CELEBRATING 20 YEARS IN 2017

LOCAL RESEARCH AND DEVELOPMENT RESULTS

RESULTS FROM 2016 SEASON

LIEBE GROUP

Working together in Agriculture

2017

Dear Liebe Group Members and Supporters,

It is with great pleasure that we present to you the Liebe Group Local Research and Development results book for 2017. This book contains results from research trials and demonstrations conducted in the Coorow, Dalwallinu, Perenjori and Wongan-Ballidu shires from the 2016 season. The book also outlines current Liebe Group projects to keep you updated with the interesting work that is going on in the district. Due to unavoidable circumstances, there are some results that are not available at the time of printing; these will be published in subsequent Liebe Group newsletters.

Many thanks must go to the researchers, agribusiness organisations and growers who have cooperated to conduct valuable local research and development. We thank you for the opportunity to present these results in our 2017 book. A special thankyou to Chris O'callaghan, Rob Sands, Farmanco and Wayne Parker, DAFWA who have provided extra support with reports this season.

Also we would like to remind you that many trial results will be reviewed at the the **2017 Liebe Group Crop Updates** on **Wednesday 1st March** at the Dalwallinu Recreation Centre**.**

The **AGM** will be held during the **Strategic Plan Workshop** on **Thursday 16th February**, members interested in becoming more involved in the direction and workings of the Liebe Group are encouraged to attend and join one of our many committees.

Please interpret the results in this book carefully. Decisions should not be based on one season of data. Please contact the Liebe office if you have any further queries.

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 Agriculture and Food, WA (DAFWA), Australian Government Department of Agriculture, Rabobank, CSBP, RSM, CBH Group, AFGRI Equipment, the Farm Weekly, WFI, Shire of Dalwallinu, the Grower Group Alliance, our gold and silver sponsors and many others.

2017 marks the 20th Anniversary of the Liebe Group. We look forward to celebrating with all our members, partners and the local community.

All the best for the 2017 season and let's hope it brings plenty of rain!

Kind regards,

Clare Johnston	Executive Officer (2014 – 2017)	
Rebecca McGregor	Executive Officer	eo@liebegroup.org.au
Katrina Venticinque	Administration Officer	admin@liebegroup.org.au
Merrie Carlshausen	Sponsorship Coordinator	mcarlshausen@bigpond.com
Sophie Carlshausen	Finance Manager	sophie@liebegroup.org.au
Lilly Martin	Research and Extension Agronomist (2014-2016)	
Jenni Clausen	Research Agronomist and Coordinator (2015-2016)	

PO Box 340
Dalwallinu WA 6609
Ph: (08) 9661 0570
Fax: (08) 9661 0575
Web: www.liebegroup.org.au

Facebook: The Liebe Group

Twitter: @LiebeGroup

LIEBE GROUP SUPPORTERS

The Liebe Group would like to thank the following organisations for their invaluable support:

- Grains Research and Development Corporation (GRDC)
- Department of Agriculture and Food, WA (DAFWA)
- Australian Government Department of Agriculture
- Curtin University
- The University of Western Australia
- CSIRO
- Farm Weekly
- Shire of Dalwallinu
- Grower Group Alliance
- Northern Agricultural Catchments Council
- Wheatbelt NRM
- Regional Development Australia

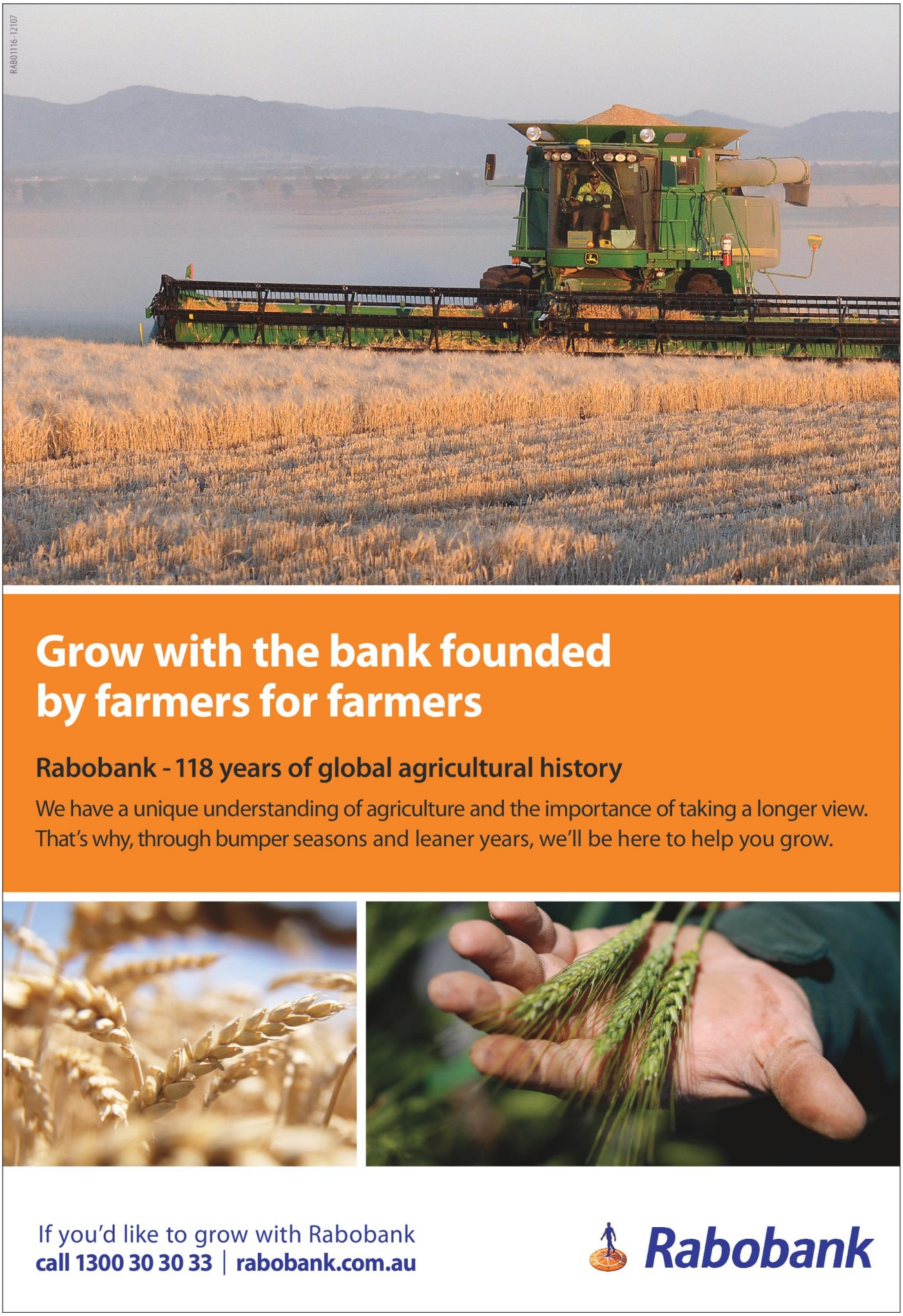
LONG TERM RESEARCH SITE SUPPORTERS

The Liebe Group would like to acknowledge and thank all the sponsors and contributors to the Long Term Research Site for 2016. Without the generous support and assistance from supporters and contributors the management of this unique site would not be possible.

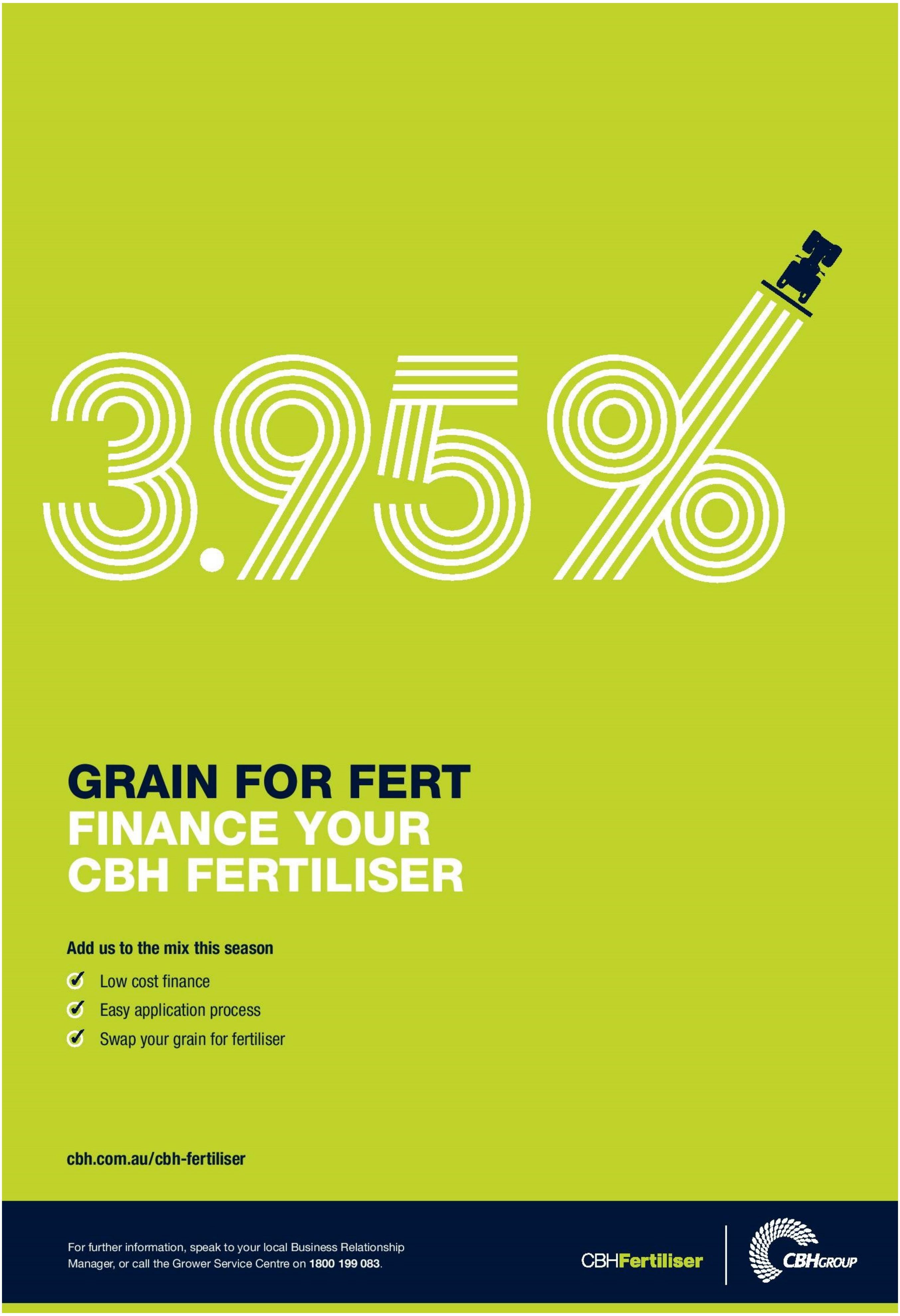
The following is a list of people/organisations the Liebe Group would like to thank:

- **Stuart McAlpine and staff** - For donating seed, seeding, spraying and harvesting the site, agronomic assistance and monitoring the site throughout the season.
- **Grains Research and Development Corporation (GRDC)**
- **Department of Agriculture and Food WA** - Technical advice throughout the year and harvesting of the trials.
- **The University of Western Australia** - For technical assistance, collaboration opportunities and providing the weather station.
- **CBH Group** - Grain sampling and analysis.
- **CSBP labs** - Analysing soil samples.
- **Michael Dodd and staff** - For use of his machinery and agronomic assistance.
- **Elders Scholz Rural Dalwallinu** - Agronomic advice throughout the season and donation of chemical.
- **Imtrade** - For the donation of chemical for the 63ha site.
- **Syngenta** - For the donation of chemical for the 63ha site.
- **Landmark Dalwallinu** - For donation of chemical for the 63ha site and agronomic advice.
- **Wesfarmers Federation Insurance** - For the donation of crop insurance.
- **Farmanco** - For agronomic advice during the season.
- **Living Farm** - For technical assistance.

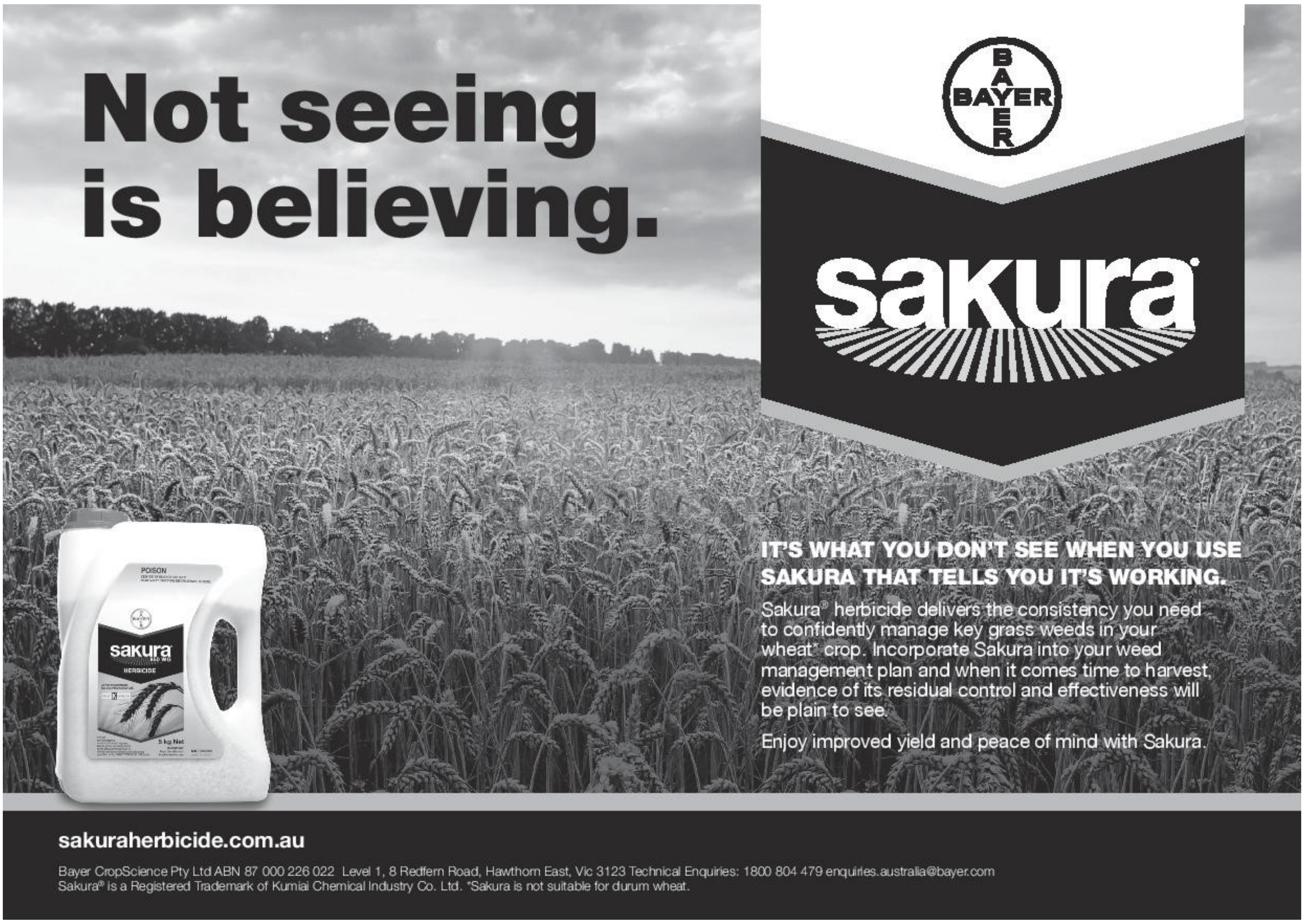

Get off to a good start with K-Till
K-Till has the perfect balance of N,P,K,S and trace elements, making it the ideal starter fertiliser for WA conditions. Banding potassium has been shown to be twice as effective as top dressing which means K-Till can deliver the best results.
To make K-Till your first choice cropping fertiliser, contact your local CSBP Area Manager or visit www.csbp-fertilisers.com.au.
K-TILL
CSBP
CSBP1010

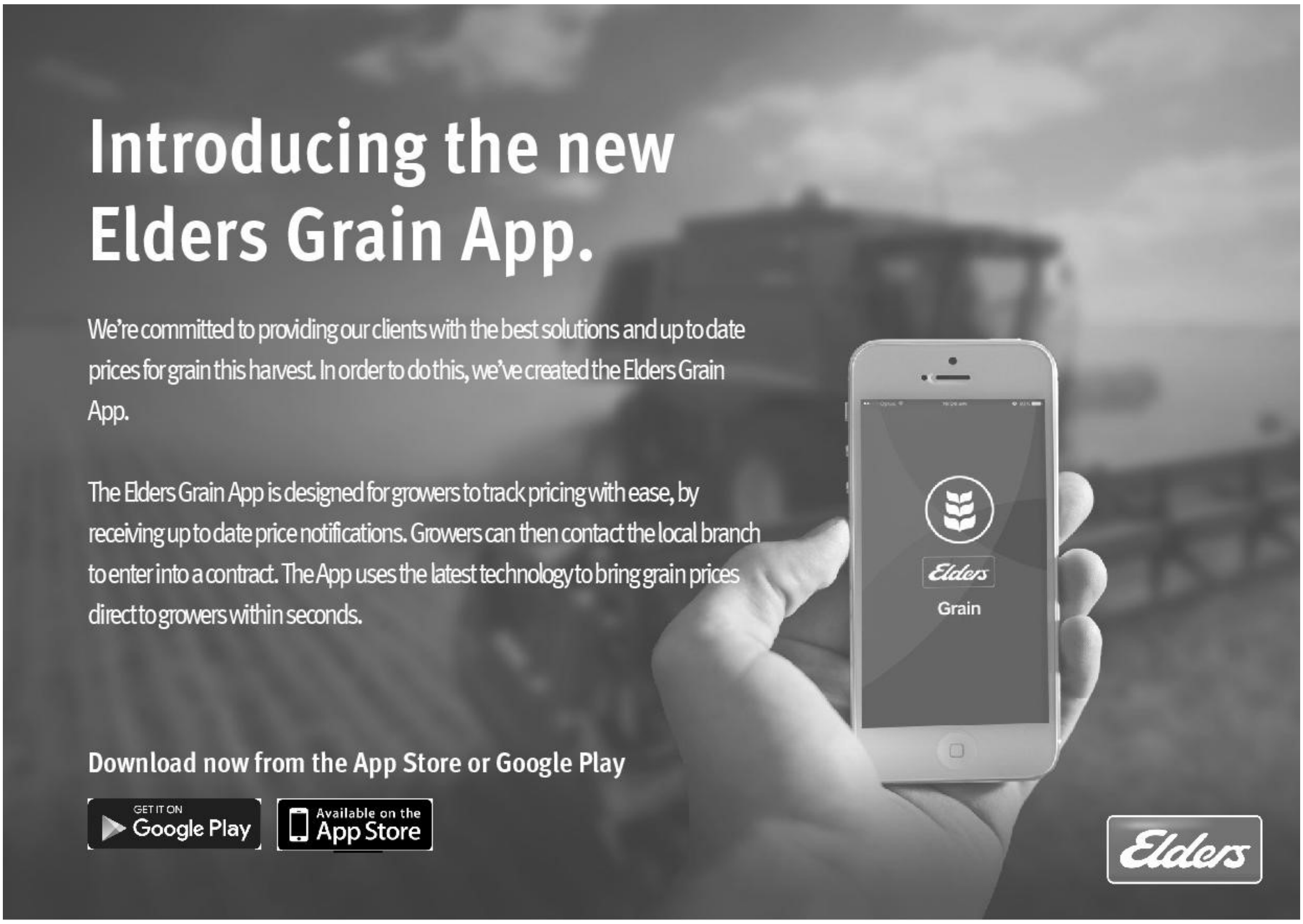

Grow with the bank founded
by farmers for farmers
Rabobank - 118 years of global agricultural history
We have a unique understanding of agriculture and the importance of taking a longer view.
That's why, through bumper seasons and leaner years, we'll be here to help you grow.
If you'd like to grow with Rabobank
call 1300 30 30 33 | rabobank.com.au
Rabobank


Anticipating challenges, identifying opportunities.
If your hopes of record crops have been dashed by frost just weeks before harvest, pre-harvest tax advice and forward planning could help mitigate some of the financial impact on your farm. Getting strategic advice on managing your cashflow for next year could make a big difference.
Our advisers can guide you through these challenging times. We can advise on:
▪ Tax advisory
▪ Business planning
▪ Succession and estate planning
▪ Self managed superannuation funds
For more information please contact:
Judy Snell
T 96511606
E judy.snell@rsm.com.au
rsm.com.au

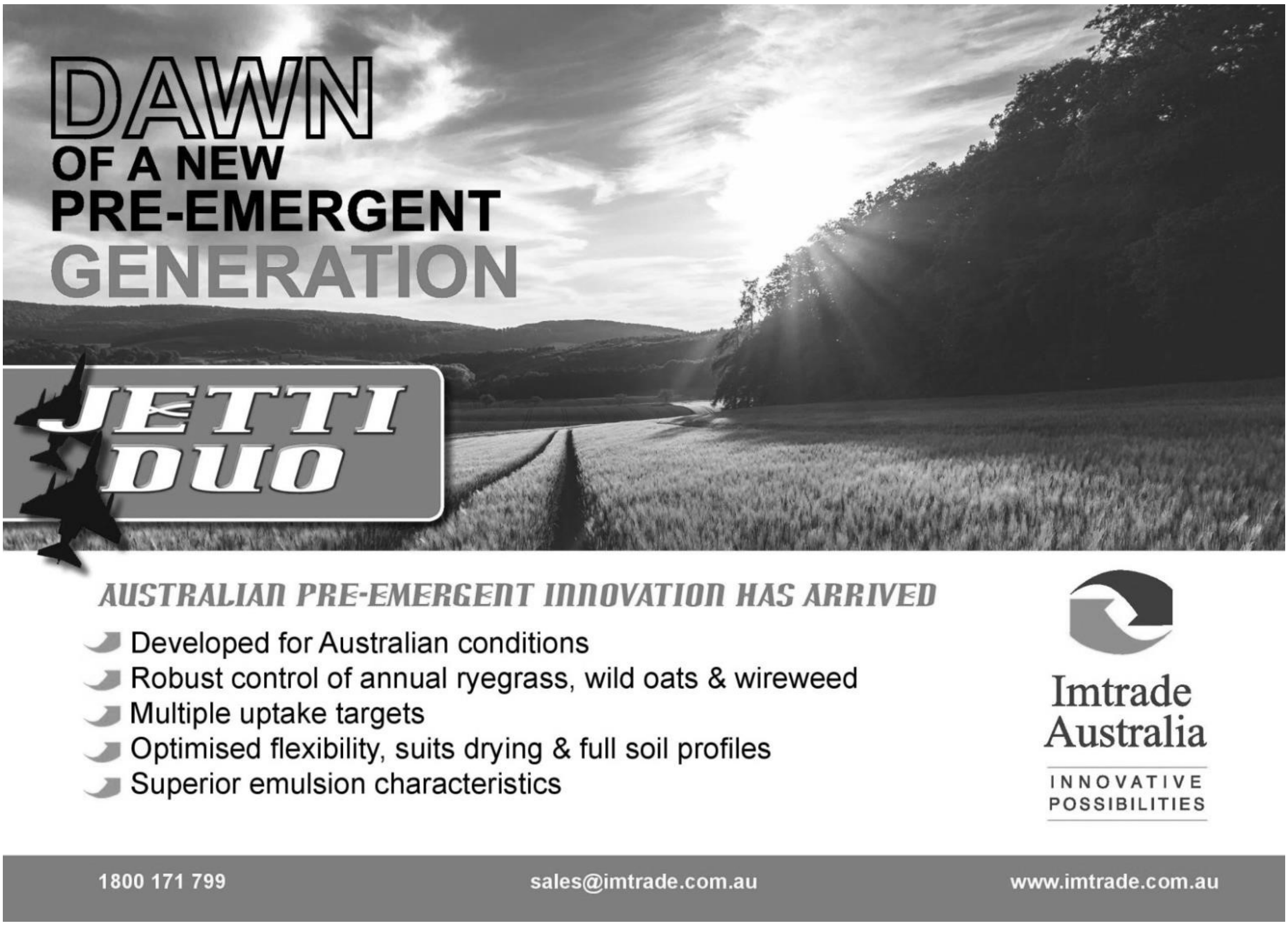

3.95%
GRAIN FOR FERT
FINANCE YOUR
CBH FERTILISER
Add us to the mix this season
Low cost finance
Easy application process
Swap your grain for fertiliser
cbh.com.au/cbh-fertiliser
For further information, speak to your local Business Relationship Manager, or call the Grower Service Centre on 1800 199 083.
CBHFertiliser
CBHGROUP


FARMANCO
THE FARMANCO BENEFITS
As one of Australia's largest agricultural management consultancy practices, our success has been built upon partnering with our clients and understanding their goals and objectives.
Our team of professionals has extensive knowledge of the farming regions and is dedicated to providing sustainable, profitable advice.
OUR PRODUCTS
• Profit Series
• Pesticide Handbook
• Farmanco Facts Newsletter
• Grain Comment & Strategy Newsletter
• Project Series
Go to: www.farmanco.com.au
ABOUT FARMANCO
FARMANCO has been operating for 38 years, we work with over 750 clients producing an annual average of 4.7 million tonnes of grain, 1.7 million sheep, producing 9.3 million kilograms of wool, from a farming asset base of $6.5 billion.
Your Complete Australian Farm Advice Company
Today, our highly skilled and experienced consultancy team provides independent advice in all areas. Our obligation in the market is to provide our clients with innovative solutions; ensuring their businesses remain progressive, sustainable and profitable.
We Offer the Competitive Advantage in Agriculture
You Tube
www.farmanco.com.au
We take pride in the provision of our comprehensive range of services:
• Innovative Business Analysis
• Complete and Customised Farm Management Packages
• Feasibility Studies
• Grain Marketing
• Financial Planning
• Agronomy Services
• Boomspray Application Services
• Precision Ag technology
• Research, Development and Extension


Not seeing is believing.
BAYER
sakura
IT'S WHAT YOU DON'T SEE WHEN YOU USE SAKURA THAT TELLS YOU IT'S WORKING.
Sakura® herbicide delivers the consistency you need to confidently manage key grass weeds in your wheat* crop. Incorporate Sakura into your weed management plan and when it comes time to harvest, evidence of its residual control and effectiveness will be plain to see.
Enjoy improved yield and peace of mind with Sakura.
sakuraherbicide.com.au
Bayer CropScience Pty Ltd ABN 87 000 226 022 Level 1, 8 Redfern Road, Hawthorn East, Vic 3123 Technical Enquiries: 1800 804 479 enquiries.australia@bayer.com
Sakura® is a Registered Trademark of Kumiai Chemical Industry Co. Ltd. *Sakura is not suitable for durum wheat.



Introducing the new
Elders Grain App.
We're committed to providing our clients with the best solutions and up to date prices for grain this harvest. In order to do this, we've created the Elders Grain App.
The Elders Grain App is designed for growers to track pricing with ease, by receiving up to date price notifications. Growers can then contact the local branch to enter into a contract. The App uses the latest technology to bring grain prices direct to growers within seconds.
Elders
Grain
Download now from the App Store or Google Play
GET IT ON
Google Play
Available on the
App Store
Elders



DAWN
OF A NEW
PRE-EMERGENT
GENERATION
JETTI
DUO
AUSTRALIAN PRE-EMERGENT INNOVATION HAS ARRIVED
Developed for Australian conditions
Robust control of annual ryegrass, wild oats & wireweed
Multiple uptake targets
Optimised flexibility, suits drying & full soil profiles
Superior emulsion characteristics
Imtrade
Australia
INNOVATIVE
POSSIBILITIES
1800 171 799
sales@imtrade.com.au
www.imtrade.com.au

Local Research & Development Results February 2017

Index

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 it 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 difference 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)
Variety1	2.1[a]
Variety2	2.2[a]
Variety3	2.0[a]
Variety4	2.9[b]
Variety5	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 variation. Having less variation means there is more confidence in the trial results. Having high variation could mean that factors other than the one being tested are influencing the result (e.g. soil type), and if the same trial was repeated 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 a 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 a 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 carefully 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 situations 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.

2016 Season Overview

The 2016 season was a long season, long in many ways. It commenced with spraying for summer weeds before the 2015 crop was harvested. Spraying continued through autumn preparing paddocks for the break which came early and was not false.

The consistent rain from March onwards allowed for a tremendous knock-down of weeds and early sowing opportunities. It was not straight forward though as a significant area of emerged crop was damaged by spray drift, especially where drift prone paraquat and diquat was used for double-knocking. Late single-knocks were found wanting on larger weeds with well developed root systems. These weeds proved costly and difficult to remove later in-crop.

Burning was compromised by the wet conditions and machinery preparation was cut short by the need to get sowing. Subsequently, there were the most mechanical challenges I have ever seen at seeding.

Time was on our side though, and people took the opportunity to spread their sowing dates and increase the area of non-wheat crops planted. The aim was to get the wheat crop into a 'safe' window which would avoid bolting, and minimise the frost and heat stress risks. Of course, this met with varied success as the early conditions remained mild and did not cause photo-sensitivity issues. There was no heat stress, and the high frequency of frosts damaged most crops. In fact the mid May sown Mace was amongst the most damaged.

There was canola flowering and forming pods in June this year and some of this was shedding by the time harvest came. While yields and oil contents were high there was still frost damage in this less sensitive crop.

Canola (and later in the season lupin) was infected with sclerotinia for the first time for most in the Liebe area. For the second year running this area was the epicentre for powdery mildew in wheat.

It was a career highlight for all of us to experience a season with a good start and no heat stress during flowering and grain-fill. While much of the area did see September and October rainfall drop off, good soil water with mild conditions made for great grain yields where there was no frost damage.

Unfortunately the frost did a great deal of damage to all crops, especially wheat. Having said this, on most farms the frost stripped out less tonnes of grain than heat and terminal drought usually does. This being the case it is hard to change anything because of these frost events.

I trust you will enjoy reading the results from the 2016 trial program. The trials this year will need to be interpreted carefully because of the frost, disease, nutrition (supply and demand), and the good conditions themselves. The high yields need to be kept in context with nature of the season and how unusual it was.

All the best for the 2017 season.

David Cameron,
Agronomy Consultant, Farmanco

Cereal Research Results

Wheat National Variety Trial - Nugadong

Australian Crop Accreditation System Limited

Aim

To evaluate yield and quality of new and existing wheat varieties.

Background

The wheat National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate wheat varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT wheat trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to wheat varieties.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	10m x 1.75m x 3 replications
Soil type	Sand/sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.9 10-20cm: 5.4 20-30cm: 6.1
EC (dS/m)	0-10cm: 0.054 10-20cm: 0.037 20-30cm: 0.038
Paddock rotation	2013 fallow, 2014 wheat, 2015 canola
Sowing rate	80 kg/ha
Seeding date	10/05/2016
Fertiliser	10/05/2016: 100 kg/ha Gusto Gold, 80 kg/ha Urea 29/06/2016: 100 kg/ha Flexi N
Herbicides, insecticides & fungicides	10/05/2016: 118 g/ha Sakura, 0.25 kg/ha Diuron, 2 L/ha Trifluralin, 2 L/ha Paraquat & Diquat, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 15/06/2016: 2 L/ha Prosulfocarb S-Metolachlor, 22/06/2016: 0.67 L/ha Bromoxynil & Pyrasulfotole, 0.15 L/ha Prothioconazole & Tebuconazole, 0.05 L/ha Isoclast

Annual rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

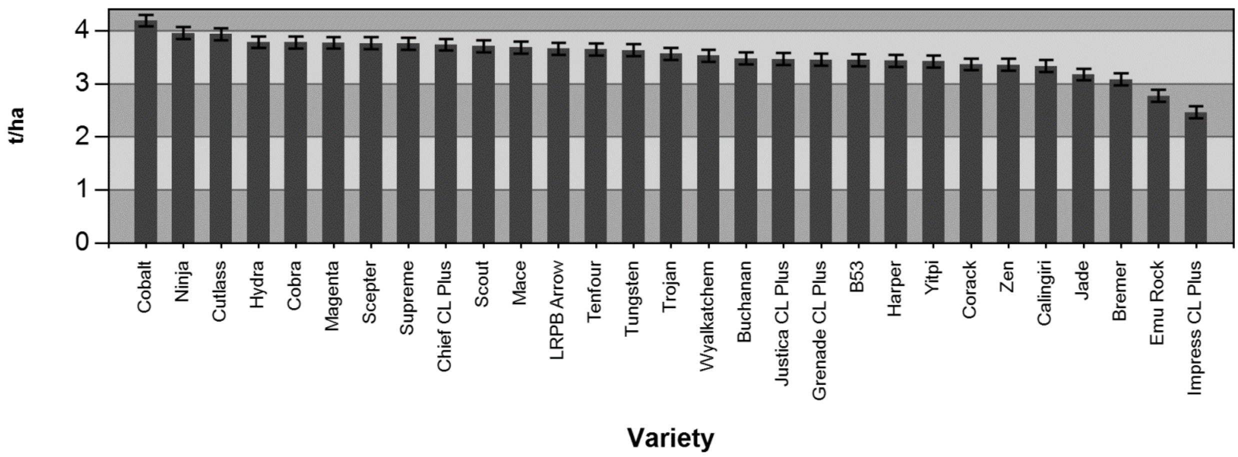


Figure 1: Yield comparison of wheat varieties sown at Nugadong, 2016.

Table 1: Yield and grain quality data for wheat varieties grown at Nugadong, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Cobalt	4.19	117	83.67	8.20	1.87
Ninja	3.96	111	82.04	8.40	2.04
Cutlass	3.94	110	81.87	8.10	2.79
Cobra	3.79	106	81.42	9.00	2.81
Hydra	3.79	106	81.42	8.80	4.57
Magenta	3.78	106	82.53	8.40	3.45
Scepter	3.77	106	82.19	8.20	3.90
Supreme	3.76	105	82.42	8.90	2.69
Chief CL Plus	3.74	105	82.02	9.10	2.76
Scout	3.71	104	83.89	8.50	3.86
Mace	3.69	103	81.30	9.00	2.03
LRPB Arrow	3.66	103	83.10	8.60	1.38
Tenfour	3.65	102	77.75	9.00	3.19
Tungsten	3.64	102	79.70	8.40	3.96
Trojan	3.57	100	84.86	8.40	2.45
Wyalkatchem	3.53	99	81.54	9.10	1.56
Buchanan	3.48	97	80.90	9.20	2.34
Justica CL Plus	3.47	97	81.62	9.00	1.47
B53	3.45	97	82.27	9.40	1.89
Grenade CL Plus	3.45	97	81.42	9.20	2.03
Harper	3.44	96	83.32	8.80	3.86
Yitpi	3.43	96	82.72	8.70	6.67
Corack	3.37	94	78.58	9.40	2.10
Zen	3.36	94	81.21	8.90	1.70
Calingiri	3.34	94	82.39	9.10	2.00
Jade	3.18	89	79.02	9.60	4.73
Bremer	3.09	87	81.65	9.30	1.00
Emu Rock	2.78	78	72.33	10.00	3.64
Impress CL Plus	2.46	69	76.78	11.00	2.65
Site Mean (t/ha)	*3.57*				
CV (%)	*3.6*				
P value	*<0.001*				
LSD (t/ha)	*0.22*	*6*			

Variety Descriptions

Variety	Description
Ninja	Highest yielding noodle wheat, 5-6% higher than Mace. Mid-season, between Zen and Mace in flowering time. MR-MS Yellow Spot, MS Stripe Rust, S-VS Stem Rust, MR Leaf Rust. Calingiri/Wyalkatchem derivative.
Cutlass	Mid-late maturing, similar maturity to Yitpi. Excellent rust resistance, better Yellow Spot resistance than Yitpi. APW classification.
Cobra	High yielding mid to long season variety developed for Western Australia. AH classification. Excellent Yellow Spot resistance.
Hydra	Mid-short season maturity. Outstanding Yellow Spot resistance, excellent rust package. APW classification.

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.6°C on Aug 1, -0.5°C on Aug 2, -1.2°C on Aug 23, -0.5°C on Sep 17, -1.1°C on Sep 24. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 34.9°C on Oct 12, 35.9°C on Oct 13, 37°C on Oct 23, 32.8°C on Oct 28. Interpret results with caution.

Comments
For more information please refer to www.nvtonline.com. This trial is classfied under Buntine.

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION
National Variety Trials A GRDC INITIATIVE

Wheat National Variety Trial - Ballidu

Australian Crop Accreditation System Limited

Aim
To evaluate yield and quality of new and existing wheat varieties.

Background
The wheat National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate wheat varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT wheat trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to wheat varieties.

Trial Details

Property	David Hood, Ballidu												
Plot size & replication	10m x 1.75m x 3 replications												
Soil type	Sandy loam												
Soil pH ($CaCl_2$)	0-10cm: 5.4 10-60cm: 5.4												
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.1												
Paddock rotation	2015 pasture spray topped												
Seeding date	16/05/2016												
Fertiliser	16/05/2016: 100 kg/ha Gusto Gold, 50 kg/ha Urea 08/07/2016: 80 kg/ha Flexi N												
Herbicides, insecticides & fungicides	16/05/2016: 118 g/ha Sakura, 0.25 kg/ha Diuron, 2.5 L/ha Trifluralin, 2 L/ha Glyphosate, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 23/06/2016: 1 L/ha Bromoxynil & Pyrasulfotole, 0.15 L/ha Prothioconazole & Tebuconazole, 0.5 L/ha Isoclast 08/07/2016: 0.15 L/ha Prothioconazole & Tebuconazole 30/08/2016: 0.15 L/ha Prothioconazole & Tebuconazole, 0.05 L/ha Isoclast												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	14.4	0.0	94.0	49.6	29.6	30.0	41.4	36.0	20.0	9.2	-	-	324.2

Results

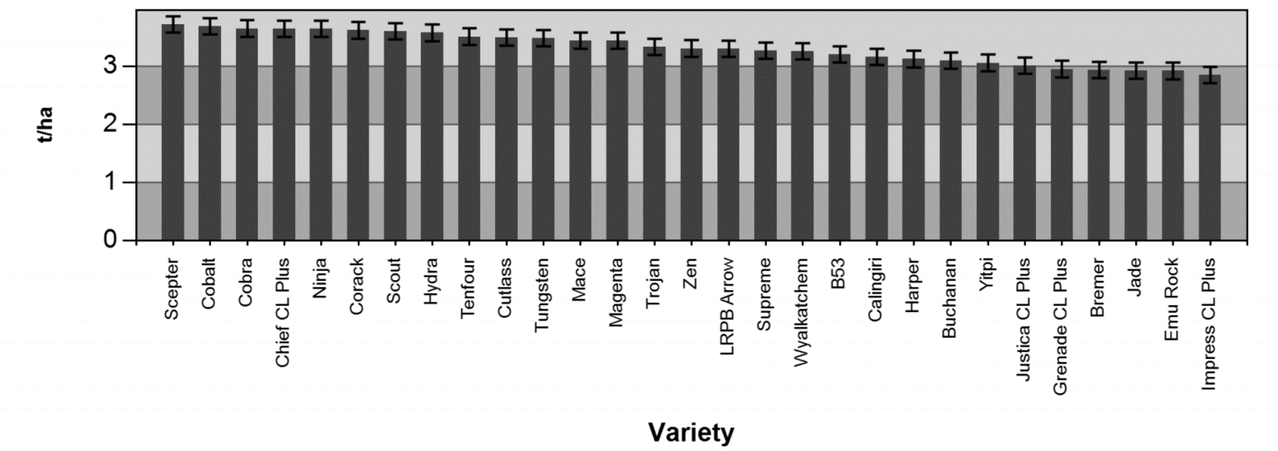


Figure 1: Yield comparison of wheat varieties sown at Ballidu, 2016.

Table 1: Yield and grain quality data for wheat varieties grown at Ballidu, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Scepter	3.72	110	81.36	8.60	1.15
Cobalt	3.68	109	81.68	8.60	1.38
Chief CL Plus	3.65	108	81.84	8.90	0.70
Cobra	3.65	108	80.63	9.00	0.88
Ninja	3.65	108	81.81	8.70	0.77
Corack	3.62	107	82.07	9.40	0.57
Scout	3.60	107	82.44	9.00	0.86
Hydra	3.57	106	81.23	8.90	1.79
Tenfour	3.51	104	80.24	9.80	1.01
Cutlass	3.49	103	81.33	8.60	0.83
Tungsten	3.48	103	79.29	8.40	1.15
Mace	3.44	102	78.74	9.20	0.80
Magenta	3.44	102	81.21	9.00	1.14
Trojan	3.34	99	83.09	8.70	0.71
LRPB Arrow	3.30	98	79.62	9.10	1.18
Zen	3.30	98	81.16	8.70	0.71
Supreme	3.27	97	82.69	9.50	0.87
Wyalkatchem	3.26	96	81.64	9.10	0.64
B53	3.20	95	81.03	9.80	0.58
Calingiri	3.16	93	81.02	9.10	0.76
Harper	3.12	92	81.91	9.20	1.06
Buchanan	3.09	91	80.74	9.50	1.83
Yitpi	3.06	91	81.17	9.30	1.62
Justica CL Plus	3.01	89	80.41	9.30	0.96
Grenade CL Plus	2.95	87	78.75	10.20	0.83
Bremer	2.93	87	79.89	9.60	0.69
Jade	2.93	87	78.77	10.20	2.02
Emu Rock	2.92	86	80.29	11.10	1.05
Impress CL Plus	2.85	84	80.59	10.40	0.72
Site Mean (t/ha)	*3.38*				
CV (%)	*5.1*				
P value	*<0.001*				
LSD (t/ha)	*0.28*	*8*			

Comments

For more information please refer to www.nvtonline.com

Wheat National Variety Trial - Pithara

Australian Crop Accreditation System Limited

Aim

To evaluate yield and quality of new and existing wheat varieties.

Background

The wheat National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate wheat varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT wheat trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to wheat varieties.

Trial Details

Property	Brad McIlroy, Pithara												
Plot size & replication	10m x 1.75m x 3 replications												
Soil type	Loam clay												
Soil pH ($CaCl_2$)	0-10cm: 4.5 10-60cm: 5.9												
EC (dS/m)	0-10cm: 0.3 10-60cm: 0.0												
Paddock rotation	2015 canola												
Seeding date	12/05/2016												
Fertiliser	12/05/2016: 100 kg/ha Gusto Gold, 50 kg/ha Urea 08/07/2016: 80 kg/ha Flexi N 16/08/2016: 60 kg/ha Flexi N												
Herbicides, insecticides & fungicides	12/05/2016: 118 g/ha Sakura, 0.25 kg/ha Diuron, 2 L/ha Trifluralin, 1.5 L/ha Glyphosate, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 23/06/2016: 0.67 L/ha Bromoxynil & Pyrasulfotole, 0.15 L/ha Prothioconazole & Tebuconazole, 0.05 L/ha Isoclast 08/07/2016: 0.15 L/ha Prothioconazole & Tebuconazole,												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	0	0.4	84.6	45.0	46.2	41.2	42.2	39.2	14.0	8.0	-	-	320.8

Results

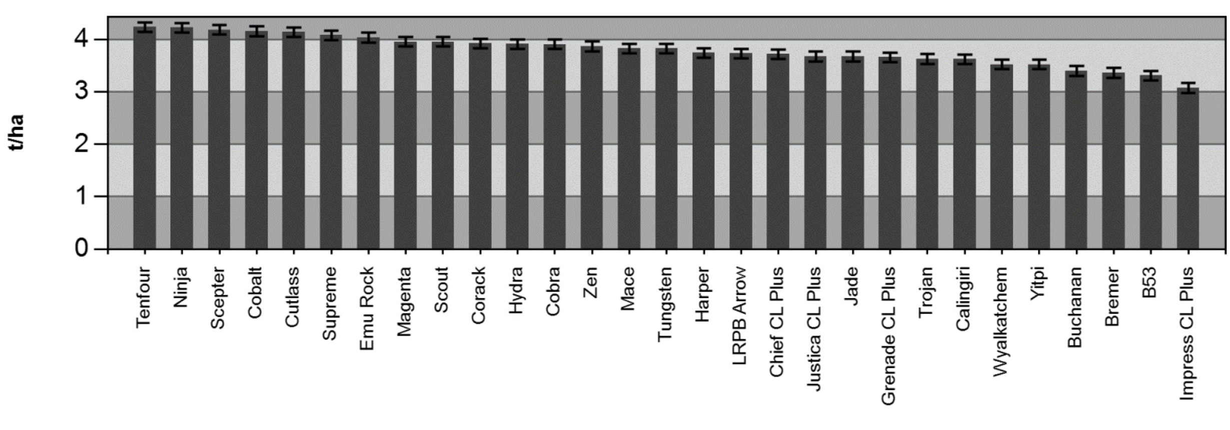


Figure 1: Yield comparison of wheat varieties sown at Pithara, 2016.

Table 1: Yield and grain quality data for wheat varieties grown at Pithara, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Tenfour	4.24	110	81.79	9.20	2.35
Ninja	4.23	110	83.11	9.00	1.87
Scepter	4.19	109	83.59	8.70	1.96
Cobalt	4.16	108	82.92	8.70	1.98
Cutlass	4.14	107	82.22	8.50	1.73
Supreme	4.08	106	83.75	8.60	1.93
Emu Rock	4.04	105	82.30	9.10	2.49
Magenta	3.96	103	83.95	8.70	1.91
Scout	3.96	103	82.41	8.90	1.97
Corack	3.93	102	83.41	9.40	1.03
Hydra	3.92	102	82.75	9.00	4.01
Cobra	3.91	101	82.19	9.40	2.41
Zen	3.87	100	83.50	9.30	1.16
Mace	3.83	99	82.02	9.10	1.16
Tungsten	3.83	99	79.43	8.80	2.95
Harper	3.74	97	83.09	9.10	3.19
LRPB Arrow	3.74	97	82.57	9.10	1.00
Chief CL Plus	3.72	96	83.37	9.10	0.99
Jade	3.68	95	81.91	9.50	2.40
Justica CL Plus	3.68	95	82.30	9.10	1.26
Grenade CL Plus	3.66	95	80.95	9.20	1.70
Calingiri	3.63	94	82.59	9.10	2.08
Trojan	3.63	94	85.48	9.40	0.90
Wyalkatchem	3.53	91	83.09	9.80	0.95
Yitpi	3.52	91	83.39	9.20	2.76
Buchanan	3.40	88	81.56	10.00	2.61
Bremer	3.36	87	81.80	9.80	1.18
B53	3.31	86	81.70	10.10	1.27
Impress CL Plus	3.07	80	79.61	10.70	1.56
Site Mean (t/ha)	*3.86*				
CV (%)	*2.7*				
P value	*<0.001*				
LSD (t/ha)	*0.18*	*5*			

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.7°C on Aug 1, -1.6°C on Aug 2, -0.1°C on Aug 19, -0.3°C on Aug 23, -0.6°C on Sep 15, -0.7°C on Sep 18, -1.5°C on Sep 24, -0.5°C on Sep 29. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 36.3°C on Oct 12, 35.9°C on Oct 13, 32.3°C on Oct 22, 38.2°C on Oct 23, 32.1°C on Oct 24, 32.7°C on Oct 27, 32.8°C on Oct 28. Interpret results with caution.

Comments

For more information please refer to www.nvtonline.com

Practice for profit trial

Chris O'Callaghan, consultant and Clare Johnston, Liebe Group

Key Messages

- High input canola had the highest gross margin in 2016.
- High input canola has overtaken the low input wheat treatment as the highest cumulative gross margin.
- Are we beginning to see some cracks appear in the low input continuous wheat system this year?
- 2017 and 2018 crops will be interesting to assess the impact of the rotational crop in the system.

Aim

To examine the difference in profitability between low and high input cropping practices over an extended period of time.

Background

The Practice for Profit trial is in its sixth consecutive season, located on the Mills' property east of Dalwallinu. Since 2011 we have compared the following two scenarios:

- **Low input** treatments based grain production at the lowest possible cost, regardless of seasonal conditions.
- **High input** treatments to simulate a paddock with high yield potential matched with increased inputs to maximise yield and quality potential.

2011 was the setup phase of the trial, the wheat treatment received high and low inputs while the rotational crops received the same seeding and fertiliser rates (no high and low) dependant on the rotation standard practice (Appendix B).

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. The whole site was thus fallowed in 2013. 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 in 2011, all rotation inputs were adjusted for high and low treatments (Table 2).

It is important to note that high and low inputs of this trial are considered on a seasonal basis, and on the back of a chemical fallow in 2013 all nutrient levels were high. On the trial to date the low input treatments have received maintenance levels of phosphorus (P) and nitrogen (N). The soil nutrition levels will be tested at the start of the 2017 season and fertiliser rates will be adjusted accordingly with high input treatments reviewed midseason.

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: 5.3 10-20cm: 7.1 20-40cm: 7.5
EC (dS/m)	0-10cm: 0.036
Sowing date	13/05/2016
Seeding rate	See Table 2
Paddock rotation	See Table 1
Amelioration	11/05/2016: 500 kg/ha gypsum
Fertiliser	See Table 2
Herbicides, Fungicides & Insecticides	06/05/2016: 2.5 L/ha Glyphosate 13/05/2016: 200 mL/ha Alpha-cypermethrin, 200 mL/ha Chlorpyrifos, 3 L/ha Spray.Seed 250, 2 L/ha Trifluralin, 1.2 Kg/ha Terbuthylazine Field Peas and Canola only: 23/08/2016: 200 mL/ha Alpha-cypermethrin
Growing season rainfall (April – October)	2016: 212mm (+ 67mm in March), 2015: 236mm, 2014: 187mm, 2013: fallow, 2012: 321mm, 2011: 232.8mm

Trial Layout

Table 1: Practice for Profit trial, rotation history.

Treatment	2011	2012	2013	2014	2015	2016	Input Level
1	Wheat	Wheat	Fallow	Wheat	Wheat	Wheat	Low
2	Wheat	Wheat	Fallow	Wheat	Wheat	Wheat	High
3	Canola	Wheat	Fallow	Wheat	Wheat	Canola	Low
4	Canola	Wheat	Fallow	Wheat	Wheat	Canola	High
5	Volunteer Pasture (Spraytopped)	Wheat	Fallow	Wheat	Wheat	Volunteer Pasture/Fallow	Low
6	Volunteer Pasture (Spraytopped)	Wheat	Fallow	Wheat	Wheat	Volunteer Pasture/Fallow	High
7	Field Peas	Wheat	Fallow	Wheat	Wheat	Field Peas	Low
8	Field Peas	Wheat	Fallow	Wheat	Wheat	Field Peas	High

Note: Stated input levels are for all treatment years, except rotation crops in 2011 and 2016 (Appendix B).

Table 2: 2016 Practice for Profit input rates.

Treatment	2016 Rotation	Variety	Input	Sowing rate (kg/ha)	Agstar Extra (kg/ha)	Urea (kg/ha)	Agflow (kg/ha)	Flexi-N 4 WA-S (L/ha)
1	Wheat low	Mace	Low	40	50	50	-	-
2	Wheat high	Mace	High	80	70	50	-	50
3	Canola	Stingray	Low	3	50	50	-	-
4	Canola	Stingray	High	3	70	70	-	60
5	Vol Pasture	-	Low	-	-	-	-	-
6	Vol Pasture	-	High	-	-	-	-	-
7	Field Peas	Twilight	Low	90	-	-	30	-
8	Field Peas	Twilight	High	120	-	-	60	-

Results

Table 3 shows soil properties taken from the trial site from 2012-2016. In 2012, the site had an average topsoil (0-10cm) and subsoil (10-20cm) pH of 6.6 and 7.3 respectively. When this is broken down into the low and high inputs, the high input pH in the topsoil is 6.5 and the low is 6.7. The first two successive years of implementing the trial saw little acidification caused by the applied fertiliser treatments and crop removal. However, the treatments impact on the pH levels can be observed in 2014 when they declined by an average of 0.9 units.

Table 3: Average organic carbon (OC) and pH ($CaCl_2$) across high and low input treatments taken from 2012-2016.

Year	Depth (cm)	Average pH ($CaCl_2$)	High Input pH ($CaCl_2$)	Low Input pH ($CaCl_2$)	Average OC (%)	High Input OC (%)	Low Input OC (%)
March	0-10	6.6	6.5	6.7	0.66	0.68	0.64
2012	10-20	7.3	7.2	7.3	0.60	0.65	0.55
	20-30	8.0	8.0	8.1	0.42	0.43	0.41
July	0-10	5.3	5.3	5.4	0.89	0.90	0.87
2013	10-20	7.1	7.1	7.1	0.48	0.48	0.46
	20-30	7.9	7.9	7.9	0.33	0.35	0.32
March	0-10	5.7	5.5	5.9	0.89	0.90	0.89
2014	10-20	7.1	7.2	6.9	0.56	0.60	0.52
	20-30	7.5	7.5	7.4	0.51	0.53	0.53
November	0-10	5.7	5.7	5.7	0.80	0.79	0.81
2015	10-20	6.9	6.8	6.9	0.52	0.52	0.51
	20-30	7.4	7.4	7.4	0.42	0.42	0.43
April 2016	0-10	5.4	5.2	5.5	0.83	0.84	0.82

Note: 2013 was a chemical fallow across all plots.

Wheat high yielded significantly higher than wheat low in 2016. Yields of rotation treatments, canola and field pea, did not yield significantly different between respective high and low regimes. Please interpret economics with this in mind.

Table 5: Yield, quality and grade of wheat sown in 2016, east Dalwallinu.

Treatment	Yield (t/ha)	Protein (%)	Hectolitre (g/hL)	Screenings (%)	Grade
Wheat low	2.38[b]	9.90	83.20	4.04	APW2
Wheat high	2.84[a]	10.63	82.31	3.86	APW1
LSD (P=0.05)	*0.237*	*NS*	*NS*	*NS*	
CV (%)	*2.58*	*3.25*	*0.68*	25.78	
P value	*0.014*	*0.115*	*0.191*	*0.851*	

Means followed by a different letter are significantly different.

Table 6: Yield, quality and grade of canola sown in 2016, east Dalwallinu.

Treatment	Yield (t/ha)	Protein (%)	Oil (%)	Admixture (g/hL)	Large Admixture (%)	Grade
Canola low	0.94	23.23	43.37	3.27	14.47	CAN2
Canola high	1.16	23.67	43.17	5.47	3.56	CAN2
LSD (P=0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	
CV (%)	*46.26*	*3.94*	*1.73*	*39.27*	80.16	
P value	*0.630*	*0.623*	*0.775*	*0.257*	0.205	

Table 7: Yield, quality and grade of field peas sown in 2016, east Dalwallinu.

Treatment	Yield (t/ha)	Protein (%)	Moisture (%)	Grade
Field Peas low	0.76	24.63	8.70	PKA1
Field Peas high	0.54	24.63	8.87	PKA1
LSD (P=0.05)	*NS*	*NS*	*NS*	
CV (%)	*18.73*	*1.72*	*0.93*	
P value	*0.150*	*1.000*	*0.129*	

Economic Analysis

Table 6: Economic analysis of each treatment over the 2011, 2012, 2014, 2015 & 2016 seasons.

		Gross Margin ($/ha)					
	Treatment	**2016**	**2015**	**2014**	**2012**	**2011**	**Cumulative Total**
4	Canola high	414	582	399	138	392	1,925
1	Wheat low	309	495	409	204	448	1,865
3	Canola low	344	509	329	303	303	1,788
2	Wheat high	390	566	305	66	440	1,767
7	Field Peas low	87	453	325	315	188	1,368
8	Field Peas high	-8	576	365	144	222	1,299
5	Vol Pasture/Fallow low	-	356	314	102	61	833
6	Vol Pasture/Fallow high	-	470	221	-159	61	593

Note: More detail of income and cost figures can be seen in Appendix A.
2013 was a chemical fallow with all plots treated the same.
Economics are based on treatment averages which may not be significantly different. Therefore these must be used with care.

The 2011 treatments only varied input levels for the wheat rotation. The canola, field peas and volunteer pasture plots were treated as one input level with targeted nutrient inputs based on the rotation.

Costs taken into account include fertiliser and herbicide costs, seed and CBH receival and handling fees ($38/t). In 2011, the volunteer pasture plots, while not creating profit via yield provided a value in sheep grazing; this was valued at $74/winter grazed hectare, assumed from district practice. Due to low weed/pasture population in 2016 the site was treated as a chemical fallow, with no sheep grazing value.

2016 income was based on grade of sample tested at CBH site. Wheat income was based on an APW1 price of $250/t and an APW2 price of $238/t. Canola income was based on a CAN1 price of $572/t and field pea income based on $345/t. The volunteer pasture treatments, were bare and are treated as a fallow.

The economic analysis completed for this trial is a basic gross margin analysis based on variable costs and does not include any fixed costs. Costs should be adjusted to suit your own situation.

Comments

The 2016 season for the practice for profit trial was planted to the rotation crops being canola, field peas, fallow or wheat. Each crop received high and low input and this break/rotation crop is considered a 'set up' year for the following two seasons of wheat.

In 2016, high input wheat, followed by high input canola had the highest gross margins, which reflects the better season that was had in the area. There was statistically significant yield difference between the high and low input wheat treatments. There was no statistically significant yield difference between the high and low input canola treatment or the high and low input field pea treatment. In the canola plots there was a high level of variation between replications, with machinery error being identified as the source of the variation. This is reflected in the high CV, Table 6.

Low input wheat has been overtaken as the highest cumulative gross margin across all years, with high input canola showing a $60/ha benefit over the six years. These figures must be treated with caution given there was no statistically significant difference between the high and low canola treatments in this season.

In 2016, the low input continuous wheat had lower protein levels than the high input continuous wheat and as a result was graded APW2, which effected the gross margin. This is an interesting result and perhaps begins to answer one of the original questions of the trial, which was 'how sustainable is continuous low input wheat'. The next two years will be interesting in this regard, as we will be able to assess what the implications of the rotational crop are on high and low input wheat regimes compared to that of the high & low continuous wheat systems. The site has a low weed burden, which provides less pressure on the continuous wheat rotation.

Much will depend on the season next year, however there will be a few things to look out for. These include whether the 2016 fallow has an impact on yield and protein next year, particularly interesting if it is a dry season. How beneficial will having field peas as a legume in the rotation be in a low input system to maintain yield and protein levels in the wheat crop? What impact will a hungry canola crop have on a low input system? And of course, what will the economics across all of this look like?

It will be important to take comprehensive soil samples before the 2017 season to build our understanding of what is happening with the yields and protein at the end of the season and why.

This trial is unique in comparing low versus high input rotation systems over six seasons with physical data. It is worth acknowledging that trial work conducted in this manner does have its flaws, given the number of variables in the treatments. However it is also worth acknowledging that farmers are dealing with a whole system, which includes numerous variables. As such, this trial should be interpreted from the angle of farming system versus farming system that trades off statistical rigour, in favour of increased relevance to a farmer.

Acknowledgements
Thank you to the Mills family for hosting the trial and to CSBP for trial support. This project has been possible due to historical funding by the Australian Government Department of Agriculture.

Paper reviewed by: Wayne Parker and Martin Harries, DAFWA

Contact
Liebe Group
admin@liebegroup.org.au
(08) 9661 0570

Appendix A: Cumulative income and costs over five cropping seasons: 2011, 2012, 2014, 2015 and 2016 at east Dalwallinu.

	Income ($/ha)						Variable Costs ($/ha)					
Treatment	**2016**	**2015**	**2014**	**2012**	**2011**	**Cumulative Income**	**2016**	**2015**	**2014**	**2012**	**2011**	**Cumulative Costs**
Canola high	664	928	667	371	539	3,169	249	346	269	233	147	1,244
Wheat low	566	752	584	328	699	2,929	257	257	175	124	251	1,064
Canola low	538	766	493	427	443	2,667	194	257	164	124	140	879
Wheat high	710	912	562	299	750	3,233	320	346	257	233	310	1,466
Field Peas low	262	702	487	440	350	2,241	176	249	162	124	161	871
Field Peas high	186	922	629	377	388	2,503	194	346	264	233	166	1,204
Vol Pasture low	591	474	226	74	1,365		234	160	124	13	532	
Vol Pasture high	799	469	73	74	1,415		329	248	232	13	822	

Note 2013 was a chemical fallow.

Appendix B: 2011 trial inputs.

Treatment	2011	Input	Seed (kg/ha)	Gusto Gold (kg/ha)	Urea (kg/ha)
1	Wheat	Low	30	65	10
2	Wheat	High	80	65	65
3	Canola	Low	5	65	100
4	Canola	High	5	65	100
5	Volunteer Pasture	Low	0	0	0
6	Volunteer Pasture	High	0	0	0
7	Field Peas	Low	90	65	0
8	Field Peas	High	90	65	0

Barley National Variety Trial - Nugadong

Australian Crop Accreditation System Limited

Aim
To evaluate yield and quality of new and existing barley varieties.

Background
The barley National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate barley varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT barley trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to barley varieties.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	10m x 1.75m x 3 replications												
Soil type	Sandy Loam												
Soil pH ($CaCl_2$)	0-10cm: 5.9 10-60cm: 6.1												
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.0												
Paddock rotation	2013 fallow, 2014 wheat, 2015 canola												
Seeding date	10/05/2016												
Fertiliser	10/05/2016: 100 kg/ha Gusto Gold, 50 kg/ha Urea												
Herbicides, insecticides & fungicides	10/05/2016: 0.25 kg/ha Diuron, 2 L/ha Trifluralin, 2 L/ha Paraquat & Diquat, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 15/06/2016: 2 L/ha Prosulfocarb & S-Metolachlor 22/06/2016: 0.67 L/ha Bromoxynil & Pyrasulfotole, 0.15 L/ha Prothioconazole & Tebuconazole, 0.7 L/ha Isoclast												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

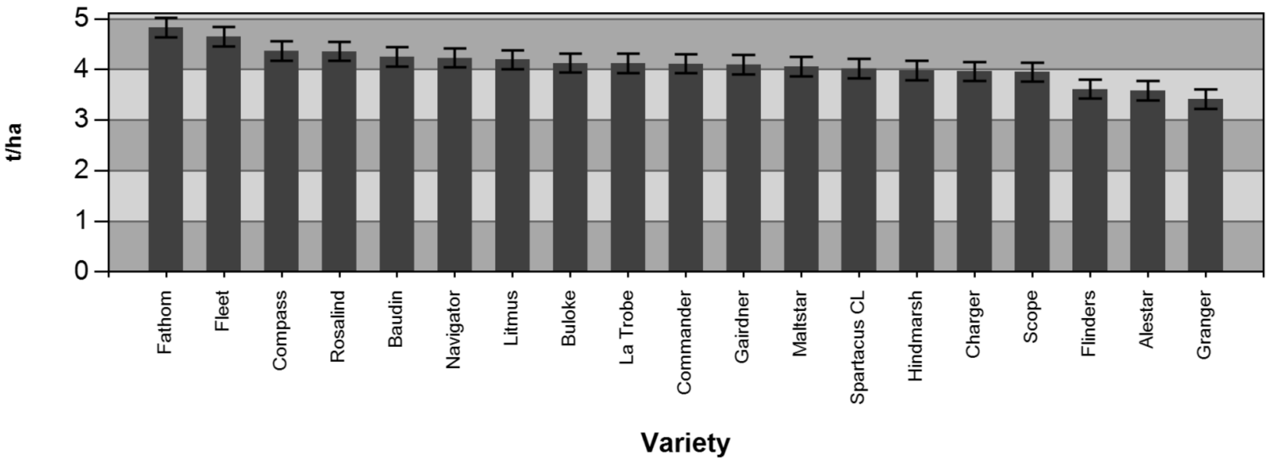


Figure 1: Yield comparison of barley varieties sown at Nugadong, 2016.

Table 1: Yield and grain quality data for barley varieties grown at Nugadong, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings <2.5 (%)
Fathom	4.83	119	62.28	8.40	3.20
Fleet	4.65	115	62.77	8.40	3.10
Compass	4.36	108	64.56	8.30	3.40
Rosalind	4.36	108	63.36	9.20	3.40
Baudin	4.25	105	66.84	8.80	5.20
Navigator	4.23	104	63.94	8.40	3.80
Litmus	4.19	103	64.36	9.30	6.10
Buloke	4.13	102	64.00	8.90	7.80
La Trobe	4.12	102	67.01	8.50	5.20
Commander	4.11	101	64.35	8.60	7.10
Gairdner	4.10	101	64.42	9.20	9.40
Maltstar	4.06	100	61.70	8.60	11.70
Spartacus CL	4.02	99	65.35	9.20	4.20
Hindmarsh	3.98	98	64.50	8.70	4.70
Charger	3.96	98	56.32	8.80	11.60
Scope	3.95	98	62.62	9.30	11.80
Flinders	3.61	89	63.61	9.80	6.40
Alestar	3.58	88	58.82	9.20	10.10
Granger	3.41	84	58.93	10.00	18.90
Site Mean (t/ha)	*4.05*				
CV (%)	*5.2*				
P value	*<0.001*				
LSD (t/ha)	*0.38*	*9*			

Comments

For more information please refer to www.nvtonline.com. This trial is classfied under Buntine.

Barley National Variety Trial - Ballidu

Australian Crop Accreditation System Limited

Aim

To evaluate yield and quality of new and existing barley varieties.

Background

The barley National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate barley varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT barley trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to barley varieties.

Trial Details

Property	David Hood's Property, Ballidu												
Plot size & replication	10m x 1.75m x 3 replications												
Soil type	Sandy Loam												
Soil pH ($CaCl_2$)	0-10cm: 5.4 10-60cm: 5.4												
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.1												
Paddock rotation	2015 wheat												
Seeding date	16/05/2016												
Fertiliser	16/05/2016: 100 kg/ha Gusto Gold, 50 kg/ha Urea												
Herbicides, insecticides & fungicides	16/05/2016: 2.5 L/ha Trifluralin, 0.25 kg/ha Diuron, 2 L/ha Glyphosate, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 23/06/2016: 0.67 L/ha Bromoxynil & Pyrasulfotole, 0.15 L/ha Prothioconazole & Tebuconazole, 0.1 L/ha Isoclast 08/07/2016: 0.15 L/ha Prothioconazole & Tebuconazole 30/08/2016: 0.15 L/ha Prothioconazole & Tebuconazole, 0.05 L/ha Isoclast												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	14.4	0.0	94.0	49.6	29.6	30.0	41.4	36.0	20.0	9.2	-	-	324.2

Results

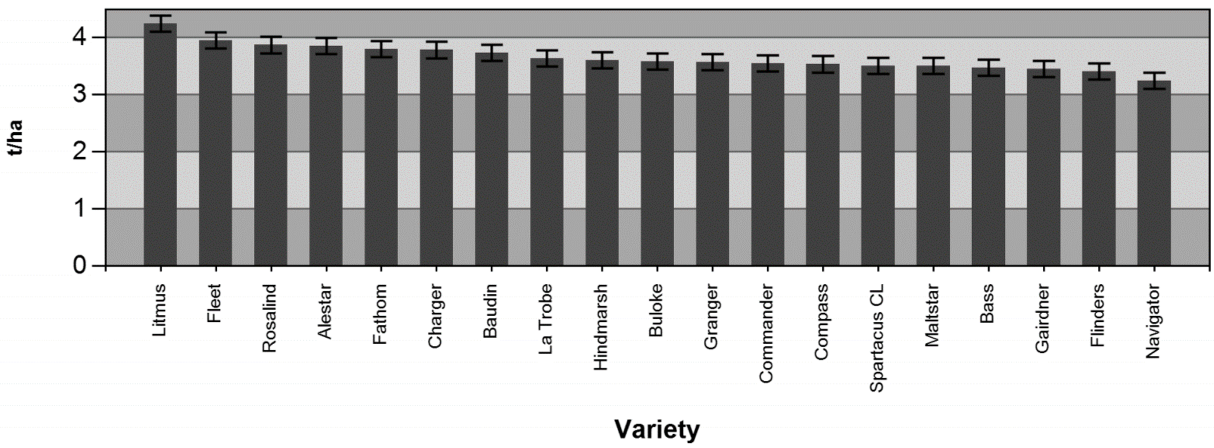


Figure 1: Yield comparison of barley varieties sown at Ballidu, 2016.

Table 1: Yield and grain quality data for barley varieties grown at Ballidu, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings <2.5 (%)
Litmus	4.25	117	70.98	8.20	1.00
Fleet	3.95	109	65.12	8.40	1.20
Rosalind	3.87	107	68.86	8.60	2.10
Alestar	3.85	106	67.77	8.10	1.70
Fathom	3.80	105	67.57	8.60	1.30
Charger	3.78	104	65.55	8.00	2.10
Baudin	3.73	103	69.47	8.60	1.10
La Trobe	3.63	100	70.79	8.30	1.40
Hindmarsh	3.61	100	71.71	8.60	1.30
Buloke	3.58	99	68.60	8.50	1.70
Granger	3.57	99	67.70	8.50	2.00
Commander	3.55	98	67.07	8.20	2.00
Compass	3.53	98	67.63	8.10	1.10
Spartacus CL	3.51	97	70.92	8.80	1.50
Maltstar	3.50	97	67.86	7.80	3.00
Bass	3.47	96	70.30	9.10	1.10
Gairdner	3.45	95	68.91	8.60	1.40
Flinders	3.41	94	70.55	9.10	1.00
Navigator	3.24	90	64.54	8.00	1.30
Site Mean (t/ha)	*3.62*				
CV (%)	*4.5*				
P value	*<0.001*				
LSD (t/ha)	*0.28*	*8*			

Comments

For more information please refer to www.nvtonline.com

Row spacing x density effect on yield and quality in three hay oat varieties in a medium/low rainfall environment

Alana Hartley, Gilmac Hay Pty Ltd

Aim

To compare the responses of three oaten hay varieties to changes in row spacing and density, in the medium to low rainfall environment and, to determine if there are significant interactions between row spacing and density.

Background

Current grower standard practice for oaten hay production, in the medium/low rainfall environment, is to sow oats at a high seeding rate of 100 kg/ha or more with row spacing of between 8 to 10 inches. This seeding set up provides good crop establishment (plants/m^2), encourages crop competition with weeds and, encourages tillering which restricts stem diameter, increasing the probability of growers meeting export market demand. The variable of row spacing has only been measured in the medium/high rainfall environment which has driven interest in this trial area. Data for growing export quality hay crops, in medium/low rainfall environment in WA, is limited to the recent work conducted by the DAFWA Oat Agronomy program (DAW00227), supported by the National Oat Breeding Program. Gilmac aim to use this trial to provide growers in the medium/low rainfall environment with the information they require to grow a high yielding and high quality export hay crop.

The varieties analysed by this trial are, Carrolup, Yallara and Durack (WAO2Q302-9). Carrolup and Yallara are considered mid season varieties whilst Durack is a mid-early season variety; maturing approximately 7-10 days earlier than Carrolup and Yallara.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	10m x 1.8m x 2 replications												
Soil type	Sandy Loam												
Soil pH ($CaCl_2$)	0-10cm: 5.8			10-20cm: 4.8			20-30cm: 4.7						
EC (dS/m)	0-10cm: 0.061			10-20cm: 0.34			20-30cm: 0.035						
K (mg/kg)	0-10cm: 75			10-20cm: 52			20-30cm: 61						
Paddock rotation	2013 fallow, 2014 wheat, 2015 canola												
Sowing date	12/05/2016												
Sowing rate	160, 240 and 360 plants/m^2												
Varieties	Carrolup, Yallara, Durack												
Fertiliser	12/05/2016: 80 kg/ha Macro-Pro Plus												
Herbicides, insecticides & fungicides	12/05/2016: 1.2 kg/ha Terbyne Extreme, 2 L/ha Spray.Seed 14/06/2016: 20 g/ha Chlorsulfuron 22/06/2016: 1 L/ha Precept, 0.5% MSO												
Hay cut	20/09/2016												
Harvest - grain	27/10/2016												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Treatments

Factors (treatments cover all combinations of variables below)

Varieties	Density	Row spacing
Durack, Yallara, Carrolup	320 plants/m^2, 240 plants/m^2 160 plants/m^2	30cm (12 inch), 25 cm (10 inch) 20cm (8 inch)

Results and Discussion

Harvest data was collected from the Gilmac trial site and has been analysed in this report.

Hay results have not been published in this report due to cutting date causing the data to be unfavourably skewed for Durack, across all treatments. Some of the data is still useful and a comparison to the National Oat Breeding variety trial (2011-2014) results will be made for the purpose of this discussion.

Grain Yield

Varieties differed in their grain yield (t/ha) (Figure 1). Yallara was the highest yielding variety, 0.07 t/ha higher than Carrolup and 0.2 t/ha higher than Durack. Results concluded that there was no significant difference between treatments at the various row spacing, nor was there a significant difference between treatments influenced by density.

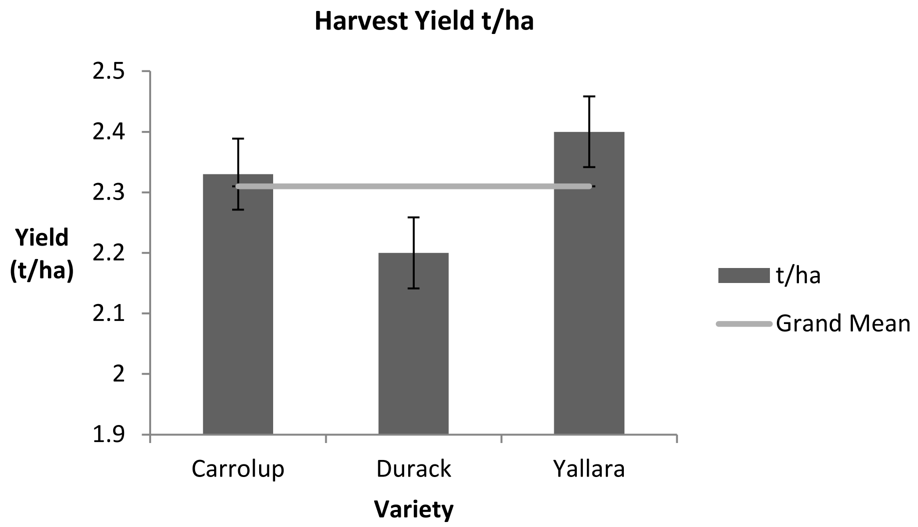


Figure 1: Varietal effect on grain yield (t/ha) with an L.S.D. of 0.1009.

Hay yield and quality

Results of the hay trial were unable to be published due to a single cutting date of the hay. This skewed the results unfavourably because Durack matures 7-10 days earlier than Carrolup and Yallara; meaning Durack was cut at a later maturity to that of the other two varieties in this trial.

From 2011 to 2014, the National Oat Breeding program, an industry initiative supported by DAFWA, SARDI and GRDC, conducted variety trials across WA, SA, NSW and Vic, assessing yield and quality. Sites selected for WA were at Cunderdin and Wongan Hills. Some of the varieties selected, Carrolup, Yallara and Durack, were the same as those varieties used in the Gilmac trial. The results from these varieties will be discussed, in comparison to the results and trends obtained by the Gilmac trial.

Hay Yield

Hay yield results from the Western Australian trial were averaged across the four seasons the trial was run.

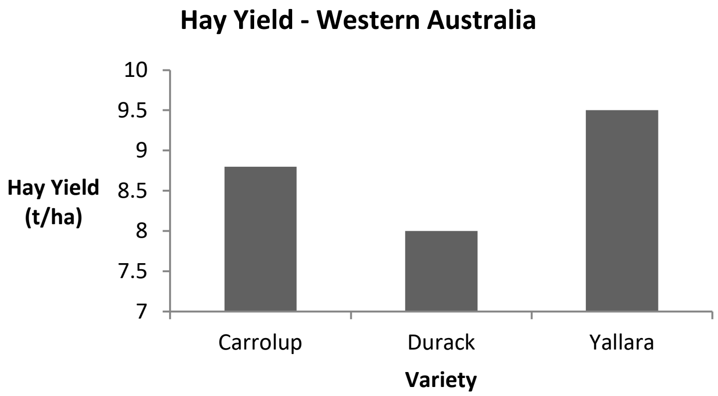


Figure 2: Average hay yield, WA, National Oat Breeding program.

Quality results
There are some noticeable trends in quality results which support the initial hypothesis behind the Gilmac trial. The characteristics which describe Yallara, from the National Oat Breeding program (NOBP), allowed us to hypothesise that not only will yield be improved (Figure 2) but, quality would also be improved. It was also hypothesised that Durack would also produce similar improvements in yield and quality however; according to the results from the NOBP, when compared to Yallara and Carrolup, this was not the case.

The national data and the Western Australian data indicated that Yallara performed well, with Water Soluble Carbohydrate (WSC), Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) well within the parameters of export grade (table 3); closely followed by Carrolup.

Table 1: National Oat Breeding program - National average quality results.

Variety	WSC %	ADF %	NDF
Carrolup	25.2	32.7	52.4
Durack	23.8	33.1	53.2
Yallara	**27.5**	**31.8**	**51.0**

Water Soluble Carbohydrate (WSC) – sugar content such as sucrose, glucose and fructose (high is better).
Acid Detergent Fibre (ADF) - least digestible plant components, including cellulose and lignin (low is better).
Neutral Detergent Fibre (NDF) - structural component of the plant, it provides bulk or fill (low is better).

Table 2: National Oat Breeding program - WA average quality results.

Variety	WSC %	ADF %	NDF
Carrolup	23.8	**32.8**	48.8
Durack	21.4	33.8	49.4
Yallara	**24.9**	33.0	**48.4**

Table 3: Gilmac export Hay standard for NDF, ADF and WSC.

	WSC %	ADF %	NDF
OH1QQQV	>23	<27	<52
OH1QQV	>20	<29	<54
OH1QV	>18	<30	<56
OH1	>12	<33	<59
OHMIN	>6	<36	<64

In the Gilmac trial at Nugadong, Durack was cut at the same time as the Carrolup and Yallara. Given that it is an early maturing variety, this meant that it was cut around milky dough. When the crop transitions from a vegetative growing phase to a reproductive grain producing phase, sugars, moisture and other nutrients are relocated to the flowering head, where grain development occurs. This change causes the stems to become more fibrous and lacks nutritional attributes and palatability. As shown by tables one and two, the results from the NOBP provide an insight in to how this early maturity influences ADF, NDF and WSC.

Carrolup was an all-rounder in terms of its yield and quality, performing consistently across all sites within this trial whilst Yallara was the overall top performer as a new release variety since 2009.

Conclusions
The results from the NOBP have provided an initial perspective on how the three oat-hay varieties selected perform in WA.

For the continual improvement of the industry, Gilmac intend to conduct this trial again in future seasons.

Acknowledgements
Shari Dougall and the team at Department of Agriculture and Food, Wongan Hills – for seeding and managing the trial on behalf of Gilmac.
Andrew Van Burgel (DAFWA) for the statistical analysis of the trial data
Georgie Troup (DAFWA Oat Agronomy) for support in writing this report
Liebe Group, for monitoring and feedback.
Butcher family for hosting the trial.

References
National Oat Breeding Program 2016 Newsletter

Contact
Arthur Hall, Gilmac Hay
Arthur.Hall@gilmac.com.au
(08) 9654 8023

GILMAC
Mackie Hay

Canola & Pulses Research Results

Early Roundup Ready canola National Variety Trial - Nugadong

Australian Crop Accreditation System Limited

Aim
To evaluate yield and quality of new and existing canola varieties.

Background
The canola National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate canola varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT canola trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to canola varieties.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	8m x 1.75m x 3 replications												
Soil type	Sand/sandy loam												
Soil pH ($CaCl_2$)	0-10cm: 6.5 10-60cm: 5.5												
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.0												
Paddock rotation	2013 canola, 2014 wheat, 2015 barley												
Seeding date	23/04/2016												
Fertiliser	23/04/2016: 100 kg/ha Gusto Gold, 50 kg/ha Urea 20/06/2016: 200 kg/ha Sulphate of Ammonia, 29/06/2016: 50 kg/ha Flexi N												
Herbicides, insecticides & fungicides	23/04/2016: 1 L/ha Propyzamide, 1.5 L/ha Trifluralin, 0.06 kg/ha Clopyralid, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 15/05/2016: 0.9 kg/ha Glyphosate 15/06/2016: 0.9 kg/ha Glyphosate 29/06/2016: 0.45 L/ha Prothioconazole & Tebuconazole 25/07/2016: 0.1 L/ha Isoclast, 0.4 L/ha Prothioconazole & Tebuconazole, 0.15 L/ha Spinetoram 19/10/2016: 2 L/ha Diquat												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

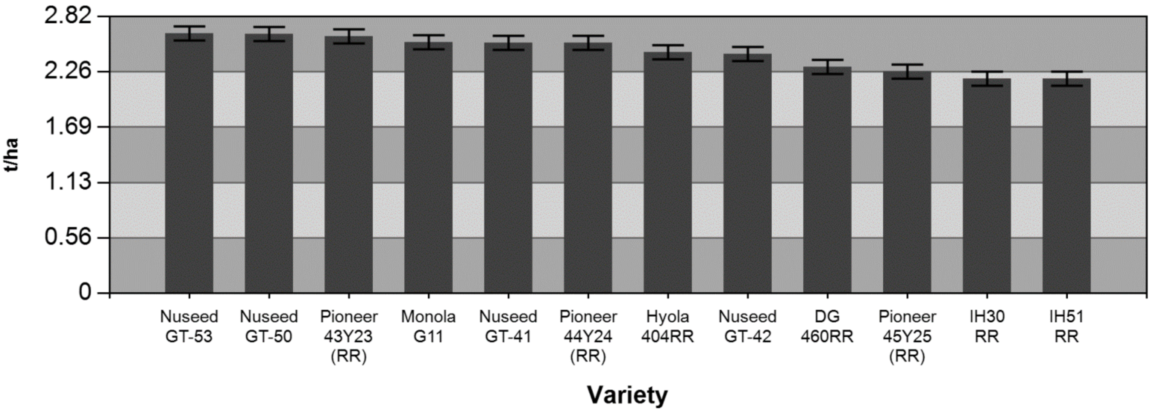


Figure 1: Yield comparison of canola varieties sown at Nugadong, 2016.

Table 1: Yield and grain quality data for canola varieties grown at Nugadong, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Oil (%)	Protein (%)
Nuseed GT-50	2.65	108	48.0	19.2
Nuseed GT-53	2.65	108	47.2	18.9
Pioneer 43Y23 (RR)	2.62	107	47.0	18.5
Monola G11	2.56	104	51.8	18.1
Nuseed GT-41	2.56	104	48.6	19.2
Pioneer 44Y24 (RR)	2.55	104	47.7	19.3
Hyola 404RR	2.46	100	49.7	19.2
Nuseed GT-42	2.44	100	46.7	20.2
DG 460RR	2.31	94	48.4	20.4
Pioneer 45Y25 (RR)	2.26	92	46.9	19.7
IH30 RR	2.19	89	47.4	19.9
IH51 RR	2.19	89	45.6	19.8
Site Mean (t/ha)	*2.45*			
CV (%)	*3.5*			
P value	*<0.001*			
LSD (t/ha)	*0.14*	*6*		

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.6°C on Aug 1, -0.5°C on Aug 2, -1.2°C on Aug 23, -0.5°C on Sep 17, -1.1°C on Sep 24. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 34.9°C on Oct 12, 35.9°C on Oct 13, 37°C on Oct 23, 32.8°C on Oct 28. Interpret results with caution.

Comments

For more information please refer to www.nvtonline.com. This trial is classfied under Buntine.

Early triazine canola National Variety Trial - Nugadong

Australian Crop Accreditation System Limited

Aim
To evaluate yield and quality of new and existing canola varieties.

Background
The canola National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate canola varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT canola trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to canola varieties.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	8m x 1.75m x 3 replications
Soil type	Sand/sandy loam
Soil pH ($CaCl_2$)	0-10cm: 6.5 10-60cm: 5.5
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.0
Paddock rotation	2013 canola, 2014 wheat, 2015 Barley
Seeding date	23/04/2016
Fertiliser	23/04/2016: 100 kg/ha Gusto Gold, 50 kg/ha Urea 20/06/2016: 200 kg/ha Sulphate of Ammonia, 29/06/2016: 50 kg/ha Flexi N
Herbicides, insecticides & fungicides	23/04/2016: 1 L/ha Propyzamide, 1.2 kg/ha Glyphosate, 1.5 L/ha Trifluralin, 0.06 kg/ha Clopyralid, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos, 1.1 kg/ha Atrazine 15/05/2016: 1.1 kg/ha Atrazine, 0.5 L/ha Clethodim 15/06/2016: 0.9 kg/ha Glyphosate 29/06/2016: 0.4 L/ha Prothioconazole & Tebuconazole 19/10/2016: 2 L/ha Diquat

Annual rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

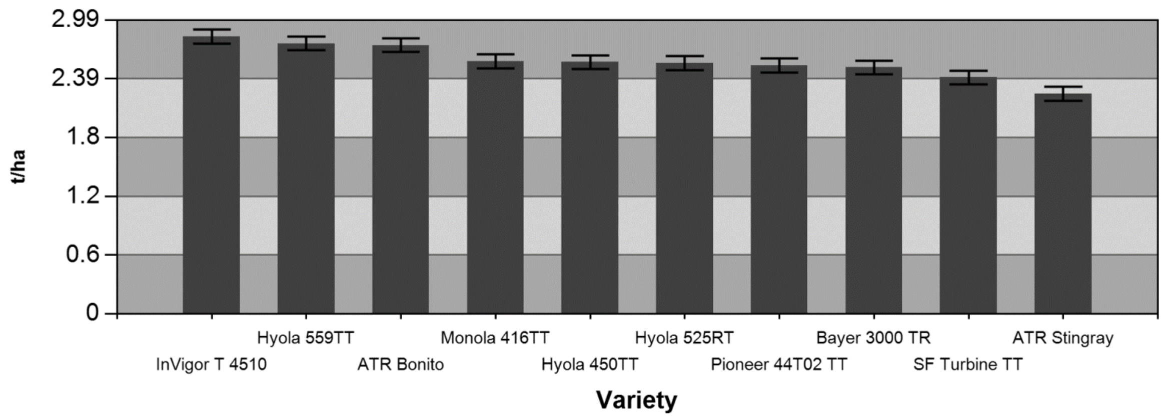


Figure 1: Yield comparison of canola varieties sown at Nugadong, 2016.

Table 1: Yield and grain quality data for canola varieties grown at Nugadong, 2016.

Variety	Yield (t/ha)	Site Mean (%)	Oil (%)	Protein (%)
InVigor T 4510	2.82	111	46.60	19.90
Hyola 559TT	2.75	108	48.80	19.90
ATR Bonito	2.73	107	49.00	19.60
Monola 416TT	2.57	101	49.90	19.00
Hyola 450TT	2.56	101	48.50	20.90
Hyola 525RT	2.55	100	48.90	19.90
Pioneer 44T02 TT	2.53	100	48.10	19.30
Bayer 3000 TR	2.51	99	47.60	20.40
SF Turbine TT	2.41	95	46.60	20.50
ATR Stingray	2.24	88	49.00	19.00
Site Mean (t/ha)	*2.54*			
CV (%)	*3.4*			
P value	*<0.001*			
LSD (t/ha)	*0.14*	*6*		

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.6°C on Aug 1, -0.5°C on Aug 2, -1.2°C on Aug 23, -0.5°C on Sep 17, -1.1°C on Sep 24. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 34.9°C on Oct 12, 35.9°C on Oct 13, 37°C on Oct 23, 32.8°C on Oct 28. Interpret results with caution.

Comments

For more information please refer to www.nvtonline.com. This trial is classfied under Buntine.

Seeding uniformity and canola yield

Martin Harries, Research Officer, DAFWA

Key Messages

- Canola yields were above 2.5 t/ha from low plant density of 10 plants/m^2.
- Spacing plants more evenly along the row did affect plant growth and yield.
- There was a trend of more yield from evenly spaced plants but this was not statistically significant.

Aim

To determine if spacing canola plants more uniformly within the row can improve yield in the WA Northern Region.

Background

Recent work in the Northern Agricultural Region has shown that canola can yield well from low plant densities of 5 to 10 plants/m^2. Canadian researchers reported that at plant densities around 20 plants/m^2 there was a significant improvement in yield when plants were spaced evenly apart rather than being spaced unevenly within the row. Given the rapid adoption of hybrid canola technology in the Northern Region and the associated increase in seed costs there is interest in precision placement of seed for two reasons 1) to reduce seed rates (input costs) and 2) to see if better placement can improve yield and yield stability. This trial tested both aspects by using a range of plant densities with plants distributed either evenly or unevenly along the row.

Trial Details

Property	DAFWA Wongan Hills Research Station
Plot size & replication	10m x 2m x 4 replications
Treatments	4 plant densities with plants spaced evenly or unevenly within the row
Soil type	Deep yellow sand
Sowing date	01/05/2016
Sowing rate	Plants were hand thinned to 10, 20, 40 and 80 plants/m^2
Fertiliser	20/04/2016: 150 kg/ha Macro Pro extra (TOS 2) 07/06/2016: 50 L/ha Flexi N
Herbicides, insecticides & fungicides	20/04/2016: 100 mL/ha Telstar, 200 mL/ha Chlorpyrifos, 1.5 L/ha Treflan, 2 L/ha Spray.Seed 06/05/2016: 900 g/ha Roundup (2 leaf spray) 20/05/2016: 900 g/ha Roundup (6 leaf spray) 29/07/2016: 450 mL/ha Prosaro 18/10/2016: 2 L/ha Reglone

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
Annual rainfall	66.2	0.0	149.2	77.6	46.0	57.0	80.8	63.6	34.8	17.0	-	-	592.2
	Growing season rainfall (April-October) 381.6mm												

Results

Higher plant density resulted in increased Normalised Difference Vegetation Index (NDVI) and a greater rate of ground cover (Table 1). Increasing plant density resulted in thinner stems, reduced stem weight and reduced pods per plant (Figure 1a). Spacing plants evenly apart increased stem weight and there was a trend of more pods per plants but this was not statistically significant (Table 1). Seed oil content and weight were not affected by plant density or uniformity (Table 1).

Table 1: Plant density (plants/m^2), NDVI/green area, stem diameter (mm), stem weight (g), pods/plant, yield (kg/ha) seed oil (%), grain weight (g).

Plant distribution	Plant density	NDVI 30/5	Stem dia.	Stem wt.	No. pods/plant	Yield	seed oil %	1000 Grain wt.
Even	10	0.21	18.0	113.2	477	2787	46.5	3.36
Uneven	10	0.24	17.7	85.1	386	2633	46.6	3.41
Even	20	0.38	13.7	55.1	250	3050	47.0	3.45
Uneven	20	0.38	12.8	38.4	165	2922	46.9	3.41
Even	40	0.60	11.7	34.3	148	3292	46.2	3.49
Uneven	40	0.60	10.6	31.3	107	3120	46.6	3.51
Even	80	0.66	8.0	11.8	46	3148	46.7	3.57
Uneven	80	0.66	8.4	13.6	62	3130	46.7	3.54
F prob density		*< 0.05*	*< .001*	*< .001*	*<. 001*	*< .001*	*NS*	*< .001*
LSD density		*0.03*	*1.528*	*14.6*	*78.3*	*195*		*0.065*
F prob distribution		*NS*		*< .05*	*0.071*	*NS*	*NS*	*NS*
LSD distribution				*10.3*	*55.4*			

Site mean yield was 3.0 t/ha and yields were above 2.5 t/ha even from low density treatments (Figure 1b). However there was a significant reduction in yield from the lowest density treatment compared to the other three densities. Yield was not significantly altered by the uniformity of plant distribution however there was a consistent trend of increased yield at even plant distribution. At the lowest three plant densities yield was approximately 5% more when plants were spaced evenly apart rather than unevenly.

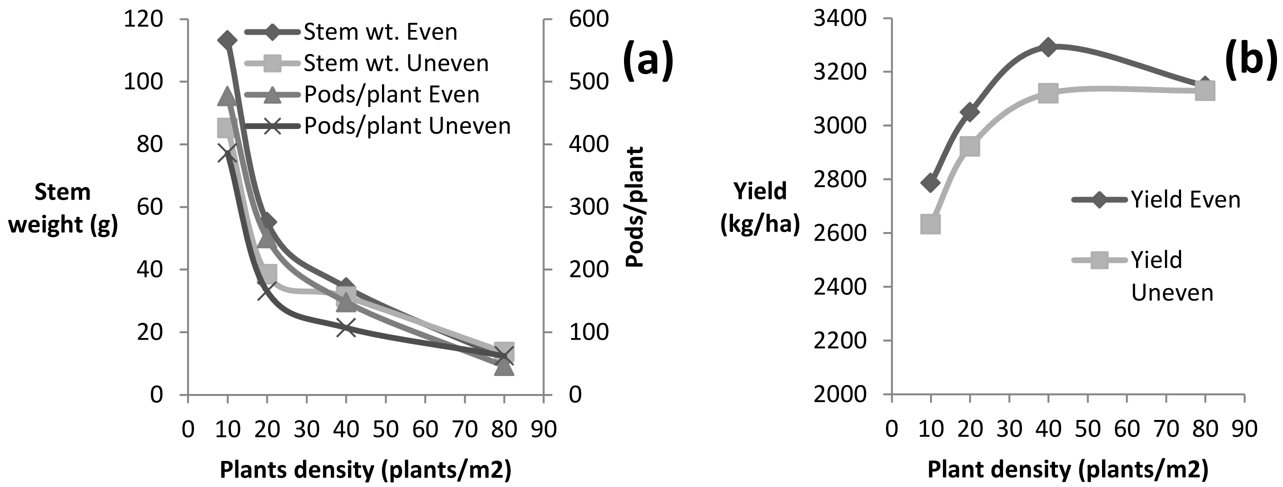


Figure 1: (a) Effect of plant density and spacing on stem weight (g), pods/plant and (b) yield (kg/ha).

Comments

Yields were high even from very low plant density which indicates that it is worth pursuing low seeding rates with precision seeders to save on upfront seed costs. Whilst there were some differences in plant growth and yield observed between uniform and un-uniform even plant spacing did not translate to statistically significant increased yield. In Canadian trials yield improvements obtained from uniform spacing were greatest at lower yields of around 1 t/ha so it would be good to repeat this work in a lower yield potential year.

Acknowledgements

Thanks to Stephanie Boyce, Shari Dougal and DAFWA Geraldton Research Support Unit for trial management and monitoring and the GRDC for project funding.

Paper reviewed by: Mark Seymour, DAFWA

Contact
Martin Harries, DAFWA
martin.harries@agric.wa.gov.au
0428 942 682

Does retaining F2 hybrid canola seed compromise crop productivity?

Sally Sprigg, Research Officer and Bob French, Senior Research Officer, DAFWA

Key Messages

- Establishment was close to target densities.
- No consistent effects of seed grading on establishment.
- F2 and F3 hybrids were less vigorous than F1.
- Grading retained hybrid seed improves crop vigour.
- Large seed yields more than ungraded seed.
- Retaining hybrid canola seed compromises oil percentage.

Aim

To measure the loss of hybrid vigour in canola seed kept for one and two generations and whether this is offset by cheaper seed costs.

Background

With only one open pollinated triazine tolerant (OP TT) line released in 2015 there are concerns 80% of WA growers who currently grow OP TT varieties may be forced into hybrid varieties. Inevitably they will look to reduce seed costs by retaining seed, but hybrid seed loses vigour in the second and subsequent generations. WA research in 2015 showed that while retained F2 hybrid seed usually reduces crop gross margin as a result of lower seed yield and oil content, this is not always the case, particularly if high rates of graded seed are used. This trial will help us draw a more complete picture of the productivity of retained hybrid canola seed in low rainfall environments.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	20m x 1.54m x 3 replications
Soil type	Gravelly sand
Soil pH ($CaCl_2$)	0-10 cm: 5.7 10-20 cm: 4.9 20-30 cm: 4.7
EC (dS/m)	0-10 cm: 0.163 10-20 cm: 0.114 20-30 cm: 0.055
Paddock rotation:	2013 canola, 2014 wheat, 2015 barley
Sowing date	28/04/2016
Sowing rate	Various calculated to give 25 or 40 plants/m², Canola: Hyola 450TT, Hyola 559TT & Bonito
Fertiliser	28/04/2016: 100 kg/ha Macro pro extra 22/05/2016: 50 L/ha Flexi-N 13/06/2016: 50 L/ha Flexi-N
Herbicides, insecticides & fungicides	28/04/2016: 2 L/ha Trifluralin, 2 L/ha Spray.Seed 250, 1.1 kg/ha Atrazine 03/05/2016: 200 mL/ha Chlorpyrifos, 100 mL/ha Talstar 27/05/2016: 1.1 kg/ha Atrazine, 1% Hasten 09/06/2016: 500 mL/ha Clethodim, 1% MSO

Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Treatments

F2 and F3 Hyola 450TT seed was retained from a 2015 trial at Grass Patch and F2 Hyola 559TT from a 2015 trial at Merredin. Graded treatments used seed that was retained on a 2mm sieve. Each seed lot was sown at two target densities: 25 and 40 plants/m². The following table gives the sizes of each seed lot and the seeding rate for each treatment.

Table 1: Size of each seed lot and seeding rate.

		Seeding rate (kg/ha)	
Seed Type	**Seeds per kg**	**25 plants**	**40 plants**
Bonito	230 000	1.6	2.6
Hyola 450TT F1	190 000	2.3	3.6
Hyola 450TT F2	182 000	2.3	3.6
Hyola 450TT F2 graded/large	260000	1.6	2.5
Hyola 450TT F3	258 000	1.7	2.8
Hyola 450TT F3 graded/large	174 000	2.6	4.1
Hyola 559TT F1	200 000	1.8	2.9
Hyola 559TT F2	341 000	1.2	1.9
Hyola 559TT F2 graded/large	236 000	1.7	2.7

Results

Table 2: Establishment counts (plants/m² on 8 June 2016).

Seed type	25 plants/m²	40 plants/m²
Bonito	20[a]	32[ab]
Hyola 450TT F1	20[a]	32[ab]
Hyola 450TT F2 large	21[ab]	38[c]
Hyola 450TT F2 ungraded	22[ab]	32[a]
Hyola 450TT F3 large	23[ab]	37[bc]
Hyola 450TT F3 ungraded	23[ab]	38[c]
Hyola 559TT F1	21[ab]	32[ab]
Hyola 559TT F2 large	26[b]	31[a]
Hyola 559TT F2 ungraded	19[a]	30[a]
LSD	*5.3*	*5.3*

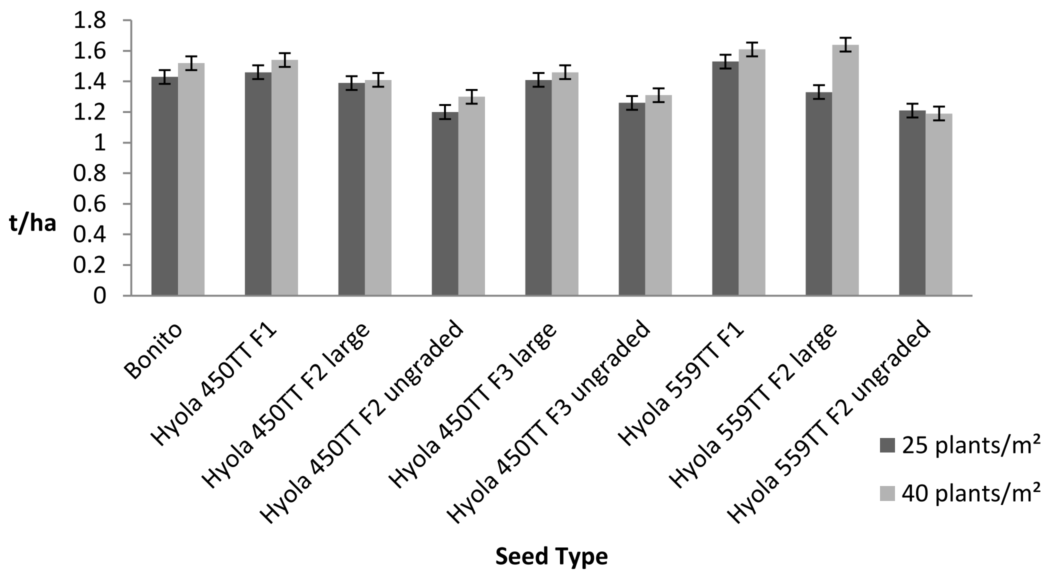


Figure 1: Seed yield kg/ha. LSD = 0.09.

Seed yield was lower in crops grown from F2 and F3 hybrid seed than from F1 seed. Grading seed and sowing at higher density reduced this effect. For example, sowing large F2 and F3 Hyola 450TT seed at 40 plants/m² produced similar seed yields to F1 sown at 25 plants/m². Whilst the same trends were seen in Hyola 559TT, no grading or density treatment for F2 or F3 retained Hyola 559TT seed matched the yield of Hyola 559TT F1 seed sown at 25 or 40 plants/m².

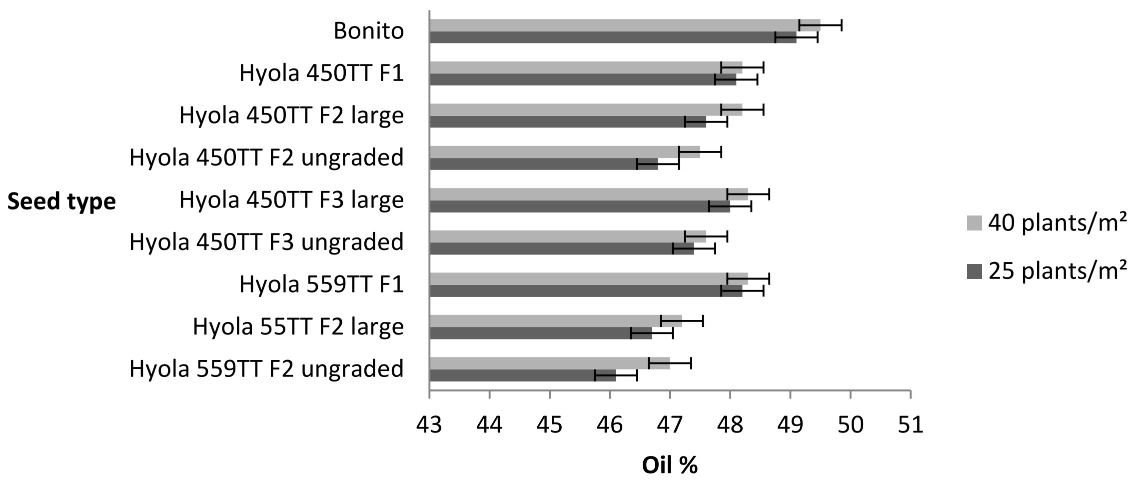


Figure 2: Oil %. LSD = 0.7.

Later generation hybrid seed produced crops with less oil than F1 hybrids, although there was no further decline going from F2 to F3 in Hyola 450TT. Grading seed increased the oil content. Nevertheless, Bonito had significantly higher oil content than any other treatments.

Economic Analysis

Bonito produced the highest gross margin at 40 plants/m² of $691/ha. Ungraded Hyola 450TT had a significantly lower gross margin than graded Hyola 450TT F2 or Hyola 450TT F1. Ungraded Hyola 450TT F3 also had significantly lower gross margin than graded Hyola 450TT F3 or Hyola 450TT F1. Hyola 559TT F1 had significantly higher gross margin than graded or ungraded F2 but graded Hyola 559TT had significantly higher gross margin than ungraded Hyola 559TT. Gross margin analysis suggested that retaining hybrid seed compromises gross margin but grading seed may improve gross margins of some hybrid cultivars in comparison to sowing ungraded seed. However, at this stage an open-pollinated cultivar like Bonito is best in this environment.

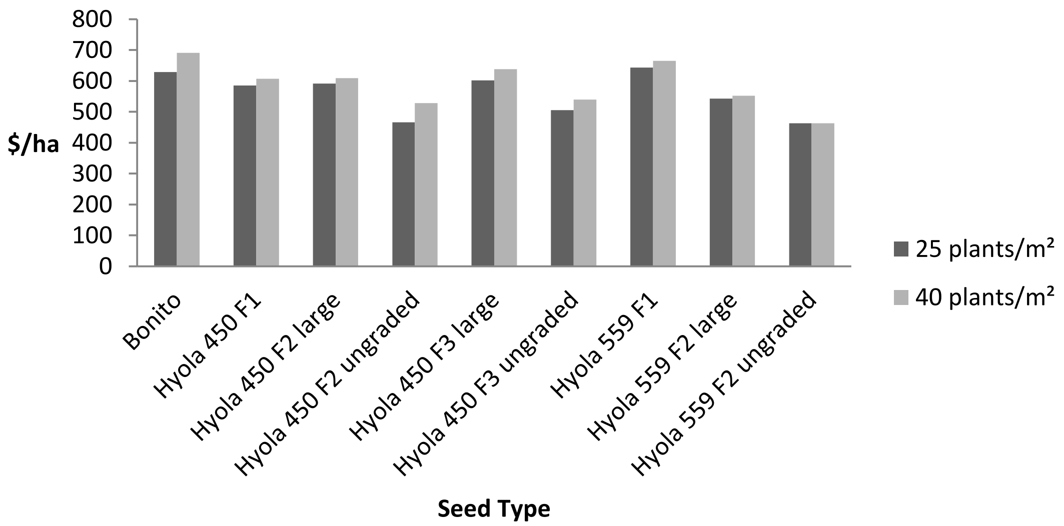


Figure 3: Gross Margin. LSD = $58/ha.

Comments
While the open-pollinated cultivar Bonito clearly gives the best gross margins currently as a consequence of its high oil content and competitive yields, these results in conjunction with those of 2015 show there is potential to retain hybrid canola seed for at least two generations in a low rainfall environment such as Dalwallinu. However, growers should remember traits like disease tolerance can change as hybrids segregate genetically and this may lead to unexpected problems in some years.

Acknowledgements
Liebe Group and the Butcher family for hosting the trial, Shari Dougall and Bruce Thorpe (DAFWA, Wongan Hills) for seeding and managing the trial, and Laurie Maiolo (DAFWA, Merredin) for technical support. This research is funded by GRDC project no DAW00227 “Tactical Break Crop Agronomy in Western Australia”.

Paper reviewed by: Mark Seymour, Senior Research Officer, DAFWA

Contact
Dr Bob French, DAFWA
bob.french@agric.wa.gov.au
(08) 9081 3126

Sally Sprigg, DAFWA
sally.sprigg@agric.wa.gov.au
(08) 9081 3153

March v April sown canola variety trial

Martin Harries, Research Officer, DAFWA

Key Messages

- Early sowing is the key to maximising canola yield in the northern region.
- Delaying sowing by 15 days after March 31 led to 195 kg/ha less yield – a loss of 13 kg/ha/day.
- When sowing in March at Wongan Hills the mid and mid/late maturity varieties performed best.
- When sowing in mid-April early and early/mid maturity varieties performed best.

Aims

1. To obtain data on late March and early April sowing of canola varieties.
2. To determine if changing variety to better match season length improves yield.

Background

Sowing canola in mid-April has become standard practice in the far north of the WA cropping zone. The benefits of early sowing were highlighted in a similar variety by time of sowing trial conducted at Binnu in 2015. In that trial (time of sowing) TOS 1 (April 14) yielded 1647 kg/ha compared to 997 kg/ha for TOS 2 (April 29). Hence delaying sowing by 15 days led to 650 kg/ha less yield – a loss of 43 kg/ha/day. This trial design was repeated in 2016 because growers were asking if further yield improvements could be obtained by sowing even earlier than mid-April.

Trial Details

Property	DAFWA Wongan Hills Research Station
Plot size & replication	18m x 2m x 4 replications
Soil type	Deep yellow sand
Sowing dates	TOS 1 31/03/2016. TOS 2 15/04/2016
Sowing rate	As per table below
Fertiliser	30/03/2016: 150 kg/ha Macro Pro extra (TOS 1) 15/04/2016: 150 kg/ha Macro Pro extra (TOS 2) 20/05/2016: 50 L/ha Flexi N (TOS 1) 07/06/2016: 50 L/ha Flexi N (TOS 2)
Herbicides, insecticides & fungicides	30/03/2016: 2 L/ha Glyphosate 31/03/2016: 100 mL/ha Telstar (TOS 1) 31/03/2016: 200 mL/ha Chlopyriphos (TOS 1) 13/04/2016: 900 g/ha Roundup (TOS 1 PE 2 leaf spray) 15/03/2016: 100 mL/ha Telstar (TOS 2) 15/03/2016: 200 mL/ha Chlopyriphos (TOS 2) 28/04/2016 900 g/ha (TOS 1 PE 6 leaf spray) 06/05/2016: 900 g/ha Roundup (TOS 2 PE 2 leaf spray) 20/05/2016: 900 g/ha (TOS 2 PE 6 leaf spray) 29/07/2016: 0.45 L/ha Prosaro 18/10/2016 2.0 L/ha Reglone (TOS 1) 03/11/2016 2.0 L/ha Reglone (TOS 2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
Annual rainfall	66.2	0.0	149.2	77.6	46.0	57.0	80.8	63.6	34.8	17.0	-	-	592.2
	Growing season rainfall (April-October) 381.6mm												

Results

Establishment

At both times of sowing a reasonable number of plants established, however plant density was lower from TOS 1 (27 plants/m^2) compared to TOS 2 (37 plants/m^2). Despite this plant density achieved for both times of sowing and all varieties were around the recommended 20-40 plants/m^2.

Plant growth

When measured on September 7 dry matter production was significantly greater (*P* <0.05) from the first time of sowing (Figure 1). The variation between varieties was almost significant (*P* <0.06). GT50 had the greatest biomass and Hyola 525RT the least (Figure 1).

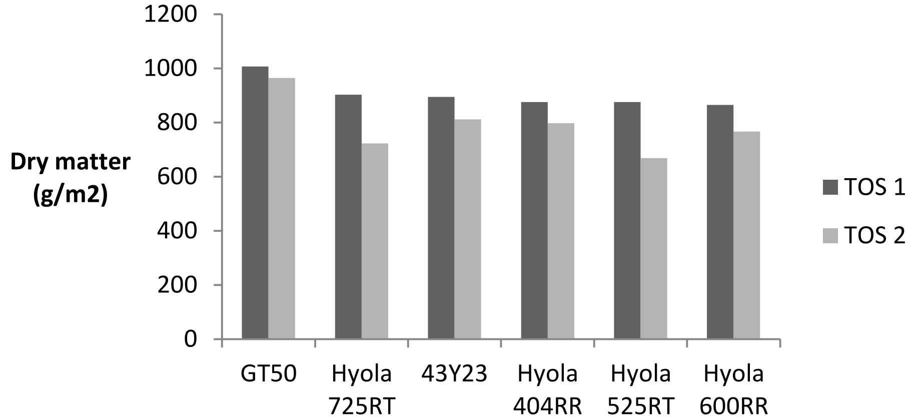


Figure 1: Plant biomass as of September 7.

Plants of all varieties were larger from TOS 1 compared to TOS 2 (*P* <0.001). Average plant weight from TOS 1 was almost double TOS 2. The plant weight of varieties did differ (*P* <0.05) although this did not correlate to season length; the longer season varieties were not always the largest plants (Figure 2).

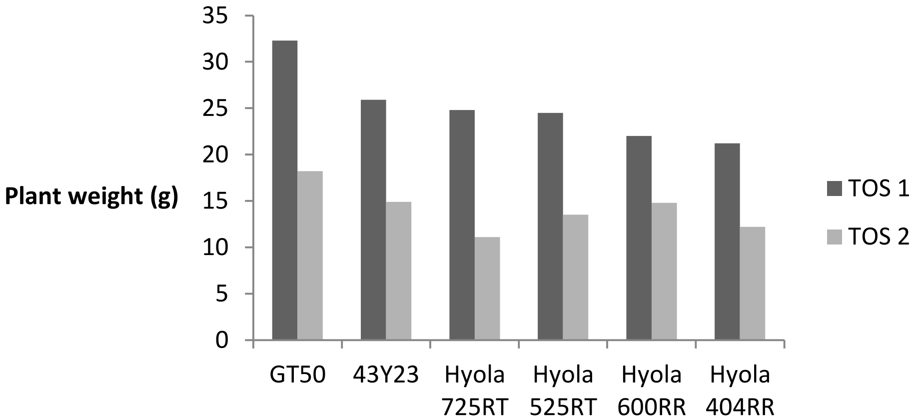
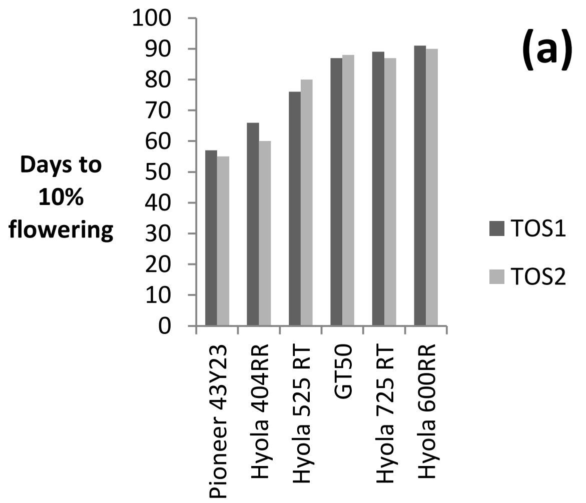


Figure 2: Single plant weight as of September 7.

Flowering time and duration

The number of days from sowing to the start of flowering (10% bloom) ranged from 56 days to 88 days and was affected by both variety and TOS, (*P* <0.001) (Figure 3a). There was only a small effect of sowing time; on average plants took 2 days longer to reach 10% bloom when sown on March 31 compared April 15. The number of days from sowing to the end of flowering was also affected by both variety and TOS, (*P* <0.001). There was a large variation between varieties with the range of 127 days (Pioneer 43Y23) to 155 days (Hyola 725RT) (Figure 3b). It was interesting to note that because longer season varieties took longer to flower they did not necessarily have a longer flowering period.



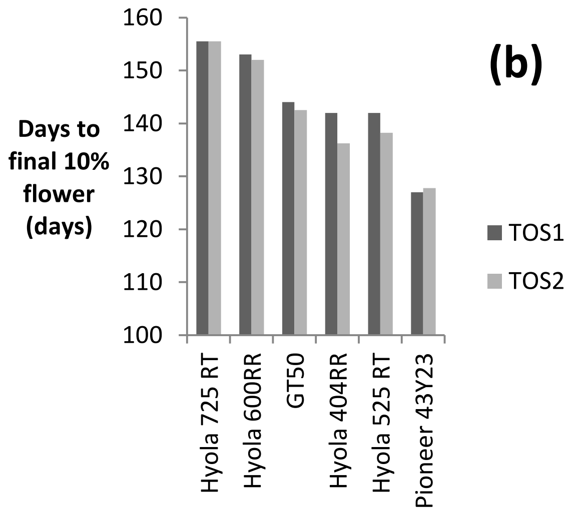


Figure 3: (a) The number of days to reach 10% bloom. (b) Duration of flowering, days from initial 10% bloom to final 10% of bloom.

Yield and seed quality

The overall yield of the trial was 2755 kg/ha. Averaged across all varieties TOS 1 yielded 2853 kg/ha compared to 2658 kg/ha for TOS 2. Hence overall delaying sowing by 15 days led to 195 kg/ha less yield – equivalent to a loss of 13 kg/ha/day. The effect of sowing time by variety was almost statistically significant $P = 0.066$ and differences in the response to TOS were associated with variety maturity length. The early varieties Pioneer 43Y23 and Hyola 404RR did not have a yield improvement from sowing earlier than mid-April. Hyola 600RR and Hyola 725RT yields increased by around 260 kg/ha from earlier sowing (17 kg/ha/day) or 9 and 10% respectively. GT50 and Hyola 525RT yields increased by 360 kg/ha (24 kg/ha/day) or 11 and 12% respectively. For both seed weight and oil content there were differences between varieties (P <0.001) but sowing date did not have a consistent effect.

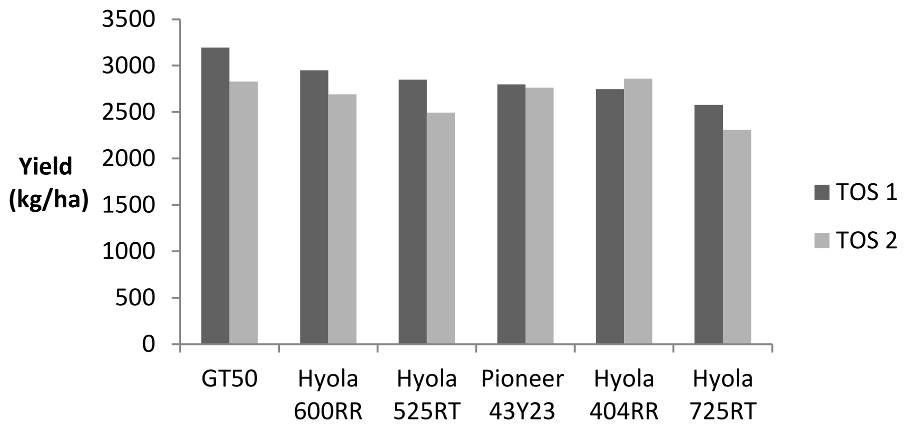


Figure 4: Yield of variety when sown on March 31 (TOS1) and April 15 (TOS2).

Economic Analysis

All treatments had positive gross margin, as expected given the yields, but there was a large range from \$1306/ha to \$837/ha. The highest gross margins were obtained from sowing mid and mid/late maturity varieties at TOS 1. Total seed costs were calculated using cost per kilo and the seeding rate, which was adjusted for seed size and germination percentage, consequently seed costs varied significantly from \$54 to \$124/ha. Seed rates could have been dropped back at TOS 2 as the plant density achieved was quite high, which would increase gross margins of TOS 2 treatments. Also for Hyola 404RR the large seed resulted in a better field establishment percentage and higher plant density so seed rates of this variety could have been reduced slightly.

Table 1: Seed cost ($/kg), seed rate, total costs ($/ha), income ($/ha) and gross margin ($/ha).

Variety	TOS	Seed rate (kg/ha)	Total seed cost ($/ha)	Total cost ($/ha)	Income ($/ha)	Gross Margin ($/ha)
GT50	1	2.2	54	479	1785	1306
Hyola 600RR	1	2.7	86	507	1722	1215
GT50	2	2.2	54	470	1594	1124
Hyola 525RT	1	2.7	96	514	1612	1098
Hyola 404RR	2	3.9	124	545	1638	1092
Hyola 404RR	1	3.9	124	543	1573	1030
43Y23	2	2.6	82	498	1518	1020
43Y23	1	2.6	82	498	1505	1007
Hyola 725RT	1	2.6	94	505	1452	946
Hyola 525RT	2	2.7	96	506	1403	897
Hyola 600RR	2	2.7	86	492	1328	837
Hyola 725RT	2	2.6	94	499	1297	798

Comments

The yield benefit in this trial from bringing seeding forward two weeks from mid-April to late March was 13 kg/ha/day. The 2015 trial showed the yield benefit from seeding in mid-April compared to late April was 43 kg/ha/day. So the benefit of early TOS seems to be dropping off when going into March. Conversely the risks of poor establishment and a long dry period after sowing increase the earlier the crop is sown. Results from this trial suggest that if sowing in March at Wongan Hills a longer season variety than a 4 series maturity will increase yield.

Acknowledgements

Thanks to Stephanie Boyce, Shari Dougal and DAFWA RSU staff for trial management and measurements and the GRDC for project funding.

Paper reviewed by: Mark Seymour, DAFWA

Contact

Martin Harries, DAFWA
martin.harries@agric.wa.gov.au
0428 942 682

Does using large seed improve emergence from deep sowing?

Sally Sprigg, Research Officer and Bob French, Senior Research Officer DAFWA

Key Messages

- Sowing at 30 or 60mm dramatically reduced canola establishment compared to sowing at 15mm.
- Within a variety large seed establishes with greater efficiency than small seed.
- Only small effects were observed of seed grading on sensitivity to deep sowing.
- Hybrid canola was less sensitive to deep sowing than open-pollinated canola.
- Sowing at 60mm had a large detrimental effect on grain yield compared to sowing at 15mm.

Aim

To test whether canola emergence from deep sowing can be improved by using larger seed.

Background

Field establishment of canola is often quite poor; commonly less than 60-70% of viable seeds sown become established. This problem is not peculiar to WA, but occurs in canola production regions around the world. This is not helped by the fact that canola must be sown shallow (12-25mm) which puts it in the most rapidly drying zone of the soil profile. Recent research from NSW (Brill et al. 2016) has shown that large canola seed (> 2mm diameter) will emerge from as deep as 75mm under the right conditions. They also found hybrid canola emerged from deep sowing better than open-pollinated cultivars. Improving canola emergence from deep sowing may enable growers to place seed in soil layers with more stable moisture content which should help improve field establishment and facilitate early establishment.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	20m x 1.54m x 4 replications												
Soil type	Gravelly sand												
Soil pH ($CaCl_2$)	0-10 cm: 5.65 10-20 cm: 4.92 20-30 cm: 4.82 30-50 cm: 5.2												
EC (dS/m)	0-10 cm: 0.135 10-20 cm: 0.103 20-30 cm: 0.062 30-50 cm: 0.043												
Paddock rotation:	2013 canola, 2014 wheat, 2015 barley												
Sowing date	29/04/2016												
Sowing rate	Various calculated to give 30 plants/m². Canola: Bonito and Hyola 559TT												
Fertiliser	29/04/2016: 100 kg/ha Macro Pro Extra banded below seed 22/06/2016: 50 L/ha Flexi-N applied to whole site												
Herbicides, insecticides & fungicides	28/04/2016: 2 L/ha Trifluralin, 2 L/ha Spray.Seed 250, 1.1 kg/ha Atrazine 03/05/2016: 200 mL/ha Chlorpyrifos, 100 mL/ha Talstar 27/05/2016: 1.1 kg/ha Atrazine, 1% Hasten 09/06/2016: 500 mL/ha Clethodim, 1% MSO												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Treatments included seven seed classes sown at 3 depths (15, 30, and 60mm). The seed classes were new commercial seed of Bonito (open-pollinated) and Hyola 599TT (hybrid); Bonito seed saved from a trial at Grass Patch in 2015; and 4 size classes separated from the saved Bonito seed. The size classes were separated using slotted screens and were >2.0mm, <2.0mm and >1.8mm, <1.8mm and >1.65mm, and <1.65mm. All seed was treated with Maxim (a.i. 25 g/L fludioxonil and 10 g/L metalxyl-M) and Cruiser (210 g/L thiamethoxam and 37.5 g/L lambda-cyhalothrin) prior to sowing.

Results

Table 1: Establishment counts (plants/m² on 8 June 2016).

	Plants/m^2		
	15mm depth	**30mm depth**	**60mm depth**
Bonito (new)	26	11	1.5
Bonito (saved)	37	15	3.3
Bonito < 1.65mm	33	13	1.1
Bonito > 1.65 and <1.8mm	34	16	2.4
Bonito > 1.8 and <2.0mm	31	15	4.8
Bonito > 2.0mm	36	18	3.8
Hyola 559TT	22	17	4.4
LSD	*6.4*	*4.7*	*2.0*

Sowing canola deeper than 15mm dramatically reduced establishment. At 30mm it was reduced by 50-60% and at 60mm by as much as 95%. Although larger Bonito seed suffered a smaller reduction in establishment due to deep sowing, the effect was very small. The hybrid Hyola 559TT was less sensitive to deep sowing. Errors in the initial germination percentage measurements used to calculate seed rates. Checking these after the trial was sown revealed that most target densities were higher than 30 plants/m²: they ranged from 30 for Hyola 559TT to 47 for Bonito <1.65mm. This means field establishment gives a truer indication of effects on establishment than the actual counts. Large seeded Bonito had higher field establishment efficiency than small seed: when sown 15mm deep only 50% of viable seeds in the smallest Bonito seed class established compared to 66% in the >2mm size class (Figure 1). The hybrid Hyola 559TT established better than Bonito when sown at 30 or 60mm but establishment from 60mm was still very poor.

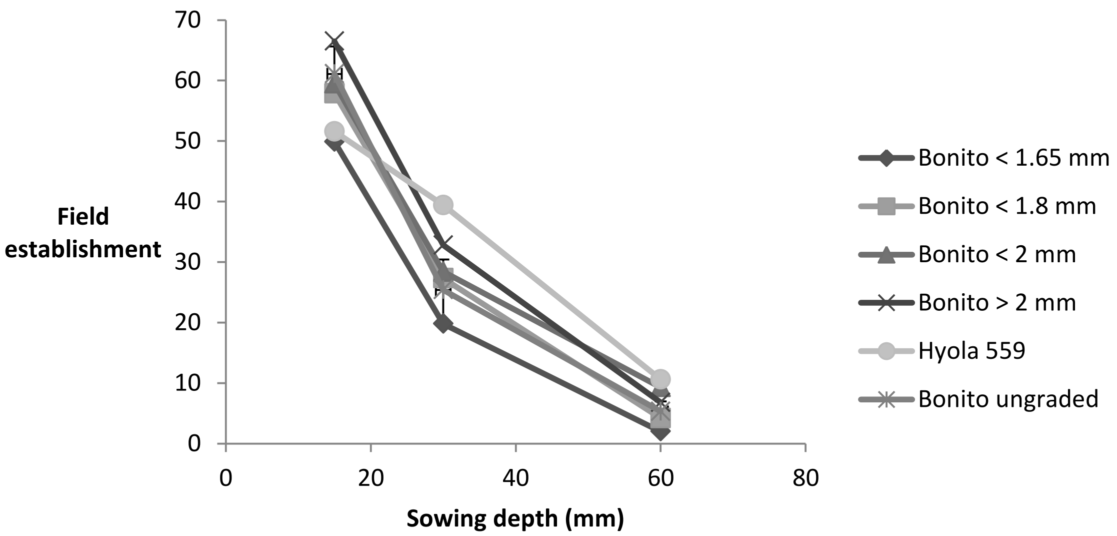


Figure 1: Field establishment (proportion of viable seeds sown that established) of different canola seed classes when sown at 3 depths.

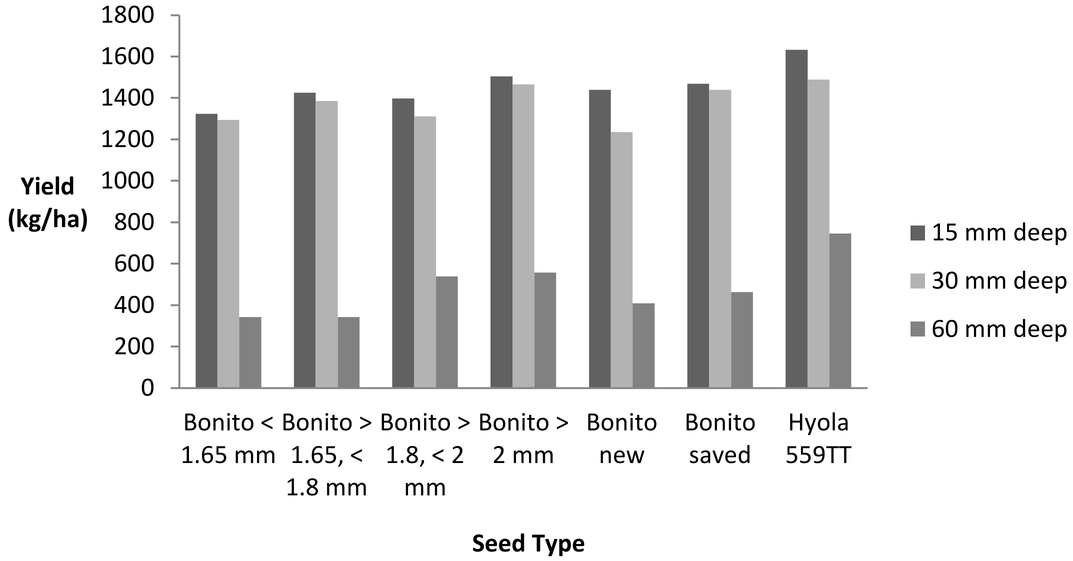


Figure 2: Seed yield kg/ha. LSD = 187.

Sowing deeper than 15mm reduced grain yield, although the capacity of canola to compensate at low density meant the reduction was not as great as might be expected from the establishment numbers. Averaged over all depths Bonito >2mm was significantly higher yielding than Bonito <1.8mm and, although not significant, it also yielded more than ungraded Bonito. The hybrid Hyola 559TT yielded more than any of the Bonito treatments, although not significantly in the case of Bonito >2mm sown at 15 or 30mm. Using new seed does not improve emergence from deep sowing, in fact in both the deeper treatments (30 and 60mm) new Bonito seed yielded significantly less than saved Bonito seed. Hybrid canola suffered less yield loss than open-pollinated canola when sown deep but its yield when sown at 60mm was still less than half the yield at 15mm.

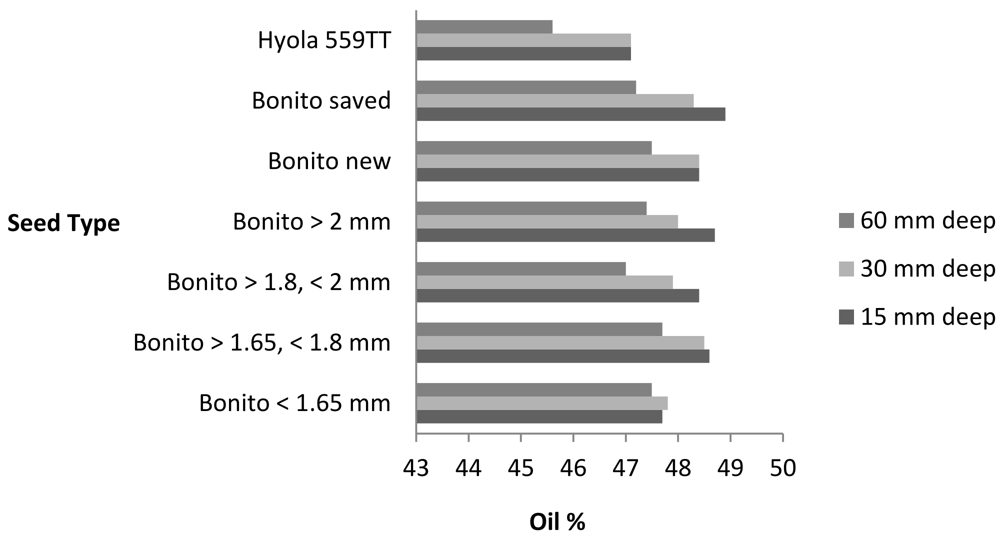


Figure 3: Oil %. LSD = 0.8.

Averaged across all seed types canola sown 15mm deep had the highest oil concentration. The reduction at 30mm was not significant, but oil was about 1% lower from treatments sown at 60mm. Seed size also had a marginal effect on oil but Hyola 559TT had significantly lower oil than Bonito.

Comments

Sowing canola deeper than 15mm reduced canola crop establishment, yield, and oil. The effects were particularly noticeable going from 30 to 60mm deep. Although hybrid canola and larger seed mitigated these effects to some extent it was not nearly enough to make deep sowing of canola to chase moisture a practical proposition.

Acknowledgements

Liebe Group and the Butcher family for hosting the trial, Shari Dougall and Bruce Thorpe (DAFWA, Wongan Hills) for seeding and managing the trial, and Laurie Maiolo (DAFWA, Merredin) for technical support. This research is funded by GRDC project DAW00227 “Tactical Break Crop Agronomy in Western Australia”.

References

R.D. Brill, M.R. Jenkins, M.J. Gardner, J.M. Lilley, B.A. Orchard (2016). Optimising canola establishment and yield in south-eastern Australia with hybrids and large seed. *Crop and Pasture Science*¸67, 409-418.

Paper reviewed by: Mark Seymour, Senior Research Officer, DAFWA

Contact

Dr Bob French, DAFWA
bob.french@agric.wa.gov.au
(08) 9081 3126

Sally Sprigg, DAFWA
sally.sprigg@agric.wa.gov.au
(08) 9081 3153

Triazine tolerant canola variety demonstration

Jenni Clausen and Clare Johnston, Liebe Group

Aim

To compare the economic competiveness of three different Triazine canola technology options.

Background

Canola crops are an important component of cropping rotations as they are a tool for managing cereal disease and allow for diversity in chemical rotations. Triazine tolerant (TT) canola varieties are a staple in many farming operations with 72% of canola grown in 2015 TT (2017 Canola variety guide for WA). The majority of TT canola varieties are retained seed of open-pollinated (OP) varieties. This low cost seed option usually has a lower yield potential compared to hybrid varieties. Buying in pedigree seed adds cost, but this can be offset by higher yields or premium payments. Three TT canola varieties that represented three differing technology options were compared side-by-side to view their value as a TT canola option.

Hyola® 559TT (Advanta Seeds) is a hybrid canola option for the 0.5-2.5 t/ha yielding zones of Australia. It has a mid-maturity. Seed for the trial was treated with Cruiser Opti and Maxim XL.

Monola® 416TT (Nuseed) is an early to mid-maturing open-pollinated variety. Seed for this trial was treated with Ponco and Maxim XL. Monola®, which is a specialty oilseed type, produces a more stable frying oil than regular canola and attracts a grain premium, currently $95/t for the 2016/17 season. Monola® is produced under a closed loop contracted tonnage arrangement either delivered to CBH Darkan or on farm storage, buyers call, delivered into Graincorp Oil's Pinjarra.

Sturt TT (Pioneer) is a low rainfall, short season open-pollinated TT variety. No seed treatment was applied.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	12m x 440m x 2 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 6.5 10-20cm: 5.2 20-30cm: 5.0
EC (dS/m)	0-10cm: 0.070 10-20cm: 0.041 20-30cm: 0.041
Paddock rotation:	2013 canola, 2014 wheat, 2015 barley
Sowing date	09/04/2016
Sowing rate	3 kg/ha Sturt TT (target density 30-40 plants/m^2) 2.5 kg/ha Monola® 416TT (target density 30-40 plants/m^2) 2 kg/ha Hyola® 559TT (target density 15-25 plants/m^2)
Fertiliser	09/04/2016: 40 kg/ha Agstar, 60 kg/ha Urea 31/05/2016: 60 L/ha Flexi-N 15/06/2016: 60 L/ha Flexi-N
Herbicides, insecticides & fungicides	08/04/2016: 1.1 kg/ha Atrazine, 1 L/ha Propyzamide, 2 L/ha Glyphosate 13/04/2016: 1.1 kg/ha Atrazine, 500 mL/ha Chlorpyrifos 31/05/2016: 1.1 kg/ha Atrazine, 80 mL/ha Alpha Duo, 0.5% Uptake

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
Annual rainfall	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

These canola strips were a broad-acre demonstration with only two replicates and therefore the harvest data must be interpreted with caution as no statistical analysis was conducted. Yield differences may not be statistically different as a result.

Table 1: Plant counts, flowering date, yield and quality of three triazine tolerant canola varieties grown at Nugadong, 2016. Values are averages of two replicates per variety.

Variety	Plants/m^2	Flowering date (5%)	Yield (t/ha)	Moisture (%)	Oil	Grade
Sturt TT	23	10/06/2016	1.66	5.2	43.6	CAN1
Monola® 416TT	21	17/06/2016	2.04	4.4	48.0	CAN1 (equivalent)
Hyola® 559TT	14	24/06/2016	1.83	5.7	46.2	CAN1

Economic Analysis

A gross margin analysis has been undertaken factoring in costs that vary for the differing technologies. As they are all TT varieties and management was identical for each, crop protection, fuel and fertiliser costs were excluded as they were all the same.

	Canola Delivered CBH - Sturt	Canola Delivered CBH - Hyola® 559TT	Delivered CBH Darkan-Monola 416	Store on Farm, Buyers Call Delivered Pinjarra-Monola 416
Mean Yield (t/ha)	1.66	1.83	2.04	2.04
Oil %	43.55	46.15	48.00	48.00
<u>Income $/t</u>				
Daily Cash price $/t (Kwinana FIS)	$ 568.00	$ 568.00	$ 568.00	
Graincorp Delivered Pinjarra Bid $/t (inclusive delivery fee @ $18)				$ 550.00
$Oil bonification ($/t)	$ 13.21	$ 35.36	$ 51.12	$ 49.50
Carry Payments for On Farm Storage (3months @ $1 per week)				$ 12.00
Monola Bonus payments			$ 95.00	$ 95.00
$/t inc bonification & premiums	$ 581.21	$ 603.36	$ 714.12	$ 706.50
Income ($/ha) subtotal	***$ 965.02***	***$ 1,104.26***	***$ 1,456.80***	***$ 1,441.26***
Costs ($/ha)				
Cost of farmer retained graded seed/ha (3 kg/ha)	$ 7.50			
Cost of TT Hybrid Seed/ha (2kg/ha)		$ 56.00		
Cost Monola Seed/ha 2.5 kg/ha			$41.63	$ 41.63
Freight charges from farm to McLevie CBH receival site/ha	$ 10.00	$ 10.00		
Estimated freight charges from farm to Darkan CBH receival site/ha ($46/t)			$ 93.84	
Freight charges from farm to Pinjarra receival site/ha ($37/t)				$ 75.48
CBH receival and shrinkage charge/ha ($20.14/t)	$ 33.44	$ 36.86	$ 41.09	
CBH freight charge/t from McLevie to Port/ha ($21.96/t)	$ 36.46	$ 40.19		
Freight charge/t from Darkan to Pinjarra/ha ($20/t)			$ 40.80	
Cost of on farm grain storage/ha ($16/t)				$ 32.64
End Point Royalty/ha (Sturt $5/t, others none)	$ 8.30			
Costs ($/ha) subtotal	**$ 95.70**	**$ 143.05**	**$ 217.35**	**$ 149.75**
Gross margin ($/ha) of canola delivered (excluding crop protection, fuel & fertiliser costs)	**$ 869.32**	**$ 961.21**	**$ 1,239.45**	**$ 1,291.52**

The highest gross margin option in this trial was the Monola 416 "Store on farm delivered Pinjarra option". This was driven by the strong yield performance of Monola 416 (23% higher yielding than Sturt and 11% higher yielding than Hyola® 559TT) and amplified by the Monola premium ($95/t) plus the carry income ($12/t) leading to a high $/t price for the grain.

The second highest gross margin was the Monola 416 delivered CBH Darkan. This was the highest cost option as a result of the freight component in delivering to CBH Darkan.

The hybrid TT, Hyola® 559TT was more profitable than the OP TT option with 9% higher yield and extra oil bonification premium offsetting the higher cost for hybrid seed.

Sturt, the OP TT option was the least profitable due to the lower yield and oil outcome however it was the lowest cost of production option. This variety is also better suited to lower rainfall environments.

Comments
Sturt was observed to be one week earlier in maturity than Monola 416, and Monola 416 was one week earlier in maturity than Hyola® 559TT.

2016 was the 3rd season of retaining the Sturt seed, some genetic degeneration could be occurring.

The Nugadong (Buntine) National Variety Trial (NVT) was located within 500m of this trial site and planted 14 days after the demonstration.

Monola premiums and delivery locations are subject to change year to year.

Monola "Store on Farm delivered Pinjarra" payment would not be processed until April after the grain is delivered. Buyers call could be anytime between the 1st of January and the 31st of March which would effect carry income and payment time.

Acknowledgements
Thank you to the Butcher's for running the demonstration and to Steve Lamb (Advanta Seeds) and Hugh Trenorden (Nuseed) for providing the seed and technical support.

Paper reviewed by: Steve Lamb, Advanta Seeds and Hugh Trenorden, Nuseed

Contact
Liebe Group
admin@liebegroup.org.au
(08) 9661 0570

Lupin National Variety Trial - Nugadong

Australian Crop Accreditation System Limited

Aim
To evaluate yield and quality of new and existing lupin varieties.

Background
The lupin National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate lupin varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT lupin trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to lupin varieties.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	8m x 1.75m x 3 replications												
Soil type	Sand/sandy loam												
Soil pH ($CaCl_2$)	0-10cm: 6.5 10-60cm: 5.5												
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.0												
Paddock rotation	2013 canola, 2014 wheat2015 barley												
Seeding date	10/05/2016												
Fertiliser	10/05/2016: 100 kg/ha Gusto Gold												
Herbicides, insecticides & fungicides	10/05/2016: 0.55 kg/ha Atrazine, 0.55 kg/ha Simazine, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos, 2 L/ha Glyphosate 15/06/2016: 0.2 L/ha Diflufenican												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

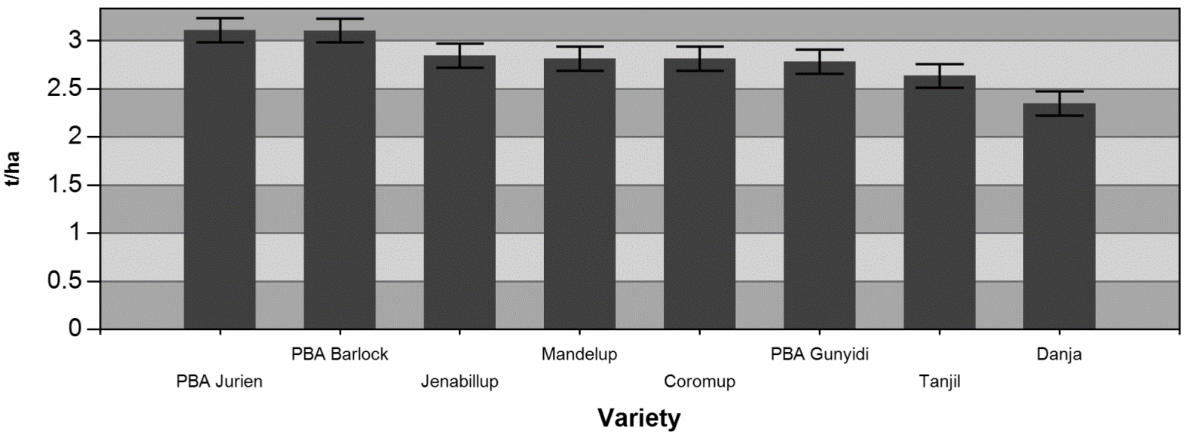


Figure 1: Yield comparison of lupin varieties sown at Nugadong, 2016.

Table 1: Yield data for lupin varieties grown at Nugadong, 2016.

Variety	Yield (t/ha)	Site Mean (%)
PBA Barlock	3.11	110
PBA Jurien	3.11	110
Jenabillup	2.84	100
Coromup	2.81	99
Mandelup	2.81	99
PBA Gunyidi	2.78	98
Tanjil	2.63	93
Danja	2.35	83
Site Mean (t/ha)	*2.84*	
CV (%)	*5.1*	
P value	*<0.001*	
LSD (t/ha)	*0.25*	*9*

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.6°C on Aug 1, -0.5°C on Aug 2, -1.2°C on Aug 23, -0.5°C on Sep 17, -1.1°C on Sep 24. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 34.9°C on Oct 12, 35.9°C on Oct 13, 37°C on Oct 23, 32.8°C on Oct 28. Interpret results with caution.

Comments

For more information please refer to www.nvtonline.com. This trial is classfied under Buntine.

Chickpea National Variety Trial - Konnongorring

Australian Crop Accreditation System Limited

Aim

To evaluate yield and quality of new and existing chickpea varieties.

Background

The chickpea National Variety Testing (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate chickpea varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The chickpea NVTs are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to chickpea varieties.

Trial Details

Property	Peter Whitfield, Konnongorring												
Plot size & replication	8m x 1.75m x 3 replications												
Soil type	Sandy loam												
Soil pH ($CaCl_2$)	0-10cm: 5.4 10-60cm: 5.5												
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.1												
Paddock rotation	2015 wheat												
Seeding date	19/05/2016												
Fertiliser	19/05/2016: 100 kg/ha Gusto Gold												
Herbicides, insecticides & fungicides	19/05/2016: 2 L/ha Glyphosate, 1.2 kg/ha Terbuthylazine, 1 L/ha Trifluralin, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 21/06/2016: 0.5 L/ha Clethodim, 0.1 L/ha Haloxyfop-R												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	46.2	0.0	112.4	57.0	32.2	41.2	56.4	46.8	22.8	14.8	-	-	429.8

Results

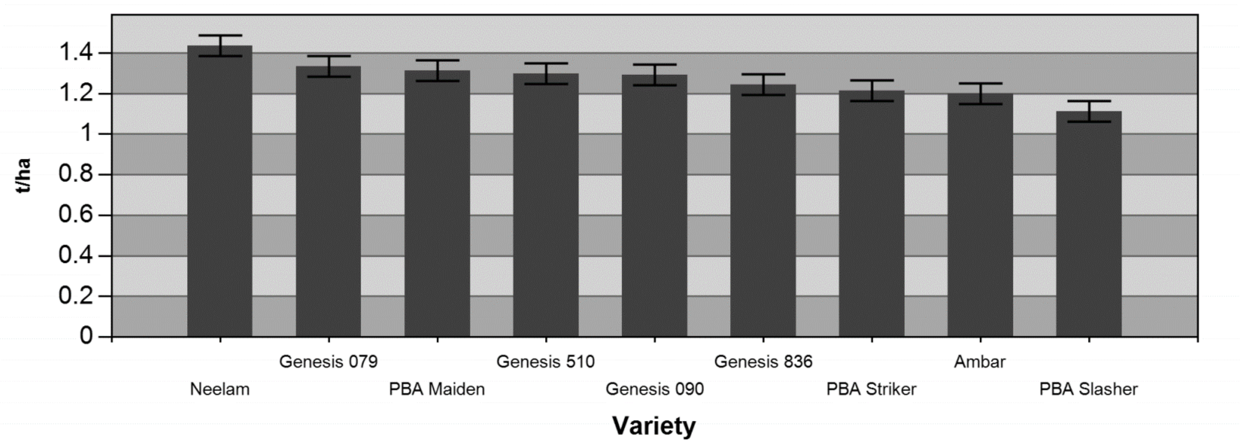


Figure 1: Yield comparison of chickpea varieties sown at Konnongorring, 2016.

Table 1: Yield and grain quality data for chickpea varieties grown at Konnongorring, 2016.

Variety	Yield (t/ha)	Site Mean (%)
Neelam	1.44	112
Genesis 079	1.33	103
PBA Maiden	1.31	102
Genesis 510	1.30	101
Genesis 090	1.29	100
Genesis 836	1.24	96
PBA Striker	1.21	94
Ambar	1.20	93
PBA Slsher	1.11	86
Site Mean (t/ha)	*1.29*	
CV (%)	*3.7*	
P value	*<0.001*	
LSD (t/ha)	*0.10*	*8*

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.7°C on Aug 1, -1.6°C on Aug 13, -0.5°C on Aug 21, -0.6°C on Aug 22, -2.4°C on Aug 23, -0.4°C on Aug 30, -0.1°C on Sep 1, -0.6°C on Sep 2, -0.2°C on Sep 3, -1.5°C on Sep 15, -2.1°C on Sep 17, -2.6°C on Sep 18, -0.9°C on Sep 21, -1.1°C on Sep 23, -2.3°C on Sep 24, -0.2°C on Sep 25, -1.9°C on Sep 26, -0.8°C on Sep 28, -1.3°C on Sep 30, -0.2°C on Oct 16. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 32°C on Oct 7, 36°C on Oct 12, 36.4°C on Oct 13, 32.3°C on Oct 22, 38.9°C on Oct 23, 32.5°C on Oct 28. Interpret results with caution.

Comments

For more information please refer to www.nvtonline.com. This trial is classed under Wongan Hills.

Field Pea National Variety Trial - Konnongorring

Australian Crop Accreditation System Limited

Aim
To evaluate yield and quality of new and existing field pea varieties.

Background
The field pea National Variety Trial (NVT) is part of a multi crop evaluation program funded by the GRDC and is designed to evaluate field pea varieties entering the market that have gone through selection and evaluation within the various national breeding programs. The NVT field pea trials are just one source of information on which growers can base management decisions on retention release or adoption of new varieties. Growers must use more than one information source when making significant management decisions in relation to field pea varieties.

Trial Details

Property	Peter Whitfield, Konnongorring
Plot size & replication	8m x 1.75m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.4 10-60cm: 5.5
EC (dS/m)	0-10cm: 0.1 10-60cm: 0.1
Paddock rotation	2015 wheat
Seeding date	19/05/2016
Fertiliser	19/05/2016: 100 kg/ha Gusto Gold
Herbicides, insecticides & fungicides	19/05/2016: 1.2 kg/ha Terbuthylazine, 1 L/ha Trifluralin, 1 L/ha Glyphosate, 0.2 L/ha Bifenthrin, 0.5 L/ha Chlorpyrifos 21/06/2016: 0.5 L/ha Clethodim, 0.1 L/ha Haloxyfop-R

Annual rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
	46.2	0.0	112.4	57.0	32.2	41.2	56.4	46.8	22.8	14.8	-	-	429.8

Results

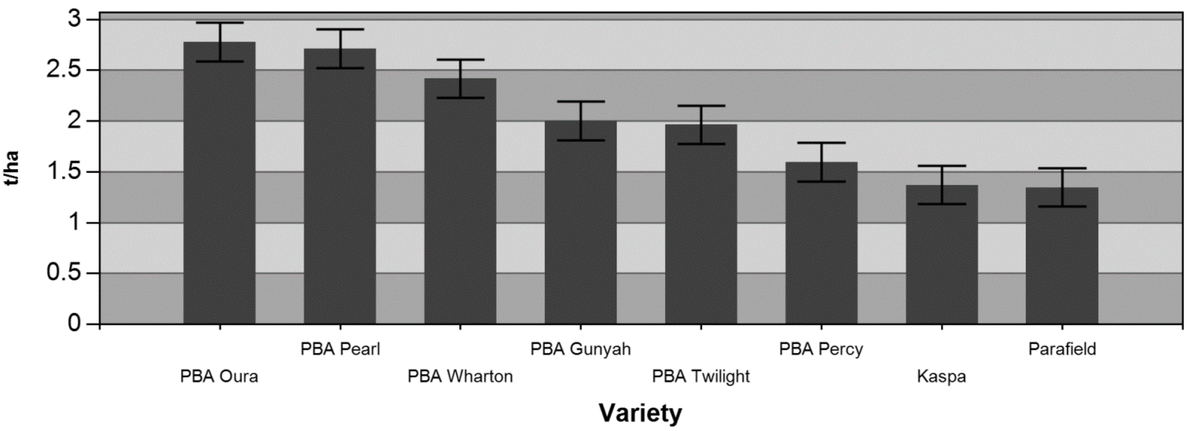


Figure 1: Yield comparison of field pea varieties sown at Konnongorring, 2016.

Table 1: Yield data for field pea varieties grown at Konnongorring, 2016.

Variety	Yield (t/ha)	Site Mean (%)
PBA Oura	2.78	118
PBA Pearl	2.71	115
PBA Wharton	2.42	103
PBA Gunyah	2.00	85
PBA Twilight	1.96	83
PBA Percy	1.60	68
Kaspa	1.37	58
Parafield	1.35	57
Site Mean (t/ha)	*2.36*	
CV (%)	*9.2*	
P value	*<0.001*	
LSD (t/ha)	*0.38*	*16*

Weather Conditions

Frost Event: This trial experienced frost conditions on the following dates throughout the flowering period: -1.7°C on Aug 1, -1.6°C on Aug 13, -0.5°C on Aug 21, -0.6°C on Aug 22, -2.4°C on Aug 23, -0.4°C on Aug 30, -0.1°C on Sep 1, -0.6°C on Sep 2, -0.2°C on Sep 3, -1.5°C on Sep 15, -2.1°C on Sep 17, -2.6°C on Sep 18, -0.9°C on Sep 21, -1.1°C on Sep 23, -2.3°C on Sep 24, -0.2°C on Sep 25, -1.9°C on Sep 26, -0.8°C on Sep 28, -1.3°C on Sep 30, -0.2°C on Oct 16. Interpret results with caution.

Heat Event: This trial experienced extreme heat conditions on the following dates throughout the flowering period: 32°C on Oct 7, 36°C on Oct 12, 36.4°C on Oct 13, 32.3°C on Oct 22, 38.9°C on Oct 23, 32.5°C on Oct 28. Interpret results with caution.

Comments

This trial has a high weed burden and suffered significant frost exposure. Interpret results with caution. For more information please refer to www.nvtonline.com. This trial is classed under Wongan Hills.

Weeds Research Results

Demonstration of pre-emergent herbicide options for controlling ryegrass in wheat

Michael Macpherson, National Technical Manager, Imtrade Australia

Key Messages

- There are multiple pre-emergent herbicides for ryegrass control.
- All pre-emergents behave differently under changing environmental conditions.
- Prompt incorporation is critical to the efficacy of some products.
- Sakura alone, Sakura tank mixes and Bolta Duo provided the best control of ryegrass to 45 DAT in this trial.

Aim

To demonstrate different pre-emergent herbicide options for control of ryegrass in wheat.

Background

Ryegrass is a serious problem in most southern 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 and tank mixes becoming more common, making the right choices can be difficult. Balancing efficacy against cost, in combination with environmental conditions is imperative for optimising outcomes. Imtrade Australia in collaboration with the Liebe Group implemented a pre-emergent trial to provide local information for growers. The trial is designed to directly represent local management strategies, with an identical time of sowing, sown with a commercial seeder bar and identical fertiliser management strategies.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	10m x 2m x 3 replications
Soil type	Grey sand
Soil pH ($CaCl_2$)	0-10cm: 5.9 10-20cm: 5.4 20-30cm: 6.1
EC (dS/m)	0-10cm: 0.054 10-20cm: 0.037 20-30cm: 0.038
Paddock rotation	2013 fallow, 2014 wheat, 2015 canola
Sowing date	07/05/2016
Sowing rate	55 kg/ha Mace wheat (70 mL/t seed Tebuconazole 430, 4 L/t seed Zinc)
Fertiliser	07/05/2016: 40 kg/ha Agstar Extra, 60 kg/ha Urea 07/06/2016: 0.5 L/ha ZincMate 15/06/2016: 60 L/ha Flexi N
Herbicides, insecticides & fungicides	06/05/2016: As per treatment list 07/06/2016: 1 L/ha Jaguar, 0.45 L/ha LVE MCPA, 0.15 L/ha Tebuconazole 430

Annual rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Note: Incorporation of the pre-emergent products was delayed by 24 hours due to mechanical issues. 4.6mm of rainfall was received post treatment application prior to incorporation. Rainfall prior to incorporation accelerates volatilisation of susceptible chemistries.

Table 1: Product and rate of treatments.

No.	Treatment	Rate (L/ha)
1	Untreated	-
2	Boxer Gold	2.5
3	Sakura	118g
4	Jetti Duo	1.8
5	Trifluralin	2
6	Trifluralin + Triallate	2 + 2
7	Boxer Gold + Trifluralin	2.5 + 2
8	Boxer Gold + Triallate	2.5 + 2
9	Sakura + Trifluralin	118g + 2
10	Sakura + Triallate	118g + 2
11	Diablo Duo	2.5
12	Bolta Duo	2.5
13	Arcade	2.5
14	Arcade	3
15	Arcade + Trifluralin	3 + 2

Results/Comments

Table 2: Mean number of germinated wheat seedlings per m^2.

No.	Treatment	Application rate (L/ha)	26 DAT 01/06/2016
1	Untreated	0	63.7
2	Boxer Gold	2.5	46.2
3	Sakura	118g	42.7
4	Jetti Duo	1.8	56.1
5	Trifluralin	2	55.6
6	Trifluralin + Triallate	2 + 2	56.0
7	Boxer Gold + Trifluralin	2.5 + 2	62.9
8	Boxer Gold + Triallate	2.5 + 2	45.9
9	Sakura + Trifluralin	118g + 2	46.1
10	Sakura + Triallate	118g + 2	53.3
11	Imtrade Diablo Duo	2.5	48.3
12	Imtrade Bolta Duo	2.5	49.1
13	Arcade	2.5	70.2
14	Arcade	3	47.4
15	Arcade + Trifluralin	3 + 2	48.1
P value			*0.591*
LSD			*NS*
CV (%)			*27.7*

NS - no statistical significance at p <0.05

Table 3: Mean number of annual ryegrass seedlings per m^2.

No.	Treatment	Application rate (L/ha)	26 DAT 1/06/2016		45 DAT 20/06/2016		Cost* ($/ha)
1	Untreated	0	67.1	b	81.8	^	0
2	Boxer Gold	2.5	12.4	a	27.4	cde	$38.28
3	Sakura	118g	10.9	a	11.9	ab	$40.10
4	Jetti Duo	1.8	20.2	a	31.6	de	$28.50
5	Trifluralin	2	23.9	a	27.1	cde	$11.80
6	Trifluralin + Triallate	2 + 2	16.1	a	23.3	bcd	$31.63
7	Boxer Gold + Trifluralin	2.5 + 2	13.0	a	22.4	abcd	$50.08
8	Boxer Gold + Triallate	2.5 + 2	8.2	a	15.2	abc	$58.11
9	Sakura + Trifluralin	118g + 2	5.4	a	7.7	a	$51.90
10	Sakura + Triallate	118g + 2	6.7	a	11.0	ab	$59.93
11	Imtrade Diablo Duo	2.5	12.8	a	30.7	de	TBA
12	Imtrade Bolta Duo	2.5	7.7	a	13.4	abc	TBA
13	Arcade	2.5	21.0	a	39.4	e	$29.75
14	Arcade	3	19.9	a	36.2	de	$35.70
15	Arcade + Trifluralin	3 + 2	16.2	a	21.7	abcd	$47.50
P value			*<0.001*		*0.002*		--
LSD			*21.16*		*15.03*		--
CV (%)			*72.6*		*40.2*		--

Means within the same cell with a letter in common are not significantly different (P>0.05)
^ - untreated removed from analysis due to large result affecting means comparison
* - Pricing current as of November 2016, prices may vary between resellers and brands (pricing ex GST)

Table 4: Mean number of annual ryegrass panicles (percentage control) and harvestable yield of Mace wheat.

No.	Treatment	Application rate (L/ha)	Panicle control 20/09/2016		Yield (t/ha)
1	Untreated	0	0.00	f	1.23
2	Boxer Gold	2.5	78.33	bcde	1.57
3	Sakura	118g	91.67	abc	1.50
4	Jetti Duo	1.8	63.33	e	1.58
5	Trifluralin	2	68.33	de	1.35
6	Trifluralin + Triallate	2 + 2	68.33	de	1.42
7	Boxer Gold + Trifluralin	2.5 + 2	79.67	bcd	1.66
8	Boxer Gold + Triallate	2.5 + 2	76.67	cde	1.51
9	Sakura + Trifluralin	118g + 2	97.67	a	1.68
10	Sakura + Triallate	118g + 2	93.00	ab	1.61
11	Imtrade Diablo Duo	2.5	70.00	de	1.41
12	Imtrade Bolta Duo	2.5	73.33	de	1.43
13	Arcade	2.5	66.67	de	1.57
14	Arcade	3	66.67	de	1.40
15	Arcade + Trifluralin	3 + 2	75.00	de	1.61
P value			*<0.001*		*0.475*
LSD			*15.39*		*NS*
CV (%)			*12.9*		*14.6*

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

NS - no statistical significance at p <0.05

- All pre-emergent herbicides provided a 50% or better reduction in annual ryegrass numbers compared to the untreated control to 45 DAT.
- Of the 'stand-alone' products, Sakura and Bolta Duo provided the best control of annual ryegrass numbers in this trial. Sakura significantly reduced annual ryegrass panicles compared to all other treatments.
- The addition of trifluralin or triallate to Boxer Gold or Arcade (prosulfocarb) improved the control of annual ryegrass compared to Boxer Gold/Arcade alone.
- The addition of trifluralin or triallate to Sakura did not generally improve the control provided by Sakura alone.
- Generally, the volatilising products (all non-Sakura treatments) when used on their own, or in combination with other volatilising partners, did not provide the level of control exhibited by the non-volatilising chemistries and in-tank blends. This is reflective of the late incorporation timing.
- Initial plant emergence counts did not demonstrate any detrimental phytotoxic effects from any treatment in this trial.
- There were no statistical differences in crop yield from any pre-emergent treatment applied. The advent of frost and the presence of annual ryegrass seeds in the harvested sample may have influenced this result by causing uncontrolled variation within the replicates.

The 2016 cropping season got off to a great start in the Dalwallinu region, with many areas receiving excellent pre-season and establishment rainfall events. Most crops were sown into moisture or received significant follow-up rainfall promptly post seeding. Due to this, conditions were optimal for moisture-activated pre-emergent herbicides like Sakura which is clearly reflected in the results. Typically it would also be expected that most volatilising chemistry options would also benefit from the optimal conditions presented, however this was not demonstrated in the results. Volatilising actives exhibit exponential rates of loss to the atmosphere when applied to bare earth, with the presence of moisture exacerbating this effect. Typically it is recommended that these actives are incorporated (covered by soil) within 12 hours of application, mostly achieved in WA by the knifepoints on the seeder bar.

Due to a mechanical breakdown, the site was sown around 24 hours post application, and the result of this extended exposure to the atmosphere can be clearly seen in the results returned by the volatilising treatments. Chemistries not requiring incorporation by sowing have not been affected, returning results that would be expected with the prevailing environmental conditions. The trial has been an excellent study into the effects of delayed incorporation, highlighting the importance of this to the efficacy of volatilising herbicides

Jetti Duo, Diablo Duo and Bolta Duo are registered trademarks of Imtrade Australia.

Acknowledgements
Thank you to the Butcher family for provision of site, seeding and maintaining site and Rick Horbury, Bayer for the conduct of panicle assessments. Harvest of the trial was funded by Imtrade and Bayer.

Paper reviewed by: Joe Delaney, Elders Scholz Rural.

Contact
Michael Macpherson, Imtrade Australia
michael.macpherson@imtrade.com.au
0427 746 029
Twitter: @Michael_Imtrade

Comparison of pre-emergent herbicides for annual ryegrass control in wheat at four locations across Western Australia in 2016

Rick Horbury, Customer Advisory Representative - North, Bayer

Key Message

Across four commercially sown trial sites at Pithara, Waddy Forest, Nugadong and Cunderdin in 2016 Sakura® 850WG consistently provided the highest level of pre-emergent annual ryegrass (ARG) control throughout the season and returned the best $ return on investment per hectare.

Aims

- Compare the efficacy of commercial pre-emergent herbicides and mixtures for ARG control across multiple soil types using grower machinery for seeding and ongoing management consistent with the grower's practice.
- Determine yield and $ return on investment to the grower from current standard pre-emergent herbicides Sakura, trifluralin, Avadex® Xtra and Boxer® Gold® with new options such as standalone prosulfocarb, the main component of Boxer Gold. Prosulfocarb (e.g. Arcade) must be incorporated within 7 days of application.

Background

- Sakura, like other root uptake herbicides i.e. propyzamide, works best when incorporated within a moist soil profile prior to or as weeds germinate.
- Sakura is not volatile, is UV stable, and can be applied up to 3 days ahead of incorporation, adding flexibility to the sowing operation. Trifluralin and Avadex Xtra both require incorporation within 24 hours of application. Boxer Gold has an incorporation requirement of up to 7 days after application.
- 2016 was a season with a longer, wetter spring than the recent seasons resulting in late weed emergence which was an issue for many growers where pre-emergent herbicides did not have sufficient residual activity to cover multiple annual ryegrass germinations in a long season.
- Pre-emergent herbicides and rotation of chemical mode of action groups should form part of a fully Integrated Weed Management program with harvest weed seed management practices strongly recommended to reduce weed numbers and delay the onset of resistance.

Seasonal conditions and site comments

Conditions at sowing were generally favourable with a reasonable soil moisture profile at all sites. As a result there was a strong early pre-sowing germination of weeds. All trials received an effective double knockdown, while Waddy Forest received a triple knockdown program consisting of glyphosate (Group M) followed by glufosinate-ammonium (Group N) and finally paraquat (Group L) applied at sowing, utilising the full range of available non-selective knockdown herbicide modes of action.

Despite the excellent pre-sowing weed control achieved at all locations weed numbers were high to very high in all four sites underlining the importance of long term management of weed seed banks to reduce annual ryegrass (ARG) numbers.

The full moisture profile in the trials resulted in the pre-emergent herbicides being well activated at sowing. The good soil moisture also meant that there was a further strong initial flush of ryegrass in all sites due to the soil disturbance by sowing, requiring immediate herbicide activity to keep the ARG under control. Without this strong initial activation of the herbicides at sowing, weed control could have been below commercially acceptable levels. In the trials at Waddy Forest, Cunderdin and Nugadong there was almost two weeks before significant follow up rainfall occurred which could have resulted in reduced efficacy had this scenario occurred on a more limited soil moisture profile.

With average, or higher than average rainfall through winter at all locations weeds continued to emerge through the later part of July as some of the herbicides ran out of efficacy before the crop had commenced stem elongation and shaded the soil on the inter-row resulting in further germinations of ryegrass competing with the crop.

Trial Details

Trial ID	**WE05**	**WE06**	**WE07**	**Liebe/ Imtrade**
Location	Waddy Forest	Pithara	Cunderdin	Nugadong
Rotation last 2 years	wheat, wheat	canola, wheat	lupin, wheat	canola, wheat
Plot size & replication	2m x 36m x 3 replications	2m x 30m x 3 replications	2m x 36m x 3 replications	2m x 10m x 3 replications
Soil type	Loam	Gravelly loam	Sandy duplex	Grey sand
pH 0-10 cm($CaCl_2$)	Mid 5	5.5	Mid 5	5.9
Stubble cover	10% (burnt)	35% weeds & stubble	~25% (range 10-60%)	Not recorded
Variety	Mace	Mace	Trojan	Mace
Seeding rate	60 kg/ha + 1 L/ha Raxil®	80 kg/ha + 1 L/ha Raxil®	70 kg/ha + 3.6 L/ha Vibrance®	55 kg/ha + 1 L/ha Raxil®
Application:	Applied by Bayer Application Trailer 80 L/ha at 12 km/h using DG110002 nozzles with a medium droplet spectrum at 3 bar			Applied by Michael Macpherson Imtrade
Sowing date	27/05/2016	19/05/2016	06/05/2016	07/05/2016
Hours to incorporation	~12 hours	≤2 hours	≤2 hours	~25 hours
Seeder type	knife points	Bourgault 8800 with Maxi knife points	John Deere with Conserva Pak Knife points	knife points
Press wheels	Yes	Yes	Yes	Yes
Row spacing	25.43cm	20.3cm	25.43cm	25.43cm
Sowing speed	8 km/h	8.5 km/h	9 km/h	Not recorded
Soil moisture	Moist, cloddy	Slight dry top, moist at depth, cloddy	Slight dry top, moist at depth,	Moist
Rainfall notes	9mm that day, 5mm in next 14 days with 20mm after that	12.5mm that night and 40mm in first 7 days	Nil for 11 days then 21mm on 07/06/2016	5mm that day then no significant rain until 15mm on 20/05/2016
Fertiliser	27/05/2016: 100 kg/ha Agras	19/05/2016: 100 kg/ha Agras	06/05/2016: 50 kg/ha Agras®, 40 L/ha Flexi-N® in-furrow July: 40 L/ha Flexi-N	07/05/2016: 40 kg/ha Agstar® Extra, 60 kg/ha Urea 07/06/2016: 500 mL/ha ZincMate® 15/06/2016: 60 L/ha Flexi-N
Herbicides: knockdown	01/05/2016: 2 L/ha glyphosate 13/05/2016: 3 L/ha Basta® (glufosinate-ammonium)	28/04/2016: 1.1 kg/ha Ken-Up® dry 680, 100 mL/ha oxyfluorfen	21/04/2016 - Roundup® Ultra® 1 L/ha + Estercide® 680 300 mL/ha + SOA + LI700	Glyphosate rate and date not recorded
Herbicides: knockdown with pre-emergent treatments	27/05/2016: 3 L/ha paraquat	19/05/2016: 3 L/ha paraquat	06/05/2016: 2 L/ha Roundup® Attack	07/05/2016: 2 L/ha Eradicator® 450
Herbicides and fungicides: post-emergent	Not recorded	July: 670 mL/ha Velocity®, 0.5 % v/v Uptake®	July: 700 mL/ha Jaguar®	07/06/2016: 1 L/ha Jaguar, 450 mL/ha MCPA LVE, 150 mL/ha tebuconazole 430
Growing season rainfall	299mm	236mm	248mm	236mm

Table 1: Average pre-emergent ARG control (%) ratings at early and mid-season with final panicle counts by herbicide across four WA locations in 2016.

Location	WE05 Waddy Forest (1831 panicles/m^2)			WE06 Pithara (843 panicles/m^2)			WE07 Cunderdin (1033 panicles/ m^2)			Liebe - Nugadong (493 panicles/m^2)					
Treatments applied	27/05/2016			19/05/2016			06/05/2016			06/05/2016					
Soil type/rainfall 24 hrs	Loam, nil			Gravel loam, 15 mm			Sandy loam, 12 mm			Sandy, nil					
Assessment Date	22/06	27/07	20/09	23/06	26/07	21/09	16/06	11/08	23/09	16/06	11/08	23/09	**Average ARG % control all sites**		
Treatment	Early - 26 DAA	Mid - 61 DAA	Final - 116 DAA	Early - 35 DAA	Mid - 68 DAA	Final - 125 DAA	Early - 41DAA	Mid - 97 DAA	Final - 140 DAA	Early - 26 DAA	Mid - 45 DAA	Final - 137 DAA	**Early (26-41 DAA)**	**Mid (45-97 DAA)**	**Final panicle (116-140 DAA)**
Sakura WG 118 g/ha + Trifluralin 1.5 L/ha	92	95	97	97	95	96	90	90	90	92	91	98	**93**	**93**	**95**
Sakura 118 g/ha	89	94	93	97	95	95	90	90	92	84	85	92	**90**	**91**	**93**
Boxer Gold 2.5 L/ha + Trifluralin 2 L/ha	90	76	69	93	89	87	90	82	79	81	73	80	**88**	**80**	**79**
Boxer Gold 2.5 L/ha	88	79	75	91	77	75	88	83	70	82	67	78	**87**	**76**	**75**
Prosulfocarb 3 L/ha	84	84	76	96	87	83	87	80	72	70	56	67	**84**	**77**	**74**
Prosulfocarb 2.5 L/ha	85	80	73	93	76	77	84	72	61	69	52	67	**83**	**70**	**69**
Trifluralin 2 L/ha + Avadex Xtra 2 L/ha	87	70	62	89	82	66	70	60	53	76	72	68	**81**	**71**	**62**
Avadex Xtra 3 L/ha	83	65	58	82	73	63	68	62	53	-	-	-	**78**	**67**	**58**
Trifluralin 2 L/ha	73	58	48	82	73	58	53	37	35	64	67	68	**68**	**59**	**52**

Weed control ratings comments

It is important to note that early weed control in June or July does not equate to final ARG control at the end of the growing season which is what really counts for seed bank management. The best assessment of a treatments performance is the final panicle counts highlighted in grey.

Early season assessment 26-41 days after application (DAA)

Based on ratings, Sakura treatments recorded the highest control of ARG across the four sites. Boxer Gold with or without trifluralin was comparable to Sakura stand alone. Prosulfocarb treatments recorded slightly lower control with trifluralin and Avadex treatments lower again. The Cunderdin site in particular is suspected of having trifluralin resistance (Group D).

Mid-season assessment 45-97 DAA

Sakura treatments continued to record ARG control consistent with early season ratings. Most other treatments recorded lower levels of control than in the first assessment, indicating that activity of these herbicides had reduced with new ARG germinations occurring.

Final panicle control – What is going back into my seed bank?

Panicle counts are the most reflective measure of the effectiveness of an herbicide program's impact on how much weed seed is being set and being contributed to the seed bank of the paddock for future crop rotations.

Based on final panicle ratings only the two Sakura treatments recorded commercially acceptable control of ARG due to Sakura's long residual activity. The tank mixture of Sakura with trifluralin, a shoot uptake and volatile herbicide, recorded an increase in control (4-6%) on the two sites with sandier soil types - Cunderdin and Nugadong. On the heavier soil types at Pithara and Waddy Forest there was no significant weed control benefit from the addition of trifluralin to Sakura.

Reduced weed competition from an effective herbicide like Sakura with its long residual activity can improve the water and nutrient efficiency of the crop to maintain yield potential.

Based on the four site average, Boxer Gold (75%) and 3 L/ha prosulfocarb (74%) recorded comparable final ARG panicle control with a rate response from the lower prosulfocarb rate of 2.5 L/ha (69%). The tank mixture of trifluralin + Avadex (62%) performed slightly ahead of 3 L/ha Avadex (58%) in two of the three sites the straight Avadex was present in. Trifluralin at 2 L/ha recorded the lowest average level of control (52%) influenced by poor results at the Waddy Forest and Cunderdin trial sites.

With the long, soft conditions throughout spring, surviving ryegrass was able to produce high numbers of panicles and therefore seed. Growers with this scenario need to consider the implications of this seed set for following seasons and implement measures to control weed numbers with herbicides, rotations and harvest weed seed management techniques.

Table 2: Yield (t/ha), gross margin ($/ha) and $ return on investment ($ROI/ha) from Waddy Forest and Pithara in Mace wheat.

Trial Location and weed density		**16WE05 – Waddy Forest (1831 panicles/ m^2)**			**16WE06 - Pithara (843 panicles/ m^2)**			
Treatment	**Cost $/ha**	**Yield t/ha**	**Gross $/ha**	**$ROI/ ha**	**Yield t/ha**	**Grade**	**Gross $/ha**	**$ROI/ ha**
Untreated	*$0.00*	1.57 a	$329.70		2.30 b	ASW1	$510.60	
Sakura WG 118 g/ha + Trifluralin 1.5 L/ha	$51.90	2.60 a	$546.00	$158.40	2.82 a	ASW1	$626.04	$57.54
Sakura 118 g/ha	$40.10	2.31 a	$485.10	$109.30	2.81 a	ASW1	$623.82	$67.12
Prosulfocarb 2.5 L/ha	$29.75	2.31 a	$485.10	$119.65	2.65 ab	ASW1	$588.30	$41.95
Avadex Xtra 3 L/ha	$29.75	1.85 a	$388.50	$23.05	2.41 ab	ASW1	$535.02	-$11.33
Prosulfocarb 3 L/ha	$35.70	1.91 a	$401.10	$29.70	2.70 ab	AGP1	$567.00	$14.70
Boxer Gold 2.5 L/ha	$38.28	2.14 a	$449.40	$75.42	2.40 ab	ASW1	$532.80	-$22.08
Trifluralin 2 L/ha	$11.80	1.87 a	$392.70	$45.20	2.35 ab	ASW1	$521.70	-$6.70
Boxer Gold 2.5 L/ha + Trifluralin 2 L/ha	$50.08	2.22 a	$466.20	$80.42	2.28 b	AGP1	$478.80	-$87.88
Trifluralin 2 L/ha + Avadex Xtra 2 L/ha	$31.63	1.75 a	$367.50	$0.17	2.43 ab	AGP1	$510.30	-$37.93
Application cost $6/ha	***LSD***	*0.665*			*0.285*			
Kwinana ASW1 09/11/2016 - $222	***St. Dev***	*0.388*			*0.166*			
Kwinana AGP1 09/11/2016 - $210	***CV (%)***	*18.66*			*6.58*			

Means followed by same letter do not significantly differ (P ≥5%), Duncan's New Multiple Range.
Note: All treatments met AGP1 grade at Waddy Forest, Cunderdin and Nugadong. Pithara grades noted.

Treatments that failed to make ASW1 at Pithara were due to the grain samples exceeding the 0.6% allowable level of small foreign seeds in this case annual ryegrass.

Table 3: Yield (t/ha), gross margin ($/ha) and $return on investment ($ROI/ha) from Cunderdin (Trojan) and Nugadong (Mace) with average gross margin ($/ha) and average $ROI/ha across the four trials in wheat.

Trial Location and weed density		**16WE07 - Cunderdin (1033 panicles/m^2)**			**Liebe - Nugadong (493 panicles/m^2)**			**Average of all four sites**	
Treatment	**Cost $/ha**	**Yield t/ha**	**Gross $/ha**	**$ROI/ ha**	**Yield t/ha**	**Gross $/ha**	**$ROI/ ha**	**Average Gross $/ha**	**Average $ROI/ ha**
Untreated	*$0.00*	1.50	$315.00		1.23	$257.32		$353.16	
Sakura WG 118 g/ha + Trifluralin 1.5 L/ha	$51.90	1.81	$434.40	$61.50	1.68	$351.77	$36.55	$489.55	$78.50
Sakura 118 g/ha	$40.10	1.95	$468.00	$106.90	1.50	$314.01	$10.59	$472.73	$73.48
Prosulfocarb 2.5 L/ha	$29.75	1.66	$348.60	-$2.15	1.57	$329.06	$35.99	$437.76	$48.86
Avadex Xtra 3 L/ha	$29.75	1.75	$420.00	$69.25	-	-	-	$447.84	$26.99
Prosulfocarb 3 L/ha	$35.70	1.65	$396.00	$39.30	1.40	$294.53	-$4.49	$414.66	$19.80
Boxer Gold 2.5 L/ha	$38.28	1.67	$350.70	-$8.58	1.57	$330.44	$28.84	$415.84	$18.40
Trifluralin 2 L/ha	$11.80	1.31	$314.40	-$18.40	1.35	$283.82	$8.70	$378.15	$7.20
Boxer Gold 2.5 L/ha + Trifluralin 2 L/ha	$50.08	1.69	$354.90	-$16.18	1.66	$348.82	$35.42	$412.18	$2.94
Trifluralin 2 L/ha + Avadex Xtra 2 L/ha	$31.63	1.50	$315.00	-$37.63	1.42	$297.21	$2.26	$372.50	-$18.28
Application cost $6/ha	***LSD***	*NS*			*NS*				
Kwinana ASW1 09/11/2016 $222	***St. Dev***	*0.3*			*0.3*				
Kwinana AGP1 09/11/2016 $210	***CV (%)***	*16*			*18*				

Note: All treatments met AGP1 grade at Waddy Forest, Cunderdin and Nugadong. Pithara grades noted.

Yield discussion - four trial average

Over all four trials both Sakura treatments maintained a positive $ROI/ha with Sakura + trifluralin ($78.50) slightly ahead on average $ROI/ha to the standalone Sakura ($73.48).

Sakura 118 g/ha recorded a $55.08 increase in $ROI/ha over Boxer Gold across the four trials. Boxer Gold $ROI was generally in line with that of the prosulfocarb treatments in three of the sites, except from Waddy Forest where 2.5 L/ha prosulfocarb recorded a higher yield. Why this occurred is not clear as results were cross checked back with the contractor to ensure there was not a transcription error.

Trifluralin, due to its poor weed control, especially at Cunderdin, returned a slight positive $ROI/ha ($7.20) across the four trials.

All four sites to some extent were affected by frost which may have affected yield outcomes.

Getting weed control right is the key to ensuring the longevity of any herbicide but it also allows the crop it's best possible chance of achieving its yield potential. Using a program of effective knockdowns and a product with a long residual activity like Sakura can deliver higher yields and returns across a variety of soil types and locations as seen across the four trials conducted during the 2016 season.

Acknowledgements

To the grower's (Patton, McIlroy, Butcher and Syme families) that each hosted one of the trials, thank you for all your work in sowing and maintaining the sites and your understanding when hosting field walks. Thanks to Living Farm for the harvest of Waddy Forest, Pithara and Cunderdin, and DAFWA at Nugadong.

To Michael Macpherson from Imtrade Australia, thanks for the use of your early season assessments and allowing your trial to be included in this multi-site review.
Paper reviewed by: David Gregor – Regulatory Affairs Manager, Bayer

Contact

Rick Horbury, Bayer
rick.horbury@bayer.com
0429 055 154
Twitter: @HorburyRick

Uragan for long term weed control and resistance management

Bevan Addison, Market Development Manager, Adama Australia

Key Messages

- Over several seasons now Uragan has been tested in the Ballidu – Dalwallinu area with good long term residual weed control on fencelines.
- Fencelines and firebreaks are a major source of resistance development.
- We need to avoid continual reliance on commonly used products such as Glyphosate, Atrazine and Diuron which are also widely used in paddock situations.
- Weeds along fencelines act as "highways" for insect movement through the property and sanctuaries for insects and diseases. This promotes resistance build up in these pests as well as weeds.

Aim

To showcase the residual control of annual weeds over two seasons and compare commonly used mixes with Uragan at different rates.

Background

Uragan is Bromacil, a group C herbicide which falls into a different sub group to the commonly used group C's such as diuron and triazines. As such it doesn't have any known cross resistance and is an important resistance management tool.

The trial was sprayed in July 2015 to reproduce the effect of long term weed control and showcase 12 months of residual activity.

Trial Details

Property	O.J Butcher & Son, Nugadong
Plot size & replication	10m x 5m x 2 replications
Soil type	Sandy loam
Paddock rotation	No rotation, area is unused along roadside
Spraying date	17/07/2015
Herbicide Treatments	1. 5 kg/ha Uragan, 2.5 L/ha Wipe-out 450, 0.2% wetter 2. 2.5 kg/ha Uragan, 2.5 L/ha Wipe-out 450, 0.2% wetter 3. 3.5 kg/ha Uragan, 2.5 L/ha Wipe-out 450, 0.2% wetter 4. 3 kg/ha Atrazine, 15 g/ha Chlorsulfuron, 2.5 L/ha Wipe-out 450, 0.2% wetter 5. 3 kg/ha Diuron, 15 g/ha Chlorsulfuron, 2.5 L/ha Wipe-out 450, 0.2% wetter
Weeds Present	Mintweed, Windmill grass, Mulla mulla, Capeweed, Radish. All well established.

Comments and conclusions

Observations 05/11/2015

All knockdown treatments worked very well and achieved total weed control initially. Most plots still very clean but low levels of mintweed and windmill grass present across the Diuron and Atrazine treatments. Highest rate of Uragan is 100% bare ground.

Observations 15/06/2016

Removal of most other weeds seems to have encouraged invasion by slender ice plant which was not present in 2015 at spraying time. Highest rates of Uragan have given excellent residual of other weeds but more space for ice plant to flourish. Highest rates were best of all treatments for traditional annual weeds. If ice plant is likely to be an issue, addition of an SU herbicide would be advised.

Observations 19/12/2016

All weeds were dead due to lack of moisture so visual results reflected the levels of control until the end of season. After 18 months the 5 kg/ha rate of Uragan had provided an excellent level of control of all weeds other than the iceplant. Across the 5 kg/ha Uragan areas it was approximately 15-20% ground cover and would still be considered acceptable control for fencelines especially after having had two seasons of residual. There was still some effect from the 3.5 kg/ha rate although with this weed spectrum it was not acceptable with 75% ground cover. None of the other treatments had provided enough residual control through this season and had high levels (85-90%) of ground cover.

As a follow up from the 2015 fenceline demonstration at Ballidu, there was still bare ground in the 3.5 kg/ha Uragan treatments which had given excellent control of broadleaf and grasses since spraying in July 2015.

Uragan is more expensive than other options however for all weeds other than iceplant, the residual will save at least one and probably two applications of traditional firebreak treatments that most farmers will use.

Figure 1: Butcher's trial. Areas treated with 5 kg/ha Uragan, only iceplant surviving.

Figure 2: 2015 Ballidu trial site. Area sprayed with 3.5 kg/ha Uragan.

Both sites sprayed 17/07/2015 and photos taken 19/12/2016.

Acknowledgements

Butcher and Hood families for hosting trial sites.

Paper reviewed by: Jason Stokes, Adama Australia

Contact

Bevan Addison, Adama
bevan.addison@adama.com
0427422852

The importance of early application and multiple mode of action herbicides for wild radish control in wheat

Bevan Addison, Market Development Manager, Adama Australia

Key Messages

- With the prevalence of hard to control radish populations, the use of good rates of a multi-mode of action herbicide can still get good control.
- Spraying small weeds for good initial knockdown and utilising a two spray strategy is key to successful radish control.

Aim

To undertake two herbicide trials side by side approximately three weeks apart to demonstrate the successful utilisation of multi-mode of action herbicides and highlight the importance of spraying small weeds.

Background

Radish control had been difficult on the property in the past. Small scale single strip hand boom sprays of large weeds last season highlighted that weeds were hard to control in neighbouring paddocks. In many regions where multiple herbicide resistance in wild radish has been problematic for control and hence seed set reduction, aggressive early herbicide applications using multiple modes of action has enabled growers to get on top of radish and start to drive down seed banks.

This trial was set up to prove this concept as well as test some products which are under development by Adama.

Trial Details

Property	Murray Dickins, West Pithara
Plot size & replication	15m x 2.5m x 3 replications
Soil type	Sandplain
Paddock rotation	2013 canola, 2014 wheat, 2015 barley
Sowing rate	80 kg/ha Mace wheat
Fertilisers	Seeding: 80kg/ha MAPSCZ MOP, 60 kg/ha Urea Early tillering: 40 kg/ha Urea
Herbicides, insecticides & fungicides	Trial 1 15/06/2016: 2.25 -2.45pm, 14.2 ^oC, RH 65%, cloud cover 85%, delta T 3, adequate soil moisture. radish 2-4 leaf, Mace wheat Z 13.22. Trial 2 6/7/2016: 1.45-2.15pm, 16.5 ^oC, RH 56%, cloud cover 10%, delta T 4, good subsoil moisture. All treatments applied using 2.5 m hand boom. Water rate 100 L/ha, med spray quality.
Growing season rainfall	Approx. 200mm (May – October)

Results

The two side by side trials varied slightly with a higher rate of Colt utilised in conjunction with LVE MCPA in Trial 2 due to the size of radish. The stand-alone Colt treatment was changed to the more robust Paragon Xtra due to weed size. The other treatments were the same for both sites.

Trial 1

Both initial radish populations and second germinations were counted and final radish numbers for each treatment were measured. This gave some indication of the residual value of some of the active ingredients as well as the knockdown control on the primary germinations.

All treatments gave significant control of the primary population and in terms of final radish numbers, achieved in the range of 75-98% control compared to untreated.

When comparing individual products, Triathlon 750 mL, Colt 750 mL + LVE MCPA 570 300 mL and the lowest rate of experimental product AD AU 1603 gave significantly less control than all other treatments with the exception of Velocity + MCPA.

In untreated plots there was limited second germination due to the high competition exerted by the larger primary populations.

When comparing the level of secondary germination, Velocity + LVE MCPA plots had the highest level of radish due to low residual control. This was significantly different to all other treatments apart from the Colt + LVE treatment. All other treatments were not significantly different from each other.

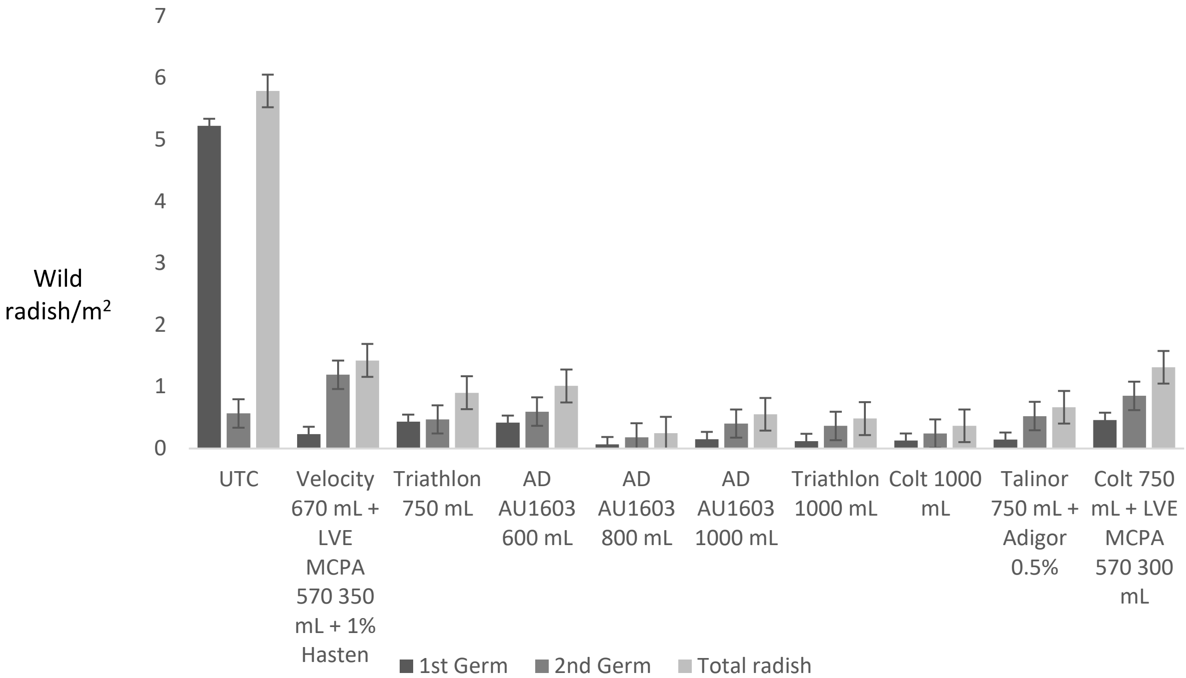


Figure 1: Wild radish/m^2 36 Days After Treatment (DAT) showing control of primary and secondary germinations and overall wild radish population. (Error bars = LSD 5% - UTC).

All treatments gave significant improvement in yield over the untreated plots. Yield increases ranged from 330 kg/ha for Colt at 1000 mL/ha to 640 kg/ha for the experimental product AD AU 1603 at 800 mL/ha.

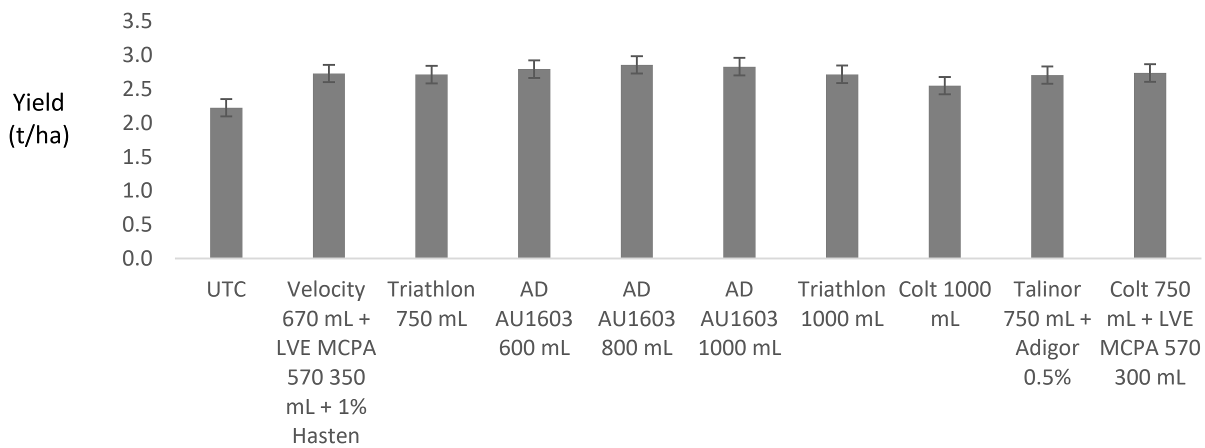


Figure 2: Yield (t/ha) (Error bars = LSD 5%).

Trial 2
This trial was an example of how radish numbers do not always reflect the biomass of the population. The actual radish numbers/m^2 were not particularly high but radish biomass, especially in the UTC and low performing treatments was extreme.

Assessment was based on plant numbers and visual biomass reduction. There was no attempt to differentiate between primary and secondary germinations as the weeds were significantly larger and over time appeared to smother most second germinations.

The performance of the different herbicides, in contrast to Trial 1, was highly variable with a much poorer level of control overall and a much bigger spread of control based on the products and rates applied. There was a clear rate response with AD AU 1603 which was not seen in Trial 1. Control from Velocity + LVE MCPA was poor.

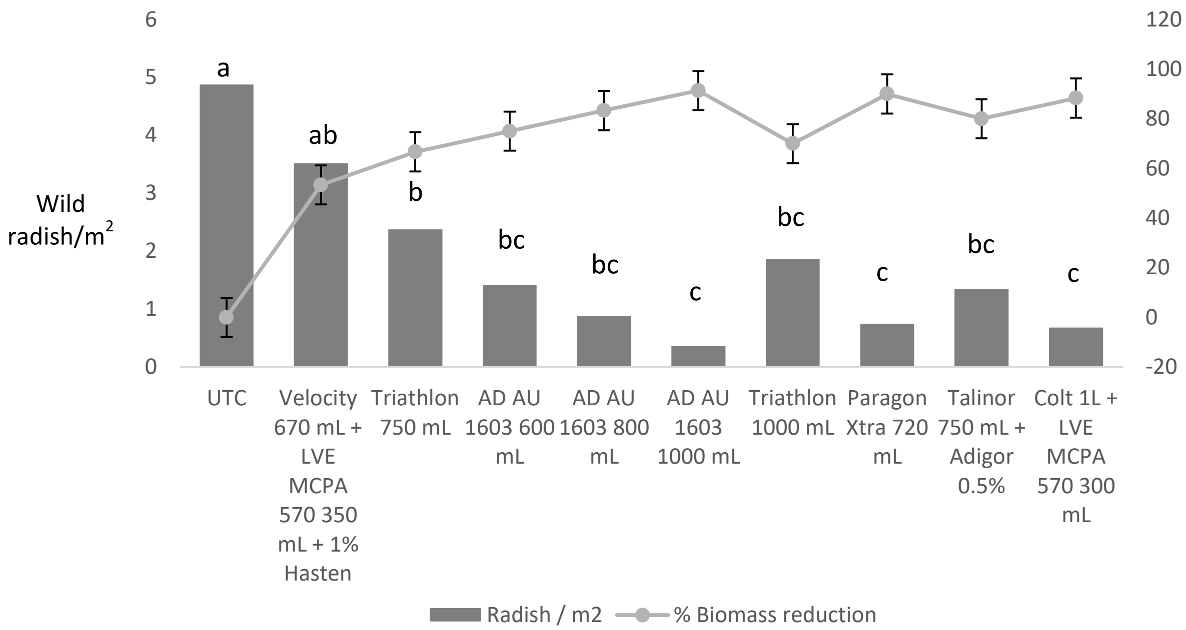


Figure 3: Wild radish plants/m^2 and % biomass reduction (57DAT) (Error bars = LSD 5% - UTC).

All treatments gave significant increase in yield over the control however there was no significant difference in yield between the treatments.

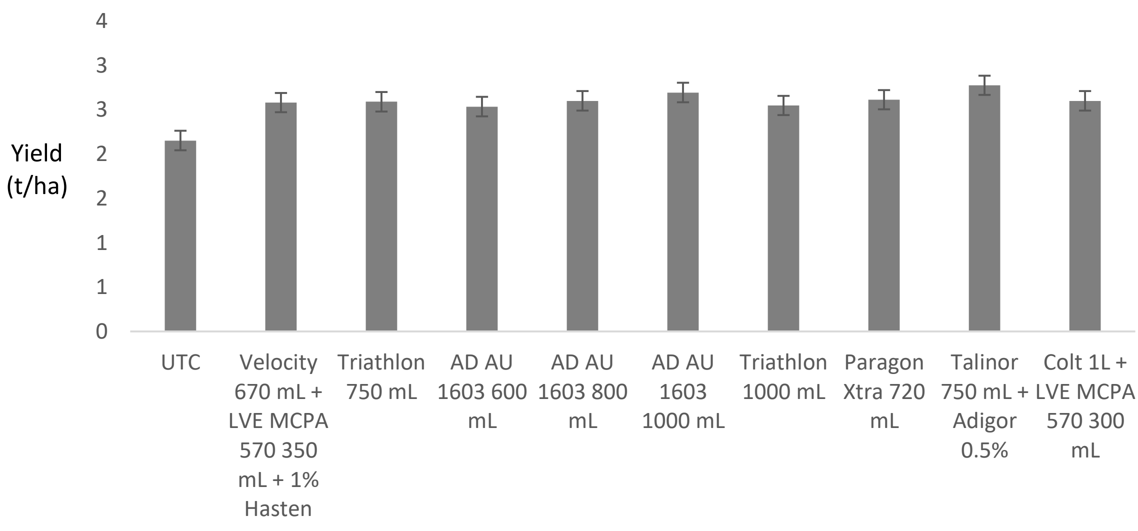


Figure 4: Yield (t/ha) (Error bars LSD 5%).

Comments
Although radish populations at this site were relatively low, there were good responses to different treatments and clear visual differences between the two side by side trials.

Trial 1 overall gave very high levels of control from most treatments, highlighting the benefits of early spraying with good rates of robust products. Indeed, some of the better treatments would have resulted in radish setting very little seed.

The products with a known level of residual control reduced the number of secondary germinating radish and kept the population in check for longer.

As part of a two spray strategy for driving down radish numbers, all treatments would have reduced populations and reduced the vigour and biomass of any survivors, meaning that you could have confidently achieved high levels of control with a second spray. A residual product may provide greater "breathing space" in terms of the timing to get back to undertake the mop up spray.
This two spray strategy was undertaken on the surrounding crop with excellent results.

In contrast, the second timing left a large biomass of weeds no matter what the treatment. This would make second follow up spraying more difficult with a greater risk of failure due to a reduced ability to contact all weeds, as well as larger weeds being more difficult to control.

In both trials, Velocity performed relatively poorly based on historical understanding. In Trial 1 conditions at spraying were very cloudy. This may have affected the product as it performs best in high light intensity situations. In Trial 2 weeds were large and in one replicate there were higher numbers which potentially meant shading and coverage issues due to the large weed size.

The earlier spraying of weeds provides a greater yield response and also highlights differences between products. Yield improvements ranged from 330 kg/ha to 640 kg/ha depending on product used. While not all products are commercially available, this represents in the order of 5:1 return on investment (ROI).

In the later sprayed trial the yield response was similar compared to the untreated, there was no significant difference between products and the overall trial yield was lower, probably due to the competition of weeds earlier in the life of the crop.

While not assessed, the radish seed set would have been high across the site at Trial 2, as the surviving weeds were large and vigorous with significant flowering.

Acknowledgements
Murray Dickins for use of the site and Joe Delaney for trial site identification and assistance.

Paper reviewed by: Jason Stokes, Adama Australia

Contact
Bevan Addison, Adama
bevan.addison@adama.com
0427 422 852

Disclaimer: Triathlon® and Colt® are registered trademarks of Adama Australia. Velocity® is a registered trade mark of Bayer. Talinor® and Adigor® are registered trademarks of Syngenta. Paragon Xtra® is a registered trademark of Nufarm.

ADAMA

Population growth rate of emerging weed species

Dr Catherine Borger, Research Officer and Dr Abul Hashem, Principal Research Officer, DAFWA

Key Messages

- Great brome grass emerges at the same time as the crop.
- Barley grass, sowthistle and doublegee emerge after the crop, and were poorly competitive in a good season. However, the staggered cohorts make it difficult to control all plants with herbicide.
- Sowthistle and doublegee plants commence seed production and shedding at a very young age, and need to be targeted for early weed control to prevent a build-up of the weed seed bank. Late emerging cohorts will escape in-crop control options and seed collection at harvest, requiring further control over summer.

Aim

This trial investigated the biology and ecology of the following weed species: great brome grass, barley grass, doublegee, sowthistle, wireweed, button grass, windmill grass, roly poly, caltrop and afghan melon.

The trial aims to determine how quickly these weed species can establish and spread (via harvest movement) on farm when resistant seeds are introduced in contaminated grain at sowing. This will be investigated by monitoring emergence, survival, seed production, time of shedding, build-up of the weed seed bank and population growth rate of these increasingly problematic weeds.

Background

Weed species like great brome grass, barley grass, doublegee, sowthistle, wireweed, button grass, windmill grass, roly poly, caltrop and afghan melon are becoming increasingly problematic in cropping systems of Western Australia. For growers to develop successful management programs for these weeds, they need to know basic ecological facts about each species; i.e. when do they germinate, what proportion of plants survive, how much seed do they produce, when does the seed shed, how much seed is captured at harvest (potential weed dispersal via harvest/grain movement or harvest weed seed destruction), how quickly the weed seed bank builds up and how quickly the population can increase (population growth rate).

To investigate these factors, a trial was established at the Department of Agriculture and Food Western Australia (DAFWA) Wongan Hills Research Station. The trial site was relatively clean at the start of the season. A few weeds emerged prior to seeding (mainly annual ryegrass and wild radish), and were killed with non-selective herbicide. An autumn tickle was used to simulate weed germination, for optimal control by non-selective herbicides.

There were 12 treatments in the trial: great brome grass, barley grass, doublegee, sowthistle, wireweed, button grass, windmill grass, roly poly, caltrop, afghan melon, annual ryegrass and a weed free control. Annual ryegrass was included for comparison, as we already know the population growth rate of annual ryegrass under varying conditions (Fernandez-Quintanilla *et al.* 2000; Gonzalez-Andujar and Fernandez-Quintanilla 2004; Monjardino *et al.* 2003). Weed seeds were placed in the plots directly prior to seeding, at a density of 100 seeds/m^2. This was done to simulate a situation where weed seeds are introduced at seeding, in contaminated grain. No in-crop herbicides were applied, to simulate a scenario where the introduced weed species were resistant to selective herbicides. Following crop emergence, weed density was assessed in two quadrats of 50cm by 50cm. As the weeds germinated, ten individual weed plants were marked in each plot. The labelled weeds were monitored throughout the season, to assess their development and survival. Total seed production, time of shedding and number of seeds captured by the harvester was also assessed from these plants.

This trial will continue for 2 or 3 seasons (depending on seasonal conditions and how well the weed populations establish). This will allow us to assess the rate of build-up of the weed seed bank and population growth rate of each species.

Trial Details

Property	DAFWA Wongan Hills Research Station
Plot size & replication	5m x 3m x 3 replications
Soil type	Grey/white sand
Paddock rotation:	2013 wheat, 2014 pasture, 2015 pasture
Sowing date	26/05/2016
Sowing rate	80 kg/ha Mace wheat (22cm spacing)
Fertiliser	26/05/2016: 80 kg/ha MacroPro Plus
Herbicides, insecticides & fungicides	08/02/2016: 60 mL/ha Garlon, 500 mL/ha Ester, 1.5 L/ha Glyphosate 07/04/2016: Cultivate (i.e. autumn tickle) 14/07/2016: 2 L/ha Glyphosate, 25 mL/ha Hammer 16/08/2016: 150 mL/ha Prosaro, 250 mL/ha Alpha-cypermethrin
Growing season rainfall	223mm (May to October)

Results

The grass weed species (great brome grass, barley grass and annual ryegrass) have growth stages that are similar to wheat, as described in Zadoks growth scale (Zadoks *et al.* 1974). However, once the seed head was produced on great brome grass, barley grass or annual ryegrass plants, the plants were classified as 'seed head' stage. The grain production stage in the weeds was not differentiated into milk development, dough development and ripening, as for a crop, because these stages are difficult to distinguish in weed seeds in the field. Following seed head production and senescence (death) of the great brome grass or barley grass plants, there is a further 'shedding' stage that is obviously not seen in wheat, because crops do not shed seed.

Great brome grass

Great brome grass had an initial density of 60 plants/m^2. The largest cohort of seedlings emerged about two weeks after sowing, at the same time as the wheat (Figure 1). Smaller cohorts emerged later in the year, but the majority of the great brome grass plants were at the same developmental stage as the wheat throughout the year. Great brome grass was shorter than the crop for most of the year, but by late October the great brome grass heads were taller than the wheat canopy. The seed heads took three months (September to November) to fully ripen. Shedding of great brome grass seed did not commence until mid-November, when the crop was already fully mature (ready for harvest). However, quite a few great brome grass plants lodged prior to harvest, so not all seed heads would be caught by the harvester.

Figure 1: The percentage of great brome grass plants at each growth stage (seedling, tillering, jointing, boot, seed head, senescence, shedding) throughout the growing season (from crop sowing on 26/05/2016 to crop maturity on 14/11/2016).

Barley grass

Barley grass (68 plants/m^2) emerged in late June and early July, when the wheat was already at the seedling stage (Figure 2). Barley grass plants progressed through tillering, jointing and booting before seed heads emerged in October (although 7% of plants died prior to seed set). The majority of barley grass plants emerged in the first cohort, and so most plants reached each growth stage at a similar time. The barley grass was always one development stage behind the crop, throughout the growing season. A few barley grass seeds shed prior to crop maturity (in early November). However, barley grass plants were short (generally less than 10cm tall) because the crop was highly competitive. As a result, barley grass plants were protected from the wind and most seed did not shed, even after senescence. However, most seeds were not captured at harvest, because the plants were too short.

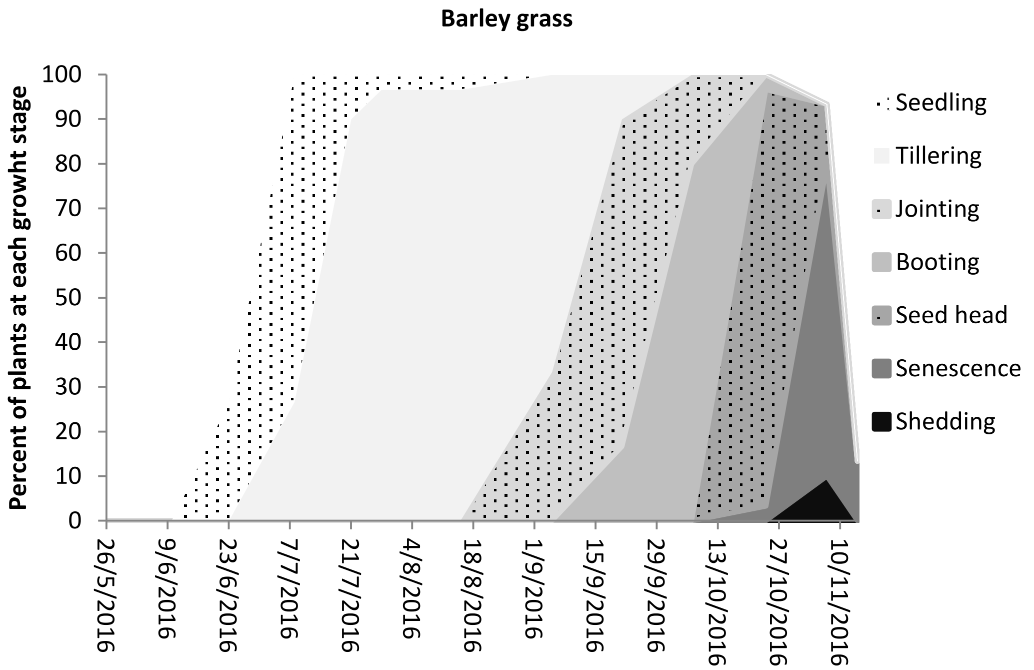


Figure 2: The percentage of barley grass plants at each growth stage (seedling, tillering, jointing, boot, seed head, senescence, shedding) throughout the growing season (from crop sowing on 26/05/2016 to crop maturity on 14/11/2016).

Annual ryegrass

Annual ryegrass growth was similar to that of great brome grass. The majority of annual ryegrass seedlings emerged at the same time as the crop (65 plants/m^2) and stayed at the same development stage as the crop throughout the growing season (Figure 3). Most annual ryegrass plants were at the same growth stage. Annual ryegrass seeds did not shed. Some seed heads lodged at the end of the season, and some were below harvest height, but a large proportion of heads were caught by the harvester. As mentioned in the 'Background' section, annual ryegrass was included as a control. We already know the population growth rate of this weed in varying crops and seasonal conditions, and can compare it to the other weed species, to determine how problematic they would be if they developed resistance.

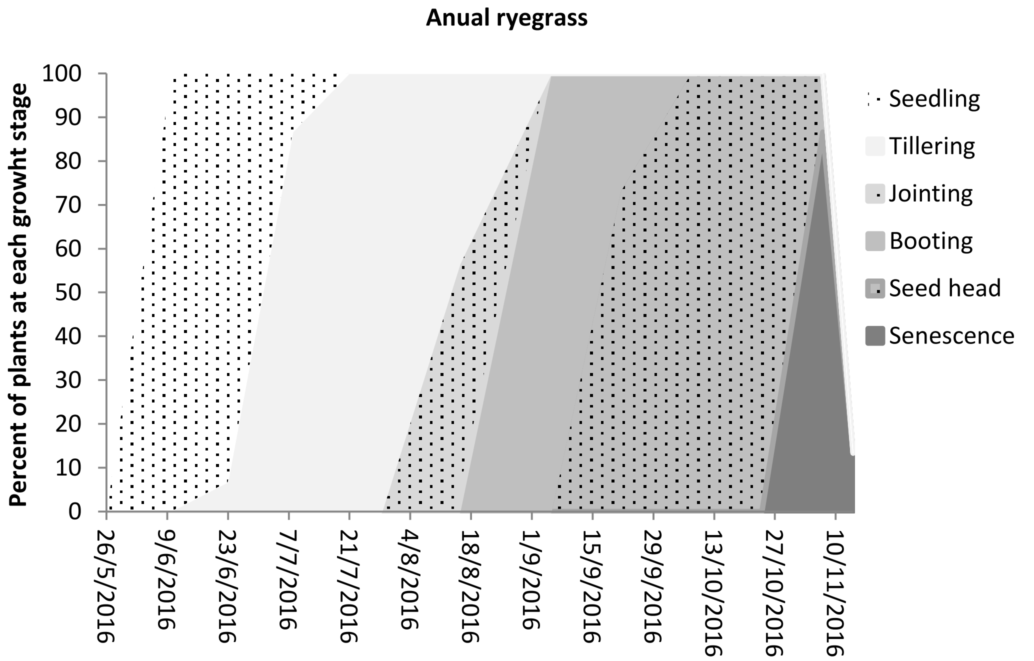


Figure 3: The percentage of annual ryegrass plants at each growth stage (seedling, tillering, jointing, boot, seed head, and senescence) throughout the growing season (from crop sowing on 26/05/2016 to crop maturity on 14/11/16).

Broad leaf weed growth stages were developed by Hess et al (1997), and include: stage 0 – cotyledons emerge, stage 1 – leaf development on the main shoot, stage 2 – formation of side shoots, stage 3/4 – stem elongation/shoot development, stage 5/6 – inflorescence emergence/flowering, stage 7/8 – development and ripening of fruit/seeds and stage 9 – senescence/death. These growth stages were adapted to suit doublegee, sowthistle and wireweed.

Doublegee

Doublegee (55 plants/m^2) emerged in June when the crop was at the seedling stage (Figure 4). After the cotyledons emerged, leaves grew on the main shoot until August and September. Plants started flowering and produced seed from August onwards. However, unlike great brome grass or barley grass, doublegee plants were at a range of different growth stages throughout the season. Plants could flower and set seed from the four leaf growth stage. The first seeds form at the junction between the main plant stem and the root, just under the soil surface. They cannot be seen until the plant is pulled out of the ground. Plants started dying and/or shedding seed in October. Very small plants, with an average dry weight of 0.33g, still held an average of 3 seeds per plant (at the base of the main stem). By the time the crop was ready to harvest, only 17% of doublegee plants were still alive, and these plants formed side shoots and continued to set seed. Doublegee growth is indeterminate (i.e. plants continue to flower and produce seed until killed by environmental conditions such as moisture stress). The 17% of plants that are still alive are likely to continue setting seed after harvest (depending on soil moisture), as most were too short to be captured/killed by the harvester.

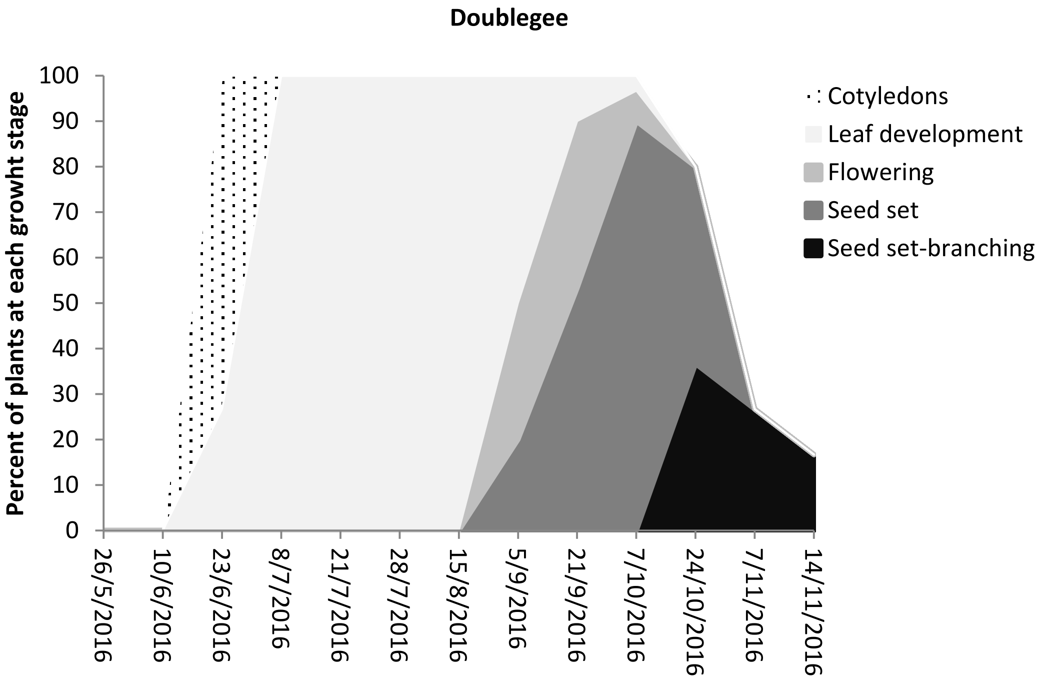


Figure 4: The percentage of doublegee plants at each growth stage (cotyledons, leaf development, flowering, seed set and seed set/branching) throughout the growing season (from crop sowing on 26/05/2016 to crop maturity on 14/11/2016).

Sowthistle

Sowthistle (50 plants/m^2) germinated in June (Figure 5). Plants progressed through the leaf development stage to stem elongation in August and September. Plants started flowering and producing seed heads in late September. Sowthistle, like doublegee, has indeterminate growth, and so the plants were at different growth stages throughout the season. Those plants at the seed head/shedding stage were also still flowering. About 10% of the population remained in the vegetative stage until crop maturity, and will probably flower after crop harvest (depending on rainfall). Shedding and senescence started in October, although a few plants died without setting seed. The plants dying in October were generally small (average dry weight of 0.25g) and had an average of four seed heads per plant (average of 51 seeds per plant).

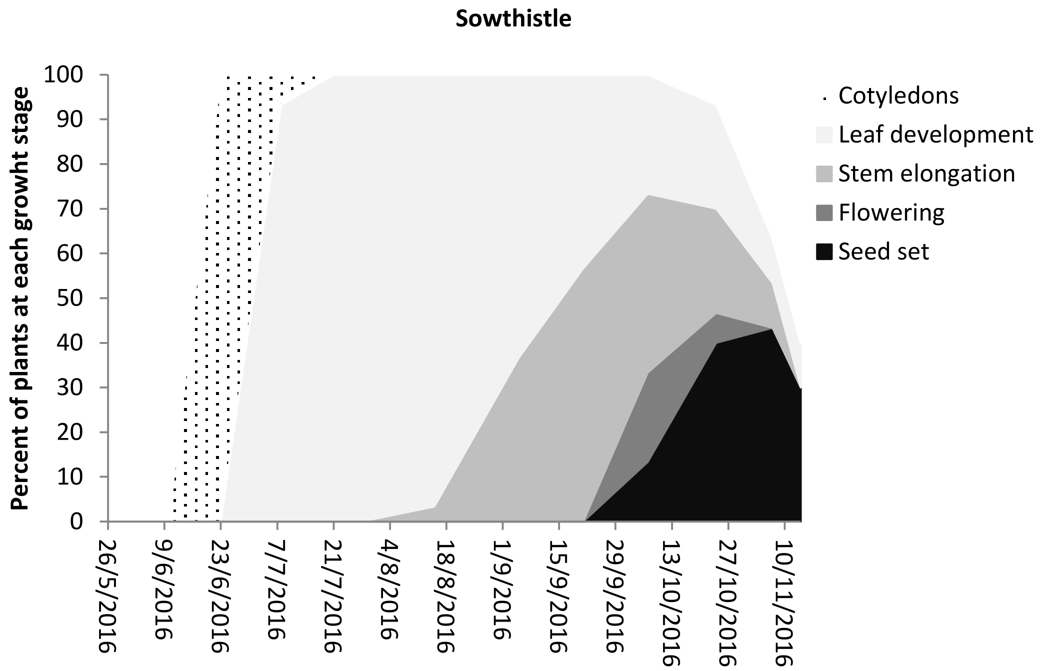


Figure 5: The percentage of sowthistle plants at each growth stage (cotyledons, leaf development, stem elongation/bolting, flowering, seed set/seed shedding) throughout the growing season (from crop sowing on 26/05/2016 to crop maturity on 14/11/2016).

Wireweed

The wireweed seedlings (11 plants/m^2) emerged in July and August, when the crop was at late tillering to early boot stage and highly competitive (Figure 6). Wireweed plants progressed to leaf development on the main shoot, but did not produce side shoots or flower/set seed. By mid-November, when the crop was ready to harvest, 70% of wireweed had died. However, those surviving plants may develop further after harvest.

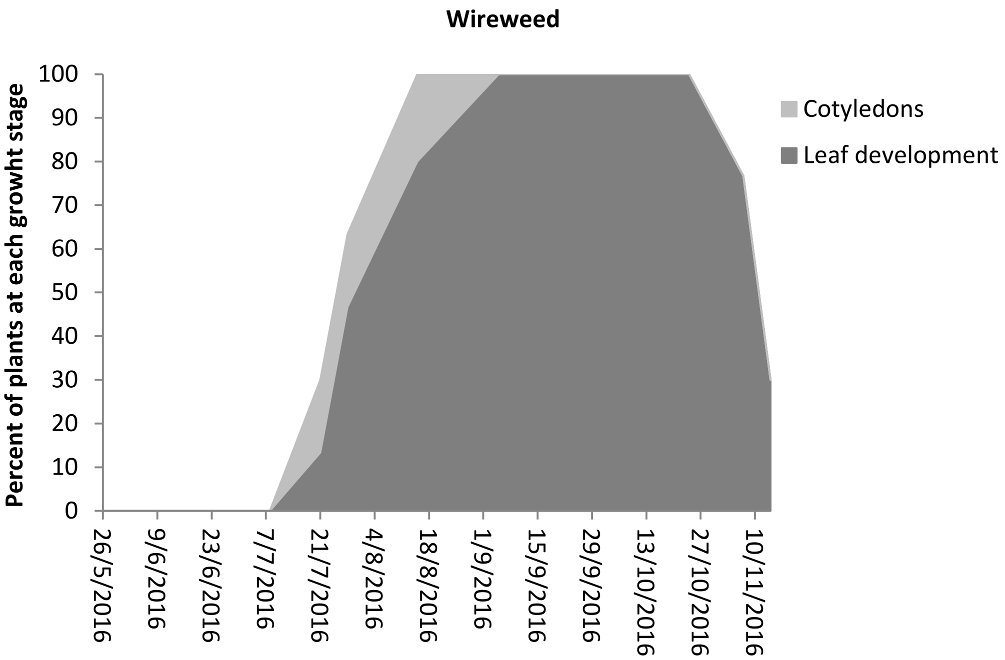


Figure 6: The percentage of wireweed plants at each growth stage (cotyledons or leaf development) throughout the growing season (from crop sowing on 26/05/2016 to crop maturity on 14/11/2016).

The data on seed production, time of seed shedding and seed capture at harvest are incomplete, as some species are still setting seed. Weed seed samples and harvest data are still being processed. The summer weeds (button grass, windmill grass, roly poly, afghan melon and caltrop) have not yet germinated. These species will be monitored after summer rainfall.

Comments

The results highlighted that great brome grass or annual ryegrass emerges with the crop. The largest cohorts of these species emerge at a similar time to the crop, making it relatively easy to control all weed plants with a single selective herbicide application within the crop. The amount of seed that can be captured at harvest is unknown, as the final harvest data is still being processed. However, it will depend on seed retention or shedding, height of the weed plants and lodging.

Doublegee, sowthistle, barley grass and wireweed emerged after the crop. There are two optimal methods to manage weeds that emerge late: a) sow the field as early as possible to ensure the crop is highly competitive when the weeds emerge (if adequate in-crop selective control options are used), or b) sow the field as late as possible to control some of the late germinating weeds with non-selective (knockdown) herbicide. Doublegee, sowthistle and wireweed had staggered emergence with multiple cohorts. These species have indeterminate growth, and there are plants at different growth stages throughout the season. The varied emergence times and growth stages make these species more difficult to target with a single application of in-crop herbicide. Total seed production by these species has not been assessed, as some of the plants are still producing seed at the time this article was produced (through crop harvest/early summer). However, the research highlighted that even a tiny (4-6 leaf) doublegee or sowthistle plant, which dies prior to crop harvest (due to crop competition, not in-crop herbicide use) can still produce enough seed to ensure the population expands (average of 3 seeds on small doublegee plants and 51 seeds on sowthistle plants). Doublegee seeds are particularly problematic because they can remain dormant at least 5 years (Cheam and Lee 2009). Further, the first doublegee seeds to form on the plant are underground and not readily apparent from observation of the aboveground plant biomass. To prevent all seed set, these species need to be targeted in-crop and over summer, or in-crop with residual herbicides, when the plants are at the seedling stage (younger than the 4 leaf growth stage).

Future work on this trial will measure summer weed growth, and determine seed bank build-up and population growth rate of all weed species. Further, there is a lot of variation in the way weeds develop in crop, and several years of data are required to capture this variation for each species.

References

Cheam A, Lee S (2009) Inversion ploughing: effects of long-term deep burial on weed seed reserves. In 'Agribusiness Crop Updates' pp. 282-283. (Department of Agricultural and Food Western Australia, Grains Research and Development COrporation: Perth, WA).

Fernandez-Quintanilla C, Barroso J, Recasens J, Sans X, Torner C, Sanchez del Arco MJ (2000) Demography of *Lolium rigidum* in winter barley crops: analysis of recruitment, survival and reproduction. *Weed Research* 40, 281-291.

Gonzalez-Andujar JL, Fernandez-Quintanilla C (2004) Modelling the population dynamics of annual ryegrass (*Lolium rigidum*) under various weed management systems. *Crop Protection* 23, 723-729.

Hess M, Barralis G, Bleiholder H, Buhr L, Eggers TH, Hack H, Stauss R (1997) Use of the extended BBCH-scale - general for the description of the growth stages of mono- and dicotyledonous weed species. *Weed Research* 37, 433-441.

Monjardino M, Pannell DJ, Powles SB (2003) Multispecies resistance and integrated management: a bioeconomic model for integrated management of rigid ryegrass (*Lolium rigidum*) and wild radish (*Raphanus raphanistrum*). *Weed Science* 51, 798-809.

Zadoks JC, Chang TT, Konzak CF (1974) A decimal code for the growth stages of cereals. *Weed Research* 14, 415-421.

Acknowledgements
Thanks are due to Dave Nicholson and Nerys Wilkins, for their assistance with the trial. Thanks are also due to Shari Dougall and Bruce Thorpe at the Wongan Hills Research Station, who are excellent at running trials and very patient when we want to introduce new weeds to their fields.

Paper reviewed by: Dr Mohammed Amjad, DAFWA

Contact
Dr Catherine Borger, DAFWA
catherine.borger@agric.wa.gov.au
0467 816 082

Integrated weed management demonstrations to improve adoption of wild radish control practices at Dalwallinu

Abul Hashem, Principal Research Officer, Mohammad Amjad, Research Officer, Catherine Borger, Research Officer, and Glen Riethmuller, Development Officer, DAFWA

Key Messages

- Three years (2014 to 2016) of integrated weed management (IWM) to control wild radish have shown that effective knockdowns (single or double knock), non-chemical weed control options and application of effective in-crop herbicide mixtures can significantly reduce the wild radish population.
- Effective post-emergent (PO) mixtures of herbicides provide greater gross margin than use of higher seed rate, although non-chemical weed control options are of significant importance to delay the evolution of resistance by wild radish.
- High seed rate reduced radish density in one out of three years but did not increase grain yield in any year at this site. The overall grain yield of wheat was low, probably due to the high soil compaction level at 100-300mm depth.

Aim

To conduct integrated weed management (IWM) trials demonstrating the effect of chemical and non-chemical weed control options to improve adoption of wild radish IWM and reduce the risk of herbicide resistance in wild radish.

Background

One effective way to raise the awareness of IWM practices among the growers is to conduct IWM demonstrations. This IWM demonstration trial on wild radish control was established at Dalwallinu in collaboration with Liebe Group in 2014 and continued in 2015 and 2016. Selective control options available at pre-sowing, sowing, post-emergence (PO), and at harvest time were incorporated into IWM options. In-crop herbicides included Triathlon® (mixture of Group C+F+I) and Velocity® (mixture of Group C+H) to minimise the risk of resistance development. All treatments from 2014 to 2016 are provided in Table 1.

Trial Details 2014 to 2016

Property location	Harding Sawyer, Nugadong
Plot size & replication	10m x 3m x 4 replications in 2016; 20m x 3m x 4 replications in 2014 and 2015
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.3
EC (dS/m)	0-10cm: 0.15
Paddock rotation:	2013 canola, 2014 wheat, 2015 wheat, 2016 wheat
Sowing date	30/05/2014, 12/05/2015, 27/05/2016
Sowing rate	50 kg/ha or 100 kg/ha Mace wheat
Fertiliser	Sowing: 80 kg/ha Macropro Plus Maximum tillering stage every season: 50 L/ha Flexi-N 22/08/2016: 35 kg/ha sulphate of ammonia
Herbicides	First knockdown 1-3 weeks before sowing; Second knockdown 0-3 days before sowing. At sowing, 12/05/2015: 118 g/ha Sakura, 27/05/2016: 2 L/ha trifluralin First post-emergence (PO) herbicide applied at Z13 Second PO herbicide at Z30 each year.
Growing season rainfall	April to October: 209mm in 2014; 291mm in 2015; 188mm in 2016.

Table 1: Cumulative effect of chemical and non-chemical weed control options applied from 2014 to 2016 on the 2016 density of wheat heads and initial and final density of wild radish counted in wheat crop in July and August of 2016 at Dalwallinu, Western Australia[1].

	2014 treatments	2015 treatments	2016 treatments	Wheat heads/m²	Initial radish plants/m²	Final radish plants/m²
1.	Roundup® / Alliance® / 60 kg / no in-crop herbicides / WRB	Roundup® / Alliance® / 60 kg / no in-crop herbicides	Roundup® / Alliance® / 50 kg/ no in-crop herbicides.	203[a]	341.0[c]	70[c]
2.	Roundup® / Alliance® / 60 kg / Triathlon® Z13 / Velocity® Z30	Roundup® / Alliance® / 60 kg / Triathlon® Z13 / Velocity® Z30	Roundup® / Alliance® / 50 kg / Triathlon® Z13	234[abc]	0.5[a]	0[a]
3.	Roundup® / Alliance® / 60 kg / Velocity® Z13 / Triathlon® Z30	Roundup® / Alliance® / 60 kg / Velocity® Z13 / Triathlon® Z30	Roundup® / Alliance® / 50 kg / Velocity® Z13	221[ab]	1.0[a]	0.57[a]
4.	Para-Trooper® / 60 kg / Velocity® Z13 / Triathlon® Z30	Cultivation / Para-Trooper® / 60 kg / Velocity® at Z13 / Triathlon® Z30	Para-Trooper® / 50 kg / Velocity® Z13 / Triathlon® Z30	234[abc]	0.5[a]	0.28[a]
5.	Roundup® / Alliance® / 60 kg / Velocity® Z13 / Triathlon® Z30 / HWSR	Roundup® / Alliance® / 60 kg / Velocity® Z13 / Triathlon® Z30	Roundup® / Alliance® / 50 kg / Velocity® Z13	240[bc]	1.2[a]	0[a]
6.	Roundup® / Alliance® / 60 kg / Velocity® Z13 / Triathlon® Z30 / WRB	Roundup® / Alliance® / 60 kg / Velocity® Z13 / Triathlon® Z30	Alliance® / 50 kg / Triathlon® Z30	242[bc]	0.9[a]	0[a]
7.	Roundup® / Alliance® / 120 kg / no in-crop herbicides / WRB	Roundup® / Alliance® / 120 kg / no in-crop herbicide	Roundup® / Alliance® / 100 kg/ no in-crop herbicides.	265 [cd]	162.0[b]	31[b]
8.	Roundup® / Alliance® / 120 kg / Triathlon® Z13 / Velocity® Z30	Roundup® / Alliance® / 120 kg / Triathlon® Z13 / Velocity® Z30	Roundup® / Alliance® / 100 kg / Triathlon® Z13	294[de]	0.6[a]	0[a]
9.	Roundup® / Alliance® / 120 kg / Velocity® Z13 / Triathlon® Z30	Roundup® / Alliance® / 120 kg / Velocity® Z13 / Triathlon® Z30	Roundup® / Alliance® / 100 kg / Velocity® Z13	284[de]	0.3[a]	0[a]
10.	Para-trooper® / 120 kg / Velocity® Z13 / Triathlon® Z30	Cultivation / Para-trooper® / 120 kg / Velocity® Z13 / Triathlon® Z30	Para-Trooper® / 100 kg / Velocity® Z13 / Triathlon® Z30	315[e]	0.2[a]	0[a]
11.	Roundup® / Alliance® / 120 kg Velocity ®Z13 / Triathlon® Z30 / HWSR	Roundup® / Alliance® / 120 kg Velocity ®Z13 / Triathlon® Z30	Roundup® / Alliance® / 100 kg / Velocity® Z13	289[de]	0.7[a]	0[a]
12.	Roundup® / Alliance® / 120 kg / Velocity® Z13 / Triathlon® Z30 / WRB	Roundup® / Alliance® / 120 kg / Velocity® Z13 / Triathlon® Z30	Alliance® / 100 kg /Triathlon® Z30	293[de]	0.2[a]	0.28[a]
			P-value	*<.001*	*0.006*	*<.001*
			LSD (5%)	*32.9*	*73.81*	*10.59*

[1] Initial density of wild radish before any treatment in 2014 was 70 plants/m²; Average wild radish before harvest of wheat in 2014 was 17 plants/m²; Average wild radish before harvest of wheat in 2015 was 1-3 plant/m² in the in-crop treated plots and less than 1 in 2016; / = followed by; HWSR = Harvest weed seed removal at 2014 harvest only; WRB = Windrow burning was performed in April of 2015 only; Herbicide rates: 2.5 L/ha Alliance®, 1.6 L/ha Para-Trooper®, 2 L/ha Roundup®, 670 mL/ha Velocity® (Group C+H), 1 L/ha Triathlon® (Group C+F+I); *Cultivation* was done in 2015; initial wild radish plants counted on 5/7/2016 after weed emergence but before selective herbicide application at Z13; final wild radish was counted on 7/9/2016 after Z13 and Z30 application of selective herbicides.

Results

Wild radish control

Three years (2014 to 2016) of integrated weed management (IWM) to control wild radish in this trial have shown that effective knockdowns (double knock is better than single) and application of effective in-crop herbicides (mixtures from 2-3 modes of action) significantly reduced this wild radish population.

In 2016, a high seed rate of wheat increased wheat plant density by 57%, wheat heads by 27% but reduced initial wild radish density by 52% with double knockdowns but without any application of in-crop herbicides (Treatments 1 vs 7, Table 1).

In all three years knockdowns reduced in-crop wild radish by 40-45% compared to no knockdown (untreated buffer) (data not presented). Although high seed rate in previous years increased plant and head density of wheat, this neither increased crop yield, nor influenced radish control in 2014 and 2015. In 2016, a high seed rate increased plant and head density of wheat, and also reduced initial density of radish by 52% and final density by 56% (Treatment 1 vs 7, Table 1) but did not increase grain yield of wheat (Table 2).

The combination of single or double knockdowns, seed removal or windrow burning, and two in-crop selective herbicides (mixtures of C + H or C + I + F) at Z13 and/or Z30 of wheat crop in 2014 and 2015 reduced the wild radish density to a very low level in 2015 season compared to Treatment 1 and 7.

In 2016, knockdown followed by only one PO herbicide reduced wild radish density from 341 plants/m^2 (Treatment 1) to less than 1 plant/m^2 (Treatment 2-6 and 8-12, Table 1).

Although wild radish density was 70 plants/m^2 in 2014, density of wild radish was poor in 2015 (initial density 10.5 plant/m^2 but 1-3 plant/m^2 before harvest). High density of wild radish (up to 341 plants/m^2 in no PO herbicide plots sown with 50 kg/ha) was recorded in 2016 season. This data once again confirm the fact that wild radish seed dormancy and persistence in soil is long. Effective control of high density wild radish in 2016 is expected to significantly reduce the soil seed bank in this site in the future.

Results in Table 1 showed that to reduce the impact of radish, it is important to apply double knockdowns (season permitting) and two effective in-crop herbicides (early and late crop growth stages) during the first and second year. In the third year, one knockdown and one in-crop effective herbicide seems to be enough to control almost 100% of wild radish. However, in absence of effective in-crop herbicides, radish population will build-up to enrich soil seed bank quickly (Treatments 1 and 7, Table 1).

Grain yield and economics

Despite achieving good radish control and application of all standard agronomic practices, overall grain yield at this site was low. This could be due to the high level of soil compaction at 100-300mm soil depth (Figure 1). The soil resistance level for restricted root growth is considered to be 2500kPa and this level was reached at only 100mm deep. On the average, gross margin was greater at 50 kg/ha seed rate (for example, $326/ha in 2016) than 100 kg/ha (for example, $298/ha in 2016) mainly due to the cost for additional seed (Table 2). Although seed rate did not increase grain yield or gross margin, there was a 56% reduction in final radish density in 2016 at 100 kg/ha compared to 50 kg/ha (Treatment 1 vs 7, Table 1 and 2). Reducing radish density by 56% just by increasing seeding rate is a great achievement by knockdowns and a non-chemical weed control option only.

Overall grain yield of wheat was the highest in 2015 followed by 2016 and 2014. High seed rate did not increase wheat grain yield in any year although final radish density was reduced by 56% in 2016 (Treatment 1 vs 7, Table 2). Windrowing at 2014 harvest and windrow burning in April 2015 did not reduce radish density. The like hypothesis being the intensity and duration of the fire in small amount of fuels collected on windrows from a 2m wide plot was not effective on radish seed. Radish seed collection at harvest time in 2014 was also not effective as most wild radish pods shattered on the ground before harvest.

Regardless of seed rate, double knockdown followed by application two PO herbicides (one early and one late) in 2014 and 2015 and then one knockdown followed by one application of effective herbicides at PO in 2016 produced the highest gross margin due to higher grain yield in 2016 (Treatment 3, Table 2). One knockdown followed by two applications of PO herbicides also increased grain yield and gross margin in 2015 and 2016 while controlling radish effectively (98-100%) (Treatment 4, Table 2).

Table 2: Effect of chemical and non-chemical weed control options on wheat grain yield, gross margin and radish control in 2014, 2015 and 2016 seasons in the Integrated Weed Management trial for wild radish at Dalwallinu, Western Australia.

Treatments	Wild radish control (%)			Wheat grain yield (t/ha)			Gross margin ($/ha)		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
1	93^{a}	40^{a}	0^{a}	1.05^{bcd}	1.96	0.8^{a}	216	422	139
2	100^{b}	100^{b}	100^{c}	1.04^{bc}	1.98	1.75^{bc}	178	394	354
3	100^{b}	100^{b}	99^{c}	1.09^{cd}	2.17	2.13^{c}	193	445	429
4	98^{b}	100^{b}	100^{c}	1.08^{cd}	2.23	1.82^{bc}	217	468	348
5	100^{b}	100^{b}	100^{c}	1.13^{d}	1.94	1.67^{b}	195	383	335
6	97^{b}	100^{b}	100^{c}	1.08^{cd}	2.2	1.68^{b}	190	451	352
7	90^{a}	42^{a}	48^{b}	0.92^{a}	2	1.09^{a}	117	373	150
8	100^{b}	92^{b}	100^{c}	0.97^{ab}	2.09	1.67^{b}	97	364	310
9	99^{b}	100^{b}	100^{c}	1.03^{bc}	2.12	1.78^{bc}	115	372	332
10	100^{b}	99^{b}	100^{c}	0.97^{ab}	1.99	1.67^{b}	124	344	317
11	100^{b}	100^{b}	100^{c}	1.03^{bc}	2.23	1.94^{bc}	105	401	381
12	100^{b}	100^{b}	100^{c}	0.99^{ab}	2.05	1.53^{b}	93	351	297
P-value	*<.001*	*<0.01*	*<.001*	*<.01*	*NS*	*<.001*	-	-	-
LSD (5%)	*3.6*	*18.3*	*2.05*	*0.084*	*NS (0.316)*	*0.426*	-	-	-

[1] See Table 1 for treatment details in 2014, 2015 and 2016; Windrow burning (WRB) cost ($2.05/ha) was included in 2015 variable cost only; cost of HWSR (Harvest weed seed removal) included in 2014 only= $10/ha; Price of herbicides ($/ha): Alliance® $25, Roundup®= $14, Para-trooper®= $12, Velocity®=$20, Triathlon®= $15.5: cost of wheat seed = $1/kg in 2014 and 2015 and $0.3/kg in 2016 assuming that growers used their own seed; Cost of cultivation ($20/ha) is included in 2015 only as pre-sowing cultivation ($20/ha) was performed in 2015; in the untreated control (untreated buffer in 2014 and 2015 but treatment 1 in 2016), wild radish density was 70, 10.5 and 341 plants/m^2 in 2014, 2015 and 2016. Price of wheat grain in December 2016 = $248/t (www.graincorp.com.au).

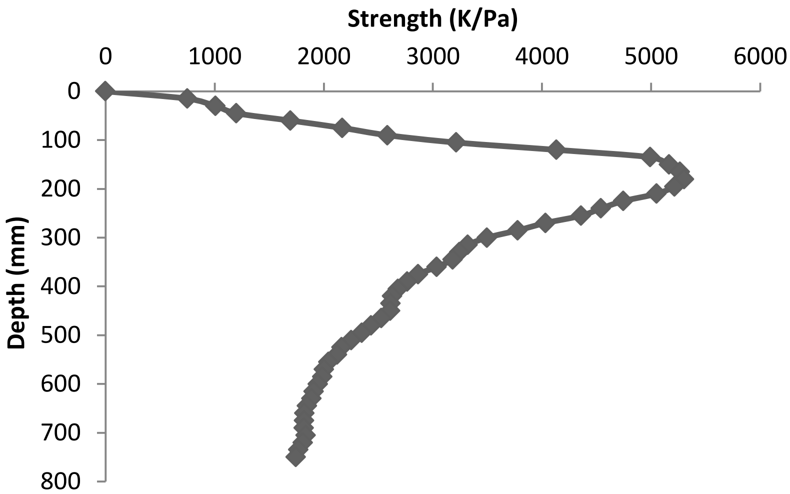


Figure 3: Representative soil compaction level (soil penetration resistance) recorded on 8th September 2016 at the integrated weed management site for wild radish management site under a canola-wheat-wheat-wheat rotation at Dalwallinu, Western Australia.

This IWM trial has clearly demonstrated that, despite developing resistance to various groups of herbicides, wild radish can be effectively managed by effective application of knockdowns, application of effective herbicide mixtures and inclusion of non-chemical weed control options such as high seed rate. Effective execution of windrow burning and weed seed removal at harvest time will further improve radish control. This approach of IWM will decline soil seed bank, delay the evolution of herbicide resistance in wild radish and produce greater gross margin.

Comments

Knockdowns alone provided 40-45% control of wild radish in absence of PO herbicides in the wheat crop compared to untreated control (untreated buffer). Based on the results of 2014, 2015 and 2016 seasons, double knockdowns and application of post-emergent (PO) herbicides from diverse modes of action (for example, Triathlon® and Velocity®) provided 92-100% control of wild radish in 2014, 90-100% in 2015, and 99-100% in 2016. Further success in 100% radish control in subsequent years should deplete the radish seed bank to a further low level.

Despite achieving higher plant density and higher head numbers of wheat, higher seed rate did not result in greater weed control in the 2014 and 2015 seasons although a significant reduction in wild radish density was recorded in the high seed rate plots in the 2016 season. Grain yield did not increase with increases in seed rate in any season. However, economic analysis of 2014, 2015 and 2016 showed that the gross margin in the high seed rate was always lower than normal seed rate due to additional costs for higher seed rate.

These results suggest that herbicides are more cost effective than higher seed rate if radish is effectively controlled by herbicides. Although more expensive, two PO sprays (mixture of 2-3 modes of action) appear to be necessary to achieve 100% control of seasonal wild radish for first couple of years but in the third year (2016), one PO herbicide was enough to effectively control radish.

The efficacy of windrow burning in reducing the radish seed bank is unclear probably due to the low intensity and short duration of fire in the small quantity of stubble fuels windrowed by a small plot harvester from 2m wide plots in this trial. Analysis of trash collected as an attempt to collect wild radish seed at 2014 harvest time in treatments 5 and 11 (harvest weed seed removal, HWSR) recorded only few radish seed (0-4 seed per plot of $36m^2$) indicating that wild radish seed had already shattered on the ground prior to harvest in 2014 season.

The initial wild radish density counted in April 2014 at this site was 70 plants/m^2 while average final density of wild radish in 2015 was reduced to 1-3 plants/m^2 (95% reduction), probably due to effective control of radish.

In the 2016 season, the combination of knockdowns and PO herbicides reduced in-crop wild radish from 341 (in the no PO herbicide plots) to less than 1 plant/m^2 (Table 1). However, soil compaction at 100-300mm depth appears to be a serious constraint to improvement of grain yield at this site and it is speculated that deep ripping may reduce soil compaction and will improve crop grain yield.

Wild radish has developed resistance to most of the available selective and non-selective herbicides including glyphosate in WA. Application of herbicide mixtures from diverse modes of action at knockdown and post-emergence and their rotation is very important to reduce the risk of herbicide resistance development. The wild radish seed bank should decline by an IWM approach which includes as many weed control options as possible. Growers should adopt IWM approaches for the control of wild radish and other major weeds to minimise the impact of herbicide resistance and sustain grain productivity.

Acknowledgements
This is a collaborative project with University of Adelaide. We would like to thank GRDC for funding the project (UA00149). Thanks are due to Department of Agriculture and Food Western Australia (DAFWA) Technical Support Unit at Wongan Hills. Thank you also for Technical Officers Dave Nicholson, Barb Sage and Nerys Wilkins for technical assistance. Special thanks are due to Michael Sawyer's Family for providing the land and allowing access to their farm for the trial, and Liebe Group for their kind collaboration and having a field day presentation.

Paper reviewed by: Glen Riethmuller, Development Officer, DAFWA

Contact
Dr Abul Hashem, DAFWA
Abul.hashem@agric.wa.gov.au
(08) 9690 2136

Physical and chemical control of wild radish in lupins at Dalwallinu

Mohammad Amjad[1], Abul Hashem[1] and Glen Riethmuller[2], DAFWA Northam[1] and Merredin[2]

Key Message

Integrated weed management (IWM) strategies employing both chemical and non-chemical weed control options in the lupin phase were effective in controlling wild radish without yield penalty in a lupin-wheat cropping system.

Aim

To investigate the effect of on-row and inter-row physical and chemical weed control options on wild radish (weed population and crop damage) and performance of a lupin crop sown in wide rows.

Background

Wild radish has developed resistance to most of the herbicide groups (including glyphosate) that are used in Western Australia (WA). Integrated weed management (IWM) strategies employing both chemical and non-chemical weed control options need to be incorporated into the lupin production systems to minimise the impact of herbicide resistance within WA Wheatbelt. The IWM tactics are aimed at effectively stopping weed seed set (as much as 100%) by applying double-knock techniques (non-selective chemical) and physical weed control, cultural methods, rotation of crop species, rotation of herbicide modes of action, and in-crop physical weed control options.

Recent work on physical and chemical weed control options in wide row lupins (Riethmuller *et al*., 2014; Hashem *et al.,* 2010) concluded that inter-row cultivation or shielded spraying (if on-label) can be used in wide row crops in order to reduce weed growth between crop rows while causing minimal damage to the crop plants. They also suggested that shielded spraying may be worth further investigation as it did reduce weed seed numbers without a significant yield penalty.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	20m x 1.54m x 4 replications												
Soil type	Sandy soil												
Paddock rotation	2015 wheat												
Sowing date	11-12/05/2016												
Sowing rate	100 kg/ha Barlock lupins												
Fertiliser	11/05/2016: 100 kg/ha Big Phos Manganese deep banded												
Herbicides, Insecticides & Fungicides	Pre-sowing: Double knockdown 18/04/2016: 2 L/ha Glyphosate, 25 mL/ha Hammer 06/05/2016: 3 L/ha Spray.Seed All other herbicides applied as per treatments schedule												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

The trial was laid out in a randomised complete block design in two banks with 12 combinations of treatments and four replications. Barlock lupins were sown at 100 kg/ha. The control treatment was 1 kg/ha simazine 900 applied before sowing (BS) at a row spacing of 22cm followed by 150 g/ha metribuzin and 100 mL/ha Brodal® at 3 leaf stage of wild radish or 5 leaf stage of lupins. Most of treatments were applied on wide rows at 66cm as listed in Table 1. Some of physical and chemical treatment combinations were also slightly modified and adjusted in some replications later in the season.

Results

Lupin emergence in 2016 season was good due to a good rainfall at the start of the season. There was no treatment effect on lupin establishment, averaged 77 plants/m^2 (Table 1). Similarly, the pre-seeding herbicides worked very well and kept the wild radish density at around 20 plants/m^2 across the treatments when assessed on 16th July 2016. The post seeding pre-emergent (PSPE) herbicide X1 (treatment 1) was applied on the whole plots and had significantly reduced the emergence of wild radish density to 2 plants/m^2.

The post-emergent (PO) application of herbicides (on-row and inter-row), inter-row cultivations (IR) and slashing (mowing) were performed according to the treatment schedule (as listed in Table 1). Ryegrass was appropriately controlled on the site (across the whole trial) by spraying Select® herbicide during the growing season.

Table 1: Lupins and wild radish plant count (plants/m^2) as recorded on 16 June 2016 at Dalwallinu.

Trt No.	Treatment description	Lupin (plants/m^2)	Wild radish (plants/m^2)
1	66cm row spacing: Herbicide X1 after seeding (PSPE)	77	2
2	22cm row spacing: Herbicide Product (1311) before seeding (BS) followed by 150 g/ha metribuzin + 100 mL/ha Brodal® @ 3 leaf stage of wild radish or 5 leaf stage of lupins	82	21
3	22cm row: Control - 1 kg/ha Simazine 900 before sowing (BS) followed by 150 g/ha metribuzin + 100 mL/ha Brodal @ 3 leaf stage of wild radish or 5 leaf stage of lupins	62	35
4	66cm row spacing: 1 L/ha Outlook® after sowing (PSPE) followed by 150 g/ha metribuzin + 100 mL/ha Brodal @ 3 leaf stage of wild radish or 5 leaf stage of lupins	84	22
5	66cm row spacing: 1 L/ha Terbyne® after sowing (PSPE) followed by 150 g/ha metribuzin + 100 mL/ha Brodal @ 3 leaf stage of wild radish or 5 leaf stage of lupins	76	31
6	66cm row spacing: On-row herbicide X1 at sowing and an early inter-row cultivation @ 3 leaf stage of wild radish or 5 leaf stage of lupins	81	26
7	66cm row spacing: On-row herbicide X1 at sowing and inter-row herbicide X5 @ budding stage of lupins	83	17
8	66cm row spacing: On-row herbicide X1 at sowing and an early and late inter-row cultivation @ 5 leaf stage and flowering of lupin	78	25
9	66cm row spacing: On-row herbicide X1 at sowing and inter-row spray-shield herbicide X2 @ budding stage of lupins	80	17
10	66cm row spacing: On-row herbicideX1 at sowing and inter-row herbicide X3 @ budding stage of lupins	72	15
11	66cm row spacing: On-row herbicide X1 at sowing and inter-row spray-shield herbicide X4 @ budding stage of lupins	74	19
12	66cm row spacing: Silage making: On-row herbicide X1 at sowing and inter-row slashing/mowing of wild radish at flowering of wild radish or at budding stage of lupins followed by inter-row spray-shield herbicide X2 @ budding stage of lupins	75	15
LSD (0.05)		*16*	*15*
CV (%)		*14.4*	*52.8*

Lupin growth and on-row wild radish control were visually rated (Table 2) on 15 August 2016; however, the inter-row wild radish controls were found to be significantly different among treatments. The control treatment of 1 kg/ha Simazine 900 before sowing (BS) followed by 150 g/ha metribuzin + 100 mL/ha Brodal at the 3 leaf stage of wild radish or 5 leaf stage of lupins worked very well in controlling the wild radish on the site.

The on-row herbicide application, inter-row cultivation and shielded sprayed combinations reduced wild radish numbers and no effect on lupin yield was observed in 2016 (Table 2); however, some crop damage was previously observed in 2015 and resulted in comparatively reduced lupin yield (Amjad *et al.*, 2016). The lupin yield in 2016 was relatively low at the site and as such no treatment effect was observed at Dalwallinu, which may be due to a tough grain filling period and the dry finish of the season 2016. These chemical and non-chemical strategies tested in 2016 look promising in reducing the wild radish seedbank and managing the herbicide resistance. These need to be tested across seasons to control wild radish to avoid yield losses and improve the efficiency of cropping systems while minimising the impact of herbicide resistance within WA Wheatbelt.

Table 2: Lupin growth and wild radish control (as assessed on 15 August 2016) and lupin yield at Dalwallinu (the treatment combinations are listed in Table 1).

Trt No.	Lupin growth & Wild radish control rated on 15 August 2016 (%)			Lupin yield (t/ha)
	Lupin growth	Inter-row radish control	On-row radish control	
1	88	98^{cde}	99	1.40^{c}
2	85	70^{abc}	72	1.31^{bc}
3- Control	85	100^{e}	100	1.19^{abc}
4	83	66^{ab}	69	1.02^{a}
5	89	58^{a}	86	1.08^{ab}
6	81	75^{abcd}	84	1.16^{abc}
7	90	83^{bcde}	83	1.00^{a}
8	91	78^{abcde}	70	1.14^{ab}
9	81	74^{abcd}	66	1.01^{a}
10	81	94^{cde}	94	1.11^{ab}
11	84	78^{abcde}	81	1.08^{ab}
12	87	95^{de}	96	1.14^{ab}
LSD (0.05)	*22 (NS)*	*24*	*34 (NS)*	*0.24*
CV (%)	*17.7*	*21.2*	*29.4*	*14.8*

Acknowledgements
Research was supported by DAFWA and GRDC under the emerging summer weeds project (UA00149). Thanks to Barb Sage, Dave Nicholson, Nerys Wilkins, Shari Dougall and Bruce Thorpe for their technical support in conducting the trial and collecting data. Special thanks to the Liebe Group and Butcher family for hosting the trial.

References
Amjad, M. Hashem A. and Riethmuller G. (2015). Physical and chemical control of wild radish in lupins at Ballidu. Liebe Group R & D Book 2016, 104-108.

Hashem, A. Collins M. and Bowran D. (2010) Efficacy of Inter-row Weed Control Techniques in Wide Row Narrow-leaf Lupin (Lupinus angustifolius) *Weed Technology* 25:135-140.

Riethmuller, G. Borger C. and Hashem A. (2014). Physical and herbicide weed control in wide row lupins in Western Australia. Proceedings 19th Australian Weeds Conference, Hobart, Tasmania, Sep 1-4, 79-82.

Paper Reviewed by: Dr Harmohinder Dhammu, DAFWA Northam

Contact
Mohammad Amjad, DAFWA
mohammad.amjad@agric.wa.gov.au
(08) 9690 2249

Pre-emergent use of Sentry for control of brome grass in Spartacus CL barley

Steven Tilbrook, Research and Development Officer, Crop Care

Key Messages

- Sentry is the only Imidazolinone herbicide (imi) registered for pre-plant (IBS) use in imi tolerant barley.
- Sentry offers the advantage of increased yield potential due to reduced weed competition at establishment and during the early weeks of crop growth.
- Sentry demonstrated excellent early control of brome grass at this trial site.
- Sentry IBS treatments generally improved yield compared to the untreated control (UTC) and a one-off post-emergent treatment of Intercept.

Aim

Demonstrate early weed control advantages of Sentry applied IBS and compare with Intercept applied post-emergent.

Background

Sentry is safe to use on Clearfield (CL) canola, single gene CL wheat and imidazolinone tolerant barley. The pre-emergent application controls early emerging weeds and this can lead to yield improvements.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	10m x 5m x 4 replications												
Soil type	Sand												
Paddock rotation	2015 wheat												
Sowing date	03/05/2016												
Sowing rate	50 kg/ha Spartacus CL barley												
Fertiliser	03/05/2016: 40 kg/ha Agstar Extra, 60 kg/ha Urea 15/07/2016: 60 L/ha Flexi N												
Herbicides, insecticides & fungicides	03/05/2016: 150 g/ha Metribuzin, 1.8 L/ha Trifluralin, 0.8 L/ha Paraquat, 1.8 L/ha Triallate, 200 mL/ha Chlorpyrifos, 0.1% BS1000 (surrounding crop) 13/06/2016: 1 L/ha Jaguar, 0.45 L/ha LVE MCPA, 0.25 L/ha Propiconazole, 0.5 L/ha ZincMate 15/07/2016: 0.25 L/ha Propiconazole 250, 70 mL/ha Alpha-Cypermethrin												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Treatments

Number	Treatment
1	Untreated
2	Intercept @ 750 mL/ha Post Emergent
3	Sentry @ 50 g/ha IBS
4	Sentry @ 40 g/ha IBS fb. Intercept @ 300 mL/ha Post-emergent
5	Sentry @ 50 g/ha + TriflurX @ 2 L/ha IBS
6	Sentry @ 50 g/ha + TriflurX @ 2 L/ha + Avadex Xtra @ 2.4 L/ha
7	Sentry @ 50 g/ha + TriflurX @ 2.4 L/ha + Tomahawk @ 120 g/ha
8	Sentry @ 50 g/ha PSPE

Results

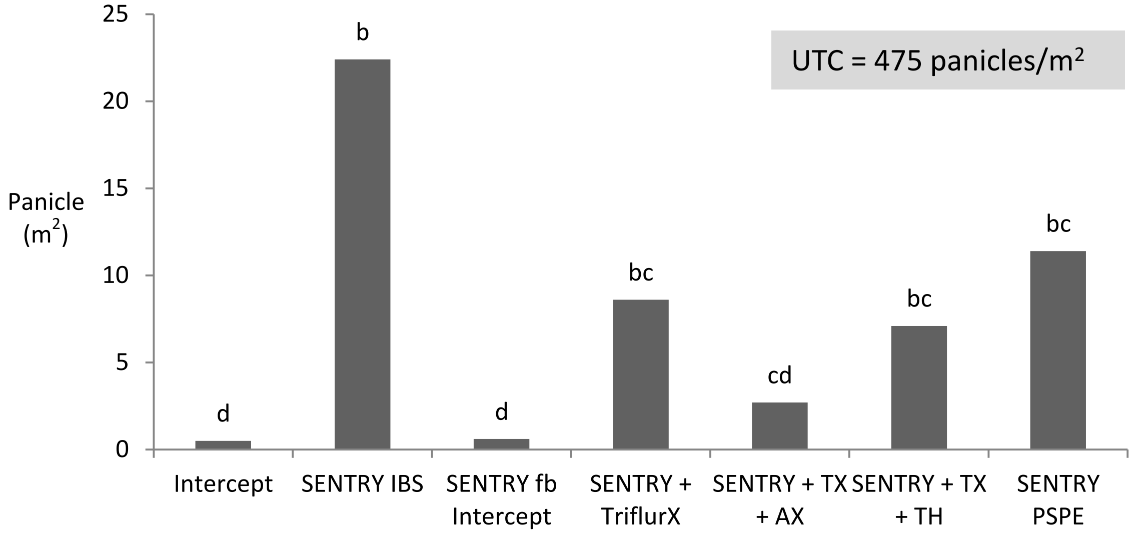


Figure 1: Brome grass panicle density (/m^2) at 168 Days after application (DAA).

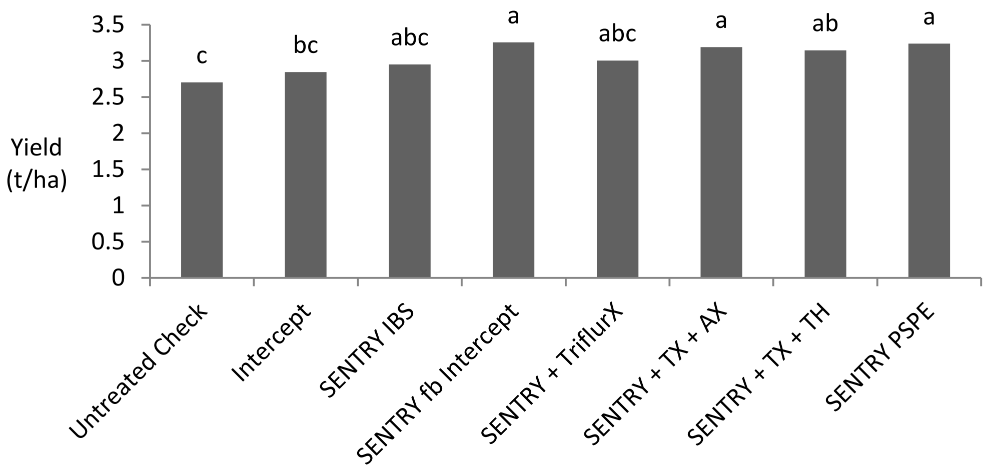


Figure 2: Yield data (t/ha).

Comments

Weed pressure at the trial site was reasonably high (100-150 plants/m^2 in the untreated areas) despite receiving two knockdowns prior to sowing. Early observations noted a substantial decrease in brome grass density in all Sentry treated plots. These plots benefitted from a reduced level of early weed competition when compared to the Untreated Control (UTC) or the Intercept post emergent treatment. These observations were supported by final brome grass panicle counts which demonstrated a 95% decrease in panicles from Sentry applied IBS compared to the UTC. The addition of TriflurX at 2 L/ha and Avadex Xtra at 2.4 L/ha to Sentry IBS significantly reduced final panicle counts by 99.5% of the UTC. The reduction in early weed competition resulted in higher yields from treatments with Sentry IBS.

A post emergent application of Intercept reduced brome grass panicle density when compared to Sentry stand alone IBS. However, an IBS application of Sentry + TriflurX + Avadex Xtra was as good as a post emergent application of Intercept in terms of brome grass panicles and yield was significantly greater. This one pass strategy would allow the grower a greater number of options for post emergent radish control and further flexibility in paddock management.

The Sentry followed by Intercept treatment demonstrated the benefits of a sequential spray strategy on staggered germinating brome grass. The Sentry reduced early weed pressure and this improved yield while the post emergent Intercept controlled later germinating brome grass and reduced the seed bank for the following year. In terms of resistance management, this strategy provides less selection pressure for herbicide resistance than spraying the same group of chemistry on successive generations of weeds for two years in a row.

When tackling brome grass it is important that an integrated approach is taken and some form of harvest weed seed set control is always recommended. Spartacus CL was sown at a low seeding rate since it was a seed increase. This low seeding rate further exacerbated the low early vigour of this variety, which has a similar growth habit to Hindmarsh and La Trobe. Thus the early weed control demonstrated by Sentry applied IBS was particularly useful in this situation and the Sentry IBS use pattern appears to have a good fit with Spartacus CL.

Acknowledgements
Crop Care would like to thank Gary and James Butcher for their cooperation and the use of the land and the Liebe Group for their help and cooperation.

Paper reviewed by: Andrew Wherrett, Living Farm

Contact
Steven Tilbrook, Crop Care
steven.tilbrook@au.nufarm.com
0447 370 049

Options for knockdown control

Joe Delaney, Agronomist, Elders Scholz Rural

Key Messages

- There was no significant difference between standalone glyphosate treatments in weed control. However, rates of glyphosate applied were robust and conditions were favorable. To achieve a true comparison between formulations lower rates i.e. 500 mL/ha – 1 L/ha of 450 should be used.
- Sharpen performed well at 34 g/ha rate.
- Amitrole based products were slow acting but achieved good control.
- Knockdown sprays should have multiple modes of action and the double knock technique used when trying to control large weeds.

Aim

To evaluate the effectiveness of different knockdown herbicides in a very challenging weed burden. The trial focuses on Group G herbicides and how they react with both glyphosate and paraquat in controlling weeds.

The trial also compares two products that include amitrole with paraquat. Similarly the trial evaluates different strength glyphosate products on the market in controlling weeds present at seeding.

Background

With knockdowns becoming ever important in controlling weeds before seeding, in this trial we are trying to evaluate Group G herbicides also known as 'spikes' in knockdown brews as they are increasing in usage with growers. The trial site had no summer spraying on it before the trial was undertaken, therefore weed size and weed burden was big.

The weeds rated in the trial include:

- Wild Radish - Raphanus raphanistrum 2 leaf - flowering
- Capeweed - Arctotheca calendula 2cm – 30cm
- Annual Ryegrass - *Lolium rigidum* 2 leaf – head emergence

Trial Details

Property	Batterhams, East Wubin
Plot size & replication	3m x 40m no replications
Paddock rotation	2013 fallow, 2014 wheat, 2015 wheat, 2016 fallow
Sprayed	04/05/2016 in good conditions
Herbicides	See Table 1

Table 1: Treatment list.

Treatment number	Treatment product
1*	1.8 L/ha Glyphosate 450 + 0.2% Deluge 1000 + 1% AMS
2*	1.72 L/ha DST + 0.2% Deluge 1000 + 1% AMS
3*	1.5 L/ha 540K Glyphosate (Titan) + 1% AMS
4*	1.5 L/ha Argo
5*	1.42 L/ha Roundup Ultramax
6	1.42 L/ha Roundup Ultramax + 15 mL/ha Nail 600
8	1.42 L/ha Roundup Ultramax + 25 g/ha Logran B-Power + 0.5% Hasten
9	1.42 L/ha Roundup Ultramax + 50 g/ha Logran B-Power + 0.5% Hasten
10	1.42 L/ha Roundup Ultramax + 75 mL/ha Cavalier
11	1.42 L/ha Roundup Ultramax + 120 mL/ha Cavalier
12	1.42 L/ha Roundup Ultramax + 17 g/ha Sharpen + 1% Hasten
13	1.42 L/ha Roundup Ultramax + 34 g/ha Sharpen + 1% Hasten
14	1.42 L/ha Roundup Ultramax + 300 mL/ha Estercide 680
15	1.42 L/ha Roundup Ultramax + 500 mL/ha Estercide 680
16	2 L/ha Gramoxone
17	2 L/ha Paratrooper
18	2 L/ha Spray.Seed
19	1.7 L/ha Alliance
20	2 L/ha Gramoxone + 45 mL/ha Nail 600
21	2 L/ha Gramoxone + 50 g/ha Logran B-Power + 0.5% Hasten
22	2 L/ha Gramoxone + 120 mL/ha Cavalier
23	2 L/ha Gramoxone + 34 g/ha Sharpen + 1% Hasten
24	2 L/ha Gramoxone + 250 g/ha Diuron

*The first five treatments were designed that each plot has the same amount of glyphosate gram active/ha, so we could evaluate the efficacies of the five different glyphosate strengths.
**Disclaimer Cavalier at 120 mL/ha is not a registered rate. Nail 600 at 45 mL/ha is not a registered rate.

Results

Table 2: Percentage control of weeds 42 days after application of treatments.

Treatment number	42 Days after application DAA Radish	Ryegrass	Capeweed
	% Control - 0% no Control, 100% Full Control		
1	60	85	75
2	63	86	76
3	64	87	76
4	64	87	76
5	64	87	76
6	80	86	82
8	80	88	82
9	82	89	82
10	79	89	80
11	76	90	81
12	80	92	95
13	85	93	99
14	86	85	82
15	88	84	82
16	50	90	20
17	66	87	28
18	62	84	35
19	68	80	50
20	81	91	50
21	79	90	50
22	80	89	50
23	85	93	95
24	83	91	45

Note: Wild radish numbers on the Paraquat side of the trial were less than on the glyphosate side.

Conclusion

In this trial the weeds present were very large in size and would not be typical of the majority of grower's paddocks, since the trial site did not receive a summer knockdown.

There was no real difference in weed control between the different glyphosate products applied at equivalent gram active/ha. However, the higher loading products did not let the radish produce viable seed unlike the 450 strength due to radish size. That being said glyphosate should not be used to decrease viable seed on big weed plants as it leads to resistance in the future and should only be used to control weeds. Therefore in choosing a glyphosate product it comes down to price/ha and ease of use.

With the paraquat products, there were some significant differences. While paraquat alone was good on ryegrass, performance was poor for the broadleaf weeds (wild radish and capeweed). With the addition of diquat to Paraquat i.e. Spray.Seed, it did increase the control on capeweed, however with less gram active of paraquat in Spray.Seed efficacy on ryegrass did decrease. The two products with amitrole included Alliance (250 g/L amitrole, 125 g/L Paraquat) and Paratrooper (10 g/L amitrole, 250 g/L Paraquat,) gave 16-18% better control on wild radish than paraquat and 4-6% on Spray.Seed. However, Alliance struggled on ryegrass with 5% less control than paraquat. This could be due to the fact there is only 125 g/L of paraquat in Alliance also added to the fact that there was a 15% reduction in the rate of Alliance versus the paraquat. The Alliance was slow acting on the capeweed but any capeweed that wasn't bigger than 25cm was eventually controlled. Capeweed above that size did start to grow back. Paratrooper had reduced efficacy on capeweed than Alliance, most likely due to the reduced loading of amitrole.

Glyphosate with the group G treatments did increase the percentage control of the broadleaf weeds with the addition of Logran B-Power, Cavalier and Sharpen also increasing the control of ryegrass against the stand alone glyphosate treatment. With the Cavailier (240 g/L oxyfluorfen) the higher rate of 120 mL/ha decreased the efficacy of the glyphosate as it browned off the wild radish quicker than the all the glyphosate could get into the plant. 75 mL/ha is probably the highest rate of Cavailier that should be used without compromising the glyphosate. Logran B-power increased the control of ryegrass when used with the glyphosate, thus indicating that the triasulfuron still had some effect on ryegrass. Glyphosate plus Sharpen at the lower rate of 17 g/ha didn't control the larger radish that were present, indicating that it needs the higher rate when spraying larger radish. Glyphosate and Ester performed well on the radish and maybe should be used as a three mode of action brew when controlling large wild radish.

With the paraquat and the Group G chemicals, Sharpen was the best performing. It had the best control on capeweed and radish, however like the glyphosate brew, the 17 g/ha rate did struggle on the bigger radish present. It also increased the efficacy of paraquat on ryegrass when mixed together.

If this was a paddock with the same weed burden again, a double knock should be used to control weeds, and in the future maybe a knockdown brew with three chemical groups should be used to get the best control i.e. Glyphosate + Ester + Group G Spike followed by a Paraquat product. However more work needs to be done on the three way brew to find out the interactions between the different herbicides mixed in a spray treatment.

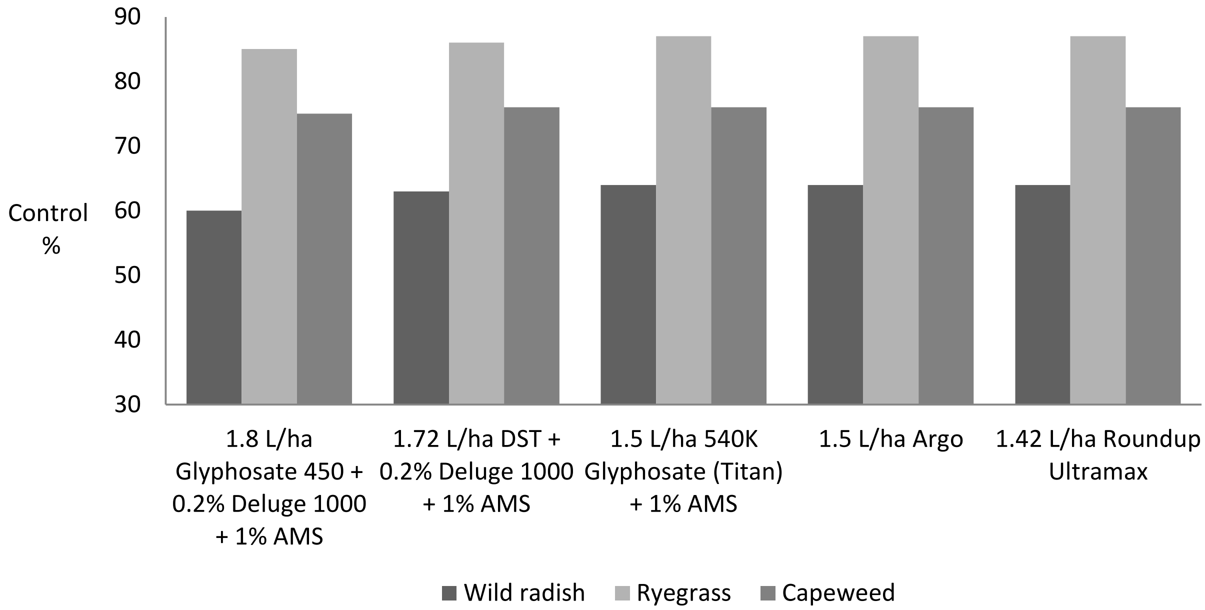


Figure 1: Percentage (%) control using glyphosate products.

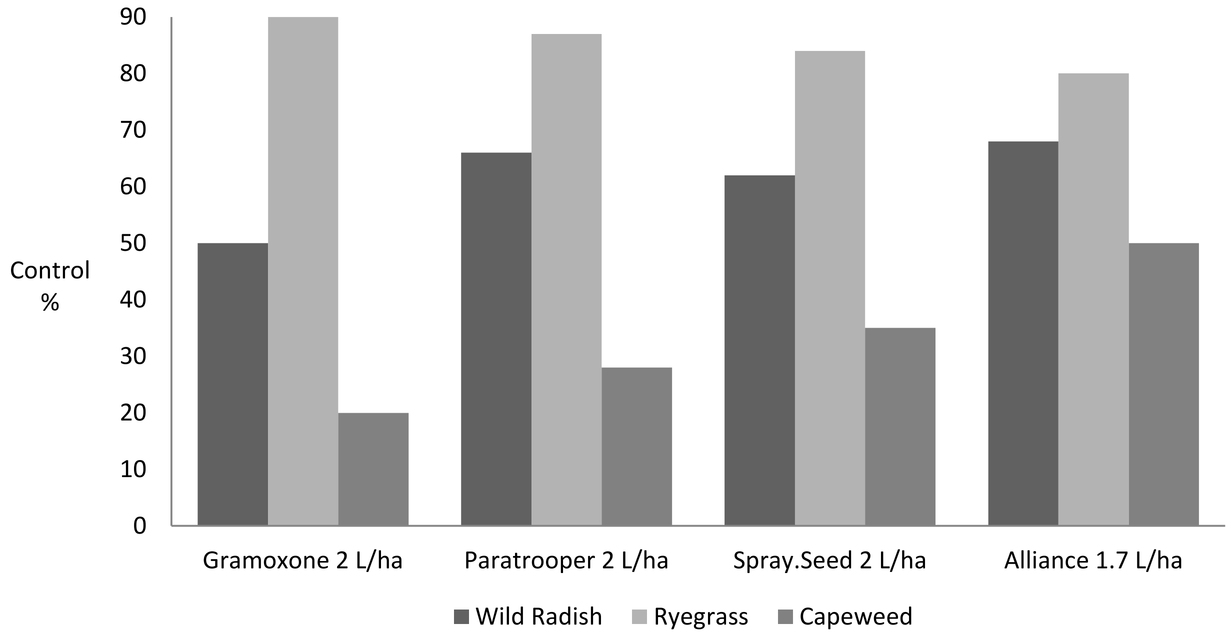


Figure 2: Percentage (%) control using paraquat products.

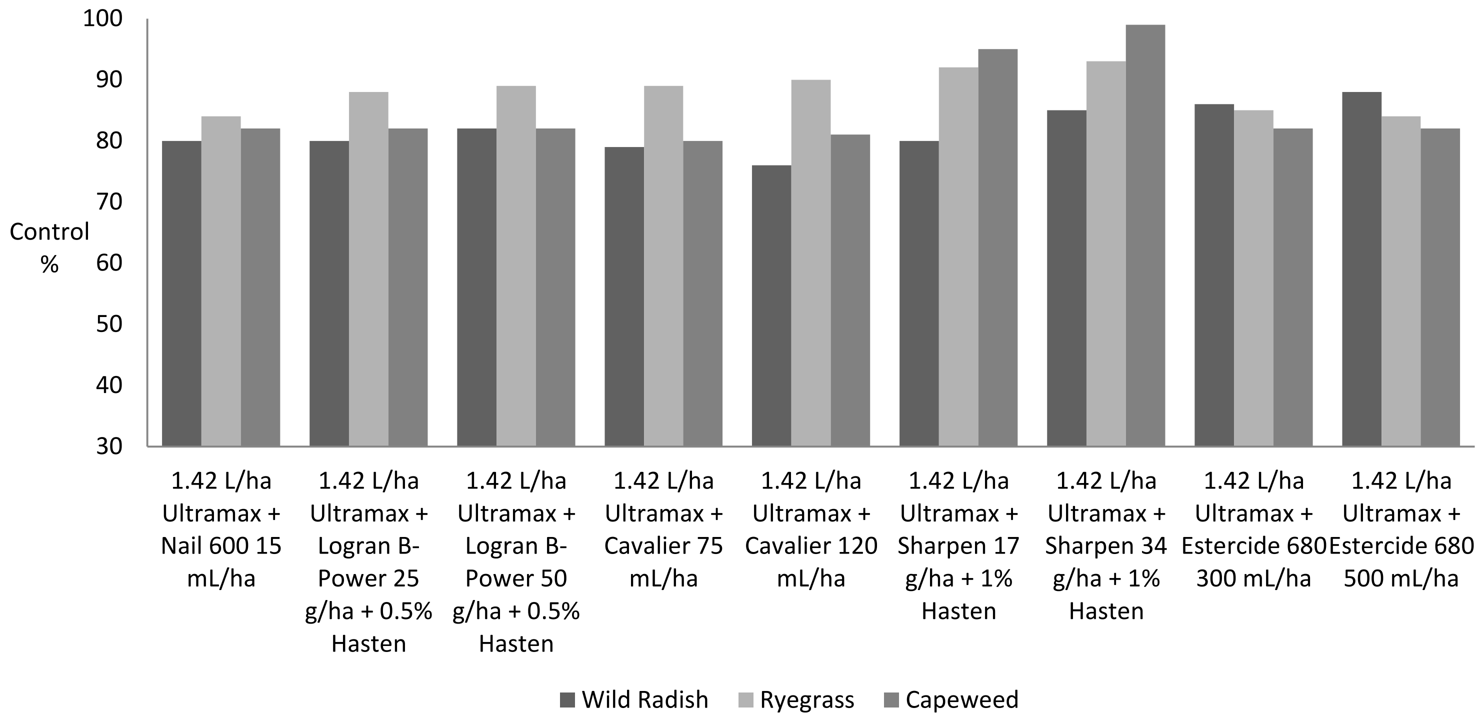


Figure 3: Percentage (%) control using Group G products with glyphosate.

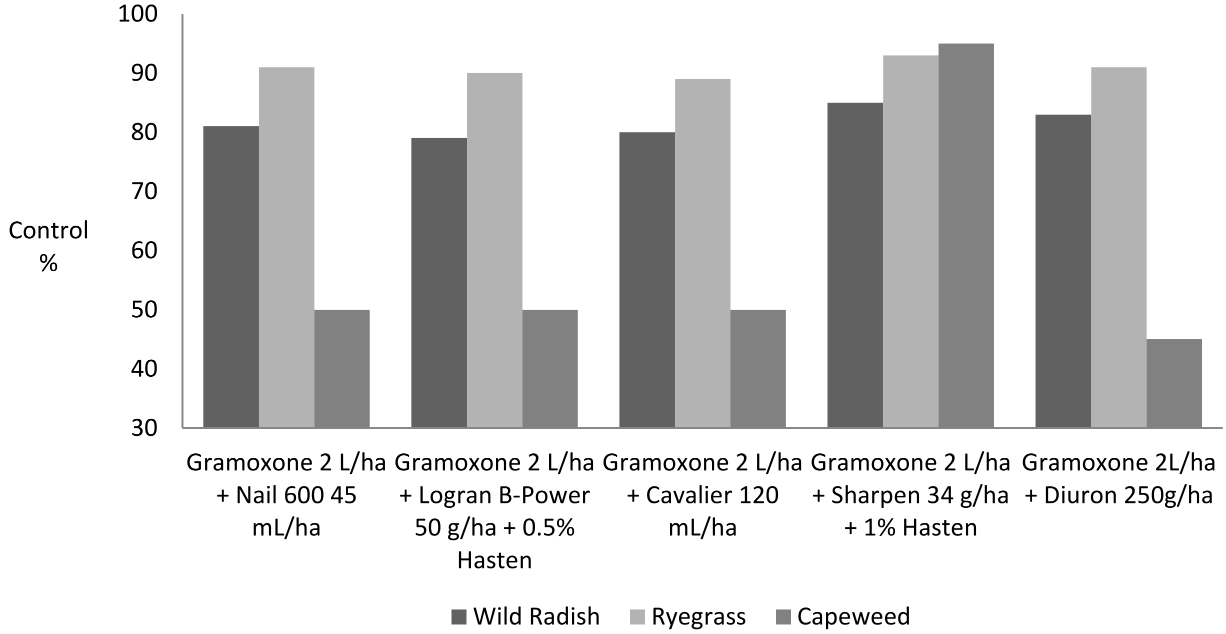


Figure 4: Percentage (%) control using group G Products with Paraquat.

Peer reviewed by: Steve Tilbrook Research & Development Officer, Nufarm & Cropcare

Contact

Joe Delaney, Elders Scholz Rural
Joe.Delaney@elders.com.au
0418 212 961

Disease & Pests Research Results

Control of loose smut & spot form net blotch (SFNB) in LaTrobe barley through soil and foliar fungicides

Rick Horbury, Customer Advisory Representative - North, Bayer

Key Messages

- EverGol® Energy and EverGol Prime recorded excellent control of loose smut in this trial when applied with even seed coverage in a slurry volume of 6 L/t. The use of a 3 L/t slurry volume compromised coverage and reduced control of loose smut was recorded.
- The use of succinate dehydrogenase inhibitors (SDHI) chemistry like bixafen the new active ingredient found in Aviator® Xpro® as a foliar application or Systiva® seed treatment containing fluxapyroxad both recorded excellent control of spot form net blotch (SFNB) in this trial.
- While relatively new in Australia SDHI chemistry is considered high risk for developing fungicide resistance and the application of this fungicide class with an alternative mode of action like a triazole i.e. prothioconazole is recommended as part of a fungicide resistance management strategy rather than stand-alone application of the SDHI group.

Aims

1. Evaluate foliar spot form net blotch (SFNB) control from seed treatment or in-furrow applied fungicides.
2. Compare combinations of soil and foliar applied fungicides for SFNB control.
3. Evaluate loose smut control from a range of seed treatments.

Background

- Genetic disease tolerance to SFNB is generally rated low with many of the recently commercially released varieties i.e. LaTrobe and Spartacus CL.
- SFNB is a stubble-borne disease and with an increase in plantings of Clearfield® barley across Western Australia, it is becoming more common to see barley planted on barley stubble thereby increasing SFNB risk.
- Loose smut is the hardest of the smut diseases to control because it is an internally seed borne infection and most current seed treatments are not as effective on internally seed borne diseases.
- Delayed plant emergence on a crusting soil type can cause establishment issues. Penflufen the SDHI class active ingredient in EverGol Prime does not negatively impact emergence like some triazole fungicides.
- DAFWA trial work has shown that foliar fungicides provide the best return on investment when applied proactively around Z30 to Z39 to protect the yield producing top 3 leaves.
- Aviator Xpro is anticipated to be registered for use in cereals for the 2018 season and contains the high performing triazole prothioconazole + bixafen the first registered SDHI for foliar application.
- Aviator Xpro should always be used according to the most recent approved label.
- EverGol Energy is an experimental seed treatment being evaluated by Bayer CropScience.

Trial Details

Property	O.J. Butcher and Son, Nugadong
Plot size & replication	2m x 15m x 3 replications
Soil type	Duplex sand
Soil pH ($CaCl_2$)	0-10 cm:6.3 10-20 cm: 4.9 20-30 cm: 5.1
Paddock rotation	2013 canola, 2014 wheat, 2015 Hindmarsh barley
Sowing date	15/05/16
Sowing rate	70 kg/ha LaTrobe barley
Fertiliser	15/05/2016: 30 L/ha UAN banded, 70 kg/ha Gusto® Gold
Herbicides, insecticides	08/05/2016: 2 L/ha Glyphosate 15/05/2016: 2 L/ha Spray.Seed, 2 L/ha Trifluralin, 2 L/ha Avadex Xtra, 100 mL/ha Chlorpyrifos Late July: 800 mL/ha Velocity®
Foliar fungicide (C)	13/07/2016: Z25/26 100 L/ha water volume, 5 km/h, 2 bar DG110015's
Foliar fungicide (D)	10/08/2016 – Z37 100 L/ha water volume, 5 km/h, 2 bar DG110015's

Annual rainfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

Table 1: Emergence 17 days after application A/B and establishment (NDVI).

	Assessment Date	01/06/2016			22/06/2016	
	Days after application	17 DAA			38 DAA	
No.	**Seed treatment/ infurrow**	**Plants per m^2**	**% Emerg.**	**SFNB 0-5 rating**	**NDVI Biomass**	**% Untreated**
1	Untreated	165 a	100	2.2	0.303	100
2	Baytan® T 1 L/t	157 a	95	1.1	0.287	94
3	Vibrance® 1.8 L/t	160 a	97	0.9	0.301	99
4	EverGol Prime 0.4 L/t	167 a	101	1.4	0.299	99
5	EverGol Energy 0.65 L/t	179 a	108	2.1	0.300	99
6	EverGol Energy 1.3 L/t	177 a	107	1.7	0.302	99
7	EverGol Energy 2.6 L/t	168 a	102	1.1	0.302	100
8	Baytan T 1 L/t + flutriafol 400 mL/ha	171 a	103	1.7	0.294	97
9	EverGol Energy 1.3 L/t + flutriafol 400 mL/ha	165 a	100	1.8	0.301	99
16	Systiva 1.5 L/t	169 a	102	**0.5**	0.293	97
17	Untreated + Uniform® 400 mL/ha	155 a	94	1.5	0.309	102
LSD		*23.6*	*(NS)*			
St. Dev		*13.8*				
CV (%)		*8.31*				

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

A slight reduction (delay) in emergence was observed in the Baytan and Uniform treatments at 17 days after application (17 DAA) with the crop emerged for approximately 5-6 days at the time of the plant counts.

There were early SFNB lesions observed in the trial with a 0-5 rating of severity recorded. 0 meaning no infection and 5 being a rating of greater than 50% leaf area infected with SFNB.

At 38 DAA based on NDVI biomass recordings made with the Greenseeker only the Baytan treatment recorded a persistent reduction in biomass compared to the untreated.

Table 2: Loose smut infection - whole plot plant counts and % control from seed treatments.

Date	07/09/2016	
Days after application	115 DAA	
Assessment	Loose Smut infection	
Application A: Seed treatment	**Plants Infected per plot**	**% Control**
Untreated	20.7 a	0
Baytan T 1 L/t	3.0 cd	85
Vibrance 1.8 L/t	5.3 c	74
EverGol Prime 0.4 L/t	0.7 d	97
EverGol Prime 0.4 L/t applied at 3 L/t slurry volume	*2.7* -	*87*
EverGol Energy 650 mL/t	5.0 c	76
EverGol Energy 1.3 L/t	0.3 d	98
EverGol Energy 2.6 L/t	0.0 d	100
Systiva 1.5 L/t	9.3 b	55
LSD	*3.4*	
St. Dev	*1.9*	
CV(%)	*32.0*	

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

Note: All treatments were applied in a total slurry volume of 6 L/t apart from a treatment of EverGol Prime 0.4 L/t applied in a total slurry volume of 3 L/t as noted in the table above (shaded treatment). This was applied to the trial buffers so while there were 3 replicated plots it was not included in the statistics above.

EverGol Prime 0.4 L/t applied in a total slurry volume of 6 L/t recorded excellent control (97%) of loose smut. Using a lower slurry volume of 3 L/t EverGol Prime recorded a 10% reduction in control.

EverGol Energy at 130mL/100kg recorded excellent control (98%) and 260mL/100kg recorded complete control in this trial. The 65mL/100kg rate recorded comparable control to Vibrance in this trial which was not commercially acceptable (74%).

Table 3: Seed treatment SFNB control % leaf area infected (%LAI) 59 days after A/B (DAA/B) and 28 days after foliar spray application C (DAC).

	Date	13/07/2016		10/08/2016		
	Days after application	59 DAA/B		87 DAA/B		
	Days after last application	-		28 DAC		
	Assessment	% LAI		% LAI		
A: Seed treatment **B: in-furrow rate/ha**	**Application** **C: Z25/26**	**Leaf 2**	**Leaf 3**	**FL-1**	**FL-2**	**FL-3**
Untreated		8.2 abc	31.0 a	5.5 a	12.9 a	37.6 a
Baytan T 1 L/t	Cogito® 250 mL/ha	4.3 cd	17.5 b	0.6 b	4.0 bcd	8.0 b
Vibrance 1.8 L/t	Cogito 250 mL/ha	9.0 ab	24.0 ab	0.2 b	3.4 bcd	6.0 b
EverGol Prime 0.4 L/t	Cogito 250 mL/ha	11.2 a	27.5 a	1.6 b	2.7 cd	6.4 b
EverGol Energy 0.65 L/t	Cogito 250 mL/ha	9.3 ab	27.5 a	1.4 b	6.4 bc	9.8 b
EverGol Energy 1.3 L/t	Cogito 250 mL/ha	9.5 ab	23.5 ab	2.5 b	6.7 b	10.9 b
EverGol Energy 2.6 L/t	Cogito 250 mL/ha	6.2 bcd	23.5 ab	2.6 b	4.6 bcd	8.4 b
Baytan T 1 L/t + flutriafol 400 mL/ha	Cogito 250 mL/ha	11.7 a	30.0 a	1.6 b	7.1 b	10.9 b
EverGol Energy 1.3 L/t + flutriafol 400 mL/ha	Cogito 250 mL/ha	9.4 ab	27.0 a	2.2 b	4.5 bcd	10.9 b
EverGol Energy 1.3 L/t	Amistar® Xtra 400 mL/ha			0.8 b	2.4 d	8.1 b
EverGol Energy 1.3 L/t	Aviator Xpro 300 mL/ha			2.0 b	1.9 d	3.6 b
EverGol Energy 1.3 L/t	Aviator Xpro 500 mL/ha			0.6 b	1.7 d	4.4 b
EverGol Energy 1.3 L/t	Prosaro® 150 mL/ha + BS1000® 0.2% v/v			1.0 b	4.3 bcd	6.0 b
Systiva 1.5 L/t	Nil	2.4 d	4.0 c	0.6 b	1.2 d	4.5 b
Untreated + Uniform 400 mL/ha	Nil	3.1 d	7.4 c	0.8 b	1.8 d	7.8 b
LSD (P=Various)		*3.9*	*8.45*	*2.37*	*3.56*	*11.21*
St. Dev		*1.75*	*3.79*	*1.35*	*2.04*	*6.4*
CV (%)		*22.8*	*17.2*	*84.6*	*46.66*	*67.03*

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

Seed treatment or in-furrow application

At 59DAA/B only Systiva and Uniform recorded significant reductions ($P \geq 0.05$) in %LAI from SFNB compared to the untreated. The addition of flutriafol to Baytan or EverGol Energy did not result in any significant change in the %LAI of SFNB.

Interaction with seed treatment and foliar fungicide 28 days after application

At 28 DAC based on ratings of the %LAI by SFNB, application of any of the foliar fungicides significantly reduced %LAI compared to the untreated. Systiva and Uniform with no additional foliar fungicide at that mid-tillering timing recorded comparable %LAI to Aviator Xpro at 500 mL/ha.

Table 4: Spot form net blotch control % leaf area infected (%LAI), % Green leaf area and % SFNB Incidence 30 DAD.

		Date	09/09/2016				09/09/2016	
		Days after application	117 DAA/B				117 DAA	
		Days after last application	30 DAD				30 DAD	
		Assessment	% LAI				% SFNB Incidence	
A: Seed treatment B: in-furrow rate/ha	**Application C: Z25/26,**	**Application D: Z37**	**FLAG**	**FL-1**	**FL-2**	**% Green leaf area FL-2**	**FLAG**	**FL-1**
Untreated			17.1 a	28.0 a	44.3 a	28.8 f	100 a	100 a
Baytan T 1 L/t	Cogit 250 mL/ha	Soprano® 250 mL/ha	4.1 bc	9.1 bc	13.0 bc	69.8 cde	93 a	100 a
EverGol Energy 1.3 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	8.3 b	9.3 b	13.5 bc	66.0 de	100 a	100 a
EverGol Energy 2.6 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	5.7 bc	9.6 b	13.7 bc	63.9 e	93 a	100 a
Baytan T 1 L/t + flutriafol 400 mL/ha	Cogito 250 mL/ha	Soprano 250 mL/ha	5.8 bc	8.9 bc	8.3 cde	74.9 bcd	100 a	100 a
EverGol Energy 1.3 L/t + flutriafol 400 mL/ha	Cogito 250 mL/ha	Soprano 250 mL/ha	4.2 bc	6.1 bcd	11.5 bcd	73.4 b-e	86 a	100 a
EverGol Energy 1.3 L/t	Cogito 250 mL/ha	Aviator Xpro 300 mL/ha	1.8 bc	1.2 d	**4.1 e**	**88.1 a**	**46 b**	**30 b**
	Cogito 250 mL/ha	Amistar Xtra 400 mL/ha	**0.7 c**	3.2 d	7.6 cde	82.7 ab	47 b	90 a
	Amistar Xtra 400 mL/ha	Soprano 250 mL/ha	3.5 bc	9.9 b	16.7 b	70.3 cde	80 a	100 a
	Aviator Xpro 300 mL/ha	Soprano 250 mL/ha	1.7 bc	**2.7 d**	7.6 cde	77.1 bc	77 a	90 a
	Aviator Xpro 500 mL/ha	Soprano 250 mL/ha	2.1 bc	5.4 bcd	8.7 cde	80.0 abc	73 ab	100 a
	Prosaro 150 mL/ha + BS1000 0.2% v/v	Soprano 250 mL/ha	1.9 bc	6.2 bcd	10.9 b-e	71.7 cde	73 ab	93 a
Systiva 1.5 L/t	up to Z55 control on label		3.5 bc	3.9 cd	4.2 e	74.7 bcd	87 a	93 a
Untreated + Uniform 400 mL/ha	Nil	Soprano 250 mL/ha	6.0 bc	4.8 bcd	5.0 de	77.4 bc	93 a	100 a
LSD (P=Various)			*6.1*	*4.7*	*6.0*	*9.3*	*25.7*	*13.6*
St. Dev			*3.5*	*2.7*	*3.5*	*5.4*	*15.0*	*7.9*
CV (%)			*74.1*	*35.0*	*29.0*	*7.6*	*18.3*	*8.6*

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

% LAI - At 30 DAD based on ratings all seed treatment and foliar combinations significantly reduced %LAI compared to the untreated. % LAI from Aviator Xpro, Amistar Xtra and Prosaro at timing C was comparable to Systiva seed treatment and Uniform in-furrow.

Green leaf area

The highest % green leaf area was recorded from a program of EverGol Energy + Cogito + Aviator Xpro.

% SFNB Incidence

The lowest % incidence of SFNB on the flag leaf and FL-1 was recorded from a program of EverGol Energy + Cogito + Aviator Xpro.

Table 5: Yield (t/ha), screenings (%) and Gross margin ($/ha) in LaTrobe barley.

		Date	28/10/2016			
		Days after application	166 DAA			
		Days after last application	70 DAD			
		Assessment	**Grain yield**		**Quality**	
A: Seed treatment B: in-furrow rate/ha	**Application C: Z25/26,**	**Application D: Z37**	**t/ha**	**% Untreated**	**Screenings (%)**	**Gross margin $/ha**
Untreated			3.18	100	6.2	$594.66
Baytan T 1 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	3.21	101	2.6	$600.27
Vibrance 1.8 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	3.38	106	3.4	$632.06
EverGol Prime 0.4 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	3.34	105	3.2	$624.58
EverGol Energy 0.65 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	3.31	104	4.3	$618.97
EverGol Energy 1.3 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	3.33	105	3.5	$622.71
EverGol Energy 2.6 L/t	Cogito 250 mL/ha	Soprano 250 mL/ha	3.38	106	3.8	$632.06
Baytan T 1 L/t + flutriafol 400 mL/ha	Cogito 250 mL/ha	Soprano 250 mL/ha	3.40	107	3.5	$635.80
EverGol Energy 1.3 L/t + flutriafol 400 mL/ha	Cogito 250 mL/ha	Soprano 250 mL/ha	3.31	104	3.8	$618.97
EverGol Energy 1.3 L/t	Cogito 250 mL/ha	Aviator Xpro 300 mL/ha	3.42	108	3.7	$639.54
	Cogito 250 mL/ha	Amistar Xtra 400 mL/ha	3.41	107	3.7	$637.67
	Amistar Xtra 400 mL/ha	Soprano 250 mL/ha	3.19	100	3.4	$596.53
	Aviator Xpro 300 mL/ha	Soprano 250 mL/ha	3.38	106	3.5	$632.06
	Aviator Xpro 500 mL/ha	Soprano 250 mL/ha	3.32	104	3.2	$620.84
	Prosaro 150 mL/ha + BS1000 0.2% v/v	Soprano 250 mL/ha	3.19	100	4.0	$596.53
Systiva 1.5 L/t	up to Z55 control on label		3.28	103	3.1	$613.36
Untreated + Uniform 400 mL/ha	Nil	Soprano 250 mL/ha	3.52	111	3.7	$658.24
LSD (P=Various)			*NS*			
St. Dev			*0.1*			
CV (%)			*3.6*			

No significant difference between treatments means (Duncan's New Multiple Range at 5% significance level).

Grain samples from all treatments were rated as Feed 1 due to low protein levels. Kwinana delivered F1 9/11/16 = $187.

Some treatments are not yet registered so without a market price $ROI/ha cannot be determined.

The low protein levels indicate that the fertiliser applied to the trial may have been insufficient in a season like 2016 with a long spring. This coupled with some minor frost impacts across the trial particularly at the western end has reduced confidence in comparison of yield as a measure of treatment efficacy and conclusions as to which program would return the best result to a grower in the Liebe Group geography.

Acknowledgements
Thanks to the Butcher family for hosting the site and to Living Farm for the sowing of the trial, trial maintenance and harvesting of the treatments.

Paper reviewed by: David Gregor, Regulatory Affairs Manager, Bayer

Contact
Rick Horbury, Bayer
rick.horbury@bayer.com
0429 055 154
Twitter @HorburyRick

Yield loss of barley and wheat varieties to Fusarium Crown Rot

Daniel Hüberli, Plant Pathologist, DAFWA

Key Messages

- Yield loss to crown rot varied significantly among wheat and barley varieties ranging from 0 to 0.8 t/ha for wheat and 0.5 to 1.4 t/ha for barley.
- An understanding of the crown rot disease history of a paddock and choosing varieties with appropriate disease resistance ranking can improve crop yield substantially.

Aim

To evaluate the relative yield loss (tolerance) of commonly grown and newly released wheat and barley varieties to Fusarium crown rot.

Background

Fusarium crown rot, caused predominately by the stubble-borne fungus *Fusarium pseudograminearum*, is one of the major root and crown disease constraints on cereal production in Australia. In 2009 it was estimated to cost Australian grain growers $97 million annually in wheat and barley (Murray and Brennan, 2009, 2010). WA's losses to this disease were estimated at that time to be $7 million annually. In 2014, many growing regions in WA were impacted by crown rot, exacerbated by dry weather conditions during grain fill. For example, reports from Merredin indicated that crown rot affected 30-50% of wheat paddocks.

There is an on-going need to evaluate wheat and barley varieties to demonstrate to growers the economic benefits of adoption of varietal selection in paddocks with high crown rot disease pressure. Particularly as several new wheat varieties have been released recently with improved tolerance to crown rot. The field trials reported here is part of a three year series of Western region based trials to provide WA grain growers experimental field evidence of the effect of crown rot on variety yields in local environmental conditions.

Trial Details

Property	DAFWA Wongan Hills Research Station
Plot size & replication	10m x 1.8m x 4 replications
Trials & Treatments	Two trials – wheat and barley trial 12 wheat varieties – Calingiri, Cobra, Corack, Emu Rock, Harper, Justica, Mace, Magenta, Scepter, Trojan, Westonia, Wyalkatchem 12 barley varieties – Bass, Baudin, Compass, Fathom, Flinders, Granger, La Trobe, Litmus, Mundah, Rosalind, Scope, Spartacus Uninoculated and inoculated with *F. pseudograminearum* paired plots for each variety
Soil type	Yellow brown sand
Soil pH ($CaCl_2$)	0-30cm: 4.7 30-60cm: 5.8 60-90cm: 5.9 90-120cm: 5.8
EC (dS/m)	0-30cm: 0.033 30-60cm: 0.032 60-90cm: 0.027 90-120cm: 0.028
PreDicta B DNA soil test for soilborne diseases	Below detection level for crown rot tests
Sowing date	01/06/2016
Seeding rate	75 kg/ha
Paddock rotation	2012 wheat, 2013 wheat, 2014 lupin, 2015 wheat
Fertiliser	01/06/2016: 80 kg/ha Macropro Plus 11/07/2016: 60 L/ha Flexi-N 18/08/2016: 25 L/ha Flexi-N
Herbicides, Insecticides & Fungicides	01/06/2016: 2 L/ha Spray.Seed 250, 2 L/ha Trifluralin, 1.2 kg/ha Terbuthylazine 06/07/2016: 800 mL/ha Velocity 15/08/2016: 250 mL/ha Alpha-cypermethrin

Annual rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
	66.2	0.0	149.2	77.6	46.0	57.0	80.8	63.6	34.8	17.0	-	-	592.2
	Growing season rainfall (April-October) 381.6mm												

Results

Grain yield for both barley and wheat were good, averaging 3 t/ha for wheat and 5.1 t/ha for barley in the uninoculated plots. No yield loss was sustained by Emu Rock, a wheat variety known for crown rot tolerance. All other barley and wheat varieties had reduced yield (Figure 1 and 2) in plots inoculated with crown rot and significant differences were evident between varieties. In the barley trial, Spartacus, La Trobe and Litmus had the lowest yield reductions from crown rot at less than 600 kg/ha, with Litmus having significantly higher yields apart from Compass, Rosalind, and La Trobe, than any other variety in the presence of crown rot (Figure 1). Bass, Scope, Granger, and Flinders were the most heavily impacted by crown rot losing over 1 t/ha yield to the disease. In the absence of the disease, grain yield of the highest yielding variety, Litmus, was not significantly different to Rosalind, Fathom, Compass, and Mundah.

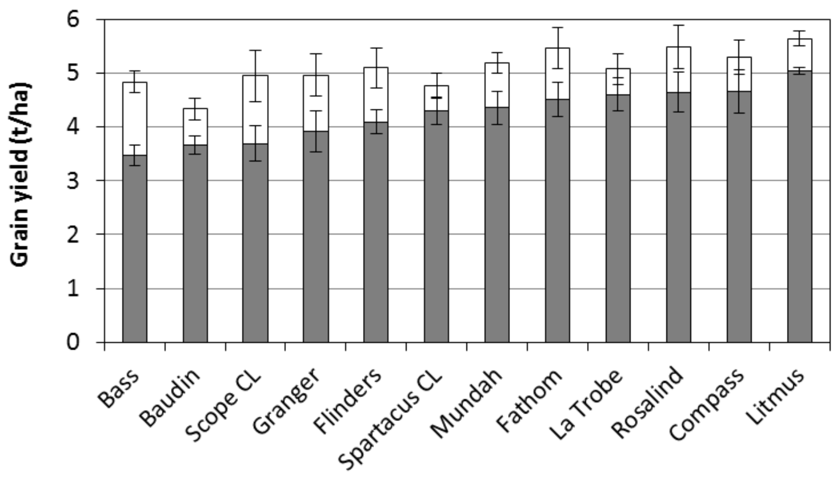


Figure 1: Grain yield for 12 barley varieties in nil (white bars) and *Fusarium pseudograminearum* inoculated (grey bars) plots at Wongan Hills in 2016. NVT crown rot resistance rankings are not available.

In wheat, Emu Rock had no yield loss while Mace, Justica, and Magenta had over 500 kg/ha yield loss to crown rot. Scepter had the highest yield in crown rot inoculated plots which was significantly different to the remaining varieties except Calingiri, Magenta, Emu Rock, and Cobra.

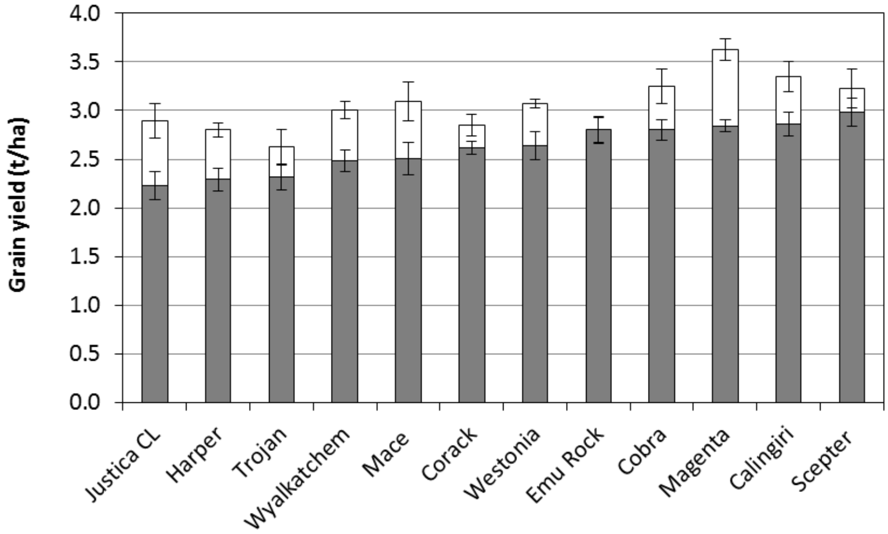


Figure 2: Grain yield for 12 wheat varieties in nil (white bars) and *Fusarium pseudograminearum* inoculated (grey bars) plots at Wongan Hills in 2016. NVT resistance rankings for Emu Rock and Trojan are moderately susceptible (MS), Magenta is MS to susceptible (MSS), and remaining varieties are susceptible to crown rot, except for Scepter for which NVT crown rot resistance rankings are not available.

Comments

This is the third and final year of inoculated crown rot field experiments to evaluate yield loss in barley and wheat varieties in WA. As in the previous two years, with the exception of Emu Rock in 2016, all varieties of barley or wheat were found to be affected by the disease and all had some level of yield reduction, however, significant differences between varieties were evident (see Huberli *et al*. (2015) for 2014 results, and Huberli (2016) for 2015 results). In all years, Emu Rock has had the lowest actual yield loss and has been the highest yielding in the presence of disease with the exception of 2016 where Scepter was the highest yielding. Justica was the lowest yielding in crown rot inoculated plots with the highest actual yield loss in 2014 and 2015, while Magenta suffered the highest yield loss in 2016. For barley, Litmus and La Trobe have been the best performers under crown rot pressure and Compass has had the largest yields loss to the disease in 2014 and 2015, and Bass in 2016.

Yield losses in 2016 for barley and wheat ranged substantially with the worst performers in barley losing over 1 t/ha and in wheat over 500 kg/ha to the disease. For wheat, the resistance rankings have been determined through the NVT screening system, and all varieties with high yield losses in 2015, except Magenta, are susceptible. For barley, resistance ranking have not yet been determined. As this is now the final year of trials a final analysis of the three years' yield losses will be completed and presented at Research Updates 2017.

The results show that variety choice under high crown rot disease pressure can have an impact on yield. For example, with added crown rot inoculum, Emu Rock yielded 294 kg/ha (statistically significant) more than Mace in 2016. However, in the plots without crown rot, Mace out-yielded Emu Rock by 295 kg/ha in 2016 (statistically significant).

These preliminary results indicate that understanding the crown rot disease history of a paddock and choosing varieties with appropriate disease resistance ranking can improve crop yield substantially. It is important to understand that in a year with good rainfall and no or very low level of disease expression (white heads), inoculum levels can build up substantially on tight cereal rotation paddocks.

References

Murray, G.M. and Brennan, J.P. (2009). Estimating disease losses to the Australian wheat industry. *Australasian Plant Pathology* 38: 558-570.

Murray, G.M. and Brennan, J.P. (2010). Estimating disease losses to the Australian barley industry. *Australasian Plant Pathology* 39: 85-96.

Hüberli, D., Connor, M. and Gajda, K. (2015) Yield loss to Fusarium crown rot: is there a better choice among barley and wheat varieties? In: Australasian Plant Pathology Society Conference Handbook, 14 - 16 September, Fremantle, Western Australia. Download PDF conference paper, poster, and presentation: http://researchrepository.murdoch.edu.au/28457/

Hüberli, D., Connor, M. and Gajda, K. (2016) Yield loss of barley and wheat varieties to Fusarium crown rot. Liebe Group Research and Development Book. Liebe Group, Dalwallinu, Western Australia. pp. 25-27. Download PDF: http://researchrepository.murdoch.edu.au/29623/

Acknowledgements

Technical support from Miriam Connor and Kris Gadja. DAFWA Research Support Units at Wongan Hills seeded, managed and harvested trials. Funding from GRDC project DAN00175 "National crown rot epidemiology and management program."

Paper reviewed by: Sarah Collins, DAFWA.

Contact

Daniel Hüberli, DAFWA
daniel.huberli@agric.wa.gov.au
(08) 9368 3836

Management of powdery mildew and other diseases of wheat with seed dressing, in-furrow and foliar fungicides

Geoff Thomas, Ciara Beard, Andrea Hills, Kith Jayasena & Jason Bradley, Plant Pathologists, DAFWA

Key Messages

- Powdery mildew became apparent nine weeks after sowing, infection incidence increased slowly for six weeks reaching 90% of plants affected but at severity of less than 5% leaf area affected.
- Registered fungicides applied as seed dressing or in-furrow applications delayed the development of powdery mildew.
- Foliar fungicide applied at stem extension, as disease became apparent, delayed development of powdery mildew.
- Under low and declining disease pressure no response to flag leaf fungicide application was seen.
- Registered seed dressing fungicides are effective for control of flag smut, reducing infection from 0.8% incidence to undetectable levels.
- In the absence of yield limiting levels of powdery mildew or other foliar diseases, neither seed dressing, in-furrow nor foliar applied fungicides had an impact on grain yield or quality.

Aim

Assess potential efficacy and benefits from early fungicide application (at-seeding and Z31 foliar fungicide) in management of powdery mildew of wheat.

Background

Powdery mildew was widespread and reached damaging levels in several regions in 2015. As it is a stubble borne disease the risk of early powdery mildew was significant in 2016 and would be amplified where there was autumn green bridge as this disease is also carried over on volunteer wheat. A range of systemic seed dressing and in-furrow fungicides are registered for other diseases in wheat and have been shown to be effective in managing powdery mildew in barley. These products are applied prophylactically and require investment prior to knowing a crop will be infected but in the presence of disease can delay the onset of infection in susceptible crops and potentially reduce or delay the need for foliar fungicide intervention. The efficacy of these products for delaying onset and reducing severity of powdery mildew in wheat and potential yield benefit compared to foliar application need further investigation.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	10m x 1.54m x 4 replications
Soil type	Sand/sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.9 10-20cm: 5.4 20-30cm: 6.1
EC (dS/m)	0-10cm: 0.054 10-20cm: 0.037 20-30cm: 0.038
Paddock rotation:	2012 wheat (Magenta), 2013 fallow, 2014 wheat (Mace), 2015 canola (Sturt TT)
Sowing date	06/05/2016
Sowing rate	Corack wheat (~70 kg/ha to achieve 125 plants/m^2)
Fertiliser	06/05/2016: 100 kg/ha Agras 29/06/2016: 50 L/ha Flexi-N 02/08/2016: 30 L/ha Flexi-N
Herbicides, insecticides & fungicides	06/05/2016: 1 L/ha Trifluralin, 2 L/ha Spray.Seed, 2.5 L/ha Boxer Gold 14/06/2016: 20 g/ha Chlorsulfuron, 0.5% wetter 22/06/2016: 800 mL/ha Velocity, 0.5% Mso

Annual rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Treatments

18 treatments x 4 reps (10m plots).

Factor 1 - Early season treatments

1. Untreated
2. Untreated
3. Prosaro at 150 mL/ha at Z30 (7th July)
4. Flutriafol in-furrow (Flutriafol 250® 400 mL/ha)
5. Fluquinconazole on seed (Jockey stayer® at 450 mL/100kg seed)
6. Fluxapyroxad on seed (Systiva® at 150 mL/100kg seed)
7. Triadimenol (Baytan T® at 150 mL/100kg seed)
8. Triadimefon in-furrow (Triadimefon 500 Dry® at 200 g/ha)
9. Azoxystrobin & Metalaxyl-M in-furrow (Uniform® at 400 mL/ha)

Factor 2 - Foliar Spray (split plots into 10m sections)

1. Untreated
2. Foliar Fungicide applied at ~Z45 Awn peep (Prosaro 150 mL/ha + 0.2% BS1000) (2nd August)

Results

The variety used for this trial was Corack, it is SVS for powdery mildew (the target disease). The trial was sown on 6th May into good soil moisture and emergence was even across the site. Plant establishment in untreated plots was 99 plants/m^2, with no significant treatment effects on emergence, except in plots sown with triadimenol seed treatment (Baytan®) where 14% reduction in establishment was noted.

At no point during the season were there any significant levels of either yellow spot or septoria nodorum blotch and fungicide treatments had negligible effect on leaf necrosis during the season.

Powdery mildew was detected at trace levels on stem bases in Untreated plots on 7th July (~Z30), as a result of this detection, the first foliar application (Prosaro® @ 150 mL/ha) was applied on this date. At this time, no disease was evident in plots with seeding treatments.

Plants were rated for incidence and severity of mildew at fortnightly intervals from the first detection. Incidence of affected plants reached a maximum of 90% in untreated plots six weeks after first detection, however disease severity was significantly less than 5% leaf area affected at all times. Eight weeks after detection, mildew incidence and severity were diminishing naturally and by early September infection was at negligible levels.

While treatment effects need to be interpreted with care given the low disease development at this site, there were significant differences between treatments in development of mildew. Consistent with results from other sites, Flutriafol in furrow delayed incidence and reduced severity of powdery mildew infection. Most treatments reduced mildew infection, although Systiva® and Uniform® were less effective.

The application of Prosaro® at ~Z30, when mildew was first detected, provided significant reduction of disease development similar to the best of the at-seeding treatments, however given the low disease pressure it is difficult to determine the potential length of protection this spray may have provided.

Flag smut is a soil and seed borne disease which was present in this trial at moderate levels. The disease occurred uniformly across all untreated plots (0.8% plants affected) and in adjacent untreated wheat trials and so would appear to have been caused by soil borne inoculum. Assessments of incidence of infected plants showed that in all seed treatment plots (Systiva®, Baytan T®, Jockey Stayer®) flag smut infection was not detected (0%). Interestingly in-furrow fungicides reduced flag smut incidence (Flutriafol 0.2%, Triadimefon 0.2%, Uniform 0.6%), but not as successfully as seed dressings. Neither of the foliar application timings had any effect on flag smut incidence (0.8%).

Untreated yield was 2.7 t/ha. In the absence of yield limiting levels of either root or foliar disease, there were no significant yield responses to any fungicide treatment. Neither was there any response to fungicide in grain quality assessments.

In the absence of significant grain yield and quality responses, none of the treatments applied will have returned a positive return on investment at this site in this season.

Table 1: Effect of fungicide treatments on incidence and severity of powdery mildew and grain yield of Corack wheat at Nugadong in 2016. Mildew first detected at trace levels on 7th July.

	Incidence of powdery mildew (% plants affected)				**Powdery mildew severity (% leaf area affected on top 3 leaves)**				**Yield (kg/ha)**
	21-Jul	**21-Jul**	**4-Aug**	**17-Aug**	**30-Aug**	**4-Aug**	**17-Aug**	**30-Aug**	
Untreated	70	77	90	60	Trace	0.8	1.0	0.5	2.7
Jockey Stayer® (SD)	25	***51***	***67***	23		0.3	*0.2*	0.1	2.8
Systiva® (SD)	70	69	77	50		0.5	0.6	0.3	2.8
Baytan T® (SD)	***10***	***40***	***60***	33		0.2	*0.5*	0.2	2.6
Flutriafol 250 (IF)	***5***	***51***	***53***	30		0.2	*0.2*	0.1	2.7
Triadimefon500 (IF)	25	***47***	73	27		0.2	*0.3*	0.1	2.7
Uniform® (IF)	65	80	***65***	40		1.0	*0.4*	0.2	2.8
Prosaro® 150mL -Z30	***5***	***38***	***47***	40		0.2	*0.2*	0.3	2.6
Prosaro® 150mL -Z39	-	-	***47***	45		-	*0.3*	0.2	2.7
P Value	*0.063*	*0.012*	*0.002*	*0.063*		*0.245*	*0.003*	*0.062*	*NS*
LSD	*51*	*23*	*19*	*25*		*0.8*	*0.4*	*0.2*	*0.21*

SD = seed dressing, IF = coated on fertiliser applied in-furrow, NS = no significant difference.

Comments

Powdery mildew became evident at trace levels in Corack wheat approximately nine weeks after sowing. Despite Corack being SVS for powdery mildew, disease development was slow and while 90% of untreated plants eventually became infected, severity of infection was significantly less than 5% leaf area affected.

Flutriafol and Triadimefon applied in-furrow, Triadimenol and fluquinconazole seed dressings and Prosaro® applied at first detection (Z30) all significantly delayed the spread of powdery mildew infection.

All seed dressings provided an added benefit of eradicating flag smut infection, while in-furrow treatments significantly reduced infection without eradicating it.

In the absence of yield limiting disease, no fungicide treatments provided a yield benefit and would have given a negative return on investment. However the majority of at-seeding treatments provided a delay of disease development until flag leaf which may have prompted a decision to not apply a foliar fungicide at this time, potentially saving an in-season investment.

This trial indicates that under low disease pressure, most at-seeding fungicides (eg. flutriafol in-furrow) can delay development of powdery mildew similar to a foliar fungicide applied at early stem extension. In this low disease pressure trial, fungicide applied at-seeding or as foliar at stem extension (when disease occurred) delayed disease development until natural disease decline occurred and stopped the need for a flag leaf foliar fungicide application.

Powdery mildew occurrence in a crop depends on variety resistance, inoculum pressure and seasonal weather conditions. Use of at-seeding fungicides for susceptible varieties when disease risk is present can help insure against early season disease when seasonal conditions are more favourable than in this trial.

Acknowledgements
DAFWA Wongan Hills RSU staff, particularly Shari Dougall, for sowing and maintenance of the trial.
Liebe Group and the Butchers for the trial site.
DAFWA and GRDC (DAW00229) for funding.
Companies (BASF, Bayer, 4Farmers, Syngenta) for product treatments.

References

C. Beard *et al.* (2016). Foliar fungicide strategies for Managing Wheat Powdery mildew, GRDC Grains Research Update, http://www.giwa.org.au/_literature_210420/Beard_Ciara_Powdery_mildew_paper_GRDC_Grains_Research_Updates_2016

C. Beard *et al.* (2016) Foliar fungicide strategies for managing wheat powdery mildew, GRDC Grains Research Update, https://www.agric.wa.gov.au/spring/managing-powdery-mildew-wheat

Paper reviewed by: Andrea Hills, DAFWA

Contact

Geoff Thomas, DAFWA
geoff.j.thomas@agric.wa.gov.au
(08) 9368 3262
0428 947 287

Using seed dressings and in-furrow fertiliser treatments to control diseases in barley

Nathan Dovey, Agronomist; Richard Stone, Agronomist; Neil Mortimore, General Manager, 4Farmers

Key Messages

- Application of selected fungicide ingredients as seed and fertiliser treatments and as a foliar spray to La Trobe barley did not give a financial return in season 2016.
- Where risk of disease onset at early crop growth stages is high, introducing fungicides at sowing through fertiliser or seed treatments potentially offer a low cost and effective defence against target diseases.
- Fungicides applied at sowing can save or delay application costs for post-emergent treatments, however in the absence of target disease then benefits from prophylactic applications are less likely to be economic.
- Choice of fungicide product and application method needs to be suitable for the diseases likely to be present in treated crops.

Aim

To investigate the value of in-furrow fungicides and seed dressings for control of barley disease and benchmark these against a standard post emergent treatment.

Background

Post-emergent fungicide trials have demonstrated that fungicide applications to prevent or delay disease at early growth stages can be an effective part of a program when disease pressure is high. Applying systemic fungicides at sowing is now considerably more viable since fungicide cost can be as little as $2/ha. Variety susceptibility and target disease risk will influence the choice of whether or not to treat and which product is most suitable. This trial investigated the value of upfront protection of various fungicides applied at seeding. Fertiliser treatments, Flutriafol 500 and Triadimefon 500 Dry, and seed dressings Triticonazole 200 and Jockey Stayer® were compared and evaluated at varying rates on LaTrobe barley. Propiconazole 500 (250 mL/ha) was applied at growth stage 31 to replicate a standard post emergent foliar fungicide application.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	18m x 1.8m x 3 replications												
Soil type	Sand-sandy loam												
Soil pH ($CaCl_2$)	0-10cm: 6.5 10-20cm: 5.2 20-30cm: 5.0												
EC (dS/m)	0-10cm: 0.070 10-20cm: 0.041 20-30cm: 0.041												
Paddock rotation	2013 fallow, 2014 wheat, 2015 canola												
Sowing date	17/05/2016												
Sowing rate	80 kg/ha LaTrobe barley												
Fertiliser	17/05/2016: 120 kg/ha NPK Blue 29/06/2016: 50 L/ha Flexi-N 02/08/2016: 30 L/ha Flexi-N												
Leaf assessments	07/09/2016: See table 2 08/09/2016: See table 2 14/09/2016: Not presented 27/09/2016: Not presented												
Plant emergence	07/09/2016: Not presented												
Plot Biomass	08/09/2016: Not presented 27/09/2016: Not presented												
Harvest date	03/11/2016												
Annual Rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Method for leaf assessments

A total of 16 plants per plot were visually scored for necrotic leaf area (Flag-2, Flag-3) and spot form net blotch (SFNB) (Flag-1, Flag-2) severity on the 7th and 8th of September (GS39). Additional SFNB assessments were completed on the 14th and 27th of September. Natural plant senescence allowed assessment of flag-1 only, on the final assessment date. Harvest was completed just over a month later on the 3rd of November.

Results

Table 1: Effect of seed dressing, in-furrow and foliar applied fungicides on yield of SFNB infected La Trobe barley at the Liebe main trial site, Nugadong 2016. A common letter indicates no significant difference between treatments.

Treatment name	Yield (t/ha)
1 Untreated Check	2.31[ab]
2 Untreated Check	2.09[ab]
3 4Farmers "Experimental"	2.07[ab]
4 4Farmers "Experimental"	2.25[ab]
5 4Farmers "Experimental"	2.29[ab]
6 1.5 L/t Jockey Stayer	2.38[ab]
7 3.0 L/t Jockey Stayer	2.35[ab]
8 6.0 L/t Jockey Stayer	2.21[ab]
9 0.75 L/ha 4Farmers Triticonazole 200	2.19[ab]
10 1.5 L/ha 4Farmers Triticonazole 200	2.00[a]
11 0.1 kg/ha 4Farmers Triadimefon 500 Dry	2.45[b]
12 0.2 kg/ha 4Farmers Triadimefon 500 Dry	2.16[ab]
13 0.4 kg/ha 4Farmers Triadimefon 500 Dry	2.25[ab]
14 0.1 L/ha 4Farmers Flutriafol 500	2.17[ab]
15 0.2 L/ha 4Farmers Flutriafol 500	2.38[ab]
16 0.4 L/ha 4Farmers Flutriafol 500	2.17[ab]
17 250 mL/ha 4Farmers Propiconazole 500 (@ GS 31)	2.33[ab]
LSD (P = 0.5)	*0.41*
St. Dev	*0.24*
CV (%)	*10.93*

Table 2: Effect of seed dressing, in-furrow and foliar applied fungicides on necrotic and SFNB affected leaf area in La Trobe barley at the Liebe main trial site, Nugadong 2016. Means with the same letter within a column are not significantly different. Means in bold are significantly different to the untreated control.

Treatment name	Leaf area necrotic (% leaf area affected) 7th September		SFNB severity (% leaf area affected) 8th September	
	Flag -2	Flag -3	Flag -1	Flag -2
1 Untreated Control	29.9cd	80.1d	4.4ab	7.9abc
2 Untreated Control	26.4bcd	74.1abcd	3.6ab	6.2c
3 4Farmers "Experimental" *on seed*	16.6ab	58.9a	3.5b	6.0c
4 4Farmers "Experimental" *on seed*	22.8abcd	73.5abcd	3.8ab	8.9ab
5 4Farmers "Experimental" *on seed*	20.8abc	73.1abcd	3.4b	6.2c
6 1.5 L/t Jockey Stayer *on seed*	23.0abcd	64.1abc	4.0ab	6.4bc
7 3.0 L/t Jockey Stayer *on seed*	21.6abcd	75.4bcd	4.0ab	5.7c
8 6.0 L/t Jockey Stayer *on seed*	20.3abcd	60.6ab	3.6ab	6.0c
9 0.75 L/ha 4Farmers Triticonazole 200 *on seed*	26.1bcd	65.7abcd	3.8ab	7.7abc
10 1.5 L/ha 4Farmers Triticonazole 200 *on seed*	25.1bcd	73.6abcd	3.9ab	7.3abc
11 0.1 kg/ha 4Farmers Triadimefon 500 Dry *on fert*	24.8bcd	67.1abcd	3.6ab	7.3abc
12 0.2 kg/ha 4Farmers Triadimefon 500 Dry *on fert*	32.3d	75.4bcd	4.9a	7.0abc
13 0.4 kg/ha 4Farmers Triadimefon 500 Dry *on fert*	17.1ab	63.6abc	4.4ab	9.1a
14 0.1 L/ha 4Farmers Flutriafol 500 *on fert*	21.1abc	65.0abcd	3.7ab	7.6abc
15 0.2 L/ha 4Farmers Flutriafol 500 *on fert*	26.0bcd	78.4cd	3.6ab	6.0c
16 0.4 L/ha 4Farmers Flutriafol 500 *on fert*	17.7ab	61.0ab	3.8ab	7.2abc
17 250 mL/ha 4Farmers Propiconazole 500 *(@ GS 31)*	**12.0a**	62.3ab	**1.6c**	**2.5d**
LSD (P = 0.5)	*11.1*	*15.75*	*1.40*	*2.58*
St. Dev	*6.65*	*9.43*	*0.19t*	*1.55*
CV (%)	*29.54*	*13.68*	*9.43t*	*22.85*

Crop safety

There were no significant differences between any treatments for plant counts, plot biomass and final grain yield. A lack of significant differences between the untreated controls and any seed treatment indicates there are no negative effects on crop safety for any of the products used in this trial.

Comments

The absence of significant yield response to any of the fungicide treatments in this trial is explained by the overall lack of target disease pressure at the Nugadong site. The main disease present was SFNB. None of the upfront treatments, Jockey Stayer®, Triadimefon 500, Triticonazole 200 or Flutriafol 500 are registered for control of this disease. The only treatment to have significant effect on SFNB severity, assessed on the 8th of September, was 4Farmers Propiconazole 500 as a foliar spray at Z31. This is a registered product for the control of SFNB and propiconazole is an industry standard treatment for this disease. There were no adverse yield effects of any of the seed treatment, fertiliser or foliar applied treatments.

Assessments taken on the 14th and 27th of September (not presented) showed no significant differences between any treatments in the trial. The relatively low severity of SFNB and lack of treatment difference in SFNB severity and green leaf retention during heading and grain fill was reflected by lack of treatment yield response, including for the partially effective foliar treatment.

The target disease for this trial was powdery mildew which is on the label for all of the above treatments. Unfortunately, the moderate resistance of La Trobe and low incidence of barley powdery mildew in other trials at the Nugadong site contributed to the lack of disease pressure seen in our trial.

Results from this trial indicate that expenditure on seed dressings and in-furrow fertiliser treatments did not give a financial return in season 2016. Target diseases such as barley powdery mildew or leaf rust did not occur and these products were not effective against SFNB. Even though foliar fungicide applied at stem extension provided reduction in SFNB severity, this did not show a significant yield response. Upfront products are applied as insurance against the risk of disease occurring and as a method of eliminating or delaying the need for foliar application. The relatively low cost of many in-furrow seed and fertiliser treatments offer cost effective insurance for protection of the crop early in the season if target diseases are present.

Acknowledgements
Thank you to Shari Dougall and the DAFWA team for planting and maintaining the trial. Thank you to Geoff Thomas providing a layout and trial randomisation. Thank you to the Butcher family for hosting the trial.

Paper reviewed by:
Geoff Thomas
Research officer, Plant Pathology DAFWA
(M) 0428 947 287

Contact
Nathan Dovey, 4Farmers
nathan@4farmers.com.au
0427 563 445

Resistance and tolerance of wheat, barley, lupins and canola varieties to *Pratylenchus neglectus* root lesion nematode

Dr Sarah Collins, Senior Nematologist, DAFWA

Key Messages

- Lupin yields were not impacted by the presence of high *P. neglectus* populations at sowing.
- Lupins are resistant to root lesion nematode (RLN) *P. neglectus* and reduced the nematode population over the season.
- Wheat, barley and canola yields were all significantly reduced by high *P. neglectus* populations at sowing.
- Wheat, barley and canola varieties all increased populations of *P. neglectus* over the season but variety choice impacted the degree of RLN multiplication.

Aim

Investigate the resistance (impact of crop on nematode population) and tolerance (impact of nematode on crop yield) of wheat, barley, lupins and canola varieties to *Pratylenchus neglectus* root lesion nematode.

Background

Root lesion nematodes (RLN; *Pratylenchus* species) are significant pests that feed on the roots of crop plants and cause yield loss. In the Western region, RLN are widespread and losses are potentially large. RLN are managed through the cultivation of resistant crops (which reduce nematode densities) and/or tolerant crops (which have reduced yield loss in the presence of RLN). Increased understanding of the effects of rotational crops on RLN densities will improve our ability to determine their potential effects on subsequent cereal crops. Likewise an understanding of the RLN tolerance of current wheat, barley, pulse and oilseed varieties helps estimate the potential economic effects of RLNs in the Western region and aid in appropriate choices for infested paddocks.

A series of trials are underway across the grain-belt investigating the impacts of the three RLN species known to cause major yield losses in the Western region; *P. neglectus*, *P. quasitereoides,* and *P. penetrans*. A range of WA specific crops, varieties and agro-ecological zones are targeted so that an array of WA growing conditions is well represented in RLN research results for the state. Field experimentation is predominantly conducted on WA grain grower properties and all WA field-based RLN research is conducted through the manipulation of natural populations of target *Pratylenchus* species. These trials are conducted over two years. In the first year, resistant and susceptible crops are bulk sown to manipulate nematode levels to produce ‘high’ and ‘low’ populations at which to compare yields of test crop varieties in the following year. In this way, relative variety tolerances are determined based on the yield differences that occur between the ‘high’ and ‘low’ nematode populations. The larger the yield difference, the more intolerant the variety. For tolerant varieties, there will be little difference in yield between the ‘high’ and ‘low’ RLN populations. The Western region’s most commonly grown grain crops; wheat, barley, canola and lupins are investigated in this field research series.

Pratylenchus neglectus is the main RLN species known to cause impacts in the central agricultural region so an infested paddock at the DAFWA Wongan Hills Research Station was utilised to exemplify potential crop resistance and tolerance to RLN in the area.

Trial Details

Property	DAFWA Wongan Hills Research Station
Plot size & replication	10m x 1.54m x 20 entries x high vs low nematode x 6 replications
Soil type	Yellow sand
Soil pH ($CaCl_2$)	0-10cm: 6.8 10-40cm: 5.5 40-70cm: 5.7 70-100cm: 6.5
Paddock rotation	2013 pasture, 2014 wheat

Varieties assessed

Wheat	Barley	Lupins	Canola
Calingiri	Bass	Barlock	Cobbler
Cobra	Granger	Gunydi	Snapper
Corack	Hindmarsh	Jenabillup	Stingray
Mace	La Trobe		Sturt
Wyalkatchem	Scope		Telfer
Yitpi			

Sowing date	18/05/2015: lupins & canola 22/05/2015: wheat & barley
Fertiliser	Cereals, Canola, Lupins: 80 kg/ha Macropro plus (at sowing) Cereal, Canola: 38 kg/ha Urea (post-emergent)
Herbicides	11/02/2015: 0.8 L/ha Ester 680, 0.8 L/ha Glyphosate 27/03/2015: 0.5 L/ha Ester 680, 1 L/ha Glyphosate 16/04/2015: 0.02 L/ha Hammer, 1.5 L/ha Glyphosate 18/05/2015: 1.1 kg/ha Simazine, 2 L/ha Trifluralin, 2 L/ha Spray.Seed 250 (Lupins/canola) 22/05/2015: 1 L/ha Trifluralin, 2 L/ha Spray.Seed 250 (cereals) 24/06/2015: 1 L/ha Velocity (cereals) 24/06/2015: 0.5 L/ha Clethodim (Lupins) 02/07/2015: 0.15 L/ha Brodal (Lupins) 19/10/2015: 3 L/ha Reglone (Canola)

Annual rainfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
66.2	0.0	149.2	77.6	46.0	57.0	80.8	63.6	34.8	17.0	-	-	592.2

Growing season rainfall (April-October) 381.6mm

Methods

Variety entries were determined in consultation with DAFWA cereal and canola variety evaluation projects. The trial was sown using a split plot design oversowing blocks where *P. neglectus* populations had been manipulated into high and low densities in the previous season. RLN densities were measured in each plot at the beginning (Pi) and end (Pf) of season to determine field multiplication (resistance information). This testing was conducted by collecting 400g soil samples for each plot using a CSBP soil corer. All samples were tested by SARDI DNA analysis. Plots were harvested and yield was compared between 'low' (3 nematodes/g soil) and 'high' (17 nematodes/g soil) nematode plots using ANOVA to determine if RLN had significantly impacted yields (tolerance information).

Results

Crop resistance to P. neglectus

Multiplication of *P. neglectus* differed between crop types, and it also differed between the varieties tested for each crop type ($P < 0.001$). Lupin crops were resistant to *P. neglectus* and nematode numbers in plots reduced by 37% and 32% in low and high plots, respectively. *P. neglectus* multiplied most readily in wheat followed by barley, then canola (Figure 1). Overall, wheat and barley crops were highly susceptible and canola was susceptible to *P. neglectus* (Figure 1).

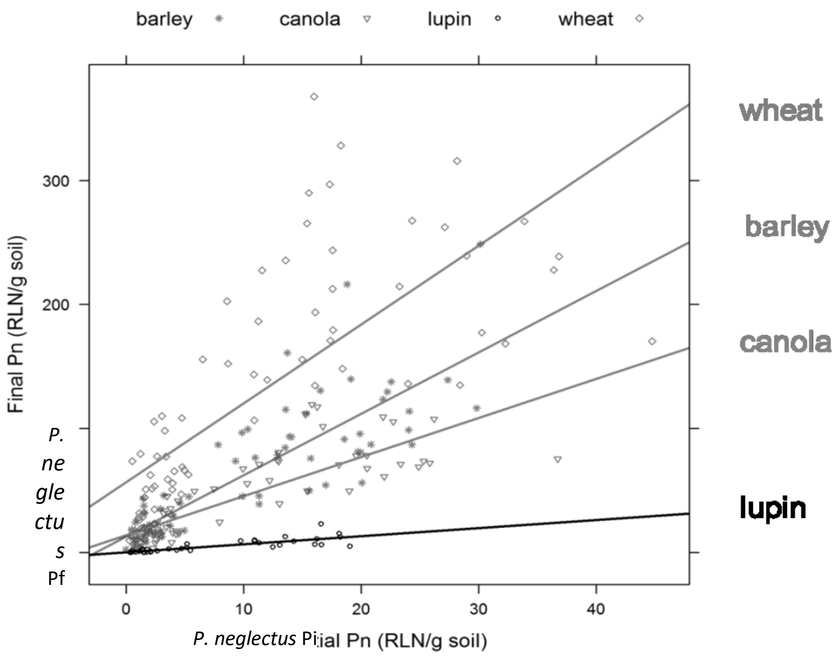


Figure 1: Scatter plot showing the relationship between *P. neglectus* populations in wheat, barley, canola and lupin plots at the beginning of season (Pi) compared to the end of season (Pf). Simple regression lines for each crop are presented.

Variety resistance to P. neglectus

All three lupin varieties tested (Jenabillup, Gunyidi and Barlock) reduced RLN populations over the season and were therefore all resistant to *P. neglectus* (Table 1). Of the six wheat varieties, Corack and Wyalkatchem were the least susceptible with significantly lower *P. neglectus* multiplication compared to Calingri, Cobra and Yitpi (Table 1), however even Corack as least susceptible, increased nematode population approximately ten-fold. Hindmarsh, with a five-fold increase in population, was least susceptible of the five barley varieties with significantly lower multiplication compared to the Bass, Granger and Scope (Table 1). Cobbler, with approximately four fold increase, was the least susceptible of the 5 canola varieties tested with significantly lower *P. neglectus* final populations compared to Stingray (Table 1).

Table 1: Comparing *P. neglectus* multiplication rate (Mrate) of wheat, barley, canola and lupin varieties assessed at Wongan Hills.

Wheat	Mrate	Barley	Mrate	Canola	Mrate	Lupins	Mrate
Corack	9.8 [a]	Hindmarsh	4.9 [a]	Cobber	3.7 [a]	Jenabilup	0.6 [a]
Wyalkatchem	10.1 [a]	La Trobe	5.9 [ab]	Snapper	4.2 [ab]	Barlock	0.7 [a]
Mace	12.0 [ab]	Granger	6.1 [bc]	Telfer	4.4 [ab]	Gunydi	0.7 [a]
Yipti	13.7 [b]	Scope	7.1 [bc]	Sturt	4.9 [ab]		
Cobra	14.1 [b]	Bass	7.7 [c]	Stingray	5.6 [b]		
Calingiri	19.3 [c]						
LSD	*1.9*		*1.6*		*1.9*		*0.4*
P value	*0.05*		*0.05*		*0.05*		-

Multiplication rate was commonly greater (but not significantly different, P = 0.147) in plots that had lower RLN numbers at the beginning of the season, adhering to the theory that competition between nematodes may restrict RLN multiplication when populations are higher. *P. neglectus* multiplication was extremely high at this site, with an average of 206 RLN/g soil across the trial and plots with up to 368 RLN/g soil recorded at the end of season. These are the highest recorded RLN levels in our DAFWA research field trials.

Crop Tolerance to P. neglectus
Lupin yields were not impacted by the presence of high *P. neglectus* at sowing but wheat, barley and canola all suffered significant yield loss (P < 0.01). Canola and wheat yields were most impacted followed by barley with average yield losses of 16, 15 and 5% respectively (P < 0.05).

Variety tolerance to P. neglectus
All canola varieties sustained significant yield loss (P < 0.05) due to the presence of high *P. neglectus* population at sowing, (Figure 2) with 11% to 21% yield reductions. Stingray was the highest yielding variety when RLN was low but was the most intolerant variety with a loss of 590 kg/ha where *P. neglectus* populations were high and the degree of loss was significantly higher than Sturt, Telfer and Cobbler (p < 0.05) (Figure 2). Snapper had the highest yield in the presence of high nematodes at 2.38 t/ha while losing 12% yield (320 kg/ha) compared to low RLN plots. Cobbler was the most tolerant variety tested, with a 270 kg/ha penalty (11% loss) (Figure 2).

P. neglectus significantly impacted the yield of all wheat varieties in this trial (Figure 3). While yield under high nematode population was similar for all varieties, the yield under low population and therefore the percentage yield loss from increased nematode number did vary between varieties. Wyalkatchem was the most tolerant variety with 11% yield loss (570 kg/ha) compared to Calingiri, the most intolerant variety tested, with 18% (980 kg/ha) loss under high RLN pressure.

Barley variety yields were less impacted by *P. neglectus* than canola or wheat. While barley varieties sustained yield impacts in the presence of high RLN at sowing, La Trobe and Scope were not statistically significant (Figure 3). Bass yields were most impacted with a 500 kg/ha loss (10 %). All yields were high in this trial and La Trobe performed very well at 6.14 t/ha with low nematode pressure compared to 5.86 t/ha when RLN was high.

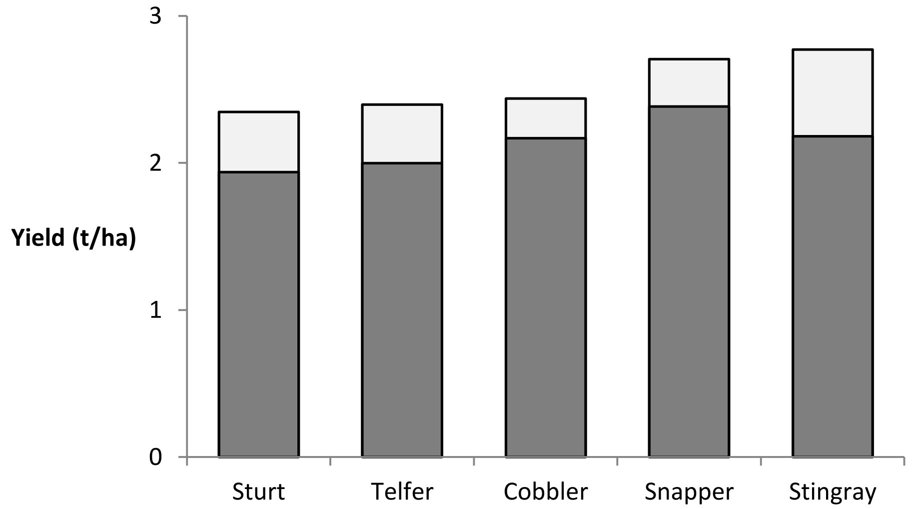


Figure 2: All grain yields were significantly different (P < 0.05) at Wongan Hills for 5 canola varieties from plots that had high (av. 17 RLN/g soil) *P. neglectus* levels (grey bars) compared to corresponding plots with low (av. 3 RLN/g soil) *P. neglectus* levels (white bars) at the beginning of season.

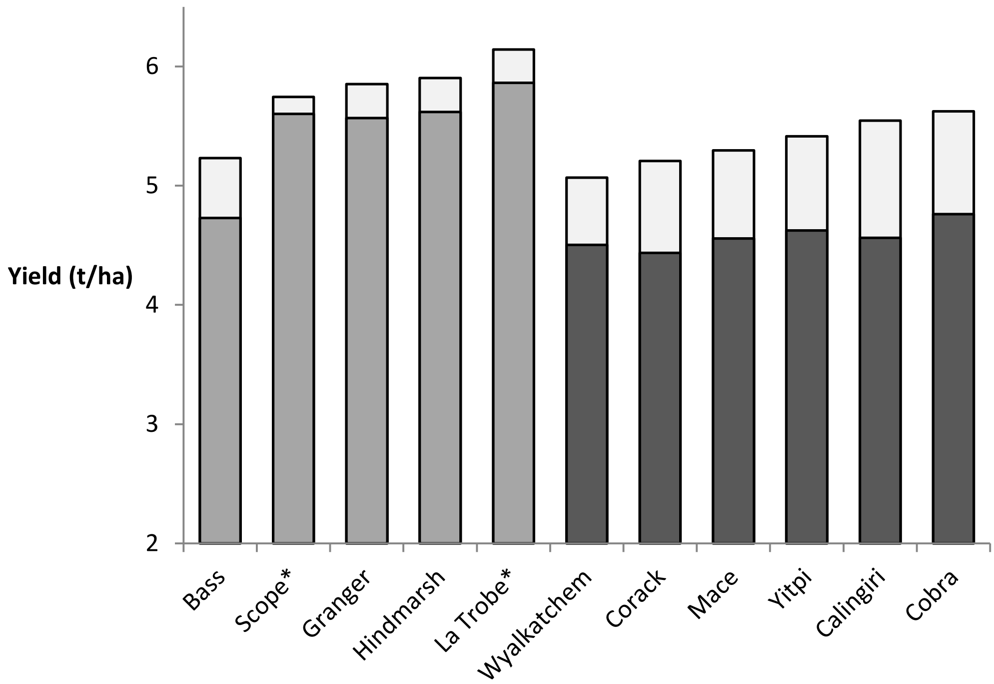


Figure 3: Grain yield at Wongan Hills for 5 barley (grey bars) and 6 wheat (black bars) varieties from plots that had high *P. neglectus* levels (av. 17 RLN/g soil) compared to corresponding plots (white bars) with low *P. neglectus* levels (av. 2 RLN/g soil) at the beginning of season. * denotes variety impacts that were not significantly different ($P < 0.05$).

Comments

Canola, wheat and barley crops proved to be susceptible and intolerant to root lesion nematode species *P. neglectus;* however lupins are a tolerant crop and offer a viable rotation choice to effectively reduce RLN over a season. Growers can expect that a move to place lupins into crop rotation cycles will provide effective RLN management in infested paddocks and improve yield potential in the next season.

Canola yields were highly impacted by increased RLN at sowing and all 5 TT canola varieties sustained significant yield loss. Visual symptoms of *P. neglectus* infestation are very difficult to identify in canola crops which may explain why yield losses directly related to RLN have not been realised until now. Canola is effective for the reduction of other soil borne diseases that are significant in WA like rhizoctonia and take-all, so it's important that growers are aware of the specific cause of patchy growth or underperforming areas visible in cereals.

In cereals both wheat and barley were susceptible and intolerant of *P. neglectus*; however yield of barley was less impacted than wheat and may provide a better cropping option in a paddock infested with this RLN species. The opposite has been found in similar field trials assessing resistance and tolerance to RLN species *P. quasitereoides* where barley was most impacted. This highlights the importance of RLN species identification for effective management. Variety choices are available for both wheat and barley that can limit both potential yield loss and the level of RLN multiplication that could impact crops in the following season.

These Wongan Hills field trial results contribute to a larger data set of resistance and tolerance trials to be conducted in the Western Region over the period between 2015-2017. The array of WA growing conditions is well represented in this RLN research project. To date, RLN yield impacts are found to vary with both season and agro-ecological zones. All results will be compared regionally and nationally to improve knowledge of potential economic impacts in a range of crops caused by RLN.

Acknowledgements
DAFWA nematology staff: Carla Wilkinson, Sean Kelly, Lucy De brincat and Helen Hunter. Kefei Chen provided biometric analysis and interpretation. Wongan Hills RSU and particularly Shari Dougall provide quality trial management. Jeremy Wish provided expertise for Agricultural Production Systems sIMulator (APSIM) use and interpretation. Funding from GRDC project DAV00128 "National nematode epidemiology and management program".

Paper reviewed by: Geoff Thomas, DAFWA.

Contact
Sarah Collins, DAFWA
sjcollins@agric.wa.gov.au
(08) 9368 3612
0404 488 113

Nutrition Research Results

NPK compound vs NPK blend

Luke Dawson, Senior Agronomist, CSBP

Key Messages

- A compound fertiliser with nitrogen (N), phosphorous (P) and potassium (K) in every granule significantly out yielded a blend.
- A compound NPK fertiliser provides much better distribution of K down the drill row.

Aim

To compare the effectiveness of a compound NPK fertiliser versus an NPK blend.

Background

With the increase in potassium requirements in intensive cropping situations, CSBP have shown that placement of potassium in the drill row is much more effective than top-dressing potassium. However, the distribution of potassium in the drill row is greater using a compounded NPK fertiliser compared to a NPK blend with MoP as the potassium source. Using a MoP blend reduces the distribution of potassium along the drill row which can have an impact on the availability of potassium to the crop.

Trial Details

Property	Thomas, East Arrino
Plot size & replication	20m x 2.5m x 7 replications
Soil type	Yellow sandplain
Soil pH ($CaCl_2$)	0-10cm: 5.2 10-20cm: 4.7 20-30cm: 5.6
EC (dS/m)	0-10cm: 0.06 10-20cm: 0.2 20-30cm: 0.02
Paddock rotation:	2013 wheat, 2014 pasture, 2015 pasture
Sowing date	19/05/2016
Sowing rate	74 kg/ha Mace
Fertiliser	23/06/2016: 80 kg/ha Urea 09/08/2016: 80 L/ha Flexi-N
Herbicides, insecticides & fungicides	19/05/2016: 2 L/ha Glyphosate, 2 L/ha Trifluralin, 118 g/ha Sakura 19/07/2016: 800 mL/ha Velocity, 400 mL/ha LVE, 300 mL/ha Prosaro, 1% oil 09/08/2016: 300 mL/ha Prosaro, 150 mL/ha Alpha-cypermethrin
Growing season rainfall	346mm (April-October) & 52mm (January-March)

Results

Table 1: Soil test results.

Depth (cm)	pH	EC	OC	Nit N	Amm N	P	PBI	K	S
0-10	5.2	0.06	0.8	16	3	10	30	36	6
10-20	4.7	0.2	0.6	4	1	3	23	19	5
20-30	5.6	0.02	0.2	2	1	2	28	17	4

Table 2: Trial results.

	Treatment						19-Jul		30-Aug	Harvest
	Banded	Banded	9-Aug				K	K Uptake	NDVI	Yield
Trt	(L/ha)	(kg/ha)	(L/ha)	N*	P	K	(%)	(mg/plant)	Rating	(t/ha)
1	70 Flexi-N	72 Agstar Extra	80 Flexi-N	110	10	0	2.4[a]	11.5[a]	4.7[a]	2.90[a]
2	83 Flexi-N	44 MAP + 27 MoP	80 Flexi-N	110	10	13	2.8[b]	12.9[ab]	4.1[a]	2.99[a]
3	70 Flexi-N	100 K-Till Extra Plus	80 Flexi-N	110	10	13	2.7[b]	13.9[b]	7.3[b]	3.16[b]
						P Value	*<0.001*	*0.071*	*0.025*	*<0.001*
						LSD	*0.11*	*2.01*	*2.3*	*0.126*

*includes 80 kg/ha urea topdressed by the farmer and 80 L/ha Flexi-N (basal)

- Plant tests indicated marginal potassium (K) supply but there were no visual responses.
- An independent analysis of NDVI imagery showed that K-Till Extra Plus was more effective than the MAP/MoP blend and this was supported by significant yield differences.
- NPK Compound (K-Till Extra Plus) out yielded the NPK Blend (MAP/MoP) by 170 kg/ha.
- No significant yield differences between using an NPK Blend versus no K.
- Grain quality was not significantly affected by treatments - protein 11.4%, hectolitre weight 80 kg/hL, screenings 4%.

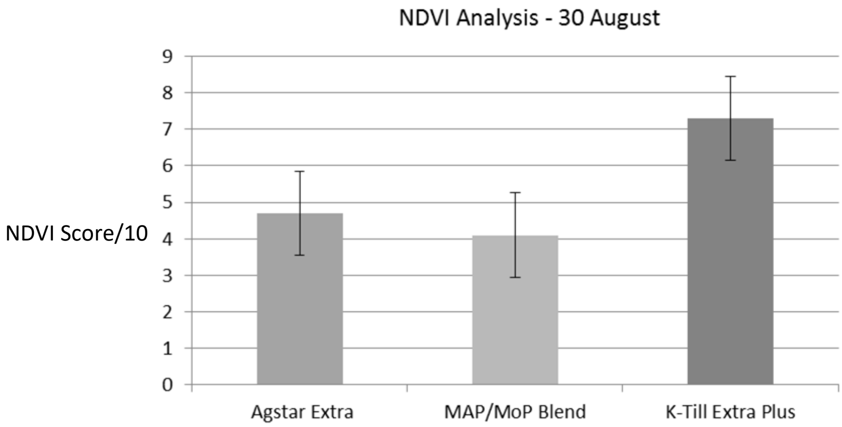


Figure 1: Independent NDVI analysis, conducted 30 August 2016.

Economic Analysis

Table 3: Economic analysis.

	Treatment						Harvest	Fertiliser Economics		
	Banded	Banded	9-Aug				Yield			
Trt	(L/ha)	(kg/ha)	(L/ha)	N*	P	K	(t/ha)	Response ($/ha)	Cost ($/ha)	Profit ($/ha)
1	70 Flexi-N	72 Agstar Extra	80 Flexi-N	110	10	0	2.90[a]	638	169	469
2	83 Flexi-N	44 MAP + 27 MoP	80 Flexi-N	110	10	13	2.99[a]	658	175	483
3	70 Flexi-N	100 K-Till Extra Plus	80 Flexi-N	110	10	13	3.16[b]	695	189	506
						P Value	*<0.001*			
						LSD	*0.126*			

Note: assuming wheat @ $220/t. Fertiliser costs based off list price January 2017, includes 80 kg/ha urea top up across all treatments, on 23/06/2016.

Comments

This trial highlighted that in K responsive situations the distribution of K along the drill row is as important as the placement of K. Using an NPK blend did not have any positive effect on yield whereas using an NPK compound gave better distribution of K along the drill row which resulted in 170 kg/ha extra yield and an additional return of $37/ha compared to a blended NPK and $57/ha compared to not applying any K.

Acknowledgements

CSBP Field Research
The Thomas Family

Paper reviewed by: James Easton, CSBP

Contact

Luke Dawson, CSBP
Luke.dawson@csbp.com.au
0427 427 101

Practice for profit – nutrition x disease following canola

Darren Chitty, Product Development Agronomist, Landmark

Key Messages

- Nitrogen application has been highly effective in this trial with profitability continuing to increase up to 80 units N/ha, the top rate used.
- Despite adequate soil phosphorus levels there has been an economic phosphorus response up to 12 units P/ha.
- There was no response to fungicide application with only low levels of powdery mildew present.

Aim

To evaluate the most profitable nutrient (nitrogen x phosphorus) and disease strategy following canola.

Background

Cereal nutrition and disease strategies following canola vary from those implemented in a cereal on cereal rotation. Recent analysis of Better Fertiliser Decisions (BFD) data suggests a critical Colwell P of 27 mg/kg for wheat following a cereal crop and a critical Colwell P of 41 for wheat following canola (Craig Farlow, 2013). Cereal disease pressure following canola is also much less. This trial will evaluate the phosphorus and nitrogen interaction plus or minus fungicide.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	20m x 2m x 3 replications												
Soil type	Sandy loam over gravel base												
Soil pH ($CaCl_2$)	0-10cm: 5.8 10-20cm: 4.8 20-30cm: 4.7												
EC (dS/m)	0-10cm: 0.061 10-20cm: 0.034 20-30cm: 0.035												
Paddock rotation	2013 fallow, 2014 wheat, 2015 canola												
Sowing date	12/05/2016												
Sowing rate	70 kg/ha Scepter wheat												
Fertiliser	12/05/2016 All phosphorus treatments applied as Landmark CropBuilder 18 09/06/2016: All nitrogen treatments applied as Urea.												
Herbicides, insecticides & fungicides	12/05/2016: 2 L/ha Paraquat, 2 L/ha Trifluralin, 1 L/ha Cobalt 09/06/2016: 2.5 L/ha Boxer Gold, 800 mL/ha Velocity, 0.5% Liberate, 15 mL/ha Trojan Opus fungicide was applied at GS 33 to the front 10m of replicates at 250 mL/ha. All treatments received 350 mL/ha Coptrel 500 at GS 33.												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

Table 1: Soil test results, May 2016.

Depth (cm)	pH	OC %	Nit N	Amm N	P	PBI
0-10	5.8	1.02	5	1	26	32
10-20	4.8	0.68	3	1	20	41
20-30	4.7	0.44	3	1	12	48

Good growing conditions were experienced in Nugadong in 2016 with an early break to the season and good stored soil moisture at seeding following 75mm of rain in March. Early crop vigour and NDVI readings (Table 2) demonstrated a clear response to nitrogen with increased growth and tillering with higher rates. There was also a measurable response to phosphorus; however this was not as visual as the response to nitrogen.

Table 2: Crop vigour and NDVI ratings at 69 and 102 DAS (days after seeding).

	Treatment		Phosphorus	Nitrogen	Cost $/ha	Vigour 69 DAS		NDVI 102 DAS	
1	Low P	Low N	6	40	58	5.3	f	0.41	d
2	Low P	Medium N	6	60	74	6.0	ef	0.47	bc
3	Low P	High N	6	80	90	7.0	bcd	0.51	ab
4	Medium P	Low N	9	40	70	6.3	de	0.41	d
5	Medium P	Medium N	9	60	86	6.5	cde	0.47	bc
6	Medium P	High N	9	80	102	7.5	b	0.50	bc
7	High P	Low N	12	40	82	6.0	ef	0.45	cd
8	High P	Medium N	12	60	98	7.2	bc	0.51	ab
9	High P	High N	12	80	114	8.3	a	0.55	a

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

Plant tissue tests taken mid-July showed nitrogen to be limiting on the low nitrogen treatments. There was also marginal phosphorus and copper from the high nitrogen treatments, a result of better plant growth and nutrient demand. Copper oxide was subsequently applied at 500 mL/ha to all plots at GS33 (stem elongation) to eliminate copper as a yield limiting variable.

Powdery mildew was detected in the trial at GS31 at very low levels. Opus (epoxiconazole) fungicide was applied at 250 mL/ha to the front 10m of plots at GS33. Disease levels remained low independent of fungicide application, and there was no yield response to fungicide application in this trial.

A significant grain yield response (Figure 1) to both nitrogen and phosphorus has seen yield increase from 2.71 t/ha up to 3.39 t/ha. Increasing nitrogen from 40 to 80 units has increased yield by over 400 kg/ha. The nitrogen response was linear and still increasing; indicating that yield potential was not reached in this trial. Grain protein levels (Table 3) were also low. Phosphorus has also increased yield with an average response of 240 kg/ha when increasing the rate from 6 to 12 units. This supports the theory of increased phosphorus demand following canola despite adequate soil test P levels.

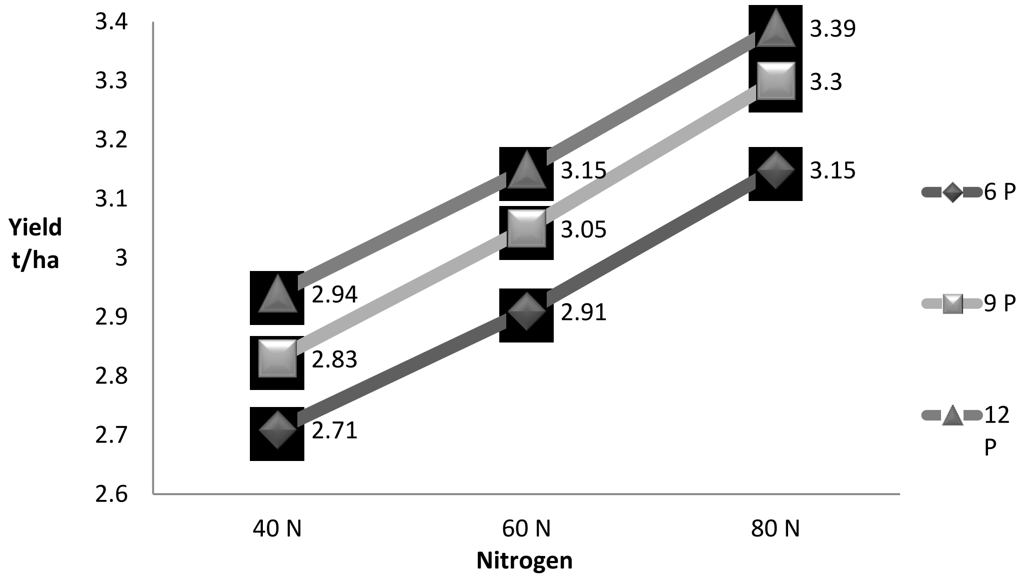


Figure 1: Average grain yield for Scepter wheat at Nugadong 2016. LSD (P=.05) 0.23 t/ha, CV 4.43, P value 0.0002

Economic Analysis

Low grain protein (Table 3) from all treatments has resulted in ASW classification. The highest gross margin was achieved from the High P High N (12 P, 80 N) treatment with a gross margin of $734 /ha. The top three gross margin treatments all received the high rate of nitrogen (80 units N/ha) and highlights the responsiveness of nitrogen at this site in 2016.

Table 3: Summary of grain protein, screenings, grade, cost and gross margin.

Treatment		Protein %	Screenings %	Grade	Cost $/ha	GM $/ha
Low P	Low N	7.3	2.7	ASW	58	620
Low P	Medium N	7.8	3.1	ASW	74	654
Low P	High N	7.9	2.5	ASW	90	698
Medium P	Low N	7.3	2.8	ASW	70	638
Medium P	Medium N	8.0	3.4	ASW	86	677
Medium P	High N	8.5	3.2	ASW	102	723
High P	Low N	7.3	2.8	ASW	82	653
High P	Medium N	7.8	2.7	ASW	98	690
High P	High N	8.2	2.6	ASW	114	734

NB - Grain price based on 5 year average ASW1 decile 5, minus CBH charges and freight. $240 on farm.

Comments

A key finding from the trial is the profitability of increased nitrogen in years of high yield potential. Despite applying a top rate of 80 units N/ha, grain yield was still increasing and was likely well short of yield potential. Low protein grain highlights that additional yield was achievable at this site and further applied nitrogen would have been profitable. This trial demonstrates the importance of adapting to the season and matching nitrogen demand to yield potential and growing season rainfall expectations.

Phosphorus also proved to be a profitable nutrient in this trial despite typically adequate phosphorus levels in the soil (26 Colwell P). This finding supports recent analysis of BFD data and recommends higher phosphorus demand in cereals following canola. Applying adequate phosphorus at seeding is essential to achieving full yield potential as in-season application to rectify deficiencies are normally ineffective and uneconomic.

Acknowledgements

Thank you to the Butcher’s for hosting the trial.

Paper reviewed by: Grant Thompson - Crop Circle Consulting, and Karrie Stratford - Landmark Senior Agronomist.

Contact

Darren Chitty, Landmark

darren.chitty@landmark.com.au

0438 982 485

Liquid fertiliser strategies

Angus McAlpine, Area Manager, CSBP

Key Messages

- This trial has shown that there were no significant yield responses to in-furrow applications of Intake fungicide, SE14 soil wetter or zinc (Zn).
- The compatibility of several products with Flexi-N provides opportunities to address nutritional or agronomic challenges from season to season.

Aim

To demonstrate the value of Flexi-N as a carrier for Intake fungicide, SE14 and Zinc banded in furrow.

Background

Banding liquids at seeding provides opportunities to apply products that cover a range of nutritional and agronomic benefits. Intake Hiload Gold is a fungicide designed to be applied at seeding, either coated on granular fertiliser or through liquid banding systems. The fungicide is used to prevent and control a broad spectrum of diseases in wheat, barley and canola. SE14 is a moisture retaining agent designed to improve early seedling emergence and vigour by retaining moisture within the germination zone. Zinc is an essential trace element needed for plant growth and plays an important role in early root development and crop establishment.

Trial Details

Property	O.J. Butcher & Son, Nugadong												
Plot size & replication	20m x 2.5m x 3 replications												
Soil type	Sandy loam duplex, gravel present at depth												
Soil pH ($CaCl_2$)	0-10cm: 6.3 10-20cm: 4.9 20-30cm: 5.1												
EC (dS/m)	0-10cm: 0.06 10-20cm: 0.03 20-30cm: 0.03												
Paddock rotation	2013 canola, 2014 wheat, 2015 barley												
Sowing date	19/05/2016												
Sowing rate	74 kg/ha Mace wheat												
Fertiliser	As per treatments below in Table 2												
Herbicides, insecticides & fungicides	19/05/2016: 118 g/ha Sakura (Farmer) 09/08/2016: 300 mL/ha Prosaro, 150 mL/ha alphacypermethrin												
Annual rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Results

Table 1: Soil test results.

Depth	pH	EC	OC	Nit N	Amm N	P	PBI	K	S
0-10	6.3	0.06	1.0	6	1	27	25	94	7
10-20	4.9	0.03	0.9	2	1	29	26	41	11
20-30	5.1	0.03	0.6	2	1	9	29	35	13

Table 2: The effect of fertiliser and liquids on yield and quality.

	Treatment									Harvest	
Trt	Description	Band (L/ha)	Band (L/ha)	Band (L/ha)	Band (L/ha)	Band (kg/ha)	N*	P	Zn	Yield (t/ha)	Protein (%)
1	Complete	Intake	SE14	0.36 Twin Zinc	50 FN	80 Agstar	96	11	0.25	2.59[a]	10.5[ab]
2	No Intake	-	SE14	0.36 Twin Zinc	50 FN	80 Agstar	96	11	0.25	2.74[a]	10.5[ab]
3	No SE14	Intake	-	0.36 Twin Zinc	50 FN	80 Agstar	96	11	0.25	2.73[a]	10.5[ab]
4	No Zinc	Intake	SE14	-	50 FN	80 Agstar	96	11	0	2.76[a]	10.8[a]
5	No Additives	-	-	-	50 FN	80 Agstar	96	11	0	2.70[a]	10.3[b]
6	Agstar only	-	-	-	-	80 Agstar	11	11	0	2.17[b]	8.4[c]
									Prob	*<0.001*	*<0.001*
									LSD	*0.20*	*0.33*

*includes top ups of 100 and 50 L/ha Flexi-N (trt 1-5)

Comments
There were no significant yield responses to in-furrow applications of Intake fungicide, SE14 soil wetter or zinc (Zn), compared to the no additive treatment.

The Flexi-N applied at seeding (50 L/ha) and post seeding (100 and 50 L/ha) increased yield from 2.2 to 2.7 t/ha and lifted protein from 8.4 to about 10.5%.

The products tested can improve crop health and yield under the right conditions however, due to the favourable 2016 seasonal conditions, there were no responses.

The plant tests indicated that Zn was not a limiting nutrient (about 22 mg/kg Zn at early tillering where Zn was not applied). Furthermore, plant diseases such as powdery mildew were present at the main trial site early however cool conditions slowed the spread of the diseases and ultimately did not have a significant negative impact on the crop yield.

The ability to band various liquid products during seeding offers opportunities to reduce risk and maximise yield potential. For example, Intake could be used where there is heavy disease pressure from the previous year or from tight cropping rotations with susceptible varieties. The SE14 could be used if dry periods are more common post seeding or if early season rains are minimal. Zinc can be used in certain situations or on specific soils types where required. Zinc deficiencies and or symptoms generally occur on soils with a high pH or under cold and wet conditions early in the season which reduce root exploration and uptake. Some agricultural herbicides that are soil active (e.g. sulphonylureas) can cause zinc deficiency symptoms from root pruning.

Acknowledgements
CSBP Field Research
The Butcher Family

Paper reviewed by: James Easton, CSBP

Contact
Angus McAlpine, CSBP
Angus.mcalpine@csbp.com.au
0437 222 419

Machinery Research Results

Comparison of four different seeding bars

Max Kerkmans, Branch Manager, AFGRI; Jenni Clausen & Clare Johnston, Liebe Group

Aim

To compare the precision seeding of four knifepoint bars at three different speeds.

Background

Different bars will perform better in certain situations, for example different soil types or moisture profiles. Four different bars were compared in a sandy loam soil at different speeds: 7, 8 and 9 km/hr.

Trial Details

Property	O.J. Butcher and Son, Nugadong												
Plot size & replication	Paddock length x 40ft x various replications												
Soil type	Sandy loam												
Paddock rotation	2013 wheat, 2014 barley, 2015 canola												
Sowing date	10/05/2016												
Sowing rate	55 kg/ha Mace wheat (70 mL/t seed Tebuconazole 430, 4 L/t seed Zinc)												
Fertiliser	10/05/2016: 40 kg/ha Agstar Extra, 60 kg/ha Urea (John Deere & Equalizer) 10/05/2016: 60 kg/ha Agstar Extra (Bourgault & Horsch) 15/06/2016: 60 L/ha Flexi N												
Herbicides, insecticides & fungicides	10/04/2016: 200 g/ha Diuron, 1 L/ha Paraquat, 2.5 L/ha Boxer Gold, 200 mL/ha Chlorpyrifos 11/06/2016: 0.5 L/ha ZincMate, 0.450 L/ha LVE MCPA 570, 1 L/ha Jaguar, 0.150 L /ha Tebaconizole 430 SC, 70 L/ha water rate												
Annual Rainfall	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YTD**
	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Treatments

#	Bar	Speed (km/hr)
1	John Deere 1870	7
2	Equalizer 12000V	7
3	Bourgault 3320	7
4	Horsch Sprinter 12NT	7
5	John Deere 1870	8
6	Equalizer 12000V	8
7	Bourgault 3320	8
8	Horsch Sprinter 12NT	8
9	John Deere 1870	9
10	Equalizer 12000V	9
11	Bourgault 3320	9
12	Horsch Sprinter 12NT	9

Bar	Boots	Tyne Spacing (inch)	Fertiliser at seeding
John Deere 1870 with Conserva Pak	Split	12	40 kg/ha Agstar Extra, 60 kg/ha Urea
Equalizer 12000V	Split	11	40 kg/ha Agstar Extra, 60 kg/ha Urea
Bourgault 3320	Single	12	60 kg/ha Agstar Extra
Horsch Sprinter 12NT	Single	12	60 kg/ha Agstar Extra

Results

Due to the demonstration having a number of variables, including fertiliser rates, statistical analysis is not possible. Please interpret results with care.

Table 1: Early plant establishment 22 DAS (days after sowing); growth stage - early tillering.

Bar	Speed (km/hr)	Plants/m^2	Vigour %	Uniformity of plot %	Average across all speeds		
					Plants/m^2	Vigour %	Uniformity %
John Deere 1870	7	147	90	90	161	88	83
	8	157	85	70			
	9	178	90	90			
Equalizer 12000V	7	147	80	70	143	78	77
	8	140	75	80			
	9	143	80	80			
Bourgault 3320	7	130	70	90	133	72	75
	8	131	65	65			
	9	139	80	70			
Horsch Sprinter 12NT	7	117	85	90	145	87	82
	8	160	80	75			
	9	157	95	80			

The tyne depths and press wheels affected early plant establishment. With the favourable start to the season, the firmer furrow formation on the Bourgault restricted root growth compared to the John Deere and Horsch Bars, reflected in the lower plant vigour assessment.

Table 2: Seed depth across three neighbouring furrows 16 DAS, growth stage 2-3 leaf. Target depth was approx. 40mm.

Bar	Speed (km/hr)	Row 1	Row 2	Row 3	Max. difference within plot (mm)	Average difference from target depth (mm)
			Depth (mm)			
John Deere 1870	7	41	50	52	11	8
	8	41	43	52	11	5
	9	48	53	67	19	16
Equalizer 12000V	7	41	50	52	11	8
	8	42	45	47	5	4
	9	48	59	71	23	19
Bourgault 3320	7	41	49	53	12	8
	8	41	42	44	3	2
	9	40	46	52	12	6
Horsch Sprinter 12NT	7	26	38	42	16	-4
	8	35	35	40	5	-3
	9	40	48	49	9	6

The seed depth was measured across three neighbouring rows in order to establish the amount of soil throw at each speed. The 9 km/hr had higher variation in depth in the John Deere and Equalizer. All bars had a target seeding depth of approximately 40mm, however the Horsch was sown slightly shallower than the other bars. The 8 km/hr seeding speed resulted in the seed placement closest to the target depth.

All treatments matured faster than the crop surrounding the trial sown with Butchers own bar, a Bourgault 8810 spring tyne bar with gang press wheels. This is likely to be a result of the individual press wheels on each of the trial bars creating a better seed bed with greater contact seed to the soil, allowing for quicker germination.

The paddock was affected by frost, downgrading all treatments due to the number of frosted grains and light hectolitre weights.

Table 3: Average yield and quality results.

Bar	Yield	Protein	Moisture (%)	Hectolitre (kg/hL)	Frost	Grade
John Deere 1870	1.55	10.4	7.5	72.04	20	AGP1
Equalizer 12000V	1.55	11.3	7.5	70.44	30	AGP1
Horsch Sprinter 12NT	1.36	10.3	7.5	68.56	30	FED1
Bourgault 3320	1.12	11.2	7.6	69.68	50	FED1

Acknowledgements
Thank you to the Butcher family for hosting and maintaining the trial and for helping on the day of seeding.

Contact
Max Kerkmans, AFGRI
mkerkmans@afgri.com.au
(08) 9661 1105

Soil Health Research Results

Liebe Group Soil Biology Trial

Chris O'Callaghan, consultant and Lilly Martin, Liebe Group

Key Messages

- The Soil Biology Trial continues to provide valuable information around the role of soil carbon and microbial biomass in our farming systems.
- Addition of 20 t/ha of organic matter continues to drive up soil carbon levels at around 0.8-0.9 t/ha/yr.
- The grain yield response of the crop to this increase is variable, however most years it drives an increase in crop biomass.
- There is still a significant amount of knowledge to be gained from this trial and we still have a lot to learn about what the true potential of our soils are.

Aim

To investigate the potential for organic matter inputs to increase yield and improve soil health.

Background

This long term trial was established in 2003 to investigate how soil biology and carbon affect crop yield and soil health. The trial site was selected as it had no significant chemical or physical soil constraints, therefore capacity to increase grain production through improved moisture conservation and enhanced soil biota can be demonstrated.

The trial aims to understand how agronomic factors such as yield and grain quality are affected by organic matter (OM) breakdown and cycling. Although the application of 20 t/ha of organic matter is not practical in a commercial farming enterprise this treatment is designed to demonstrate the potential upper limit of organic carbon for sandy soils in our environment. The plots have now received a total of 100 t/ha of organic matter across five separate applications (2003, 2006, 2010, 2012 and 2015) of chaff. Future modelling and soil analysis will determine whether the soil is nearing its upper limit soil organic carbon storage. Recent modelling prior to the latest addition of chaff, suggested the organic matter plots have reached approximately 80% of the attainable soil organic carbon storage capacity.

Trial Details

Property	Long Term Research Site, west Buntine
Plot size & replication	10.5m x 80m x 3 replications
Soil type	Deep yellow sand
Soil pH ($CaCl_2$)	0-10cm: 6.3 10-20cm: 4.8 20-30cm: 4.9
EC (dS/m)	0-10cm: 0.044 10-20cm: 0.024 20-30cm: 0.025
Sowing date	22/04/2016
Seeding rate	3 kg/ha Bonito
Paddock rotation	2012 canola, 2013 barley, 2014 oats, 2015 oats
Fertiliser	22/04/2016: 10 L/ha Flexi N, 10 L/ha Furrow PK, 5 L/ha Calsap 08/06/2016: 60 L/ha Flexi N
Herbicides	01/03/2016: 1 L/ha Glyphosate, 0.4 L/ha Ester 680, 80 mL/ha Triclopyr, 0.25% Liberate 07/04/2016: 1.5 L/ha Paraquat, 15 mL/ha Hammer, 0.2% wetter 22/04/2016: 1.1 kg/ha Atrazine, 550 g/ha Propyzamide, 1.4 L/ha Paraquat, 0.2% wetter 20/05/2016: 1.1 kg/ha Atrazine, 0.5 L/ha Clethodim, 1% sulphate of ammonia, 1% Liberate
Growing season rainfall	222.6mm

2016 Treatment List

1. Minimum tillage (with knife points and full stubble retention).
2. Tilled soil (offset discs).
3. Organic matter (chaff is applied once every 3 years last applied 2015 at rate of 20 t/ha; tilled with offset discs).
4. Organic matter run down (plots with chaff previously applied in 2003 & 2006 but not since).
5. Burnt (stubble burnt annually in March; minimum till). *Burnt plots unable to be completed due to summer rainfall.*
6. Brown manure. *Not conducted in 2016 due to comparison (burnt treatment) not being conducted.*

Table 1: Trial History.

Year	Crop type	Yield range	Treatment notes
2003	Lupin	None recorded	Set up phase: 20 t/ha barley chaff applied, lupin crop brown manured.
2004	Wheat (cv. Wyalkatchem)	2.9-3.5 t/ha	Brown manuring and addition of 20 t/ha organic matter increased yield by 18-22%.
2005	Wheat (cv. Wyalkatchem)	2-2.8 t/ha	Burnt plots yielded 25% higher than control.
2006	Lupins	None recorded	Set up phase: 20 t/ha canola chaff applied, lupin crop brown manured.
2007	Wheat (cv. Wyalkatchem)	None recorded	Sprayed out due to high weed burden.
2008	Wheat (cv. Wyalkatchem)	2.4-3.4 t/ha	Addition of organic matter increased yield by 23% compared to control.
2009	Lupin	1.5 t/ha	Set up phase: lupin crop brown manured.
2010	Wheat (cv. Magenta)	2.5-1.9 t/ha	Set up phase: 20 t/ha oaten chaff applied. No significant yield difference between treatments.
2011	Wheat (cv. Wyalkatchem)	3-3.8 t/ha	No significant difference in yield.
2012	Canola (cv. Telfer)	0.7-0.9 t/ha	Set up phase: 20 t/ha oaten chaff applied, canola crop brown manured.
2013	Barley (cv. Hindmarsh)	2.3-3.6 t/ha	Addition of organic matter increased yield.
2014	Oats (cv. Brusher)	0.49-0.68 t/ha	No significant difference in yield.
2015	Oaten hay (cv. Yallara)	3.6-6.85 t/ha	Set up phase: 20 t/ha oaten chaff applied.
2016	Canola (cv. Snapper)	1.88-2.04 t/ha	Unable to implement burnt treatment, therefore did not brown manure.

Results

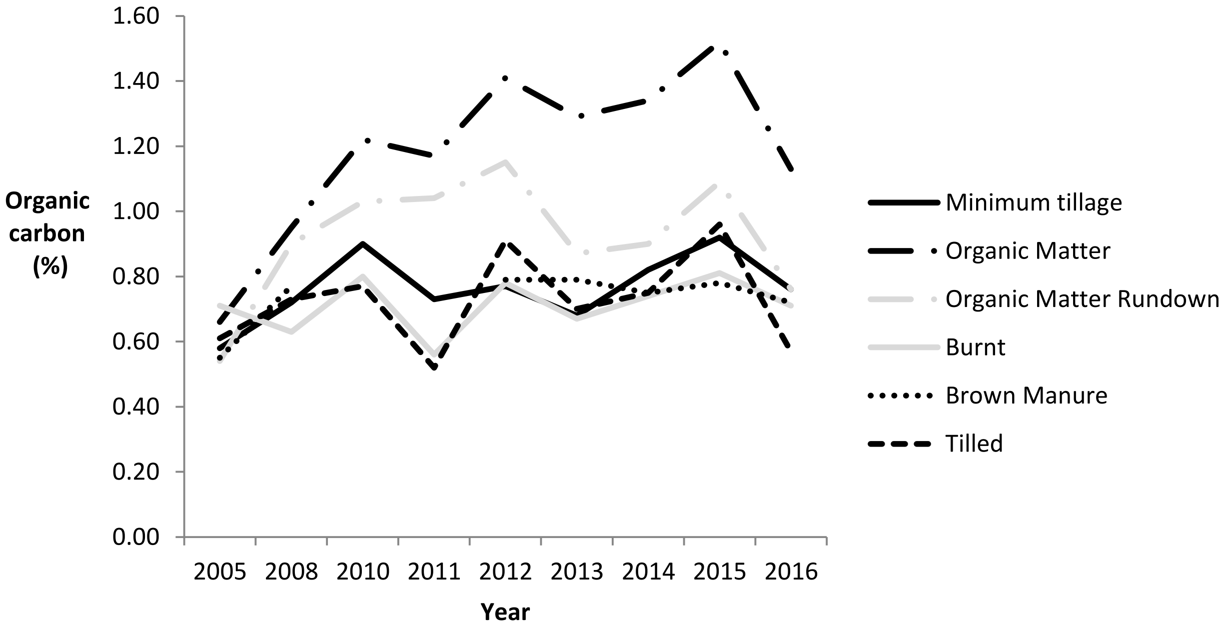


Figure 2: Organic carbon in topsoil (%, 0-10cm) for all treatments in selected years. Note: Organic carbon percentage was not recorded for brown manure treatment in 2010 and 2011.

Table 2: Selected soil properties (0-10, 10-20, 20-30cm) for soil collected at west Buntine, June 2016.

Treatment	0-10cm					10-20cm					20-30cm				
	EC (dS/m)	pH (CaCl2)	Bulk Density	Organic Carbon (%)	Organic Carbon (t/ha)	EC (dS/m)	pH (CaCl2)	Bulk Density	Organic Carbon (%)	Organic Carbon (t/ha)	EC (dS/m)	pH (CaCl2)	Bulk Density	Organic Carbon (%)	Organic Carbon (t/ha)
Minimum tillage	0.044[b]	6.3	1.42[d]	0.76[b]	9.0[b]	0.02[b]	4.8[c]	1.69	0.31	5.3	0.03[b]	4.9	1.76	0.22	3.9
Tilled	0.037[b]	6.2	1.21[ab]	0.57[b]	9.3[b]	0.03[b]	5.3[ab]	1.60	0.39	6.2	0.03[b]	5.0	1.74	0.22	3.8
Tilled + Organic Matter	0.079[a]	6.2	1.17[a]	1.13[a]	18.3[a]	0.07[a]	5.4[a]	1.59	0.44	7.1	0.56[a]	5.6	1.71	0.28	4.8
Organic Matter Rundown	0.450[b]	6.4	1.28[bc]	0.76[b]	9.7[b]	0.03[b]	5.2[abc]	1.72	0.38	6.5	0.03[b]	4.9	1.73	0.19	3.4
Brown Manured	0.040[b]	6.3	1.31[c]	0.72[b]	8.3[b]	0.03[b]	5.4[ab]	1.67	0.38	6.2	0.03[b]	5.5	1.62	0.24	3.9
Burnt	0.043[b]	6.4	1.43[d]	0.71[b]	7.0[b]	0.03[b]	5.0[bc]	1.74	0.30	5.1	0.03[b]	5.5	1.72	0.22	3.7
LSD	*0.02*	*NS*	*0.07*	*0.20*	*7.20*	*0.01*	*0.37*	*NS*	*NS*	*NS*	*0.02*	*NS*	*NS*	*NS*	*NS*
CV (%)	*26.68*	*3.13*	*3.0*	*14.11*	*39.39*	*22.5*	*3.9*	*3.6*	*26.9*	*28.30*	*29.62*	*7.59*	*2.7*	*29.10*	*27.90*
P value	*0.023*	*0.748*	*<0.001*	*0.002*	*0.007*	*<0.001*	*0.035*	*0.056*	*0.515*	*0.722*	*0.030*	*0.157*	*0.53*	*0.716*	*0.760*

Results followed by the same letter do not significantly differ from each other (P= 0.05). Bulk density measurements taken 2015.
NS=Not significant.

Table 3: Selected soil properties (0-10, 10-20, 20-30cm) for soil collected at west Buntine, June 2016.

Treatment	0-10cm					10-20cm					20-30cm				
	NH_4 (mg/kg)	NO_3 (mg/kg)	P (mg/kg)	K (mg/kg)	S (mg/kg)	NH_4 (mg/kg)	NO_3 (mg/kg)	P (mg/kg)	K (mg/kg)	S (mg/kg)	NH_4 (mg/kg)	NO_3 (mg/kg)	P (mg/kg)	K (mg/kg)	S (mg/kg)
Minimum tillage	2	9	28^{b}	63^{b}	5	<1	3^{b}	20	40^{b}	8 $(2.01)^{abc}$	<1	5	5	39^{b}	14
Tilled	3	9	25^{b}	76^{b}	3	<1	7^{b}	20	43^{b}	4 $(1.43)^{c}$	<1	6	7	33^{b}	8
Tilled + Organic Matter	1	18	40^{a}	141^{a}	6	<1	16^{a}	23	158^{a}	14 $(2.55)^{a}$	<1	12	12	135^{a}	19
Organic Matter Rundown	1	10	31^{b}	72^{b}	4	<1	6^{b}	24	58^{b}	6 $(1.83)^{bc}$	<1	6	7	50^{b}	13
Brown Manured	<1	8	27^{b}	73^{b}	3	<1	4^{b}	16	56^{b}	6 $(1.70)^{bc}$	<1	6	7	35^{b}	13
Burnt	2	7	28^{b}	67^{b}	6	<1	5^{b}	18	39^{b}	9 $(2.18)^{ab}$	<1	5	7	34^{b}	15
LSD		*NS*	*7.11*	*17.81*	*NS*		*4.80*	*NS*	*20.88*	*(0.59)**		*NS*	*NS*	*39.13*	*NS*
CV (%)		*17.66*	*13.11*	*11.92*	*35.33*		*38.62*	*24.21*	*17.43*	*16.81*		*15.08*	*16.77*	*39.63*	*13.23*
P value		*0.078*	*0.009*	*<0.001*	*0.242*		*0.002*	*0.473*	*<0.001*	*0.025*		*0.062*	*0.275*	*0.001*	*1.195*

Results followed by the same letter do not significantly differ from each other (P= 0.05).
NS=Not significant.
*log transformed

Table 4: 2016 yield and quality results comparing different tillage and stubble retention treatments in west Buntine from 2010 to 2016. Note: all 2016 treatments achieved CAN1.

Treatment	Canola 2016 (t/ha)	Canola 2016 Protein %	Canola 2016 Oil %	Hay (Oats) 2015 (t/ha)	Oats 2014 (t/ha)	Barley 2013 (t/ha)	Canola 2012 (t/ha)	Wheat 2011 (t/ha)	Wheat 2010 (t/ha)
Brown manure	1.88	16.4[b]	50.0[a]	4.83[c]	0.49	2.74[bc]	Brown manured	-	-
Burnt	1.89	16.7[b]	50.0[a]	4.43[c]	0.63	2.35[d]	0.78	3.78	2.4
Tilled + OM	1.93	20.6[a]	46.5[b]	5.85[b]	0.60	3.69[a]	0.97	4.23	1.9
Minimum tillage	1.94	16.9[b]	50.0[a]	3.64[d]	0.68	2.62[cd]	0.71	3.31	2.5
Tilled	1.96	17.7[b]	49.6[a]	6.85[a]	0.54	2.88[bc]	0.78	3.41	2.4
OM rundown	2.04	17.7[b]	49.3[a]	4.89[c]	0.52	3.03[b]	0.87	4.00	2.5
LSD	*NS*	*2.23*	*1.94*	*0.74*	*NS*	*0.37*	*NS*	*NS*	*NS*
CV (%)	*8.5*	*6.9*	*2.2*	*11.3*	*15.6*	*7.1*	*16.1*	*19.0*	*17.4*
P value	*0.858*	*0.018*	*0.016*	*<0.001*	*0.193*	*<0.001*	*0.236*	*0.513*	*0.439*

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

Comments

Applying 100 t/ha of chaff to the soil, though not currently practical in a broadacre system, has been shown to supply large amounts of nutrients to the soil and drive changes in soil health that have resulted in variable yield increases since the trial was established in 2003.

Yield

In previous seasons significant differences in yield have been observed in treatments where organic matter has been added to the soil. This has been driven by increases in nutrition as well as changes in soil properties, such as improved pH as a result of applying large amounts of organic matter.

In 2016, no statistically significant differences in yield were recorded (table 4), however there were visually significant differences in biomass where OM had been applied. Furthermore, one of the OM plots was difficult to harvest as it had lodged, due to its weight. This had a large effect on harvested yield and it is suspected that this influenced the statistics in this season.

Soil Carbon

In 2012, after 9 years of the running the trial, the Liebe Group reported (March 2012 Newsletter), the addition of 20 t/ha of organic matter every three years, had resulted in an increase of 8 t/ha of carbon (0-30cm) over the control (tilled plots). This year, after 13 years of running the trial, the continued addition of 20 t/ha of organic matter has added an extra 10.9 t/ha of organic carbon into the soil over the control (0-30cm) (Table 2).

There is consistency in these results and it indicates approximately 0.8-0.9 t/ha of carbon added to the soil each year over the life of the trial. Interestingly, the total carbon stock in the plots where the organic matter plots have been left to 'run-down', i.e. no more organic matter applied after 2006, have returned to similar levels of that of the control plot.

Modelling by Fran Hoyle at the University of Western Australia, suggests the upper limit of total carbon storage is 38 t/ha, assuming a continuous cropping system retains 50% of plant material as stubble and uses a water use efficiency of 46% (which is the average for the area).

Building organic carbon takes time and this trial is unique in that it is pushing the system to explore what the long term impacts of building soil carbon are.

Nutrition

The tilled + organic matter plots show potassium levels increased significantly at all depths (table 3) reflecting the applied oaten chaff as a large source of potassium.

There is a trend of increased nitrate levels at all depths, which is statistically significant at 10-20cm and indicates increased storage and mineralisation of N. There is also a trend of increased P levels at all depths where OM had been applied, statistically significant in the 0-10cm zone.

In previous seasons, microbial biomass has been significantly higher in plots where organic matter has been applied, and is potentially one of the drivers behind changes in nutrition. One of the original objectives of this trial was to determine the maximum microbial population and what effect this has on both the soil and crop.

Some of the benefits of a higher microbial population include improved pH buffering capacity, increased nutrient turnover making nutrients more available, improved soil structure and degradation of pesticides and other pollutants (Hoyle, Baldock & Murphy, 2011).

In this trial we have regularly observed increases in grain yield and/or crop biomass, in plots where additional organic matter has been added. However it has not been possible to isolate the contribution of the various changes in soil properties make to this increase. For example, yield and/or crop biomass increase could be driven by an increase in microbial biomass and the aforementioned benefits of this, or it could be driven through increases in soil moisture achieved through the mulching effect applying large amounts of chaff, or it could be the increase in nutrients that have been imported via the chaff. It is highly likely to be combination of all these factors plus more. In continuing this trial, it would be beneficial to begin quantifying the relative contribution of these factors, as it will provide further insights into the role soil biology actually plays in Western Australian cropping systems, leading to practical innovations in this field.

Other observations

Here are some observations of what has occurred in this trial over the 13 years it has been operating:

- Applied organic matter can cause poor seed-soil contact in the first year after application, which can have an effect on crop establishment.
- Most years has seen a significant increase in plant biomass where organic matter has been applied. In some seasons this leads to haying off of the crop, while in other years it results in good yields.
- In some years we have observed a liming effect with the organic matter application.

Conclusion

The big question for this trial though, is what it means for the farmer and Western Australian farming systems? It is not practical to spread 20 t/ha of organic over every paddock. The concept of a brown manure is a potential practice that could replicate this, however it needs to stack up economically, and given the volatility in seasonal conditions it can be difficult to justify. It has nonetheless shown there is an importance in retaining as much organic material on the paddock as possible whether through full stubble retention or spreading chaff back out onto the paddock. However this has to be considered in the context of the full farming system and the necessity of burning or removing material for weed control purposes.

This remains an important trial as it provides an opportunity to study factors such as soil carbon storage potential and soil microbial function, giving insights into what our soils can potentially achieve. While we may not yet have the technology or knowledge that allows us to completely capitalise on this potential, we will at least know that it may be possible to achieve something better, which in turn provides the platform for some innovation and creativity to find a way to achieve it practically and economically.

Acknowledgements
This project is funded by Department of Agriculture and Food, WA; historical funding for this trial has come from the Australian Government Department of Agriculture and Grains Research and Development Corporation.

Reference
Hoyle, F, Baldock, J. & Murphy, D. 2011, 'Soil organic carbon – role in rainfed farming systems: with particular reference to Australian conditions'.

Paper reviewed by: Andrew Wherrett, Living Farm

Contact
Liebe Group
admin@liebegroup.org.au
(08) 9661 0570

Can subsoil constraints be combated economically?

Clare Johnston and Lilly Martin, Liebe Group, Yvette Oliver, CSIRO and Rob Sands, Farmanco

Key Messages

- In 2016, the soil mixing (grizzly or spader) had a greater wheat yield than the control (0.27-0.42 t/ha), regardless of product applied. The incorporation treatments are still being paid off and therefore have not produced the greatest net margin.
- Limesand/No till returned the best net margin for the 2nd consecutive year due to the low yield increases from either application of product or mixing treatment.
- The lime or dolomite treatments had greater yields (0.22-0.5 t/ha) regardless of mixing treatment.
- Care must be taken in interpretation of results due to pH variation across the site.

Aim

To determine which ameliorant practice is the most effective and economic in remediating subsoil acidity at depth.

Background

It is estimated that more than 14.25 million hectares in the Western Australian Wheatbelt is acidic or at risk to become acidic (Gazey et al, 2014) making acidity one of the major limiting production factors to modern day farming systems. In monetary terms this is estimated to cost the agricultural industry $498 million per annum equating to 9% of WA's annual crop (Herbert, 2009).

Soil acidity is a natural process however; modern farming systems accelerate the process through production (Gazey, P, 2015). Two of the main contributing factors to soil acidification in broadacre cropping systems is the use of ammonium based fertilisers and the export of alkaline products in the form of crop (Gazey & Ryan, 2015 a).

Aluminium toxicity is one of the major subsoil constraints that are clearly linked to soil acidity. Elevated levels of aluminium in the soil lead to root pruning resulting in decreased crop growth and yield. Generally aluminium toxicity will be an issue if your soil pH is ≤ 4.3 (Gazey & Ryan, 2015 b). 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, grizzly) 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 1m in a selection of the plots.

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 tammin sand
Soil pH ($CaCl_2$)	Figure 1
EC (dS/m)	Table 2
Sowing date	23/05/2016
Seeding rate	65 kg/ha Mace wheat
Incorporation	23/02/2015: Tiny Grizzly (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
Fertiliser	07/03/2016: 40 kg/ha MoP 23/05/2016: 55kg/ha DAPSZC 28/06/2016: 75 kg/ha Urea
Herbicides & Fungicides	24/04/2016: 2 L/ha Glyphosate 450, 300 mL/ha LV Ester 680, 5 g/ha Metsulfuron, 0.25% SP 700 Surfactant 23/05/2016: 2.2 L/ha Glyphosate 450, 300 mL/ha LV Ester 680, 20 mL/ha Hammer, 2 L/ha Trifluralin 480, 2 L/ha Boxer Gold, 200 mL/ha Chlorpyrifos 500EC, 1% Ammonium Sulphate 06/07/2016: 1 L/ha Velocity, 0.5% MOS
Growing season rainfall	90mm (Jan-April), 179mm GSR (April – Oct)

Table 1: The mixing treatments and the products applied in the Liebe lime trial at Barnes property (randomised over three replications).

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

Results

Now in its second year, crop establishment was far better with an established seed bed. Frost was not an issue on the site in 2016. The trial has a number of factors influencing the results with inconsistent soil acidity profiles and a large weed burden. Both factors are believed to have had an impact on yield and quality. As a result, care must be taken when interpreting data.

Limesand was applied to the paddock on two occasions prior to the trial being implemented in 2009 (1 t/ha) and 2014 (1.5 t/ha). From the baseline soil results in Figure 1a it can be observed that this lime has not moved through the profile and is still sitting in the 0-5cm layer of topsoil.

Table 2: Baseline soil properties (0-40cm) collected prior to treatments being imposed, February 2015 by Liebe Group.

Depth (cm)	EC (dS/m)	Organic Carbon (%)	NH_4 (mg/kg)	$N0_3$ (mg/kg)	Phosphorus Cowell (mg/kg)	Potassium Cowell (mg/kg)	Sulphur (mg/kg)	Aluminium (meq/100g)
0-5	0.104	0.79	3	23	38	42	15.4	0.12
5-10	0.048	0.71	1	13	36	24	9.7	0.24
10-20	0.029	0.36	1	7	16	22	11.6	0.42
20-30	0.025	0.28	1	5	6	17	19.4	0.34
30-40	0.025	0.16	2	4	3	18	24.7	0.24

Variability of pH across the trial

The pH was measured in 10 plots across the trial in 2015 (after 1.5 t/ha lime applied in 2014) but prior to the mixing and lime treatments being applied. Soils are classed as acidic when the pH is less than 5.5 in topsoil and less than 4.8 at depth (Gazey et al. 2014). There were two types of pH profiles which related to difference in the soil type (as classed by CSBP) (Figure 1a).

1) Acid band - Soils which are acidic in 10-30 or 10-40cm layers and not acidic below these depth. These were more commonly the sandy earth (more clay soils).
2) Acid to depth – Soil which were acidic from 5cm to 60cm or deeper (these were the sandy soils).

After the soil restructuring was applied and settled over 2015, the soil was resampled in every plot in May 2016. The soils were then separated into 5 classes using as acidic (Fig 1b).

1) Acid to depth
2) Acid from 10-20cm layer to depth
3) Acid band 10-20cm layer and non-acid at depth
4) Acid band 10-30cm layers and non-acid at depth
5) Non-acid

There were moderate aluminium levels (2-4ppm) in the acid 0+ and acid 10/20+ profiles. However these pH profiles belonged to a range of management options (treatment by product).

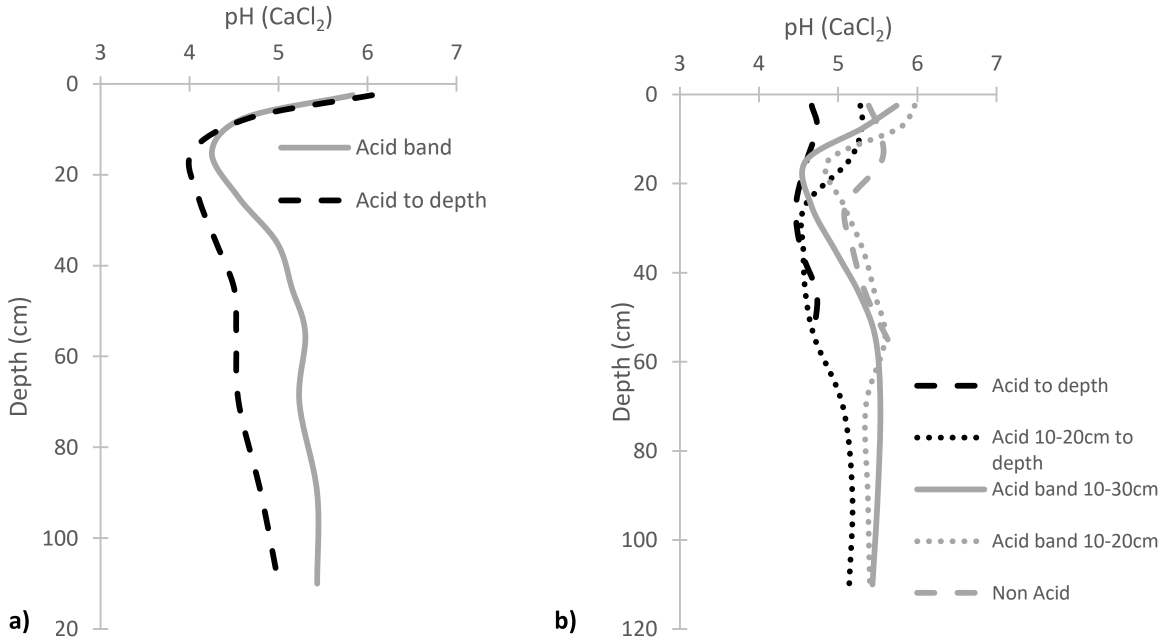
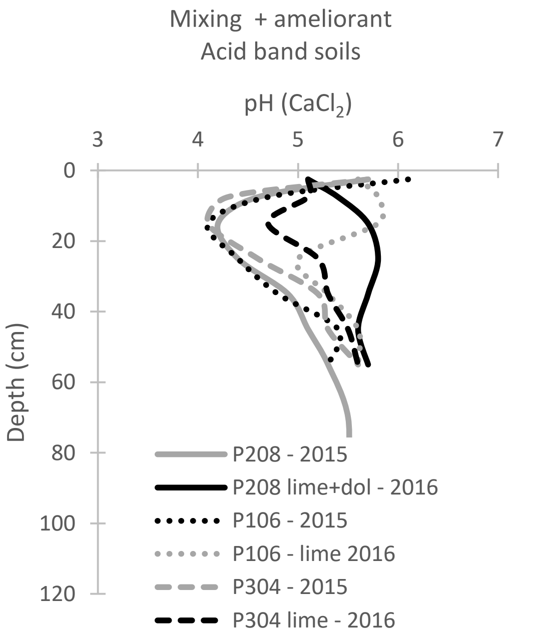
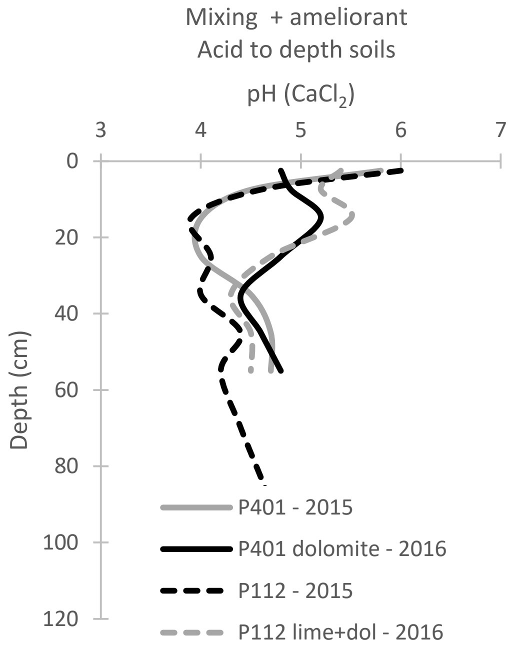


Figure 1: The pH profile for the 10 plots measured in 2015 grouped by their profile type as Acid to depth (**--**) and Acid band soils (--) (a) and the five different pH profile types of all plots (48) after soil mixing treatments and different products have been imposed measured in 2016 (b).

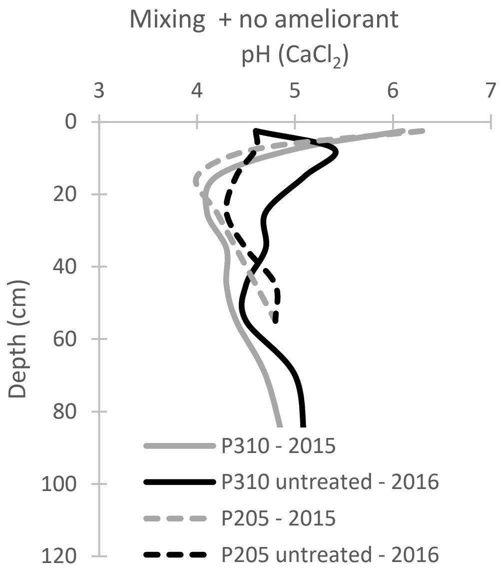
The changes in the pH profiles from lime and mixing can be seen with the 10 pH profiles which were measured before and one year after treatments had been applied (Fig 2). Mixing with product reduced the high pH in the 0-10cm layer, and increased the pH in the 10-30cm layers (Fig 2a,b). Without mixing, the products did not greatly change the pH of the soil (Fig 2d).



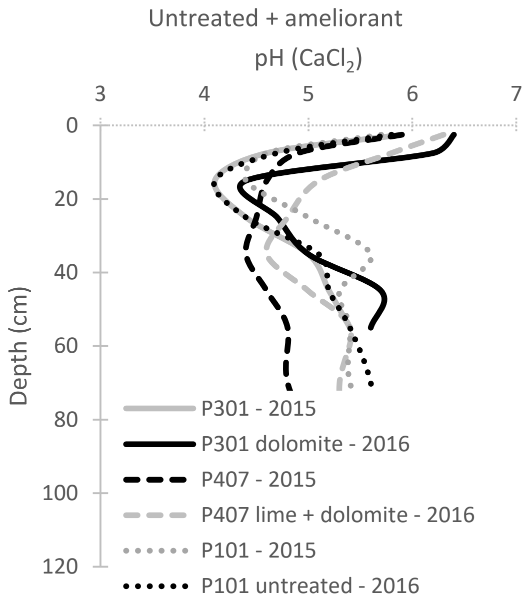
a)



b)



c)



d)

Figure 2: The pH profiles of the 10 plots which were measured in 2015 and 2016, grouped by mixing (grizzly/spading or none) and addition of lime (or lime + dolomite or none) separated into acid to depth or acid band pH profile type**.**

Weed burden and crop establishment
The site had a significant weed burden, particularly brome grass and radish, which had a significant impact on grade and is expected to have had a detrimental effect on yield. Tillage treatments didn't have a significant effect on weed burden in the final grain sample.

Crop establishment was much more even in the second year following the grizzly and spading. All plots averaged 19-22 plants/m^2 in comparison to last year's poorer establishment of approximately 8 plants/m^2 on the grizzly and spaded treatments.

Harvest results
The 2016 growing season received 179mm rainfall with only 10 rainfall events over 10mm. Soil moisture probes showed the small events only filled the top 20cm of the soil profile. This is believed to have limited treatment response as the increased soil profile available was not capitalised. In a lower rainfall year or when rainfall is more sporadic the benefit of ameliorated subsoils is expected to be more evident.

All lime + dolomite treatments have performed unusually poorly (Table 3) in comparison to the products individually. This is not due to the products but instead reflective of the original soil profile which is more acid. Five of the nine lime + dolomite treatments were acid 10-20cm to depth with only one treatment classified as non-acid.

Table 3: Main effect of lime treatments on yield and quality at west Wubin, 2016.

Treatment Number	Lime Treatment	Yield (t/ha)	Protein (%)	Hectolitre (kg/hL)	Screenings (%)
1,2,3	Control	2.22 b	9.35 b	80.78	3.14
4,5,6	Limesand	2.40 ab	9.56 a	79.97	2.84
7,8,9	Dolomite	2.72 a	9.33 b	80.53	2.78
10,11,12	Lime & Dolomite	2.18 b	9.50 ab	74.00	2.67
P value		*0.016*	*0.033*	*0.351*	*0.608*
LSD		*0.358*	*0.108*	*NS*	*NS*
CV (%)		*18.1*	*2.3*	*13.4*	*30.9*

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

Table 4: Main effect of tillage treatments on yield and quality at west Wubin, 2016.

Treatment Number	Tillage Type	Yield (t/ha)	Protein (%)	Hectolitre (kg/hL)	Screenings (%)
1,4,7,10	No Till	2.15 b	9.32 b	75.39	2.97
2,5,8,11	Spader	2.57 a	9.54 a	81.38	2.95
3,6,9,12	Grizzly	2.42 ab	9.44 ab	79.70	2.65
P value		*0.028*	*0.022*	*0.267*	*0.516*
LSD		*0.310*	*0.156*	*NS*	*NS*
CV (%)		*18.1*	*2.3*	*13.4*	*30.9*

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

Table 5: Interaction of cultivation and lime on yield and quality results for Mace wheat at west Wubin, 2016.

Treatment Number	Lime Treatment	Tillage Type	Yield (t/ha)		Protein (%)		Hectolitre (kg/hL)	Screenings (%)
1	Control	No Till	1.90	cd	9.33	bc	80.51	3.28
2	Control	Spader	2.34	abcd	9.48	b	81.90	3.72
3	Control	Grizzly	2.41	abcd	9.25	bc	79.94	2.41
4	Limesand	No Till	2.52	abc	9.08	c	80.54	2.78
5	Limesand	Spader	2.78	ab	9.43	b	81.14	3.12
6	Limesand	Grizzly	2.86	a	9.48	b	79.92	2.44
7	Dolomite	No Till	2.29	abcd	9.35	bc	80.03	2.76
8	Dolomite	Spader	2.74	ab	9.83	a	80.94	2.51
9	Dolomite	Grizzly	2.17	bcd	9.50	b	78.94	3.24
10	Lime & Dolomite	No Till	1.88	d	9.53	ab	60.49	3.05
11	Lime & Dolomite	Spader	2.43	abcd	9.45	b	81.53	2.46
12	Lime & Dolomite	Grizzly	2.23	bcd	9.53	ab	80.00	2.49
P value			*0.042*		*0.011*		*0.309*	*0.534*
LSD			*0.619*		*0.312*		*NS*	*NS*
CV (%)			*18.1*		*2.3*		*13.4*	*30.9*

NS=Not significant.

Economic Analysis

For the second year the lime sand/no till treatment has given the greatest gross return at 225% Return on Investment (ROI) in 2015 and 190% in 2016, returning a net benefit of $334.95/ha. While still producing return on investment, the lime/dolomite/spader (11) treatment has yet to produce a net benefit, Table 6. This is reflecting the -11% ROI from 2015 and only 59% ROI in 2016 which means the payback period is more than two years. In 2016 the poorest performing treatment was the lime/dolomite/no till (10), Table 6.

Table 6: Economic analysis of different soil ameliorant treatments at west Wubin, 2015, 2016 and combined.

Treatment #	Investment - Cultivation	Investment - Product	Total Investment	Yield	Average Profit 2015	Return on Investment 2015	Yield	Average Profit 2016	Return on Investment 2016	Combined Profit	Extra Profit/year from Investment	Average Return on Investment	Net Benefit (Combined Profit - Investment)
11	$120.00	$84.15	$204.15	2.1	66	-11%	2.43	132	59%	199	49	24%	-$5.22
10	$0.00	$84.15	$84.15	1.8	94	8%	1.88	7	-7%	101	0	0%	$17.24
2	$120.00	$0.00	$120.00	1.8	104	13%	2.34	112	83%	216	57	48%	$95.84
12	$85.00	$84.15	$169.15	2.1	179	54%	2.23	87	44%	266	83	49%	$96.86
9	$85.00	$60.00	$145.00	1.9	169	56%	2.17	75	43%	244	71	49%	$98.67
1	$0.00	$0.00	$0.00	1.8	88		1.90	13		101			$100.95
8	$120.00	$60.00	$180.00	1.9	125	20%	2.74	205	107%	330	114	64%	$149.66
5	$120.00	$74.20	$194.20	2.2	207	61%	2.78	213	103%	419	159	82%	$225.18
7	$0.00	$60.00	$60.00	2.3	219	218%	2.29	102	149%	321	110	183%	$260.77
6	$85.00	$74.20	$159.20	2.2	209	76%	2.86	232	138%	441	170	107%	$281.51
3	$85.00	$0.00	$85.00	2.4	245	184%	2.41	129	137%	374	136	160%	$288.63
4	$0.00	$74.20	$74.20	2.2	255	225%	2.52	154	190%	409	154	208%	$334.95

Note: Grain prices based on farm gate price, standard across all treatments.

Total Cropping Costs based on the actual Fertilisers and Chemicals applied plus the Farmanco Benchmarking 2015 low and medium rainfall average crop costs including fixed costs of $125/ha and excluding Fertiliser and Chemical have been utilised.

Cultivation cost based on an average contractor rate of $85/ha (Grizzly) $120/ha (Spader). Cartage cost based on contractor rate of $10/t dolomite (Watheroo) and $21/t limesand (Greenhead). Spreading of lime treatments based on contractor rate of $8/ha. Cost of lime applied prior to trial being implemented not taken into account.

Table 7: Economic analysis of different lime treatments at west Wubin, 2015, 2016 and combined.

Product	Investment - Cultivation	Investment - Product	Total Investment	Yield 2015	Average Profit 2015	Return on Investment 2015	Yield 2016	Average Profit 2016	Return on Investment 2016	Combined Profit	Extra Profit/year from Investment	Average Return on Investment	Net Benefit (Combined Profit - Investment)
Control	$68.33	$0.00	$68.33	2.0	$104.48	-	2.22	$43.66	-	$148.14	$64.60	-	$79.81
Lime Sand	$68.33	$74.20	$142.53	2.2	$182.52	55%	2.40	$158.56	81%	$341.08	$161.07	61%	$198.55
Dolomite	$68.33	$60.00	$128.33	2.0	$129.85	20%	2.72	$86.18	33%	$216.03	$98.54	39%	$87.70
Lime/ Dolomite	$68.33	$84.15	$152.48	2.0	$72.24	-21%	2.18	$34.54	-6%	$106.78	$43.92	-60%	-$45.71

Table 8: Economic analysis of different cultivation treatments at west Wubin, 2015, 2016 and combined.

Tillage	Investment - Cultivation	Investment - Product	Total Investment	Yield 2015	Average Profit 2015	Return on Investment 2015	Yield 2016	Average Profit 2016	Return on Investment 2016	Combined Profit	Extra Profit/year from Investment	Average Return on Investment	Net Benefit (Combined Profit - Investment)
No Till	$0.00	$54.59	$54.59	2.0	$123.16	-	2.15	$27.90	-	151	66	-	$96.48
Spader	$120.00	$54.59	$174.59	2.0	$84.41	-22%	2.57	$124.54	55%	209	95	54%	$34.37
Grizzly	$85.00	$54.59	$139.59	2.2	$159.24	26%	2.42	$89.76	44%	249	115	82%	$109.42

The lime sand treatments appear to be retaining the benefits (or increasing in the second year) while the Grizzly only treatment is dropping rapidly as the initial response was likely to be due to the large release of nitrogen through increased mineralisation (Davies, 2011).

References

Davies, S. (2011). Using mouldboard ploughs and rotary spaders to ameliorate water repellent sandplain soil – where do they fit? Esperance Crop Updates.

Gazey, C., Davies, S., Master, D. (2014). Soil Acidity: A Guide for WA Farmers and Consultants (2nd Edition). Bulletin 4858.

Gazey, C., and Ryan, L. (2015 a) Causes of soil acidity. Retrieved November 5, 2015, from https://www.agric.wa.gov.au/soil-acidity/causes-soil-acidity

Gazey, C., and Ryan, L. (2015 b) Effects of soil acidity. Retrieved November 5, 2015, from https://www.agric.wa.gov.au/soil-acidity/effects-soil-acidity

Gazey, P. (2015) Factsheet Soil Acidity. Retrieved November 5, 2015, from http://www.soilquality.org.au/factsheets/soil-acidity

Herbert, A. (2009). Opportunity cost of land degradation hazard in the south-west agricultural region. Resource management technical report 349, Department of Agriculture and Food, Western Australia.

Hollamby, N., Petersen, E. (2012). Liebe Group Technical Audit Results Executive Summary.

Acknowledgements

Many thanks to the Barnes family for all their help and input in setting up and managing the trial. Thanks to McIntosh and Son, Wongan Hills for use of the Tiny Grizzly and to Rohan Broun, Liebe member, for his time and the use of the spader; Scott's Watheroo Dolomite for donating dolomite and the McNeill family, Dalwallinu for donating the limesand. Michael MacPherson, Imtrade for completing the statistical analysis and Rob Sands, Farmanco for the economic analysis.

This trial is funded by GRDC through LIE00008: Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management.

This trial is also supported by GRDC funded project DAW00242: Subsoil constraints - understanding and management and through support from the Wheatbelt NRM.

Paper reviewed by: Wayne Parker, DAFWA

Contact

Liebe Group
admin@liebegroup.org.au
(08) 9661 0570

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/

Demonstration of deep offset discs over three soil types at west Wubin

Clare Johnston and Lilly Martin, Liebe Group

Key Messages

- The Grizzly treatment of the red clay and yellow tammin soil types resulted in a response in the first year which more than covered the cost of the treatment.
- The response in the second year was a lot lower but still return a return on the investment cost of the Grizzly treatment.
- Cultivating the yellow tammin soil type changed it from a loss making soil type into a profitable soil type.
- The acid sand soil type made a large loss over the two years. The cultivation improved the result by a significant amount although it was still unprofitable. However the cultivation did improve the income enough to cover the variable costs and make a small contribution to fixed costs.
- Establishment was an issue on grizzly plots.
- Care must be taken in interpreting results as the demonstration was not fully replicated.

Aim

To determine the effect of incorporating lime using deep offset discs on yield and quality over three different soil types.

Background

Soil acidity is a major constraint in WA agricultural areas, with an estimated 14.25 million hectares of Wheatbelt soils affected to the point of restricting production and agricultural sustainability (Gazey et al, 2014). In 2015 the Liebe Group, West Midlands Group and Mingenew-Irwin Group surveyed over 130 farmers in the Northern Agricultural Region (NAR) on subsoil constraints and associated penalties. Of these, 68% rated soil acidity as their number one constraint. The grower group's survey represented 1.1 million hectares of agricultural land in the NAR. If each farmer is losing 5% wheat yield at $250/t, the region is missing out on $27.5 million every year.

The demonstration paddock has three very different soil types which lead to difficulties in management. The Barnes' identified the issues in the paddock as having the potential to be remediated through cultivation and liming. The paddock was top dressed with lime on two occasions (see demonstration details), but there was no significant improvement in yield. pH indicator testing carried out prior to cultivation showed that limesand top dressed in 2009 and 2014 was still sitting in the 0-2cm layer of the topsoil (average pH 7-7.5 (H_2O) decreasing to 6-4 (H_2O) in the 3-10cm). $CaCl_2$ pH testing was only carried out in 10cm increments and indicated an average 0.8 units lower than H_2O. These demonstrations tested the responsiveness of deep lime incorporation abilities by the cultivator (Tiny Grizzly, 36 inch discs) over three different soil types in the same paddock and rainfall zone at west Wubin. This is the second crop following incorporation to determine impact after initial nutrient flush.

Demonstration Details

Property	AJ & JA Barnes, west Wubin
Plot size	6.8m x 200m x various replications*
Soil type	Acid sand, yellow tammin sand, heavy red clay
Soil pH ($CaCl_2$)	See Table 1
EC (dS/m)	See Table 1
Sowing date	23/05/2016
Seeding rate	65 kg/ha Mace
Incorporation	23/02/2015: Tiny Grizzly; 36 inch discs
Lime history	2009: 1 t/ha lime, 2014: 1.5 t/ha lime
Paddock rotation	2012 wheat, 2013 fallow, 2014 wheat, 2015 wheat
Fertiliser	07/03/2016: 40 kg/ha MoP on yellow tammin and acid sand only 23/05/2016: 50 kg/ha DAPZAC 28/06/2016: 75 kg/ha Urea
Herbicides, insecticides & fungicides	25/04/2016: 2 L/ha Glyphosate, 300 mL/ha Ester 680, 5 g/ha Metsulfuron, 0.25% sp700 23/05/2016: 2.2 L/ha Glyphosate, 20 mL/ha Hammer, 300 mL/ha Ester 680, 2 L/ha Trifluralin, 2 L/ha Boxer Gold, 200 mL/ha Chlorpyrifos, 1% Ammonium Sulfate 06/07/2016: 1 L/ha Lobak, 200 mL/ha Tebuconizole, 500 mL/ha LVE MCPA 19/08/2016: 200 mL/ha Chlorpyrifos, 250 mL/ha Tebuconizole
Growing season rainfall	90mm Jan-March, 179mm GSR (April – Oct)

Note: *Acid sand and yellow tammin sand have three replications. Heavy red clay has only two replications.

Results

This is a nearest neighbour farmer demonstration which is not fully replicated, results should be treated with caution. Now in its second season there has been limited yield or quality response between treatments. This could be explained by the regular, small rainfall events of 2016 which kept the top 20cm of the soil profile moist, limiting benefit of greater soil profile in cultivated plots.

Table 1: Soil results for selected properties (0-40cm) collected May 2016 at Wubin.

Depth (cm)	EC (dS/m)	pH ($CaCl_2$)	Aluminium (mq/kg)	EC (dS/m)	pH ($CaCl_2$)	Aluminium (mg/kg)
	Acid sand Grizzly			**Acid sand Control**		
0-10	0.035	5.3	0.34	0.030	5.9	0.20
10-20	0.040	5.1	0.75	0.028	4.6	0.97
20-30	0.028	4.9	0.28	0.023	5.4	0.20
30-40	0.019	5.4	0.20	0.023	5.5	0.20
	Yellow tammin sand Grizzly			**Yellow tammin sand Control**		
0-10	0.049	4.9	0.40	0.035	5.5	0.24
10-20	0.035	4.4	3.07	0.026	4.2	7.16
20-30	0.027	4.4	4.61	0.026	4.4	3.84
30-40	0.025	4.8	1.16	0.026	4.8	0.48
	Heavy red clay Grizzly			**Heavy red clay Control**		
0-10	0.145	5.7	0.20	0.126	5.9	0.20
10-20	0.042	6.0	0.20	0.038	5.9	0.20
20-30	0.039	6.3	0.20	0.032	6.1	0.20
30-40	0.045	6.5	0.20	0.062	6.7	0.20

Table 2: Average yield and quality results for Mace wheat grown at west Wubin in 2016.

Soil Type	Treatment	2015 Yield (t/ha)	2016 Yield (t/ha)	Protein (%)	Hectolitre (g/hL)	Screenings (%)	Moisture (%)	Grade
Acid sand	Grizzly	1.3	1.2	9.6	80.5	9.3	9.5	AGP1
	Control	0.5	0.9	9.3	78.7	13.4	9.6	FED1
Red clay	Grizzly	3.3	2.9	9.6	81.2	1.0	9.2	ASW1
	Control	2.9	2.8	9.7	81.1	1.0	9.2	ASW1
Yellow tammin sand	Grizzly	1.8	1.7	9.3	81.3	3.3	9.5	ASW1
	Control	1.3	1.7	9.5	81.7	3.3	9.5	ASW1

Note: All treatments were top dressed with 1 t/ha lime in 2009 and 1.5 t/ha in 2014.

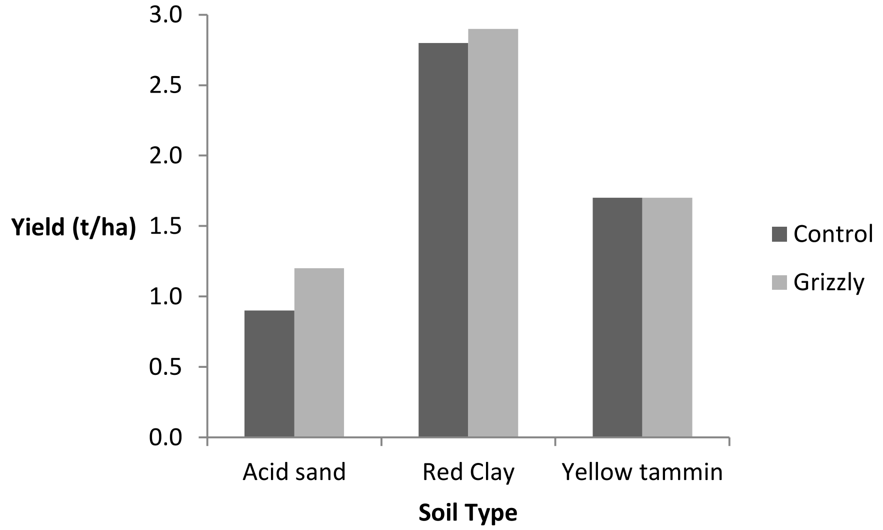


Figure 1: Yield results of Mace wheat grown at west Wubin in 2016.
Note: All treatments were top dressed with 1 t/ha lime in 2009 and 1.5 t/ha in 2014.

Economic Analysis

Table 3: Economic analysis for deep offsets over three different soil types at west Wubin, 2016.

Soil Type	Treatment #	Investment - Cultivation	Total Investment	Average Profit 2015	Return on Investment 2015	Average Profit 2016	Return on Investment 2016	Combined Gross Margin	Combined Profit	Extra Profit/year from Investment	Average Return on Investment	Net Benefit (Combined Profit - Investment)
Acid sand	Control	$0.00	$0.00	-229		-252		-232	-482			-481.56
Acid sand	Grizzly	$85.00	$85.00	-22	244%	-169	98%	59	-191	145	171%	-275.57
Red clay	Control	$0.00	$0.00	394	0%	234		878	628	0		627.82
Red clay	Grizzly	$85.00	$85.00	511	138%	253	23%	1015	765	68	81%	679.77
Yellow tammin	Control	$0.00	$0.00	-34	0%	-29		187	-63	0		-62.56
Yellow tammin	Grizzly	$85.00	$85.00	105	163%	-18	13%	337	87	75	88%	2.03

Note: Grain prices based on farm gate price, ANW1 for all 2015 samples, 2016 quality varied between soil types impacting grade (see Table 2).
Total Cropping Costs based on the actual Fertilisers and Chemicals applied plus the Farmanco Benchmarking 2015 low and medium rainfall average crop costs including fixed costs of $125/ha and excluding Fertiliser and Chemical have been utilised.
Cultivation (Grizzly) cost based on an average contractor rate of $85/ha.

Comments

As these demonstrations were implemented opportunistically there are no baseline soil pH results. However, pH indicator testing carried out prior to offsetting showed that limesand top dressed in 2009 and 2014 was still sitting in the 0-2cm layer of the topsoil (average pH 7-7.5 (H_2O) decreasing to 6-4 (H_2O) in the 3-10cm). This information highlights the importance of incorporating lime products.

The acid sand samples for both the grizzly and control were downgraded due to excess screenings. These were consistent of cracked grain. The cause of the cracked grain is unknown, harvester settings were not changed and there was little change in environmental conditions.

The Grizzly treatment of the red clay and yellow tammin soil types resulted in a response in the first year which more than covered the cost of the treatment, which is a one year payback and therefore a low risk investment. A significant part of this response is likely to be the increased availability of a number of nutrients from the mineralisation through the cultivation of the soil, with the remainder being from the act of mixing the lime to get a reduction in aluminium toxicity in the root zone. The response in the second year was a lot lower but still gave a return on the investment cost of the Grizzly treatment.

Importantly the Grizzly treatment changed the result on the yellow tammin soil type from a loss making outcome over the two years to a profitable outcome. Future years may see this difference increase as the pH in the treated area is corrected.

The acid sand soil type made a large loss over the two years. Reinforcing the need to assess the suitability of some soil types for cropping in the first place, or looking to apply a lower cost structure to these soil types to try and generate a small profit margin. The Grizzly treatment improved the income of the acid sand by a significant amount however it was still unprofitable over the two years. It is worth noting that the Grizzly treatment did change the ability of the soil type to cover its variable costs. The combined gross margin of the Grizzly treatment of $59 means at least this treatment would allow the soil type to make a small contribution to fixed costs rather than increasing the burden on the remainder of the farm. It will be interesting to see whether the longer term results enable this soil type to continue to cover the variable costs, as most of the benefit was in the first year.

References

Gazey, C., Davies, S., Master, D. (2014). Soil Acidity: A Guide for WA Farmers and Consultants (2nd Edition). Bulletin 4858.

Acknowledgements

This project is supported by funding from the Australian Government.
Many thanks to the Barnes family for all their help and input in setting up and harvesting the demonstrations. Thanks to Rob Sands, Farmanco for technical support and McIntosh and Son, Wongan Hills for the use of the Tiny Grizzly.

Paper reviewed by: Rob Sands, Farmanco

Contact

Liebe Group
admin@liebegroup.org.au
(08) 9661 0570

Wodjil workout - rise of the pH

Tyrone Henning, Director/Agronomist, Tek Ag

Key Messages

- Good year, highlighted site variation.
- Site variation has clouded the effects of lime application and incorporation.
- pH is changing in midsoils within incorporated treatments.
- Expensive incorporation methods are cost prohibitive.
- Compaction issues are becoming a problem at the site.

Aim

To identify economical rates and methods of lime incorporation.

Background

The trial was initially setup in 2014 to test different methods of lime incorporation and rate responses over the long term i.e. 20 years. The treatments applied in 2014 compared seven incorporation methods; no incorporation, one disc, twin disc, mouldboard, spader, chisel plough and scarifier, across six rates of lime; 0, 1, 2.5, 5, 7.5 and 10 t/ha.

The initial project, 'Wodjil Workout', was only funded for one year, and due to the tough season of 2014, there were minimal responses to applied lime. The project has since been extended until the end of 2017 season. The site has very low pHs of 3.4 - 4.1 ($CaCl_2$) and extremely high aluminum levels ranging between 30-60ppm.

2014 and 2015 were both very harsh years. This resulted in minimal differences between treatments due to weather conditions being the major limiting factor. Having insufficient moisture to facilitate chemical reactions between the lime and acid soil would have limited pH change. 2016 however, had good summer rainfall and a kind finish, which could be argued to favor the control treatments. There is variation within the site which has been expressed in 2016, see yield and biomass.

Trial Details

Property	Vancarla, north west Koorda		
Plot size & replication	27.5m x 27.5m, nearest neighbour control		
Soil type	Deep wodjil sandy loam		
Soil pH ($CaCl_2$)	0-10cm: 3.8-4.2	10-20cm: 3.7-4.1	20-30cm: 3.4-3.8
EC (dS/m)	0-10cm: 0.04933	10-20cm: 0.0353	
Paddock rotation:	2014 triticale, 2015 triticale		
Sowing date	19/04/2016		
Sowing rate	60 kg/ha Carrolup oats		
Fertiliser	19/04/2016: 38 kg/ha MAP, 40 kg/ha Urea (banded) 09/06/2016: 45 kg/ha Urea, 45 kg/ha MOP		
Herbicides, insecticides & fungicides	19/04/2016: 1.1 L/ha Metalochlor 720, 500 g/ha Diuron, 110 mL/ha Alpha-cypermethrin + Chlorpyrifos, 1 L/ha Glyphosate 450, 100 mL/ha Oxyflurofen, 1% AMS, 0.2% BS1000 02/06/2016: 1.25 L/ha Precept, 180 mL/ha Dicamba 500, 60 g/ha Lontrel, 0.5% Uptake		
Growing season rainfall	220mm		

Results

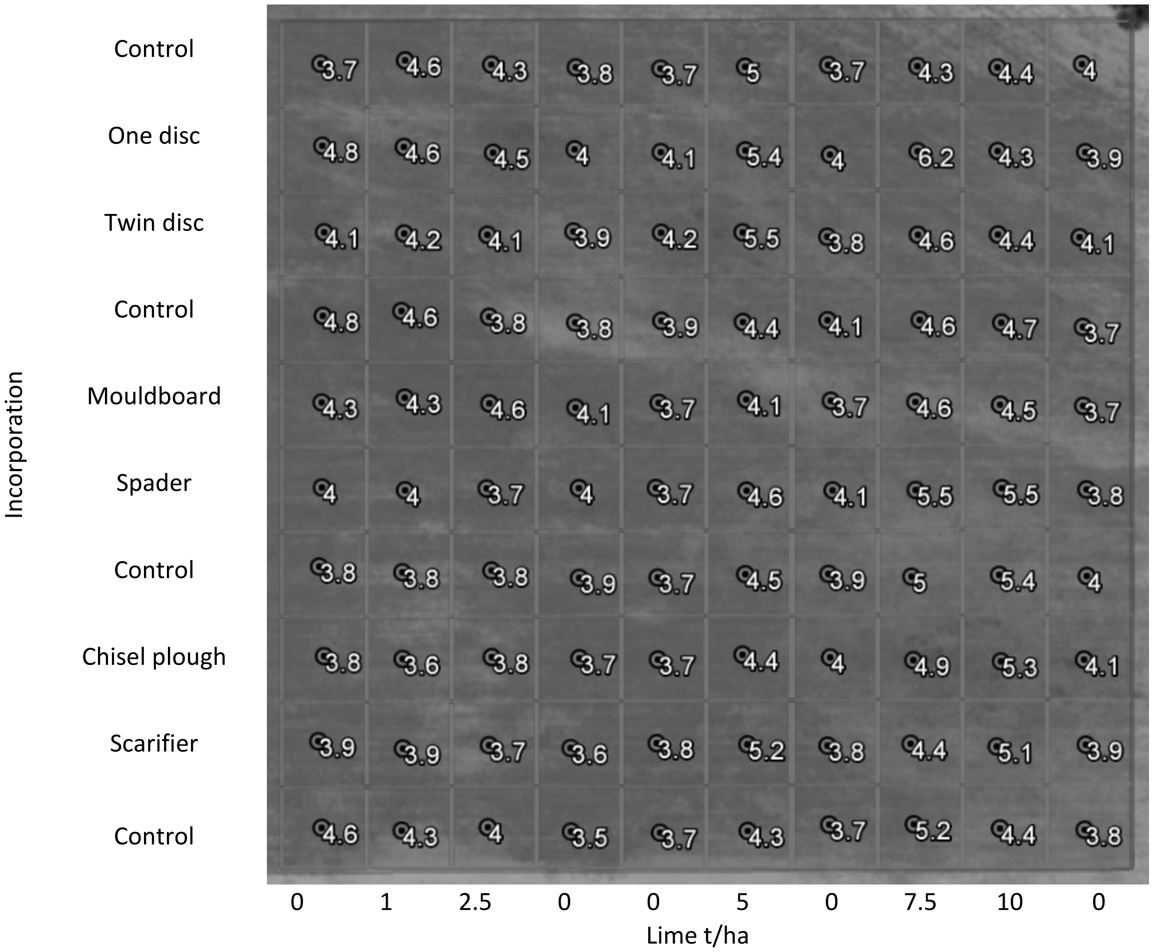


Figure 1: Midsoil pH 10-20cm tested April 2016 by Soiltech.

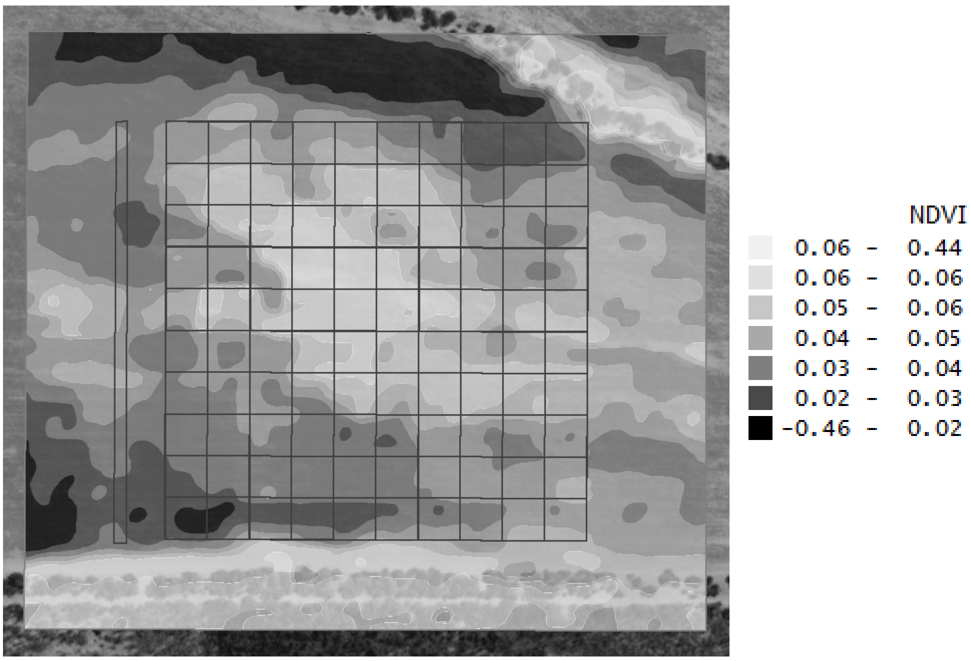


Figure 2: NDVI imagery taken 27/08/16 which demonstrates biomass variation. Light = poor crop, dark = good crop.

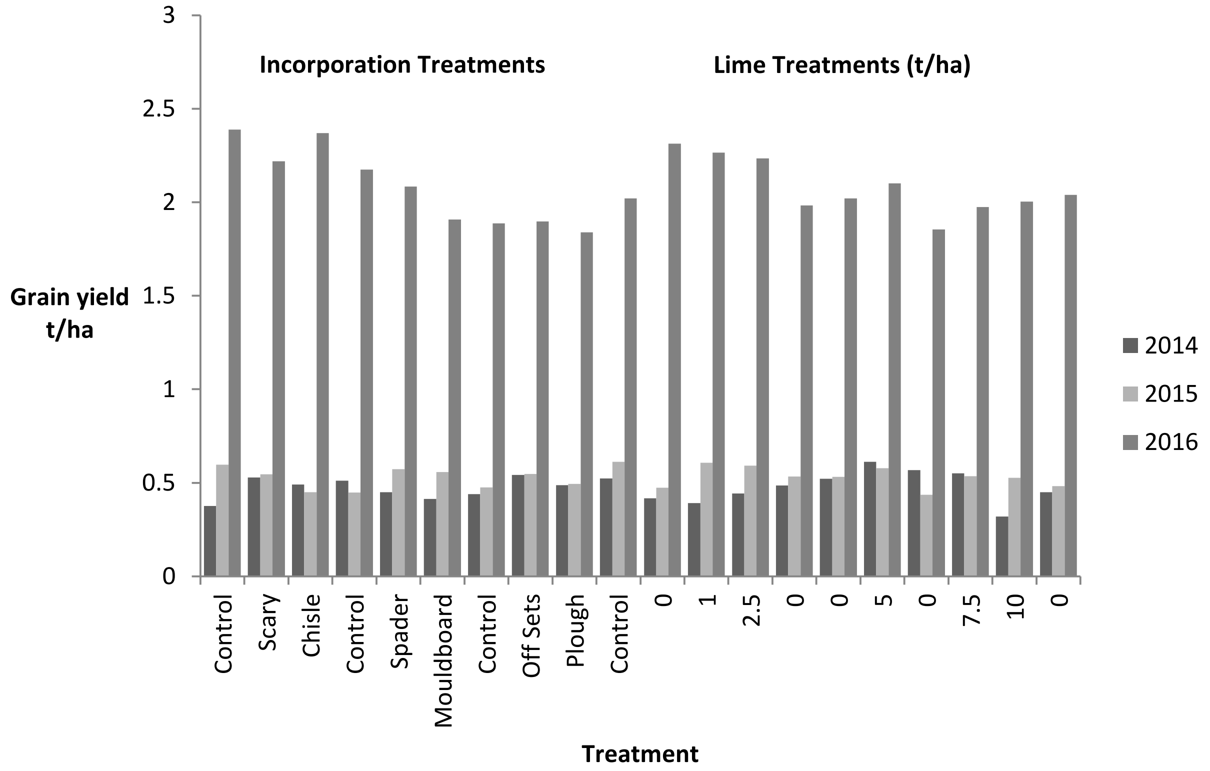


Figure 3: Yield comparison of lime and incorporation treatments 2014 (triticale), 2015 (triticale) and 2016 (oats). Incorporation treatments averaged all lime treatments that cross the plot, along with lime treatments averaged across all the control and incorporation methods.

Economic Analysis

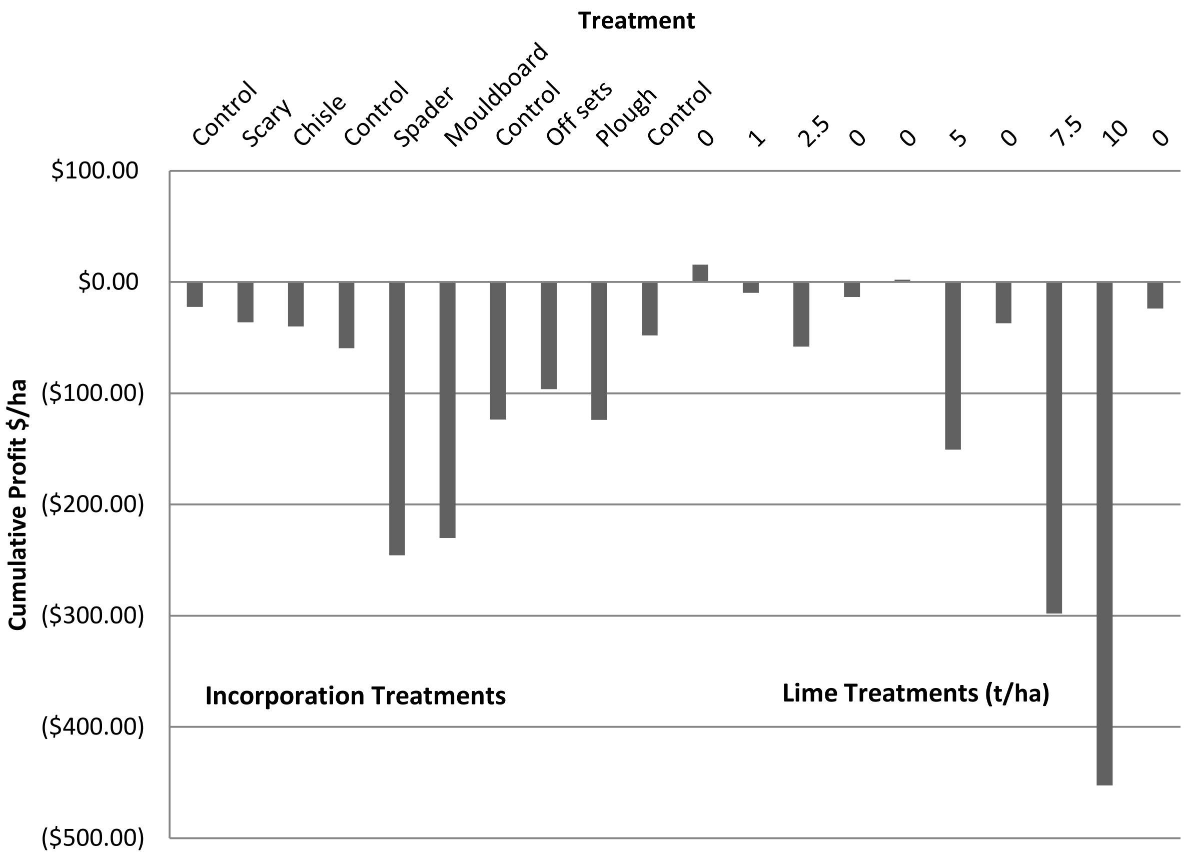


Figure 4: Cumulative profit comparison of lime and incorporation treatments of years 2014 (triticale), 2015 (triticale) and 2016 (oats).

As demonstrated in figure 4, the two poor Triticale crops following lime and incorporation treatments in 2014/2015 have not facilitated a good return on investment. The oat crop from 2016 has been profitable and brought deficit levels back, but at this point in time the control plots are looking to be the most economical.

Comments

We have had a good growing season in 2016 however; it has brought out site variation which is clouding the results from lime and incorporation methods. Compaction is becoming an issue at the site due to the lack of controlled traffic and this could be impinging on responses to lime and incorporation methods due to restriction of root growth from compaction rather than the aluminium levels.

Expensive incorporation methods are cost prohibitive therefore rule themselves out as viable options in the Eastern Wheatbelt of W.A. for lime incorporation in this time period.

This project has one more year with current funding and the aim will be to sow to canola to further highlight treatment differences in 2017.

Acknowledgements
GRDC RCSN – Kwinana East
Fuchsbichler Family

Paper reviewed by: Jenni Clausen, DAFWA

Contact
Tyrone Henning, Tek Ag
ty@tekag.com
0429 843 025

Managing constrained repellent sands with soil wetters and deep ripping

Stephen Davies, Joanne Walker, Chad Reynolds, DAFWA

Key Messages

- The effect of deep ripping with topsoil slotting on water repellent sand was inconsistent likely due to inconsistent crop establishment.
- Soil wetter effects were inconsistent, there was no benefit in wheat but in lupins certain wetter and placement combinations improved grain yield but with no consistent combination or pattern making it difficult to predict which approach would give a reliable return on investment.
- There was no interaction between soil wetters and deep ripping with topsoil slotting for the 2016 season at either site. The trials will continue in 2017.

Aim

To determine if using a combination of soil wetters and deep ripping with topsoil inclusion can effectively overcome soil constraints including water repellence, subsoil compaction and subsoil acidity.

Background

Soil wetting agents can improve yield potential on repellent deep sands by improving crop establishment. Soil wetting agents work by reducing surface tension of the water, allowing it to wet the repellent waxy surfaces of the soil particles and improving water infiltration through the soil pores. However, this improved yield potential is not always realised, possibly due to other subsoil constraints. Deep ripping with topsoil inclusion can help overcome subsoil compaction and acidity allowing crops to better access subsoil moisture and nutrients resulting in improved tiller numbers, grain filling and yield. Topsoil slotting has the advantage of providing a nutrient and organic matter rich pathway. This promotes root growth and overcomes the aluminium toxicity associated with soil acidity as the free-Al in solution is complexed with the buried organic matter. This research is testing whether soil wetting agents (to improve crop establishment) and deep ripping with topsoil inclusion (to remove subsoil constraints) positively interact to overcome multiple constraints and further increase yields on repellent sands. This would represent an alternative approach to more aggressive strategic tillage, such as soil inversion or rotary spading.

Trial Details

Property	Site 1) Phil and Serge Martin, 'Warrooga', Marchagee Site 2) Paul Kelly, 'Santa Fe', Irwin
Plot size & replication	15m x 2m centres x 4 replications
Soil type	Site 1) Yellow deep water repellent sand Site 2) Pale deep water repellent sand
Soil pH ($CaCl_2$)	Site 1) To be assessed Site 2) 0-10cm: 6.2 10-20cm: 5.9 20-30cm: 5.8 (2 t/ha Lime, 2011)
Paddock rotation	Site 1) Wheat 2015, Lupin 2016 Site 2) Vol. pasture 2013, Saia oats 2014, vol. pasture 2015, wheat 2016
Sowing date	Site 1) 06/05/2016 (Marchagee) Site 2) 11/05/2016 (Irwin)
Sowing rate	Site 1) 100 kg/ha Mandelup lupins Site 2) 75 kg/ha Mace wheat
Banded soil wetters (applied at seeding)	Products: 2 L/ha SACOA Irrigator; 2 L/ha SACOA SE14, 2 L/ha SST Bi-Agra Band applied with a water rate of 100 L/ha. Water only used as true control. Placement: on-furrow behind press wheels; in-furrow near the seed; split half on-furrow and half in-furrow
Deep ripping	Agroplow Deep Ripper with topsoil slotting (inclusion) plates, tine spacing was 33cm and ripping to a depth of 42cm
Fertiliser	Site 1) 06/05/2016: 100 kg/ha Big Phos Manganese and MOP 3:1 Site 2) 11/05/2016: 80 kg/ha Agstar Extra, 50 kg/ha urea 16/06/2016: 65 L/ha UAN
Herbicides, insecticides & fungicides	Site 1) 06/05/2016: 0.2 L/ha Lorsban, 0.2 L/ha Dominex, 1 L/ha Outlook, 1.5 L/ha Simazine, 1.5 L/ha Trifluralin, 2 L/ha Spray.Seed Site 2) 11/05/2016: 0.2 L/ha Lorsban, 0.2 L/ha Dominex, 118 g/ha Sakura, 1.5 L/ha Trifluralin, 2 L/ha Spray.Seed 19/07/2016: 0.2 L/ha Dominex, 0.3 L/ha Prosaro
Growing season rainfall	Site 1) 299mm (Apr-Oct) Site 2) 436mm (Apr-Oct)

Results

Soil at both sites was water repellent, rating very severe for the pale sand at Irwin and moderate for the yellow sand at Marchagee (Table 1). Soil compaction and the effectiveness of deep ripping in overcoming it were assessed using a soil penetrometer. At Marchagee, the sand was compacted at 20cm and severely compacted at 30 and 40cm while for the pale sand at Irwin the compaction was even worse at depth, with extreme compaction at 30 and 40cm (Table 1). Deep ripping relieved the compaction on the rip line to 40cm for the Marchagee yellow sand and to 30cm for the Irwin pale sand, but it was still compacted at 40cm (Table 1). The openers on the back of the ripping tines achieved effective slotting of the topsoil to a depth of about 30cm (Image 1).

Table 1: Severity of soil water repellence measured using the molarity of ethanol droplet (MED) test and soil strength measured using a cone penetrometer for unripped control (Con) and deep ripped (Rip) treatments on repellent deep sands at Marchagee and Irwin, 2016.

Soil and Site	Soil Water Repellence		Soil penetration resistance (MPa)							
	MED	Rating	10cm		20cm		30cm		40cm	
			Con	Rip	Con	Rip	Con	Rip	Con	Rip
Deep yellow sand, Marchagee	1.6	Moderate	0.7	0.3	2.0	0.5	3.0	0.4	3.4	0.6
Pale deep sand, Irwin	3.6	Very severe	0.7	0.4	2.3	0.5	3.9	0.7	4.9	2.1

Image 1: Soil profile in severely repellent pale deep sand showing seams of topsoil (darker soil) incorporated to about 30cm into the subsurface soil from use of soil openers attached to the back of deep ripping tines working at a depth of 40cm. Note how the slotted topsoil provides a 'root friendly' pathway through the subsurface soil layer.

Plant establishment counts were undertaken in early June. For both sites, plant establishment was significantly lower in the deep ripped treatments (Table 2) but at Marchagee the lupin establishment on the ripped plots was still within the optimum density of 40-45 plants/m^2. There was no significant effect of soil wetters on crop establishment at either site (data not shown). At Irwin, dry patch was common and wheat establishment was staggered despite good rains and use of soil wetters. At this site plant numbers will have increased over time as subsequent cohorts of plants emerged. NDVI measurements taken in early July indicated that there was no impact of deep ripping in the lupins at Marchagee. There was a statistically significant but relatively small effect of the soil wetters on NDVI, with all three wetters increasing the NDVI by 11% (data not shown). For the wheat at Irwin, ripping had a much larger effect, increasing the NDVI by 28% (Table 2) but wetters had no effect.

Table 2: Impact of deep ripping with topsoil slotting on plant establishment, normalised difference vegetation index (NDVI) and grain yield for lupins growing on deep yellow sand at Marchagee and wheat growing on pale deep sand at Irwin, 2016. (NS = not significant).

Crop and Site	**Crop establishment (plants/m^2)**			**Normalised Difference Vegetation Index (NDVI)**			**Grain yield (t/ha)**		
	Control	Ripped	*LSD*	Control	Ripped	*LSD*	Control	Ripped	*LSD*
Lupins, Marchagee	52	47	*4*	0.20	0.19	*NS*	1.7	1.5	*0.08*
Wheat, Irwin	78	68	*5*	0.25	0.32	*0.01*	1.9	2.5	*0.06*

Grain yield response to deep ripping with topsoil slotting contrasted at each site (Table 2). Lupin yields were reduced by 7% as a result of deep ripping at Marchagee whereas wheat yields at Irwin were increased by 31% (600 kg/ha) as result of the deep ripping (Table 2). Soil wetters had no significant impact on the grain yield of wheat at Irwin. There was an interaction between wetters and placement on lupin grain yield at Marchagee with a unique response of each wetter placement (Figure 1). Bi-Agra Band increased the grain yield by 13% (190-200 kg/ha) when there was at least some banded on the surface. Irrigator responded to the split application with a 20% yield increase, while SE14 did not significantly increase yield or respond to placement (Figure 1).

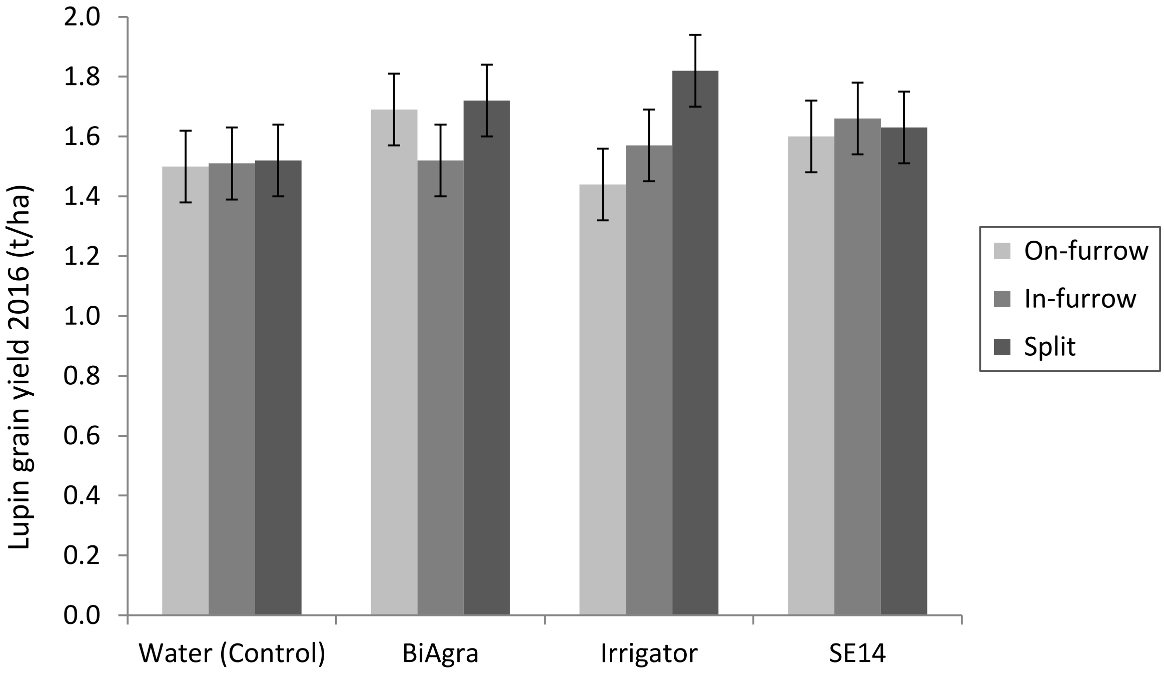


Figure 1: Impact of soil wetting agents and wetter placement on lupin grain yield on deep yellow water repellent sand at Marchagee, 2016. Bars show the least significant difference (LSD) at P≤0.1.

Economic Analysis

The approximate costs of the soil management treatments are shown in Table 3. Grain prices used in the analysis were $220 for wheat and $275 for lupins. At Irwin, wetters provided no yield increase so their use would have increased costs by $14-17/ha. Deep ripping with topsoil inclusion did increase the grain yield at this site by 600 kg/ha, which at a wheat price of $220/ha would have improved the gross income by $132/ha with a net return of $77/ha. At Marchagee, deep ripping reduced the lupin yields by an average 120 kg/ha which added $33/ha onto the ripping cost, resulting in an average total reduction of $88/ha. Some wetter and placement combinations did increase the yields at this site by 200-300 kg/ha, giving additional returns of $55-82.50/ha.

Table 3: Approximate costs of soil wetters and total soil treatment costs inclusive of wetters and deep ripping with topsoil inclusion for treatments applied to water repellent deep sands at Marchagee and Irwin in 2016. The cost of deep ripping to 42cm with inclusion (slotting) plates was estimated to be $55/ha. Note product prices can change and vary depending on volume purchased.

Soil Wetter and rate	Wetter cost ($/L)	Total soil treatment cost, wetters & tillage ($/ha)	
		Unripped	Ripped
Nil	0	0	55
Bi-Agra @ 2 L/ha	7.5	15	70
Irrigator @ 2 L/ha	8.5	17	72
SE14 @ 2 L/ha	7.0	14	69

Comments

The 2016 season was good for crop establishment with effective opening rains and this resulted in the expression of soil water repellence typically being less than usual. Despite the good rains throughout the season establishment was still staggered and dry patches persisted on the very severely repellent sand at Irwin and the soil wetters did not significantly improve this.

Subsoil compaction was severely to extremely compacted at both sites and deep ripping effectively overcame this on the rip lines to a depth of 42cm. Topsoil slotting was effective at incorporating seams of organic matter into the subsoil at both sites. This nutrient-rich organic matter can form complexes with free aluminium associated with low pH overcoming any risk of aluminium toxicity and can improve nutrient availability and promote root development in the rip line. For the wheat at Irwin this translated into a large yield response but the lupins at Marchagee did not respond. While average lupin plant numbers were within the acceptable range, there were still some significant gaps in the ripped treatments and this may have impacted on the yield.

The soil wetters gave some response in the lupins but they were inconsistent and only significant for certain product placements. These trials will be continued for several more seasons so the interaction between wetters and ripping can be further assessed in the rotation.

Acknowledgements
This research is funded by GRDC and DAFWA through DAW00244: "Delivering enhanced agronomic strategies for improved crop performance on water repellent soils" and is part of GRDC's Soil Constraints West group of projects. Thanks to Phil and Serge Martin and Paul and Sue Kelly for hosting the trial sites. Thanks to Trevor Bell, Greg Brown, Larry Prosser and Steve Cosh for technical support.

Paper reviewed by: Giacomo Betti, Soils Researcher, DAFWA Geraldton

Contact
Stephen Davies, DAFWA
stephen.davies@agric.wa.gov.au
9956 8515 or 0408 439 497

Understanding biological farming inputs

Dr Mark Farrell, Principal Research Scientist, CSIRO

Key Messages

- Fourteen biological inputs and alternative fertilisers tested alongside a conventional fertiliser response curve.
- 50% district practice fertiliser included with each alternative input.
- Across two years, no significant differences in wheat grain yield were observed between the control and any of the biological treatments tested.

Aim

This trial aims to investigate the in-field efficacy of 14 alternative farming inputs of a predominantly biological nature. These include biostimulants, humates, organic inputs (e.g. manures, composts), microbial inocula and alternative fertilisers (those specifically marketed as having less impact on soil quality than conventional fertiliser). The trial forms part of a wider national project funded by the GRDC, with eight field sites running for two years, and multiple laboratory and pot experiments to support the field data being conducted by CSIRO and University of Western Australia (UWA) scientists.

Background

Biological inputs include a wide range of products aimed at supporting soil fertility, biological activity, and plant growth. They include microbial inocula (such as rhizobium), biostimulants that promote favourable microbial populations and plant growth, composts and compost teas, manures, and biochars. These inputs are often used with the broad aim of reducing the use of traditional chemical fertilisers and agro-chemicals, but they may also form the backbone of organic farming systems.

The trial at the Liebe Group Long Term Research Site forms one of a network of eight trials across the country (1x WA, 3x SA, 1x Vic, 2x NSW, 1x Qld). In addition to these field trials, comprehensive chemical analysis of approximately 80 biological inputs is being conducted by CSIRO. Incubation and pot experiments are being conducted to both screen larger numbers of amendments than would be possible in the field, and to perform targeted mechanistic studies to investigate the mode of action of products of interest.

The rigorous assessment of biological inputs can often be problematic due to inappropriate experimental design, replication, or control treatments. In the present study, we used a replicated block experiment with four blocks, each containing one replicate of each treatment. In order to ascertain whether a crop response observed with a biological input could have been obtained with a different conventional fertiliser regime, an eight-point fertiliser response curve ranging from nil fertiliser to 200% district practice was included in the trial design. As the objective of this research was not to ascertain whether biological inputs could replace conventional inputs, but rather to investigate where they might facilitate reduced inputs while maintaining yields, we applied a base of 50% district practice fertiliser under all biological inputs. In order to understand whether effects were incremental, all treatments (inclusive of the conventional fertiliser treatments in the response curve, and the underlying 50% application under the biological inputs) were re-applied in the 2016 growing season.

In addition to the crop yield and grain N concentration data discussed in this article, an assessment of soil nutrient availability is being undertaken on soil samples retrieved from the field at close to the five leaf stage. This will enable an assessment of whether the addition of the biological inputs will have improved the release of nitrogen and phosphorus for the crop at this early growth stage. Additionally, we will be assessing the size and, in selected treatments, the composition of the soil microbial biomass in order to understand whether treatments have effected changes in the underlying soil microbiology.

Trial Details

Property	Liebe Long Term Research Site, west Buntine
Plot size & replication	13m x 2m x 4 replications
Soil type	Sandy
Soil pH ($CaCl_2$)	0-10cm: 6.35
EC (dS/m)	0-10cm: 0.08
Paddock rotation	2015 wheat, 2016 wheat
Sowing date	23/05/2016
Harvest date	29/11/2016
Fertiliser	District practice is 65 kg/ha Agstar Extra, 25 kg/ha MOP, 30 L/ha Flexi-N 50% of this was applied under all 14 biological inputs A fertiliser response curve ranging from nil to 200% district practice (eight treatments total) was also included within the trial
Biological treatments	2x Humates 3x Biostimulants 2x Microbial inocula 4x Alternative fertiliser 3x Organic inputs
Growing season rainfall	222.6mm

Results

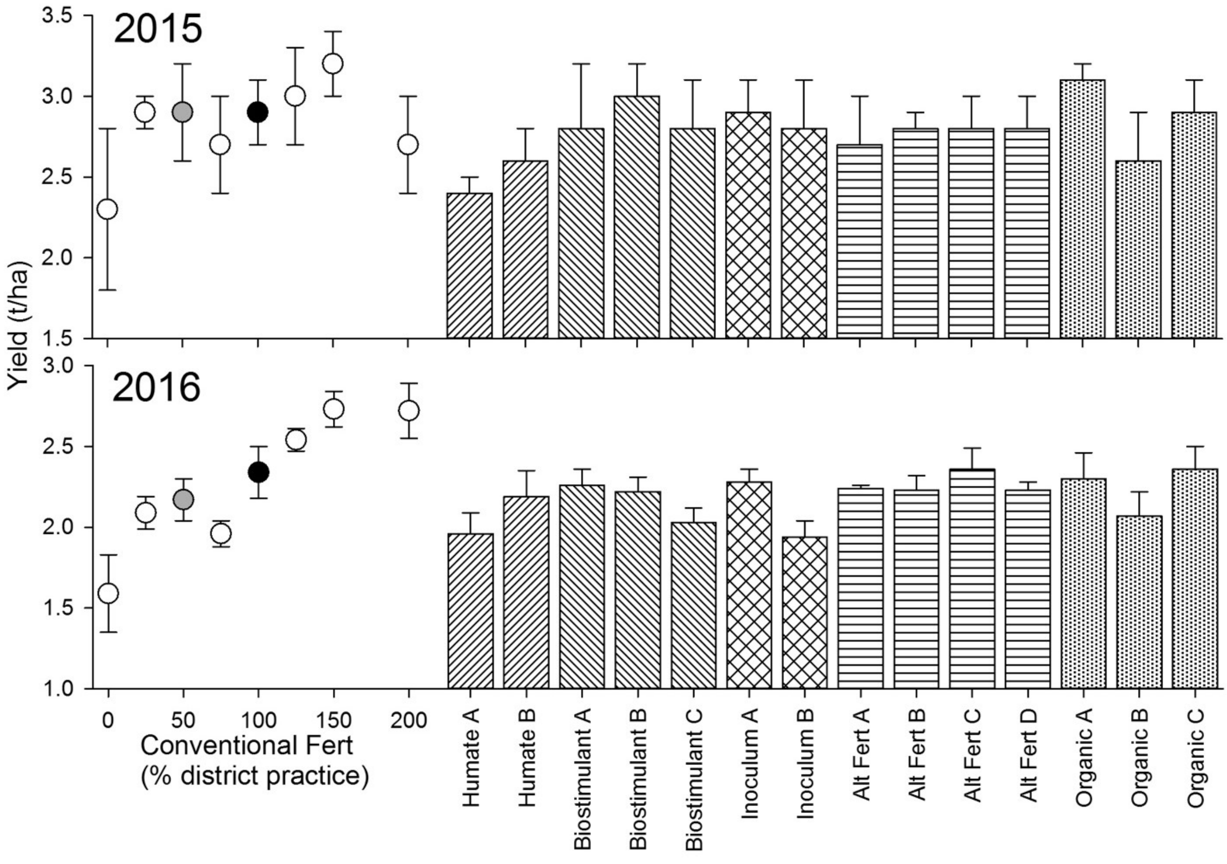


Figure 1: Wheat grain yield for the field experiment in both 2015 and 2016 years. Values are means (*n*=4 +/- standard error of the mean). The fertiliser response curve (dots) ranges from 0-200% district practice (where 100% district practice was 65 kg/ha Agstar Extra, 25 kg/ha MOP, 30 L/ha Flexi-N). The grey dot is the response to 50% district practice that underlies all the biological input treatments and is thus the true control. The black dot is 100% district practice. No significant differences were observed between any of the biological treatments and the 50% district practice control in either year. Note the change in y-axis between the years to enable patterns between treatments to be more easily compared.

There was a response to added conventional fertiliser relative to the nil treatment in both years, though this was far more apparent in 2016 where there was a clear response above the 50% district practice application which underlies all the biological input treatments. Across the 14 biological input plots, average yield in 2015 was 2.8 t/ha, whereas it was slightly lower in 2016 at 2.2 t/ha (Figure 1). Grain nitrogen concentration (not presented) from 2015 was highly variable with an average of 17.4 mg/g, equivalent to 10.9% protein assuming a conversion factor of 6.25. Grain N concentration for the 2016 treatment is currently being analysed, along with the soil chemistry and microbiology data mentioned in the background section above.

Comments

The wheat yield data presented here from two years of trials indicates that all 14 biological inputs tested here had no effect at a site typical of the sandy soils present in this region of the WA Wheatbelt. When this information is taken along with the inconclusive and highly variable grain N concentration (data not presented), it is difficult to conclude that within the two-year timeframe of this study that the inclusion of biological farming inputs will have an immediate effect on crop performance.

However, it should be noted that the data presented here represent only one trial. Additionally, as the trial only ran for two years, longer term benefits from some biological inputs cannot be discounted. It is hoped that once the soil chemical and biological analyses are completed, along with the wider project's work for seven other field trials as well as pot and lab experiments, the project as a whole will be able to provide a firmer case for or against the inclusion of biological inputs in broad-acre cropping systems of Australia.

Acknowledgements

This project was funded by the GRDC under the project title "Understanding Biological Farming Inputs" (CSO00044). Scientific input from project scientists (Dr Lynne Macdonald, Dr Mike Webb, Dr Mike Wong – CSIRO; Dr Sasha Jenkins, Prof Lyn Abbott – UWA), and technical staff (Thomas Carter – CSIRO; Ian Waite – UWA) is acknowledged.

Paper reviewed by: Dr Mike Webb, CSIRO

Contact

Dr Mark Farrell, CSIRO
mark.farrell@csiro.au
(08) 8303 8664

Bioprime: Impact on yield, soil carbon and nitrogen use

Peter Keating, Managing Director & Falko Mathes, Environmental Microbiologist, Bioscience

Key Messages

- Granular fertiliser delivered significantly higher yields than liquid fertiliser (+4.4% across two sites).
- Bioprime application increased yield on average by 4.3% across three sites.
- Foliar Bioprime application combined with granular fertiliser achieved highest yield increase of 10.3% across three sites.

Aim

The 2016 Bioprime field trials – one being located adjacent to the Long Term Research Site of the Liebe Group – tested the effects of the seed dressing form of Bioprime and its post emergence spray form, in interaction with granular or liquid fertilisers. Both fertilisers had the same nutrient composition and were applied at the same rates of nitrogen, phosphorus and potassium.

Background

Bioprime is a patented ferment of molasses (patent number: WO2014082130 A1) that is applied as a seed coating, or foliar and soil spray. It contains many diverse carbon compounds that elicit different functions in the soil. Firstly, certain Bioprime constituents such as 2,3-Butanediol and acetoin have been shown to improve plant growth directly (Ruy et al., 2003). Secondly, the labile carbon compounds of Bioprime will stimulate the microbial activity in the soil as a whole – a process known as the soil priming effect. Finally, the furanones in Bioprime directly influence certain members of the soil microbial community (Bais et al., 2006) that potentially colonise plant roots. Bioprime suppresses non-beneficial bacteria, and promotes the growth of plant beneficial bacteria and fungi. Bioprime causes an overall increase in the biodiversity of microbes associated with roots. The actions of Bioprime are hormonal in nature, so application rates are very small, thereby making it a cost effective soil management tool.

The 2016 Bioprime trial at the Liebe site was conducted to investigate the interactions of Bioprime application with in-furrow liquid fertiliser application compared to conventional granular fertiliser, and their effects on plant growth and productivity. Bioprime was added as a seed dressing (2 L/t seed), and/or as a post emergence spray (4 L/ha). This is the fourth year of Bioprime field trials (three previous years with Liebe Group and at Forrestdale with different crops). The Liebe Group trial design was replicated exactly at the West Midlands Group (WMG) and to some extent at Forrestdale in 2016.

In addition to agronomic outcomes, the trial has also been sampled for molecular biological analysis of wheat rhizosphere and phyllosphere microbial communities. This is to investigate the links between root and plant colonisation by beneficial bacteria and fungi with Bioprime application and growth improvements. These data are currently being analysed at Bioscience.

Trial Details

Property	Liebe Group, Long Term Research Site, Buntine
Plot size & replication	12m x 2.4m x 9 replications
Soil type	Sand/sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.5
EC (dS/m)	0-10cm: 0.1
Paddock rotation:	2015 lupin, 2016 wheat
Sowing date	14/06/2016
Sowing rate	75 kg/ha Mace wheat
Fertiliser	14/06/2016: 100 kg/ha Gusto Gold and 50 kg/ha Urea, or liquid: 160 g/L Monopotassium phosphate, 96 g/L potassium sulphate and 20 g/L urea Post seeding: 50 L/ha UAN
Herbicides, insecticides & fungicides	14/06/2016: 1.5 L/ha Glyphosate, 2 L/ha Trifluralin, 118 g/ha Sakura, 400 g/ha Diuron, 1 L/ha Chlorpyrifos, 300 mL/ha Bifenthrin 24/07/2016: 1 L/ha Velocity
Growing season rainfall	222.6mm

Results

The treatment structure and yield data are given in Table 1. At the Liebe site, the type of fertiliser applied at seeding had a statistically significant effect on grain yield ($p = 0.02$). On average, granular fertiliser resulted in 3.45 t/ha grain while liquid fertiliser delivered only 3.31 t/ha (~4% less). Although Bioprime application did not result in statistically significant yield differences, there were trends towards increased yield for treatments 2 and 7 (+5% and +4%, respectively; Table 1, Fig. 1) compared to the respective controls (treatment 1 and 5, Table 1, Figure 1). Treatments 6 and 8 had no effect on grain yield while treatments 3 and 4 resulted in a slight decrease in yield (-3% and -2%, respectively). The highest yield with 3.63 t/ha (+5.3%) was achieved with treatment 2 (foliar Bioprime application).

In addition to the wheat trial at the Liebe site, we also conducted wheat trials with the West Midlands Group (WMG) near Moora and at Forrestdale (Metro Perth).

At the WMG, all Bioprime treatments showed a trend of a positive effect on yield except for treatment 7 which had no effect. Although not statistically significant, the average yield increase was 4%. Treatment 6 (foliar application with liquid fertiliser) resulted in the highest yield increase (8%) compared to the corresponding control (Fig. 1) whereas the highest yield for this site was achieved with treatment 3 (2.3 t/ha, Table 1).

At Forrestdale, treatment 2 (foliar application) resulted in a yield increase of 24% while the combined seed and foliar treatment culminated in only 10% yield increase (Table 1, Figure 1). Unfortunately, the plots for treatment 3 erroneously received foliar Bioprime and as such no data on the impact of seed treatment on its own is available for Forrestdale.

In summary, out of 14 Bioprime treatments spread across three sites, nine treatments increased yield (between +1% and +24)%, three treatments had no effect (≤ 0.3% difference compared to control) and two treatments resulted in a slight decrease in yield (-2% and -3%). This resulted in an overall yield improvement of 4.3%. The most successful Bioprime treatment was foliar application with granular fertiliser and without seed dressing (treatment number 2, Figure 1) which increased yield by 10% averaged across all three sites.

Table 1: Yield results for 2016 Bioprime wheat field trials at the Liebe Group, West Midlands Group (WMG) and Forrestdale. Standard error is given in parentheses. For each site highest yields are bold and underlined.

Treatment No.	**1** (control)	**2**	**3**	**4**	**5** (control)	**6**	**7**	**8**
Fertiliser	**Granular**	**Granular**	**Granular**	**Granular**	**Liquid**	**Liquid**	**Liquid**	**Liquid**
Seed treatment	**None**	**None**	**Bioprime**	**Bioprime**	**None**	**None**	**Bioprime**	**Bioprime**
Foliar treatment	**None**	**Bioprime**	**None**	**Bioprime**	**None**	**Bioprime**	**None**	**Bioprime**
Grain yield	**(t/ha)**	**(t/ha)**	**(t/ha)**	**(t/ha)**	**(t/ha)**	**(t/ha)**	**(t/ha)**	**(t/ha)**
Liebe Group	3.45 (±0.04)	**<u>3.63</u>** (±0.18)	3.34 (±0.05)	3.39 (±0.10)	3.27 (±0.07)	3.28 (±0.09)	3.39 (±0.08)	3.28 (±0.06)
WMG	2.20 (±0.09)	2.23 (±0.06)	**<u>2.33</u>** (±0.09)	2.29 (±0.07)	2.11 (±0.05)	2.28 (±0.08)	2.11 (±0.09)	2.13 (±0.07)
Forrestdale	1.88 (±0.15)	**<u>2.34</u>** (±0.19)	n.d.	2.08 (±0.13)	n.d.	n.d.	n.d.	n.d.
Average %	100%	**<u>110%</u>**	101%	104%	100%	104%	102%	101%

n.d. = no data.

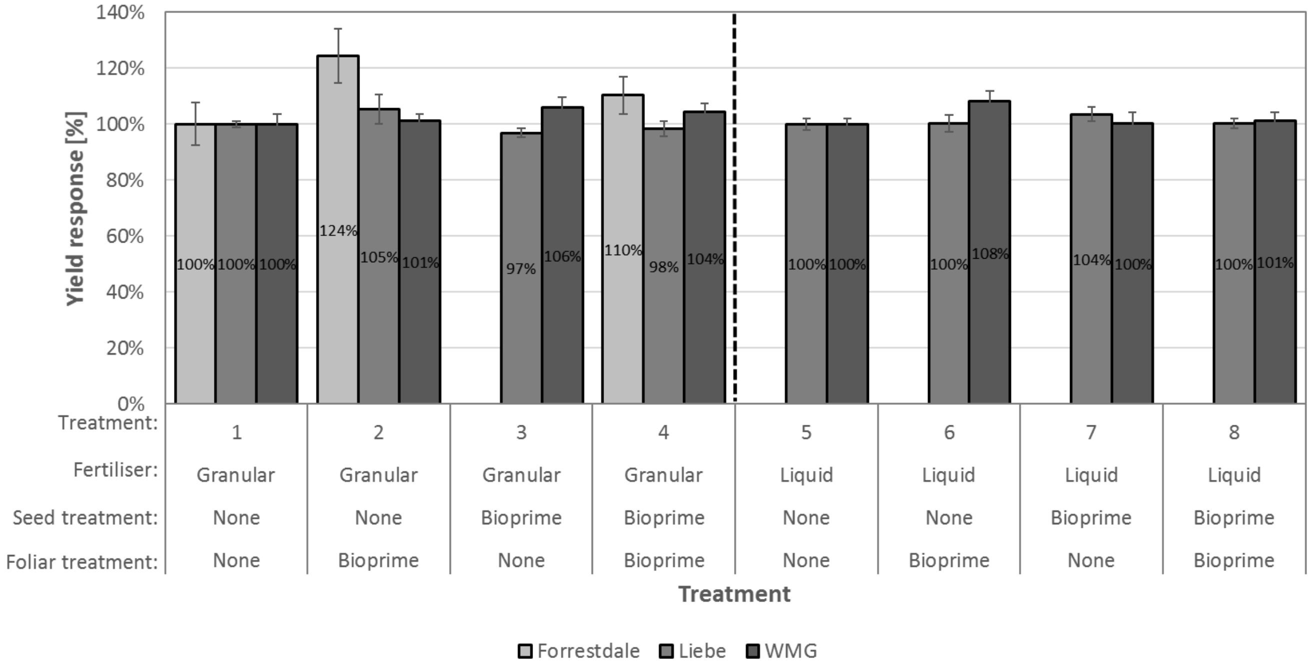


Figure 1: Yield results for 2016 Bioprime wheat field trials at the Liebe Group, West Midlands Group (WMG) and Forrestdale. Results are expressed as a percentage compared to the respective control for each site. Vertical line divides granular from liquid fertiliser treatments.

Table 2: Soil parameters (0-15cm) for 2016 Bioprime wheat field trials at the Liebe Group, West Midlands Group (WMG) and Forrestdale. All were sandy Tenosols with less than 3% clay content.

Analytes	Unit	Forrestdale	Liebe	WMG
Electrical Conductivity	mS/cm	0.04 – 0.06	0.1	0.05 – 0.08
pH - $CaCl_2$	-	5.9	5.5	4.5 – 4.6
pH - H_2O	-	6.2 – 6.3	6.1 – 6.3	5.4 – 5.5
Ammonium-N	mg/kg	10.5 – 18.8	<0.01 – 1.13	2.09 – 3.25
Nitrate-N	mg/kg	0.74 – 1.40	16 – 17	6.0 – 21.5
Phosphate-P	mg/kg	17.2 – 28.1	9.0 – 11.8	7.60 – 7.96
Exchangeable Calcium	mg/kg	589 – 1040	755 – 896	285 – 348
Exchangeable Magnesium	mg/kg	144 – 216	46.6 – 73.1	34.5 – 38.9
Exchangeable Sodium	mg/kg	32.5 – 35.3	49.3 – 57.0	36.6 – 57.0
Exchangeable Potassium	mg/kg	9.99 – 18.6	48.7 – 81.3	30.7 – 36.9
Carbon	%	1.02 – 1.42	0.50 – 0.66	0.70 – 0.75
Sulphur	%	0.009 – 0.010	0.002 – 0.01	0.007 – 0.009

Economic Analysis

The estimated on-farm profit using Bioprime as a foliar spray resulting in a 10% yield increase in wheat as seen for treatment 2 across all three sites (Table 1) equates to $45/ha for $8 spent, so $37/ha (Table 3).

Table 3: Estimate of on-farm profit when using Bioprime treatment 2 (example calculation).

Factor	Without foliar Bioprime	With foliar Bioprime
Assumed average wheat yield	2.0 t/ha	2.2 t/ha
Price of ASW wheat (based on $225 per tonne)	$450/ha	$495/ha
Effective increase of on-farm profit (based on $2 per L Bioprime* and a 4 L/ha application rate = $8 per ha)	$0/ha	**$37/ha**

*if purchased in 1000L IBCs

Comments

The Liebe Long Term Research Site had a good growing season in terms of rainfall and seasonal distribution. The average yield was about 50% higher than previous wheat trial years. This was similar to Forrestdale which also had good rainfall and seasonal distribution. The West Midlands site had an average yielding year for the Moora area.

On average, all Bioprime treatments combined resulted in a 4% yield increase. Treatment 2 (foliar Bioprime and granular fertiliser) performed best, achieving a 10% yield increase averaged across the three sites. At the Liebe site, two Bioprime treatments resulted in positive yield responses whereas this number was higher at the WMG (5 treatments). Given that the Liebe site, relative to the WMG site had a higher soil pH, and higher pre-seeding phosphate and exchangeable cations concentrations (Table 2), an average higher yield was expected and achieved here compared to the WMG (3.36 t/ha and 2.15 t/ha, respectively in unamended control treatments). Thus, the higher soil quality and soil health present at the Liebe site combined with the good 2016 season in terms of rainfall likely narrowed the yield gap.

As such any management options aiming to close the gap between actual and potential yield, would have had less scope to achieve this at the Liebe site in 2016. In contrast, the lower soil fertility at the WMG allowed Bioprime to more consistently improve crop production. The 2016 data suggest the opportunity to improve yield on a poor soil in a poor year is greater than on good soil in a good year.

Ongoing research will continue to further develop Bioprime technology as a tool to improve soil biology and maintain plant health and yield. There is a substantial database of microbiological and yield results which continues to expand with the expectation of understanding the links between root and plant colonization by beneficial bacteria and fungi with Bioprime application and growth improvements.

References

Ryu, C. M., M. A. Farag, C. H. Hu, M. S. Reddy, H. X. Wei, P. W. Pare, and J. W. Kloepper. 2003. Bacterial volatiles promote growth in Arabidopsis. PNAS **100** (8): 4927-4932.

Bais, H. P., T. L. Weir, L.G. Perry, S. Gilroy, and J.M. Vivanvo. 2006. The role of root exudates in rhizosphere interactions with plants and other organisms. Annual Review of Plant Biology **57**: 233–266.

Acknowledgements

We would like to thank Richard Devlin and the Living Farm staff for expertly conducting the field trials.

Paper reviewed by: Dr Deirdre Gleeson, UWA

Contact

Peter Keating, Managing Director, Bioscience Pty Ltd
bioscience@biosciencewa.com
(08) 9397 2446

Disclaimer:

Bioprime is manufactured and distributed by Liquid Fertiliser Systems Pty Ltd. The company is owned by Peter Keating.

Consider topsoil slotting plates if deep ripping clay loams

Wayne Parker, Research Officer, DAFWA

Key Messages

- Topsoil slotting plates provided additional yield response when ripping a sodic clay loam.
- Ripper tines spaced at 100cm do provide an economic benefit to the whole farm business despite yielding less than 50cm row spacing provided ripping speed and area covered are increased.

Aim

To evaluate the feasibility of deep ripping up to 500mm with inclusion plates and different tine spacings on heavier soil types.

Background

Cultivation is the predominant management tool for subsoil compaction. This may be in the form of deep ripping, spading or ploughing - each with varying costs, benefits and disadvantages of the chosen application.

The majority of Liebe growers are currently deep ripping their paddocks to a depth of up to 300mm to combat subsoil compaction. However larger, heavier machinery have pushed these hard pans to depths greater than 400mm. Deep ripping to depths >400mm is limited by machinery and soil type. To combat this issue the Department of Agriculture and Food, Western Australia (DAFWA) designed a double-row ripper that has shallow leading tynes and deeper following tynes, allowing for a greater depth of penetration with less draft and reduced cloddiness when ripping in dry conditions. Deep ripping is the first step in removal of compaction and compliments Control Traffic Farming (CTF) to protect the soil resource from re-compaction.

Inclusion plates are a new component to the DAFWA deep ripper designed to incorporate the topsoil and/or soil ameliorants to depth behind the tine. This innovation decreases the cost of incorporating soil amendments although ameliorating a smaller soil volume. The inclusion plates also aim to improve the longevity of ripping with the addition of soil organic matter down the ripping slot to improve soil structure stability. This is the second year since the inclusion plates were developed and as such they require further trial work to improve their fit in the system. The addition of inclusion plates to the deep ripper gives growers the ability to remediate multiple constraints in one pass, giving great efficiencies and returns on investment.

Ripping row spacing was also considered in this trial as grower experience has found the extra draft added by ripping deeper with topsoil slotting plates has exceeded the capacity of their big tractors. A more preferable option would be to reduce the row spacing rather than reduce the width of the ripper to 4 or 6m.

In 2015 the whole paddock was deep ripped to a depth of 300mm on 50cm tyne spacing. This trial investigates the value of ripping to 500mm, using topsoil slotting plates, in 2016. The value of deeper ripping and inclusion plates has been shown on sandier soils; this trial demonstrates the machinery across various soil types.

Trial Details

Property	O.J. Butcher & Son, Nugadong
Plot size & replication	3.5m x 500m x 4 replications
Treatments	Ripping; nil, 500mm, 300mm Slotting plates; plus, minus
Soil type	Various: sand over clay, loam, clay, gravel
Paddock rotation:	2013 fallow, 2014 wheat, 2015 canola
Sowing date	10/05/2016
Sowing rate	55 kg/ha Mace wheat (70 mL/t seed Tebuconazole 430, 4 L/t seed Zinc)
Fertiliser	10/05/2016: 40 kg/ha Agstar Extra, 60 kg/ha Urea 07/06/2016: 0.5 L/ha ZincMate 15/06/2016: 60 L/ha Flexi N
Herbicides, insecticides & fungicides	10/05/2016: 200 g/ha Diuron, 1 L/ha Trifluralin, 1 L/ha Paraquat 250, 1.7 L/ha Boxer Gold, 0.2 L/ha Chlorpyrifos, 0.2% BS1000 07/06/2016: 1 L/ha Jaguar, 0.45 L/ha LVE MCPA, 0.15 L/ha Tebuconazole 430

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
Annual rainfall	57.2	7.8	78.8	33.4	39.0	34.6	37.8	29.8	11.2	-	-	-	329.6

Table 1: Results of soil analysis to depth from clay loam soil, including conductivity, presence of sodium and pH.

Soil Type	Depth (cm)	Conductivity (dS/m)	Exc. Sodium (Meq/100g)	pH Level (CaCl2)
Clay Loam	0-10	0.040	0.17	6.1
	10-20	0.051	0.32	6.0
	20-30	0.064	2.36	7.4
	30-40	0.068	2.89	7.4
	40-50	0.055	2.81	7.5
	50-60	0.081	2.87	7.4
	60-70	0.106	2.73	7.5

Results

The large size of this trial was both of benefit and disadvantage. The site has numerous soil types within making analysis challenging, however there was sufficient replication on respective soil types to allow investigation. The eastern end of the trial has a gradient of brown loamy sand through to clay loam. The western end of the trial has distinct boundaries between shallow gravel and clay loam. There was a distinct and measurable biomass difference in the crop that could be seen that related to the specific soil type. Due to this the western and eastern ends of the trial were analysed separately, with the gravel soil and clay loam soil plots selected for analysis.

Ripping the clay loam increased yield by 300-600 kg/ha although there was no significant difference between row spacing or depth (Table 1). Ripping to 500mm with topsoil slotting plates further increased yield from unripped by 1200 kg/ha in 50cm and 800 kg/ha in 100cm row spacing, again this was not significantly different. There was no yield benefit to ripping the gravel soil. Results indicate there was a penalty ripping on 100cm spacing however the large variation in results meant this was not significant.

Table 2: Yield results (t/ha) from depth of ripping trial investigating the benefits of topsoil slotting plates when ripping below 300mm on clay loam soil.

Clay loam		Yield (t/ha)		
Tine spacing (cm)	Plates	Depth (mm)		
		300	500	nil
-	Nil			1.98[a]
50	Minus	2.35[ab]	2.64[bc]	
50	Plus		3.2[c]	
100	Minus		2.3[b]	
100	Plus		2.8[bc]	
LSD		*0.59*		
P value		*0.088*		
CV(%)		*6.4*		

NS=Not significant.

Table 3: Yield results (t/ha) from depth of ripping trial investigating the benefits of topsoil slotting plates when ripping below 300mm on gravel soil.

Gravel		Yield (t/ha)		
Tine spacing (cm)	Plates	Depth (mm)		
		300	500	nil
-	Nil			1.36
50	Minus	1.11	1.4	
50	Plus		1.13	
100	Minus		0.61	
100	Plus		0.78	
LSD		*NS*		
P value		*-*		
CV(%)		*32*		

NS=Not significant.

Economic Analysis

A basic economic model was developed to determine the added value to a farm business from annually ripping a greater area with larger ripper tine spacing but lower yield response, than a smaller area with closer ripper tine spacing and higher yield response. The assumptions of this model included:

- The yield responses from this trial, in the clay loam sodic at depth were 1200kg to ripping with tines plus plates at 50cm and 800kg with tines plus plates at 100cm;
- We are able to annually rip 480ha on 50cm and 840ha on 100cm; Ripper width 12m;
- Yield response to ripping does decline with time, though it is not accounted for in this simple model. It is assumed that ripping responses remain constant for ten years and is not re-compacted by cropping traffic.
- Machinery depreciation and fuel cost were not included in this analysis;
- Grain price of $250/t.

The hypothetical property has 5000ha to rip, which is achieved in the sixth year of ripping when tines are at 100cm. In the first year of ripping there is an additional $24,000 come into the business ripping on 100cm row spacing. It is not until the ninth season of ripping, three years after completion with 100cm, that 50cm begins to provide more income to the business than 100cm. This is because the yield benefit from ripping on 50cm is higher. However the ripping response does decline over time depending on soil type therefore it is likely after 6 years the ripping program will begin again. The longevity of ripping with plates is being measured at six sites in WA on different soil types as part DAFWA's GRDC funded project DAW00243.

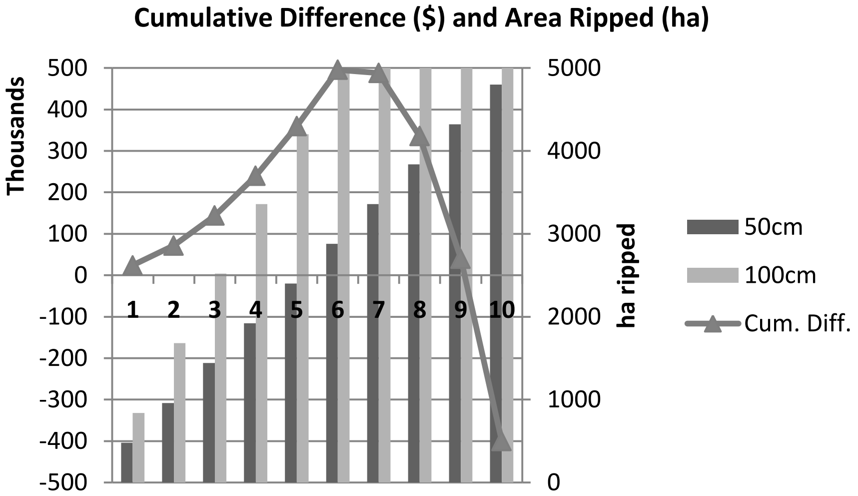


Figure 3: The cumulative totals of area ripped (ha) and total business benefit ($) for ripping spacings 50cm and 100cm.

Comments

The intent of the trial was to determine the response of a clay loam to ripping below 300mm. There was no difference between ripping at 300mm and 500mm in this trial, though either is better than not ripping at all, given the seasonal conditions of 2016. In this trial the biggest, and most significant, response was given with the use of topsoil slotting plates.

The clay loam soil becomes sodic at depth. Similar responses to ripping with topsoil slotting plates were observed at Beacon in 2015 in a Morrel soil. The ripping itself did not improve the yield response. Yield was improved with the addition of topsoil slotting plates. It is hypothesised that the topsoil plates have created leaching pathways through the sub-soil allowing rain to leach the Na^+ from the immediate profile. Further soil testing is required to confirm this.

Ripping did not improve the yield on this gravel soil. Further, it is likely that low establishment in the 100cm, with plates, reduced yield potential of this ripping treatment. The gravel soil has a number of constraints that will need addressing before ripping. While not recorded, it is likely that the aluminium and pH levels in this soil are toxic and restrict root development. Such constraints are typical of gravel soils in this region, often rectified with copious lime application.

The trial shows there is a benefit of ripping with topsoil slotting plates in clay loam soils, however no benefit of ripping these specific gravels. Ripping with wider row spacing has potential to increase whole farm economic benefit where larger areas can be ripped. Increasing the spacing may allow ripping in less favourable soil conditions where the tractor is unable to pull a 12m ripper on 50cm spacing.

Acknowledgements

Thanks to James and Gary Butcher for their time and machinery used to implement and manage this trial. The efforts of Jenni Clausen, then Liebe Group Research Officer, to record observations at appropriate times was greatly appreciated.

This is an activity of DAFWA's GRDC funded project DAW00243 Minimising the impact of soil compaction on crop yield.

Paper reviewed by: Jenni Clausen and Bindi Ibister, DAFWA

Contact

Wayne Parker, DAFWA
wayne.parker@agric.wa.gov.au
0429 080 074

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

Can Liebe growers achieve greenhouse gas abatement and profits?

Nikki Dumbrell[1], Elizabeth Meier[2], Peter Thorburn[2], Marit E. Kragt[1,3], Jody Biggs[2]
[1] School of Agricultural and Resource Economics, UWA
[2] Agriculture and Food, CSIRO
[3] Institute of Agriculture, UWA

Key Messages

- Increasing soil organic carbon was predicted to be the major driver of greenhouse gas abatement.
- Improved pastures (non-grazed) in crop rotations were predicted to provide abatement and maintained/increased profitability.
- Management practices that provide the most abatement were predicted to cost farmers the most.

Background and Aim

Grain farming produces greenhouse gas (GHG) emissions. Apart from machinery use, transport and electricity, greenhouse gases are produced as a result of mineralisation of soil carbon and excess nitrogen in the soil. These soil processes release carbon dioxide and nitrous oxide into the atmosphere. Changes to agricultural management have emerged as options to help reduce agriculture's GHG emissions.

A project was conducted to investigate management practices that can reduce GHG emissions from crop and livestock farming, and to identify the impacts on farm productivity and profits. The focus was on storing carbon in soils and reducing nitrous oxide emissions from soil. The management practices investigated in this study are those most applicable to Australian grains farms, taking into account the trade-offs and/or interactions associated with farming practicalities and economics.

Methods

With input from Liebe Group staff and members, a representative case study farm was established for the Liebe region. The representative farm was used to model management practices to reduce greenhouse gas emissions. Key characteristics of this farm are described in Table 1.

Table 1: Representative farm characteristics.

Effective farm area	6,000 ha
Soil types	Yellow deep sand (area: 1,800 ha; pH 0-15 cm: 6; PAWC: 90 mm) Red duplex with alkaline subsoil (area: 1,800 ha; pH 0-15 cm: 7.5; PAWC: 120 mm) Yellow sand over gravel (area: 1,200 ha; pH 0-15 cm: 5.2; PAWC: 102 mm) Red duplex with non-alkaline subsoil (area: 300 ha; pH 0-15 cm: 4.8; PAWC: 52 mm) Red clay (area: 300 ha; pH 0-15 cm: 8.8; PAWC: 140 mm) Shallow sandy duplex (area: 300 ha; pH 0-15 cm: 5.3; PAWC: 50 mm) Duplex sandy gravel (area: 300 ha; pH 0-15 cm: 6.3; PAWC: 44 mm)
Crop rotations	Canola x wheat x wheat x barley Canola x wheat x lupin x wheat x wheat Canola x pasture x wheat x wheat x barley
Nitrogen fertiliser	40-60 kg N/ha for cereals, <20kg reduction following legumes, 0 for legumes
Average annual rainfall	307mm

Management scenarios

The baseline management scenario for the case study farm was based on typical N-fertiliser application rates, crop rotations and fallow management combined with low organic matter inputs (Scenario S1; Table 2).

A set of alternative management scenarios that could potentially increase soil carbon stocks and/or decrease nitrous oxide emissions was developed and modelled for the representative farm. These practices include: increasing inputs of carbon to the soil by retaining stubble instead of burning it (S2, S5–S10); modifying nitrogen fertiliser rates or timing (S3–S6); increasing inputs of carbon to the soil by applying manure (S7); and increasing cropping intensity (S8-S10). The GHG emissions and profitability of each alternative scenario was then compared to the baseline management scenario (S1). This allowed us to identify the economic impact of changing farm management to achieve GHG abatement.

Table 2: Greenhouse gas abatement baseline and alternative scenarios modelled for the representative farm.

Scenario Number	Scenario Description
S1	**Baseline** = Stubble burnt, chemical fallows over summer, pasture in rotation is unimproved
S2	Stubble retained, chemical fallows over summer, pasture in rotation is unimproved
S3	Stubble burnt, chemical fallows over summer + 25% extra N fertiliser
S4	Stubble burnt, chemical fallows over summer - 25% less N fertiliser
S5	Stubble retained, chemical fallows over summer + 25% extra N fertiliser
S6	Stubble retained, chemical fallows over summer - 25% less N fertiliser
S7	Stubble retained, chemical fallows over summer + 5 t/ha of feedlot manure[1] every 5 years
S8	Stubble retained, short-term green manure legume crop grown over summer
S9	Stubble retained, chemical fallows over summer, improved legume pasture grown in rotation
S10	Stubble retained, short-term, legumes for summer, green manure crops and improved legume pasture

[1]Feedlot manure water content 20%; carbon fraction 0.4; C:N ratio 20:1, fertiliser applications were adjusted based on the nutrients available in the manure.

Biophysical modelling

Each management scenario was simulated using the Agricultural Production Systems sIMulator (APSIM). The APSIM model was configured with data for representative local soils (from APSoil database: www.apsim.info/Products/APSoil.aspx) and local climate data for Wubin, 1906–2014. Crop management information for each scenario (e.g. plant density, sowing depth and sowing window) was provided by Liebe Group staff and members. APSIM was used to predict crop yield, nitrous oxide emissions, and changes in soil carbon stocks for each scenario and soil type. The APSIM model accounts for changes in nutrient use efficiency and soil water availability as a result of the changes in soil carbon stocks. Simulation runs were conducted for 25 and 100 year periods. These time periods correspond to the permanence requirement under the Emissions Reduction Fund Policy[1]. Each simulation was run using 10 different starting years, 1906 to 1915. This was done to avoid cyclical patterns in the climate data interacting with crop rotations and affecting initial conditions, particularly soil carbon, and subsequent changes in soil carbon and nitrous oxide emissions. The results were averaged over the starting years to give results for a 25 or 100 year simulation period.

Changes in soil carbon stocks (0.0-0.3m) and nitrous oxide emissions were converted to carbon dioxide equivalents (CO_2 e) using conversion factors of 3.67 and 298[2] respectively and summed to predict the net GHG abatement for each scenario S2-S10 relative to the baseline.

Economic modelling

The profitability at the whole-farm scale was measured by *operating profit,* total revenue minus total cost, before tax and interest payments. The annual operating profit accounts for the revenues and costs of multiple crops grown on various soil types. Total revenue was derived by multiplying APSIM simulated yields with the five-year-average farm-gate price for each relevant crop. Total cost includes the variable costs associated with producing a crop including seed, fertiliser, chemicals, machinery maintenance and repairs, fuel, lime, manure, freight, casual labour, and crop insurance. All these variable costs correspond to the management inputs used in the APSIM model and were based on regional practices. Total costs

[1] Information about the Emissions Reduction Fund policy can be found at www.environment.gov.au/climate-change/emissions-reduction-fund and www.mycarbonfarming.com.au

[2] Conversion factors based on IPCC (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA. The conversation factors represent the capacity of one tonne of carbon or nitrous oxide to warm the atmosphere, relative to one tonne of carbon dioxide.

also include fixed or whole-farm operating costs, these costs are incurred regardless of whether a crop is grown and include overheads (electricity and phone bills, insurance, advisory and accounting services, administration expenses etc.), the farmer's wage, machinery costs, and other capital expenditure.

Results and discussion

The modelling shows that increasing soil carbon stocks is the main driver of GHG abatement for the representative farm (Figure 1). Farms in the Dalwallinu area have sandy, well-drained soils and winter-dominant rainfall, which result in low nitrous oxide emission in this region. As such, the scope to achieve GHG abatement by reducing nitrous oxide emissions is limited. For this case study farm, the management scenarios that were predicted to provide abatement are those that increase carbon inputs into the soil (S2, S5–S10), namely:

- Retaining stubble
- Using improved legume pastures instead of weedy volunteer pastures
- Summer cropping with a short-term green manure legume
- Regular applications of feedlot manure

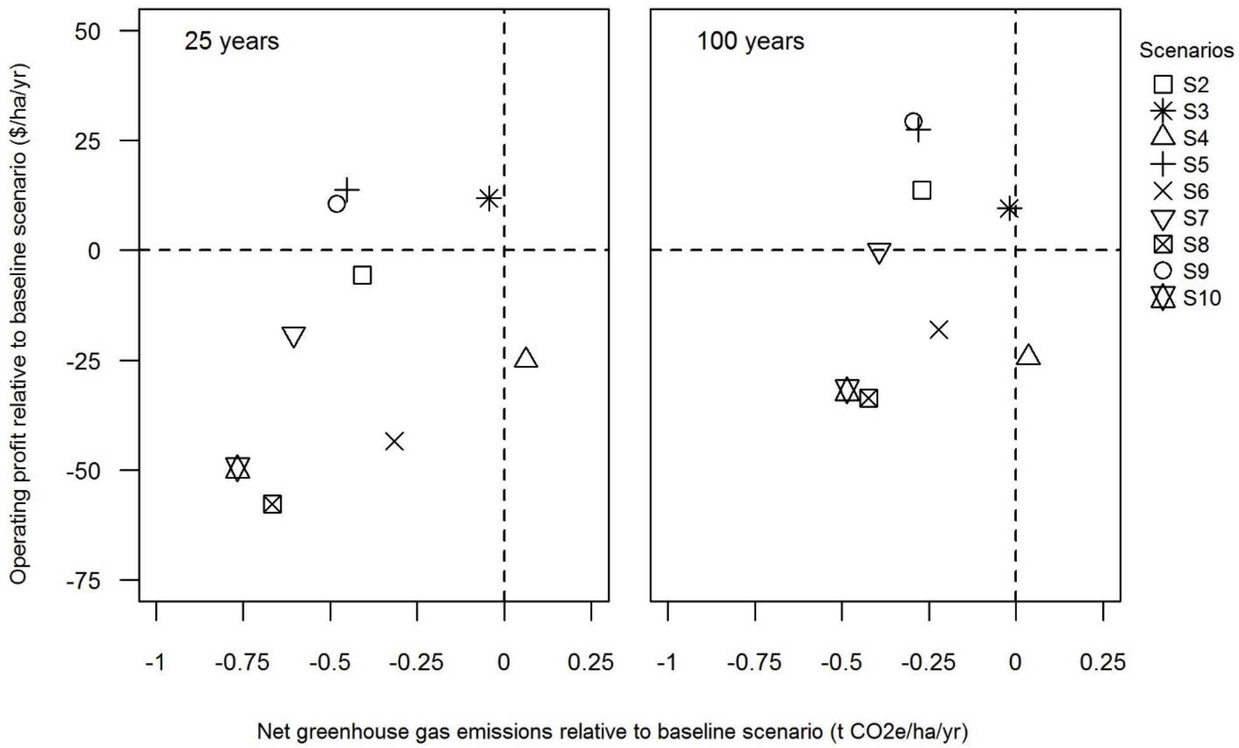


Figure 1: Trade-off in CO_2e and operating profit from adopting scenario practices compared to the baseline for a 25-year simulation (left) and 100-year simulation (right). Points left of the dotted vertical line provide, abatement relative to the baseline scenario (e.g. S6). Points above the dotted horizontal line generate, on average, greater operating profits relative to the baseline scenario (e.g. S5). Scenarios are described in Table 2.

The cost of implementing practices to achieve emissions reductions varies. For example, replacing summer fallows with a short-term green-manure legume crop reduced operating profits by $58 per hectare per year. This lower profitability is driven by higher costs associated with planting and managing the summer crop. By comparison, replacing winter fallows with improved legume pastures (S9) over a 25-year period increased farm operating profits by $11 per hectare per year. This increase in profitability is a result of higher yields in the subsequent winter crops, and lower fertiliser input costs. This finding indicates there may be value in investing in improving the pasture phase of crop rotations.

Comments
Overall, the results show that there are management practices that can contribute to reduced greenhouse gas emissions in the Liebe area. There are some feasible changes to farm management that can reduce net greenhouse gas emissions that do not necessarily reduce profitability (e.g. retaining stubble or replacing winter fallows with improved pastures). However, to achieve the maximum greenhouse gas reductions modelled in this study (through, for example, summer cropping), more substantial changes to the system were required which may reduce profitability, for example, increasing carbon inputs through summer cropping. These results indicate there may be limited opportunities for grain farmers to significantly and profitably reduce greenhouse gas emissions.

It is important to note that greenhouse gas emission reductions under different management practices will vary with climate, soil type and crop rotations. It is therefore important to investigate opportunities for greenhouse gas abatement on a case-by-case basis.

Acknowledgements
This project was a Carbon Farming Futures Filling the Research Gap project funded by the Australian Department of Agriculture and Water Resources and the GRDC.

Paper reviewed by: Dr Penny Roberts Craig

Contact
Peter Thorburn, CSIRO
peter.thorburn@csiro.au

Nikki Dumbrell
nikki.dumbrell@adelaide.edu.au

Liebe Group Projects

Figure: Lebeckia 4 weeks after sowing.

Perennial legume pastures to transform the sandplain

Jill Wilson, Secretary WA Landskills Inc & farmer

Aim

The original aim of the project was to demonstrate on-farm two recently developed perennial pasture legumes: Tedera and Lebeckia (from Dept of Agriculture and Food WA & Murdoch University respectively). Due to some logistical issues with Tedera, the focus of the project is now mainly Lebeckia.

Background

Both pasture types are adapted to the infertile soils and Mediterranean climate of WA and have been sourced from the Canary Islands (Tedera) and South Africa (Lebeckia). They are both perennial legumes. Local sandplain soils would benefit greatly from the addition of a perennial pasture legume to the farming system. These soils are infertile, highly leaching, with a low carbon content and poor nutrient holding capacity and they are also prone to wind erosion and salinity. An herbaceous legume pasture with the attributes of both perenniality and nitrogen fixing ability would provide multiple benefits. While lucerne is available to fit this niche, its establishment and persistence on the poorer soil types is a challenge.

Activities

Under this project, three demonstrations have been set up: at Carter's in Wubin, at Badgingarra Research Station, and at JJs Farm Karakin (east of Lancelin).

Owing to the shortage of Tedera seed, a small plot of this was sown only at the Wubin site. However, establishment has not been successful. The Tedera germinated and survived for approximately three months before dying. Pot tests are currently being run with the Wubin soil to determine if the soil was the inhibiting factor.

Lebeckia was sown at all three sites. In addition, John Howieson has demonstration and experimental plots in many other places including Mingenew and Binnu as well as several down south. Some successful trials have also been running at Harrismith near Narrogin for a couple of years.

The Lebeckia plots were established in August 2016 using a small scale seeder developed by Murdoch University. The seeds, and germinating plants, are tiny, but develop into robust shrubs.

Project Outcome

So far Lebeckia establishment has been successful at all sites, though weed control has been a challenge. Demonstrations will be on show at field days in 2017.

Figure 1: John Howieson seeding Lebeckia.

Figure 2: Brad Nutt adjusting mini seeder.

Figure 3: Young Lebeckia at Wubin.

Acknowledgements

The project has been developed by community group WA Landskills in conjunction with the Liebe Group and the West Midlands Group. There is now significant input from Professor John Howieson and his Crops and Plant Sciences staff at Murdoch University. Dr Daniel Real who developed Tedera at DAFWA was also involved in the Wubin site. Funding is provided by a Farm Demonstration grant from the Northern Agricultural Catchments Council via the federal government's National Landcare Program.

Contact

Dr Jill Wilson, WA Landskills
landskills@bigpond.com
0429087172

Implementing change and innovation through a farmer-based mentoring program

Katrina Venticinque, Administration Officer, Liebe Group

Aim

The project aims to build the capacity of farmers in the region and improve sustainability through on farm changes made during the project.

Background

Agriculture is highly diverse in nature and, as a result, there is a wealth of knowledge and experience within the community. This project will engage those farmers who are willing to offer their support and advice to innovative young growers. The Liebe Group will facilitate this throughout the mentoring program and provide formal guidance through the process. This will involve workshops, surveys and periodic catch-ups to ensure the program and partnerships are running smoothly and where necessary changes be made.

Liebe Group members expressed their interest in this type of formalised mentoring program following on from the 2015-2016 Rabobank Knowledge Partnership Program. There was an identified need to utilise the assets within the local community to support the up and coming generation of farmers, as well as the reciprocal learning opportunities. Growers were highly interested in areas of business management, agronomy, farming systems, accounting, succession planning, natural resource management, soil health, social media and new technologies.

Check ins with the mentors and mentees will be conducted throughout the program to ensure the partnerships are being maintained, as well as an opening and closing workshop. A survey will also be completed by participants of the program to measure the outcomes from the project including the success and opportunities for improvement within the program.

A case study will be compiled and extended on different mentoring partnerships to promote the on farm changes that have resulted.

Project Outcome

The project outcome will be the increased capacity of farmers within the region, creating networking and partnership opportunities that are sustainable into the future.

Acknowledgements

This project is being delivered by the Liebe Group. It is supported by the Northern Agricultural Catchments Council, through funding from the Australian Government's National Landcare Programme.

Contact

Katrina Venticinque, Liebe Group
admin@liebegroup.org.au
(08) 9661 0570

General Information

Planfarm Bankwest Benchmarks 2015 – 2016 Season

Both Planfarm and Bankwest – producers of the two dominant and most respected farm business benchmarking surveys in Western Australia, have joined forces to create the Planfarm Bankwest Benchmarks.

The Planfarm Bankwest Benchmarks are a comprehensive annual farm business analysis derived from the records of Planfarm, Bankwest, Bedbrook Johnston Williams, Business Ag and Ag Asset, and represents a large cross section of WA broadacre farm businesses.

The survey results need to be viewed in context of the individual situation. If the performance of a business is low in a certain area then the factors affecting this area will need to be analysed. If the lower performance can be justified by something which cannot be changed (e.g. the farm in question has a lower than average rainfall or poorer than average soils than the group) then there may be little need for concern. However, where there are factors affecting performance that are directly influenced by management, then an assessment should be made on what changes will improve performance and profitability.

Definition of terms

Effective Area (ha) – land area used directly for the purposes of producing crops or livestock. Does not include non-arable land such as salt lakes, rocks and bush.

Gross Farm Income ($Eff/ha) – all income produced from farm related activities with respect to the area farmed.

Fertiliser ($Eff/ha) – cost of fertiliser applied with respect to the area farmed.

Plant Investment ($/Crop ha) – measures the value of machinery with respect to the area cropped.

Operating Costs (OPEX) – relates to any payments made by the farm business for materials and services excluding capital, finance and personal expenditures.

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.

Operating Surplus ($Eff/ha) – farm income less operating costs. Measures the return on farming activity before account is taken of depreciation expense.

Pesticides/Herbicides ($/ha Crop) – cost of any pesticides or herbicides used with respect to the area cropped.

April – September Rainfall (mm) – growing season rainfall (April - September) of survey participants.

Total Sheep Shorn – total number of sheep shorn including lambs.

Wool Cut (Kg/WGha) – amount of wool cut with respect to winter grazed hectares.

Wool Price ($/kg) – value of wool sold with respect to the amount of wool cut.

Bottom 25% – the average of the low 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.

These results have been extracted from the 'Planfarm Bankwest Benchmarks 2015/2016'.
For more information please contact the Bankwest Agribusiness Centre on (08) 9420 5112.

Figure 1: The regions used in the Planfarm Bankwest Benchmark survey.

Table 1: Farm Group Statistics - Low Rainfall Zone, Region 2 from the 2015/2016 season.

Variables	Unit	Top 25%	Average	Bottom 25%
Effective Area	ha	6,643	6,954	5,572
April - September Rainfall	mm	225	222	237
Permanent Labour	person	2.2	2.3	2.3
Casual Labour	wks	24.6	29.4	12.3
Effective Area/Perm Labour	ha	5,549	2,505	2,564
Income/Perm Labour	$	1,294,083	961,650	633,897
Operating Surplus/Perm Labour	$	656,920	416,192	189,633
Gross Farm Income (GFI)	$/eff ha	524	400	294
Operating Costs (OPEX)	$/eff ha	252	232	215
Farm Operating Surplus	$ eff ha	273	168	79
Farm Oper. Surplus/mm GSR Rainfall*	$/eff ha	1.41	0.90	0.42
OPEX as % GFI	%	48	58	73
Return on Capital	%	16.5	10.9	4.1
Total Crop Area	ha	5,594	5,206	3,720
% Effective Area Crop	%	87	77	72
% Of Crop as Legumes	%	0	2	2
% Of Crop Oil Seed	%	12	7	6
% Effective Area Pasture	%	13	23	28
Wheat Yield	t/ha	2.01	1.71	1.48
Wheat Area	ha	4,534	4,199	2,862
Wheat kg/mm Average	kg/mm	10.58	9.29	7.86
Lupin Yield	t/ha	-	1.33	1.40
Lupin Area	ha	-	212	247
Barley Yield	t/ha	2.91	2.01	1.80
Barley Area	ha	1,248	627	406
Canola Yield	t/ha	0.93	0.83	0.70
Canola Area	ha	778	527	348
N Use on Cereals	kg/ha	28.39	24.17	24.08
P Use on Whole Farm	kg/ha	6.54	5.61	4.93
Herbicide Costs	$/ha crop	58	57	58
Plant Investment	$/ha crop	320	314	273
Opening Sheep Number	hd	1,422	2,043	833
Closing Sheep Number	hd	3,390	2,542	570
Number of Ewes Mated	hd	956	1,296	382
Lambs/wg ha	no.	0.5	0.7	0.4
Wool Price	$/kg net	6.74	6.81	6.72
Wool Cut/Grazed Area	kg/wgha	5.52	6.44	3.80
Stocking Rate	dse/wgha	1.21	1.25	0.58
Wool Production	kg greasy	7,783	11,061	4,482
Average kg/Sheep Shorn	kg	4.09	4.69	5.92

*Top and bottom 25% groups are sorted by farm operating surplus/effective ha/mm growing season rainfall.

Table 2: Farm Group Statistics - Medium Rainfall Zone, Region 2 from the 2015/2016 season.

Variables	Unit	Top 25%	Average	Bottom 25%
Effective Area	ha	4,719	4,081	3,063
April - September Rainfall	mm	238	243	256
Permanent Labour	person	2.8	2.2	1.9
Casual Labour	weeks	38.6	23.9	12.9
Eff Area/Perm Labour	ha	1,375	1,533	1,407
Income/Perm Labour	$	1,024,664	898,162	591,021
Op Surplus/Perm Labour	$	445,287	296,168	112,639
Gross Farm Income (GFI)	$/eff ha	790	600	433
Operating Costs (OPEX)	$/eff ha	454	403	353
Farm Operating Surplus	$/eff ha	336	197	81
Farm Oper. Surplus/mm GSR Rainfall*	$/eff ha	1.75	1.02	0.41
OPEX as % GFI	%	57	67	81
Return on Capital	%	9.3	4.2	-0.1
Total Crop area	ha	4,212	3,404	2,072
% Effective area crop	%	90	82	70
% Of crop as legumes	%	5	7	8
% Of crop oil seed	%	18	16	9
% Effective area pasture	%	10	18	30
Wheat Yield	t/ha	2.63	2.22	1.87
Wheat Area	ha	2,513	2,018	1,265
Wheat kg/mm ave	kg/mm	13.96	11.66	9.60
Lupin Yield	t/ha	1.65	1.48	1.35
Lupin Area	ha	326	346	321
Barley Yield	t/ha	2.95	2.52	2.02
Barley Area	ha	670	581	411
Canola Yield	t/ha	1.47	1.34	1.16
Canola Area	ha	801	738	432
N Use on Cereals	kg/ha	68.51	54.33	56.63
P Use on Whole Farm	kg/ha	11.17	10.16	9.78
Herbicide Costs	$/ha crop	78	82	79
Plant Investments	$/ha crop	472	453	473
Opening Sheep Numbers	hd	3,626	2,680	2,572
Closing Sheep Numbers	hd	3,873	2,728	2,920
No. of Ewes Mated	hd	1,818	1,373	1,266
Lambs/wg ha	no.	2.3	1.7	1.2
Wool price	$/kg net	7.98	6.83	6.02
Wool cut/grazed area	kg/wgha	23.60	19.30	16.42
Stocking rate	dse/wgha	6.18	4.43	4.16
Wool production	kg greasy	15,986	12,192	11,690
Ave kg/sheep shorn	kg	4.03	4.31	4.40

*Top and bottom 25% groups are sorted by farm operating surplus/effective ha/mm growing season rainfall.

2016 Rainfall Report

	Dalwallinu	Kalannie	Coorow	Carnamah	Latham	Perenjori	Wongan Hills	Goodlands	MTS Nugadong	LTRS West Buntine
Jan	10.4	34.3	18.2	58.1	41.8	25.3	90.6	71.0	57.2	41.8
Feb	0.4	5.0	19.2	0.0	1.4	0.0	0.4	26.0	7.8	1.6
Mar	84.6	71.8	93.6	55.9	44.4	29.3	93.0	80.0	78.8	64.4
Apr	45.0	44.2	67.5	68.8	45.6	42.9	55.8	27.6	33.4	48.4
May	46.2	55.4	37.3	26.2	32.4	29.4	42.2	44.6	39.0	25
June	41.2	28.8	61.3	42.2	43.6	28.8	64.2	40.8	34.6	24
July	42.2	41.6	49.5	58.2	56.6	-	68.6	46.2	37.8	48.4
Aug	39.2	37.6	41.6	40.6	38.8	-	50.6	37.4	29.8	47.0
Sep	14.0	30.4	33.7	12.9	17.6	-	25.4	16.8	11.2	21.2
Oct	8.0	6.6	7.7	1.2	7.2	-	15.2	12.2	0.0	8.6
Nov	0.6	0.0	8.4	3.6	0.8	-	2.0	0.0	0.0	4.0
Dec	1.2	-	-	0.2	0.4	-	5.8	8.0	0.0	3.6
GSR (Apr-Oct)	235.8	244.6	298.6	250.1	241.8	101.1	322.0	225.6	185.8	222.6
Total	333.0	355.7	438.0	367.9	330.6	155.7	513.8	410.6	329.6	296.2

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 on (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.

2016 Liebe Group R&D Survey Results

Conducted September 2016 at the Spring Field Day

What are the key problems affecting your farm business that could be addressed through research by the Liebe Group?

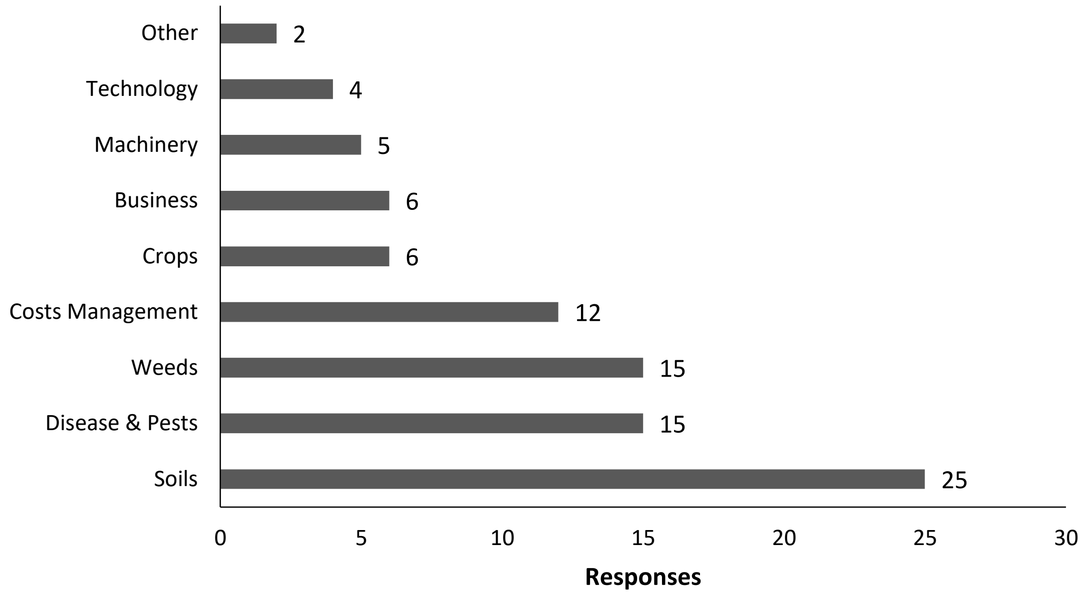


Figure 1: Farmers' responses when asked about key problems affecting their farm business, recorded at the Liebe Group Spring Field Day 2016.

What are the key areas of interest in relation to soils? (Figure 1)

- pH, soil acidity
- Subsoil constraints
- Subsoil health: getting lime, nutrients, topsoil down to depth
- Soil acidity
- Compaction
- Ways to manage salt/stop salinity spreading
- Soil amelioration incorporation techniques and long-term results of doing this
- Soil balance
- Use of burnt lime for subsoil acidity
- pH stratification - limed soil on top good, sub soil still low
- Sandplain limiting yield increases
- Better nutrient decisions with subsoil nutrient testing

What are the key knowledge and skill issues that could be addressed through training, workshops or other communication activities organised through the Liebe Group?

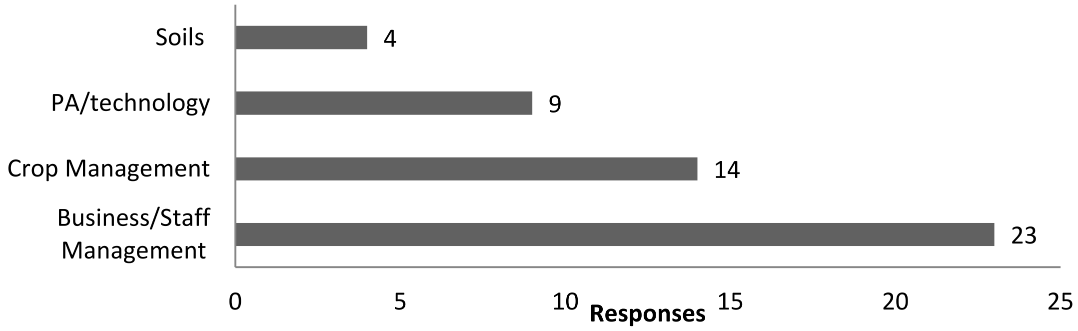


Figure 2: Farmers' responses when asked what key issues could be address in the training or workshops, measured at the Liebe Group Spring Field Day 2016.

Business/Staff Management interest areas based on grower responses at the Liebe Group Spring Field Day 2016 (Figure 2):

- Grain training (marketing) better understanding of futures/swaps
- Greater interaction with universities, networking with researchers
- Economics
- Financial planning and management
- Farm safety compliance
- Team management
- Understanding cost x growth
- More mentoring
- Ways to get your business out of a sticky situation, i.e. tight year, high debt - if you are in this situation what are some strategies you can employ, how do businesses get in trouble the first place?
- How to create a financial buffer in a good year
- Social media workshops - twitter
- Business decision skills workshop
- Study tours information gained from other groups or locations
- Business management
- Decision making around seasonal events
- Farm business planning and structures
- Off-farm investment

What particular concept/products/practices would you like to see demonstrated by the Liebe Group?

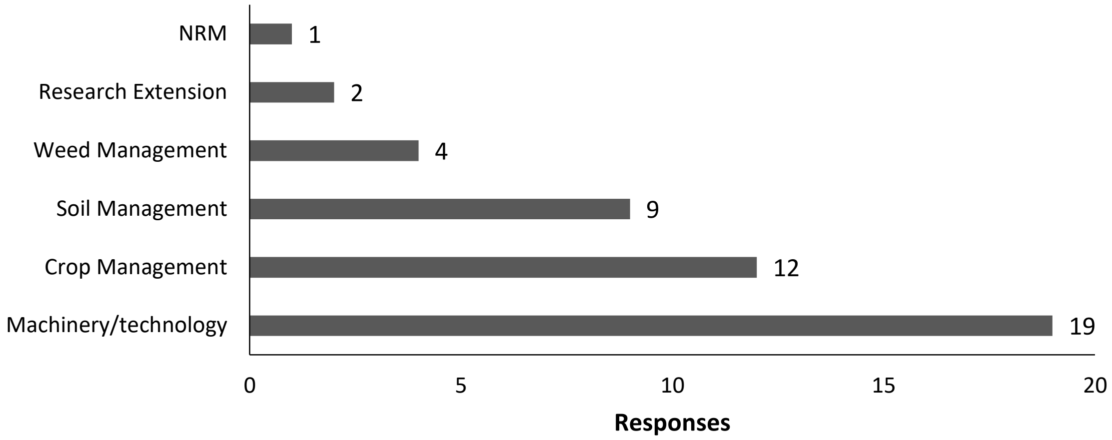


Figure 3: Farmers' responses when asked what concepts/products/practices they would like to see demonstrated, measured at the Liebe Group Spring Field Day 2016.

Machinery/technology interest areas based on grower responses at the Liebe Group Spring Field Day 2016 (Figure 3):

- Variable rate implementation and decision making
- Deep tillage
- Discs
- Deep ripping
- Deep ripping heavy country
- Controlled Traffic Farming (CTF)
- Drones
- Precision ag
- Even spreading concepts
- Lime incorporation
- Harrington seed destructor
- More machine demonstrations
- Variable rate and controlled traffic costs vs benefits
- Comparison of cultivation options
- Local/soil type controlled traffic response in yield

What long term research would you like the Liebe Group to invest in?

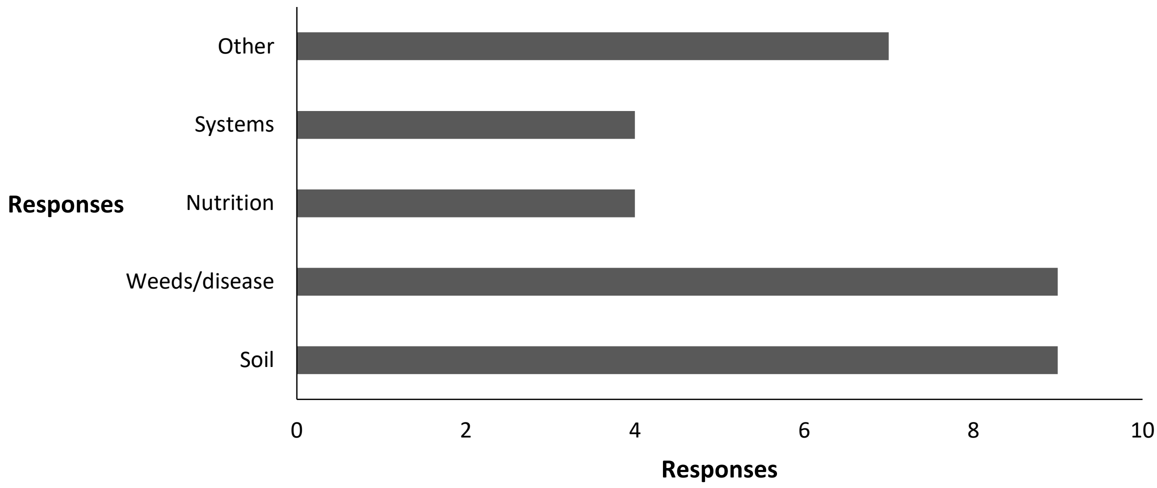


Figure 4: Farmers' responses when asked what long term research they would like to see invested in by the Liebe Group, measured at the Liebe Group Spring Field Day 2016.

Long term research areas based on grower responses at the Liebe Group Spring Field Day 2016 (Figure 4):

Soils
- Soil biology
- How to increase soil health
- Subsoil constraints – acidity and compaction (ripping to 500mm)
- Calsap vs lime in tackling acidity
- Gypsum and dolomite application

Weeds/disease
- Integrated weed management
- Herbicide resistance
- Resistant ryegrass (glyphosate) management over the long-term
- Seedbank - depletion of weeds
- Summer weed control methods
- Economics of disease control
- Root lesion nematodes

Nutrition
- Liquid ferterliser with fungicide/trace elements
- Long-term nutrition effects and carry over
- Targeted lime application/fertiliser rates
- Variable rate long term decision making and economics

Systems
- Full farm management systems
- Lower cost farming practices (dollars and time)
- Continual cropping rotations, which is most viable and profitable?
- Crop grazing/cell grazing
- Better water harvesting

Other

- Rock gone machine trial
- Frost tolerance
- Low rainfall alternatives to all aspects of current research (<200 mm in season)
- Innovative technologies
- Big data
- Economics of leasing

The Liebe Group Strategic Plan 2012 – 2017

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 implementation.
- 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 Group is here for its members, it must be to their cause and benefit. R&D, technology and capacity building is local and relevant and prioritised 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 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 career directions.

Independence
The Group is independent and acts from 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 their supporting sub committees which use accountable and transparent processes. We expect staff to be confidential in their dealings with in the group.

Working Together
Effective networking and links to beneficial partnerships is encouraged to add value and opportunities for the group. The Group works collaboratively within the agricultural industry to value add. The group maintains an ethos of team work and cooperativeness.

Respect
The Group always values and respects their members and their resources and experience. We expect people to be open and honest, and build processes that reflect transparency of the administration and processes used in the group.

Fun
There is a social and fun philosophy within the group.

Introduction

The 2012-2017 strategic plan was developed in September 2011 with the assistance of Nigel McGuckian from RM Consulting Group and builds on the existing strategic plan. Strategic planning has always been a 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 is the fourth strategic planning exercise the group has conducted.

During this process members were asked to describe the current external agricultural environment they are working in and what it may look like in 10 years' time.

They described the future as having the following characteristics:
- Faster and more diverse modes of communication.
- Real-time accessibility to anything, anywhere.
- Food is highly valued and as a result, quality and accountability pressures are high.
- Rapid technology advancement in crops, soils and input efficiencies leading to significant productivity gains.
- Declining and more diverse rural populations.
- Information is readily available and comes in many different forms and from many different sources.
- Time pressures continue to increase.

Members were then asked to define what role a farmer group may play in the future.

They described a group having the following characteristics:
- Strong networks at a lot of different levels - locally, nationally and internationally.
- Impartial and independent information is highly valued in times of 'information overload'.
- Increased capability to capture, filter, catalogue and provide more targeted information.
- Ability to validate new technologies on-farm in a variety of different ways.
- Face-face interaction is valued more than ever and the group has good systems to support this.

The members acknowledged that the future and the environment we are currently operating in is continually changing and the role of the Liebe Group needs to continually change and adapt in order to stay relevant. During this time, there will be opportunities for the group to capitalise on and threats to manage.

OPPORTUNITIES

- Capturing and fostering the group philosophy and energy to engage more people with similar interests;
- Increase the use of new and varied tools for communication and extension;
- New systems to utilise and access knowledge from anywhere in the world instantly;
- Increase problem solving capacity – highly skilled staff and contractors;
- New methods of validating information and technology on-farm that is quicker and impartial;
- Strong processes to capture, catalogue, filter and extend information;
- Encouragement of new growth in rural towns through development of value adding projects;
- Develop methods to support and stimulate innovative thinking and new ideas;
- Creation of a more positive and attractive image of agriculture;
- Continual engagement and support of young people in agriculture.

THREATS

- Creation of a large gap between generations and those who don't relate to technology;
- Lack of new ideas and innovation;
- Loss of group vibrance through distance, population decline and burnout;
- Farmers becoming distracted from their core business and what they do well;
- Loss of capacity to operate at a continually growing level;
- Vision is too far ahead of the membership which risks losing member involvement;
- Declining profitability of farms;
- Decline in agricultural students coming through the system leading to a skills drought;
- Increasing call on resources increasing the risk of being too thinly spread to be effective;
- Uneven distribution of technology through membership e.g. variable mobile signal coverage;
- Loss of representation of members in the industry.

Strategy Area 1

High Priority Research and Development, Supported by Targeted Extension and Improved Validation Methods

Rationale

Conducting high priority research and development is important to foster growth in the agricultural sector. R&D improves the capacity of people to make effective decisions, and when supported by targeted extension activities and validation methods, growers will have an increased capacity to make effective adoption decisions.

Liebe Group members will have access to the latest research and development activities conducted in Liebe Group area. R&D activities will be targeted towards issues identified by the members and prioritised by Liebe Group management. The prioritisation will be supported by a research and development advisory committee. The group will assist growers with implementation through conducting appropriate extension activities and methods to improve on-farm validation.

2012-2017 Targets

- 100% of Liebe Group members have made an effective adoption decision concerning the adoption of new technology assist by the Liebe Group.
- 10% increase of attendees under the age of 25 at major events.
- A quality rating of 80% or greater by attendees of major events.

Activities

Attract and develop partnerships with agribusiness and research organisations

- Include key industry personnel on the Liebe Group mailing list.
- Maintain close relationship with Department of Agriculture and Food WA, Universities, CSIRO and other agribusiness.
- Keep abreast of GRDC research priorities and maintain close relationships Western Panel and grower group contact.
- Develop and maintain partnerships with other industry and research bodies when opportunities arise.
- Distribute Liebe R&D priorities and trial site details to major research organisations and agribusiness.

Develop trials and demonstration to address local priorities at the Main Trial Site, Long Term Research Site, satellite sites and on farm

- Determine research and development priorities from annual member survey and R&D planning meeting.
- Develop trial program for the satellite sites in conjunction with DAFWA and agribusiness.
- Organise and conduct on-farm demonstrations.
- Discuss strategic R&D priorities at general meetings.
- Ensure we seek R&D opportunities that encompass a whole systems approach.
- Maintain Soil Biology Trial at the Long Term Research Site.
- Raise profile of the Long Term Research Site and attract research bodies wishing to conduct trials of a long term nature to the site.
- Maintain trial program at the Long Term Research Site.
- Ensure R&D protocols are adhered to

Increasing adoption of new technologies

- Benchmark adoption levels of Liebe members every three years.
- Conduct farmer case studies and economic analysis on growers that have adopted new technology.

- Conduct on-farm demonstrations and economic modelling with growers that are considering technology adoption.

Extend Results of Research, Development and Validation
- Conduct a Spring Field Day at the Main Trial Site.
- Conduct field walks at satellite sites and the Long Term Research Site.
- Hold an annual Crop Updates to prepare growers for the coming season.
- Extend results in an annual R&D Book and review priority research at a Trials Review Day.
- Promote results to the wider community.
- Assist in attracting members to events by having a high profile guest speaker.
- Develop and maintain a website.

Performance Measures
- Research and Development advisory committee to meet at least three times a year to develop R&D priorities and discuss issues with industry partners.
- Conduct an annual membership survey to understand farming issues and priorities.
- Conduct a technical audit every three years to benchmark technology adoption.
- Conduct an evaluation of every event.
- Review website contents monthly.

Strategy Area 2

Members with High Business & Farming Aptitude

Rationale

Making good decisions is a product of understanding the issues and the opportunities and risks associated with these. By providing training in areas of skills gaps within the membership ensures members have the capacity to function effectively and efficiently to improve their businesses and reach their potential. This strategy will give Liebe members access to professional training conducted in areas of identified skills gaps as well as well-targeted, high quality, independent and factual information.

Activities

Workshops and study tours
- Use member survey and feedback to identify member requirements.
- Conduct high priority workshops annually (e.g. agronomic, management, financial, skills, communication).
- Conduct intra or interstate tours, visiting innovative, interesting and sustainable farming systems.

Communication
- Members informed of local, relevant and timely information in newsletters, e-news, Facebook and Twitter.
- Early notification of all dates and opportunities to provide members with plenty of time to schedule time off farm. Add dates to GGA calendar and check with local organisations to avoid clashes.
- Case studies of innovative farm practices produced.

Encourage all sectors of the community to attend Liebe Group events
- Conduct events that encourage young farmers and women to be involved.
- Encourage mentorship within the Liebe Group through encouraging interaction at events.
- Ensure we are being inclusive when catering for events.

Member Development

- Encourage greater input from non-involved members to come along to Liebe events. Bring a buddy philosophy.
- Promote external workshop or development opportunities to members via email and newsletter (Investigate sources of financial assistance for members to take up development opportunities or investigate possibility for Liebe Group to provide financial assistance).
- Review standard proposal for members to receive remuneration for voluntary time.
- Ensure members are being well serviced and areas for improvement are sought by phone interviews, farm visits and discussions at events.
- Ensure a sense of fun is incorporated at all Liebe events.

Efficient Information Management

- Cataloguing new and existing information.
- Improving searchability of new and existing information.
- Filtering information.
- More accessible information.

Performance Measures

- Conduct three major events annually
- Conduct three training workshops on prioritised subjects annually
- Produce nine monthly newsletters
- Produce six media releases per year
- Produce an annual calendar of events.

Strategy Area 3

A Collaborative and Connected Organisation

Rationale

The Liebe Group strives to connect its members to the industry and the media to ensure they are fairly represented and their successes are acknowledged. Collaborations with specific industry bodies allow for a participatory approach to research and a two-way feedback cycle to occur. Connections to other people whether locally, nationally or internationally allow members to share experiences with other like-minded people or groups. This approach fosters innovation and progress.

2012-2017 Targets

Recognised by stakeholders as a leading farmer group involved in rural profitability, lifestyle and natural resources.

Activities

Develop and maintain linkages with agribusiness, government agencies, tertiary institutions and political organisations

- Maintain ‘friends’ list for publications with all industry contacts made throughout the year and reviewed annually.
- The prospectus to be made available to the above bodies with an update occurring when necessary.
- Liebe Group website to be updated monthly and placed under high priority as our industry face.
- Encourage relevant industry to attend General Meetings.
- Attend an agricultural industry workshop developed by GGA and similar opportunities.
- Maintain industry profile, so that we are approached to facilitate contact if farmer’s individual opinions are required.

Promote agricultural successes in rural and non-rural media

- Maintain partnership with Farm Weekly to produce monthly Liebe updates for the paper.
- Invite media to main Liebe Group events and publish appropriate press releases.
- Develop contact and build rapport with the West Australian and Sunday Times to promote agriculture outside of the industry.
- Publish monthly updates in the local papers.

Celebrate Liebe and member successes

- Keep abreast of awards and nominate appropriate members.
- Hold an annual Liebe Dinner.
- Cater for post-event celebrations.
- Promote great achievements and member success in Liebe newsletter.
- Maintain and develop Liebe Group identity through staff uniform and badges to be worn at all events, promote sale of Liebe shirts and jumpers on membership flyer.
- Develop system to recognise members who have contributed significantly to the Liebe Group.

Network Building

- Utilise existing partnerships to build strong networks locally, nationally & internationally to foster innovation.
- Utilise new ways of interacting (e.g. social media, websites, electronic tablets etc.).
- Develop a ‘sister’ group with an overseas group.
- Ensure members are supported to be involved in networks.
- Get timely feedback from members.
- Build networks at a local level through mentoring, social interaction and fostering relations between various Liebe stakeholders.

Performance Measures

- Liebe Group to be represented at appropriate industry forums such as the Grower Group Alliance forum and Agribusiness Crop Updates.
- Contribute 6 media releases per year to the Farm Weekly.
- Hold an annual Liebe Dinner celebrating the success of the past year.

Strategy Area 4

Sustainable Group Finances

Rationale

Sound finances give the group the flexibility and control over its activities and progression. The Liebe Group seeks funding from different sources including membership, sponsorship and project funding.

2012-2017 Targets

To have one year’s overhead costs in reserve.

Activities

Finance sub-committee to oversee Liebe Group financials and budget

- Review project funding timeline.
- Prepare budget and allocations for management.
- Approve finance for expensive purchase items.
- Review and account for the Liebe Group finances.
- Track progress of income and expenditure areas.

- Committee meets regularly and when necessary**.**
- Recommendation of fees and value of membership.

Seek Funding
- Maintain strong links with industry partners.
- Seek new sponsors and partners.
- Review sponsorship guidelines and return on investment for each.
- Identify and target high-return sources of funding (sponsors, programs, membership and subcontracting).

Develop membership contributions
Review stability of membership numbers and ensure members are being well serviced.

Performance Measures
- Finance subcommittee to meet at least quarterly and make recommendations to the management committee.
- Prepare a budget annually, to be signed off by the management committee.
- Membership fees to cover administration officer's position.

Strategy Area 5

High Performing Skilled Staff

Rationale
Maintaining and supporting appropriately skilled staff is a priority for the Liebe Group to ensure the group grows and roles are carried out effectively and efficiently. The staff is employed to manage the strategy and policies set by the Management Committee, by maintaining a philosophy of continual support and improvement in employees, the strategy can be implemented to its full potential.

2012-2017 Targets
- The Liebe Group will retain staff for an average of 2.5 years per staff member.
- Staff will consistently rate the Liebe Group as a 'highly desirable' workplace, as determined by an annual survey completed during the performance appraisal process.

Activities
Support and develop Liebe Group employees each year
- Review performance appraisal document.
- Review performance, salary, goals and objectives taking care to enhance employee's areas of interest.
- Conduct annual performance appraisal including SWOT.
- Review new employee induction program, guided by protocol and list of training requirements.
- Identify and provide staff with professional development.
- Conduct fortnightly team meetings.
- Ensure management maintain an ethos of supporting staff.
- Develop and review a mentoring policy for employees.

Maintain and increase employment base in order to meet group requirements
- Review list of all roles and responsibilities, delegating each responsibility to appropriate staff members.
- Identify gaps in roles and skills, and investigate employment options.
- Seek external contracting of specialist skills where necessary.
- Seek feedback from employees to develop and maintain a conducive working environment.

Performance Measures
- Hold an annual performance review for each staff member.
- Provide $1000/yr training budget for each staff member.
- Each staff member to meet with staff support officer at least 3 times a year, including training.
- Exiting staff to complete exit survey.
- Produce an annual social calendar.

Strategy Area 6

Highly Effective Governance

Rationale
Good corporate governance underpins the success of an organisation. The ability of the Management Committee, supporting committees and staff to make well informed and effective decisions is driven by effective process and well supported personnel. The Liebe Group is driven by the decision making capacity of its members and as such needs to adopt a process of constant review to ensure new committee members are continually up-skilled and aware of their roles and responsibilities on the committee. Good governance maintains integrity, accountability, transparency and quality in performance and reporting of our activities.

2012-2017 Targets
The Liebe Group will be a 'best-practice' community group, as measured by an external audit.

Activities
Management Committee, subcommittee and reporting structure
- Management Committee meet on a monthly basis at a general meeting and are responsible for governing the Liebe Group. This involves policy development.
- The Management Committee directs staff through the employment of an Executive Officer.
- A Finance subcommittee of the Management Committee provide recommendations to the Management Committee. This subcommittee consists of some personnel with specialist skills in financial management.
- An Ethics subcommittee of the Management Committee to provide recommendation to the Management Committee on issues of an ethical nature.
- A Research & Development advisory committee and Women's advisory committee, advise staff on operational activities. These committee's consists of some personnel with specialist skills and interests in these areas.
- An Employment advisory committee employs an Executive Officer and provides advice and support to the Executive Officer to employ other staff.
- The Executive Officer must sit on every Liebe Group committee.
- Review Management Committee, subcommittees and advisory committees' purpose and responsibilities annually at the Annual General Meeting.
- Analyse resources, skills and interests required for successful Liebe Group governance and management and individually approach members to be involved in various subcommittees.
- Distribute guidelines for effective committee meetings to all committee members annually.
- Follow succession strategy to increase member involvement on committees as per succession protocol.

Effective group process
- Develop 5 year strategic plan and review objectives annually as a working document.
- Committee members understand their roles and responsibilities.

- Communicate Liebe Group strategy to Liebe Group stakeholders.
- Ensure inclusive processes are always used.
- Maintain transparency in processes.
- Develop written protocols on Liebe Group process to aid in transition of staff and group positions.
- All committees and staff are to operate by the Liebe Group code of ethics.

Performance Measure

- Conduct and Annual General Meeting in February every year.
- Hold 9 General Meetings per year.
- Review strategic plan objectives and targets annually.
- Skills audit conducted annually.

Liebe Group Calendar of Events – 2017

EVENT	DATE	LOCATION
February General Meeting	13th February	Dalwallinu Discovery Centre
Strategic Plan Review, AGM & Celebrations	16th February	Dalwallinu Bowling Club
Crop Updates	1st March	Dalwallinu Recreation Centre
March General Meeting	13th March	Dalwallinu Discovery Centre
April General Meeting	10th April	Dalwallinu Discovery Centre
June General Meeting	12th June	Dalwallinu Discovery Centre
Women's Field Day	20th June	Dalwallinu Recreation Centre
July General Meeting	10th July	Dalwallinu Discovery Centre
Post Seeding Field Walk & Beer 'n' Burger Night	20th July	Main Trial Site – Dodd's Property, west Buntine
August General Meeting	14th August	Dalwallinu Discovery Centre
Liebe Group 20th Anniversary Celebration Dinner	TBC	TBC
September General Meeting	4th September	Dalwallinu Discovery Centre
Spring Field Day	14th September	Main Trial Site – Dodd's Property, west Buntine
October General Meeting	16th October	Dalwallinu Discovery Centre
December General Meeting	11th December	Dalwallinu Discovery Centre

Contact all Liebe Group staff on (08) 9661 0570.


The best value Australian made farm chemicals are at the end of a phone
Call 4Farmers on 1800 038 445...
...Factory direct chemical delivered on-farm to you!
www.4farmers.com.au
35 McDowell Street
WELSHPOOL WA


INNOVATIVE CROP SOLUTIONS
TOP IWM TOOLS
INTEGRATED WEED MANAGEMENT
Hyola®
PACIFIC SEEDS HYBRID CANOLA
TT TRIAZINE TOLERANT HYBRIDS
TT FOR IN-CROP RESIDUAL WEED CONTROL
PROVEN HIGH YIELD & HIGH OIL
'R' BLACKLEG PROTECTION - HIGHER THAN OP TT
#1 TT HYBRID IN AUS FOR OVERALL PERFORMANCE
HYOLA® 559TT
ADVANTA
pacificseeds.com.au
@pacseedswinter
PACIFIC SEEDS