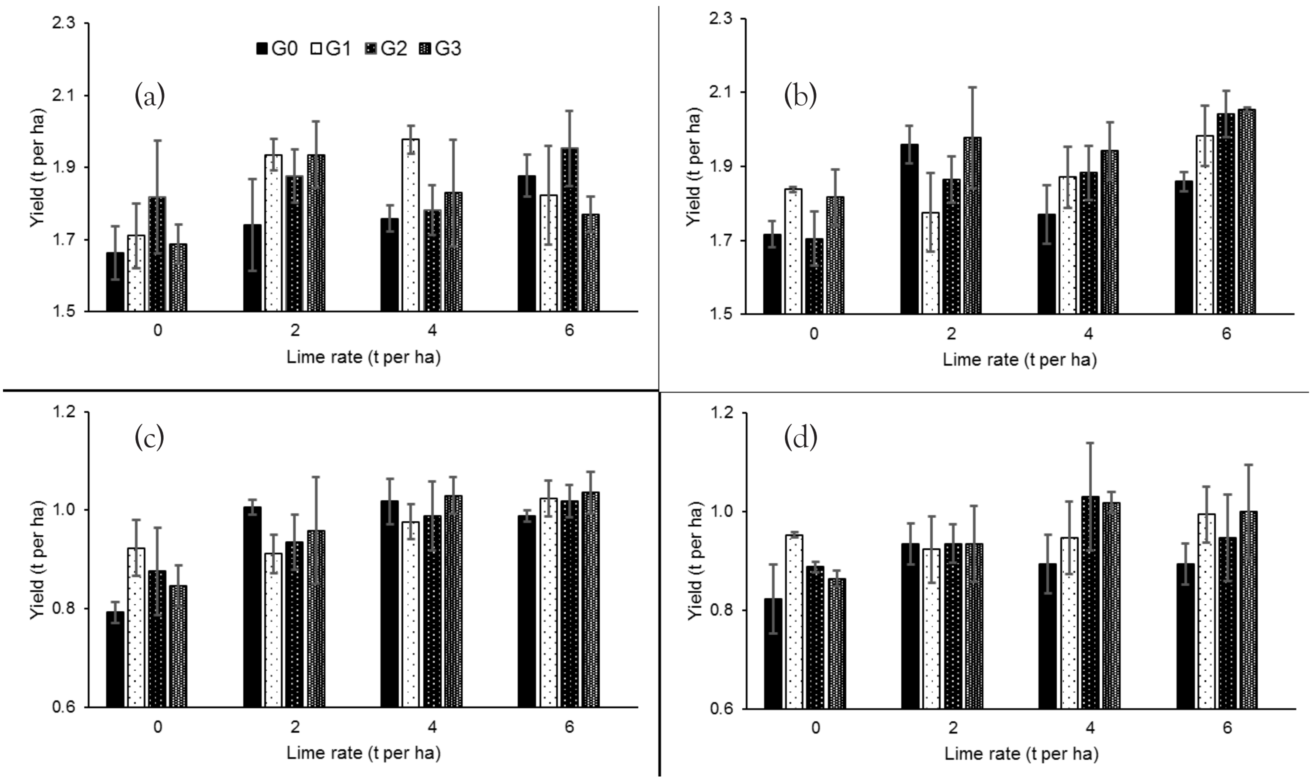

Figure 2: Improvement in wheat grain yield in 2017 (c and d) and 2018 (a and b) due to interactive application of lime and gypsum under no incorporation (a and c) and incorporation (b and d) treatments. Vertical bars represent ± standard error of the mean wheat yield. Scales on Y-axes are different due to varying responses from crop in two different seasons. Trend lines show the mean grain yield across the lime rates.

Amelioration of acidity and Al toxicity

The interaction of lime rates x tillage treatments as well as the individual effects of these two factors significantly increased soil pH_{Ca} in the top 20 cm (Fig. 3a and 3b). There was no interaction with gypsum and the main effect of gypsum did not change soil pH_{Ca}.

Without incorporation, all lime treated plots had higher soil pH_{Ca} in 0-5 and 5-10 cm depths compared to the unlimed control plots. Top soil target pH_{Ca} (>5.50) was achieved but only in 0-5 cm depth. No significant increase in soil pH_{Ca} was recorded in soil below 0-10 depth. On the other hand, with incorporation all lime rates had significantly higher pH_{Ca} to the depth of cultivation (in top 20 cm). There were some positive changes in soil pH_{Ca} in 20-30 cm depth but the difference was not significant. Under both tillage treatments, higher lime rates tended to have higher pH_{Ca}.

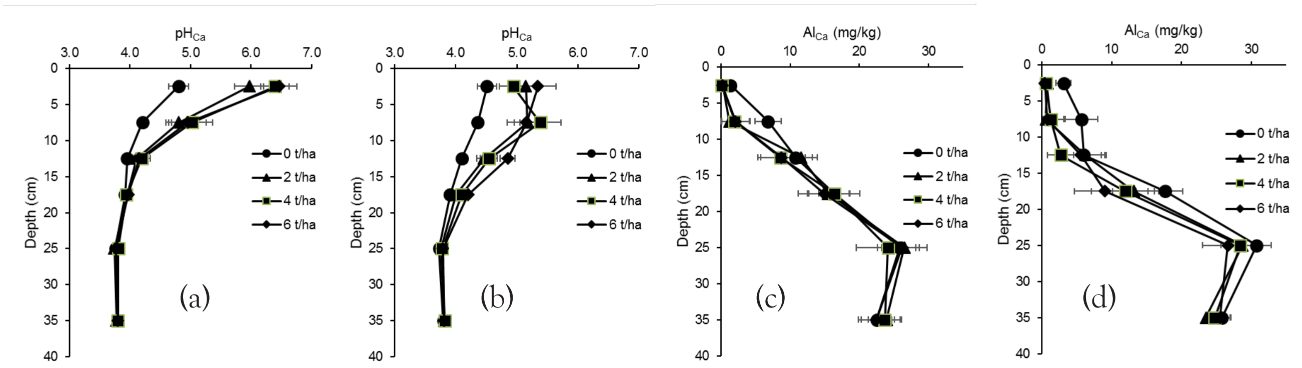

Figure 3: Changes in soil pH (a and b) and aluminium chemistry (c and d) due to application of lime under no incorporation (a and c) and incorporation (b and d) treatments. Horizontal bars represent ± standard error of the mean pH and aluminium concentration.

Again the interaction of lime rates by tillage treatments was significant to decrease soil Al_{Ca}. The individual effect of lime was also significant to decrease concentration of Al_{Ca} (Fig. 3c and 3d). Without incorporation, all lime rates decreased Al_{Ca} concentration but only in 0-10 cm depth (Fig. 3c). Whereas with incorporation lime decreased Al_{Ca} in 0-30 cm depth (Fig. 3d). It was noticed that a very small increase (statistically not significant) in soil pH_{Ca} (Fig. 3b) could decrease the concentration of Al_{Ca} significantly in 20-30 cm depth (Fig. 3d). The interaction of tillage and gypsum had a negative effect on Al_{Ca} below 20 cm depth where there was an increase in Al_{Ca} concentration (probably a less toxic aluminium complex, for example, aluminium sulphate) accumulated from the leachate of the gypsum incorporated layer (data not presented).

Gypsum application significantly increased soil EC throughout the profile (0-40 cm) and hence the ionic strength (I_s) of the soil (data not presented). In general, the I_s of gypsum treated soil was at least doubled compared to the control. The effect of lime rates on EC and I_s was inconsistent and not as great as gypsum. Tillage treatment had no effect to increase soil EC and I_s.

There was no difference between treatments in soil moisture content (data not presented). Lime treated plots tended to have lower soil moisture in the subsoil but it was not significant and not consistent throughout the season.

Nutrient concentration in wheat tissue

The interaction of lime and gypsum application had a significant effect to increase total N concentration in wheat tissue at Z65 growth stage but no such effect was noticed in P and K concentrations. The main effect of liming was significant to increase the concentrations of total N (data not presented), P (Fig. 4a) and K (data not presented). Liming also increased Ca (Fig. 4c) and Mg (data not presented) uptake as we saw higher concentration in wheat tissue collected from limed plots. The main effect of gypsum was not significant for N, P and K but, as expected, gypsum application significantly improved S and Ca concentration in wheat tissue (Fig. 4b and 4c). Tillage did not decrease or increase the concentration of macronutrients in plant tissue.

Gypsum application increased the concentration of B (data not presented), Mn (Fig. 4d) and Zn concentration (data not presented) in wheat tissue collected at Z65 stage. On the other hand, lime decreased the concentration of Mn (Fig. 4d) and Zn in wheat tissue (data not presented). Neither lime nor gypsum application affected the concentration of Cu, Mo and Fe (data not presented). None of the treatments decreased nutrient level below the critical levels.

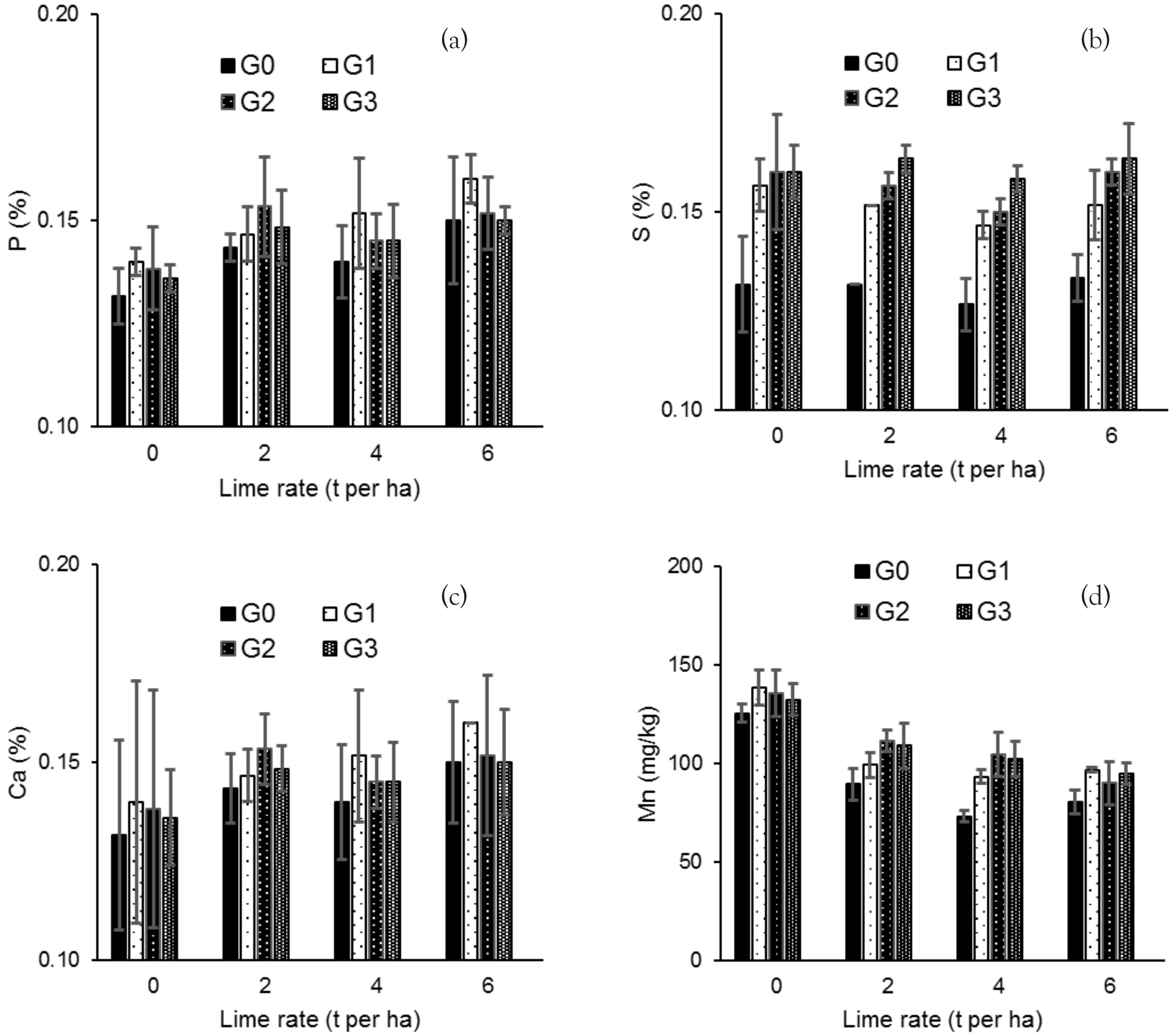

Figure 4: Concentration of P (a), S (b), Ca (c) and Mn (d) in wheat tissue at Z65 growth stage due interactive application of lime and gypsum. It should be noted that measurements on some of the nutrients are not presented here. Vertical bars represent ± standard error of the mean nutrient concentration.

Comments

It is clear from this field trial that liming can significantly increase grain yield. This effect was consistent across two contrasting seasons in the low rainfall zone of WA. This yield improvement is driven by the increase in soil pH and hence decrease in Al toxicity (e.g. our data and Li et al., 2019). Increased soil pH also leads to improved uptake of major macronutrients (Scanlan et al., 2017). In this experiment, increased soil pH resulted in a decreased uptake of some micronutrients (especially for Zn and Mn). However, none of nutrients was below the critical level and therefore there was no negative effect of these micronutrient levels on grain yield nor quality.

It is also evident from this trial that gypsum can improve wheat grain yield, which is similar to McLay et al. (1994a), but not by improving soil pH nor total aluminium concentration, as found by McLay and his colleagues (1994b). In our experiment, the result was consistent whether gypsum was applied at the surface or incorporated. However, gypsum increased total Al concentration deeper in the soil horizon. A large proportion of this total Al measurement could be in non-toxic forms of Al, as shown by Damon et al. (2018). Gypsum greatly improved the ionic strength of soil and this was observed at every depth as found by McLay et al. (1994b). Obviously, gypsum provided extra S and Ca in the soil solution that led to their increased uptake by the crop. Gypsum also increased plant uptake of some micronutrients such as B, Mn, and Zn.

The application of lime and gypsum together had a synergistic effect on grain yield. This is a similar result to that reported by others (e.g. McLay et al., 1994a). This is likely due to the fact that lime increased soil pH and hence decreased the total amount of toxic Al in soil solution. Gypsum on the other supplied additional Ca and S as well as improving the uptake of micronutrients. In addition, gypsum probably helped by changing toxic Al into non-toxic forms and caused Al to leach deeper. Increases in the 20-40 cm soil samples were observed with gypsum application, however, it did not reduce the total amount of Al in soil solution. The combined application of lime and gypsum also had a synergistic effect in improving uptake of the most macronutrients, especially total N.

In the first year, the lime and gypsum incorporation by tillage (one-way plough) treatment was not as good as surface application of the ameliorants. It is likely that ploughing induced higher loss of soil water through evaporation, as evidenced by a negative effect on crop establishment. Ploughing is also likely to degrade soil structure and change soil chemistry established in a minimum tillage system (Whitten et al, 2000). However, in the second year, lime and gypsum incorporation treatments, especially with higher rates, outperformed the surface application. This trend is likely to continue in future years.

Acknowledgements
The research undertaken as part of GRDC invested project DAW00252, the author would like to thank them for their continued support. We would also like to thank staff at the Department of Primary Industries and Regional Development at Northam. We are also very grateful to the Nixon family for allowing us to conduct this trial on his property and providing machinery support.

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Recurring lime applications to fix acidity in the whole soil profile

Gaus Azam, Chris Gazey and Richard Bowles, DPIRD

Key Messages

- Un-limed soil was acidified in the subsurface by almost a whole pH unit over 23 years. Once-off lime application in 1994 was not sufficient to move any alkalinity from lime to the subsurface soil.
- Soil that was limed three times over the 23-year period had higher soil pH throughout the top 30 cm. These soils had a soil pH higher than 5.5 in the top 10 cm, thus allowed movement of alkalinity to the subsurface soil.
- The long-term benefit of surface liming to boost the grain yield was clear, however, deep re-incorporation of undissolved in situ lime (without any new application) was able to increase grain yield further within a cropping season.

Aim

The aim of this study was to estimate the long-term effect of recurring lime applications on subsurface soil acidity. The study also aims to measure the potential use of undissolved lime in the surface soil to improve subsurface soil pH through incorporation at different equivalent depths.

Background

Soil acidity (low soil pH) is a widespread problem in Western Australia (Gazey et al., 2013). At low soil pH the increase in the concentration of toxic forms of aluminium (Al) significantly limits root growth and crop yield (Kopittke et al., 2015). Agricultural lime is usually applied to the surface of the soil to manage acidic soils. Li et al. (2019) found that surface application of superfine (≤250 µm) agricultural limestone with 98% neutralising value at high rates and multiple supplementary maintenance applications took almost two decades to increase subsurface soil pH and exchangeable Al. However, the improvement in subsurface acidity was not up to the target pH_{Ca} of 4.8. Hence the changes in the subsurface soil pH did not equate to the large amount of lime used by Li et al (2019). What fraction of applied lime remained undissolved and how it stratified in the soil profile are yet to be quantified. There are not very many studies on the repeated applications of lime to manage acidity in whole soil profile for the long-term (e.g. 20 years after lime application)—this is particularly the case for WA lime which is coarser than that available in the eastern states. The study consisted field based experimentation using long-term soil acidity management trial at of the Department of Primary Industries and Regional Development (DPIRD) Wongan Hills research station.

Trial Details

Location	Wongan Hills Research Station
Plot size & replication	5m x 1.8m x 4 replications
Soil type	Acidic loamy sand
Soil pH ($CaCl_2$)	0–10cm: 5.1 10–20cm: 4.2 20–30cm: 3.9
Paddock rotation:	2018 wheat
Sowing date	28 May 2018
Sowing rate	60 kg/ha Mace wheat
Fertiliser	11 May 2018 (MAP 37 kg/ha, SOP 10 kg/ha); 29 May 2018 (Urea 57 kg/ha)
Herbicides, Insecticides & Fungicides	10 May 2018 (Pre-sowing: Triflur 2 L/ha, Sprayseed 250 2 L/ha, Sakura 118 g/ha); 11 July 2018 (Post-emergence: Velocity 670 mL/ha, MSO 1%)

Treatments

Lime rates

1994 rates (t/ha)	1998 rates (t/ha)	2014 rates (t/ha)	Total (t/ha)
0	0	0	0
	1.5	0	1.5
		3	4.5
2	0	0	2
	1.5	0	3.5
		3	6.5
4	0	0	4
	1.5	0	5.5
		3	8.5

Incorporation treatments in 2018

T1: no incorporation

T2: rotary spading up to 15cm depth.

T3: rotary spading up to 25cm depth.

Results

Soil pH and aluminium profiles

The 2018 measurements from the Wongan Hills trial showed that soil pH_{Ca} (0–10cm) was significantly higher than the untreated control following a single lime application in 1994 of either 2 or 4 t/ha (Figure 1a). The nil lime and 2 t/ha lime application treatments was significantly more acidic deeper in the profile, especially in 30-40cm depth, by nearly 1 pH unit than the original pH profile measured in 1994 (baseline pH). The 4 t/ha treatment in 1994 had higher pH at 30–40cm than either the nil or 2 t/ha treatment, but no such difference was observed at 10–20cm and 20–30cm soil depths.

Re-liming half the plots with 1.5 t/ha lime in 1998 increased topsoil pH_{Ca} compared to the original levels (Figure 1b). This re-liming, in addition to the previously applied 2 t/ha, did not increase the soil pH_{Ca} of 20-30 and 30-40cm soil above the original 1994 level nor the nil lime treatment. However, addition of 1.5 t/ha of lime with previously applied 4 t/ha in 1994 resulted in higher pH_{Ca} throughout the profile (Figure 1b) compared with the nil limed treatment (Figure 1a).

A second re-liming of 3 t/ha in 2014 resulted in significantly higher pH_{Ca} in 0-10 and 10-20cm depths in 2018 for all treatments, including the nil lime, compared with the original pH in 1994 (Figure 1c). Plots receiving the highest cumulative lime rate (8.5 t/ha) had the highest soil pH_{Ca} at all depths.

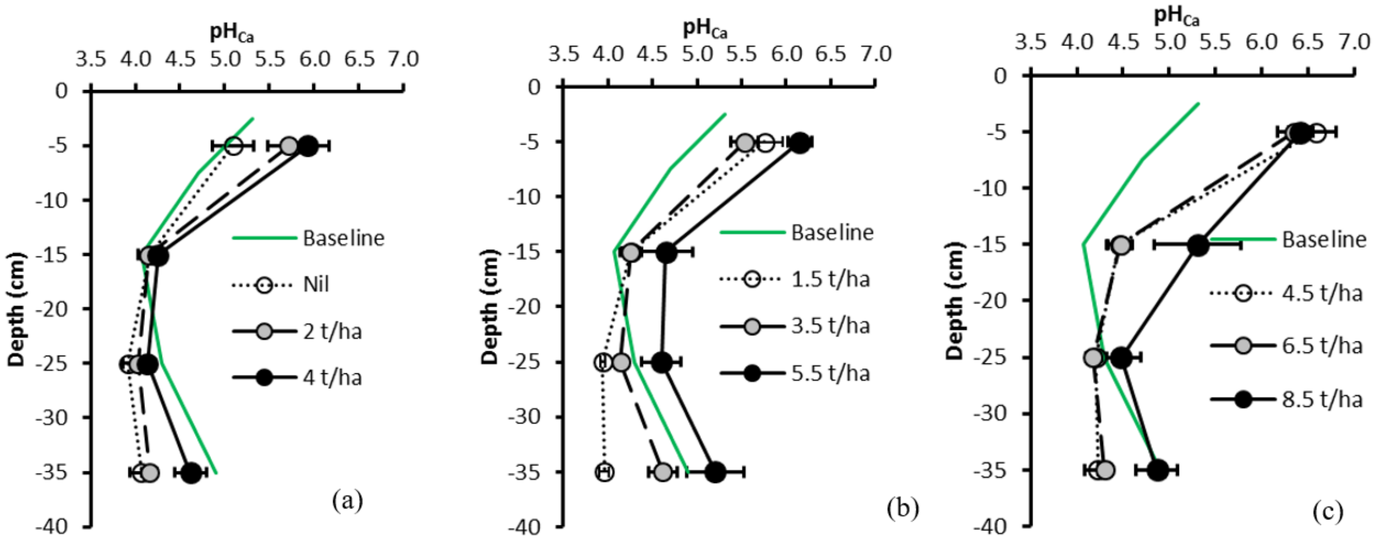

Figure 1: Soil pH profiles measured in autumn 2018 for (a) three original lime treatments applied in 1994, (b) re-limed with an additional 1.5 t in 1998, and (c) re-limed with 3 t in 2014. Green solid lines represent baseline soil pH_{Ca} profile measured in 1994 before the application of lime treatments. Horizontal bars represent ± standard error of the mean soil pH_{Ca}.

The measurements of total Al show that liming had a stronger effect in decreasing total Al than on increasing soil pH_{Ca} (Figure 2). A single lime application in 1994 of 2 or 4 t/ha significantly decreased concentration of total Al at all depths (Figure 2a). Such difference was not observed in soil pH_{Ca} (Figure 1a) because pH is measured in a logarithmic scale. Application of additional 1.5 t lime with previously applied 2 or 4 t/ha had significantly lower total Al than the plots that were not limed in 1994 (Figure 2b). Total Al concentration decreased further with the second re-liming at 3 t/ha in 2014 (Figure 2c). All experimental plots (including zero limed plots in 1994) that received two additional applications (in 1998 and 2014, Figure 2c) had significantly lower total Al at all depths compared to the untreated control (Figure 2a).

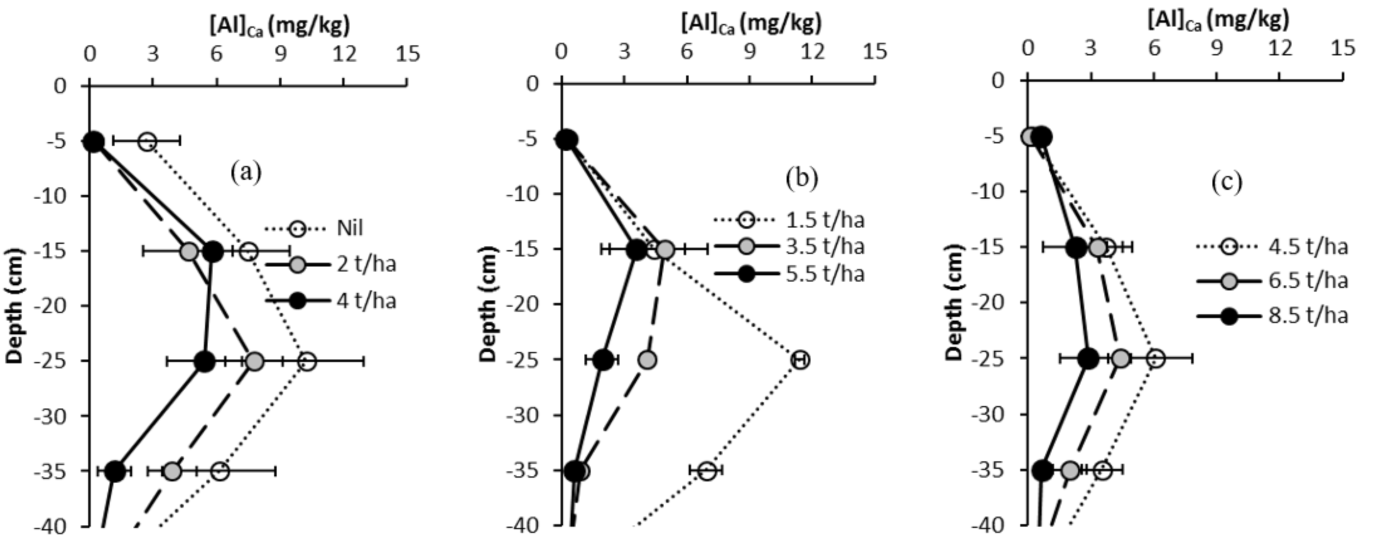

Figure 2: Soil Al profiles measured in autumn 2018 for (a) three original lime treatments applied in 1994, (b) re-limed with an additional 1.5 t/ha in 1998, and (c) re-limed with 3 t/ha in 2014. Horizontal bars represent ± standard error of the mean total Al.

Grain yield

The original lime rates in 1994 x tillage treatments in 2018 significantly increased wheat grain yield (Table 1). Plots that were limed in 1994 at 2 or 4 t/ha and were spaded at 25cm depth had an extra yield of up to 0.9 t/ha (31% yield advantage) over the plots that had never been limed and not been spaded in 2018. Shallow incorporation (15cm) had some negative effect on grain yield compared to the no incorporation or deep incorporation (25cm). The interaction of re-liming in 2014 and tillage treatments in 2018 also had a positive effect on grain yield. No such effect on grain yield was observed for 1998 re-liming.

Table 1: Effect of original lime rates and incorporation depths on the wheat grain yield in 2018. The yield predicted from REML model is shown first, with the measured mean grain yield data in parentheses.

1994 lime rates (t/ha)	No incorporation	Spading (15 cm)	Spading (25 cm)
0	2.86 (2.82)	2.76 (2.70)	2.96 (3.06)
2	3.49 (3.19)	3.36 (3.16)	3.51 (3.33)
4	3.62 (3.20)	3.48 (3.07)	3.75 (3.29)
LSD(5%) = 0.50			

Comments

Soil pH profile data from the Wongan Hills field trial showed that overall lime treated plots had higher soil pH and lower total aluminium concentration than the untreated soils. In untreated soil, pH decreased further from the baseline pH measured at the onset of the trial, in line with results of Li et al. (2019). Two lime rates applied in 1994 were able to increase surface soil pH and protect subsurface soils from further acidification. This once-off lime application was not sufficient to maintain top soil pH high enough to move any alkalinity in the subsurface soil. Plots that received recurrent applications of lime increased soil pH throughout the top 30cm over the 23-year period. These plots with higher rates consistently had a soil pH higher than 5.5 in 0-10 cm depth that allowed movement of alkalinity from lime to the subsurface. Total Al concentration was negligible in top 10 cm soil with one application of lime in 1994. Subsurface total Al also decreased over time to very low levels (< 5 mg/kg).

The long-term liming benefit to increase the grain yield was evident from the Wongan Hills field trial. However, re-incorporation of undissolved lime in the top soil to 25cm depth was able to increase grain yield further from no incorporation within a cropping season. Incorporation of lime can rapidly increase soil pH and decrease Al concentration to the depth of incorporation (Azam et al. 2019). This also can improve availability and uptake of nutrients (Scanlan et al., 2017). Liming also decreased weed growth and density that reduced the competition for water and nutrient (Borger et al., 2019). We recommend that soil should be limed routinely to maintain soil pH profile and grain yield. Lime rates should be sufficient to maintain 0-10 cm soil pH ≥5.5 allowing movement of alkalinity to the subsurface soils.

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Can subsoil constraints be combated economically?

Yvette Oliver, CSIRO

Key Messages

- Spading was slightly better at reducing compaction and incorporating high pH topsoil than the than the offset disc.
- Both offset disc and spading were effective in incorporating the additional surface lime application to increase the soil pH in the top 30cm in about half of the plots.
- Reducing the compaction and increasing the soil pH, improved the root growth and water extraction in the cultivated treatments.
- The yields were higher on acid band soils (acid to 30cm depth) than soils which are acidic to depth (60cm or greater) regardless of treatment.
- Care must be taken in interpretation of yield results due to the variation across the sites of pH deeper in the profile and issues with weeds and establishment.

Aim

To determine which method of amelioration is the most effective and economic in remediating subsoil acidity at depth.

Background

It is estimated that more than 11 million hectares in the Western Australian Wheatbelt are moderately to strongly effected by acidity (Petersen, 2016), making acidity one of the major limiting production factors to modern day farming systems. In monetary terms, this is estimated to cost Western Australian growers $141/ha/year ($1.6 billion/year in lost production potential) while other constraints such as compaction is said to cost the industry just under $1.0 billion/ year (Petersen, 2016). As a consequence, lime has been one of the major inputs in broadacre farming over the last 20 years, with 100% of Liebe members liming in 2012 (Hollamby, 2012).

This trial was designed by a project committee of Liebe members to determine the most effective liming strategy to maximise the return on investment in the Liebe region. The trial is located west of Wubin on a poor performing paddock that has the potential to improve once subsoil constraints have been addressed. A target pH of 5.5 to a depth of 300mm was identified and entered into the Liebe Group's Lime Calculator along with the baseline soil pH results. The Lime Calculator generated a recommendation for lime rates required to achieve the target pH of 5.5. Dolomite has a lower neutralising value than limesand, therefore more product is required to reach the target pH of 5.5 (see trial details).

The trial was implemented in 2015 and consists of four replicates of different mixing (untreated, spaded, offsets) with products applied (untreated, lime, dolomite and lime + dolomite) (Table 1). The trial was top dressed with product and then the different mixing equipment used at right angles to direction of top dressing. In 2015, the pH was measured to a depth of 1m in a selection of the plots. Each plots has been re-sample in Feb 2019, but the results are yet to be analysed.

An automated weather station and moisture probes have been installed at the site to monitor the impacts of treatments, giving further insight into cultivation methods and their effect on water use efficiency (WUE). The soil moisture probes were installed in July 2015 in the 3 replicates of the combinations of spaded and untreated mixing with nil product and lime + dolomite (treatment numbers 1, 2, 10 and 11).

Trial Details

Property	AJ & JA Barnes, west Wubin
Plot size & replication	11.65m x 14m x 4 replications
Soil type	Yellow tammar sand
Sowing date	8/05/2018
Seeding rate	Bonito 2.8 kg/ha
Incorporation	23/02/2015: Offsets Tiny Offset (36 inch discs) 05/03/2015: Spader
Lime History	Pre-trial 2009: 1 t/ha lime Pre-trial 2014: 1.5 t/ha lime 2015: 3.2 t/ha lime only plots, 3.4 t/ha dolomite only plots, 1.65 t/ha each lime & dolomite plots
Paddock rotation	2013 wheat, 2014 fallow, 2015 wheat, 2016 wheat, 2017 fallow (wheat for trial), 2018 canola
Fertiliser	40 kg/ha Urea spread pre seeding 50 kg/ha DAP CZ:MOP (80:20)
Herbicides & Fungicides	Pre-emergent: Glyphosate 450 1.5 L/ha, Atrazine 1.4 kg/ha, Chlorpyrifos 0.2 L/ha Post emergent: Atrazine 1.4 kg/ha, Clethodim 0.5 L/ha, QPE 0.2 L/ha, Chlorpyrifos 0.2 L/ha Late aerial insecticide: Alpha cypermethrin 0.2 L/ha, Chlorpyrifos 0.15 L/ha
Growing season rainfall	199 mm

Table 1 Treatments including two variables - Amelioration product and Cultivation Type

Treatment Number	Lime Treatment	Cultivation Type
1	Control	No Till
2	Control	Spader
3	Control	Offsets
4	Limesand	No Till
5	Limesand	Spader
6	Limesand	Offsets
7	Dolomite	No Till
8	Dolomite	Spader
9	Dolomite	Offsets
10	Lime & Dolomite	No Till
11	Lime & Dolomite	Spader
12	Lime & Dolomite	Offsets

Results

Now in the fourth year the crop establishment was far better with a consolidated seed bed. The trial has a number of factors influencing the results with variable soil acidity profiles and a large weed burden. Both factors are believed to have had an impact on yield and quality and, as a result, care must be taken when interpreting data. Spatial data and soil water probes have been used to better understand the influence of the cultivation and lime treatments on this site.

Soil properties
Penetrometer readings were taken in August 2018, three years after the treatments were imposed. The site had high compaction, with the untreated plots having a penetration resisistance which severely impacts root growth (readings > 3000) in the 10-40cm layers (Figure 1). There were significant differences in the penetrometer readings at the 12cm-25cm depth between the control and the cultivated treaments. The spaded treatments also had significantly lower penetration resistance (lower compaction) than the offset treatment at 15-25cm depth (Figure 1). This may indicate the spadeing was better at reducing compaction than the offsets in this experiment.

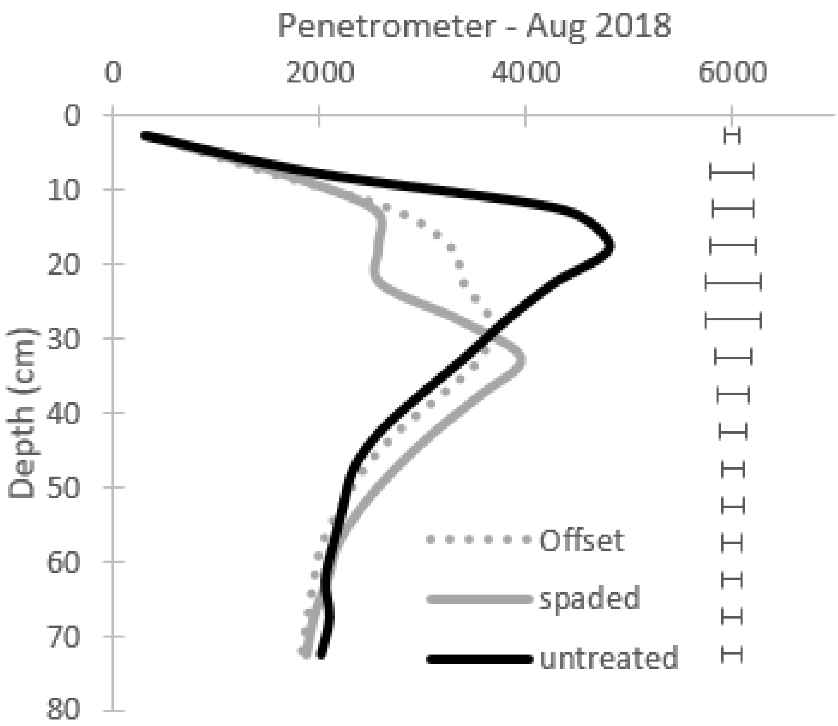


Figure 1: Penetration resistance taken in 4-5 locations in each plot and averaged for each cultivation treatment (with lsd for treatment signficance)

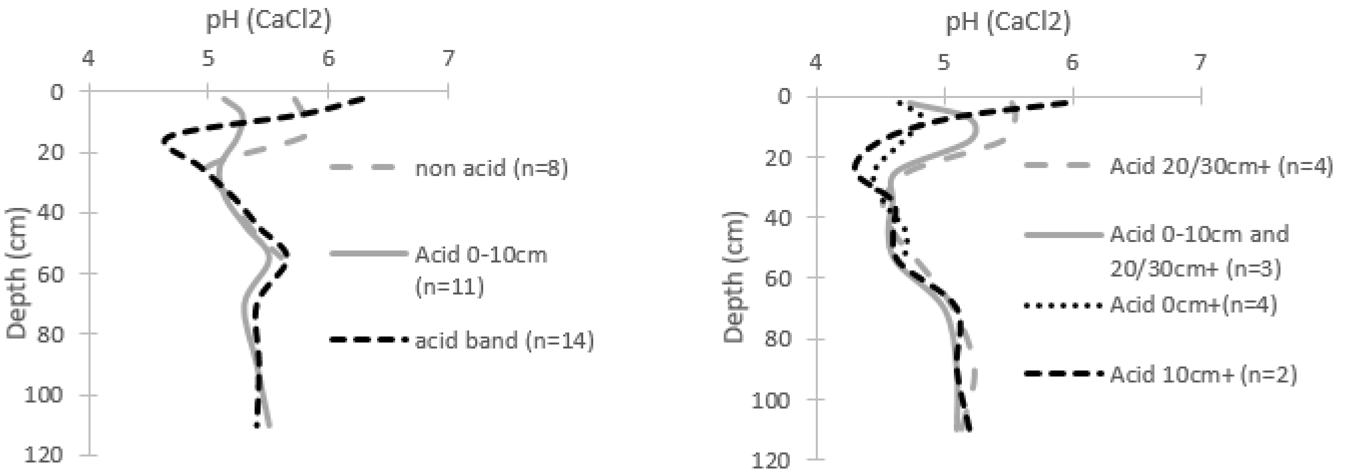
From the preliminary soil sampling (in 2015 at 10 plots, previous lime applications (in 2009 and 2014) was still sitting in the 0-5cm layer of topsoil. After the application of cultivation and lime treatments, the pH and Aluminium were re-measured in every plot in 2016 and 2019 (Figure 2, 3). Soil layers were classed as acidic when pH was < 5.5 in the topsoil and <4.8 for depths greater than 10cm. The pH below 30 or 40cm was used to define all the plots as either:

1. Acid band - Soils which have acidic layers from 10cm to 30 or 40cm depth and were not acidic below these depth (34 plots).
2. Deep acid - Soil which have acidic layers from 10cm to 60cm or deeper (14 plots)

After cultivation and lime treatments were imposed both the acid band soils and deep acid soils had four pH profile types (Figure 2 a, b), which were then related to how well the soil water ameliorated (or not) (Table 2). The deeper acid soils also had greater Aluminium content (Mg/kg) in the 10-60cm depths compared to the acid band soils (Figure 3a, b). The deeper acid plots more commonly occurred in the southern end of the trial (Figure 4) and unfortunately were not distributed evenly among the treatments.

Table 2: Soil pH profile names (used in Fig 2) for the different amounts of amelioration

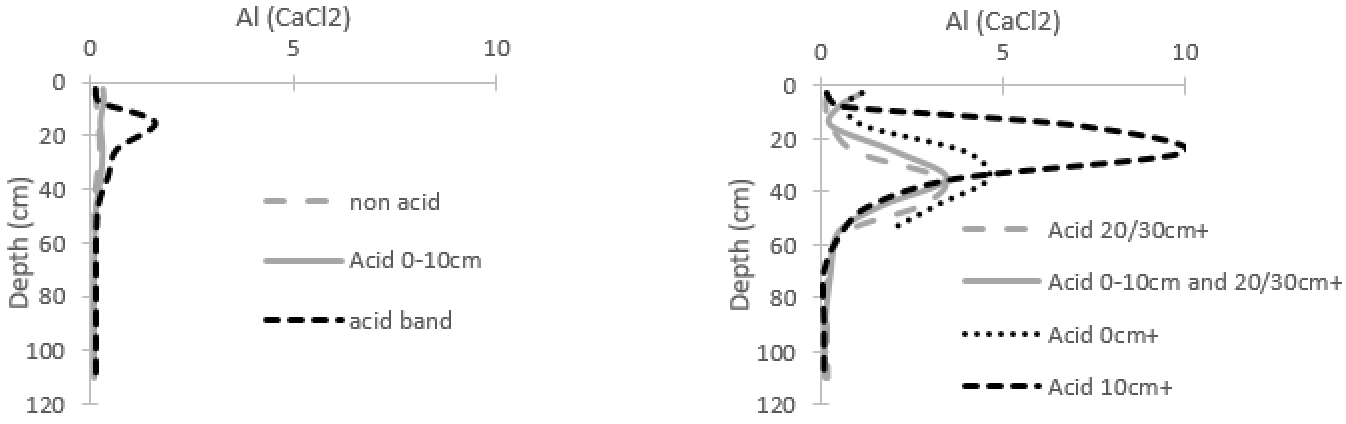
Amelioration amount	What was ameliorated	pH profile types (Figure 2)	
		Acid band	**Deep acid**
No change	no change in the pH	acid band	acid 10+ = Acid 10-60cm (or greater)
No amelioration	Reduced the pH below the 5.5 threshold in the topsoil AND the subsoil was not ameliorated		Acid 0+ = Acidic from 0-60cm (or greater)
Partially ameliorated	Reduced the pH below the 5.5 threshold in the topsoil and increased pH above 4.8 in part of the subsoil:	Acid 0-10cm = acidic 0-10cm layer	Acid 0-10cm, 20+ = Acidic 0-10cm and 20cm-60cm layers
Ameliorated soil to 30cm	Kept pH above 5.5 in topsoil AND increased PH in 0-30cm layer above 4.8.	Non-acid	acid 20/30+ = acid in the 20-60cm or 30-60cm (or greater)



a) Acid band - non acidic subsoil at 30 - 40cm

b) Deep acid - acidic to 60cm soils

Figure 2: pH profiles of every plot grouped by acid profile tyes (a) acid band (b) deep acid



a) Acid band - non acidic subsoil at 30 - 40cm

b) Deep acid - acidic to 60cm soils

Figure 3: Aluminium (mg/kg) profiles of every plot grouped by acid profile types (a) acid band (b) deep acid

Without cultivation, after four years the pH class was unchanged regardless of the application of lime treatments (16 plots) (Table 2). With cultivation but without recent addition of lime (8 plots), the high pH topsoil from historical lime applications was mixed into the subsoil either; a) no amelioration affect but reduced top soil pH (in 4 out of 8 plots) or b) partially ameliorated the subsoil but reduced the topsoil pH (in 4 out of 8 plots) (Table 2).

When culitvation and lime treatments were applied (24 plots), there were 9 plots which were partially ameliorated and 11 plots which were ameliorated to 30cm (Table 3). There were more spaded plots which were ameliorated or partially ameliorated. The pH amelioration and reduced compaction with the spader treatment may indcate better and deeper mixing than the offset disc.

Table 3: The number of plots which had different amelioration (no change, no amelioration, partial amelioration or ameliorated to 30cm) depended on the cultivation, lime application and the subsoil acidity.

		No cultivation (16 plots)		Cultivation only (8 plots)		Cultivation + lime treatments (24 plots)	
		Acid band	Deep acid	Acid band	Deep acid	Acid band	Deep acid
No change	-	12	4				
No amelioration	offset			0	1	1	2
	spader			2	1	1	0
Partially ameliorated	offset			0	1	3	1
	spader			3	0	4	1
Ameliorated to 30cm	offset					4	1
	spader					4	2

The 2018 season

In 2018, there was a large rainfall on 14th Jan (81mm) but there was only small rainfall events until 15mm on the 24th May. The Growing season rainfall (May-Sept) was 199mm which was similar to 2015. There were good May-Aug rainfall, but there was little end of season rainfall in Sept and October. These are ideal conditions for an acidity trial, as subsoil water may be required when the end of season is dry.

Table 3 Trial site rainfall (electronic rainfall gauge) over 2015-2018

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	May-Sept
2015	8.6	36.3	47.2	56.7	17	60.6	100.8	22	4.8	1.2	35.2		205
2016	72.0	0	57.4	34.0	39.6	37.2	32.0	40.4	27.2	9.0	1.6	0.8	176
2017	75.6	26.0	15.6	1.0	4.6	3.8	35.4	50.8	15.4	19.8	18		115
2018	92.2	6	2	0.8	31	42.4	60.6	60.8	4	20			199

The crop establishment measurements, taken on 29th June 2018, ranged from 7-35 plants/m^2. There was a high weed count at the site which ranged from 103 to 705 plant/m^2 (Figure 5 b) which was mostly Brome grass with small amounts of ryegrass and radish. From the UAV flight on the 7th July, the plot averages of NDVI (greenness) and % cover (using black and white photography) had some correlation to the total plant counts (weeds + crop, $r^2 = 0.44$) (Figure 4 a, % cover graph not shown). High variation meant there was no difference between lime treatments but there was significantly greater weeds on the untilled treatments. There also appeared to be a spatial component with higher weed count in the northern end which can be seen in the greener colour on the NDVI image and the higher numbers (shaded grey) (Figure 5 b).

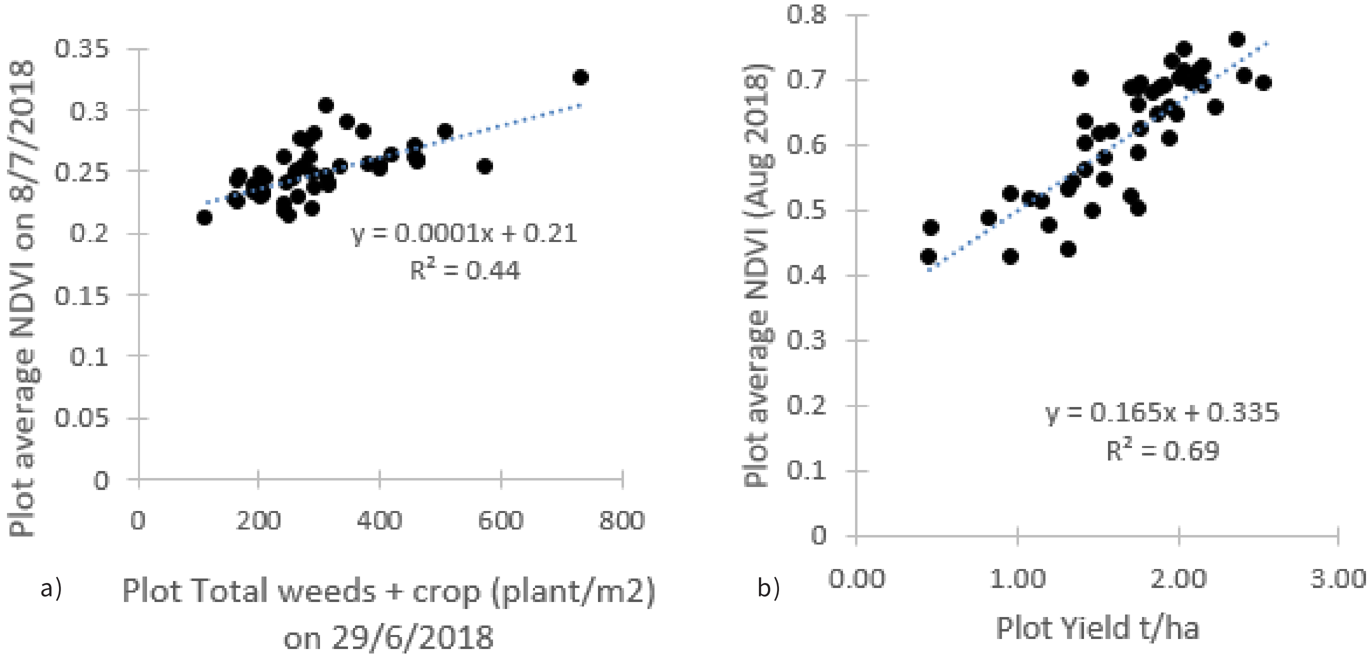
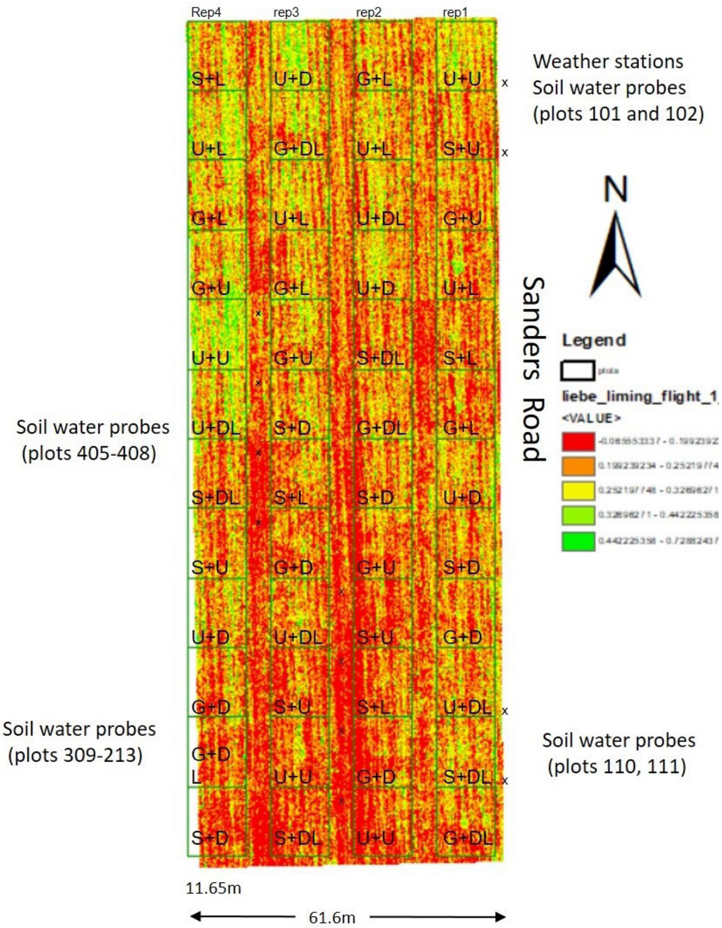


Figure 4: Correlation between the UAV plot averages of NDVI and the plot measurements with a) July NDVI and total weed + crop plant density (plant/m2) and b) August NDVI and canola yield (t/ha)

The UVA flight in August indicated the average plot NDVI was correlated strongly to the canola yield (r^2 =0.69, Figure 4 b). There is a strong spatial pattern with the poor yielding areas and those deeper acid plots (paler coloured and circled in blue in Figure 6). The southern end of the trial had a deeper acid subsoil (Figure 6).



Mixing	Lime
U = Unmixed	U = Unlimed
S = Spaded	L = Lime
G = Offsets	D = Dolomite
	DL = Dolomite and Lime

272 13	320 28	402 20	276 18
279 34	443 18	428 35	152 15
250 23	440 22	374 28	246 16
495 16	559 16	428 39	293 21
705 31	270 7	162 31	273 20
347 28	317 20	193 22	195 17
271 20	188 15	145 26	364 21
254 11	184 10	192 13	193 14
261 26	299 18	228 16	193 19
304 13	230 13	148 17	379 25
185 24	255 12	149 19	227 17
244 9	103 12	269 24	237 11

Top number is total weed count / m2 Bottom number is canola plant counts/ m2. Cell was coloured grey when weed counts >270 plants/m2

Figure 5: The trial treatments and soil water probe locations, with the July 2018 NDVI image and the plot averages of the canola plant counts (plant/m2) and the total weed count (plants/m2)

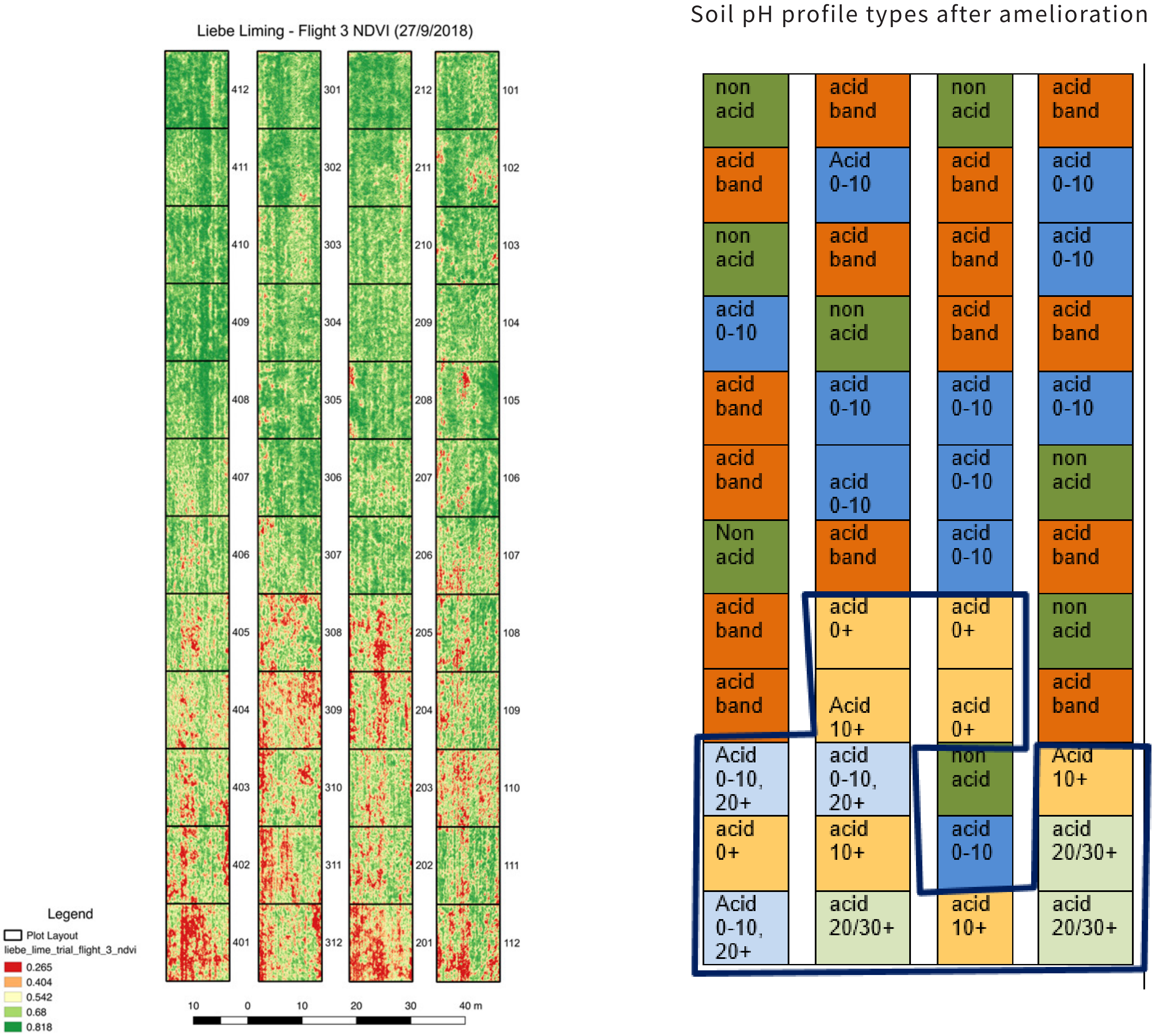


Figure 6: The NDVI image taken in August 2018 and the soil pH profiles type from 2019, showing the soils with deep acid have poorer yields (more red).

The deeper acid plots had a significantly ($p<0.05$) lower yield than soil which only have an acid band, in 2015, 2016, 2018 while in 2017 all the plots had low yields (Table 4). The deeper acid soils did not occur in all treatments (Table 2, 4, 5) and was located at one end of the trial (Figure 6). Therefore the averages for the treatments cannot be used without erroneous results, and the uneven design makes statistics on this trial difficult. For example, when comparing the lime treatment, all 12 of the limesand plots had an acid band, while the Lime + dolomite treatment only had seven plots with an acid band, so it was expected to achieve a higher average yield for the limesand, just based on soil type not treatment.

This highlighted the issue and difficulty of locating trials on uniform soil types so the underlying soil type (or pH profile in this case) does not override any treatments effects. In this trial there were greater difference in yields due whether a soil had deeper acidity than any treatment of lime or cultivation imposed. It also shows how better understanding of the trial site and soil can provide more insight into the trial results.

Table 4: Average trial yield in 2015-2018 when split into acid band or deep acid plots (statistics comparing variation between acid band and deep acid for all replicates for individual years).

	Average Yield (t/ha)		Significance
Year	**Acid band**	**Deep acid**	
2015	2.22	1.70	Sig p=0.04
2016	2.60	1.85	Sig P=0.008
2017	0.62	0.54	ns
2018	1.87	1.21	Sig P=0.002

Table 5: Effect of soil ameliorant only, on grain yield of Canola at west Wubin, 2018 (n = number of plots)

Treatment Number	Lime Treatment	Trial average		Average for Acid band		Average for Deep acid	
		Yield (t/ha)	n	**Yield (t/ha)**	n	**Yield (t/ha)**	n
1, 2, 3	Control	1.61	12	2.03	7	1.03	5
4, 5, 6	Limesand	1.89	12	1.89	12		0
7, 8, 9	Dolomite	1.58	12	1.68	9	1.28	3
10, 11, 12	Lime & Dolomite	1.63	12	1.94	7	1.31	5
		P=0.36 NS		P= 0.18 NS		P = 0.75 NS	

NS = no sig diff for product type P is > than 0.05

Table 6: Effect of cultivation only on grain yield of Canola at west Wubin, 2018 (n = number of plots)

Treatment	Cultivation Type	Trial average		Average for Acid band		Average for Deep acid	
		Yield (t/ha)	**n**	**Yield (t/ha)**	**n**	**Yield (t/ha)**	**n**
1, 4, 7, 10	No Till	1.54	16	1.79	14	0.78b	4
2, 5, 8, 11	Spader	1.75	16	1.95	10	1.30a	5
3, 6, 9, 12	Offsets	1.75	16	1.88	11	1.45a	5
		P=0.35 NS		P = 0.49 NS		P = 0.03 Sig	

Water use by the crops

The water use by the crops was determined from the capacitance probes installed in the trial. The soil water data for an individual plot was compared to that plot's pH, Aluminium and penetration resistance. We did not average the treatments due to the issues with variability highlighted above (and issues with probes not working as well)

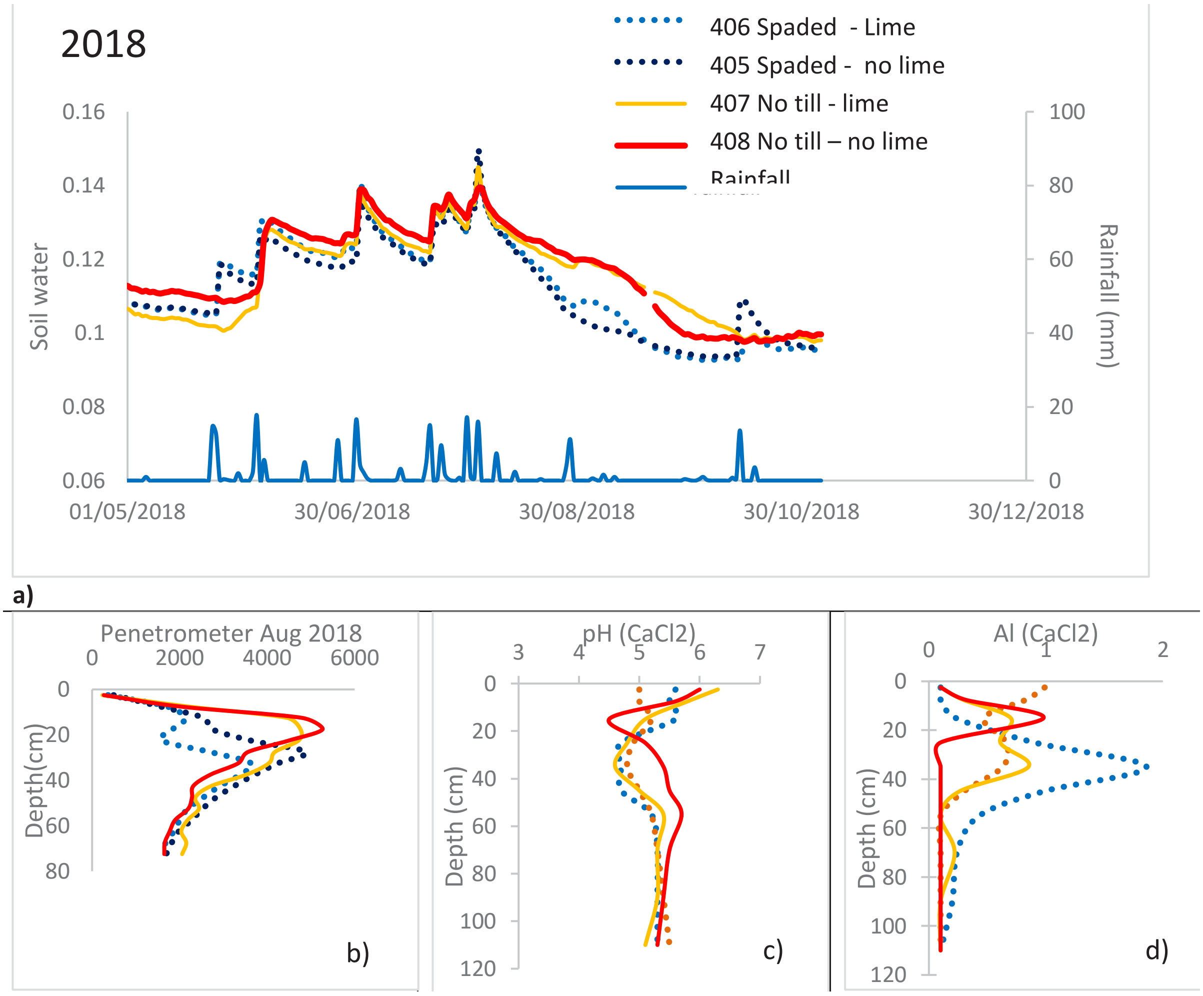


Figure 7: Soil water content (v/v) at 55cm depth for in the spaded, spaded and lime plot compared to the no tillage with and without lime plots.

The soil water graphs show the wetting up and extraction of water at the 55cm depth for individual plots in the trial (Figure 7 a) (plots 405-408). The water content in the spaded plots (dotted line) didn't decline beyond that of the untilled plots until mid-August. This indicated the roots were drying the profile in the spaded plots while the roots in the untilled plots may not have reached 55cm depth yet. Over September, which had little rainfall, the spaded plots were using the deeper water while the untilled was not.

The spaded plots having faster root growth which extracted more water may be explained by the lower penetrometer readings (Figure 7 b). Similar water content patterns for the spaded treatments with and without lime, could be explained by their similar penetrometer readings across the depths.

The pH and Aluminium profile tell a less clear story. The untilled sites have two different pH profiles – the untilled and unlimed has an acid band at 10-20cm, and the untilled and limed plot has acidity at the 20-30 cm depth. While both spaded plots have mild acidity in the 20-50cm depth. Therefore, it appears that the compaction was the first major constraint overcome at these plots but there is still compaction at depth and acidity to overcome.

Comments

This trial showed changes in compaction and acidity due to cultivation and liming. The main differences in the yield was due to the southern end having soils which were acidic to depth and the yield more constrained than the northern end which had acid band soils with higher yields (regardless of treatment). However, the yields over the trial have not been significant for differences for cultivation treatment or lime treatments alone. Some of this has been due to weeds, establishment and soil variation.

The site had high compaction in the 12-40cm layers with penetration resistance greater than 3000 kPa. Cultivation was able to reduce the compaction to 25cm depth, with the spaded cultivation slightly more effective at reducing compaction than the offset disc.

The cultivation of higher pH topsoil, without additional lime, was also more effective in the spaded cultivation than the offset disc. With the extra lime and cultivation and 2-3 years of rainfall, almost half the plots were ameliorated to 30cm regardless for both cultivation methods. This means, that due to incomplete mixing, there was half the plots which were only partially ameliorated.

The reduction in penetration resistance and improved soil pH in the spaded plot was shown to increase the root growth and increased the water the crops used from deeper in the soil, compared to the untilled treatments.

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Hollamby, N., Petersen, E. (2012). Liebe Group Technical Audit Results Executive Summary.
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Acknowledgements

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Peer review:: Phil Ward, CSIRO and David Hall, DPIRD

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Soil acidity management strategies throughout Western Australia are available for download from: http://www.liebegroup.org.au/working-together-to-deliever-multiple-benefit-messages-to-growers-through-a-whole-systems-approach-to-soil-management/

Free for download Liebe Lime Calculator:
http://www.liebegroup.org.au/lime-profit-calculator/

Demonstrating the benefits of soil amelioration (Ripper Gauge) - Dalwallinu

Alana Hartley, Research & Development Coordinator, Liebe Group

Key points

- Compaction is a major soil constraint with approximately 75% of WA's cropping land at risk of lost production due to soil compaction.
- Penetrometer readings show that deep ripping removes the compaction layer, whilst other disc type treatments do not.
- No significant yield improvement was observed under each treatment except where the maximum tillage machine, Horsch Tiger MT, was demonstrated.

Aim

To evaluate the grain yield and economic benefit of soil amelioration and controlled traffic practices on a broader range of soil types across the grain growing region of WA.

Background

Approximately 75% of WA's cropping land is at risk of lost production due to soil compaction. Compaction is conservatively estimated to cost the industry around $333 million annually (Davies et al, 2018).

Control options including cultivation practices and controlled traffic farming are costly and some growers may be reluctant to implement soil amelioration because of this. In addition to this, the multiple cultivation methods and machinery types available add to the difficulty in the decision to adopt.

To assess the effectiveness of various cultivation methods and their ability to improve yield and economic return, the Liebe Group, with support from GRDC, have implemented a three year grower scale demonstration in the Kwinana West Port Zone, at Dalwallinu. At this site, four cultivation methods are being investigated;

- Horsch Tiger (combined maximum tillage)
- Grizzly Field Boss (offset discs)
- Ausplow (deep rip)
- Deep rip + offset disc

Soil strength, NDVI and yield data will be collected and analysed, along with economic analysis over the three years of the project.

This is one of many demonstration sites being delivered across the port zones as part of the GRDC investment, Demonstrating the benefits of soil amelioration (Ripper-Gauge). Growers from each port zone will be able to use the results from the demonstrations to increase their understanding of the various cultivation methods available and their benefits.

Trial Details

Location	Carlshausen property, Bell Rd, Dalwallinu
Plot size & replication	Grower scale demonstration – 12 m x 1 replicates
Soil type	Gravelly sand
Paddock rotation:	2015: Wheat 2016: Wheat 2017: Canola/Fallow
Sowing date	11/05/2018
Sowing rate	50 kg/ha Ninja wheat
Fertiliser	11/05/2018: Agflow 40 kg/ha, Flexi N 50 L/ha, Zinc 200 ml/ha, Copper 200 ml/ha, Flutriafol 100 ml/ha 24/06/2018: Zinc 150 ml/ha 14/08/2018: Flexi N 45 L/ha
Herbicides, Insecticides & Fungicides	11/05/2018: Trifluralin 2 L/ha 24/06/2018: Paragon Extra 350 ml/ha, Bronco Max 250 ml/ha 14/08/2018: Tebuconazole 290 ml/ha (aerial applied)
Growing season rainfall	300 mm

Treatments

	Treatment
1	Control
2	Combined maximum tillage
3	Deep Rip
4	Deep Rip + Offset Disc
5	Offset Disc

Trial Layout

1	2	3	4	5	1
Control	Combined maximum tillage	Deep Rip	Deep rip & Offset Disc	Offset Disc	Control

Results

Soil test results

Table 1: Soil test results March 2018

Depth	Col P	Col K	KCl S	O C	EC	pH Ca Cl2	PBI	NO3N	NH4N	DTPA Cu	DTPA Zn	DTPA Mn	Ex Al	Ca Cl2 Al
0-10	50	99	15.7	0.75	0.090	5.7	24.2	30	2	0.33	0.48	1.72	0.145	0.22
10-20	18	46	17.7	0.50	0.047	4.9	19.4	9	< 1	0.19	0.12	0.51	0.251	0.39
20-30	10	34	25.1	0.31	0.052	4.7	23.5	10	< 1	0.14	0.13	0.32	0.302	<0.20
30-40	5	25			0.054	5.2		7	< 1					
40-50	2	19			0.046	5.4		4	< 1					

Table 2: NDVI - Greenseeker readings, taken at Z30 and Z40

Treatment		Crop Stage	Average NDVI (scale 0.0 – 1)	Crop Stage	Average NDVI (scale 0.0 – 1)
1	Control	Z 30	0.67	Z 40	0.77
2	Combined maximum tillage		0.77		0.76
3	Deep Rip		0.76		0.75
4	Deep Rip + Offset Disc		0.74		0.77
5	Offset Disc		0.75		0.72

Table 2 shows there was no significant difference between crop biomass at Z30 or Z40. A slight increase in crop biomass at Z40 was observed in treatments 1 and 4 however all treatments visually appeared the same.

Penetrometer readings – August

The working depth of each machine varied. Working depth of deep ripping achieved 300 mm while the combined maximum tillage machine cultivated to 350 mm, and the offset discs only achieved a working depth of 150 mm. The combined tillage treatment of deep rip plus offset disc achieved a working depth of approximately 200 – 250 mm.

Penetrometer readings, taken in August, both on the rip line and off the rip line (Figure 1), show the impact of each treatment on the shatter of the compaction layer below the soil surface. Root limiting compaction under the control exists at approximately 200-350 mm. The double pass of deep ripping followed by an offset disc cultivation shows marginal improvements, where deep ripping appears to have ameliorated compaction along the rip line, past 300 mm. Maximum tillage had the most significant improvement with root limiting compaction being ameliorated to 400 mm ‘between the rip line’, and almost to 500 mm ‘in the rip line’. This indicates the good depth and lateral shattering of the compaction layer achieved by the leading ripping tine and the mixing effect of the offset discs that follow.

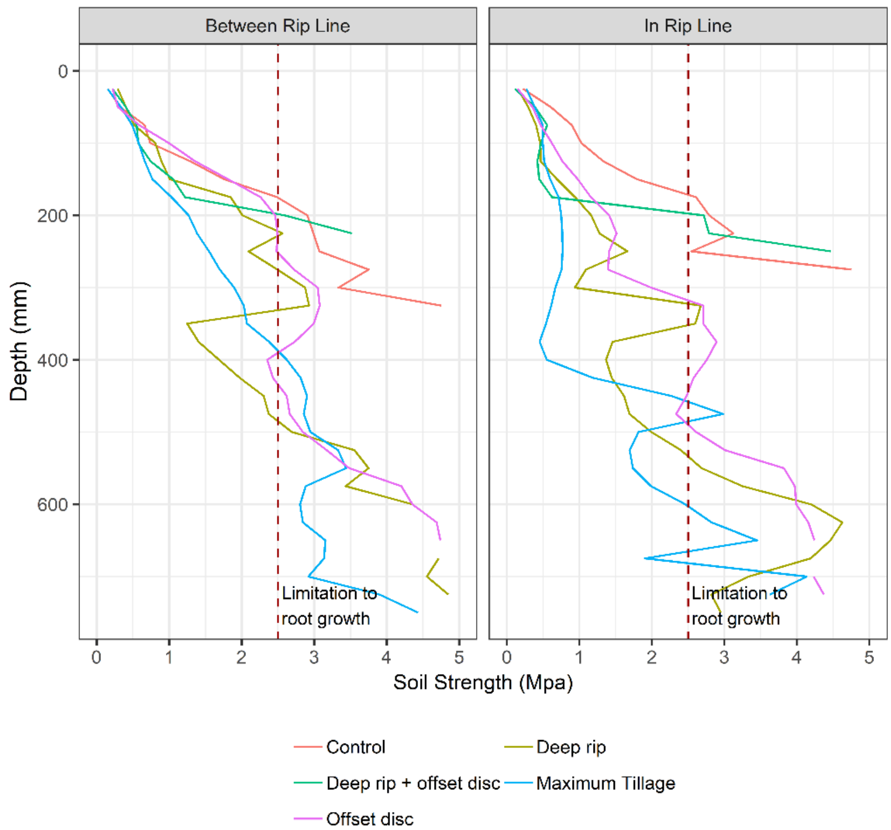

Figure 1: Penetrometer measurement of soil strength between and on the rip line, 15 August 2018.

Compaction remained an issue both 'on the rip line' and 'between the rip line' under the offset discs, double pass of offset disc and deep rip, plus the stand alone deep rip treatments. Penetrometer readings do indicate the compaction layer at approximately 200-350 mm has been ameliorated to a limited extent by those treatments however, the nature of the duplex soil type (sand over gravel and clay) suggests cultivation beyond 350 mm is required to ameliorate compaction.

Harvest results

The demonstration was harvested with yield being recorded on a yield monitor. This collection of yield monitor data points was then analysed statistically to gain an average yield across each individual treatment. The data was analysed using the R Statistical Package, using an 'nlme' analysis to apply a mixed effects model (including REML). Least Significant Differences (l.s.d) was calculated using the 'predictmeans' package within this program. The results reflect any spatial variability that is experienced within a treatment.

Significant differences were observed from one treatment at the Dalwallinu site (Figure 2); where wheat yields under the maximum tillage treatment were 0.81 t/ha higher than the next highest yielding treatment, the double pass of Deep Rip and Offset Disc at 5.34 t/ha (Table 3). No other treatments were deemed significantly different.

Table 3: Impact of cultivation treatment on yield

Treatment		Average Yield (t/ha)	Standard error
1	Control	5.04	0.02
2	Combined maximum tillage	6.15	0.02
3	Deep Rip	5.26	0.02
4	Deep Rip + Offset Disc	5.34	0.02
5	Offset Disc	5.03	0.04
	l.s.d	0.07	

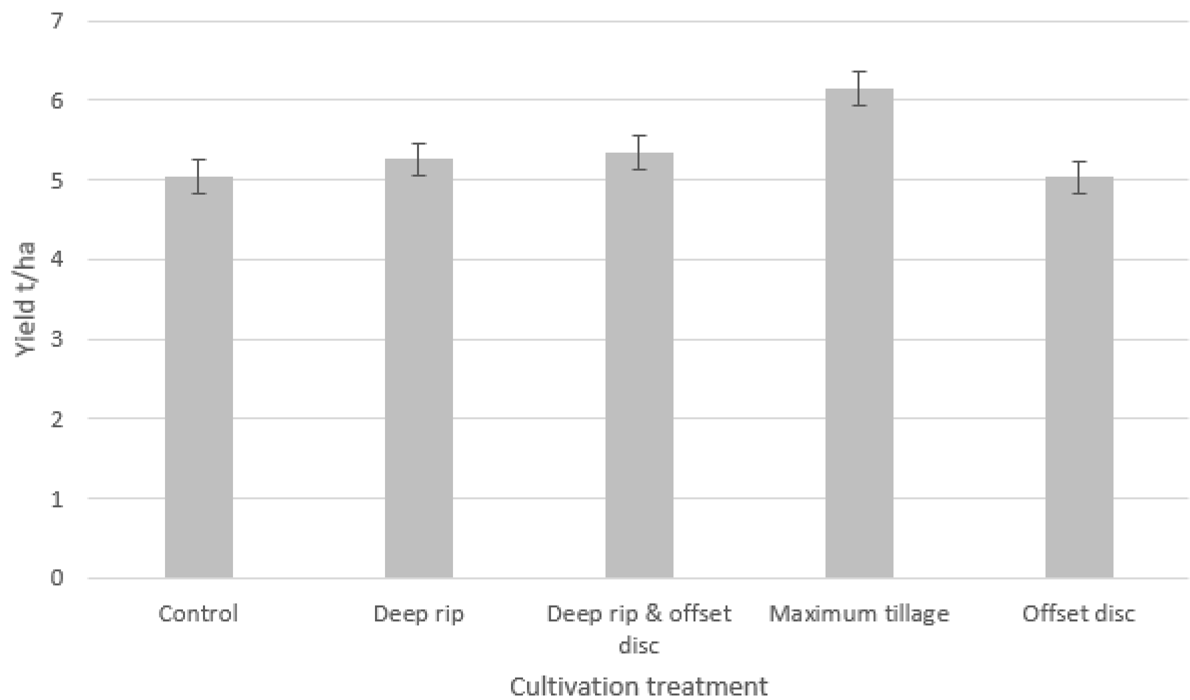

Figure 2: Yield response (t/ha) to cultivation at the Dalwallinu 'Ripper Gauge' demonstration site

The additional yield achieved under the maximum tillage treatment can be attributed to the removal of the compaction layer at 200-350 mm, increasing rooting depth and, access to subsoil moisture and nutrients.

Comments

A single pass using a combined maximum tillage machine, has been the most effective form of cultivation for the purpose of removing the compaction layer at this site, closely following by the double pass of deep ripping and offset discs.

When selecting a method of cultivation, each machine has its own unique purpose. As highlighted by this demonstration, if compaction is the main constraint, those machines with tines that are able to penetrate below the compaction layer may be of greater benefit than those machines that mix the soil, such as the disc type machines. The success of each cultivation method will also be dependent on soil type and soil moisture at the time of cultivation.

Acknowledgements

Many thanks to the Carlshausen family for hosting this demonstration site. Thank you to Ty Henning of TekAg who developed the trial design for this grower scale demonstration and assisted with the extraction and interpretation of yield data. Many thanks to AFGRI Equipment Dalwallinu for the supply of the Horsch Tiger MT. Statistical analysis of yield monitor data was conducted by project lead, Nathan Craig, West Midlands Group.

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Peer Review: Wayne Parker, Department of Primary Industries and Regional Development

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Demonstrating the benefits of soil amelioration (Ripper Gauge) - Kalannie

Alana Hartley, Research & Development Coordinator, Liebe Group

Key points

- Compaction is a major soil constraint with approximately 75% of WA's cropping land at risk of lost production due to soil compaction.
- Penetrometer readings show that deep ripping removes the compaction layer, whilst other disc type treatments do not.
- Machines using ripping tines to remove compaction provided the greatest yield improvement by 1.10 – 1.66 t/ha at this site, compared to the untreated control, and 0.61 – 1.17 t/ha compared to offset disc machine.

Aim

To evaluate the grain yield and economic benefit of soil amelioration and controlled traffic practices on a broader range of soil types across the grain growing region of WA.

Background

Approximately 75% of WA's cropping land is at risk of lost production due to soil compaction. Compaction is conservatively estimated to cost the industry around $333 million annually (Davies et al, 2018).

Control options including cultivation practices and controlled traffic farming are costly and some growers may be reluctant to implement soil amelioration because of this. In addition to this, the multiple cultivation methods and machinery types available add to the difficulty in the decision to adopt.

To assess the effectiveness of various cultivation methods and their ability to improve yield and economic return, the Liebe Group, with support from GRDC, have implemented a three year grower scale demonstration in the Kwinana East Port Zone, at Kalannie. At this site, three cultivation methods are being investigated;

- Horsch Tiger MT (combined maximum tillage),
- Grizzly Field Boss (offset discs),
- Ausplow deep ripper (with inclusion plates), and
- Horsch Joker (speed disc tillage).

Soil strength, NDVI and yield data has been collected and analysed, along with economic analysis over the three years of the project.

This site complements a number of demonstrations being conducted as part of the GRDC investment: Demonstrating the benefits of soil amelioration (Ripper-Gauge). Growers from each port zone will be able to use the results to increase their understanding of the various cultivation methods available and their benefits.

Trial Details

Location	McCreery property, Cottage Road, Kalannie
Plot size & replication	Grower scale demonstration – 12 m x 2 replicates (900m length plots)
Soil type	Loamy sand
Paddock rotation:	2015: Volunteer pasture 2016: Wheat 2017: Canola/Fallow
Sowing date	03/05/2018
Sowing rate	50 kg/ha Scepter wheat
Fertiliser	03/05/2018: K-Till Extra 70 kg/ha 19/06/2018: Urea 50 kg/ha 26/06/2018: Flexi N 30 L/ha 06/08/2018: Flexi N 30 L/ha
Herbicides, Insecticides & Fungicides	02/05/2018: Trifluralin 2 L/ha 06/08/2018: Jaguar 0.8 L/ha, LVE 600 0.2 L/ha, Lontrel 40 g/ha, Tebuconazole 0.2 L/ha
Growing season rainfall	216 mm

Treatments

	Treatment
1	Control – no tillage
2	Combined maximum tillage
3	Offset disc
4	Deep rip with inclusion plates
5	Speed disc tillage

Trial Layout

The trial has been designed as a 'nearest neighbour', which means each treatment is compared alongside a control plot.

1	2	4	1	3	5	1
Control	Combined maximum tillage	Deep rip	Control	Offset disc	Speed disc tillage	Control

Results

Table 1: Soil test results

Depth	Col P	Col K	KCl S	O C	EC	pH Ca Cl2	PBI	NO3N	NH4N	DTPA Cu	DTPA Zn	DTPA Mn	Ex Al	Ca Cl2 Al
0-10	27	73	6.0	0.92	0.077	5.1	30.9	25	2	0.25	0.31	1.15	0.108	0.44
10-20	9	41	12.3	0.69	0.037	4.2	44.6	6	< 1	0.15	0.13	0.36	0.709	10.32
20-30	3	36	30.2	0.29	0.041	4.2	52.6	4	< 1	0.10	0.08	0.24	0.789	20.51
30-40	< 2	35			0.046	4.1		5	< 1					17.74
40-50	5	42			0.053	4.2		7	1					8.63

Table 2: NDVI – Greenseeker readings, at Z30 and Z40 crop stage

Treatment		Crop Stage	Average NDVI (scale 0.0 – 1)	Crop Stage	Average NDVI (scale 0.0 – 1)
1	Control	Z 30	0.49	Z 40	0.52
2	Combined maximum tillage		0.39		0.50
3	Offset disc		0.48		0.53
4	Deep rip		0.47		0.56
5	Speed disc tillage		0.46		0.36

There was no significant difference between crop biomass at Z30 or Z40. Observed differences between treatments were at establishment, where establishment was patchy in treatment 2 (combined maximum tillage). However, later in-season observations indicated that this treatment recovered. A slight increase in crop biomass at Z40 was observed in treatment 4 (deep ripper) due to an increased ryegrass burden through the middle section of the ripping bar, where the roller was used.

Penetrometer readings – 8 August 2018

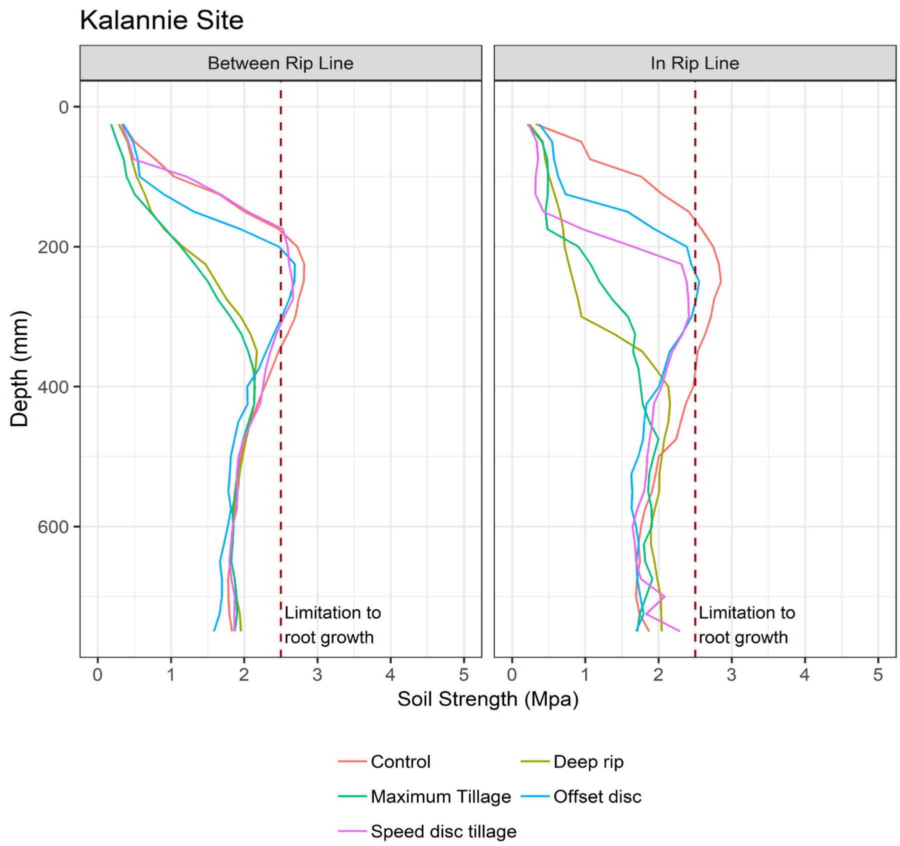

Figure 1: penetrometer measurement of soil strength between and on the rip line

The working depth of each machine varied. Working depth of the deep ripping achieved 300 mm while the maximum cultivation worked to 350 mm, and the offset discs only achieved a working depth of 150 mm. The speed disc tillage only had a working depth less than 100 mm.

Penetrometer readings, taken on the 8th August, after the site had received 28 mm in the days prior (Figure 1), show the impact of each treatment on the shatter of the compaction layer below the soil surface. Readings from the control strip indicate the compaction layer, prior to cultivation, measured approximately 200-250 mm below the soil surface. This shallow compaction has been attributed to the long history of livestock farmed on this property. The compaction layer under the control treatment does not go beyond a depth of 300 mm; meaning, beyond 300 mm soil compaction decreases providing good soil structure for roots to penetrate.

Offset discing appears to have only marginally reduced the level of compaction but has left the compaction layer at 200-250 mm intact. Speed disc tillage, adopted in this trial to demonstrate shallow cultivation, also had a similar effect to the offset disc however; this machine is designed to cut and bury crop stubbles at the soil surface, rather than cultivate to depth.

Combined maximum tillage and deep ripping had a major impact on the removal of the compaction layer, due to the deep ripping tines that exist on both machine; with resistance only reaching 1-2 Mpa at 350 mm on and off the rip line where the compaction layer was evident prior to cultivation. Each of these machines are designed to have a working depth greater than 450 mm but, due to the compaction layer existing at 200-250mm, placing resistance on the machinery, the ripping depth achieved was only 300-350mm.

Harvest results

The demonstration was harvested with yield being recorded on a yield monitor. This data was then analysed statistically to gain an average yield across each individual treatment. The data was analysed using the R Statistical Package, using an ‘nlme’ analysis to apply a mixed effects model (including REML). Least Significant Difference (l.s.d) was calculated using the ‘predictmeans’ package within this program. The results reflect any variability that is experienced within a treatment and across a paddock.

Significant differences were observed at the Kalannie site, Table 3. All treatments except the speed disc tillage were significantly higher yielding than the control (Figure 2).

Table 3: Harvest yield by treatment

Treatment		Average Yield (t/ha)	Standard error
1	Control	2.52[a]	0.08
2	Combined maximum tillage	3.62[c]	0.05
3	tillage Offset disc	3.01[b]	0.05
4	Deep rip	4.18[d]	0.03
5	Speed disc tillage	2.62[a]	0.03
	l.s.d	0.14	

There was a significantly positive yield response to the offset disc machine, maximum tillage and deep ripping, when compared to the control however; the speed disc tillage machine was not significantly different. It can be concluded that the depth of breakout of the disc type machine, had no impact on compaction as noted in Figure 1, which illustrates yield limiting compaction still existed within the rip line at 200-300 mm.

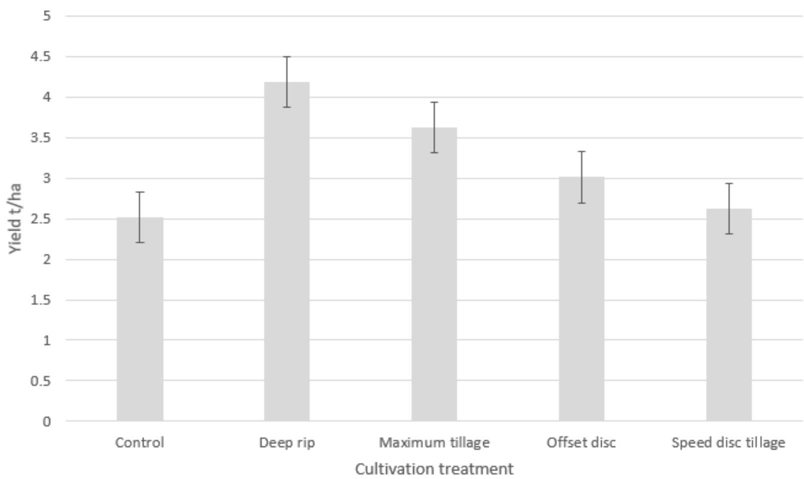

Figure 2: Yield response (t/ha) to cultivation at the Kalannie ‘Ripper Gauge’ demonstration site. Error bars represent standard error.

Those machines with tines, the deep ripper and maximum tillage machine, were significantly higher yielding (Figure 2); where tines penetrated below 400 mm, breaking the compaction layer that existed at 200-300 mm (Figure 1) allowing developing root systems greater access to moisture at depth.

Comments

Deep ripping has been the most effective form of cultivation for the purpose of removing the compaction layer at this site, closely following by the combined maximum tillage machine which adopts both tine ripping and discs for soil mixing and inclusion. The offset disc machine saw some improvement in yield as a result of soil mixing however, was unsuccessful at breaking the compaction layer at this site. The speed disc tiller is primarily a disc tillage machine that can work at speed and aids in the breakdown and incorporation of high volume crop residues and stubbles. It was of no significant benefit to yield at Kalannie in 2018.

When selecting a method of cultivation, each machine has its own unique purpose. As highlighted, if compaction is the main constraint, those machines with tines are of greater benefit than those machines that mix the soil. The success of each cultivation method will also be dependent on soil type and soil moisture at the time of cultivation.

Acknowledgements

Many thanks to the McCreery family for hosting this demonstration site and to the Kalannie locals, Travis Stanley and Bob Nixon, who provided their time and machinery to implement this demonstration. Thank you to Ty Henning of TekAg who developed the trial design for this grower scale demonstration and assisted with the extraction and interpretation of yield data. Many thanks to AFGRI Equipment Dalwallinu for the supply of the Horsch Tiger MT and Horsch Joker RT for the demonstration as well as the Equaliser Seeding Bar for the seeding of the demonstration. Statistical analysis of yield monitor data was conducted by project lead, Nathan Craig, West Midlands Group.

This project is supported through the GRDC investment 9176102: Demonstrating the benefits of soil amelioration (Ripper-Gauge) which is led by the West Midlands Group.

Peer Reviewed: Wayne Parker, Department of Primary Industries and Regional Development

References

Davies, S., Bakker, D., Lemon, J., and Isbister, B., (2018), ‘Soil compaction overview’. Accessed 10th July, 2018. www.agric.wa.gov.au/soil-compaction/soil-compaction-overview

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GENERAL INFORMATION

Farmanco Benchmarks

2017 – 2018 Season

Farmanco is one of the largest agricultural consultancy companies in Australia. Every year they produce a comprehensive farm business analysis, known as the Farmanco Profit Series.

The Farmanco Profit Series is a powerful benchmarking tool that helps clients identify strengths and weaknesses in their business by comparison to others. The Profit Series celebrated its 21st year, and is Australia's longest running profit-based farm business bench marking product.

The following information has between extracted from the 2017/18 edition and is based on the shires covered by the Liebe Group. For further information, please contact Farmanco on (08) 9295 0940 or email: mundaring@farmanco.com.au.

The three tables cover benchmarks from Agzones L2 and M2 as well as for the shires covered by the Liebe Group. Data has been omitted where the sample size is insufficient to provide effective analysis.

The survey results should be viewed in the context of the individual business situation. If the performance of the business is low when compared to the benchmark figure, then the factors affecting this performance need to be analysed. If the lower performance is due to something that can't be changed (Eg: the farm in question has lower than average rainfall, or poorer than average soils than is average for the group), then there may be little need for concern. However, if there are factors that influence performance that can be directly impacted by changing management practices within the business, then an assessment needs to be made on what changes can be made to improve performance and profitability.

Definition of terms

Effective Area (ha) - land area used directly for the purposes of producing crops or livestock, not including non-arable land such as salt lakes, rocks and bush.

Gross Farm Income (GFI) / Ha) - all income produced from farm related activities with respect to the area farmed.

Operating Costs ($Eff/ha) - relates to any payments made by the farm business for materials and services excluding capital, finance and personal expenditures with respect to the area farmed.

Farm Operating Surplus ($Eff/ha) - farm income less operating costs.

Chemical Cost ($Eff/ha) - cost of chemicals (herbicides and fertilisers) applied with respect to the area farmed.

Plant Investment ($/Crop ha)- measures the value of machinery with respect to the area cropped.

April - October Rainfall (mm) - growing season rainfall (GSR), from April – October, of survey participants. GSR is based on monthly rainfall records from April to October, with adjustments for effective summer rains and ineffective growing season rainfall.

Water Use Efficiency (WUE) = Yield (Kg) / (GSR * .66 + Stored Moisture) mm

Total Sheep Shorn - total number of sheep shorn including lambs.

Wool Production (Kg/WGha) - amount of wool cut with respect to winter grazed hectares (less crop hectares)

Wool Price ($/kg) - value of wool sold with respect to the amount of wool cut.

Lower 25% - the average of the lower 25% of farms in the group surveyed ranked by operating surplus.

Top 25% - the average of the top 25% of farms in the group surveyed ranked by operating surplus.

Figure 1: The rainfall regions used in the Farmanco Profit Series in Western Australia (Source: Department of Primary Industries and Regional Development WA)

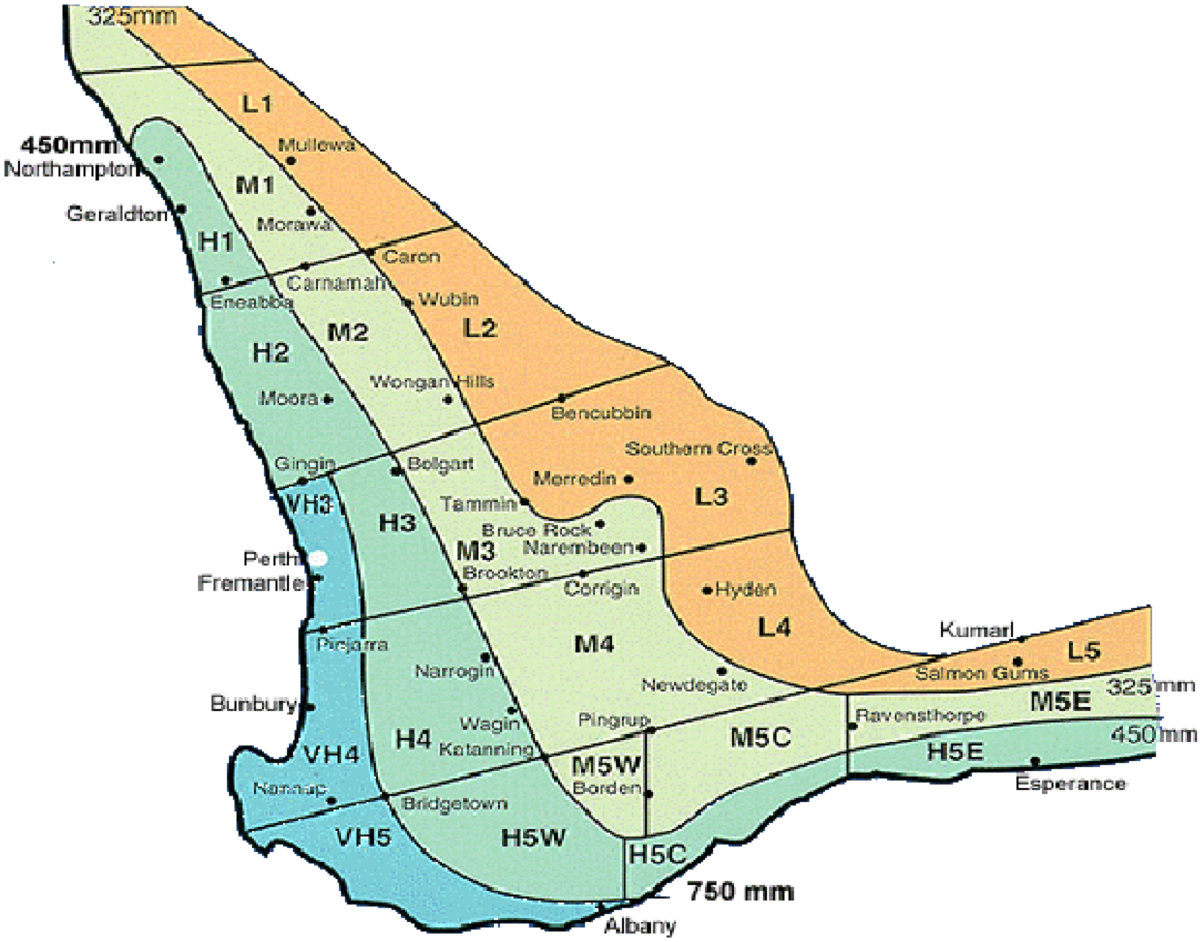

Figure 2: The four shires covered in the Liebe Group Growers Benchmarking (Table 3)

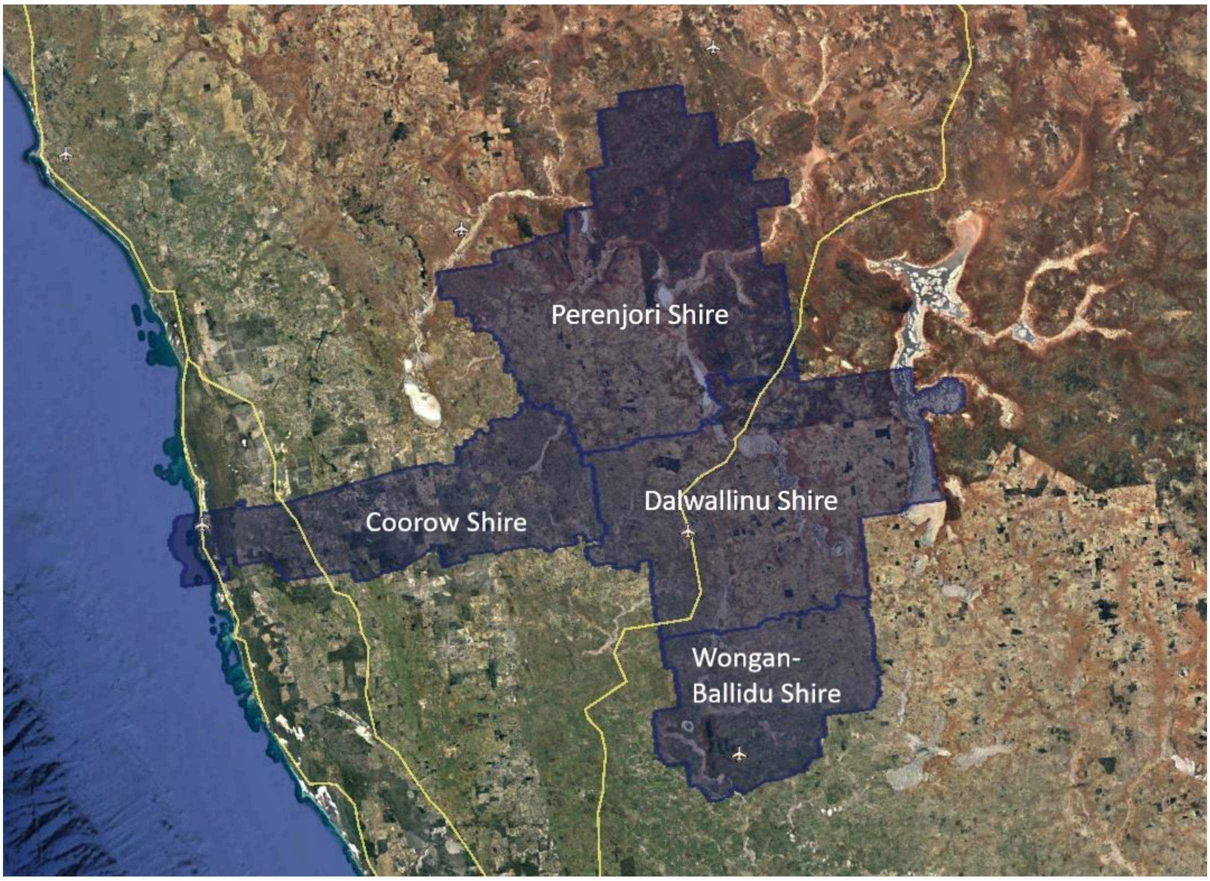

Table 1: Farm Group Statistics: Agzone L2, from 2017/18 season

	Unit	***Top 25%***	***Average***	***Lower 25%***
Agzone		L2	L2	L2
Effective Area	Ha	3,320	4,774	3,458
Permanent Labour	Person	1.8	1.9	1.9
Casual Labour	Weeks	6	19	17
Effective Area per Labour Unit	Ha	1,613	2,145	1,790
Income per Perm Labour	$	523,549	557,918	240,405
Operating Surplus per Perm Labour	$	17,841	-160,775	-243,578
Gross Farm Income (GFI) per Ha	$/Eff Ha	326	228	169
Operating Costs Per Ha	$/Ha	300	278	258
Farm Operating Surplus	$/Ha	26	-48	-88
Operating Cost %	%	69%	107%	155%
Net Farm Equity	%	86%	82%	79%
Chemical Cost	$/Ha	56	51	45
Plant Investment	$/Ha	346	533	708
Pasture Percentage*	%	20%	41%	59%
April - October Rainfall	Mm	145	132	136
Farm Operating Surplus/mm Growing Season Rainfall	**$/mm**	0.1	-0.4	-0.7
Crop Area	Ha	2,567	3,438	1,830
Crop Percentage	%	83%	74%	56%
Oil Seed Percentage	%	15%	11%	8%
Legumes Percentage	%		3%	2%
Wheat Area	Ha	1,701	2,291	1,363
Wheat Yield	T/Ha	1.31	0.99	0.86
Wheat WUE	Kg/mm	11.6	8.8	7.5
Barley Area	Ha	568	645	238
Barley Yield	T/Ha	1.64	1.24	0.83
Barley WUE	Kg/mm	13.7	11.3	8.0
Canola Area	Ha	828	642	283
Canola Yield	T/Ha	0.33	0.36	0.60
Canola WUE	Kg/mm	2.5	3.3	4.9
Lupin Area	Ha		177	64
Lupin Yield	T/Ha		0.74	1.00
Lupin WUE	Kg/mm		5.9	9.6
N Use Whole Farm	Kg/Ha	17	20	23
P Use Whole Farm	Kg/Ha	7	8	9
Sheep Wool Cut	Kg/Wgha	5.80	5.2	6.49
Sheep Stocking Rate	Dse/Wgha	1.9	1.3	1.3
Sheep Ewes Mated		835	1,079	1,215
Wool Price	$/Kg	9.50	9	9.38
Wool Production	Kg	5,263	7,658	9,067
Kgs Wool per Adult Shorn	Kg/Hd	4.60	5	4.69
Winter Number	Hd	1,076	1,283	1,444
Lambs Per	H/Wgha	0.64	1	0.59
Opening Number	Hd	1,441	1,669	2,140

*Excluding 100% cropping businesses

Table 2: Farm Group Statistics: Agzone M2, from 2017/18 season

	Unit	***Top 25%***	***Average***	***Lower 25%***
Agzone		M2	M2	M2
Effective Area	Ha	5,158	4,409	4,259
Permanent Labour	Person	2.4	2.3	2.3
Casual Labour	Weeks	28	22	17
Effective Area per Labour Unit	Ha	1,806	1,598	1,620
Income per Perm Labour	$	1,166,568	821,343	611,671
Operating Surplus per Perm Labour	$	218,395	55,041	-104,720
Gross Farm Income (GFI) per Ha	$/Eff Ha	534	433	347
Operating Costs	$/Ha	411	403	387
Farm Operating Surplus	$/Ha	119	33	-48
Operating Cost %	%	65%	77%	88%
Net Farm Equity	%	88%	83%	81%
Chemical Cost	$/Ha	76	72	70
Plant Investment	$/Ha	370	530	590
Pasture Percentage *	%	17%	31%	23%
April - October Rainfall	Mm	187	177	160
Farm Operating Surplus/mm Growing Season Rainfall	**$/mm**	0.6	0.0	-0.5
Crop Area Ha	Ha	4,802	3,588	3,566
Crop Percentage	%	92%	80%	75%
Oil Seed Percentage	%	18%	17%	16%
Legumes Percentage	%	8%	10%	14%
Wheat Area	Ha	2,574	2,005	2,201
Wheat Yield	T/Ha	2.22	1.85	1.54
Wheat WUE	Kg/mm	13.3	11.1	10.0
Barley Area	Ha	880	645	574
Barley Yield	T/Ha	1.97	2.00	1.59
Barley WUE	Kg/mm	12.3	11.5	9.6
Canola Area	Ha	932	719	778
Canola Yield	T/Ha	0.75	0.65	0.42
Canola WUE	Kg/mm	4.3	3.7	2.5
Lupin Area	Ha	467	424	547
Lupin Yield	T/Ha	1.20	1.19	1.07
Lupin WUE	Kg/mm	7.7	7.4	6.8
Field Pea Area	Ha			
Field Pea Yield	Ha			
Field Pea WUE	Kg/Ha			
N Use Whole Farm	Kg/ha	28	28	20
P Use Whole Farm	Kg/Ha	9	10	11
Sheep Wool Cut	Kg/Wgha	12.73	13.2	14.10
Sheep Stocking Rate	Dse/Wgha	4.0	3.5	3.3
Sheep Ewes Mated	Hd	4,100	1,781	1,068
Wool Price	$/Kg	9.65	9	8.25
Wool Production	Kg	20,846	13,555	8,722
Kgs Wool per Adult Shorn	Kg/Hd	2.59	5	4.90
Winter Number	Hd	2,349	2,098	1,360
Lambs Per	H/Wgha	2.28	1	1.18
Opening Number	Hd	2,111	2,659	2,196

*Excluding 100% cropping businesses

Table 3: Liebe Group Benchmarking, from 2017/18 season

	Unit	*Top 25%*	*Average*	*Lower 25%*
Effective Area	Ha	8,046	5,355	4,292
Permanent Labour	Person	3.1	2.3	2.2
Casual Labour	Weeks	48	23	20
Effective Area per Labour Unit	Ha	1,978	2,031	1,798
Income per Perm Labour	$	967,957	671,626	495,279
Operating Surplus per Perm Labour	$	-20,661	-156,855	-220,572
Gross Farm Income (GFI) per Ha	$/Eff Ha	382	274	242
Operating Costs	$/Ha	384	339	336
Farm Operating Surplus	$/Ha	-1	-61	-102
Operating Cost %	%	73%	110%	129%
Net Farm Equity	%	100%	86%	81%
Chemical Cost	$/Ha	62	62	61
Plant Investment	$/Ha	414	525	563
April - October Rainfall	Mm		35%	43%
Farm Operating Surplus/Ha/mm GSR	$/mm	138	140	141
Crop Area	Ha	-0.0	-0.5	-0.8
Crop Percentage	%	8,046	4,425	3,627
Oil Seed Percentage	%	100%	84%	79%
Legumes Percentage	%	18%	16%	16%
Pasture Percentage*	%	11%	9%	13%
Wheat Area	Ha	4,488	2,522	2,144
Wheat Yield Tonnes	T/Ha	1.66	1.23	1.13
Wheat WUE	Kg/mm	12.3	9.2	8.3
Barley Area	Ha	823	708	576
Barley Yield Tonnes	T/Ha	1.38	1.42	1.27
Barley WUE	Kg/mm	10.2	10.7	9.1
Canola Area	Ha	1,538	853	860
Canola Yield Tonnes	T/Ha	0.33	0.39	0.30
Canola WUE	Kg/mm	2.3	3.0	2.1
Lupin Area	Ha	830	434	545
Lupin Yield Tonnes	T/Ha	0.81	0.95	0.92
Lupin WUE	Kg/mm	5.5	6.2	6.8
Field Pea Area	Ha			
Field Pea Yield Tonnes	Ha			
Field Pea	Kg/Ha			
N Use Whole Farm	Kg/Ha	18	22	20
P Use Whole Farm	Kg/Ha	6	9	10
Sheep Wool Cut	Kg/Wgha		6.1	7.53
Sheep Stocking Rate	Dse/Wgha		1.6	1.6
Sheep Ewes Mated	Hd		1,143	722
Wool Price	$/Kg		9	7.80
Wool Production	Kg		7,445	4,538
Kgs Wool per Adult Shorn	Kg/Hd		5	3.94
Winter Number	Hd		1,566	820
Lambs Per	H/Wgha		1	0.73
Opening Number	Hd		1,762	1,228

*Excluding 100% cropping businesses

2018 RAINFALL REPORT

	Dalwallinu	Kalannie	Coorow	Carnamah	Latham	Perenjori	Wongan Hills	Goodlands	MTS (Kalannie)
Jan	-	77.2	43.4	67.7	64.6	55	47	81.6	74.2
Feb	27.6	11	13.4	-	34.8	15	8.2	8.6	7.6
Mar	7.2	6.8	1.5	2.2	8.6	13	3.4	2.4	10.7
Apr	2.4	2	-	-	0.4	-	0.4	0.2	-
May	42.6	17.8	31.6	29.8	24.6	28.4	33	18.6	16
Jun	57.6	48.8	38.8	41.7	40.6	32.6	53.2	40.2	47.3
Jul	87	56	78.6	67.6	67.8	55.6	89.2	55.6	54
Aug	79	59.8	56.5	41.4	49.8	53.4	100.4	56.4	58.4
Sep	6	4.8	7	3.6	6.2	1.2	11	4.4	4.4
Oct	25.4	36.4	28.7	16.6	27.2	23	35	45.4	36.4
Nov	27	16.2	3.5	19.7	7.2	15.4	8.2	17.4	10.2
Dec	-	-	-	-	2.2	0.8	10.2	0.2	5
GSR (Apr - Oct)	300	225.6	241.2	200.7	216.6	194.2	322.2	220.8	216.5
Total	362.8	336.8	303	290.3	334	293.4	399.2	331	324.2

Note: Rainfall data not available for some months.

Information gathered from the Bureau of Meteorology at www.bom.gov.au and through Liebe Group rain gauges.

Contact the Bureau of Meteorology by phone (08) 9263 2222, by fax on (08) 9263 2233 or by email at climate.wa@bom.gov.au

We have taken all due care but cannot provide any warranty nor accept any liability for this information.

2018 LIEBE GROUP R&D SURVEY RESULTS

Conducted September 2018 at the Spring Field Day.

What are the key issues affecting your farm business that could be addressed by the Liebe Group?

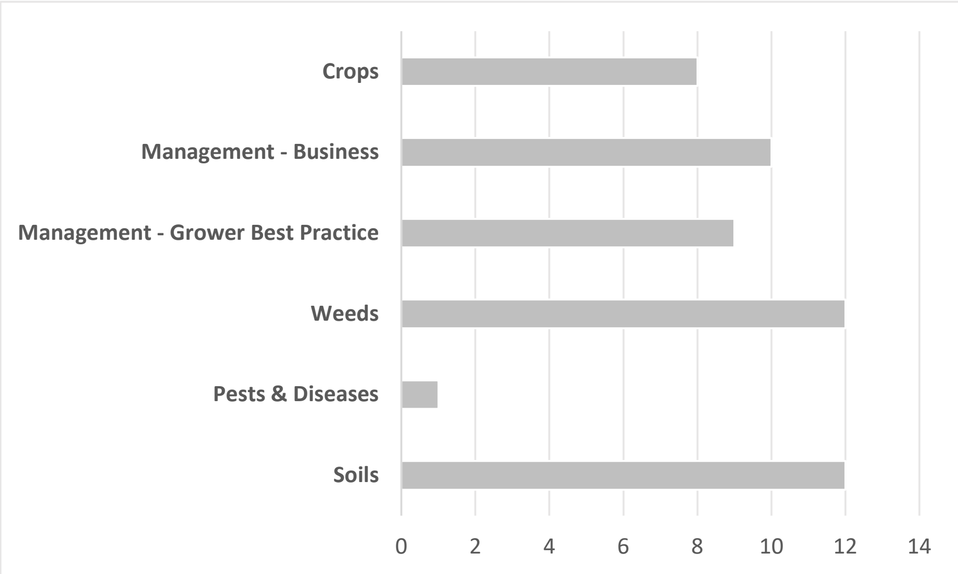

Figure 1: Farmers responses when asked about the key issues affecting their farm business, recorded at the Liebe Group Spring Field Day, 2018.

What are the key areas in relation to soils? (Figure 1)

- Soil amelioration
- Salinity
- Further trials with deep ripping/inclusion plates/amelioration effects
- Soil disease
- Non-wetting
- Soil acidity
- Compaction

What are the key areas in relation to weeds? (Figure 1)

- Weed control and resistance
- Weed mapping
- Novel chemicals
- Harvest weed management
- Weed control on leased farms - poor management history
- Grass control pasture

What are the key areas of knowledge or skills you wish to build on through training and workshops?

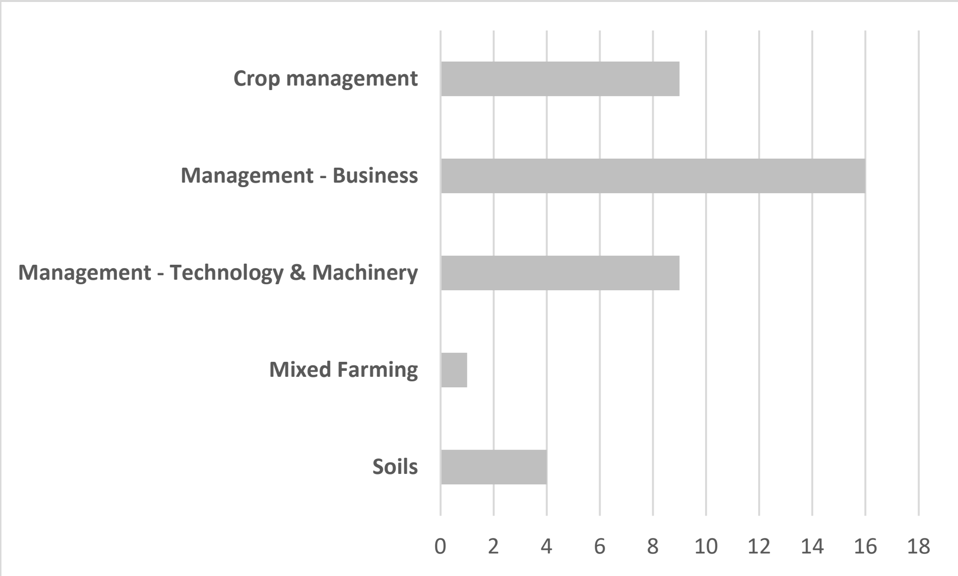

Figure 2: Farmers responses when asked what key areas could be addressed through training and workshops, recorded at the Liebe Group Spring Field Day, 2018.

Business management interest areas based on grower responses at the Liebe Group Spring Field Day 2018 (Figure 2)

- Grain marketing (swaps)
- Staff management and professional development
- Business management - financial planning, tax
- Chemical safety and handling
- Farm protocols
- Machinery - purchase decision making
- Succession planning
- Economic gain of CTF
- Trades - welding, electrics

What concepts, products or practices would you like to see demonstrated by the Liebe Group?

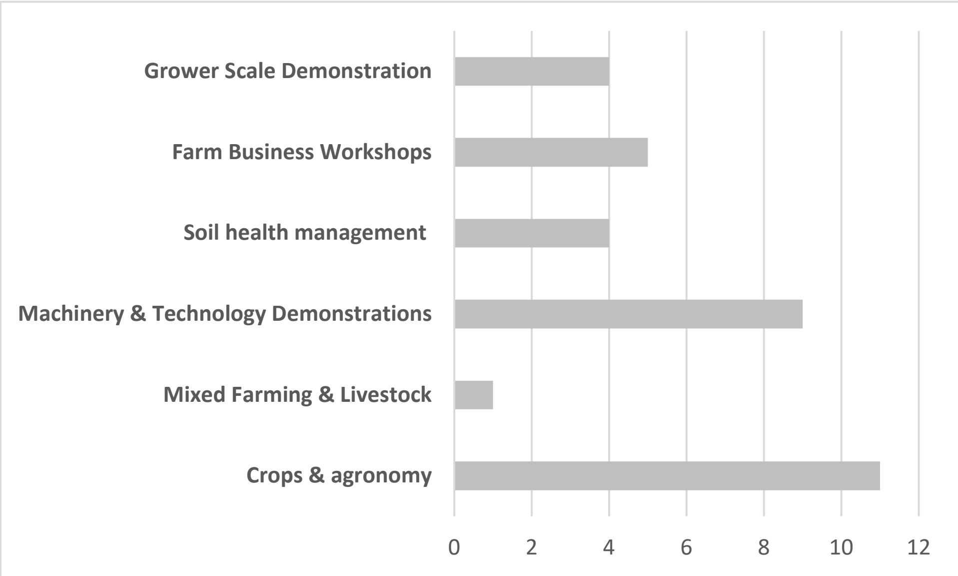

Figure 3: Farmers responses when asked what concepts, products or practices they would like demonstrated by the Liebe Group, recorded at the Liebe Group Spring Field Day, 2018.

Crops and agronomy interest areas based on growers responses at the Liebe Group Spring Field Day, 2018 (figure 3).

- Year on year trials on all chemical controls as a package
- Hay trials
- How to get something out of nothing
- Conventional practice on weed control
- All legumes in National Variety Trials - lupins, chickpeas, lentils
- Chemical resistance
- Clear-field crop rotations
- Legume rotations
- Long term rotations and nutrition
- Trial work on pre and post seeding rye grass control in wheat and barley

What are you experimenting, trialling or focusing on currently on your own farm?

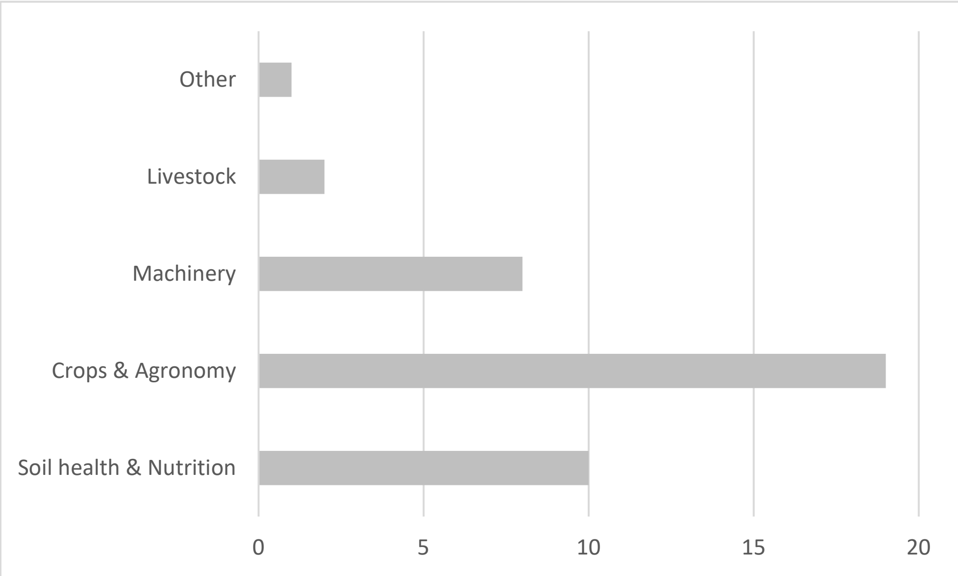

Figure 4: Farmers responses when asked what they are experimenting, trialling or focusing on currently, recorded at the Liebe Group Spring Field Day, 2018.

Crops and agronomy focus areas based on growers responses at the Liebe Group Spring Field Day, 2018 (figure 4).

- Crop rotation
- Liming and incorporation
- Better suited varieties for soil types
- New varieties
- Hay trials - pasture varieties
- Fallow as a rotation break
- Clearfield system
- Manganese nutrition strategies for split seeds in lupins
- Weed mapping
- Increased legumes and canola
- Canola varieties
- Different range of seeding rates
- Early sowing of wheat
- Deep sowing wheat
- EXTRA high rate herbicide trials

What long term research would you like to see in the Liebe region?

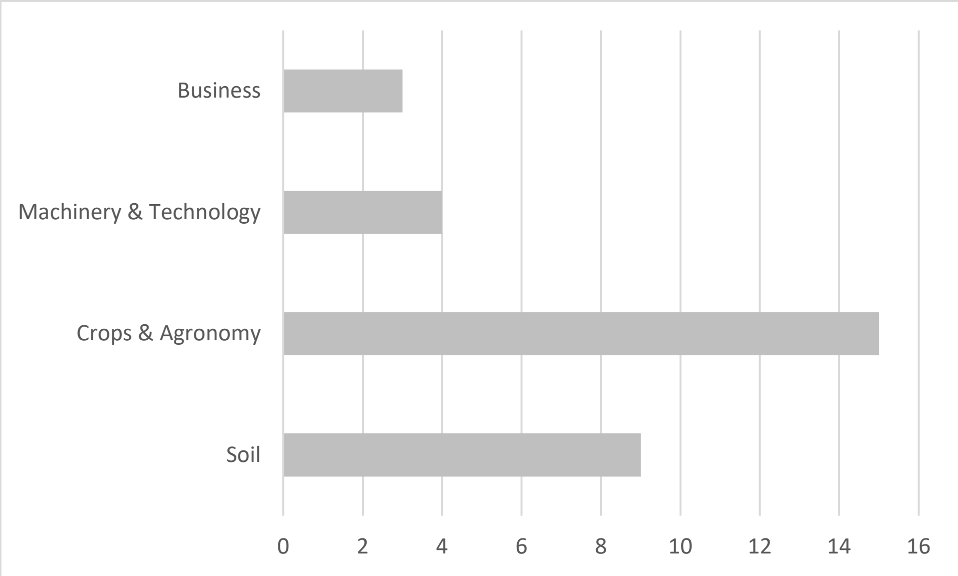

Figure 5: Farmers responses when asked what long term research they would like to see in the Liebe region, recorded at the Liebe Group Spring Field Day, 2018.

Long term research options for crops and agronomy based on growers responses at the Liebe Group Spring Field Day, 2018 (figure 5).

- Rotations
- Pasture legumes
- Frost management
- How to achieve 20kg/mm consistently
- Low rainfall region trials including continuous cropping vs cereal, pasture, break crop
- Finding best break crop including fallow
- Legumes in the system long term
- Water use efficiency
- Stubble management on crop yield and disease carryover
- Lentil/chickpea profitability
- Chemical resistance

THE LIEBE GROUP STRATEGIC PLAN 2017 – 2022

Introduction

The 2017-2022 Strategic Plan was endorsed by the Liebe Group Management Committee in August 2017. It was developed in February 2017 by the members, with the assistance of Sue Middleton, independent consultant, and reviews and builds on the previous strategic plan. Strategic planning has always been a strong focus for the Liebe Group since the group's inception in 1997 and has become part of the group's progression and success over the years. This fifth strategic planning exercise comes at a time when the group celebrates 20 years of operation and is looking to the future, and to new challenges and opportunities that will arise in the agricultural sector. The strategic plan will assist the group in achieving its vision of farming communities and family businesses that are vibrant, innovative and prosperous.

During the plan review process members were asked to describe what the agricultural environment may look like in 5-10 years time. They described the future as having the following characteristics:

- Farming businesses that are more complex, therefore greater efficiencies required to manage them
- Digital agriculture and new technologies becoming available at an ever-increasing pace
- Livestock systems declining within farming systems in the region
- Business management requirements have increased, and farmers are more time poor
- Changes to the funding environment – decrease in public funding, potential decrease in overall R&D funding
- Food is highly valued and as a result, quality and accountability pressures are high
- Continued decline and more diverse rural populations
- Information is readily available and comes in many different forms and from many different sources
- Social media has a key source of information and norm setting has grown

The acknowledgement of these environmental factors, along with a strong group vision, provide the drive for the group for the next five years. This strategic plan really defines what the Liebe Group is about, how we operate, and how we support our members.

Our strategy will be reinforced by continual improvement and evaluation of impact and success, and will continue to provide the guidance to staff in operations and planning.

ROLE OF LIEBE GROUP

The Liebe Group is a dynamic, grower-driven, not for profit organisation that operates within the Dalwallinu, Coorow, Perenjori and Wongan-Ballidu Shires in the West Australian Wheatbelt. As a leading 'grass roots' group, the Liebe Group provides its members with access to innovative, timely and relevant research along with grower and industry network opportunities from all over Australia. The group is a valued information broker for Liebe members and industry.

The Liebe Group ensures regular consultation with members and industry to guarantee the group remains relevant. Liebe is governed by a central Management Committee which is informed by a range of operational sub-committees which are comprised of local growers and Industry partners.

The group conducts valuable research, development and extension through trials, demonstrations and workshops, and provides information to over 100 farming businesses in the local region, encompassing a land area of over 1,000,000ha.

ACKNOWLEDGEMENTS

The Liebe Group would like to acknowledge everyone who contributed to this Strategic Plan, and for continuing to support the group with passion and enthusiasm. We are excited about the future and look forward to continuing this journey with you all.

Our Vision
Vibrance and Innovation for Rural Prosperity.

Our Mission
To be a progressive group, working together to improve rural profitability, lifestyle and natural resources.

Our Core Business
- Agricultural research, development, validation and adoption.
- Provide information, education, skills and training opportunities to members and wider community.
- Strengthen communication between growers, industry and whole community.

Our Values
The following are a set of evolving philosophies and values that the group maintains for members and employees. By accepting these values it enables us to build trust in order to make effective and efficient decisions and reach our potential.

Member Driven
Primarily the Liebe Group is here to create value for its members, R&D, technology and capacity building is local and relevant and prioritized by the membership.

Innovation and Progression
The group is innovative and progressive and this is encouraged and valued. An ethos of constant review is adhered to, to ensure we are on track and achieving best practice.

Inclusivity
The group is inclusive which means we involve, encourage and support staff, members and the community to take part, have a voice and maintain their ideas and views as individuals.

Apolitical
The group is apolitical, which means collectively we won't represent the members without following a process to ensure we are representing all their ideas or opinions.

Empowerment
Empowerment and capacity building is encouraged of members and staff to ensure everyone reaches their potential and supports their personal development.

Independence
The group is independent and acts under direction from the 'grass roots.' The group is objective in its views and stance.

Professionalism
The group is professional which is encouraged and nurtured in the membership. The group is driven by the decision-making capacity of the management committee and it's supporting sub-committees which use accountable and transparent processes. We expect staff to be confidential in their dealings within the group.

Collaborative
Effective networking and links to beneficial partnerships is encouraged to add value and opportunities. The group works collaboratively within the agricultural industry to value add. The group maintains an ethos of team work and cooperation within the group and values peer to peer learning.

Respect
The group values and respects it's members and partners, and their resources and experience. We expect people to be open and honest, and build processes that reflect the transparency of the administration and processes used in the group.

Fun
There is a social and fun philosophy within the group.

STRATEGY 01

High priority research and development, supported by targeted extension and driven by grower innovation

Target:
100% of Liebe Group members have made an effective adoption decision concerning the adoption of new technologies & practices.

Tactics:
1. Develop and implement trials and demonstration to address local priorities and maximise value to members
2. Attract and develop strategic, long term partnerships with agribusiness and research organisations
3. Understand the value of the group's RD&E functions for members and partners
4. Support the development of, and provide access to, innovations for farming systems
5. Extend results of Research, Development and Validation

STRATEGY 02

Supporting members to have high business & farming aptitude

Target:
Liebe Group members are recognised as being highly skilled in managing their farming enterprises.

Tactics:
1. Understand, and annually review, the key drivers of change for farming businesses and the agricultural industry
2. Provide Member Development and Leadership Opportunities
3. Communicate with members
4. Encourage all sectors of the community to attend Liebe Group events

STRATEGY 03

A Collaborative and Connected Organisation

Target:
Recognised by key stakeholders as a leading grower group in Western Australia and nationally.

Tactics:
1. Review and maintain the Liebe Group brand and identity as a leading professional grower group.
2. Pro-actively engage and maintain linkages with agribusiness, grower groups, government agencies, tertiary institutions and political organisations
3. Review, maintain and deliver a strong multifaceted communications strategy.
4. Celebrate Liebe and member successes

STRATEGY 04

Sustainable Group Finances

Target:
Have 12 months' operational costs in reserve.
Have effective levels of accountability.

Tactics:
1. Maintain highly skilled finance committee to oversee Liebe Group financials and budgets
2. Broaden Liebe Group funding base
3. Manage and measure membership contributions

STRATEGY 05

High Performing Skilled Staff and Committee

Target:
The Liebe Group is viewed by the industry as a desired place of employment.
Liebe Group leaders are professional & positions within committees are highly sought after.

Tactics:
1. Support and develop Liebe Group employee's and committee members' skills and capacity
2. Maintain and increase employment base in order to meet group requirements
3. Encourage the development of staff and committee members to build skilled leaders

STRATEGY 06

Highly Effective Governance

Target:
The Liebe Group is a 'best-practice' not for profit organisation.

Tactics:
1. Implement and maintain a professional management structure
2. Ensure that constitution is compliant and relevant and enables best practice management of the Liebe Group
3. Effective group process

LIEBE GROUP CALENDAR OF EVENTS – 2019

EVENT	DATE	LOCATION
Annual General Meeting	Wednesday 13th February	Liebe Group Office
Crop Updates & Trials Review Day	Wednesday 6th March	Dalwallinu Town Hall
Women's Field Day	Thursday 20th June	Dalwallinu Recreation Centre
Post Seeding Field Walk	Wednesday 24th July	Main Trial Site, Watheroo
Annual Dinner	TBC	TBC
Spring Field Day	Thursday 12th September	Main Trial Site, Watheroo
December Christmas Drinks	TBC	TBC


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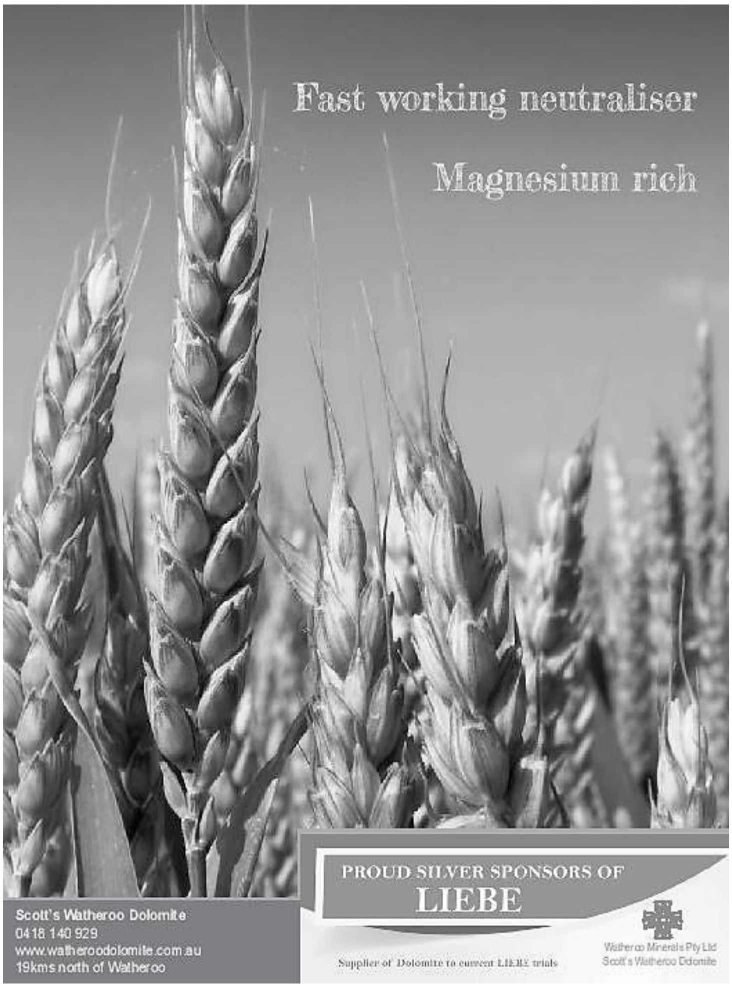
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Single Touch Payroll legislation has been passed by Senate. This means all businesses with employees are required to be Single Touch Payroll compliant from 1 July 2019.
If you're unsure how Single Touch Payroll will change the way you manage payroll, don't stress, Agrimaster is here to help.
Agrimaster has developed a Single Touch Payroll eBook and an Employee Toolkit to help you be compliant. These resources are free and can be downloaded from the Agrimaster website.
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