Local Research and Development Results

Results from 2014 season

2015

LIEBE GROUP

Working together in Agriculture

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 2015. This book contains results from research and development conducted in the Coorow, Dalwallinu, Perenjori and Wongan-Ballidu shires from the 2014 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 2015 book.

Also we would like to remind you that many trial results will be reviewed at the **2015 Trials Review Day on the Tuesday 17th February** at the Dalwallinu Bowling Club and the **2015 Liebe Group Crop Updates on Wednesday 4th March** at the Dalwallinu Recreation Centre**.** We invite you to bring this book along to these days so you can follow the trials and ask questions regarding any results you may have found interesting.

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.

Throughout the book our major partners are promoted. 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 Bird Cameron, CBH Group, the Farm Weekly, the Grower Group Alliance and many others.

All the best for the 2015 season and let's hope it brings plenty of rain!

Kind regards,

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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
- The University of Western Australia (UWA)
- The Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Farm Weekly
- Shire of Dalwallinu
- Grower Group Alliance
- Northern Agricultural Catchments Council
- Gunduwa Regional Conservation Association
- Wheatbelt NRM

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 2014. 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:

- **Grains Research and Development Corporation**
- **Department of Agriculture and Food, WA** - Technical advice throughout the year, seeding and harvesting of the trials.
- **The University of Western Australia** - For technical assistance and collaboration opportunities.
- **CBH Group** - Grain sampling and analysis.
- **CSBP labs** - Analysing soil samples.
- **Scholz Rural, Elders Dalwallinu** - Agronomic advice throughout the season and donation of chemical.
- **CSIRO** - For providing and maintaining the weather station, classifying soils, technical advice and collaboration opportunities.
- **Stuart McAlpine and staff** - For harvesting the site, agronomic assistance and monitoring the site throughout the season.
- **Michael Dodd and staff** - For use of his machinery and agronomic assistance.
- **Paul and Daniel Bryant** - Burning trial plots and seeding the site.
- **Syngenta** - Chemical donations for the 63ha site.
- **Summit Fertilizer** - Fertiliser for the site.
- **Wesfarmers Federation Insurance** - Donation of crop insurance.
- **Landmark Dalwallinu** - For donation of chemical for the 63ha site and agronomic advice.
- **Farmanco** - For agronomic advice during the season.
- **Australian Government Department of Agriculture** - Funding three of the trials on site.
- **Adama** - For donation of chemical for the 63ha site.
- **Bayer** - For donation of chemical for the 63ha site.
- **Vicchem** - For donation of chemical for the 63ha site.

LIEBE GROUP COMMITTEES

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

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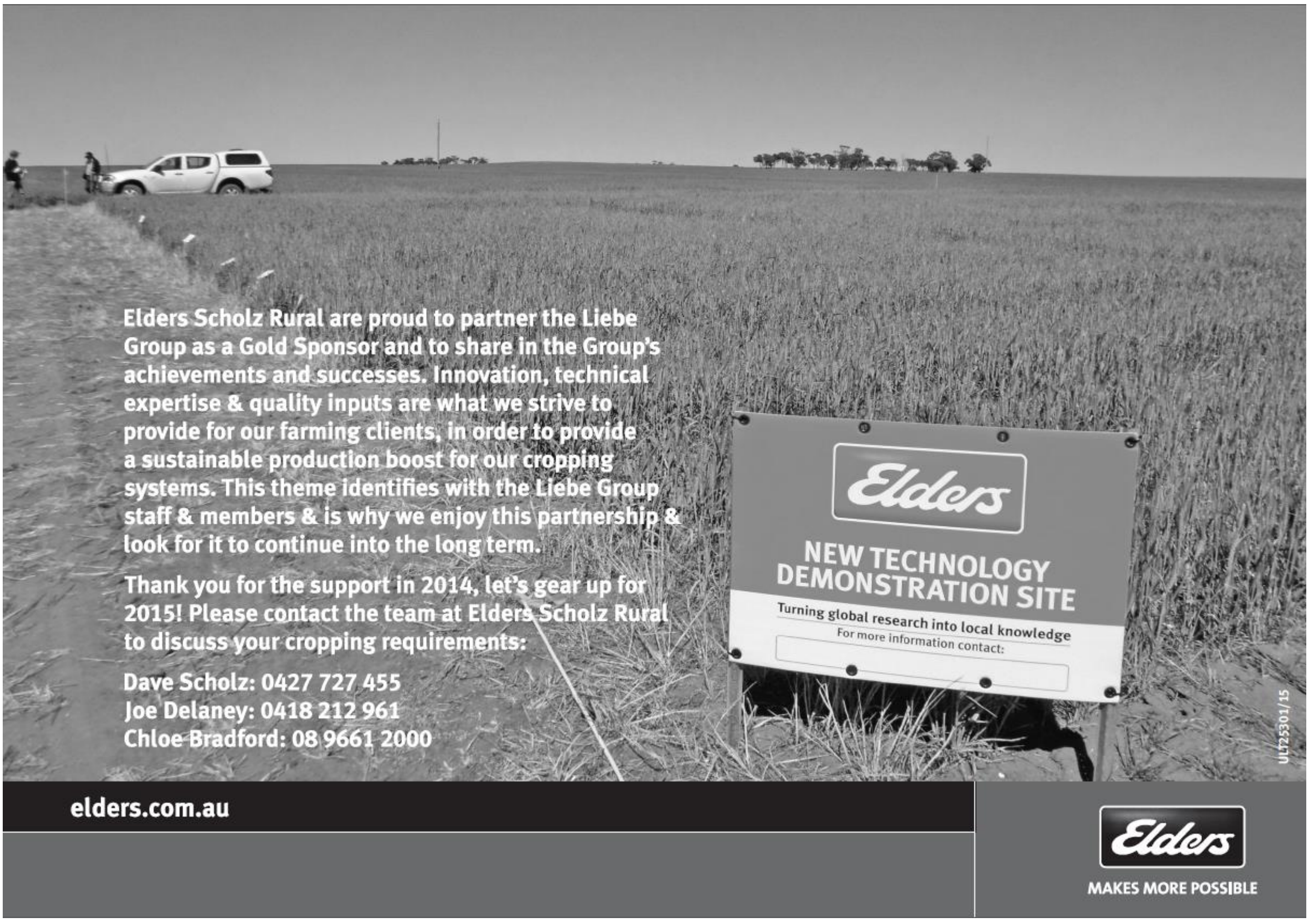
Elders Scholz Rural are proud to partner the Liebe Group as a Gold Sponsor and to share in the Group's achievements and successes. Innovation, technical expertise & quality inputs are what we strive to provide for our farming clients, in order to provide a sustainable production boost for our cropping systems. This theme identifies with the Liebe Group staff & members & is why we enjoy this partnership & look for it to continue into the long term.
Thank you for the support in 2014, let's gear up for 2015! Please contact the team at Elders Scholz Rural to discuss your cropping requirements:
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Local Research & Development Results – February 2015

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Understanding Trial Results and Statistics

We have tried to present all trial results in one format throughout this book. However, due to differences in trial designs, this is not 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 (i.e. different chemicals) or natural variability (i.e. soil type).

Significant Difference

In nearly all trial work there will be some difference between treatments, i.e. 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 (i.e. soil type). If there is a significant difference then there is a very strong chance the difference in yield is due to treatments, not other factors. The level of significance can also play a role. If it says P<0.05% there is a greater than 95% guarantee 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, therefore it is unsure if the difference is 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
LSD (P=0.05)	0.6

The Coefficient of Variation (CV %)

The CV measures the amount of variation in the data. A low CV means less background noise or variation. Generally a CV less than 6% is considered good. 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 (i.e. soil type), and if the same trial was repeated at your place, results may be different.

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 i.e. 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 un-replicated 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.

Cereal Research Results

Wheat National Variety Trial – Miling

Australian Crop Accreditation System Limited

Aim/Background

The wheat National Variety Testing (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	Wade Pearson, Miling
Plot size & Replication	12m x 1.76m x 3 replications
Soil Type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.3 10-30cm: 4.8
EC (dS/m)	0-10cm: 0.090 10-30cm: 0.038
Paddock Rotation	2012: fallow, 2013: fallow
Variety	As per protocol
Seeding Date	07/05/2014
Seeding Rate	75 kg/ha
Fertiliser	07/05/2014: 50 kg/ha Urea, 100 kg/ha Gusto Gold 15/08/2014: 150 kg/ha Maxam
Herbicides & Insecticides	06/05/2014: 4 L/ha Paraquat & Diquat, 2.5 L/ha Prosulfocarb & S-Metolachlor, 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos 04/07/2014: 1 L/ha Bromoxynil, 1% Hasten, 25g/ha Sulfosulfuron
Growing Season Rainfall	207mm

Variety descriptions

Trojan

- Mid-long season maturity, ideally suited to the medium to higher rainfall areas
- APW classification

Harper

- Ideally suited to early to mid-sowing opportunities
- APW classification with Australian Hard potential

Scout

- A high yielding variety suited to the medium to higher rainfall areas
- Medium to longer season maturity similar to Carnamah
- Contains the CSIRO Transpiration Efficiency gene, which confers improved water use efficiency
- Very good grain quality

Hydra

- APW classification
- High yielding
- Robust disease resistance
- Mid-short season maturity with moderate grain size

Cobra

- High yielding mid to long season variety developed for Western Australia
- AH classification in Western Australia
- Excellent Yellow Spot resistance

Supreme

- ANW class
- Early to mid-maturity
- Arrino alternative

Magenta

- Long season
- High yielding
- Excellent yellow spot resistance
- APW classification

Fortune

- Premium udon noodle quality
- High yielding – similar to Calingiri
- Maturity similar to Calingiri

Corack

- Early maturing Wyalkatchem type with improved vigour
- High relative yield performance in low and medium rainfall zones

Kunjin

- Triple rust resistant high yielding soft wheat
- Early maturity
- Excellent grain size and hectolitre weight

Mace

- Highest yielding bread wheat variety in WA
- Broad adaptation, with AH quality classification

Justica CL Plus

- Adapted to the mid to high yield potential areas
- Excellent sprouting tolerance
- Well suited to acid soils

Emu Rock

- High yielding, short season
- AH wheat with large grain size

Wedin

- Triple rust resistant high yielding soft wheat
- Classified as Australian Soft Superior rust package (Stem Rust R-MR, Stripe Rust MR-MS, Leaf Rust R)
- Longer maturity (not as long as Jitarning)
- Good grain size and hectolitre weight

Zen

- High yielding ANW
- Mid-long season maturity
- Excellent yield performance across a broad range of environments, similar to Mace
- Robust disease resistance package; including good yellow spot resistance

Results

Table 1: Yield and grain quality data for 20 wheat varieties grown in 2014, at Miling.

Variety	Yield (t/ha)	Percentage of Site Mean (%)	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Trojan	2.73	108	83.60	9.3	1.40
Harper	2.64	104	81.40	9.0	2.59
Scout	2.61	103	83.40	9.1	1.31
Hydra	2.59	102	81.20	9.3	4.05
Cobra	2.55	101	81.00	9.4	1.96
Supreme	2.55	101	82.80	9.3	1.34
Magenta	2.51	99	82.00	9.5	1.58
Fortune	2.48	98	80.60	9.6	1.12
Grenade CL Plus	2.48	98	79.80	9.7	0.89
Corack	2.47	98	82.00	9.6	2.29
Kunjin	2.47	98	81.20	9.7	1.47
Yitpi	2.47	98	81.20	9.5	2.35
EGA Bonnie Rock	2.46	97	81.40	9.7	0.74
Yandanooka	2.45	97	81.20	9.6	1.96
Mace	2.42	96	81.40	9.9	1.36
Westonia	2.41	95	80.20	9.4	2.23
Wyalkatchem	2.35	93	82.20	10.4	0.70
Justica CL Plus	2.30	91	79.60	10.0	2.16
Emu Rock	2.23	88	82.20	9.6	1.51
Calingiri	2.22	88	81.40	9.8	1.62
Wedin	2.20	87	78.00	8.9	1.13
Zen	2.19	87	83.20	10.2	0.58
Site Mean (t/ha)	2.53				
LSD (t/ha)	0.16	6			
CV (%)	3.7				
Probability	<0.001				

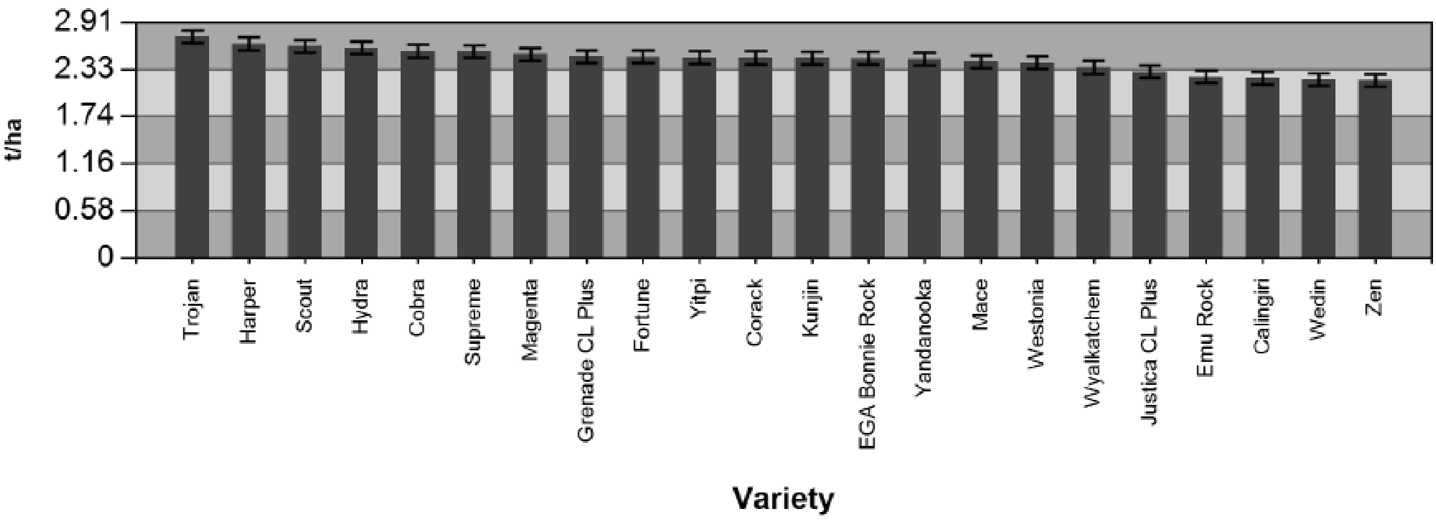

Figure 1: Yield comparison of wheat varieties sown at Miling.

Comments

All trials are sown and harvested as close to or before district grower practice to ensure variety performance is similar to that seen by growers on their farms. The trials are treated with basal fertiliser and urea rates that are significantly higher than growers would use. Weed control rates and combinations of herbicide are also typically more than grower practice.

The wheat varieties are grown to their full yield potential and as a consequence yield cannot be limited by nutrition or weeds. These trials are not grown with a view to conducting a gross margin analysis. The higher nutrition rates do not affect the relativities in variety performance, in fact over the last 7 years of NVT target wheat quality protein has rarely been overdone, generally target protein is achieved or underdone. Time of sowing, soil type, season length and variety maturity are the main parameters that have the greatest effect on variety performance in any one season.

For more information please refer to www.nvtonline.com.au

Wheat National Variety Trial – East Buntine

Australian Crop Accreditation System Limited

GRDC Grains Research & Development Corporation
National Variety Trials

Aim/Background

The wheat National Variety Testing (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	Ross Fitzsimons, east Buntine
Plot size & replication	12m x 1.76m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.0 10-20cm: 4.6 20-40cm: 4.7
EC (dS/m)	0-10cm: 0.13
Paddock rotation	2011: pasture, 2012: wheat, 2013: canola
Variety	As per protocol
Seeding date	27/05/2014
Seeding rate	75 kg/ha
Fertiliser	27/05/2014: 50 kg/ha Urea, 100 kg/ha Gusto Gold
Herbicides & Insecticides	27/05/2014: 2 L/ha Glyphosate, 2.5 L/ha Prosulfocarb & S-Metolachlor, 1 L/ha Trifluralin, 100 g/ha Clopyralid, 500 mL/ha Carfentrazone-ethyl, 1 L/ha Chlorpyrifos 23/07/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 500 mL/ha LVE MCPA, 120 g/ha Clopyralid, 150 mL/ha Prothioconazole & Tebuconazole, 1% Hasten
Growing Season Rainfall	180mm

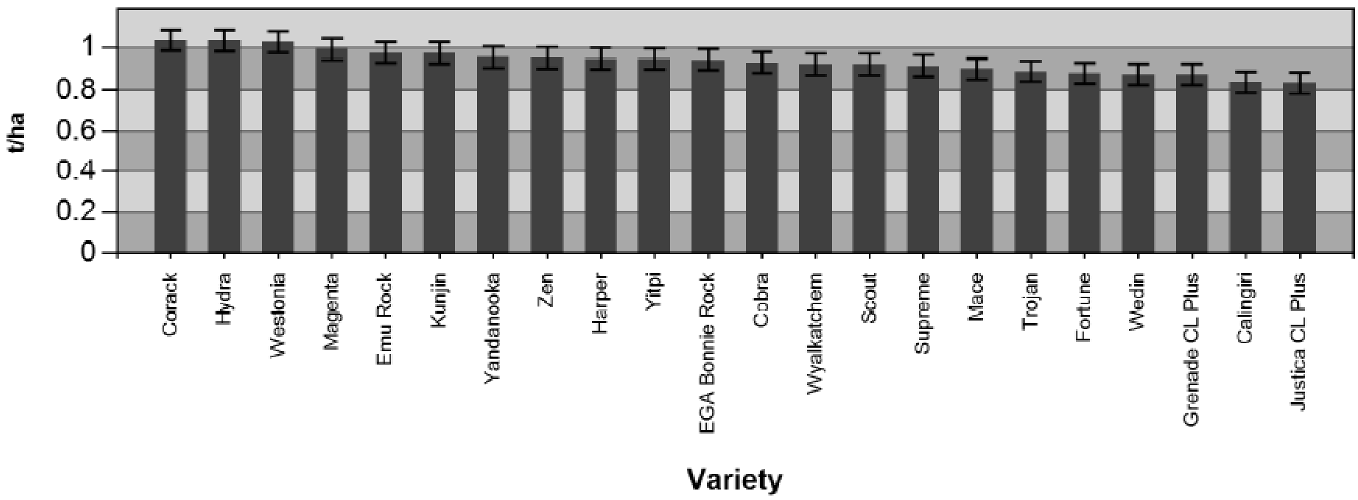

Figure 1: Yield comparison of wheat varieties sown at east Buntine.

Results

Table 1: Yield and grain quality data for wheat varieties grown in 2014, at east Buntine.

Variety	Yield (t/ha)	Percentage of Site Mean	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Corack	1.04	107	81.40	10.9	1.14
Hydra	1.03	106	78.40	10.9	2.51
Westonia	1.03	106	79.40	11.4	3.87
Magenta	1.00	103	79.60	11.6	1.93
Emu Rock	0.98	101	80.60	11.9	1.23
Kunjin	0.98	101	81.20	11.1	0.63
Yandanooka	0.96	99	80.40	11.4	0.98
Harper	0.95	98	80.80	11.1	1.74
Yitpi	0.95	98	79.80	11.3	3.76
Zen	0.95	98	79.60	11.5	0.46
EGA Bonnie Rock	0.94	97	80.80	12.0	2.93
Cobra	0.93	96	79.20	12.1	1.76
Scout	0.92	95	82.00	11.1	1.93
Supreme	0.92	95	79.00	11.3	1.37
Wyalkatchem	0.92	95	80.20	11.4	1.10
Mace	0.90	93	81.20	11.7	0.99
Trojan	0.89	92	80.80	11.2	1.63
Fortune	0.88	91	77.60	11.9	1.10
Wedin	0.88	91	77.80	11.0	1.09
Grenade CL Plus	0.87	90	78.60	11.7	2.90
Calingiri	0.84	87	79.40	11.9	0.86
Justica CL Plus	0.84	87	77.40	12.0	2.96
Site Mean (t/ha)	0.97				
LSD (t/ha)	0.10	10			
CV (%)	6.3				
Probability	<0.001				

Comments

All trials are sown and harvested as close to or before district grower practice to ensure variety performance is similar to that seen by growers on their farms. The trials are treated with basal fertiliser and urea rates that are significantly higher than growers would use. Weed control rates and combinations of herbicide are also typically more than grower practice.

The wheat varieties are grown to their full yield potential and as a consequence yield cannot be limited by nutrition or weeds. These trials are not grown with a view to conducting a gross margin analysis. The higher nutrition rates do not affect the relativities in variety performance. In fact over the last 7 years of NVT target wheat quality protein has rarely been overdone, generally target protein is achieved or underdone. Time of sowing, soil type, the season length and variety maturity are the main parameters that have the greatest effect on variety performance in any one season.

For more information please refer to www.nvtonline.com.au

Wheat National Variety Trial – Cadoux

Australian Crop Accreditation System Limited

Aim/Background

The wheat National Variety Testing (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	Mike Kalajzic, Cadoux
Plot size & Replication	12m x 1.76m x 3 replications
Soil Type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 4.8 10-30cm: 4.6
EC (dS/m)	0-10cm: 0.142 10-30cm: 0.024
Paddock Rotation	2013: canola
Variety	As per protocol
Seeding Date	06/05/2014
Seeding Rate	75 kg/ha
Fertiliser	06/05/2014: 50 kg/ha Urea, 100 kg/ha Gusto Gold
Herbicides & Insecticides	06/05/2014: 2.5 L/ha Prosulfocarb & S-Metolachlor, 4 L/ha Paraquat & Diquat, 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos 03/07/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 1% Hasten
Growing Season Rainfall	180mm

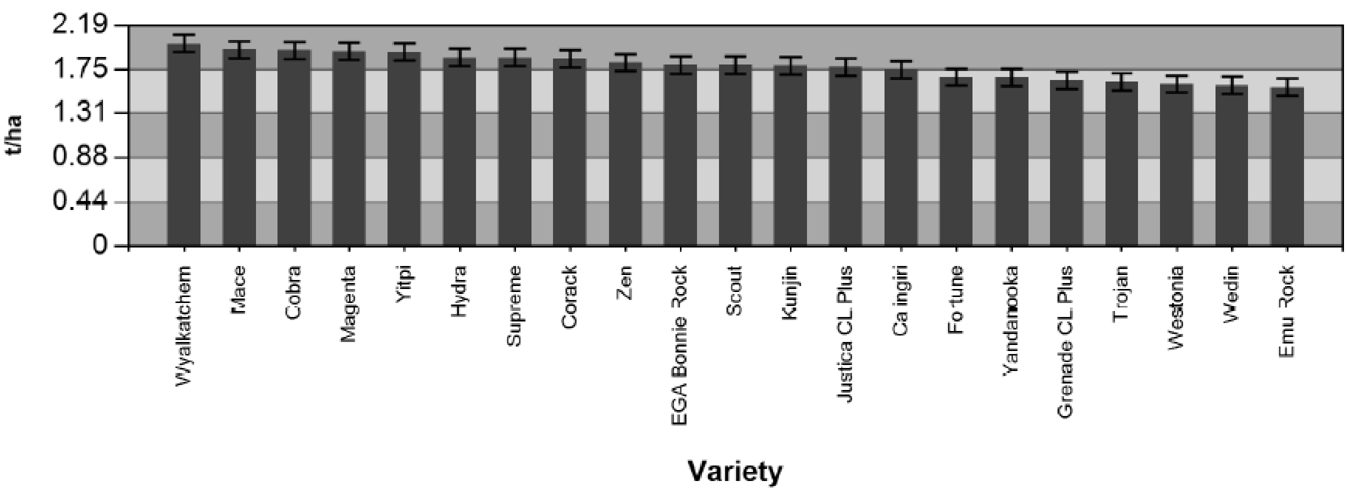

Figure 1: Yield comparison of wheat varieties sown at Cadoux.

Results

Table 1: Yield and grain quality data for wheat varieties grown in 2014, at Cadoux.

Variety	Yield (t/ha)	Percentage of Site Mean	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Wyalkatchem	2.01	109	79.00	8.9	0.36
Cobra	1.94	105	76.40	9.2	0.38
Mace	1.94	105	79.60	8.6	0.47
Magenta	1.93	105	79.00	8.9	1.21
Yitpi	1.92	104	78.40	8.7	1.16
Hydra	1.87	102	77.20	8.6	0.63
Supreme	1.87	102	77.20	8.6	1.62
Corack	1.86	101	77.80	8.7	0.42
Zen	1.82	99	79.40	9.1	0.26
EGA Bonnie Rock	1.80	98	77.60	9.3	0.78
Scout	1.80	98	79.60	8.7	1.16
Kunjin	1.79	97	76.40	8.8	0.72
Justica CL Plus	1.77	96	76.20	9.1	1.01
Calingiri	1.75	95	78.80	8.89	0.31
Fortune	1.67	91	76.20	9.0	0.26
Yandanooka	1.67	91	76.40	9.2	1.41
Grenade CL Plus	1.64	89	77.00	9.0	0.77
Trojan	1.63	89	80.60	9.1	0.44
Westonia	1.60	87	77.00	9.1	0.52
Wedin	1.59	86	76.40	9.2	1.17
Emu Rock	1.57	85	76.80	9.2	1.13
Site Mean (t/ha)	1.84				
LSD (t/ha)	0.17	9			
CV (%)	5.4				
Probability	<0.001				

Comments

All trials are sown and harvested as close to or before district grower practice to ensure variety performance is that seen by growers on their farms. The trials are treated with basal fertiliser and urea rates that are typically and significantly higher than growers would use. Weed control rates and combinations of herbicide are also typically more than grower practice.

The wheat varieties are grown to their full yield potential and as a consequence yield cannot be limited by nutrition or weeds. These trials are not grown with a view to conducting a gross margin analysis. The higher nutrition rates do not affect the relativities in variety performance; in fact over the last 7 years of NVT target wheat quality protein has rarely been overdone, generally target protein is achieved or underdone. Time of sowing, soil type, season length and variety maturity are the main parameters that have the greatest effect on variety performance in any one season.

For more information please refer to www.nvtonline.com.au

Wheat National Variety Trial – Pithara

Australian Crop Accreditation System Limited

Aim/Background

The wheat National Variety Testing (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	OJ Butcher & Son, Pithara
Plot size & Replication	12m x 1.76m x 3 replications
Soil Type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 6.3 10-20cm: 7.2
EC (dS/m)	0-10cm: 0.577 10-20cm: 0.544
Paddock Rotation	2013: fallow
Variety	As per protocol
Seeding Date	04/05/2014
Seeding Rate	75 kg/ha
Fertiliser	04/05/2014: 50 kg/ha Urea, 100 kg/ha Gusto Gold
Herbicides & Insecticides	03/05/2014: 3 L/ha Spray.Seed, 118g/ha Sakura, 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos 04/07/2014: 1 L/ha Velocity, 150 mL/ha Prosaro, 1% Hasten
Growing Season Rainfall	160mm

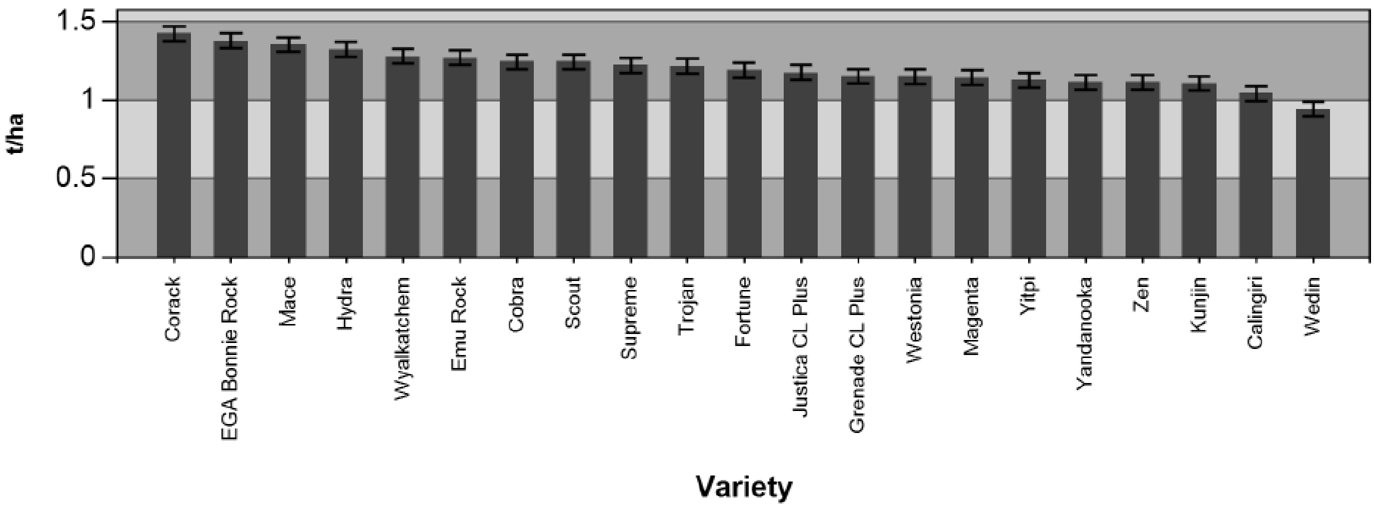

Figure 1: Yield comparison of wheat varieties sown at Pithara.

Results

Table 1: Yield and grain quality data for wheat varieties grown in 2014, at Pithara.

Variety	Yield (t/ha)	Percentage of Site Mean	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Corack	1.43	113	77.80	10.0	1.09
EGA Bonnie Rock	1.38	110	76.60	11.1	5.48
Mace	1.35	107	77.40	11.3	1.50
Hydra	1.32	105	77.00	10.8	3.50
Wyalkatchem	1.28	102	78.20	12.4	0.83
Emu Rock	1.27	101	75.60	11.7	4.10
Cobra	1.25	99	74.00	11.9	3.61
Scout	1.25	99	79.80	11.0	1.50
Supreme	1.22	97	74.60	11.2	2.40
Trojan	1.21	96	82.40	11.8	1.58
Fortune	1.19	94	74.80	11.7	1.32
Justica CL Plus	1.18	94	77.00	11.5	0.90
Grenade CL Plus	1.15	91	75.80	11.6	4.85
Westonia	1.15	91	76.20	10.8	6.05
Magenta	1.14	90	78.60	12.0	1.03
Yitpi	1.13	90	81.60	11.8	1.52
Kunjin	1.11	88	77.20	11.2	2.97
Yandanooka	1.11	88	76.40	12.0	0.85
Zen	1.11	88	80.20	11.9	0.55
Calingiri	1.04	82	79.40	11.9	0.28
Wedin	0.94	75	77.20	12.0	0.80
Site Mean (t/ha)	1.26				
LSD (t/ha)	0.09	7			
CV (%)	4.9				
Probability	<0.001				

Comments

All trials are sown and harvested as close to or before district grower practice to ensure variety performance is similar to that seen by growers on their farms. The trials are treated with basal fertiliser and urea rates that are significantly higher than growers would use. Weed control rates and combinations of herbicide are also typically more than grower practice.

The wheat varieties are grown to their full yield potential and as a consequence yield cannot be limited by nutrition or weeds. These trials are not grown with a view to conducting a gross margin analysis. The higher nutrition rates do not affect the relativities in variety performance, in fact over the last 7 years of NVT target wheat quality protein has rarely been overdone, generally target protein is achieved or underdone. Time of sowing, soil type, season length and variety maturity are the main parameters that have the greatest effect on variety performance in any one season.

For more information please refer to www.nvtonline.com.au

Wheat National Variety Trial – Wongan Hills

Australian Crop Accreditation System Limited

Aim/Background

The wheat National Variety Testing (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	Wongan Hills Research Station
Plot size & Replication	12m x 1.76m x 3 replications
Soil Type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.6 10-30cm: 4.2
EC (dS/m)	0-10cm: 0.054 10-30cm: 0.142
Paddock Rotation	2011: lupin, 2012: wheat, 2013: canola
Variety	As per protocol
Seeding Date	07/05/2014
Seeding Rate	75 kg/ha
Fertiliser	07/05/2014: 50 kg/ha Urea, 100 kg/ha Gusto Gold
Herbicides & Insecticides	06/05/2014: 4 L/ha Paraquat & Diquat, 2.5 L/ha Prosulfocard & S-Metolachlor, 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos 10/07/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 0.5 L/ha LVE MCPA, 120 g/ha Clopyralid, 150 mL/ha Prothioconazole & Tebuconazole, 100 mL/ha Cloquintocet-Mexyl, 2% Hasten
Growing Season Rainfall	243mm

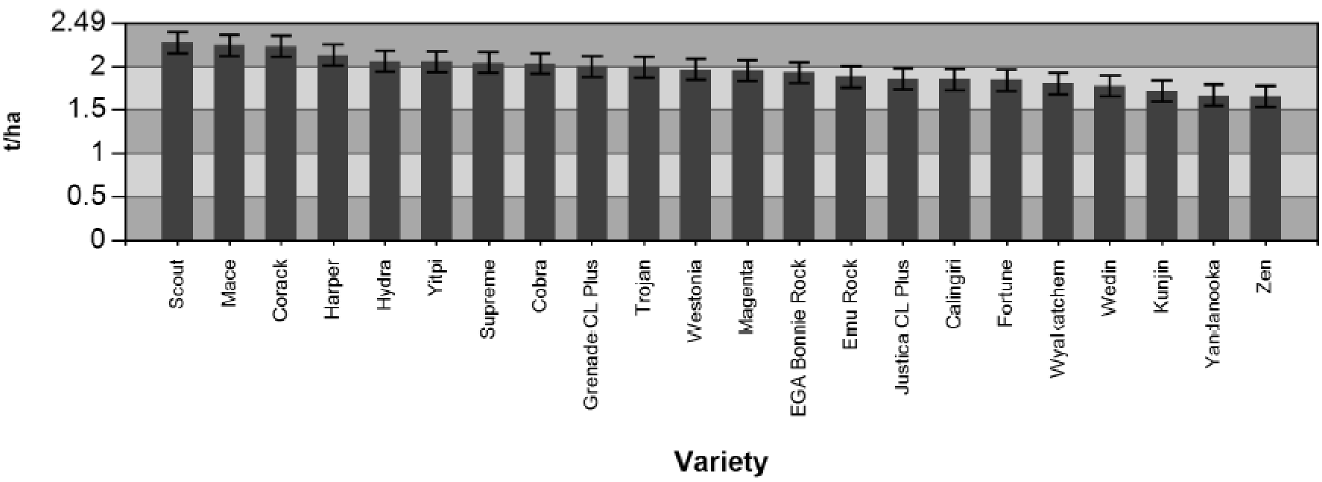

Figure 1: Yield comparison of wheat varieties sown at Wongan Hills.

Results

Table 1: Yield and grain quality data for wheat varieties grown in 2014, at Wongan Hills.

Variety	Yield (t/ha)	Percentage of Site Mean	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Scout	2.27	116	78.80	9.5	2.11
Mace	2.24	115	78.20	9.6	4.53
Corack	2.23	114	76.80	9.7	3.03
Harper	2.13	109	79.60	9.9	5.73
Hydra	2.06	106	76.20	9.8	5.09
Yitpi	2.05	105	79.20	9.6	2.32
Supreme	2.04	105	74.60	10.5	5.76
Cobra	2.03	104	73.80	11.0	5.07
Grenade CL Plus	2.00	103	76.40	10.7	2.62
Trojan	1.99	102	80.80	9.7	1.45
Westonia	1.96	101	74.60	10.2	4.11
Magenta	1.95	100	76.80	10.9	3.99
EGA Bonnie Rock	1.93	99	76.20	9.5	5.92
Emu Rock	1.88	96	76.60	10.3	4.71
Calingiri	1.85	95	77.20	11.6	1.02
Justica CL Plus	1.85	95	76.20	11.1	2.21
Fortune	1.84	94	77.40	11.2	1.61
Wyalkatchem	1.80	92	78.80	11.9	1.42
Wedin	1.77	91	74.80	10.6	0.84
Kunjin	1.71	88	75.20	10.5	5.76
Yandanooka	1.67	86	76.00	11.5	1.71
Zen	1.65	85	80.60	12.0	0.50
Site Mean (t/ha)	1.95				
LSD (t/ha)	0.24	12			
CV (%)	7.5				
Probability	<0.001				

Comments

All trials are sown and harvested as close to or before district grower practice to ensure variety performance is similar to that seen by growers on their farms. The trials are treated with basal fertiliser and urea rates that are significantly higher than growers would use. Weed control rates and combinations of herbicide are also typically more than grower practice.

The wheat varieties are grown to their full yield potential and as a consequence yield cannot be limited by nutrition or weeds. These trials are not grown with a view to conducting a gross margin analysis. The higher nutrition rates do not affect the relativities in variety performance, in fact over the last 7 years of NVT target wheat quality protein has rarely been overdone, generally target protein is achieved or underdone. Time of sowing, soil type, season length and variety maturity are the main parameters that have the greatest effect on variety performance in any one season.

For more information please refer to www.nvtonline.com.au

Wheat National Variety Trial – Coorow

Australian Crop Accreditation System Limited

Aim/Background

The wheat National Variety Testing (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	Clint Hunt, Coorow
Plot size & Replication	12m x 1.76m x 3 replications
Soil Type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.2 10-60cm: 4.4
EC (dS/m)	0-10cm: 0.1
Paddock Rotation	2013: canola
Variety	As per protocol
Seeding Date	27/05/2014
Seeding Rate	75 kg/ha
Fertiliser	27/05/2014: 100 kg/ha Urea, 100 kg/ha Gusto Gold
Herbicides & Insecticides	26/05/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 118 g/ha Sakura 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos, 1% Hasten 23/07/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 500 mL/ha LVE MCPA, 120 g/ha Clopyralid, 150 mL/ha Prothioconazole & Tebuconazole, 1% Hasten
Growing Season Rainfall	234mm

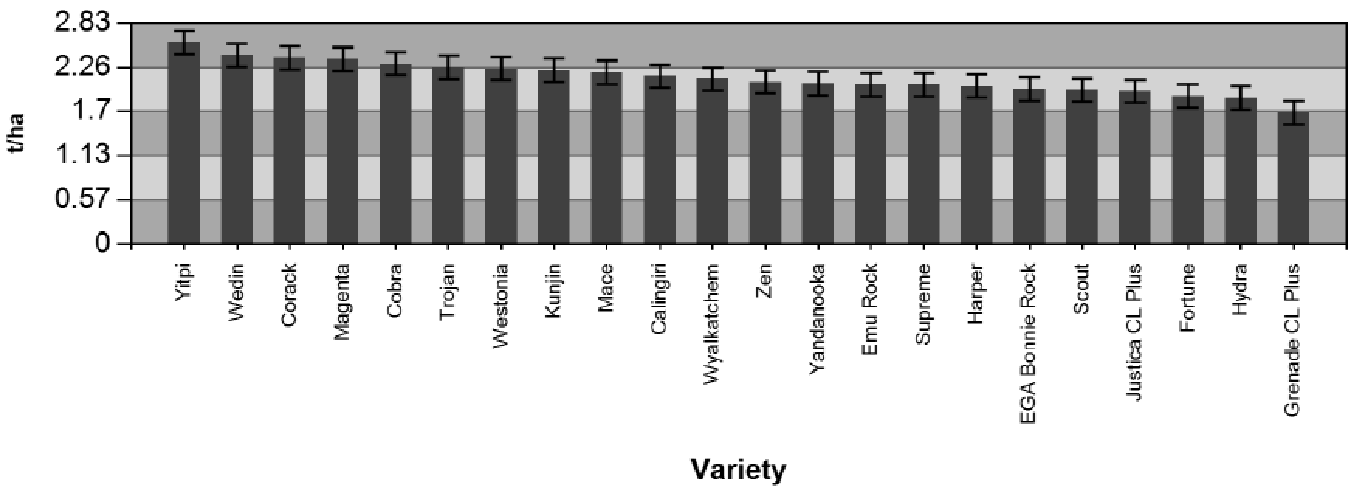

Figure 1: Yield comparison of wheat varieties sown at Coorow.

Results

Table 1: Yield and grain quality data for wheat varieties grown in 2014, at Coorow.

Variety	Yield (t/ha)	Percentage of Site Mean	Hectolitre Weight (kg/hL)	Protein (%)	Screenings (%)
Yitpi	2.58	121	77.40	11.7	1.90
Wedin	2.41	113	76.00	11.0	1.56
Corack	2.38	112	81.00	11.9	0.99
Magenta	2.37	111	80.80	11.5	2.58
Cobra	2.30	108	80.40	12.6	1.60
Trojan	2.26	106	80.60	10.9	0.63
Westonia	2.24	105	79.40	11.9	1.43
Kunjin	2.22	104	78.60	11.6	0.38
Mace	2.20	103	79.20	12.0	0.32
Calingiri	2.15	102	81.20	11.6	0.70
Wyalkatchem	2.11	99	81.60	12.5	0.33
Zen	2.07	97	80.40	11.9	0.85
Yandanooka	2.05	96	80.00	13.0	0.29
Emu Rock	2.04	96	80.00	12.5	0.77
Supreme	2.03	95	80.60	11.1	1.35
Harper	2.02	95	79.80	12.1	1.77
EGA Bonnie Rock	1.98	93	80.40	12.9	0.84
Scout	1.97	92	82.40	11.5	1.38
Justica CL Plus	1.95	92	76.80	12.1	0.58
Fortune	1.90	89	79.20	12.3	0.76
Hydra	1.86	87	80.00	11.3	1.26
Grenade CL Plus	1.68	79	80.80	12.4	1.13
Site Mean (t/ha)	2.13				
LSD (t/ha)	0.30	14			
CV (%)	7.5				
Probability	<0.001				

Comments

All trials are sown and harvested as close to or before district grower practice to ensure variety performance is similar to that seen by growers on their farms. The trials are treated with basal fertiliser and urea rates that are significantly higher than growers would use. Weed control rates and combinations of herbicide are also typically more than grower practice.

The wheat varieties are grown to their full yield potential and as a consequence yield cannot be limited by nutrition or weeds. These trials are not grown with a view to conducting a gross margin analysis. The higher nutrition rates do not affect the relativities in variety performance; in fact over the last 7 years of NVT target wheat quality protein has rarely been overdone, generally target protein is achieved or underdone. Time of sowing, soil type, season length and variety maturity are the main parameters that have the greatest effect on variety performance in any one season.

For more information please refer to www.nvtonline.com.au

Effect of Seed Size on Wheat Response to Sowing Depth

Dr Bob French, Senior Research Officer, DAFWA

Key Messages

- Sowing wheat 75mm deep compared to 40mm deep reduced crop establishment by up to 62% and wheat yield by up to 24%.
- Within the same variety small seed was much more sensitive to deep sowing than large seed.
- Corack and Mace were the least sensitive varieties to deep sowing in terms of yield.
- Growers should endeavour to use seed larger than 35 g/thousand seeds, especially if sowing into stressful conditions.

Aim

To test the interaction between wheat variety and seed size on the ability to emerge from deep sowing.

Background

There is a strong imperative to sow cereal crops early in WA. This often means sowing into drier than ideal seedbeds. Sometimes the soil surface is dry but there is moisture remaining from summer rain in soil deeper than the normal seeding depth. Deeper than normal sowing to place seed on this moisture can result in earlier crop establishment, but some wheat cultivars will emerge from depth better than others. Among other factors the ability to emerge from deep sowing is related to coleoptile length and seed size. There is also evidence for variation in tolerance to early water deficit, which may also be involved.

Trial Details

Property	Fitzsimons Farm, east Buntine
Plot size & replication	10m × 1.54m x 4 replications
Soil type	Sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 5.4 10-20cm: 4.4 20-30cm: 4.6
EC (dS/m)	0-10cm: 0.099
Sowing date	29/05/2014
Seeding rate	Various, calculated to give 120 plants/m²
Paddock rotation	2011: pasture, 2012: wheat, 2013: canola
Fertiliser	29/05/2014: 80 kg/ha Macropro Plus banded (8 kg/ha N, 11 kg/ha P, 7 kg/ha K)
Herbicides	28/05/2014: 2 L/ha Spray.Seed, 118 g/ha Sakura 30/06/2014: 670 mL/ha Velocity
Growing Season Rainfall	180mm

Results

Establishment

When sown at a normal depth of 40mm all varieties established close to the target 120plants/m² and seed size had no significant effect on establishment (Figure 1). When sown 75mm deep establishment was reduced by as little as 19% (for large Magenta) to as much as 63% (for small Wyalkatchem) compared to normal sowing depth. Small seed suffered a much greater reduction in establishment when sown deep than large seed (52% compared to 32%). There was considerable variation in seed size between varieties in each size class. Figure 2 shows how seed size influenced the effect of deep sowing on establishment. Therefore, seeds that are smaller than 35 g/thousand are much more sensitive to deep sowing.

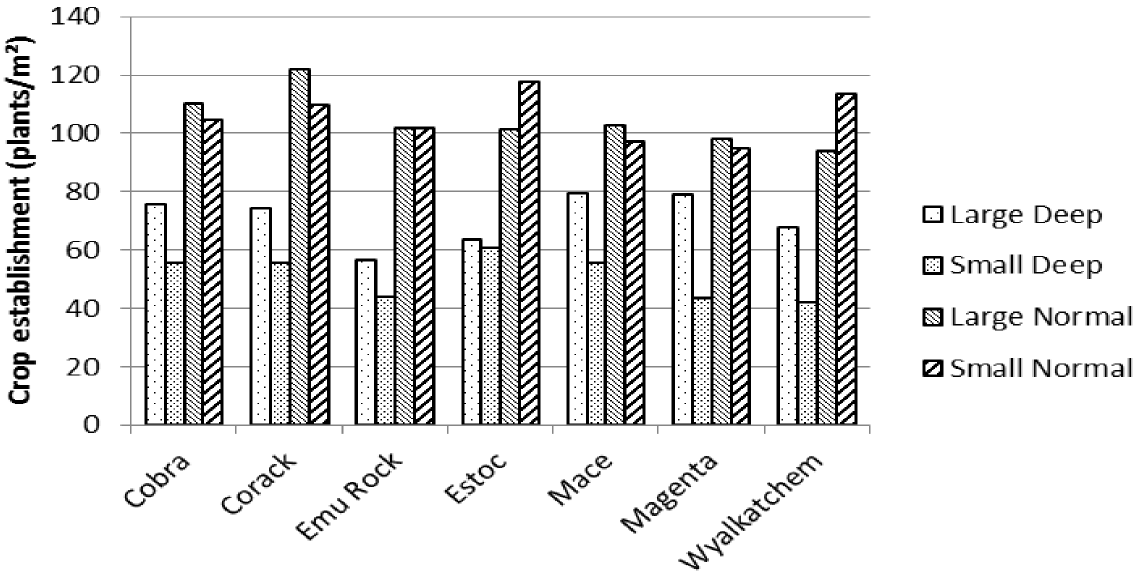

Figure 1: Establishment of seven wheat cultivars when sown using small or large seed 40mm (normal) or 75mm (deep), deep into moist soil.

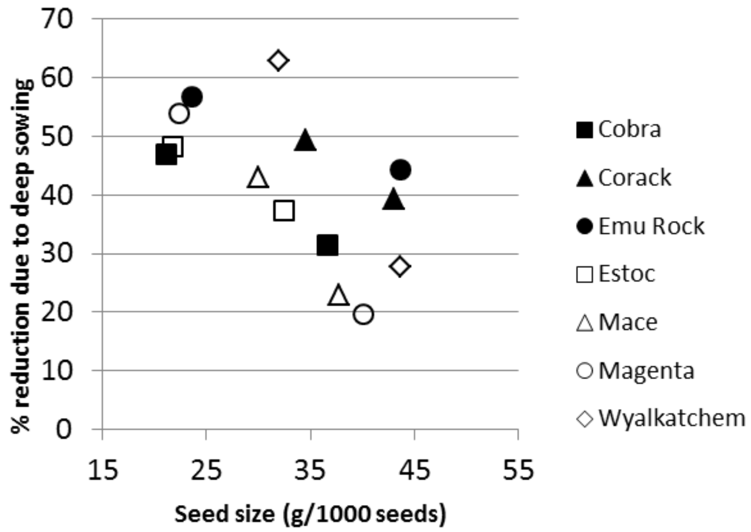

Figure 2: Influence of seed size on how much deep sowing reduces establishment of seven wheat varieties.

Growth and yield

While seed size did not affect establishment when sown at normal depth it did affect early crop growth and development. At the 5-leaf stage small-seeded Mace had 2.4 tillers compared to 3.1 for large seeded Mace, and two months after sowing NDVI (a measure of crop vigour) was 28% greater on normal depth plots sown with large seed than with small seed (Figure 3). The NDVI of large seed plots was 89% greater than small seed plots when sown deep. These early treatment differences carried through to grain yield. Deep sowing reduced grain yield by an average of 8% when using large seed, but by 16% using small seed. The yield of Mace and Corack was least sensitive to deep sowing (7.5% reduction) and that of Wyalkatchem was most sensitive (24% reduction). Corack was the highest yielding variety in the trial.

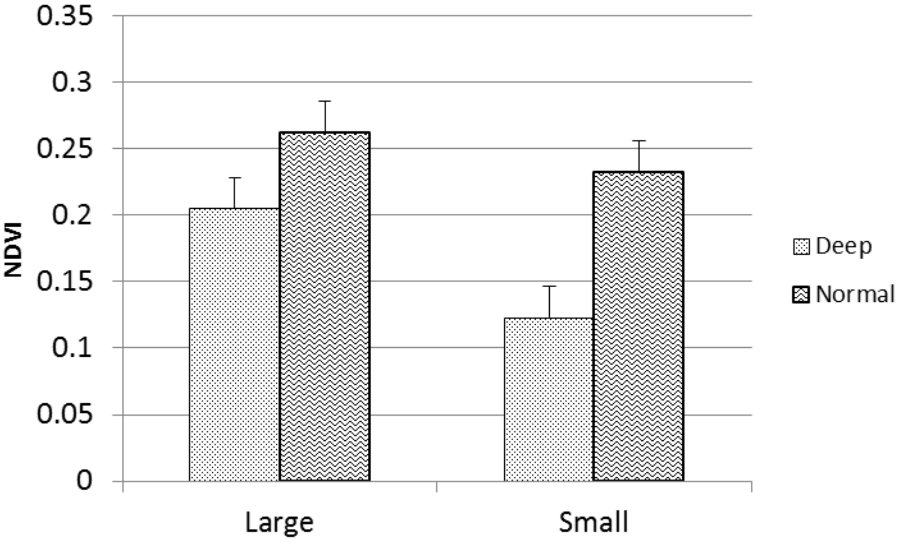

Figure 3: NDVI of wheat plots sown with small large seed at 40mm or 75mm deep on 24/07/2014.

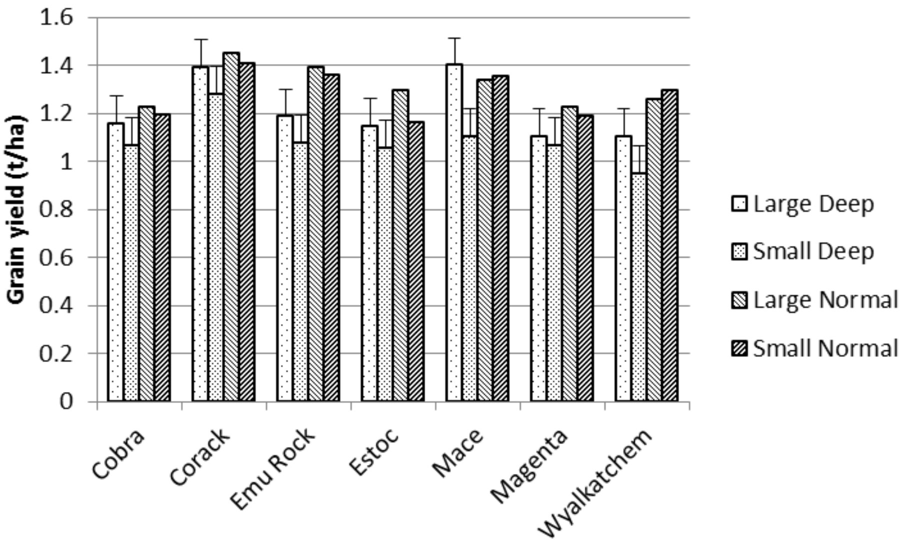

Figure 4: Grain yield of seven wheat varieties sown at 40mm or 75mm deep using small or large seed.

Comments

Deep sowing can reduce wheat crop establishment and wheat yield but is still a worthwhile strategy to achieve early sowing if there is moisture in the subsurface. Although this trial did not test that situation another, trial at Mullewa in 2014 did and found similar responses to variety as well as seed size. While there are varietal differences in how sensitive crop establishment is to deep sowing, seed size has a very large influence and can mask differences between varieties. The extra vigour of plots grown from large seed suggests it will be valuable in other stressful situations early in the life of the crop, such as early drought. Growers should use seed larger than 35 g/thousand seeds for sowing where possible and especially when sowing into a situation where the emerging crop might encounter some stress.

Acknowledgements

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Wheat Seeding Rate Demonstration in a Low Rainfall Zone

Jessica Smith, Agronomist, Landmark Dalwallinu

Key Messages

- The average sowing rate in low rainfall zones is 50 kg/ha.
- Increasing seeding rates is generally not helpful for yield as moisture is limiting in this zone.
- Higher seeding rates can have other benefits such as reducing weed burdens.

Aim

To compare three different sowing rates (in a low rainfall zone) in a farmer sized trial and monitor these plots throughout the growing season.

Background

Declining growing season rainfall is becoming a real issue for wheat yield potential in low rainfall areas. This farmer demonstration is a chance to see the strengths and weakness of each sowing rate side by side in one paddock as the season progresses.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	1000m x 18.59m with no replications
Soil type	Sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 4.5
EC (dS/m)	0.117
Sowing date	03/05/2014
Seeding rate	Calingiri: Low 30 kg/ha, Medium 60 kg/ha, High 90 kg/ha + 2 buffers at 50 kg/ha
Paddock rotation	2010: canola, 2011: wheat, 2012: wheat, 2013: lupin
Fertiliser	03/05/2014: 30 kg/ha DAPSCZ, 5.3 L/ha CalSap® 05/06/2014: 40 L/ha UAN
Herbicides & Insecticides	03/05/2014: 1.8 L/ha Trifluralin, 1.5 L/ha Gramoxone, 275 g/ha Diuron 05/06/2014: 350 mL/ha Paragon, 50 mL/ha Alpha Cypermethrin, 30 g/ha Lontrel, 4 g/ha Metsulfuron
Growing Season Rainfall	180mm

Results

Table 1: Yield, quality and grade of Calingiri sown at east Buntine.

Treatment	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre Weight (kg/hL)	Grade
Buffer 1: 50 kg/ha	1.703	11.1	0.35	83.27	ANW1
Low: 30 kg/ha	1.668	11.0	0.41	83.62	ANW1
Medium: 60 kg/ha	1.801	11.4	0.79	83.03	ANW1
High: 90 kg/ha	1.643	11.4	0.35	83.54	ANW1
Buffer 2: 50 kg/ha	1.778	11.8	0.59	82.42	ANW2

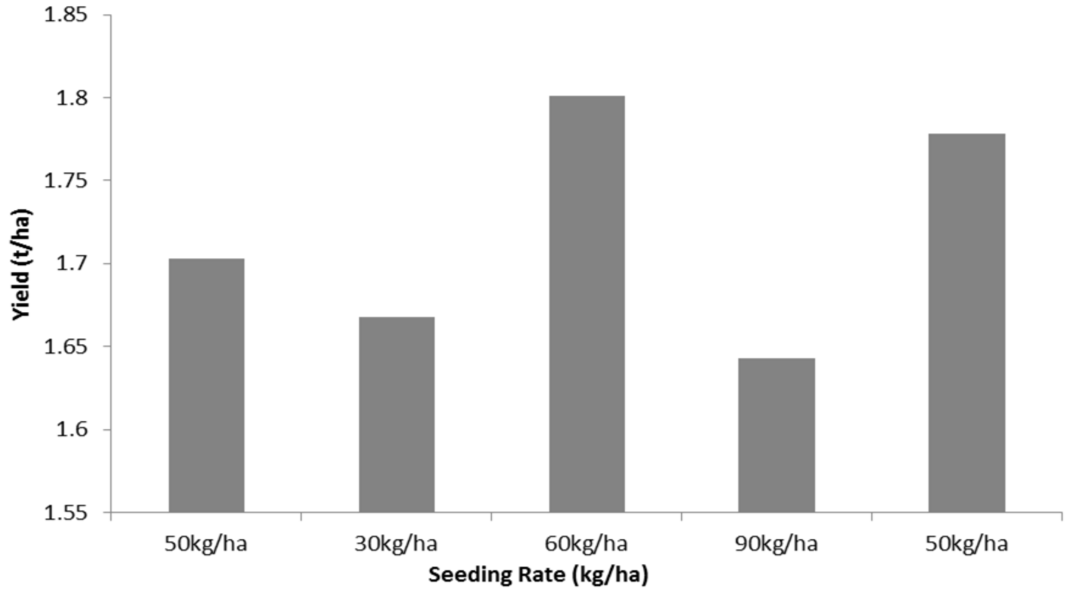

Figure 1: Yield results of three seeding rates, low, medium and high, plus buffers sown at east Buntine in 2014.

Economic Analysis

Table 2: Economic analysis of gross return ($/ha) of three seeding rate treatments, plus buffers, of Calingiri wheat grown at east Buntine. Figures are based on Cash Price Kwinana zone ANW1 22/12/2014 $293/t and ANW2 22/12/2014 $283/t.

Treatment	Yield (t/ha)	Gross Return ($/ha)
Buffer 1	1.703	$498.98
Low	1.668	$488.72
Medium	1.801	$527.69
High	1.643	$481.40
Buffer 2	1.778	$503.17

*NB: Buffer 2 was the only treatment that didn't make ANW1 grade and therefore was calculated at ANW2 grade cash price.

Comments

This trial was an un-replicated farmer scale demonstration and results should be interpreted with caution. Each run was harvested with farmer machinery with yields recorded off the yield monitor and samples taken to CBH for testing.

The trial was also sown and sprayed to grower practice with CalSap®, a liquid lime product. Extra CalSap® was applied to Buffer 2 as this ended up being the start of another trial. This may have had some effect on yield, potentially allowing roots to penetrate deeper for moisture, although this could not be confirmed as the rest of the paddock had CalSap® applied as well.

The results show that the highest yielding and highest gross return treatment was the medium treatment at a sowing rate of 60 kg/ha. However, this was closely followed by the, grower standard practice (GSP), of 50 kg/ha in the buffer's yielding greater than 1.7 t/ha. There was marginal difference between GSP and the medium treatment with less than 100kg difference between the two suggesting that a 50 kg/ha – 60 kg/ha seeding rate is ideal for low rainfall environments such as east Buntine. Low and high treatments were not far behind in gross return or yield either and could have potentially performed better, especially the high treatment if rain had fallen during August and temperatures had stayed low, tillers could of filled and not aborted.

As it was a tough year rainfall wise, there was a very limited weed burden of both ryegrass and radish populations in all plots. It would have been nice to see a heavier weed burden to compare the sowing rates competiveness against the populations, as we can only make the assumption that the high sowing rate should of performed best in that situation.

Acknowledgements
Thanks to the Fitzsimons family for implementing and managing the trial.

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Practice for Profit Trial

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages
- Low input of continuous wheat is returning the highest gross margin in this scenario.

Aim
To examine the difference in profitability between low and high input cropping practices over an extended period of time and to determine the effect these practices are having on soil carbon.

Background
The Practice for Profit trial is for the fourth season in a row located on the Mills' property east of Dalwallinu and for the next four years we will compare the following two scenarios;
- **Low input** treatments based on a farmer producing grain at the lowest possible cost, regardless of seasonal conditions.
- **High input** treatments simulate a paddock with high yield potential matched with increased inputs to maximise yields and profitability.

However, in 2013 the set rotation was not able to be planted because 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.

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 all nutrient levels were high. On the trial to date the low input treatments have received maintenance levels of P and N. The levels of P, K and S will be monitored for the 2015 season and maintenance levels will be adjusted accordingly.

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: 5.5 10-20cm: 7.3 20-40cm: 8.0
EC (dS/m)	0.107
Sowing date	02/05/2014
Seeding rate	As per protocol
Paddock rotation	2010: wheat, 2011 and 2012: as per protocol (Table 1), 2013: fallow
Fertiliser	As per protocol
Herbicides/Insecticides	03/05/2014: 3 L/ha Weedmaster DST, 118 g/ha Sakura, 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos 04/07/2014: 1 L/ha Velocity, 1% Hasten
Growing Season Rainfall	187mm

Trial Layout

Table 1: Practice for Profit trial, rotation plan.

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

Table 2: 2014 Practice for Profit treatments.

Treatment	Variety	Input	Sowing rate (kg/ha)	Gusto Gold banded (kg/ha)	Urea TD 6WA-S (kg/ha)	2011 Rotation
1	Mace	Low	30	0	0	Wheat low
2	Mace	High	80	57	45	Wheat high
3	Mace	Low	30	0	0	Canola
4	Mace	High	80	57	45	Canola
5	Mace	Low	30	0	0	Vol Pasture
6	Mace	High	80	57	45	Vol Pasture
7	Mace	Low	30	0	0	Field Peas
8	Mace	High	80	57	45	Field Peas

Results

Table 3: Average yield, quality and grade of Mace wheat sown in 2014 at east Dalwallinu over the differing treatments.

Treatment	Yield (t/ha)	Moisture (%)	Hectolitre (g/hL)	Protein (%)	Grade
Canola High	2.26	11.80	76.76	13.53	H1
Field Peas High	2.13	11.77	77.59	14.10	H1
Wheat Low	2.01	11.40	79.29	12.23	H2
Wheat High	1.96	11.77	76.04	13.23	H1
Canola Low	1.73	11.47	77.07	12.8	H2
Vol Pasture High	1.71	11.83	73.29	15.37	H2
Field Peas Low	1.66	11.43	78.69	13.37	H1
Vol Pasture Low	1.63	11.37	79.48	12.97	H2

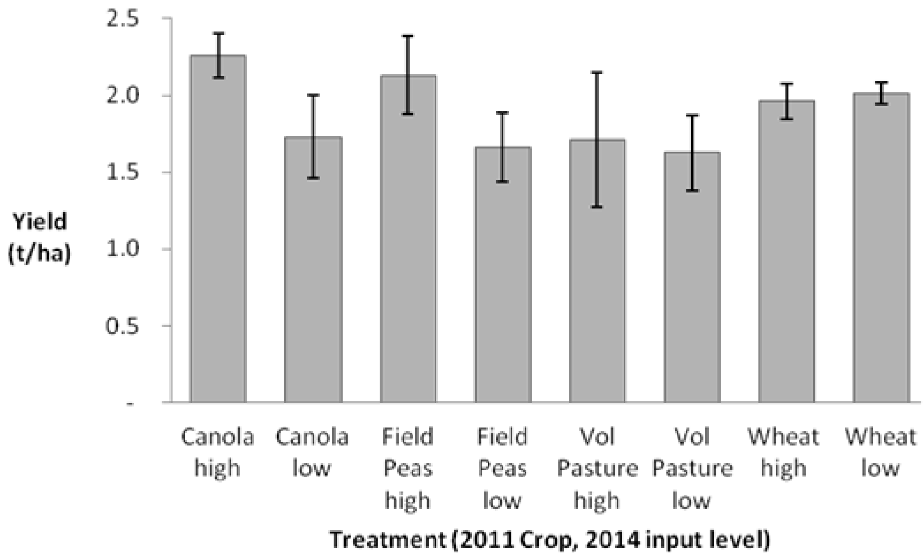

Figure 1: Yield results of Mace wheat grown at east Dalwallinu 2014 following a chemical fallow. Error bars indicate standard deviation.

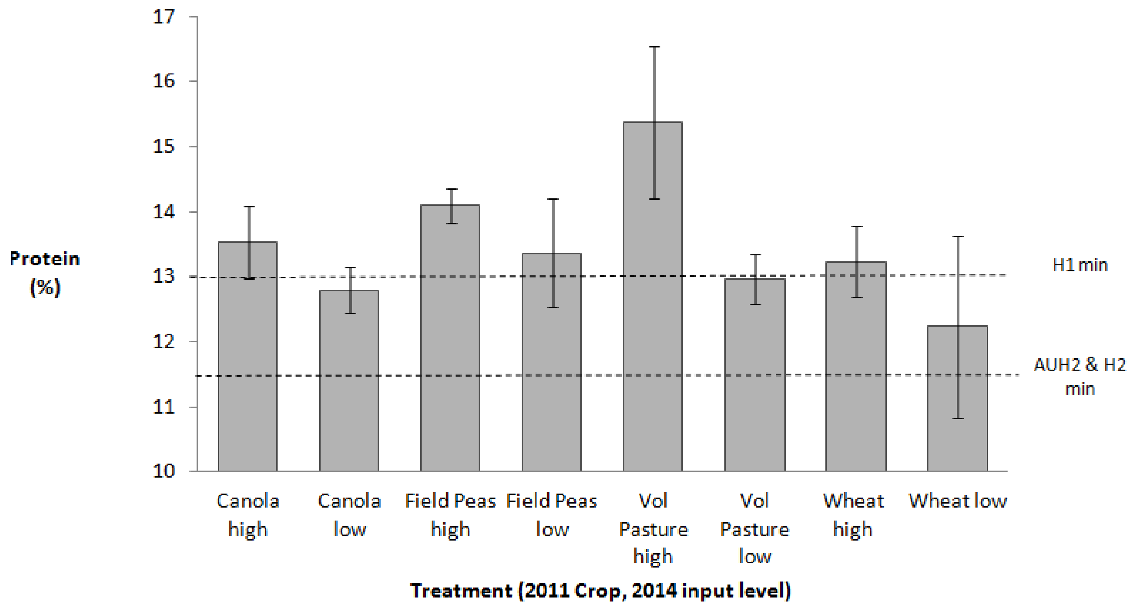

Figure 2: Average protein of Mace wheat grown at east Dalwallinu 2014 following a chemical fallow. Dotted lines represent minimum CBH receival standards for protein. Error bars indicate standard deviation.

Economic Analysis

Table 4: Economic analysis of each treatment over the 2011, 2012 and 2014 seasons.

	Gross Margin ($/ha)			
Treatment	**2014**	**2012**	**2011**	**Cumulative Total**
Wheat low	446	204	448	1098
Canola high	445	138	392	975
Field Peas high	406	144	222	772
Canola low	356	303	303	962
Field Peas low	349	315	188	852
Wheat high	340	66	440	846
Vol Pasture low	337	102	61	500
Vol Pasture high	246	-159	61	148

Note: More detail of income and cost figures can be seen in Appendix 1.

The 2014 treatments only varied input levels on wheat treatments with canola, field peas and volunteer pasture plots treated as one input level.

Costs taken into account include fertiliser and herbicide costs and CBH receival and handling fees ($37/t). The cost of wheat seed was also considered with the difference in input levels at 30kg/ha and 80kg/ha.
The volunteer pasture plots, while not creating profit via yield in 2011 provide a value in sheep grazing, this was valued at $74/winter grazed hectare, assumed from district practice.

Income was based on grade of sample tested at CBH site and price based on AWB cash prices (H1 @ $295/t, H2 @ $290/t, APW1 @ $284/t and AUH2 @ $274/t) averaged from this year. Cost of application has not been included.

Comments

Analysis shows over the 2011, 2012 and 2014 seasons, wheat grown under a low input regime returned the highest gross margin and the volunteer pasture high treatment has consecutively returned the lowest gross margin (Table 4). This trial will continue to follow the rotation plan shown in Table 1 to determine the compounding effect of high and low input regimes.

Cumulative gross margins for the volunteer pasture treatments are still significantly impacted by 2012 results in which yields were below average. The reason for this significant variation was not determined, with no significant difference observed in soil sample results or weed burden.

Acknowledgements

This project is funded by the Australian Government Department of Agriculture. Thank you to the Mill's family for hosting the trial and to CSBP for trial support.

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Appendix 1

Table 5: Economic analysis over three cropping seasons: 2011, 2012 and 2014 at east Dalwallinu.

	Income ($/ha)			Variable Costs ($/ha)			Gross Margin ($/ha)			
Treatment	**2014**	**2012**	**2011**	**2014**	**2012**	**2011**	**2014**	**2012**	**2011**	**Cumulative Income**
Wheat low	584	328	699	137	124	251	446	204	448	1098
Canola high	667	371	539	222	233	147	445	138	392	975
Canola low	493	427	443	137	124	140	356	303	303	962
Field Peas low	487	440	350	137	124	161	350	315	188	853
Wheat high	562	299	750	222	233	310	340	66	440	846
Field Peas high	629	377	388	222	233	166	407	144	222	773
Vol Pasture low	474	226	74	137	124	13	337	102	61	500
Vol Pasture high	469	73	74	222	232	13	247	-159	61	149

Agronomy of New Wheat and Barley Varieties Response to N Applied on Wheat Stubble

Christine Zaicou-Kunesch, Research Officer, DAFWA Geraldton

Key Messages

- Barley yields averaged 1.78 t/ha compared to 1.64 t/ha for wheat.
- The barley and wheat varieties differed in their response to added nitrogen (N). Cobra, Mace and Wyalkatchem yields increased at 40 kg/ha of N as did yields of Compass, La Trobe and IGB1337. The other varieties were not responsive to added N.
- Barley had a higher tillering capacity than wheat.
- Grain quality and price will influence the profitability of added N. The current high prices for barley grain make it a profitable option. However, barley is less tolerant to acid soils and so site selection is important, as is a good understanding of grain quality and end price.

Aim

To evaluate yields and quality of new and existing wheat and barley varieties and their response to N.

Background

Wheat or barley? Which crop do you think is more productive in your paddock? Current research from the Department of Agriculture and Food, Western Australia (DAFWA) indicates barley can be more productive than wheat in a range of environments. However, the profitability of those cereals will be influenced by rotations, management and price.

This experiment is one in a series of 10 trials. It compares the response of wheat and barley varieties to changes in N application across a range of environments. Trials are located from Binnu, to Merredin and Newdegate on wheat or canola stubble.

Trial Details

Property	Fitzsimons Property, east Buntine					
Plot size & replication	1.54m x 10m x 3 replications					
Soil type	Sandy loam over loam					
Soil pH ($CaCl_2$)	0-10cm: 5.3	20-30cm: 4.7				
EC (dS/m)	0-10cm: 0.052					
Soil Nitrate N (mg/kg)	0-10cm: 9	10-20cm: 7	20-30cm: 5	30-40cm:6	40-50cm: 4	50-60cm: 3
Soil Ammonium N (mg/kg)	0-10cm: 2	10-20cm: 2	20-30cm: 2	30-40cm:1	40-50cm: 1	50-60cm: 1
Paddock rotation	2011: wheat, 2012: canola, 2013: wheat					
Variety	Barley: Compass, Flinders, Granger, IGB1337, La Trobe, Scope CL Wheat: Cobra, Corack, Emu Rock, Mace, Magenta, Wyalkatchem					
Seeding date	12/05/2014: 22cm using 7 row cone seeder with press wheels					
Seeding rate	Approximately 70 kg/ha targeting 120 plants/m^2. Note: 126 plants/m^2 established					
Nitrogen treatments	N0 = nil nitrogen; N20 = 20 kg/ha of nitrogen applied at seeding; N40 = N20 + 20 kg/ha N top dressed; N80 = N20 + 60 kg/ha N top dressed					
Fertiliser	12/05/2014: 120 kg/ha Summit Super CZM banded at seeding 11/06/2014: post N treatments applied					
Herbicides	12/05/2014: 118 g/ha Sakura, 2 L/ha Spray.Seed 11/06/2014: 670 mL/ha Velocity, 1% Hasten					
Growing Season Rainfall	180mm					

Results

Barley yields (averaged across all varieties) were significantly higher than wheat at all N treatments except the control. Barley and wheat yields differed in their response to added N in 2014. When averaged across all varieties, barley yields at 40 kg/ha were significantly higher yielding than the control however, yields did not increase with added N to 80 kg/ha. In contrast, wheat yields (averaged across all varieties) did not increase significantly with added N to 80 kg/ha. Barley had a higher tillering capacity than wheat (Figure 1). At a variety level, there were different responses to added N. La Trobe and Compass were responsive at 20 kg/ha of added N compared to the control (Figure 2: LSD 0.23 t/ha). La Trobe was not responsive to further additions of N. In contrast, the yield of Compass at 80 kg/ha of N was significantly greater than 20 kg/ha of N but not 40 kg/ha of N (Figure 2: LSD 0.23 t/ha). Flinders and Granger yield responses were similar. The yields at 80 kg/ha of N were significantly greater than the control. Scope CL yields did not increase significantly with added N up to 60 kg/ha and declined significantly at 80 kg/ha of N (Figure 2: LSD 0.23 t/ha). Wheat grain yields of Cobra, Mace and Wyalkatchem at 40 kg/ha of N was significantly greater than the control (Figure 3: LSD 0.23 t/ha). Further application of N to 80 kg/ha did not significantly increase yields. In contrast Corack, Emu Rock and Magenta yields were not responsive to added N (Figure 3: LSD 0.23 t/ha).

Wheat varieties were susceptible to 'lodging' which was a result of the high wind speeds late in the season. The 'lodging' ratings increased as N rates increased. This was not as evident in the barley varieties but lodging did occur to a lesser extent in La Trobe and IGB 1337.

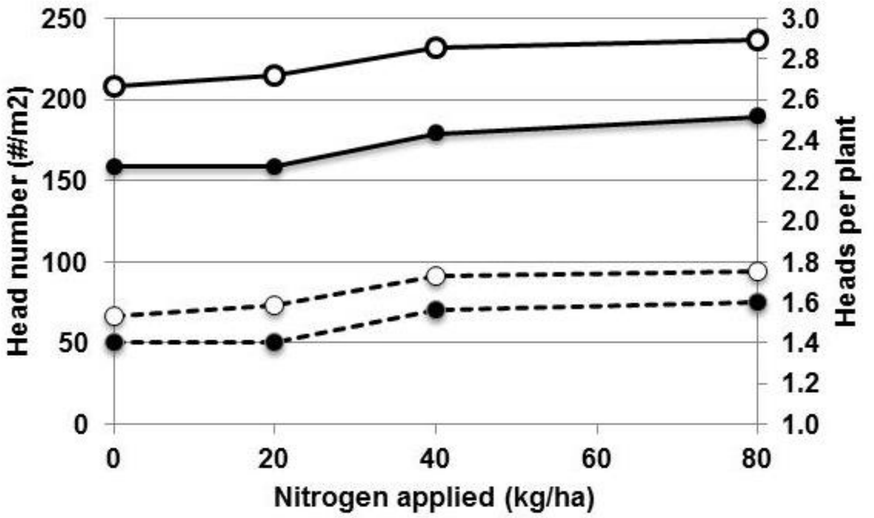

Figure 1: Head numbers per m^2 (solid line) and heads per plant (dotted line) for barley (white circles) and wheat (black circles) with added nitrogen (kg/ha) at Buntine in 2014.

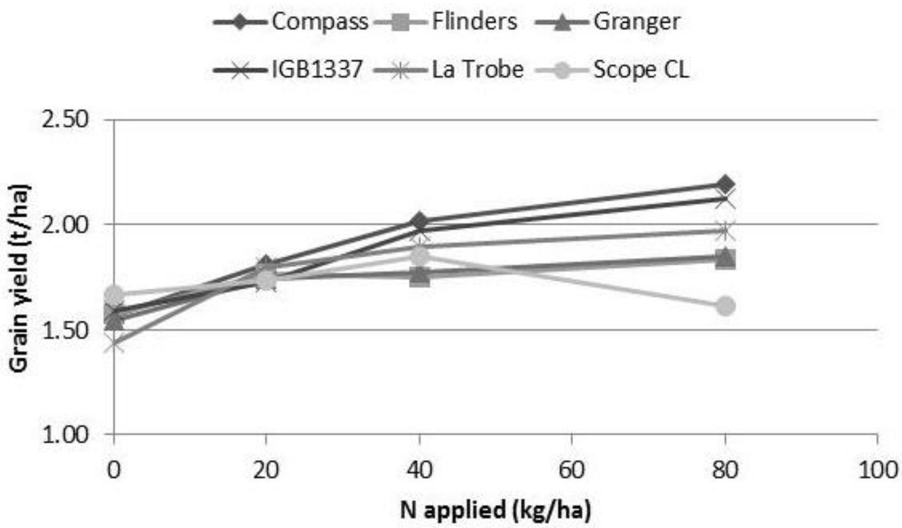

Figure 2: Response of added N to grain yield of barley varieties at Buntine in 2014. (LSD (0.05) = 0.336 t/ha between varieties and 0.231 t/ha within variety).

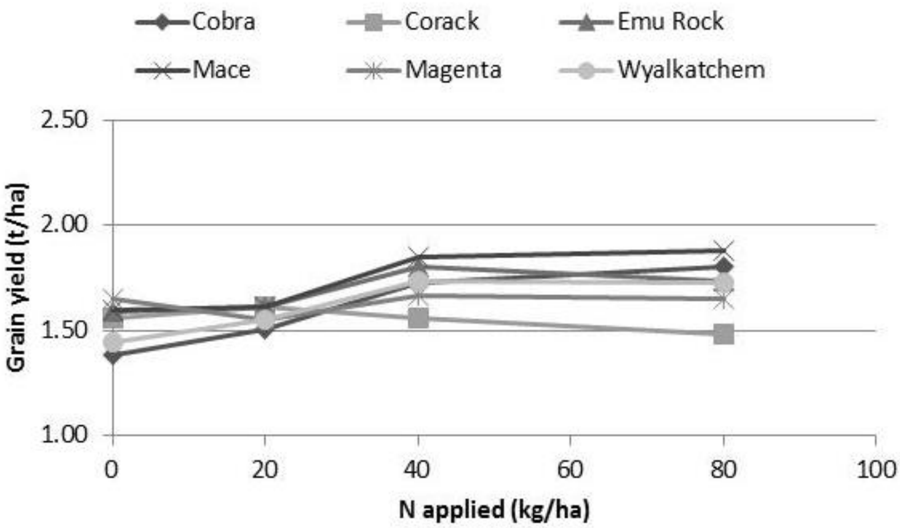

Figure 3: Response of added N to grain yield of wheat varieties at Buntine in 2014. (LSD (0.05) = 0.336 t/ha between varieties and 0.231 t/ha within variety).

Table 1: Wheat grain price ($/t) needed to offset the yield increase of barley at four barley price levels ($/t).

Barley price ($/t)	Barley minus wheat yield = 0.2t/ha	Barley minus wheat yield = 0.3t/ha	Barley minus wheat yield = 0.4t/ha	Barley minus wheat yield = 0.6t/ha
150	180	195	210	225
200	240	260	280	300
250	300	325	350	375
300	360	390	420	450

Comments

Grain quality testing is not available at the time of print. However, this will have an influence on the profitability of added N on barley and wheat production. At current high prices for barley grain, it is a profitable option. However, barley is less tolerant to acid soils and so site selection is important, as is a good understanding of grain quality and end price. The yield potential of the site will influence the wheat grain price needed to offset improved barley yields. For example where barley yields 1.5 t/ha and wheat is likely to yield 1.3 t/ha (yield difference 0.2 t/ha), at a current price for barley of $300/t and $150/t, the break even wheat prices are $346/t and $173/t respectively. The yield difference between wheat and barley will also influence break even prices. At a barley yield of 3.5 t/ha at $250/t, when the yield differences between barley and wheat is 0.2t/ha and 0.4t/h, the break even wheat price is $265/t and $282/t respectively, (Table 1).

Table 2: Wheat grain price ($/t) needed to offset the yield increase of barley at four barley price levels ($/t) at 1.5 t/ha and 3 t/ha of barley.

Barley price ($/t)	At Barley 1.5t/ha and Yield difference Barley-wheat = 0.2t/ha	At Barley 3.5t/ha and Yield difference Barley-wheat = 0.2t/ha	At Barley 1.5t/ha and Yield difference Barley-wheat = 0.4t/ha	At Barley 3.5t/ha and Yield difference Barley-wheat = 0.4t/ha
150	**173**	159	205	169
200	231	212	273	226
250	288	**265**	341	**282**
300	**346**	318	409	339

Acknowledgements

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Wheat Variety Demonstration – West Wubin

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

- Compare the new noodle wheat variety Supreme (IGW6042) against Calingiri to gauge variety performance.
- Compare noodle wheat to Mace in order to determine the economic viability of growing noodle wheat.

Background

2015 will mark the first year since Fortune came out in 2009, that there will be new noodle varieties available to growers. In response to growers' need for higher yielding and better disease resistant noodle varieties to keep up with recent APW/AH varieties, InterGrain has bred Supreme, a mid-short season Arrino type and Zen, a mid-long season Calingiri type. The new varieties released in 2014 show marked improvements in both yield and leaf disease resistances to Arrino and Calingiri respectively.

This demonstration will examine the physical quality traits and yield of Supreme versus Calingiri wheat to gain a measure of noodle wheat variety performance. It also examines the difference in yield and quality characteristics between noodle wheat and Mace. (Ideally we would have liked to compare Zen with Calingiri and Supreme against Arrino to compare similar maturities but sufficient seed of these varieties was not available).

This demonstration was conducted using farmer equipment. Farm scale demonstrations are a valuable way to explore new varieties, products or practices, complimenting results which are produced through more scientifically rigorous, small plot trials. The varieties tested include those that are widely grown in the area as well as recently released varieties.

Varieties

- Supreme – ANW class, early to mid-maturity, Arrino alternative.
- Calingiri – ANW class, late maturity, good early sowing option.
- Mace – AH class, early-mid maturity, Wyalkatchem background, high yielding.

Trial Details

Property	Miamoon Farm, west Wubin
Plot size & replication	16.65m x 200m x no replication
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 4.9 10-20cm: 4.7 20-30cm: 4.9
Soil amelioration	2012: 1 t/ha lime
Sowing date	12/05/2014
Seeding rate	65 kg/ha
Paddock rotation	2011: wheat, 2012: wheat, 2013: canola
Fertiliser	12/05/2014: 35 L/ha UAN, 50 kg/ha DAPSZC:MOP 80:20
Herbicides	09/05/2014: 1.5 L/ha Panza 450, 0.5% LI 700 12/05/2014: 800 mL/ha Spray.Seed, 120 g/ha Sakura
Growing Season Rainfall	206mm

Results

Table 1: Yield, quality, grade and gross return of wheat sown at west Wubin.

Variety	Yield (t/ha)	Protein (%)	Hectolitre Weight (%)	Screenings (%)	Grade	Gross Return ($/ha)
Calingiri	1.41	13.5	81.11	1.82	ANW2	400.44
Supreme	1.31	12.8	82.58	0.59	ANW2	372.04
Mace	1.23	14.3	83.21	0.33	H1	373.92
Calingiri	1.33	13.6	80.87	1.03	ANW2	377.72

*Note: 2014 average prices: H1 = $304, ANW2 = $284.

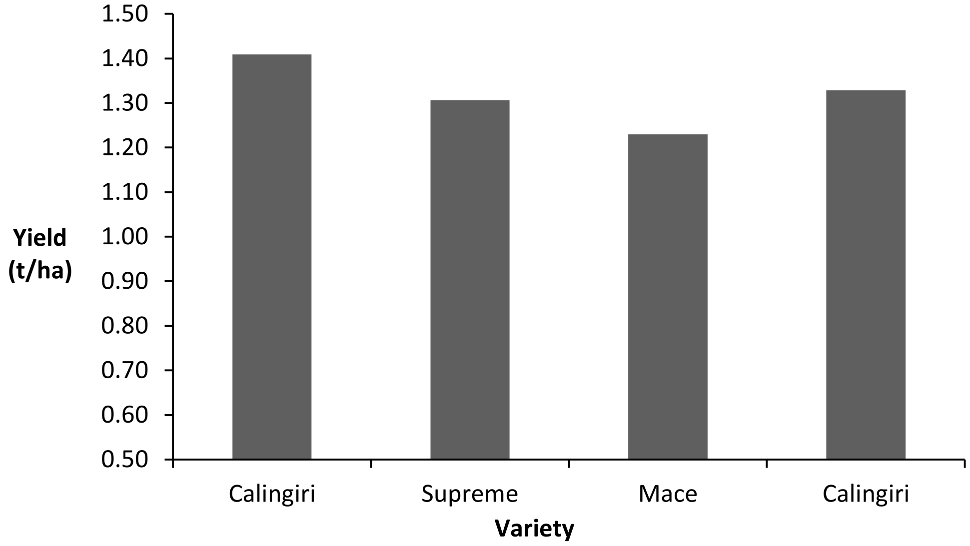

Figure 1: Yield results from wheat varieties sown at west Wubin, 2014.

Comments

The paddock was severely windblown on the 16/06/2014. All the varieties were damaged, with Calingiri being the worst. This resulted in the Calingiri plot having fewer plants per square meter which may have been beneficial in the August dry spell as the surviving plants had less competition for soil moisture.

The new noodle variety Supreme has performed similarly to Mace in a tough finish in this farmer demonstration. As Supreme is a mid-short season variety like Mace, it would be sown in a similar timeframe so this is an encouraging result for Supreme as a mid-late sowing udon noodle option. All varieties had good hectolitre weight and screenings however, the noodle varieties protein was too high to go ANW1 due to the harsh finish.

In this demonstration the extra yield achieved by Calingiri was enough to increase return over the $20 premium gained for H1 ($304) compared to ANW2 ($284), Table 1.

Acknowledgements

Thanks to the Barnes family for implementing and managing the trial and to InterGrain for providing the seed.

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Wheat Variety Demonstration – East Wubin

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

Compare the new IGW3526 imidazolinone wheat with Mace in a farm scale demonstration to compare variety performance.

Background

Herbicide resistance and continuous cropping has increased pressure on our modern farming systems and their economic viability. The Clearfield or imidazolinone tolerant crops have provided another chemical option that effectively controls hard to kill weeds. The IMI-chemistry provides broad spectrum control for broadleaf and grass weeds, in particular brome grass and barley grass. Imidazolinone tolerant crops have the potential to form part of an integrated weed management system and reduce herbicide costs and the weed seed bank.

This demonstration was conducted using farmer equipment. Farm scale demonstrations are a valuable way to explore new varieties, products or practices, complimenting results which are produced through more scientifically rigorous, small plot trials.

Varieties

- IGW3526: A mid-short maturing, Wyalkatchem type, 2-gene imidazolinone APW wheat with strong yellow spot resistance.
- Mace: AH class, high yielding, short season with very large grain size.

Trial Details

Property	KL Carter and Co. east Wubin	
Plot size & replication	13.72m x 770m x 1 replication	
Soil type	Red river flat loam	
Soil pH ($CaCl_2$)	0-15cm: 4.7	15-40cm: 4.4
EC (dS/m)	0-15cm: 0.06	15-40cm: 0.03
Sowing date	20/05/2014	
Seeding rate	40 kg/ha	
Paddock rotation	2011: wheat, 2012: wheat, 2013: lupins	
Fertiliser	20/05/2014: 30 L/ha Flexi-N, 50 kg/ha Agstar Extra	
Herbicides	20/05/2014: 0.06 L/ha EverGol, 0.02 L/ha Interco, 0.35 L/ha AuSu², 0.2 L/ha Ester 800, 0.11 L/ha LI700, 1.45 L/ha Roundup DST, 1.2 L/ha Trifluralin. 30/06/2014: 0.5 L/ha Jaguar, 0.01 kg/ha Logran	
Growing Season Rainfall	160mm	

Results

Table 1: Yield, quality and grade of wheat sown at east Wubin.

Variety	Yield (t/ha)	Protein (%)	Hectolitre Weight (%)	Screenings (%)	Grade
Mace	1.0	13.0	82.32	0.79	H1
IGW3526	1.2	13.0	80.45	2.15	APW1
Mace	1.1	12.7	82.10	1.22	H2

Comments

2013 lupins were not harvested, instead they were brown manured and incorporated. Salinity was present in the demonstration plots increasing southward. The most southern plot of Mace was the most affected.

The IGW3526 performed very similarly to the industry standard Mace in both yield and quality. The IGW3526 could provide another weed control option with the use of Intervix for troublesome weeds like brome or barley grass without sacrificing yield. Further farmer trials and NVT trials should be conducted to better predict its performance for future years.

IGW3526 is to be released in February 2015 following final chemical registration.

Acknowledgements
Thanks to the Carter family for implementing and managing the trial and to InterGrain for providing the seed wheat.

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Wheat Variety Demonstrations – Wubin

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

Compare the new IGW3526 imidazolinone tolerant wheat with Justica in a farm scale demonstration to gauge variety performance.

Background

Herbicide resistance and continuous cropping has increased pressure on our modern farming systems and their economic viability. The Clearfield or imidazolinone tolerant crops have provided another chemical option that effectively controls hard to kill weeds. The IMI-chemistry provides broad spectrum control for broadleaf and grass weeds in particular brome grass and barley grass. Imidazolinone tolerant crops have the potential to form part of an integrated weed management system and reduce herbicide costs and the troublesome weed seed bank.

This demonstration was conducted using farmer equipment. Farm scale demonstrations are a valuable way to explore new varieties, products or practices, complimenting results which are produced through more scientifically rigorous, small plot trials.

Varieties

- IGW3526 – APW class, 2-gene imidazolinone tolerant Wyalkatchem type, mid-short maturing, strong yellow spot resistance.
- Justica – APW class, mid-season maturity, bred for tolerance to Clearfield® Intervix® herbicide.

Trial Details

Property	Bwlch Hendreff (G&H Pearse Pty Ltd), west Wubin
Plot size & replication	18m x 350m x 1 replication
Soil type	Red sandy loam
Soil amelioration	March 2013: 1 t/ha Lime
Sowing date	14/05/2014
Seeding rate	50 kg/ha
Paddock rotation	2011: wheat, 2012: chemical fallow, 2013: wheat
Fertiliser	14/05/2014: 80 kg/ha Macro Pro Extra 12/06/2014: 100 kg/ha Urea
Herbicides	12/05/2014: 120 g/ha Sakura, 1.3 L/ha Roundup Ultramax, 35 g/ha Logran 10/07/2014: 720 mL/ha Flight
Growing Season Rainfall	210mm

Results

Table 1: Yield, quality and grade of wheat sown at west Wubin.

Variety	Yield (t/ha)	Protein (%)	Hectolitre Weight (%)	Screenings (%)	Grade
Justica	1.74	13.6	76.88	2.14	APW1
IGW3526	2.05	12.7	80.23	1.60	APW1
Justica	2.14	12.4	78.12	2.04	APW1

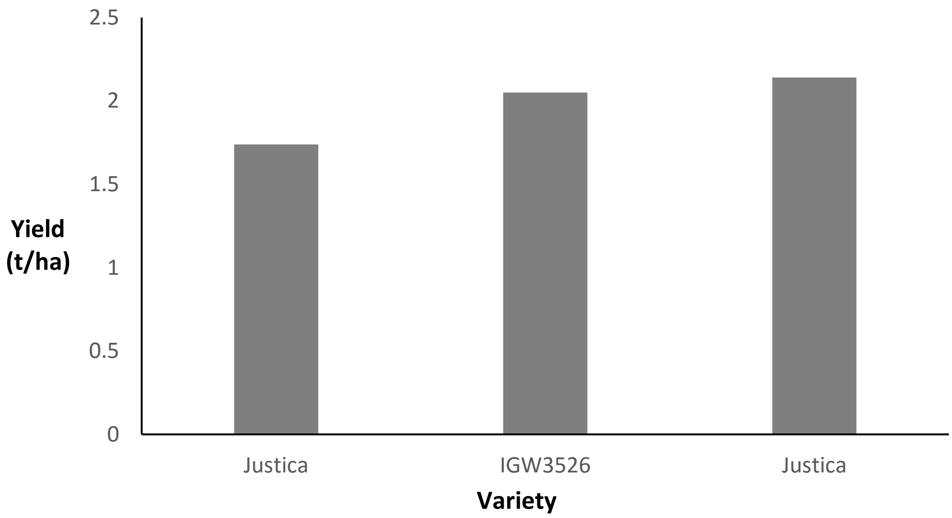

Figure 1: Yield comparison from wheat varieties sown at west Wubin, 2014.

Comments

In this farmer demonstration the IGW3526 has performed similarly to Justica however, there is some variability across the paddock. Analysing more farmer scale trials and NVT trials will help build a better indication of how IGW3526 might perform in your area. NVT trials to date indicate that in Agzone's 1, 2 and 4 IGW3526 is out-yielding Justica and also has strong yellow spot resistance (MR-MS). IGW3526 in this farmer scale trial had slightly better hectolitre weight and screenings which could be indicative of its strong Wyalkatchem background.

IGW3526 is to be released in February 2015 following final chemical registration.

Acknowledgements

Thanks to the Pearse family for implementing and maintaining the trial and to InterGrain for providing the seed wheat.

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Wheat Variety Demonstration – Ballidu

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

Comparison of the new APW wheat Hydra (IGW3422) to Emu Rock and Mace in a farm scale demonstration to evaluate performance.

Background

This demonstration was conducted using farmer equipment. Farm scale demonstrations are a valuable way to explore new varieties, products or practices, complimenting results which are produced through more scientifically rigorous small plot trials. The varieties tested include those that are widely grown in the area as well as recently released varieties.

Varieties

- Hydra: APW classification, high yielding, robust disease resistance, mid-short season maturity with moderate grain size.
- Emu Rock: AH classification, high yielding, short season with very large grain size.
- Mace: AH classification, high yielding, mid-short season with very large grain size.

Trial Details

Property	Ardoch, Ballidu		
Plot size & replication	12m x 300m x 1 replication		
Soil type	Loamy sand		
Soil pH ($CaCl_2$)	0-10cm: 4.4	10-20cm: 4.3	20-30cm: 4.5
EC (dS/m)	0-10cm: 0.178	10-20cm: 0.088	20-30cm: 0.114
Sowing date	26/05/2014		
Seeding rate	60 kg/ha		
Paddock rotation	2011: pasture, 2012: wheat, 2013: lupins		
Fertiliser	27/06/2014: 25 kg/ha Guano, 25 kg/ha MAP, 50 L/ha UAN		
Herbicides	27/06/2014: 1 L/ha Glyphosate, 300 mL/ha Ester 800, 1 L/ha Treflan		
Growing Season Rainfall	190mm		

Results

Table 1: Yield, quality and grade of wheat sown at Ballidu.

Variety	Yield (t/ha)	Protein (%)	Hectolitre Weight (%)	Screenings (%)	Grade
Emu Rock	1.40	9.7	81.68	1.91	ASW1
Hydra	1.39	10.0	81.87	2.32	APW2
Mace	1.29	10.2	81.68	1.99	APW2

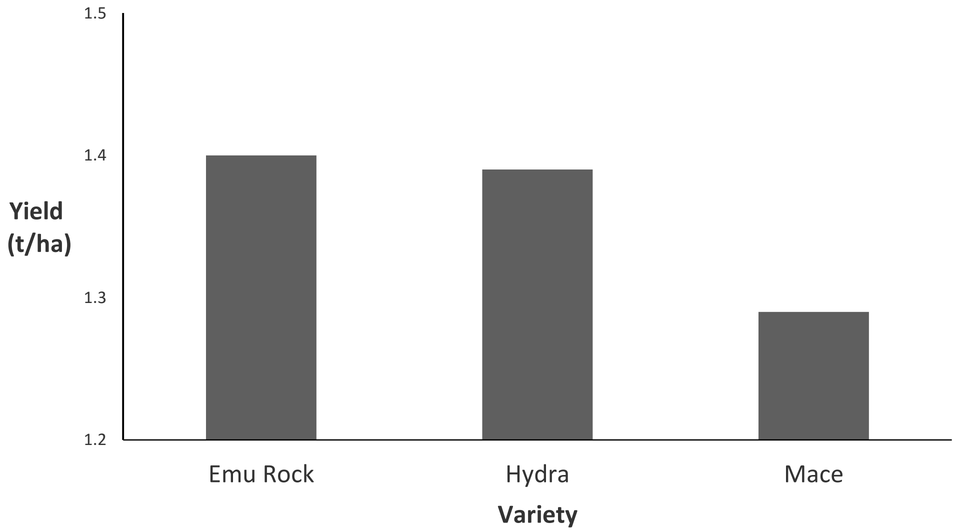

Figure 1: Yield results for wheat varieties sown at Ballidu, 2014.

Comments

The dry hot August in which only approximately 22mm of rain fell affected the performance of all varieties. On the Hood property Calingiri yielded on average half a tonne lower than Mace. Protein was the reason for Emu Rock being downgraded to ASW1 and Mace to APW2 in this trial.

Acknowledgements

Thanks to the Hood family for implementing and managing the demonstration.

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Barley National Variety Trial – Buntine

Australian Crop Accreditation System Limited

Aim/Background

The barley National Variety Testing (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	Fitzsimons Property, east Buntine
Plot size & replication	12m x 1.76m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.0 10-30cm: 4.5
EC (dS/m)	0-10cm: 0.130 10-30cm: 0.033
Paddock rotation	2011: pasture, 2012: wheat, 2013: canola
Variety	As per protocol
Seeding date	27/05/2014
Seeding rate	65 kg/ha
Fertiliser	27/05/2014: 100 kg/ha Urea, 50 kg/ha Gusto Gold
Herbicides & Insecticides	17/05/2014: 2 L/ha Paraquat & Diquat, 2.5 L/ha Prosulfocarb & S-Metolachlor, 500 mL/ha Alpha-cypermethrin, 1 L/ha Chlorpyrifos 27/05/2014: 2 L/ha Glyphosate, 2.5 L/ha Prosulfocarb & S-Metolachlor, 1 L/ha Trifluralin, 100 g/ha Clopyralid, 500 mL/ha Carfentrazone-ethyl, 1 L/ha Chlorpyrifos 23/07/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 500 mL/ha LVE MCPA, 120 g/ha Clopyralid, 150 mL/ha Prothioconazole & Tebuconazole, 1% Hasten
Growing Season Rainfall	180mm

Results

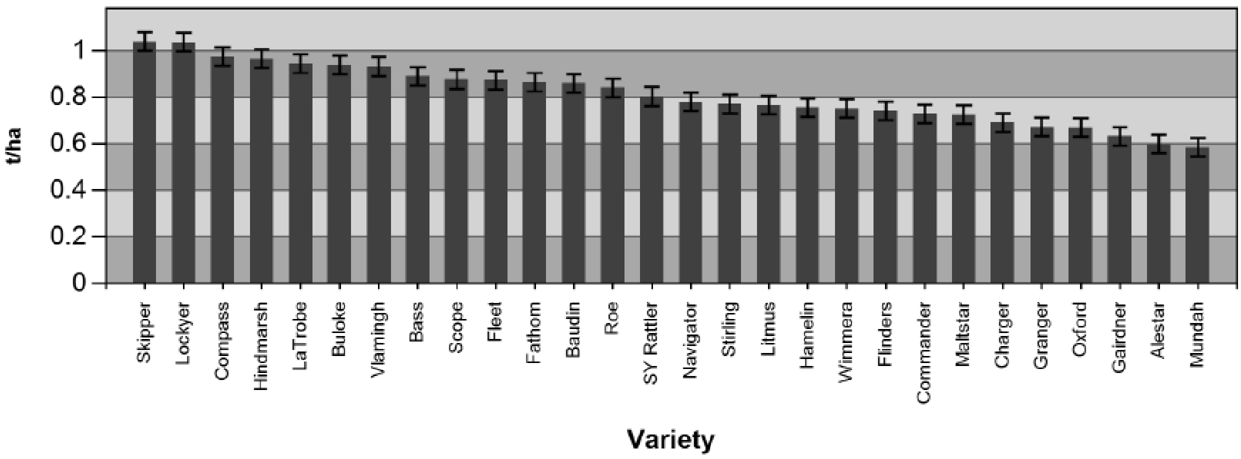

Figure 1: Yield comparison for barley varieties sown at east Buntine.

Table 1: Yield and quality results of barley varieties grown in 2014, at east Buntine.

Variety	Yield (t/ha)	Percentage of Site Mean	Hectolitre weight (kg/hL)	Protein (%)	Screenings (%)
Lockyer	1.04	128	64.60	14.2	3.0
Skipper	1.01	125	64.20	14.7	2.7
Compass	0.97	120	61.40	13.9	3.5
Hindmarsh	0.97	120	65.00	14.8	2.0
LaTrobe	0.95	117	66.60	14.5	2.4
Buloke	0.94	116	63.20	14.0	3.8
Vlamingh	0.93	115	60.60	15.5	5.7
Bass	0.89	110	60.00	15.0	3.2
Scope	0.88	109	66.00	14.6	3.5
Fathom	0.87	107	58.00	14.2	3.6
Fleet	0.87	107	53.80	14.1	4.1
Baudin	0.86	106	59.40	14.6	2.9
Roe	0.84	104	60.80	14.7	3.2
SY Rattler	0.80	99	63.00	14.1	9.5
Navigator	0.78	96	61.40	14.6	4.4
Litmus	0.77	95	67.60	14.2	1.5
Stirling	0.77	95	62.40	13.3	4.1
Hamelin	0.76	94	60.80	15.0	3.9
Wimmera	0.75	93	65.20	14.6	3.4
Flinders	0.74	91	63.40	15.8	3.4
Commander	0.73	90	62.00	13.7	8.3
Maltstar	0.72	89	63.80	13.5	8.2
Charger	0.69	85	60.40	15.0	2.2
Granger	0.67	83	63.60	15.6	3.1
Oxford	0.67	83	67.20	14.6	9.4
Gairdner	0.63	78	62.40	16.4	6.8
Alestar	0.60	74	56.00	14.6	5.4
Mundah	0.59	73	64.00	14.0	4.4
Site Mean (t/ha)	0.81				
LSD (t/ha)	0.08	10			
CV (%)	5.7				
Probability	<0.001				

Comment

For more information please refer to www.nvtonline.com.au

Barley National Variety Trial – Wongan Hills

Australian Crop Accreditation System Limited

Aim/Background

The barley National Variety Testing (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	Wongan Hills Research Station
Plot size & replication	12m x 1.76m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.6 10-30cm: 4.2
EC (dS/m)	0-10cm: 0.054 10-30cm: 0.142
Paddock rotation	2011: lupin, 2012: wheat, 2013: canola
Variety	As per protocol
Seeding date	07/05/2014
Seeding rate	65 kg/ha
Fertiliser	07/05/2014: 50 kg/ha Urea, 100 kg/ha Gusto Gold
Herbicides & pesticides	06/05/2014: 4 L/ha Paraquat & Diquat, 2.5 L/ha Prosulfocarb & S-Metolachlor, 1 L/ha Trifluralin, 1 L/ha Chlorpyrifos 10/07/2014: 1 L/ha Bromoxynil & Pyrasulfotole, 120 g/ha Clopyralid, 0.5 L/ha LVE MCPA, 150 mL/ha Prothioconazole & Tebuconazole, 300 mL/ha Cloquintocet-Mexyl, 1% Hasten
Growing Season Rainfall	243mm

Results

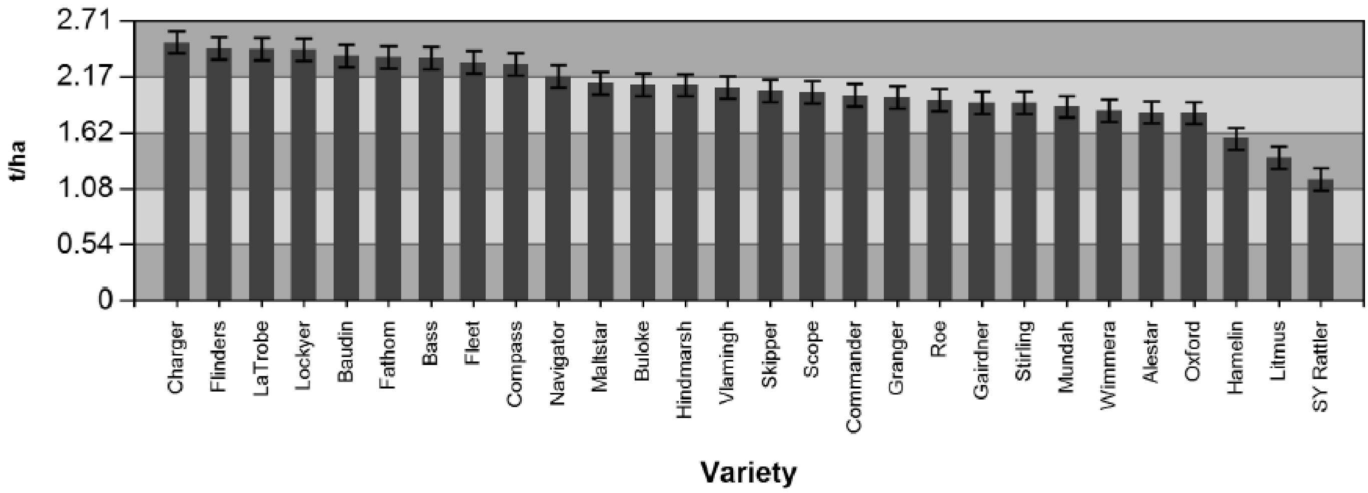

Figure 1: Yield comparison for barley varieties sown at Wongan Hills.

Table 1: Barley NVT yield results from the Main Trial Site grown in 2014, at Wongan Hills.

Variety	Yield (t/ha)	Percentage of site mean	Hectolitre weight (kg/hL)	Protein (%)	Screenings (%)
Charger	2.50	123	67.00	9.6	2.4
Flinders	2.44	120	71.80	9.7	1.0
LaTrobe	2.44	120	70.20	9.5	1.7
Lockyer	2.43	119	69.80	9.7	1.6
Baudin	2.37	116	72.40	10.	1.2
Bass	2.35	115	72.80	10.5	0.6
Fathom	2.35	115	67.40	10.3	1.7
Fleet	2.31	113	67.60	11.0	1.3
Compass	2.29	112	68.40	9.5	1.5
Navigator	2.17	106	70.80	10.6	0.3
Maltstar	2.10	103	71.60	10.1	1.6
Buloke	2.09	102	69.20	10.1	0.6
Hindmarsh	2.09	102	68.80	10.0	3.1
Vlamingh	2.06	101	72.20	10.9	0.8
Skipper	2.03	99	69.40	9.6	1.6
Scope	2.02	99	68.80	9.9	0.8
Commander	1.99	98	70.20	10.5	1.1
Granger	1.97	97	71.40	9.7	1.0
Roe	1.94	95	70.80	11.0	0.8
Gairdner	1.92	94	71.20	11.4	1.7
Stirling	1.91	94	71.20	11.0	0.9
Mundah	1.88	92	68.20	10.9	1.1
Wimmera	1.84	90	70.40	11.5	1.1
Alestar	1.82	89	71.00	10.6	0.7
Oxford	1.82	89	71.00	12.0	0.5
Hamelin	1.56	76	69.00	11.7	1.9
Litmus	1.39	68	68.40	9.9	1.8
SY Rattler	1.17	57	67.60	9.8	3.9
Site Mean (t/ha)	2.04				
LSD (t/ha)	0.22	11			
CV (%)	6.3				
Probability	<0.001				

Comment

For more information please refer to www.nvtonline.com.au

Oat National Variety Trial – Wongan Hills

Australian Crop Accreditation System Limited

Aim
To evaluate yields of new and existing oat varieties in Wongan Hills.

Trial Details

Property	Wongan Hills
Plot size & replication	1.54m x 20m x 3 replications
Sowing date	27/05/2014
Fertiliser	27/05/2014: 120 kg/ha Agras
Herbicides & pesticides	27/05/2014: 500 mL/ha Diuron, 500 mL/ha S-Metolachlor 27/06/2014: 1.4 L/ha Bromoxynil
Growing Season Rainfall	243mm

Results
Table 1: Yield of oats sown at Wongan Hills, 2014.

Variety	Yield (t/ha)
Williams	3.04
Bannister	2.97
Carrolup	2.47
Wandering	2.33
Kojonup	2.32
Mitika	2.23
Dunnart	1.89
Yallara	1.54

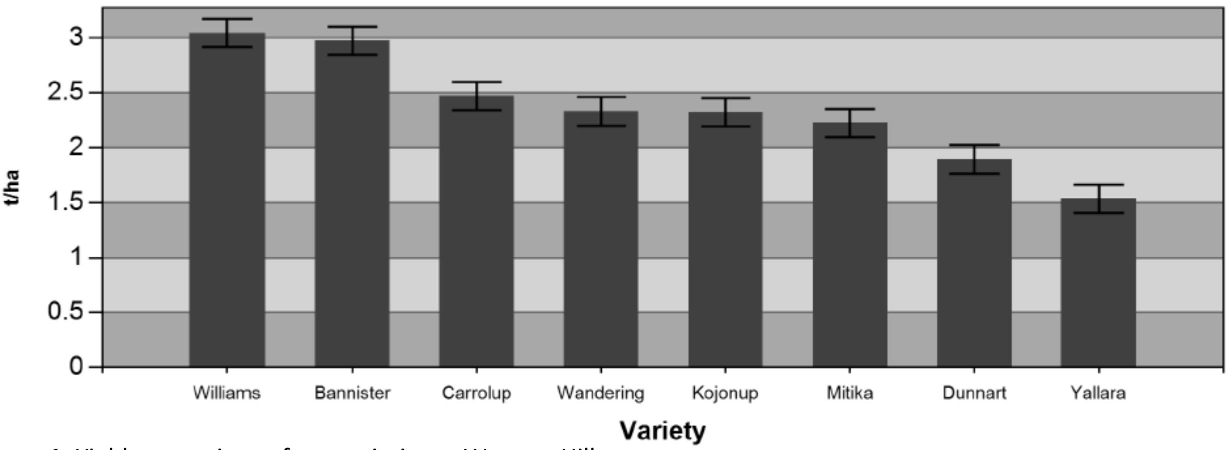

Figure 1: Yield comparison of oat varieties at Wongan Hills.

Comments
For more information please refer to www.nvtonline.com.au

Oat Variety Demonstration – Buntine

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

To evaluate the yield and quality of new and existing oat varieties in a low rainfall zone.

Background

The focus of this demonstration is WA302-9 and how it compares to existing varieties. WA302-9 is a new short season variety that reaches maturity 7-12 days earlier than Carrolup with similar grain, hay yield and quality. Carrolup provides the standard for both hay and milling oats. Brusher and Mulgara are classed specialist hay oats. Brusher is the next earliest maturing variety with a season length between WA302-9 and Carrolup. Brusher has good early vigour, is tall, but prone to lodging and shattering. Mulgara is a longer season variety, comparable to Wintaroo.

Trial Details

Property	Fitzsimons Property, east Buntine		
Plot size & replication	18m x 100m x 1 replication		
Soil type	Sandy loam		
Soil pH ($CaCl_2$)	0-10cm: 6.0	10-20cm: 4.9	20-30cm: 4.7
EC (dS/m)	0-10: 0.179		
Sowing date	02/05/2014		
Seeding rate	80 kg/ha		
Paddock rotation	2011: pasture, 2012: wheat, 2013: canola		
Fertiliser	02/05/2014: 30 kg/ha DAPSZC		
Herbicides	02/05/2014: 1.5 L/ha Gramoxone, 0.275 kg/ha Diuron		
Growing Season Rainfall	180mm		

Results

Table 1: Yield, quality and grade of wheat sown at east Buntine.

Variety	Yield (t/ha)	Protein (%)	Hectolitre Weight (%)	Screenings (%)	Grade
Mulgara	0.96	12.6	46.32	4.73	-
Brusher	0.86	12.8	47.58	5.25	-
Carrolup	0.60	13.3	50.18	11.37	Oat 2
WA302-9	0.51	12.3	52.42	2.74	Oat 2

Comments

All the oat varieties did not need a follow up weed spray due to the extra competition from good early vigour.

Brusher and Mulgara hectolitre weights were too light (below 50%) and were out of receival range.

Acknowledgements

John Sydenham and Joe Naughton (DAFWA) for supplying the seed. Ross and Shaun Fitzsimons for hosting the demonstration and seeding it.

Contact

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Canola & Pulses Research Results

TT Canola National Variety Trial – Buntine

Australian Crop Accreditation System Limited

Aim

To evaluate yields and quality of new and existing triazine tolerant canola varieties.

Background

NVT is a national program of comparative crop variety testing with standardised trial management, data generation, collection and dissemination. The program is supported by the Australian Government and growers through the Grains Research and Development Corporation and is managed by the Australian Crop Accreditation System Limited.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	12m x 1.7m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 4.4 10-30cm: 4.4
EC (dS/m)	0-10cm: 0.082
Paddock rotation	2011: wheat, 2012: wheat, 2013: lupin
Sowing date	30/04/2014
Seeding rate	50 plants/m^2
Fertiliser	30/04/2014: 100 kg/ha Gusto Gold, 100 kg/ha Urea 30/07/2014: 75 kg/ha Urea
Herbicides & Insecticides	30/04/2014: 3 L/ha Glyphosate, 2 L/ha Trifluralin, 400 mL/ha Bifenthrin, 300 mL/ha Alpha Cypermethrin 01/05/2014: 1.1 kg/ha Atrazine 01/06/2014: 600 mL/ha Clethodim, 400 mL/ha Quizalofop-P-ethyl, 100 g/ha Clopyralid, 1 L/ha Chlorpyrifos, 2 L/ha Atrazine, 1% Hasten 16/09/2014: 1 L/ha Chlorpyrifos, 400 mL/ha Alpha-cypermethrin, 200 mL/ha Bifenthrin 01/10/2014: 3 L/ha Diquat
Growing Season Rainfall	180mm

Key Triazine Tolerant Varieties

ATR Stingray

- Early maturity
- High oil content
- Blackleg rating - MR

Pioneer Sturt TT

- Very early maturity for low-medium rainfall zones
- Blackleg rating – MS
- Medium oil content

ATR Bonito

- Early/early-mid maturity
- Blackleg rating – MR (N)
- Short-medium plant height

Hyola 559 TT

- Blackleg rating – R-MR (P)
- Mid maturity hybrid
- Medium crop height with early plant vigour rating – 8.0
- Yield adaption zone – 1.25 – 3. 5 t/ha

ATR Gem

- Early-mid maturity
- High oil content
- Blackleg rating – MR

Results

Table 1: Yield and quality results of TT canola varieties grown in 2014, at east Buntine.

Variety	Yield (t/ha)	Percentage of Site Mean	Oil (%)	Protein (%)
ATR Stingray	0.42	135	40.1	24.8
Pioneer Sturt TT	0.42	135	40.3	24.8
ATR Bonito	0.39	126	39.7	24.8
Hyola 559TT	0.32	103	39.9	25.1
ATR Gem	0.29	94	38.7	25
Hyola 525RT	0.26	84	40.9	24.7
Hyola 450TT	0.24	77	40.2	25.8
Pioneer Atomic	0.23	74	36.7	27.0
Site Mean (t/ha)	0.31 t/ha			
LSD (t/ha)	0.05 t/ha	16		
CV (%)	10.4%			
Probability	<0.001			

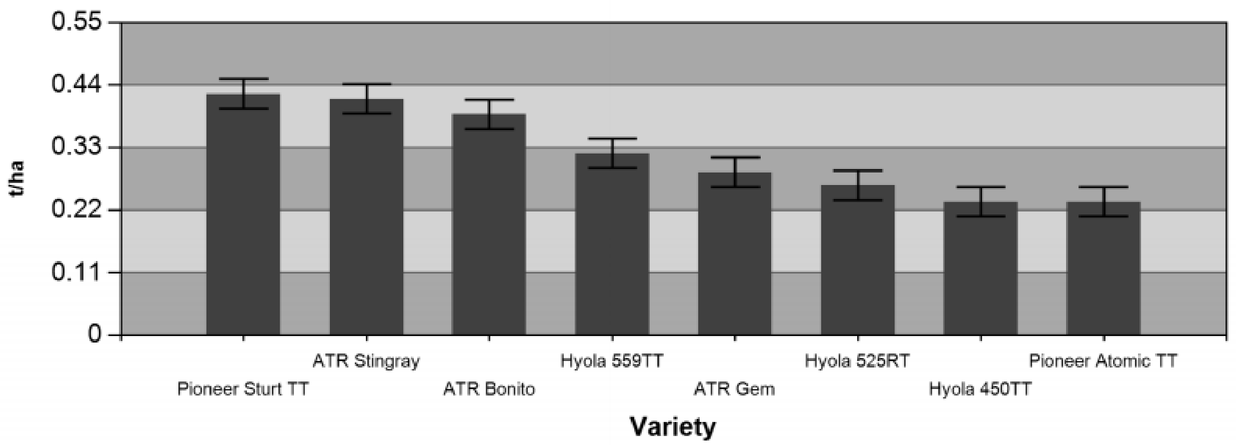

Figure 1: Yield comparison of TT canola varieties sown at east Buntine.

Comments

For more information please refer to www.nvtonline.com.au.

Timing of Nitrogen for Canola Grown in the Lower Rainfall Areas of Western Australia

Sally Sprigg, Research Officer and Mark Seymour, Senior Research Officer, DAFWA

Key Messages

- We observed no significant differences in grain yield (GY) between any treatments due to low yield potential and reasonable soil nitrogen (N) levels at seeding.
- Timing of N application had no effect on GY. This is consistent with last years' results at Wubin.
- Canola oil percentage decreased as N rate increased. High rates of N reduced oil significantly, consistent with last year at Wubin.
- The higher the rate of N the more rapidly oil percentage reduced, consistent with last year at Wubin.
- Gross margins (GM) decreased as N rates increased; all GM figures are negative due to poor GY, however, Sturt performed better than Pioneer 43Y23RR due to the higher seed costs associated with Roundup Ready (RR) seed.

Aim

To investigate the nitrogen rate and time of application response of canola varieties to yield and oil content of Triazine Tolerant (TT) and Roundup Ready (RR) hybrids in comparison with open-pollinated (OP) types to:

1. Provide growers in lower rainfall environments with guidelines on times of application to maximise grain and oil yields.
2. Determine if the management of hybrid canola nutrition is different to that of OP varieties due to different responses to N rates and timing.

Background

In 2011 DAFWA conducted N management of hybrid and OP canola in the low rainfall WA mallee. In that trial it appeared hybrids continued to respond to N in terms of GY and $/ha compared to OP varieties in both TT and RR technologies. Hybrids at rates of N below 25kg N/ha produced equal or better yields than OP varieties at higher rates. This opened up the idea of using the improved genetics of hybrids with low rates of N near seeding, watching the season and applying more N as the season allows.

As part of this project, trials were conducted in 2013 across several locations. The following general conclusions were drawn:

- It is important to assess the N status and ensure canola is not over fertilised (in low rainfall areas), as the reduction in oil content with increasing N could lead to large discounts and
- There exists opportunities to delay making N decisions for canola in low rainfall conditions.

Trial Details

Property	Fitzsimons property, east Buntine
Plot size & replication	22m x 1.54m x 3 replications
Soil type	Sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 5.6 10-20cm: 5.5 20-30cm: 4.7 30-40cm: 5.7 40-50cm: 6.1
EC (dS/m)	0-10cm: 0.046
Paddock rotation	2011: wheat, 2012: canola, 2013: wheat
Variety	Sturt and Pioneer 43Y23RR
Sowing date	01/05/2014
Seeding rate	2.4 kg/ha Sturt and 1.5 kg/ha Pioneer 43Y23RR
Fertiliser	01/05/2014: 80 kg/ha Macropro Plus banded, 22 kg/ha Urea top-dressed 27/06/2014: Urea (8wk treatments) 24/07/2014: Urea (12wk treatments)
Herbicides & Insecticides	01/05/2014: 100 mL/ha Bifenthrin, 1.5 L/ha Trifluralin, 2 L/ha Spray.Seed 250 20/05/2014: 900 g/ha Roundup Ready on RR treatments 21/05/2014: 2.2 kg/ha Atrazine on TT treatments, 1% Spray Oil 06/06/2014: 0.85 mL/ha Dimethoate 11/06/2014: 500 mL/ha Clethodim, 1% Hasten 03/09/2014: 300 mL/ha Dominex (Insecticide) 06/10/2014: 3 L/ha Reglone, 1% Wetter
Harvest date	13/10/2014
Growing Season Rainfall	136mm

Results

28 treatments: 2 cultivars (TT-OP = Sturt and RR – Hybrid = Pioneer 43Y23RR) (refer to table 4).

Table 1: Rainfall (mm) at the 2014 Main Trial Site, east Buntine in 2013 and 2014, compared to the Buntine historical long term average (1915-2013).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2013	18	0	34	6	37	7	30	38	28	12	0	0	210
2014	0	22	0	44.5	42.5	20	37	13.5	20	3	4	0	206.5
Mean	13.7	15.8	23.5	21.5	43.3	63.6	54.9	42.8	21.3	16.2	9.3	9.6	342

Table 2: Estimates of available water.

Year	Pre-sowing (mm)	Stored pre-sowing (mm) estimate	Growing Season Rainfall (GSR, mm)	GSR + (mm)
2013	58	27.5	152	179.5
2014	66.5	50	136	186
Mean	74.5	40.6	242.1	282.7

Table 3: Water limited yield calculations.

GSR + stored water minus 1/3 loss	124mm
Potential yield (10 kg/ha/mm)	1,240 kg/ha
Target yield = 75% of Potential Yield	930 kg/ha

There were no significant differences in grain yield between any treatments due to low yield potential and reasonable soil N levels at seeding. There may have been an N response if grain yields were greater. Select your nitrogen (SYN) calculations made earlier in the year suggested that the total organic N at the trial site was 59kg N/ha.

Sturt and Pioneer 43Y23RR responded in the same way to applied N at this trial at east Buntine in 2014. The grain yield of both varieties increased with total applied N up to 70kg N/ha (Table 4), though not significantly. For all rates of applied N, the timing of application had no effect on grain yield. Therefore 30kg N/ha could be applied either 30N in 8 weeks (10N at seeding and 20N at 8 weeks after sowing (WAS)) or 18N at seeding and 12N 12WAS with similar responses in grain yield.

Table 4: Grain yield (t/ha) of Sturt TT and Pioneer 43Y23RR canola varieties, also shown with average yield across varieties, for various N application rates and timings at east Buntine in 2014.

Nitrogen rate (kg/ha) & timing	Sturt (t/ha)	Pioneer 43Y23RR (t/ha)	Mean (t/ha)
Nil	361	491	426
8N seeding	440	537	489
18N seeding	440	551	496
30N in 8 weeks	454	644	549
50N in 8 weeks	435	514	475
70N in 8 weeks	444	569	507
18N seeding and 12N 12WAS	398	574	486
18N seeding and 32N 12WAS	394	588	491
18N seeding and 52N 12WAS	421	574	498
30N in 8 weeks and 10N 12WAS	454	560	507
30N in 8 weeks and 20N 12WAS	417	583	500
30N in 8 weeks and 40N 12WAS	458	523	491
Mean	**465**	**610**	**537**
LSD = 76.4.			

While N rate increased grain yield up to 70kg N/ha, N had a negative effect on canola oil percentage. Oil percentage decreased, as N rate increased (Figure 1). Oil percentage dropped approximately 0.04% for every additional unit of N applied up to 70kg N/ha. Timing did not have an effect on oil percentage.

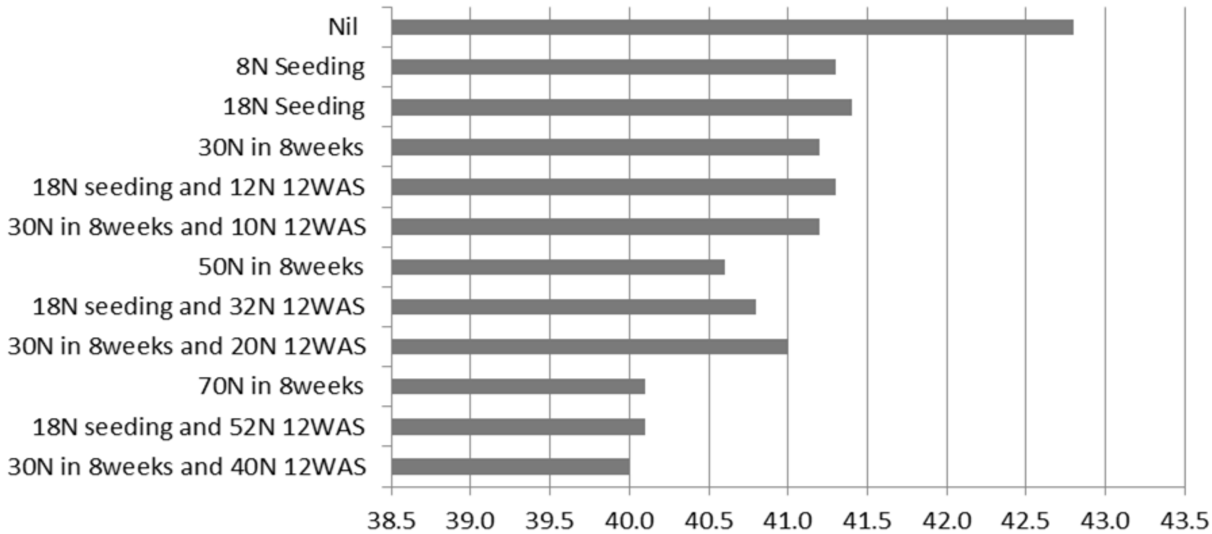

Figure 1: Effect of rate and timing of N on percentage of oil in canola at east Buntine in 2014 (mean of two varieties). LSD (P=0.96).

Economic Analysis

Gross margin analysis indicates that there was no economic benefit in applying N at east Buntine in 2014, due to very low grain yields and the price of input costs particular seed costs for 43Y23RR seed. Gross margins decreased as N rates increased (Figure 2).

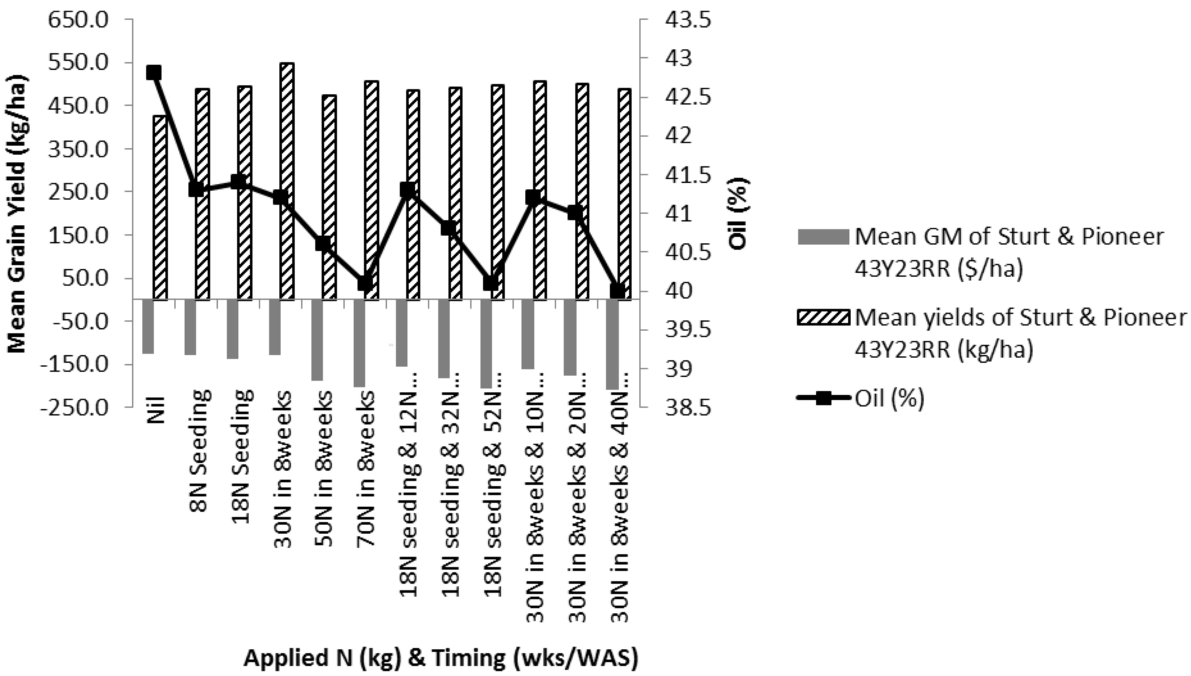

Figure 2: Effect of N on grain yield, oil and gross margin of canola at east Buntine in 2014.

Comments

Findings in response to N on grain yield and oil in 2014 are similar to those findings seen at Wubin in 2013. At this trial in 2014 in the majority of treatments, canola has responded to N up to 12 WAS, at rates up to 70kg N/ha, though not significantly.

At this trial at east Buntine in 2014 oil decreased quicker than grain yield increased in response to N. Now that markets do not have an oil limit, it is important for canola growers to have good working knowledge of soil N, target yield and the expected response of oil and yield, in order for them to maximise economic returns. We recommend people use tools to such as the application: *N broad acre* to assist with N management decisions.

Acknowledgements

GRDC and DAFWA for funding this project.

Ross Fitzsimons for hosting the trial and the Liebe Group, especially Elly Wainwright.

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Shari Dougall and Bruce Thorpe, DAFWA Wongan Hills Research Station Unit (RSU).

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Timing of Nitrogen for Canola Grown in the Medium Rainfall Areas of Western Australia

Sally Sprigg, Research Officer and Mark Seymour, Senior Research Officer, DAFWA

Key Messages
- There were significant differences in grain yield (GY) between treatments (N kg/ha and timing), however, GY was particularly low in all treatments.
- Total nitrogen (N) increased GY significantly up to 30kg N/ha.
- Canola oil percentage decreased as N rate increased. High rates of N reduced oil significantly.
- Applying N late (12 weeks after sowing (WAS) reduced canola oil percentage, however, not significantly.
- Gross margins decreased as N rates increased, but all gross margins (GM) were negative due to poor GY. Sturt had better gross margins than Pioneer 43Y23RR due to the higher seed costs associated with RR seed.
- Pioneer 43Y23RR produced higher GY at all rates and timings of applied N other than 10N seeding and 20N 12WAS.

Aim
To investigate the N rate and time of application response of canola varieties to yield and oil content of Triazine tolerant (TT) and Roundup Ready (RR) hybrids in comparison with open-pollinated (OP) types to:

1. Provide growers in lower rainfall environments with guidelines on times of application to maximise grain and oil yields.
2. Determine if the management of hybrid canola nutrition is different to that of open pollinated varieties due to different responses to N rates and timing.

Background
In 2011 DAFWA conducted N management of hybrid and OP canola in the low rainfall WA mallee. In that trial it appeared hybrids continued to respond to N in terms of GY and $/ha compared to OP varieties in both TT and RR technologies. Hybrids at rates of N below 25kg N/ha produced equal or better yields than OP varieties at higher rates. This opened up the idea of using the improved genetics of hybrids with low rates of N near seeding, watching the season and applying more N as the season allows.

As part of this project, trials were conducted in 2013 across several locations. The following general conclusions were drawn:
- It is important to assess the N status and ensure canola is not over fertilised (in low rainfall areas), as the reduction in oil content with increasing N could lead to large discounts.
- There exists opportunities to delay making N decisions for canola in low rainfall conditions.

Trial Details

Property	Wongan Hills Research Station
Plot size & replication	22m x 1.54m x 3 replications
Soil type	Brown sandy earth (with gravel)
Soil pH ($CaCl_2$)	0-10cm: 6.4 10-20cm: 5.3 20-30cm: 5.3 30-40cm: 6.0 40-50cm: 6.8
EC (dS/m)	0-10cm: 0.088 10-20cm: 0.069 20-30cm: 0.057 30-40cm: 0.058 40-50cm: 0.098
Paddock rotation	2010: barley, 2011: pasture, 2012: pasture, 2013: wheat
Variety	Sturt and Pioneer 43Y23RR
Sowing date	13/05/2014
Seeding rate	2.4 kg/ha Sturt and 1.5 kg/ha Pioneer 43Y23RR
Fertiliser	13/05/2014: 65 kg/ha Big Phos banded, 22 kg/ha Urea top-dressed 15/07/2014: Urea (8 wk treatments, applied at 9 WAS) 05/08/2014: Urea (12 wk treatments)
Herbicides & Insecticides	10/05/2014: 1.5 L/ha Roundup 13/05/2014: 100 mL/ha Bifenthrin, 1.5 L/ha Trifluralin, 2L/ha Spray.Seed 250 27/05/2014: 900 g/ha Roundup Ready on RR treatments 05/06/2014: 0.85 mL/ha Dimethoate 10/06/2014: 1% Spray Oil, 2.2 kg/ha Atrazine on TT treatments, 300 mL/ha Alpha Cypermetherin
Harvest date	27/10/2014
Growing Season Rainfall	276mm

22 Treatments: 2 Cultivars (TT-OP = Sturt and RR – Hybrid = Pioneer 43Y23RR).

Results

Table 1: Rainfall (mm) at Wongan Hills 2014, compared to Wongan Research Station historical long term average (1937-2013). NB: Rainfall records incomplete from Wongan Hills Research Station in 2014, therefore Wongan Hills records were used.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2013	3.2	2	3.3	26.2	44.4	27.2	68.8	25.6	41.4	8.7	30.2	0	281
2014	11.6	1.4	6	24.8	59.2	29.4	80.6	38.6	49.8	18.4	36.4	0	356.2
Mean	15.2	15.3	18.6	22.1	47.4	61.8	62.2	47.6	27.7	18.5	12.6	9.6	354.1

Table 2: Estimates of available water.

Year	Pre-sowing (mm)	Stored pre-sowing (mm) estimate	Growing Season Rainfall (GSR, mm)	GSR + (mm)
2013	34.7	29.2	216.1	245.3
2014	43.8	31.1	276	307.1
Mean	71.2	39	270.3	309.3

Table 3: Water limited yield calculations.

GSR + stored water minus 1/3 loss	204.7mm
Potential yield (10 kg/ha/mm)	2047 kg/ha
Target yield = 75% of Potential Yield	1535 kg/ha

Sturt and Pioneer 43Y23RR responded in the same way to applied N in this trial at Wongan Hills in 2014. The grain yield of both varieties increased with total applied N up to 30kg N/ha (Table 4). Pioneer 43Y23RR produced higher grain yields at all rates and timings of applied N other than 10N at seeding and 20N 12WAS. For all rates of applied N, the timing of application had no effect on grain yield. Therefore 30kg N/ha could be applied either 30N in 8 weeks (10N at seeding and 20N at 8WAS) or 10N at seeding and 20N 12WAS with similar responses in grain yield.

Table 4: Grain yield (kg/ha) of Sturt TT and Pioneer 43Y23RR canola varieties, shown with average grain yield across varieties, for various N application rates and timings at Wongan Hills Research Station in 2014.

Nitrogen rate (kg/ha) & timing	Sturt (kg/ha)	Pioneer 43Y23RR (kg/ha)	Mean (kg/ha)
Nil	611	713	662
10N seeding	605	667	636
30N in 8 weeks	694	781	737.5
50N in 8 weeks	703	792	747.5
70N in 8 weeks	741	764	752.5
10N seeding and 20N 12WAS	731	667	699
10N seeding and 40N 12WAS	676	796	736
10N seeding and 60N 12WAS	692	747	719.5
30N in 8 weeks and 10N 12WAS	683	785	734
30N in 8 weeks and 20N 12WAS	703	708	705.5
30N in 8 weeks and 40N 12WAS	694	750	722
Mean	**685**	**743**	**714**
LSD = 67.			

While N rate increased grain yield up to 30 kg N/ha (significant difference), N had a negative effect on canola oil percentage. Oil percentage decreased as N increased (Figure 1). Oil percentage dropped approximately 0.03% for every additional unit of N applied up to 70kg N/ha. In the majority of treatments timing also had an effect on oil percentage. Oil percentage reduced at the later timings of N, however, this only occurred when the total N rate applied over the duration of the season was 30kg N/ha and higher.

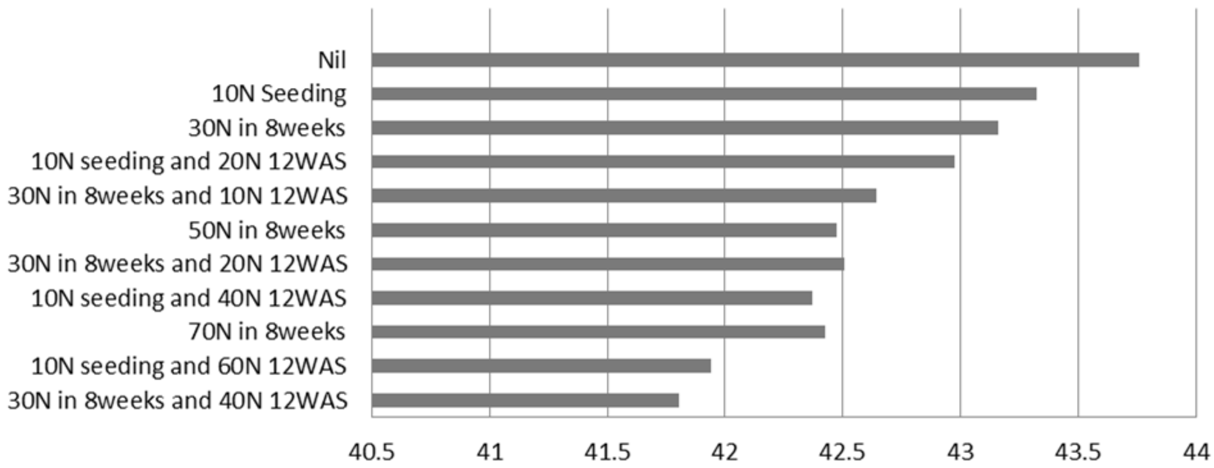

Figure 1: Effect of rate and timing of N on percentage of oil in canola at Wongan Hills Research Station in 2014 (mean of two varieties). LSD (P=0.7514).

Economic Analysis

Gross margin analysis indicates that there was no economic benefit in applying N at Wongan Hills in 2014, due to very low grain yields and the price of input costs, in particular seed costs for 43Y23RR seed. Gross margins decreased as N rates increased (Figure 2).

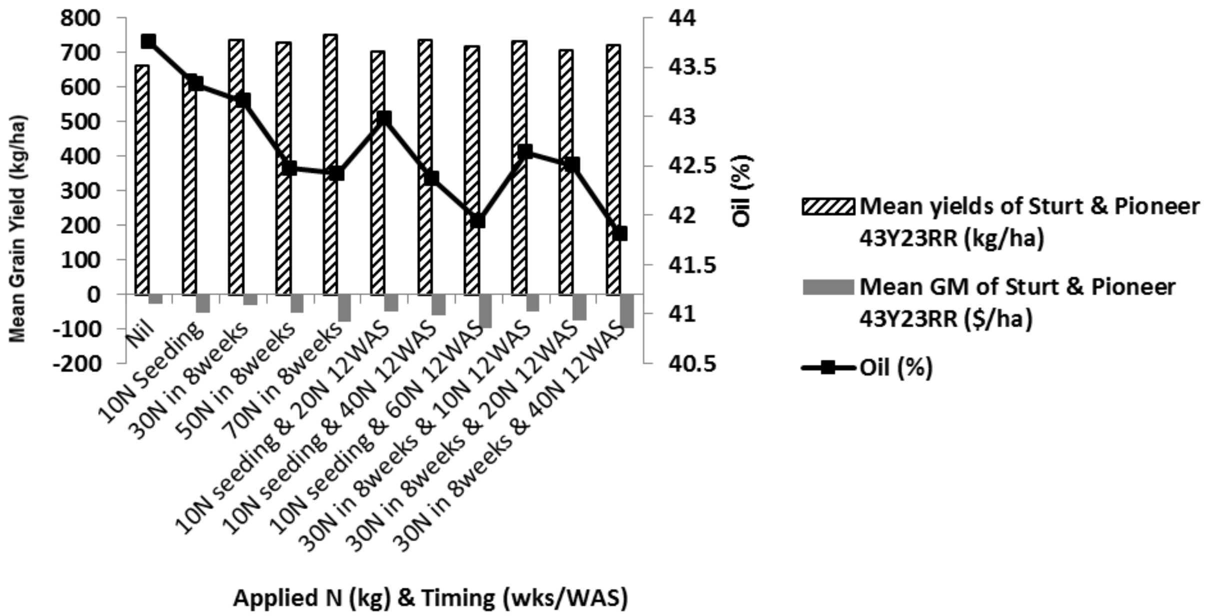

Figure 2: Effect of rate of N on grain yield (LSD = 66.8 kg/ha), oil (LSD = 0.7514%) and gross margin (LSD $33.31/ha) of canola at Wongan Hills Research Station in 2014 (mean of two varieties).

Comments

Findings in response to N on grain and oil in 2014 are similar to those findings seen at Wongan Hills in 2013. At this trial in 2014 in the majority of treatments, canola has responded to N up to 12 WAS.

At this trial at the Wongan Hills Research Station in 2014 oil decreased quicker than grain yield increased in response to N. Now that markets do not have an oil limit, it is important for canola growers to have good working knowledge of soil N, target yield and the expected response of oil and yield, in order for them to maximise economic returns. We recommend people use tools to such as the app: *N broad acre* to assist with N management decisions.

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Canola Density Response in Low Rainfall Environments – East Buntine

Dr Bob French, Senior Research Officer, DAFWA

Key Messages

- In a low yielding season canola yield reached a plateau at between 20 and 40 plants/m².
- Hybrid canola reached a plateau at lower density than open-pollinated canola.
- Canola yield held up at high density well, even though plants became severely stressed in early winter and early spring.
- Hybrid canola had a significant yield advantage over open-pollinated (OP) canola in a below average season.

Aim

To compare the plant density response of yield and oil content between hybrid and open-pollinated (OP) canola in Triazine tolerant (TT) and Roundup Ready (RR) herbicide tolerance groups.

Background

Canola is now being grown in low rainfall areas. Primarily farmers choose open pollinated Triazine tolerant (TT) varieties. However, breeding companies are favouring the development of hybrids in order to pay for breeding services. Hybrids provide growers with more vigorous seedlings, comparatively better plant establishment and generally higher yields. However, growers have to purchase new seed of hybrid varieties every year in order to get these potential yield benefits. Seed for hybrid canola can be up to 25 times more expensive than the seed of open pollinated canola. Inevitably if farmers are forced into hybrids they will wish to minimise seed costs by sowing at low densities. Trials in 2013 showed that hybrid canola had lower optimum densities than OP varieties and that RR canola had lower optimum densities than TT canola. However, the kind finish that occurred in the 2013 growing season would have favoured lower densities so this work needs to be repeated in more normal season types.

Trial Details

Property	Ross Fitzsimons, east Buntine
Plot size & replication	20m × 1.54m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.6 10-20cm: 5.5 20-30cm: 4.7
EC (dS/m)	0-10cm: 0.046
Sowing date	02/05/2014
Seeding rate	Various as per protocol
Paddock rotation	2011: wheat, 2012: canola, 2013: wheat
Fertiliser	02/05/2014: 80 kg/ha Macropro Plus (8 kg/ha N, 11 kg/ha P, 7 kg/ha K) banded 03/07/2014: 60 L/ha Flexi-N
Herbicides & Insecticides	02/05/2014: 2 L/ha Spray.Seed + 1.5 L/ha Trifluralin, 100 mL/ha Bifenthrin 20/05/2014: 900 g/ha Roundup Ready on RR treatments 21/05/2014: 2.2 kg/ha Atrazine + 1% oil on TT treatments 06/06/2014: 85 mL/ha Dimethoate 11/06/2014: 500 mL/ha Clethodim + 1% Hasten on whole trial 05/09/2014: 300 mL/ha Alpha-cypermethrin 10/09/2014: 300 mL/ha Alpha-cypermethrin 06/10/2014: 3 L/ha Reglone + 1% wetter
Growing Season Rainfall	180mm

Results

Crop establishment was very good at this site due to ideal soil conditions ensuring target density was achieved in most treatments (Figure 1). The apparently poor establishment of GT Viper was due to the seed having lower germination than assumed in the seed rate calculations rather than poor vigour. This shows up in the % field establishment (Figure 2) which takes actual germination percentage into account. Figure 2 also shows that field establishment declines sharply as density increases and that hybrid varieties have on average 10% higher field establishment than OP varieties.

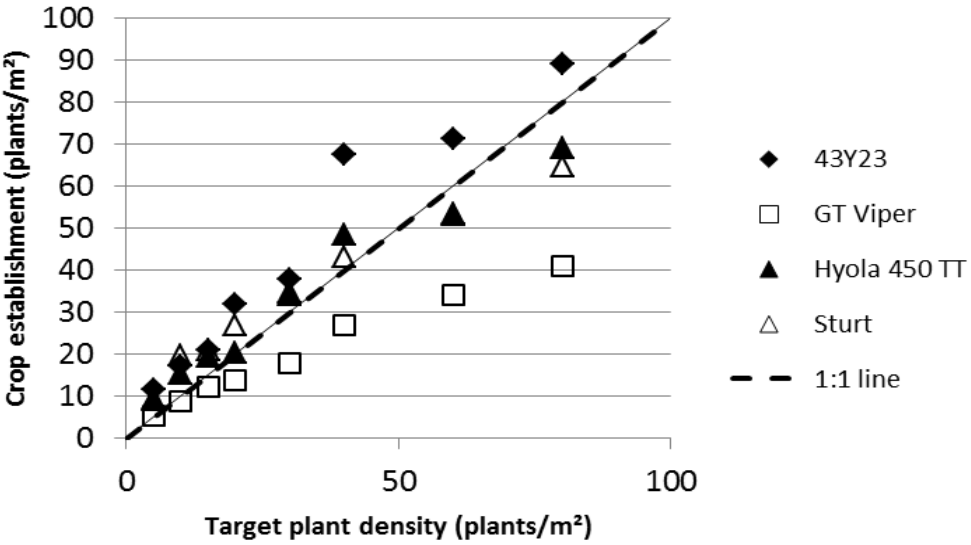

Figure 1: Crop establishment of four canola varieties across a range of target densities.

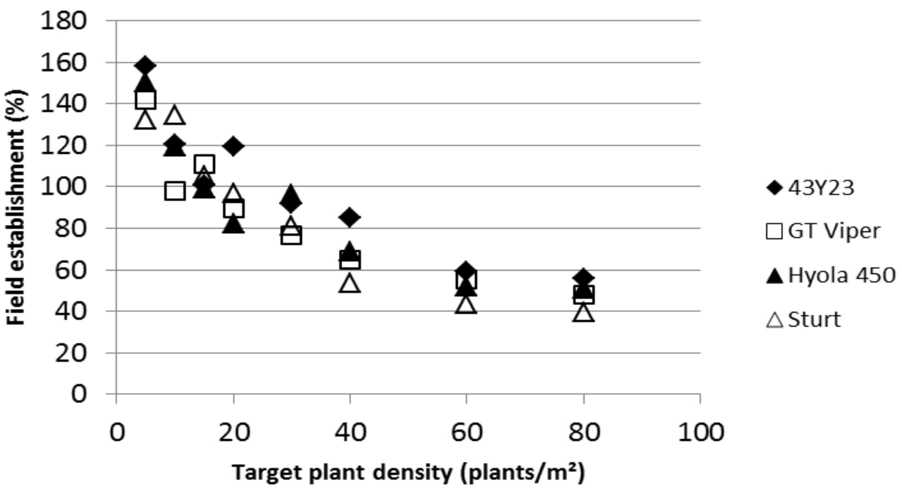

Figure 2: Field establishment of four canola varieties across a range of target densities.

Key Observations

- Hybrids (solid symbols) yielded better than OP varieties (open symbols) with a mean of 550 kg/ha compared to 381 kg/ha.
- Yield increased with density up to a maximum of about 40 plants/m² but did not decline very much at higher densities despite strong competition for water in the high density plots.
- Hybrids seem to reach maximum yield at lower density than OP varieties.
- Grain yields were low due to the dry winter and spring.

Oil content was about 42-43% in this trial. It was not affected by density in this trial but did vary between varieties. It was highest in GT Viper (average 43.3%) and lowest in 43Y23 (average 40.6%).

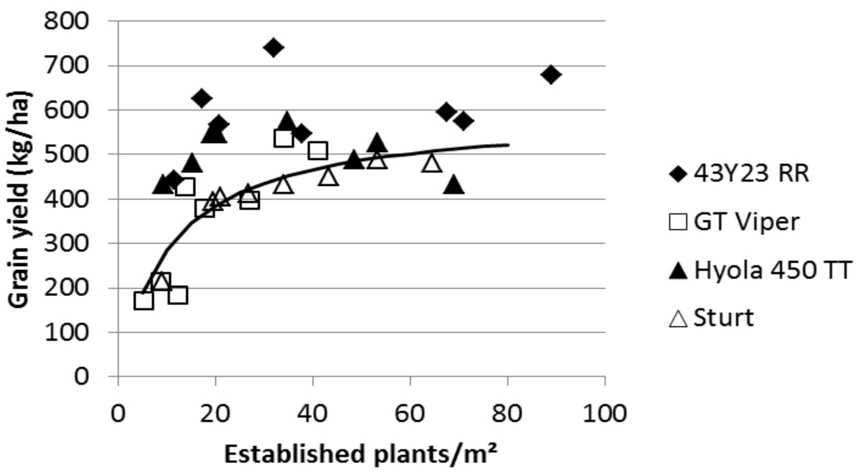

Figure 3: Grain yield of four canola varieties across a range of crop densities. The line is the fitted response curve for Sturt.

Economic Analysis
All gross margins in this trial were negative due to the low yields. However, we can still consider the economic optimum plant density. From the fitted response curve for Sturt the calculated optimum is well above the range of densities used in this trial. Hyola 450 follows a different type of response curve, with yield peaking at about 25 plants/m² and declining thereafter. The optimum density for Hyola 450 in this trial, assuming 90% field establishment (which we observed), a seed cost of $24/kg, and a grain price for non-GM canola of $463/tonne, was 12 plants/m². The difference in gross margin between the 12 plant/m² optimum and 25 plants/m², which might be your normal target density, is about $14/ha.

We can also consider whether the extra productivity of hybrid canola is worth the extra cost of the seed. At 30 plants/m² hybrid TT canola produced 142 kg/ha more grain than OP TT canola, worth an extra $65.70 at $463/tonne. Assuming a seed rate of 1.6 kg/ha (which we planted in this trial to establish 30 plants/m²), a cost of $24/kg for hybrid seed, and $2/kg for farmer-retained OP seed, the hybrid seed costs an extra $35.20/ha. Hybrid RR canola produced 151 kg/ha more grain at 30 plants/m² than OP RR canola, worth an extra $68.40 at $453/tonne. At 1.6 kg/ha the hybrid seed would cost an extra $12.80 (assuming $33/kg for hybrid RR canola seed, and $25/kg for OP RR canola seed). Thus the extra production could easily pay for the extra cost of hybrid seed.

Comments
The yield advantage and better field establishment of hybrid canola in this trial is consistent with earlier research in low rainfall WA environments. Even in a very low yielding season this extra productivity was sufficient to pay for the extra seed cost. Hybrids also reached the yield plateau at lower densities than OP varieties so lower seed rates can be used. However, optimum seed rates vary more than optimum densities. This trial had good early soil moisture encouraging excellent establishment but it will not always be this good so a lower field establishment should be used when calculating a seeding rate. Sometimes this will result in densities higher than the target, but the fact that yield did not decline steeply at high density in this trial should give confidence that does not carry high risk.

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Canola Density Response in Medium Rainfall Environments – Wongan Hills

Dr Bob French, Senior Research Officer, DAFWA

Key Messages

- In a low yielding season canola yield reached a plateau at between 20 and 40 plants/m².
- Hybrid canola reached the plateau at lower density than open-pollinated canola.
- Optimum density ranged from 10 plants/m² for hybrid canola to over 65 plants/m² for open-pollinated (OP) Triazine tolerant (TT) canola.
- Hybrid canola had a significant yield advantage over open-pollinated canola in a below average season.

Aim

To compare the plant density response of yield and oil content between hybrid and OP canola in TT and RR herbicide tolerance groups.

Background

Canola is now being grown in low rainfall areas and farmers primarily choose OP TT varieties. However, breeding companies are favouring the development of hybrids in order to pay for breeding services. Hybrids can provide growers with more vigorous seedlings, better plant establishment and higher yields. But growers have to purchase new seed of hybrid varieties each year in order to get these potential yield benefits. Seed for hybrid canola can be up to 25 times more expensive than OP canola. Inevitably if farmers are forced into hybrids they will wish to minimise seed costs by sowing at low densities. Trials in 2013 showed that hybrid canola had lower optimum densities than OP varieties and that RR canola had lower optimum densities than TT canola. However, the kind finish of the 2013 season favoured lower densities so further investigation is needed in more normal season types.

Trial Details

Property	Wongan Hills Research Station				
Plot size & replication	20m × 1.54m x 3 replications				
Soil type	Brown sandy earth (with gravel)				
Soil pH ($CaCl_2$)	0-10: 6.4	10-20: 5.3	20-30: 5.3	30-40: 6.0	40-50: 6.8
EC (dS/m)	0-10: 0.088	10-20: 0.069	20-30: 0.057	30-40: 0.058	40-50: 0.098
Sowing date	13/05/2014				
Seeding rate	Various as per protocol				
Paddock rotation	2010: barley, 2011: pasture, 2012: pasture, 2013: wheat				
Fertiliser	13/05/2015: 100 kg/ha Agstar banded at seeding 02/07/2014: 60 L/ha Flexi-N				
Herbicides & Insecticides	10/05/2014: 1.5 L/ha Roundup 13/05/2014: 100 mL/ha Bifenthrin, 1.5 L/ha Trifluralin, 2 L/ha Spray.Seed 250 27/05/2014: 900 gm/ha Roundup Ready on RR treatments 05/06/2014: 0.85 mL/ha Dimethoate 10/06/2014: 2.2 kg/ha Atrazine on TT treatments, 1% Spray Oil 10/08/2014: 300 mL/ha Alpha-cypermethrin				
Growing Season Rainfall	276mm				

Results

This trial compared the response of four canola varieties in 8 densities. A hybrid and an OP variety were chosen in each of the two main canola herbicide classes, RR and TT. Establishment was close to target across the density range (Figure 1), except in GT Viper which turned out to have a lower germination than assumed when calculating the seed rates. We calculated field establishment (the percentage of viable seeds sown that become established plants) and found no effect on density, but hybrids were better than OP varieties. The average field establishment of hybrids was 52% compared to 44% for OP varieties. This is less than the 85% we assumed for

Hyola 450 and 75% for other varieties when calculating seed rates for this trial. Figure 2 shows that hybrids had an average yield advantage over OP varieties of 47% but the poor establishment of GT Viper exaggerates this. However, at the highest density in the trial, hybrids yielded 21% more than OP. Yield responded to increasing density in a similar fashion to previous experiments, reaching a yield plateau between 20 and 50 plants/m². Hybrids reached that plateau at lower densities than OP varieties. Density did not affect oil content in this experiment however, variety did. The lowest oil content was in 43Y23 RR and Sturt, which both averaged 42.9% and the highest was GT Viper, which had 44%.

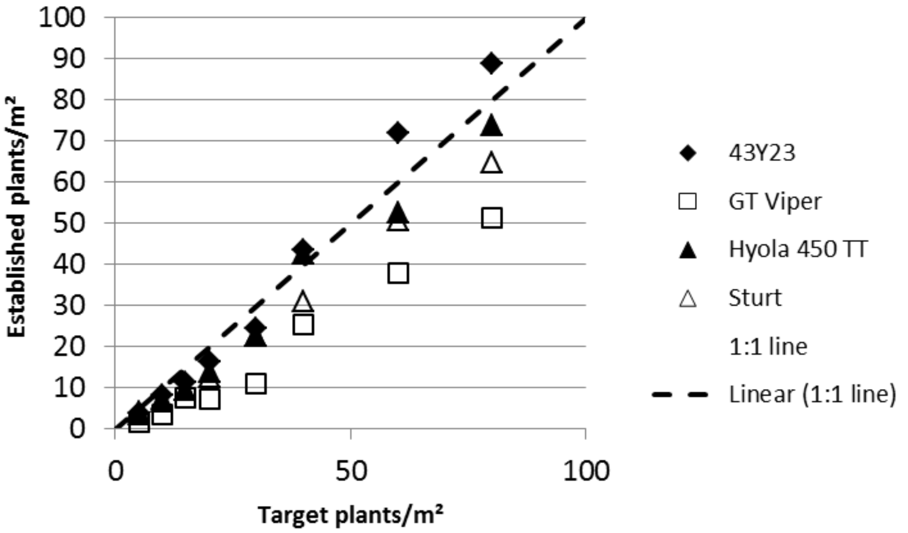

Figure 1: Crop establishment of four canola varieties across a range of target densities. Solid symbols represent hybrid varieties and open symbols open-pollinated varieties.

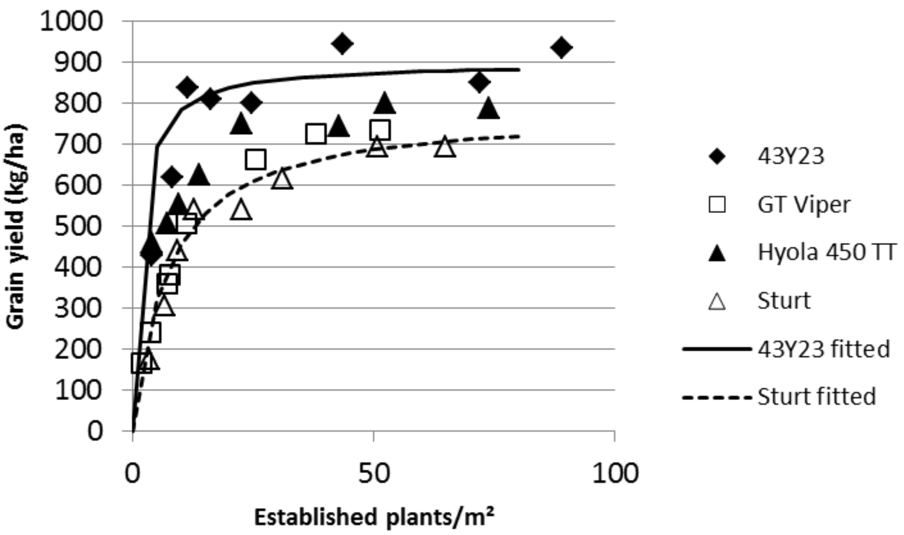

Figure 2: Grain yield of four canola varieties across a range of target densities. The solid line is the fitted response curve for 43Y23 and the dotted line is the fitted response curve for Sturt. Solid symbols represent hybrid varieties and open symbols OP varieties.

Economic Analysis

Gross margins were calculated assuming production costs (excluding seed) of $267/ha for RR and $270/ha for TT canola. Seed costs were assumed to be $2/kg for farmer retained OP TT seed, $24/kg for hybrid TT seed, $25/kg for OP RR seed, and $33/kg for hybrid RR seed. We also assumed prices of $453/tonne and $463/tonne for RR and TT grain respectively. 43Y23 produced a positive gross margin between 15 and 40 plants/m², Hyola 450 only at 30 plants/m², and Sturt only at densities above 40 plants/m². All gross margins for GT Viper were negative. We also fitted density response curves to grain yield for each variety and calculated optimum density using the same price assumptions as for the gross margins. The calculated optima were 12 plants/m² 43Y23 RR, 10 for

Hyola 450, 23 for GT Viper and 119 for Sturt. The calculated optimum for Hyola 450 is not certain due to variability in the data used to fit the response curve. But these estimates are consistent with previous work showing hybrid varieties tend to have lower optimum densities than OP varieties due to differences in seed cost and the shape of their response curves. The high value for Sturt is well outside the range of densities observed in the trial so the best we can say is that its optimum is more than 65 plants/m²; the highest measured density for Sturt.

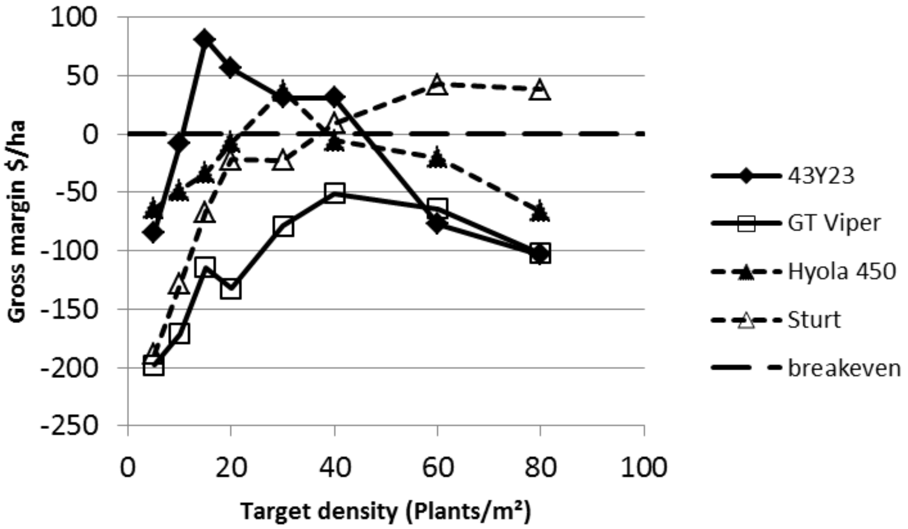

Figure 3: How gross margin varies with canola density and variety.

Comments

The yield advantage and better field establishment of hybrid canola in this trial was consistent with findings in other WA environments. Hybrids also reached the yield plateau at lower densities than OP varieties so lower seed rates can be used. Optimum densities for hybrid canola were very low in this trial, reflecting the low yields, but it also puts them on a fairly steep part of the response curve. This means that undershooting the optimum could result in significant yield losses if establishment is poorer than expected. On the other hand there is less risk associated with overshooting the optimum so it is worth considering whether to aim above the optimum for safety.

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The Value of Dual Herbicide Tolerant RT® Canola Technology for WA Growers in Broadacre Cropping Integrated Weed Management Strategies

Mitch Tuffley, Justin Kudnig, Steve Lamb, Pacific Seeds Pty Ltd

Key messages:

- The combination of Triazine Tolerant (TT) and Roundup Ready (RR) herbicide provided superior control of ryegrass and wild radish over individual chemistry treatments.
- Canola is an important rotational winter crop however, with increasing herbicide resistance across multiple chemistries in WA, growers are experiencing increasingly limited options with the current herbicide tolerance technologies available.
- Hyola RT® Technology allows the combination of strong knockdown and residual broad-spectrum herbicides from different herbicide groups and modes of action, targeting a wide range of weed species.
- Hyola RT® will provide an important role in addressing the increasing Clethodim resistance problem.
- RT® dual herbicide tolerant Hybrids have now demonstrated their value as a new competitive integrated weed management (IWM) tool, also providing increased convenience and flexibility of in-crop weed control.

Aims

To demonstrate, compare and analyse the efficacy of new herbicide combinations and sequences to achieve control of hard to kill weeds such as ryegrass and radish, whilst maximising yield in hybrid canola, using the hybrid variety Hyola 525RT® (Roundup Ready® + Triazine Tolerant) canola herbicide tolerant system.

Trial Details

Property	Candeloro's Bejoording Road, Toodyay
Plot size & replication	0.8m x 10m x 3 replications
Soil type	Grey brown sand
Soil pH ($CaCl_2$)	0-10cm: 6.6
EC (dS/m)	0-10cm: 0.054
Sowing date	04/05/2014
Seeding rate	3.5 kg/ha
Paddock rotation	2013 cereal
Fertiliser	04/05/2014: 120 kg/ha DAPSZC/SOP 80:20 blend 10/06/2014: 60 kg/ha Urea 30/06/2014: 120 kg/ha Ammonium sulfate
Herbicides	04/05/2014: 2 L/ha Roundup 12/06/2014: As per protocol 01/07/2014: As per protocol
Growing Season Rainfall	367mm

Methods

The trial was designed, conducted and analysed by an independent professional service provider organisation. The trial was sown and conducted as close as possible to district practice with a plot seeder on the 4th May 2014 into a granitic loam, located at Toodyay (York gum/jam) soil type.

There were 11 different herbicide treatments (see Table 1) including Roundup Ready® Herbicide (RRH), Atrazine (ATR), Simazine (SIM), and Select (SEL - Clethodim) with oils and/or ammonium sulphate (AMS) sprayed across Hyola 525RT®. The herbicides were used as standalone and in combinations using different rates and application timings. The target plant population across all plots was 35 plants/m^2.

All herbicides were applied according to individual labels, except five treatments where Glyphosate and Atrazine were tank mixed together (currently an unregistered practice), which were applied under a trialling permit with Monsanto.

Results and discussion

The trial site was selected to provide higher weed pressures of mixed species with the main target weeds being ryegrass and wild radish, however weed levels were not as high as anticipated. There was a significant positive response from all treated plots over the untreated control for harvested grain yield. The important result to highlight is that the combined treatments with Triazines and Roundup Ready herbicide at various application timings and rates provided the highest control levels of wild radish and ryegrass. This technology will be a critical IWM tool for lowering overall weed seed banks of different weeds and addressing the management of the growing weed resistance levels to either Clethodim or Glyphosate.

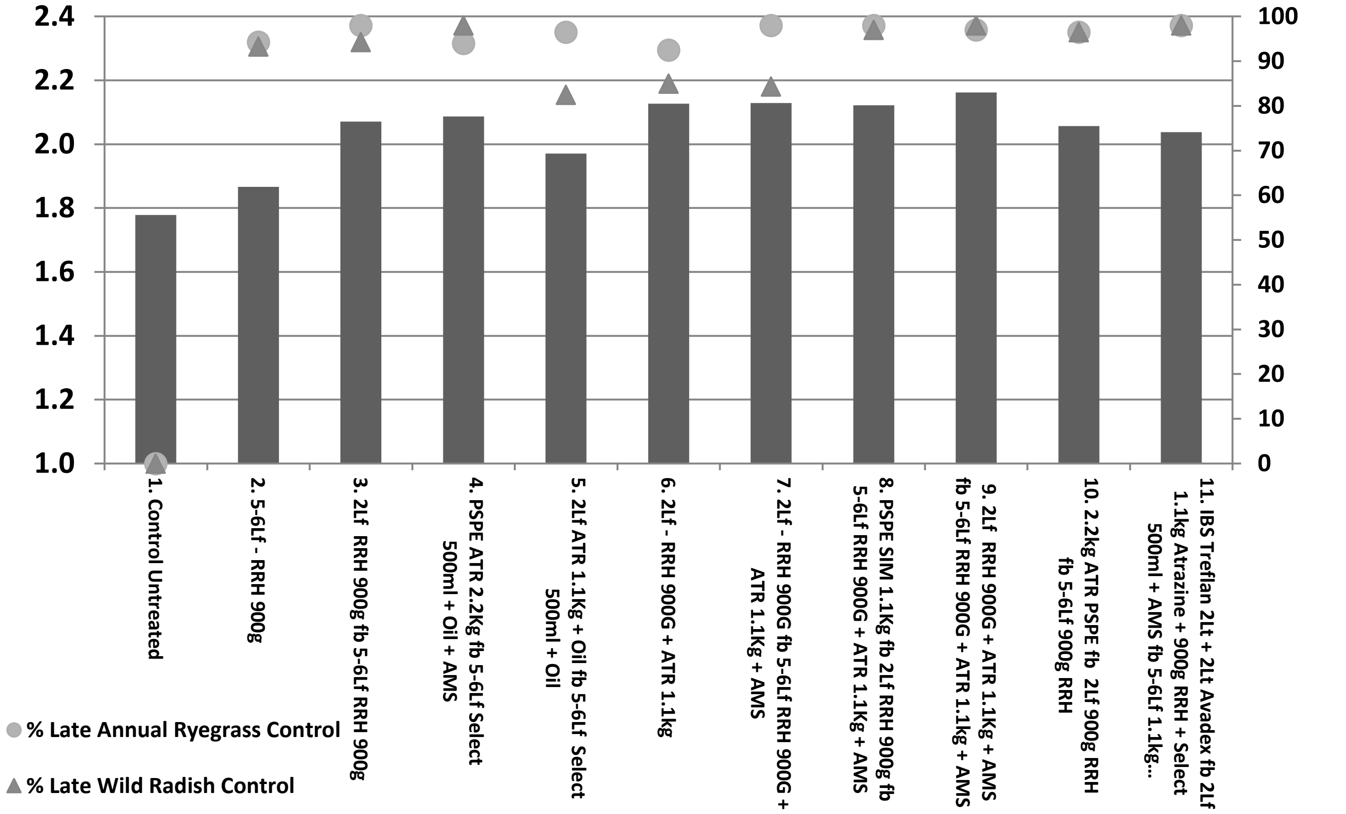

Figure 1: Mean yield (t/ha) and % weed control for 11 treatments on Hyola® 525RT® in Toodyay, 2014.

Table 1: Mean yield (t/ha) and oil (%) for 11 treatments (per/ha) on Hyola® 525RT®.

Treatments	Yield (t/ha)	Oil %
1. Control Untreated	1.67[b]	51.8
2. 5-6Lf - RRH 900g	2.02[a]	51.1
3. 2Lf RRH 900g fb 5-6Lf RRH 900g	2.07[a]	51.7
4. Post seeding pre-emergent (PSPE) ATR 2.2kg fb 5-6Lf Select 500mL + Oil + AMS	2.09[a]	51.4
5. 2Lf ATR 1.1Kg + Oil fb 5-6Lf Select 500mL + Oil	1.97[a]	51.0
6. 2Lf - RRH 900G + ATR 1.1kg	2.13[a]	51.6
7. 2Lf - RRH 900G fb 5-6Lf RRH 900G + ATR 1.1Kg + AMS	2.13[a]	51.4
8. PSPE SIM 1.1Kg fb 2Lf RRH 900g fb 5-6Lf RRH 900G + ATR 1.1Kg + AMS	2.12[a]	51.8
9. 2Lf RRH 900G + ATR 1.1Kg + AMS fb 5-6Lf RRH 900G + ATR 1.1kg + AMS	2.16[a]	51.4
10. 2.2kg ATR PSPE fb 2Lf 900g RRH fb 5-6Lf 900g RRH	2.06[a]	51.2
11. IBS Treflan 2L + 2L Avadex fb 2Lf 1.1kg Atrazine + 900g RRH + Select 500mL + AMS fb 5-6Lf 1.1kg Atrazine + 900g RRH + AMS	2.04[a]	50.9
F Probability	0.040	
LSD 5 (%)	0.3	
CV (%)	7.3	

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

Please note that the annual ryegrass and wild radish levels at the trial site were not as high as expected.

Table 2: Analysed % weed control of annual ryegrass and wild radish across 11 treatments on Hyola® 525RT®.

Treatments	% Late Annual Ryegrass Control	% Late Wild Radish Control
1. Control Untreated	0.0[d]	0.0[c]
2. 5-6Lf - RRH 900g	94.3[abc]	93.3[ab]
3. 2Lf RRH 900g fb 5-6Lf RRH 900g	98.0[a]	94.3[ab]
4. PSPE ATR 2.2Kg fb 5-6Lf Select 500ml + Oil + AMS	94.0[bc]	98.0[a]
5. 2Lf ATR 1.1Kg + Oil fb 5-6Lf Select 500ml + Oil	96.5[ab]	82.5[b]
6. 2Lf - RRH 900G + ATR 1.1kg	92.5[c]	85.0[ab]
7. 2Lf - RRH 900G fb 5-6Lf RRH 900G + ATR 1.1Kg + AMS	98.0[a]	84.3[ab]
8. PSPE SIM 1.1Kg fb 2Lf RRH 900g fb 5-6Lf RRH 900G + ATR 1.1Kg + AMS	98.0[a]	97.0[ab]
9. 2Lf RRH 900G + ATR 1.1Kg + AMS fb 5-6Lf RRH 900G + ATR 1.1kg + AMS	97.0[ab]	98.0[a]
10. 2.2kg ATR PSPE fb 2Lf 900g RRH fb 5-6Lf 900g RRH	96.5[ab]	96.5[ab]
11. IBS Treflan 2Lt + 2Lt Avadex fb 2Lf 1.1kg Atrazine + 900g RRH + Select 500ml + AMS fb 5-6Lf 1.1kg Atrazine + 900g RRH + AMS	98.0[a]	98.0[a]
F Probability	<.001	<.001
LSD 5 (%)	3.72	15.48

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Lupin Crop Variety Trial – Buntine

Australian Crop Accreditation System Limited

Aim

To evaluate yields and quality of new and existing lupin varieties.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	10m x 2m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.3 10-60cm: 5.3
EC (dS/m)	0-10cm: 0.2
Seeding date	02/05/2014
Fertiliser	02/05/2014: 80 kg/ha Big Phos
Herbicides & Insecticides	02/05/2014: 100 L/ha Bifenthrin, 2 L/ha Paraquat + Diquat, 2 L/ha Trifluralin, 1.1 kg/ha Simazine 21/05/2014: 150 mL/ha Diflufenican 11/06/2014: 500 mL/ha Clethodim, 1% Hasten 25/08/2014: 300 mL/ha Alpha-cypermethrin
Growing Season Rainfall	180mm

Results

Table 1: Yield and quality of lupins sown at east Buntine.

Variety Name	Yield (t/ha)	Percentage of Site Mean (%)
Mandelup	0.73	109
PBA Barlock	0.67	100
Coromup	0.65	97
Jenabillup	0.64	95
PBA Gunyidi	0.64	95
Tanjil	0.54	81
Danja	0.54	81
Site Mean (t/ha)	0.67	
CV (%)	14	
Probability	<0.001	
LSD (t/ha)	0.14	21

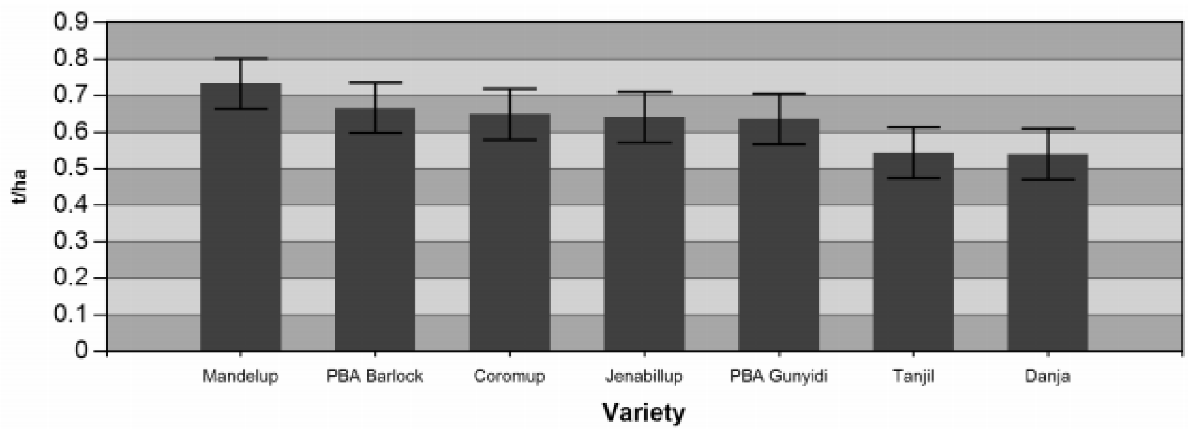

Figure 1: Yield results from lupin varieties sown at Buntine.

Comments

This trial has a high CV of 14% indicating high variability across the trial. Make variety selection decisions using information from multiple trials. The NVT 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 cropping varieties.

For more information please refer to www.nvtonline.com.au

Lupin Crop Variety Trial – Wongan Hills

Australian Crop Accreditation System Limited

Aim

To evaluate yields and quality of new and existing lupin varieties.

Background

NVT is a national program of comparative crop variety testing with standardised trial management, data generation, collection and dissemination. The program is supported by the Australian Government and growers through the Grains Research Development Corporation and is managed by the Australian Crop Accreditation System Limited.

Trial Details

Property	Wongan Hills
Plot size & replication	10m x 2m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.9
EC (dS/m)	0-10cm: 0.1
Seeding date	01/05/2014
Fertiliser	01/05/2014: 80 kg/ha Big Phos
Herbicides & Insecticides	01/05/2014: 2 L/ha Trifluralin, 2 L/ha Paraquat + Diquat, 1.1 Kg/ha Simazine 19/05/2014: 150 mL/ha Diflufenican 05/06/2014: 500 mL/ha Clethodim, 1% Hasten 10/08/2014: 300 mL/ha Alpha-cypermethrin 25/08/2014: 300 mL/ha Alpha-cypermethrin
Growing Season Rainfall	243mm

Results

Table 1: Yield of lupin varieties sown at Wongan Hills.

Variety Name	Yield (t/ha)	Percentage of Site Mean (%)
PBA Barlock	1.76	102
Jenabillup	1.75	102
Mandelup	1.74	101
PBA Gunyidi	1.72	100
Tanjil	1.50	87
Coromup	1.49	87
Danja	1.44	84
Site Mean (t/ha)	1.72	
CV (%)	9.1	
Probability	<0.001	
LSD (t/ha)	0.23	13

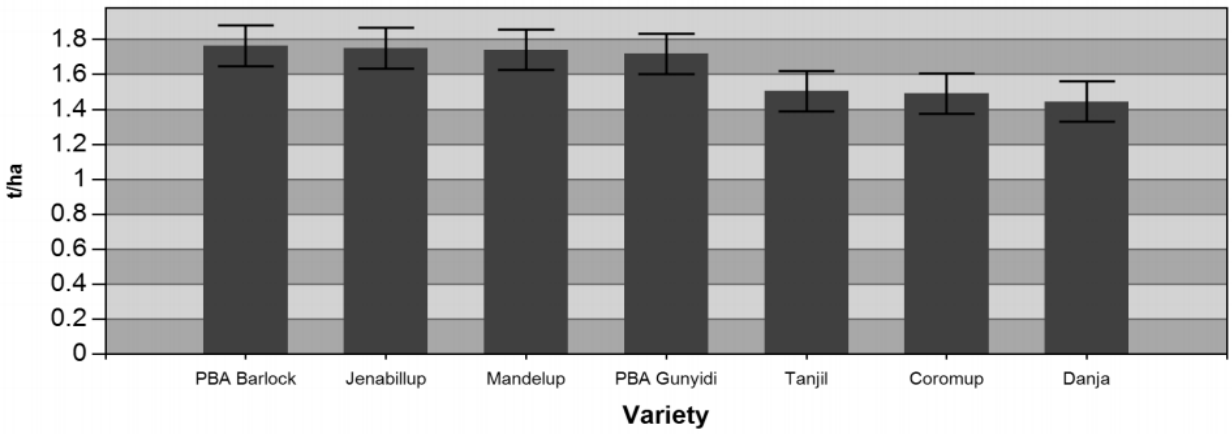

Figure 1: Yield comparison of lupin varieties sown at Wongan Hills.

Comments
For more information please refer to www.nvtonline.com.au

Field Pea Crop Variety Trial – Wongan Hills

Australian Crop Accreditation System Limited

Aim

To evaluate yields and quality of new and existing field pea varieties.

Background

NVT is a national program of comparative crop variety testing with standardised trial management, data generation, collection and dissemination. The program is supported by the Australian Government and growers through the Grains Research and Development Corporation and is managed by the Australian Crop Accreditation System Limited.

Trial Details

Property	Wongan Hills Research Station
Plot size & replication	20m x 1.54m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 6.1
EC (dS/m)	0-10cm: 0.1
Sowing date	15/05/2014
Herbicides & Insecticide	13/05/2014: 2 L/ha Glyphosate, 100 mL/ha Bifenthrin, 300 mL/ha Chlorpyrifos, 1.5 L/ha Trifluralin, 2 L/ha Paraquat & Diquat, 70 g/ha Imazethapyr 19/06/2014: 500 mL/ha Clethodim, 1% Hasten 17/07/2014: 500 mL/ha Clethodim, 1% Hasten 25/10/2014: 300 mL/ha Alpha-cypermethrin
Growing Season Rainfall	243mm

Results

Table 1: Yield of field pea varieties sown at Wongan Hills.

Variety Name	Yield (t/ha)	Percentage of Site Mean (%)
PBA Oura	1.71	103
PBA Gunyah	1.68	101
PBA Twilight	1.57	95
Kaspa	1.54	93
PBA Percy	1.52	92
PBA Wharton	1.43	86
Site Mean (t/ha)	1.66	
CV (%)	8.0	
Probability	<0.001	
LSD (t/ha)	0.20	12

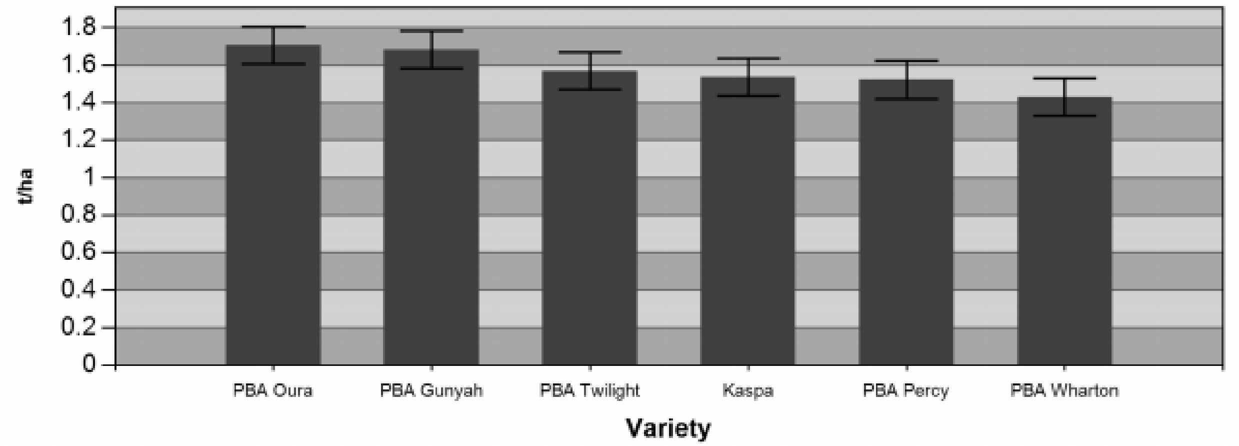

Figure 1: Yield comparison of field pea varieties sown at Wongan Hills.

Comments: For more information please visit www.nvtonline.com

Chickpea National Variety Trial – Wongan Hills

Australian Crop Accreditation System Limited

Aim
To evaluate yields and quality of new and existing chickpea varieties under farmer practice.

Background
This demonstration was conducted using farmer equipment. Farm scale demonstrations are a valuable way to explore new varieties, products or practices, complimenting results which are produced through more scientifically rigorous, small plot trials.

Trial Details

Property	Wongan Hills Research Station
Plot size & replication	20m x 1.4m x 3 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 6.10
EC (dS/m)	0-10cm: 0.1
Seeding date	15/05/2014
Seeding rate	80 kg/ha
Paddock rotation	2011: pasture, 2012: wheat, 2013: canola
Fertiliser	15/05/2014: 80 kg/ha DAP
Herbicides & Insecticides	13/05/2014: 2 L/ha Glyphosate 15/05/2014: 100 mL/ha Bifenthrin, 300 mL/ha Chlorpyrifos, 100 mL/ha Isoxaflutole, 1.5 L/ha Trifluralin, 2 L/ha Paraquat + Diquat 19/06/2014: 500 mL/ha Clethodim, 1% Hasten 17/07/2014: 500 mL/ha Clethodim, 1% Hasten 28/08/2014: 300 mL/ha Alpha Cypermethrin
Growing Season Rainfall	243mm

Results
Table 1: Yield of chickpeas sown at Wongan Hills.

Variety	Yield (t/ha)	Percentage of site Mean (%)
Neelam	0.64	118
Genesis 079	0.63	117
PBA Maiden	0.59	109
PBA Striker	0.56	104
PBA Slasher	0.54	100
Ambar	0.53	98
Genesis 836	0.53	98
Genesis 090	0.38	70
Site Mean (t/ha)	0.54	
CV (%)	13.9	
Probability	<0.001	
LSD (t/ha)	0.11	20

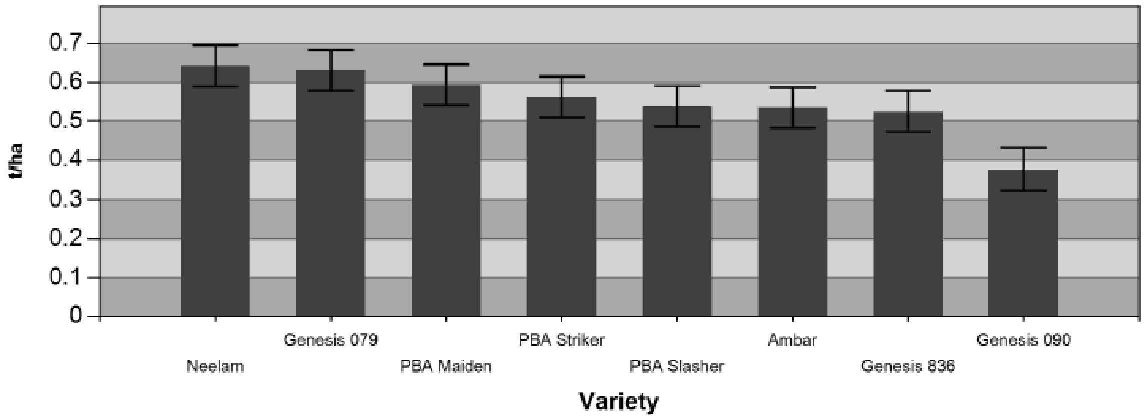

Figure 1: Yield comparison of chickpea varieties sown at Wongan Hills Research Station.

Comments

This trial has a high CV of 13.92% indicating high variability across the trial. Make variety selection decisions using information from multiple trials.

For more information please refer to www.nvtonline.com.au

Chickpea Variety Demonstrations – East Buntine

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

To evaluate the performance of new chickpea varieties under farmer practice.

Background

This demonstration was conducted using farmer equipment. Farm scale demonstrations are a valuable way to explore new varieties, products or practices, complimenting results which are produced through more scientifically rigorous, small plot trials.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	18.5m x 100m x 1 replication
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 6.0
EC (dS/m)	0-10cm: 0.179
Sowing date	02/05/2014
Seeding rate	80 kg/ha
Paddock rotation	2011: pasture, 2012: wheat, 2013: canola
Fertiliser	02/05/2014: 30 kg/ha DAPSZC
Fungicide	02/05/2014: 10 kg/ha Alosca
Herbicides & Insecticides	02/05/2014: 1.5 L/ha Gramoxone, 275 g/ha Diuron 09/05/2014: 100 g/ha Balance 28/08/2014: 300 mL/ha Alpha Cypermethrin
Growing Season Rainfall	180mm

Results

Table 1: Yield of chickpeas sown at east Buntine.

Variety	Yield(t/ha)
PBA Striker	0.32
Genesis836	0.33
Neelam	0.36
Ambar	0.38

Comments

Extreme weather conditions in August resulted in significant yield penalties.

Acknowledgements

Alan Meldrum, Pulse Australia for seed donation.
The Fitzsimons family for seeding and spraying.

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Pasture Research Results

Can Tedera Establish Well on Gutless Sand?

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages
- Tedera geminated well on gutless sand in Watheroo
- It is expected that the first tedera cultivars will be released to a commercial partner in 2015.
- Tedera can persist with an average rainfall of 150mm and up to 5 months in drought.

Aim
To determine how much green feed tedera can produce on gutless pale sandy soil and to determine if growing tedera can increase the amount of soil organic carbon in pale sandy soil.

Background
During a worldwide search for a drought tolerant plant to supply WA farmers with sheep feed during the autumn feed gap a team from the Future Farm Industries CRC found a perennial forage legume in the Canary Islands, Spain. Tedera has the ability to survive on 150mm of rainfall and can exist without rainfall for up to five months making it readily adaptable to the Northern Agriculture Region.

Since 2006 research on Tedera (*Bituminaria bituminosa* var. *albomarginata*) has been conducted at west Buntine on the Liebe Long Term Trial Site where it has undergone grazing trials for breeding selection and grazing palatability and showed excellent ability to produce green foliage in the middle of summer. However, the soil type at our Buntine site is good pear tree country where the economic returns are greater for crop production than perennial forage/sheep production. Growers wanted tedera put through its paces on land that was less suitable for cropping. An area of pale deep gutless sand on the Martin's property near Watheroo was chosen to determine the plants suitability and ability to increase organic carbon in the soil.

Trial Details

Property	Martin Family, Watheroo
Soil type	Pale deep sand
Soil pH ($CaCl_2$)	Topsoil: 5.2 Subsoil: 4.5
EC (dS/m)	0.03
Sowing date	23/05/2014
Seeding rate	10 kg/ha
Soil amelioration	09/06/2014: 1 L/ha Wetting agent irrigator
Fertiliser	None
Paddock rotation	2010 to 2012: Pasture/weeds mainly ryegrass, blue lupins
Herbicides	22/05/2014: 1.2 L/ha Roundup, 30 mL/ha Nail
Growing Season Rainfall	250mm

Results
The tedera at Watheroo has had no fertiliser since the trial was established in August 2013, which explains the low levels of nutrients in the soil. However, you can see that on the "Seedling" plot the organic carbon % has increased from 0.41% to 0.55% (Table 1). The "Seed" plot has decreased from 0.44% to 0.32%. The pH has improved in both plots compared to the August 2013 control sample (Table 1).

Table 1: Selected soil properties (0-30cm) for soil collected August 2013 (prior to treatments being imposed) and December 2014 (post treatment) at the Watheroo trial site.

Plot Name	Depth	Ammonium Nitrate (mg/kg)	Nitrogen Nitrate (mg/kg)	Phosphorus Cowell (mg/kg)	Potassium Cowell (mg/kg)	Sulphur (mg/kg)	Organic Carbon (%)	EC (dSm)	pH ($CaCl_2$)
Control 2013	0-10	4	11	11	28	3.7	0.41	0.037	5.2
	10-20	2	1	10	15	2.0	0.16	0.010	4.5
	20-30	2	1	10	20	2.0	0.08	0.010	4.4
Seedling 2014	0-10	3	2	6	30	2.6	0.55	0.039	5.3
	10-20	1	1	6	15	0.8	0.26	0.013	4.7
	20-30	1	1	5	15	0.8	0.09	0.010	4.6
Seed 2014	0-10	1	1	8	15	1.5	0.32	0.020	5.2
	10-20	1	1	8	15	0.8	0.30	0.010	4.8
	20-30	1	1	8	15	0.5	0.30	0.010	4.6

Comments & Observations

Poor establishment of the tedera was experienced in the first year of the trial as result of late seeding in August compounded by a very dry summer. As a result more tedera was sown in May 2014. There was a good early germination of seeds from 2013 following the rain in early May and following this a second germination from the seed sown on the 23rd of May 2014. Germinations were vigorous however, the trial site was badly windblown on the 18th of June. The plants that survived this wind event were very healthy and thriving with the subsequent rain events and were competing aggressively against yellow serradella.

In early December the foliage was plentiful but due to the extreme temperatures that followed the tedera had dropped its leaves by mid December. Tedera has shown the ability to recover in Buntine from the drier years and it recovered well at this site after the dry 2013/14 summer, so it is expected to recover when rain arrives.

Figure 1: Seedling on the 6th June 2014, sown August 2013.

Figure 2: Seed on 6th June sown 23rd May 2014.

Figure 3: Seed on 16th August 2014 sown 23rd May 2014.

Future Plans

The Department of Agriculture and Food, Western Australia, Meat & Livestock Australia and Seednet/Landmark are working together to continue research into the perennial legume and its potential to fill the summer feed gap and to bring Tedera into the commercial market. The Liebe Group will continue to monitor the Tedera at the Martin's property at Watheroo. However, going forward monitoring will be less rigorous than it has been to date.

Acknowledgements
Thank you to the Martin family for hosting the trial and Seednet for their permission to conduct this research. Justin Laycock and Frances Hoyle, Department of Agriculture and Food, WA for their help with bulk density testing in 2014. Daniel Real and Meir Altman of DAFWA for sourcing and planting the tedera. This project is funded by the Australian Government, Department of Agriculture.

Paper reviewed by: Daniel Real, DAFWA

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Fertiliser & Herbicide Research Results

Potassium Strategies

Angus McAlpine, Area Manager – Dalwallinu, CSBP

Key Messages

- There was no response to topdressed muriate of potash but a 0.3 t/ha response to K banded in K-Till Extra.
- Nitrogen (N) use efficiency was maximised with K-Till Extra.
- Potassium (K) was a more limiting nutrient than N.
- Dry conditions frequently experienced in the Wheatbelt limit the effectiveness of topdressed K.

Aim

To compare K fertiliser strategies and to investigate the effect of K supply on N.

Background

Fertiliser is one of the highest cropping input costs for farming businesses these days and so there is always pressure to increase the returns and profitability of every dollar invested. Finding the most efficient and effective way to maximise yields will help ensure the best return on the investment. The increasing frequency of dry periods during the growing season limits the effectiveness of topdressed fertilisers (and the availability of soil nutrient reserves), and increases the dependence upon banded fertiliser inputs. The development of nitrogen, phosphorous and potassium (NPK) compound fertilisers provide an option to help improve the efficiency of K supply to crops.

The trial conducted east of Carnamah compared some of the options for K application strategies and subsequent effects on N use efficiency.

Forward

The CSBP trial conducted this year at the Liebe Main Trial Site encountered issues due to site location thus seeding was delayed to three weeks later than planned. Consequently the ideal soil moisture and time of sowing was missed and dry conditions led to poor crop establishment and yields of less than 1.0 t/ha with no significant effects. However, CSBP has a widespread trial program across the state and a local trial at Carnamah produced some interesting results in relation to different K fertiliser strategies.

Trial Details

Property	Tremlett, east Carnamah
Plot size & replication	2.5m x 20m x 3 replications
Soil type	Yellow loamy sand
Soil pH ($CaCl_2$)	See table 1
EC (dS/m)	See table 1
Sowing date	08/05/2014
Seeding rate	64 kg/ha Mace wheat
Paddock rotation	2011: canola, 2012: wheat, 2013: wheat
Fertiliser	08/05/2014: table 2 19/06/2014: table 2
Herbicides/Fungicides	07/05/2014: 1 L/ha Roundup (Farmer) 08/05/2014: 2 L/ha Treflan, 300 mL/ha Lorsban 29/07/2014: 300 mL/ha Folicur
Growing Season Rainfall	208mm

Table 1: Soil Test Results from east Carnamah, 2014.

Depth (cm)	pH	EC	OC	Nit N	Amm N	P	PBI	K	S	Ex Ca	Ex Mg	Ex K	Ex Na	eCEC	Ex Al%	Al
0-10	6.4	0.13	1.1	10	2	37	27	35	60	4.6	0.48	0.09	0.10	1	2	<1
10-20	4.5	0.04	0.3	4	<1	11	23	16	18	0.9	0.19	0.04	0.02	1	22	2.5
20-30	4.6	0.04	0.1	4	<1	5	25	<15	31	1.0	0.26	0.03	0.02	1	11	<1
30-40	5.5	0.03	0.1	3	<1	3	40	<15	31	1.1	0.36	0.04	0.03	2	10	<1
40-50	5.4	0.03	0.1	2	<1	2	49	<15	34	1.2	0.41	0.02	0.05	2	10	<1

Table 2: Treatments and Results at east Carnamah, 2014.

Trt	IBS (kg/ha)	Banded (L/ha)	Banded (kg/ha)	Z23 (L/ha)	N	P	K	Yield (t/ha)	Protein (%)	NUE*
1	-	-	-	-	0	0	0	1.36	10.3	-
2	-	-	89 Big Phos	-	0	12	0	1.48	10.9	-
3	-	50 Flexi-N	85 Agstar Extra	65 Flexi-N	60	12	0	1.64	11.1	13
4	-	54 Flexi-N	100 K-Till Extra	65 Flexi-N	60	12	11	1.97	11.1	28
5	-	54 Flexi-N	100 K-Till Extra + 18 MoP	65 Flexi-N	60	12	20	1.80	11.2	20
6	40 MoP	50 Flexi-N	85 Agstar Extra	65 Flexi-N	60	12	20	1.61	11.6	18
7	80 MoP	-	89 Big Phos	-	0	12	40	1.41	9.8	-
8	80 MoP	50 Flexi-N	85 Agstar Extra	65 Flexi-N	60	12	40	1.62	11.4	20
							Prob	<0.001	0.094	
							LSD	0.186	1.2	

*Nitrogen Use Efficiency

Table 3: Economic Analysis for Mace wheat grown at east Carnamah, 2014.

Trt	IBS (kg/ha)	Banded (kg/ha)	N	P	K	Harvest Yield (t/ha)	K Economics Response ($/ha)	Cost ($/ha)	Profit ($/ha)
3	-	85 Agstar Extra	60	12	0	1.64	-	-	-
4	-	100 K-Till Extra	60	12	11	1.97	83	19	64
5	-	100 K-Till Extra + 18 MoP	60	12	20	1.80	40	31	9
6	40 MoP	85 Agstar Extra	60	12	20	1.61	-7	28	-35
8	80 MoP	85 Agstar Extra	60	12	40	1.62	-5	56	-61
					Prob	<0.001			
					LSD	0.186			

*Assumes wheat $250/t; K-Till Extra K $1.70/kg; MoP K $1.40/kg

Comments

This trial demonstrated the value of K banded in the NPK product K-Till Extra. There was a 0.3 t/ha response to K supplied by K-Till Extra and no response to up to 80 kg/ha MoP topdressed. The absence of a response to topdressed MoP was potentially the result of it being trapped in the inter-row after seeding, and/or post application rainfall events not being substantial enough to allow movement into the root zone.

The response to N was only 0.2 t/ha and not profitable as K was the more limiting nutrient. Despite additional N being unprofitable, N use efficiency was highest where 100 kg/ha K-Till Extra was used. This indicates that improved K uptake from K-Till Extra increased the crop's capacity to access N.

An economic analysis of the different K strategies showed that 100 kg/ha K-Till Extra was about $100/ha more profitable than topdressing 40 kg/ha MoP.

The trial clearly highlighted that fertiliser placement can be more important than the amount applied, and that nutrients have to be available to the crop to be effective.

Acknowledgements
The Tremlett Family for hosting the 2014 trial on their farm.
Ryan Guthrie, Rowan Maddern and James Easton from CSBP Field Research.

Paper reviewed by: James Easton, CSBP

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Understanding the Importance of N, P, K & S Interactions in Wheat Cropping Systems

Elliott Duncan, Postdoctoral Fellow, CSIRO Agriculture Flagship, Floreat, WA

Key Messages

At three field sites in WA, increased wheat yield was achieved at lower nitrogen (N) application rates when N was balanced with appropriate phosphorous (P), potassium (K) and sulphur (S) applications. Wheat yield was driven by the ratio of N to P and K rather than the absolute concentrations of the nutrients and it is possible to increase profit margins by balancing nutrient inputs.

The level of background nutrients present in the soil at sowing was a key factor in determining the responsiveness of yield to fertiliser applications and how profitable the fertiliser treatments were. Pre-season soil testing to determine the level of residual nutrients will allow growers to balance their nutrient inputs and help to maximise profits.

Aim

To investigate how nutrient interactions influence yield response. Specifically, if:

1. Applications of P, K and/or S fertilisers influence wheat yield under varying N concentrations.
2. "Background" nutrition influences fertiliser responsiveness.
3. Yield responses are a result of absolute nutrient concentrations or ratios between essential nutrients.

Background

Fertilisers represent a large portion of the variable costs of broad-acre cereal production. A large research effort has been undertaken to understand how cereal crops respond to applications of N, P, K and S based fertilisers. Despite this large research effort there has been very little research detailing how essential nutrients interact i.e. how changes to concentration of one nutrient influence the uptake of other nutrients. Research of this nature is important because in all cropping systems nutrients interact even if only one nutrient is applied (i.e. because nutrients are naturally in soil or left over from previous season). An improved understanding of nutrient interactions has the potential to improve nutrient use efficiency, particularly of N; reduce fertiliser expenditure by making better use of residual nutrients and also improve our understanding of how to apply nutrients in combination to improve their effectiveness.

Trial Details

Property	Wongan Hills Research Station; UWA Shenton Park Research Station
Plot size & replication	21 plots (1.54 x 10m) x 3 replicates x 3 sites (WHCAN - Wongan Hills prev canola); WHPAS - Wongan Hills prev pasture; Shenton Park (2m x 2m plots))
Soil type	Wongan Hills - Yellow sandy duplex, gravel to 30cm; Shenton Park - Deep coarse sand
Soil pH ($CaCl_2$)	WHCAN 0-10cm: 4.8 ± 0.2; WHPAS 0-10cm: 5.5 ± 1.1; Shenton Park 0-10cm: 6.3 ± 0.1
EC (dS/m)	WHCAN 0-10cm: 0.13 ± 0.05; WHPAS 0-10cm: 0.06 ± 0.03; Shenton Park 0-10cm: 0.02 ± 0.003
Sowing date	28/05/2014
Seeding rate	80 kg/ha - *Triticum aestivum* C.V. Mace
Paddock rotation	WHCAN 2013 canola; WHPAS 2013 pasture; Shenton Park 2013 lupins
Fertiliser	As per protocol: Urea (46% N); TSP (27% P); Muriate of Potash (52% K); Gypsum (14% S) (See table below for further details of individual treatments)
Herbicides	1.5 L/ha Roundup; 2 L/ha Spray.Seed250; 118 g/ha Sakura; 1% Hasten; 670 mL/ha Velocity
Growing Season Rainfall	Wongan Hills: 172mm Shenton Park: 554mm

Results

Table 1: Selected soil chemistry details of three trials used in this study before seeding.

Site	Mineral NH_4^+-N & NO_3-N (kg/ha)		Colwell P (kg/ha)		Colwell K (kg/ha)		KCl-40 S (kg/ha)		Organic C (%)	
	0-10 cm	10-30 cm	0-10 cm	10-30 cm	0-10 cm	10-30 cm	0-10 cm	10-30 cm	0-10 cm	10-30 cm
WHCAN	21	12	48	58	256	274	70	44	1.5	0.9
WHPAS	37	13	39	29	91	54	16	10	0.8	0.4
Shenton Park	5	5	67	61	59	52	3	2	0.5	0.5

Table 2: Yield of Mace in three trials under different nutrition regimes. Values in bold are significantly different from yields of unfertilised plots.

Treatment	WHCAN Yield (t/ha)	WHPAS Yield (t/ha)	Shenton Park Yield (t/ha)
Background	2.38	1.83	0.11
10 kg N ha	2.28	2.21	0.31
10 kg N ha + 2 kg P ha	2.36	2.08	0.27
10 kg N ha + 8 kg K ha	2.23	2.05	0.32
10 kg N ha + 3 kg S ha	2.30	2.06	0.31
10 kg N ha + 2 kg P ha + 8 kg K ha + 3 kg S ha	2.36	2.30	0.28
30 kg N ha	2.33	2.25	**0.66**
30 kg N ha + 8 kg P ha	2.41	2.05	**0.59**
30 kg N ha + 25 kg K ha	2.38	2.12	**0.62**
30 kg N ha + 10 kg S ha	2.29	2.05	**0.61**
30 kg N ha + 8 kg P ha + 25 kg K ha + 10 kg S ha	2.43	2.06	**0.53**
60 kg N ha	2.26	2.11	**0.74**
60 kg N ha + 16 kg P ha	2.29	2.38	**1.01**
60 kg N ha + 50 kg K ha	2.26	1.89	**0.72**
60 kg N ha + 20 kg S ha	2.29	2.03	**0.91**
60 kg N ha + 16 kg P ha + 50 kg K ha + 20 kg S ha	2.38	2.35	**0.92**
90 kg N ha	2.34	2.11	**0.87**
90 kg N ha + 24 kg P ha	2.35	1.83	**0.91**
90 kg N ha + 75 kg K ha	2.34	1.98	**0.90**
90 kg N ha + 30 kg S ha	2.40	2.29	**0.97**
90 kg N ha + 24 kg P ha + 75 kg K ha + 30 kg S ha	2.28	2.38	**1.12**
Site variability (SE)	0.08	0.11	0.05

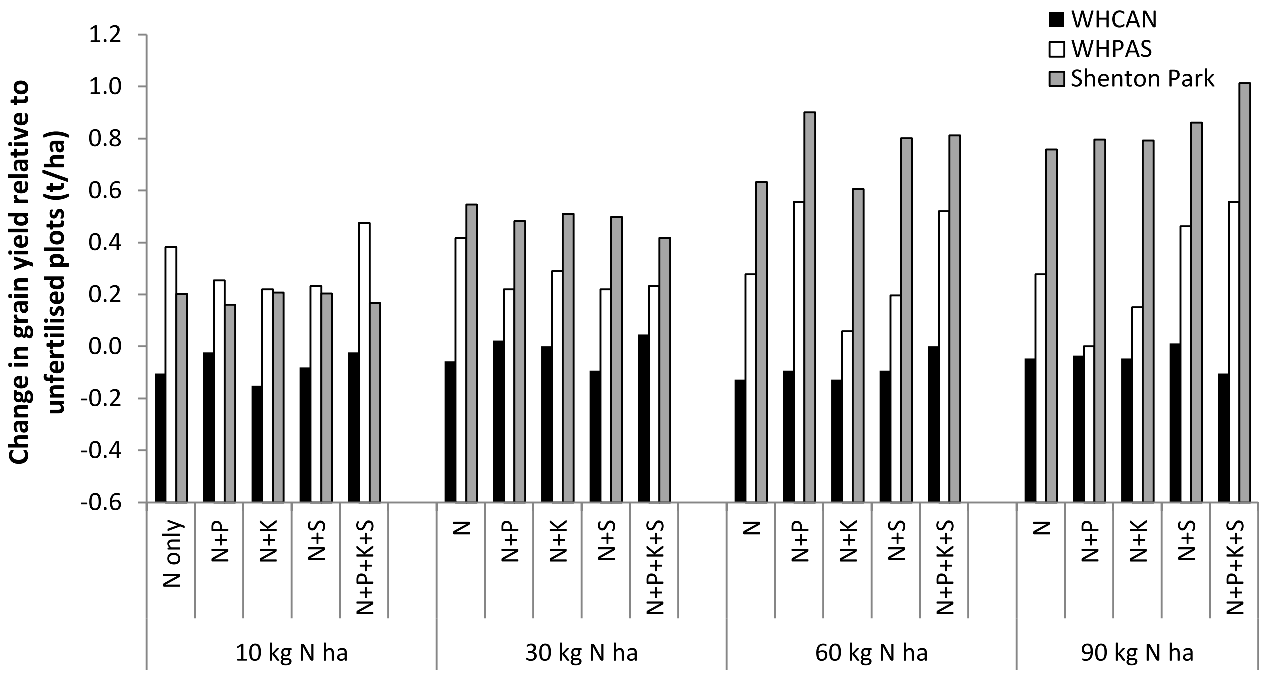

Figure 1: Change in Mace yield relative to yield from unfertilised plots across all three trials. WHCAN background yield 2.38 ± 0.08 t/ha; WHPAS background yield 1.83 ± 0.02 t/ha; Shenton Park background yield 0.11 ± 0.03t/ha. Mean error (SE) for each site - WHCAN = 0.08 t/ha; WHPAS = 0.11 t/ha; Shenton Park = 0.05 t/ha.

Economic Analysis

Table 3: Economic Analysis ($/ha) of Mace grown in three trials under different nutrition regimes. Values in bold are significantly different from gross margins of unfertilised plots.

Treatment	Fertiliser Costs ($/ha)	WHCAN Gross Margin ($/ha)	WHPAS Gross Margin ($/ha)	Shenton Park Gross Margin ($/ha)
Background	0.00	762.96	585.19	35.41
10 kg N ha	13.22	716.41	694.19	87.05
10 kg N ha + 2 kg P ha	16.71	738.85	649.96	70.27
10 kg N ha + 8 kg K ha	25.25	689.56	630.30	76.59
10 kg N ha + 3 kg S ha	14.97	722.07	644.29	85.66
10 kg N ha + 2 kg P ha + 8 kg K ha + 3 kg S ha	30.49	725.07	706.55	58.26
30 kg N ha	39.65	704.79	678.87	**170.58**
30 kg N ha + 8 kg P ha	53.60	716.77	601.95	**135.97**
30 kg N ha + 25 kg K ha	77.26	685.70	600.52	**121.36**
30 kg N ha + 10 kg S ha	45.49	687.85	610.07	**149.24**
30 kg N ha + 8 kg P ha + 25 kg K ha + 10 kg S ha	97.05	680.73	562.21	72.19
60 kg N ha	79.30	**642.92**	594.77	**158.27**
60 kg N ha + 16 kg P ha	107.21	**626.12**	655.75	**216.62**
60 kg N ha + 50 kg K ha	154.52	**567.70**	449.18	74.38
60 kg N ha + 20 kg S ha	90.97	**642.36**	557.18	**200.89**
60 kg N ha + 16 kg P ha + 50 kg K ha + 20 kg S ha	194.09	**568.87**	557.76	101.18
90 kg N ha	118.96	**629.19**	555.12	**158.93**
90 kg N ha + 24 kg P ha	160.81	**591.04**	424.37	**129.26**
90 kg N ha + 75 kg K ha	231.78	**516.37**	401.55	57.04
90 kg N ha + 30 kg S ha	136.46	**630.21**	596.88	**174.79**
90 kg N ha + 24 kg P ha + 75 kg K ha + 30 kg S ha	291.14	**438.49**	471.82	68.49

Based on EPR for 12/12/14 AH Base Price $320/tonne; Fertiliser prices based on 2012-13 ABARES average prices Urea $608 tonne; TSP $802 tonne; KCl $692 tonne; Gypsum $140 tonne.

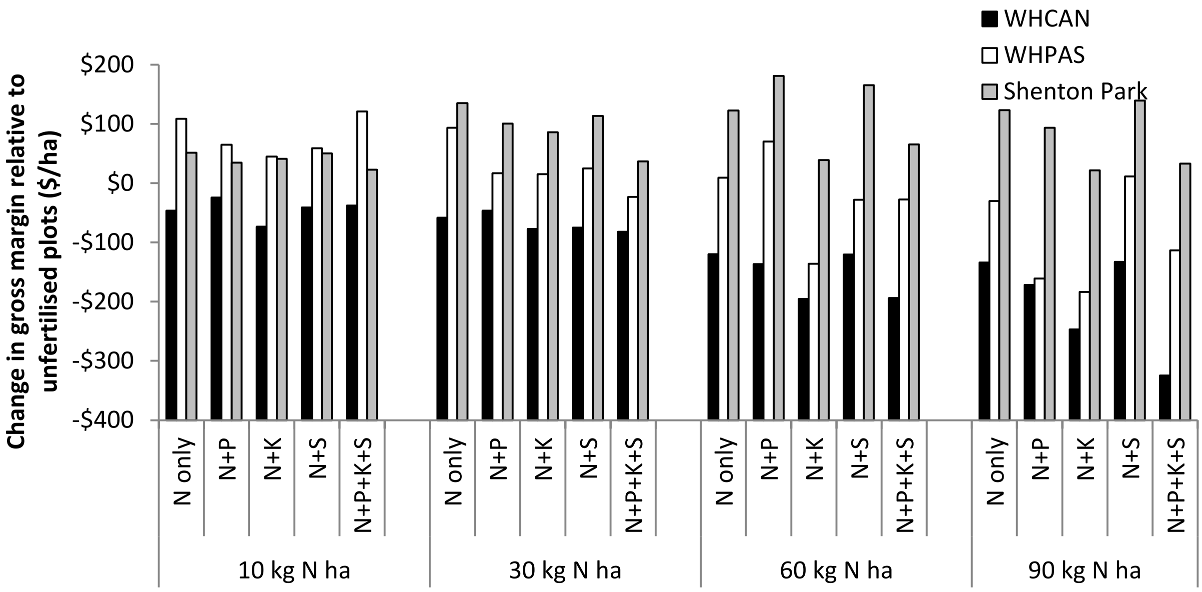

Figure 2: Change in gross margins relative to gross margins from unfertilised plots across all three trials. WHCAN background margin $762.96/ha; WHPAS background margin $585.19/ha; Shenton Park background margin $35.41/ha.

Comments

Yields, responsiveness to fertiliser N applications and economic assessments of trials

Mace yields were highest at the WHCAN site (average 2.33 ± 0.08 t/ha), followed by WHPAS site (2.11 ± 0.11 t/ha) and the, much lower Shenton Park (0.63 ± 0.05 t/ha) (Table 2). At the WHCAN site there was no yield response to fertiliser N applications, with yields in unfertilised plots (2.38 ± 0.08 t/ha) similar or higher than most other nutrition treatments. Economically, the application of fertilisers was deleterious at this site as gross margins were highest in unfertilised plots ($762.92/ha) with gross margins statistically decreasing when 60 kg N ha or more was applied (Table 3; Figure 2).

Yields at the WHPAS site responded to N applications with average yields of N fertilised plots (2.13 ± 0.08 t/ha) higher than yields of unfertilised plots (1.83 ± 0.02 t/ha) (Table 2). Mace responded to an N application of 10 kg N ha (0.3-0.5 t/ha increase), however, there were limited yield increases when N applications were increased to 30, 60 or 90 kg N ha (Table 2). Economically, most nutrition regimes which applied less than 30 kg N ha increased the gross margin by up to $120/ha (Table 3; Figure 2).

At Shenton Park, yields were responsive to N applications with increasing with fertiliser N application (Table 2). Economically, some nutrition regimes resulted in a $182/ha increase in gross margin relative to unfertilised plots with margins greater than $120/ha statistically higher than in unfertilised plots. The extremely low yields at the Shenton Park site (despite having ideal pH and high in season rainfall, see Trial Details) can be explained by very poor nutrient retaining capacity and severe leaching of the deep coarse sands. These properties were only made worse by high in season rainfall. This site was chosen to give an extreme scenario of how the nutrients would interact and perform on a deep coarse sand that was unable to hold any nutrients due to its physical make up.

Role of fertiliser P, K and/or S on wheat yield under varying N concentrations

Across the three trials, yields were increased by applications of P, K and/or S, however, only under certain situations (Table 2; Figure 1). At the WHCAN site applications of P, K and/or S had no influence on yields of Mace under varying fertiliser N applications. This is not surprising given the high background P, K and S concentrations present at this site (Table 1) and that no N response was observed.

At WHPAS and Shenton Park yield increases were observed when N was applied at 60 kg N ha or 90 kg N ha with either P, S or P, K and S also applied (Table 2; Figure 1). These yield increases typically fell in the range of 0.2-0.3 t/ha and in some cases, particularly when 60 kg N ha + 16 kg P ha was applied, they were economically beneficial increasing gross margins by between $60-70/ha (Table 3; Figure 2).

Importance of background nutrition on fertiliser responsiveness

All three trials contained very different soil nutrient profiles before seeding (Table 1). At WHCAN Colwell K concentrations were approximately 5 times higher than critical values for wheat (≈40 mg K kg) and around seven times higher for S (≈10 mg S kg) (Table 1). In addition, WHCAN also had P concentrations in excess of critical values (≈30 mg P kg) and the highest organic C content (1.5%) of all three trials. WHPAS contained available P, K and S and organic C concentrations that were considerably lower than in WHCAN (Table 1). Colwell K concentrations although far lower than at WHCAN were still approximately 2.5 times higher than critical values, whilst available P and S concentrations were similar to critical values thus explaining why P and S responses were observed.

Background nutrition levels at Shenton Park were low, with N and S limiting, K concentrations at critical levels and very low organic C content (Table 1) due to the gutless sand being prone to leaching. Available P concentrations were, however, higher than in both of the Wongan Hills sites (Table 1).

Grain yields at WHCAN > WHPAS > Shenton Park (Table 2), which is the same pattern present in pre-sowing soil tests for available K, S and organic C, whilst pH was the inverse pattern (i.e. lowest at WHCAN; highest at Shenton Park) (Table 1). The combination of high residual P, K and S concentrations plus organic C may have facilitated N mineralisation, thus explaining why yields were highest at WHCAN despite limited fertiliser N response. Decreases in both the background nutrition and organic C content resulted in the WHPAS and Shenton Park sites being more fertiliser responsive and therefore fertiliser dependent in terms of increasing yields (Table 2). Future research is needed to determine if background nutrition levels, organic carbon content, pH or interactions between background nutrition, organic C and soil pH regulate crop responsiveness to fertiliser applications.

Do nutrient concentrations or ratios between nutrients govern yield responses?

At both WHPAS and Shenton Park yield responses were observed when N+P; N+S or N+P+K+S fertiliser regimes were applied (Table 2; Figure 1). The yield responses were, however, not constant across different concentration levels (Table 2; Figure 1). For example at WHPAS a yield decrease of approximately 0.5 t/ha was observed when 90 kg N ha + 24 kg P ha applied instead of 60 kg N ha + 16 kg P ha, whilst the same scenario resulted in a 0.1 t/ha yield decrease at Shenton Park (Table 2). The ratio between N: P added in these regimes was constant (1: 0.26) however, the ratios between P: K changed from 0.47:1 (when 16 kg P ha applied) to 0.81:1 (when 24 kg P ha applied). When P: K ratios were kept constant (i.e. when 60 kg N ha + 16 kg P ha + 50 kg K ha + 20 kg S ha or 90 kg N ha + 24 kg P ha + 75 kg K ha + 30 kg S ha were applied) yields increased by about 0.2-0.3 t/ha (Table 2). This finding implies that the application of N, P, K and S are all required to increase yields when N concentration of 60 kg N ha is applied. Whether this is a result of plants requiring strict ratios between nutrients remains uncertain and requires further research, however, based on the data presented here it would appear more likely that ratios between nutrients govern yield responses rather than absolute nutrient inputs.

Major Findings and Implications

1. Ensuring a nutrient balance between N, P, K and S concentrations is key to yield increases and thus careful attention to pre-season soil tests can be economically beneficial. In some scenarios the use of targeted N+P, N+S or N+P+K+S fertiliser regimes can stimulate grain yield to be economically viable. This is, however, heavily regulated by background nutrient concentrations.
2. Interactions between background nutrients, soil organic contents and soil pH are likely to dictate whether a soil will be fertiliser responsive. Further understanding of these interactions and management of these resources has the potential to maximise grain yields and could provide economic benefits by limiting fertiliser applications.
3. On nutrient responsive sites the only way to ensure grain yield increases was through the application of fertiliser regimes encompassing targeted N+P+K+S applications. This is not always the most economically viable approach, however, it highlights that ratios between nutrients govern yield responses rather than absolute nutrient inputs. Future research highlighting critical ratios between nutrients (i.e. N:P, N:P:K etc.) may be as important as current research addressing critical nutrient concentrations.

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Controlling Annual Ryegrass on Fencelines to Reduce Glyphosate Resistance Development

Sally Peltzer and Abul Hashem, DAFWA, Albany and Northam

Key Messages

- A two spray or double knock strategy (including cultivation or another non-herbicide treatment) is often required for complete control in fencelines with the first application early in the season followed by another one later in the season (after the seeding and post-harvest operations are over).
- Tank mixes of residual herbicides plus a knockdown give the best control for the first application.
- A single application of a mixture of Uragan® (bromacil) and paraquat early in the season gives excellent weed control on fencelines.
- The addition of Alliance® (mixture of amitrole and paraquat) as the knockdown gives good broadleaf control.
- Glyphosate can still be used but intensive monitoring and complete seed set control is required to prevent resistance from developing.

Aim/Background

The aim of this work was to explore herbicide and application timing alternatives to control annual ryegrass and other weeds on fencelines and prevent the onset of resistance. Fence lines can be a 'breeding' ground for glyphosate resistance evolution due to a lack of crop competition, its repeated usage and the often late applications when weeds are large and harder to manage. Controlling weeds that grow on fencelines is important to prevent their resistance status moving into the paddock.

For the past three years, the Northern and Esperance Advisor Groups (set up as part of the GRDC-funded herbicide resistance project) have looked at annual ryegrass and other weed control on fencelines for resistance management.

In 2012, the two Groups compared 13 herbicide treatments (applied as either single herbicides (glyphosate, paraquat, Amitrole T®, glufosinate or Alliance® or as a mixture of a residual herbicide with paraquat) with glyphosate at two trial sites (Esperance and Dalwallinu).

- Tank mixes of residual herbicides plus paraquat or Alliance® gave the best control of annual ryegrass, wild radish, other grasses and broadleaf weeds.
- Applications of bromacil offered the best control at both locations but it was unregistered in 2012.
- The herbicide treatments were applied in August which tends to be a common time for many growers. In Western Australia in August however, the weeds are large and often harder to control at this time of year in Western Australia.

In 2013, two earlier (but single) application times (May and early July) of a further range of herbicides were explored in four locations: Miling, Dandaragan, Geraldton and South Stirlings.

- Similarly, tank mixes of residual herbicides plus a knockdown gave the best control.
- None of the treatments gave complete control.

In 2014, the groups decided that two control timings were needed, once early in the year with a good residual and a knockdown, followed by another one later in the season (after the seeding and post-harvest operations are over). That way you set up the fencelines early in the season then kill them off later rather than having to spray big weeds in one pass. As Uragan® (bromacil) was now registered for fencelines (the only bromacil product registered for this use), it was included as a single application mixed with paraquat in the early timing. Cultivation and slashing were also included in some of the treatments. There were six trial sites: Northampton (NAG group), Buntine (Liebe Group), Doodlakine (Kellerberrin Grower Group), east Wagin (East Wagin Top Crop

Group), Woogenellup (Stirlings to Coast Grower Group) and Esperance Downs Research Station, Gibson (SEPWA).

Buntine Trial Details

Property	Fitzsimons Property, east Buntine
Soil Type	Sand
Plot size & replication	10m x 5m x 3 replications
Herbicide applications	Various: Timing 1 - 27/05/2014 , Timing 2 - 03/07/2014, Timing 3 - 06/08/2014, Timing 4 - 20/08/2014
Water rate	130 L/ha using 360kpa pressure
Ground speed	12 km/h
Nozzle type	Teejet AIXR11004 nozzles
Weeds	Annual ryegrass, wild radish, brome grass, capeweed
Growing season rainfall	180mm

Table 1: Treatment, application rates and timing at east Buntine.

Treatment No	First application	Timing	Second application	Timing
1	simazine granules@ 4 kg/ha + Alliance® @ 4L/ha	T1	atrazine granules@ 2.2 kg/ha + paraquat 250@ 3.6 L/ha	T4
2	simazine granules@ 4 kg/ha + Alliance® @ 4L/ha	T1	cultivate	T4
3	simazine granules@ 4 kg/ha + Alliance® @ 4L/ha	T1	Nil	T4
4	simazine granules@ 4 kg/ha+ 2,4-D @ 700 mL/ha + paraquat 250@ 3.6 L/ha	T1	atrazine granules@ 2.2 kg/ha + paraquat 250@ 3.6 L/ha	T4
5	simazine granules @ 4 kg/ha+ 2,4-D @ 700 mL/ha + paraquat 250@ 3.6 L/ha	T1	cultivate	T4
6	simazine granules@ 4 kg/ha + 2,4-D @ 700 mL/ha + paraquat 250@ 3.6 L/ha	T1	Nil	T4
7	Uragan® (bromacil) @ 3.5 kg/ha + paraquat 250@ 3.6 L/ha	T1	Nil	T4
8	Uragan® (bromacil) @ 5 kg/ha + paraquat 250@ 3.6 L/ha	T1	Nil	Nil
9	Cavalier® (oxyflurofen) @ 4 L/ha + paraquat 250@ 3.6 L/ha	T1	atrazine granules@ 2.2 kg/ha + paraquat 250@ 3.6 L/ha	T4
10	Slash	T3	atrazine granules@ 2.2 kg/ha + paraquat 250@ 3.6 L/ha	T4
11	simazine granules @ 4 kg/ha + 2,4-D @ 700 mL/ha + paraquat 250@ 3.6 L/ha (July timing)	T2	Nil	Nil
12	Cultivate	T2	atrazine granules@ 2.2 kg/ha + paraquat 250@ 3.6 L/ha	T4
13	Control	Nil	Nil	Nil

Results (for Buntine and other sites)

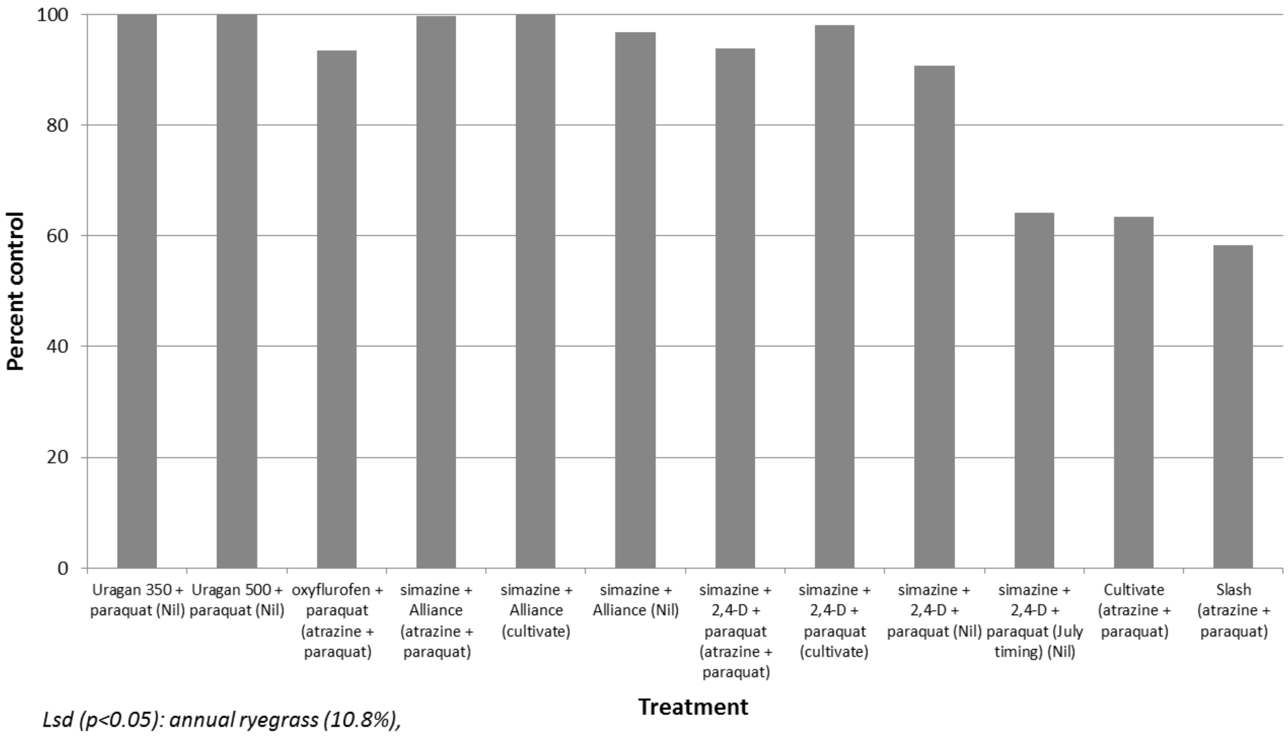

Figure 1: Percentage control (compared to untreated) of annual ryegrass after application of 12 herbicide treatments at Buntine (Liebe Group Main Trial Site 2014). (Note: second application in brackets).

Comments

- A single application of Uragan® (bromacil) plus paraquat in May (or June in Esperance) gave complete control of all weeds at all sites over both rates (350 and 500 kg/ha).
- Uragan is expensive (see Table 2) but only one application is needed to control all weeds (including summer weeds) for at least one year. There is a risk of soil erosion, as bromacil is highly residual. It is toxic to trees so can only be used where there is no remnant vegetation. Adama™ are continuing trials in 2015 to investigate weed control at lower rates which will reduce the cost and the potential environmental hazards.
- At most locations, an application of either simazine + Alliance® or simazine, 2, 4-D and paraquat in May followed by a second application of atrazine and paraquat in August gave better than 95% control. The addition of Alliance gave slightly better control especially where there were broadleaf weeds (three years results). At Northampton however, the level of control for annual ryegrass was lower than expected. It is possible that there is developing triazine resistance in annual ryegrass on this site as most of the other weed species were controlled (this has not yet been tested). Another possibility is that the soil microorganisms are breaking down the triazines quickly and reducing their residual activity. This is the subject of a study at UWA, particularly for the northern wheatbelt soils.
- Delaying the application of the first spray reduced the control by 10 to 30% across all sites.
- Slashing later in the season then spraying with atrazine and paraquat showed promise in the southern areas (80-98% control) where the season was later and there had been more rain. There was poor control (56-59%) in the northern trial sites.
- The use of cultivation as a control option did not generally work well in this series of trials except when used as the second knockdown in August at Buntine.

Table 2: The cost of the herbicide treatments ($/km based on a 3m wide fenceline).

First treatment	Active ingredient	Cost ($/km)
simazine @ 4 kg/ha	simazine	8
paraquat 250@ 3.6 L/ha	paraquat	5
Alliance® @ 4 L/ha	amitrole and paraquat	20
atrazine granules@ 2.2 kg/ha	atrazine	8
2,4-D @ 700 mL/ha	2,4-D	1.20
Uragan @ 3.5 kg/ha+ paraquat (3.6 L/ha)	bromacil and paraquat	73
Uragan @ 5 kg/ha+ paraquat (3.6 L/ha)	bromacil and paraquat	103
simazine @ 4 kg/ha + 2,4-D @ 700 mL/ha paraquat (3.6 L/ha)	simazine and paraquat	14
simazine @ 4 kg/ha + Alliance® @ 4 L/ha	simazine, amitrole and paraquat	28
Second treatment		
atrazine granules@ 2.2 kg/ha + paraquat 250@ 3.6 L/ha	atrazine and paraquat	13

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Integrated Weed Management Demonstrations to Improve Adoption of Wild Radish Control Practices – Dalwallinu

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

Key Messages

- Application of knockdown and in-crop herbicides from diverse modes of action at early and late stages provided excellent radish control (97 to 100%).
- A higher gross margin came from the 60 kg/ha seed rate than the 120 kg/ha in 2014 season mainly due to greater grain yield and lower seed costs at 60 kg/ha.
- Increasing pressure on knockdown, in-crop herbicides from diverse modes of action, and seed rate reduced gross margin but provided superior radish control.
- Wild radish has developed resistance to most of the available selective and non-selective herbicides including glyphosate in Western Australia. It is important that an integrated weed management (IWM) approach including as many weed control options as possible should be adopted by growers to manage wild radish.

Aim

To conduct integrated weed management IWM trials investigating chemical and non-chemical weed control options to minimise the impact of herbicide resistance in wild radish in Western Australian (WA) Wheatbelt and to improve adoption of wild radish IWM.

Background

One effective way to raise the awareness of IWM practices among the growers is to conduct IWM demonstrations. Three IWM demonstrations on wild radish control were established in the Northern and Central regions of WA in collaboration with growers groups, agronomists and consultants at Geraldton, Dalwallinu and Merredin. Selective control options available at pre-sowing, sowing, pre-emergence, post-emergence, and at harvest time were incorporated into IWM options.

Trial Details

Property	Harding Sawyer Co, Nugadong
Plot size & replication	20m x 2m x 4 replications
Soil type	Sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.3
EC (dS/m)	0.15
Sowing date	30/05/2014
Seeding rate	60 kg/ha or 120 kg/ha
Paddock rotation	2011: wheat, 2012: canola, 2013: wheat
Fertiliser	30/05/2014: 80 kg/ha Macropro Plus 19/07/2014: 60 L/ha Flexi-N
Herbicides	See treatments
Growing Season Rainfall	209mm

Treatments

Two seed rates of wheat (60 kg/ha and 120 kg/ha) were sown with 6 chemical and/or non-chemical weed control treatments each. Treatments included double knockdowns plus or minus selective in-crop herbicides followed by weed seed removal at harvest or windrowing to be burnt in April/May (Table 1).

Results

Knockdown herbicides applied before crop sowing controlled wild radish by 95% to 100% at this site where initial density of wild radish was 70 plants/m^2 before knockdown applications (Table 1). Annual ryegrass and voluntary canola plants present at 63 and 4 plants/m^2 respectively, were also controlled very well by knockdown herbicides. Although cultivation could not be done in 2014 season in Treatments 4 and 10, Para-Trooper® as knockdown controlled weeds very well. However, speed of killing was much faster by Roundup® followed by (fb) Alliance® than Para-Trooper® alone.

Table 1: Effect of IWM practices (knockdowns, seed rate and in-crop herbicides) on yield and quality of wheat crop, and final in-crop control of wild radish at Dalwallinu in the 2014 season[1].

Treatments		**Wild Radish Control (%)**	**Yield (t/ha)**	**Screenings (%)**	**1000-grain weight (g)**
1.	Roundup® fb Alliance® + 60 kg/ha + windrow burning	93	1.05	3.73	38.85
2.	Roundup® fb Alliance® + 60 kg/ha + Triathlon® Z12 fb Velocity® at Z30	100	1.04	1.17	38.19
3.	Roundup® fb Alliance® + 60 kg/ha + Velocity® at Z12 fb Triathlon® Z30	100	1.09	1.73	37.55
4.	Cultivation fb Para-Trooper® + 60 kg/ha + Velocity® at Z12 fb Triathlon® Z30	98	1.08	2.19	37.49
5.	Roundup® fb Alliance® + 60 kg/ha + Velocity® Z12 fb Triathlon® Z30 + HWSR[1]	100	1.13	1.12	38.23
6.	Roundup® fb Alliance® + 60 kg/ha + Velocity® at Z12 fb Triathlon® Z30 + windrow burning	97	1.08	1.99	36.48
7.	Roundup® fb Alliance® + 120 kg/ha + windrow burning	90	0.92	4.56	35.70
8.	Roundup® fb Alliance® + 120 kg/ha + Triathlon® Z12 fb Velocity® at Z30	100	0.97	1.22	35.77
9.	Roundup® fb Alliance® + 120 kg/ha + Velocity® Z12 fb Triathlon® Z30	99	1.03	1.3	36.41
10.	Cultivation[2] fb Para-trooper® + 120 kg/ha + Velocity® Z12 fb Triathlon® Z30	100	0.97	1.16	35.31
11.	Roundup® fb Alliance® + 120 kg/ha Velocity ®Z12 fb Triathlon® Z30 + HWSR	100	1.03	1.06	36.47
12.	Roundup® fb Alliance® + 120 kg/ha + Velocity® Z12 fb Triathlon® Z30 + windrow burning	100	0.99	1.38	37.09
LSD (5%)		3.6	0.084	1.054	2.378
CV (%)		2.6	5.7	6.6	4.5

[1]fb = followed by; HWSR = Harvest weed seed removal; Seasonal conditions did not allow for pre-sowing cultivation in 2014. Herbicide rates: Alliance® 2.5 L/ha, Para-Trooper® 1.6 L/ha, Roundup® 2 L/ha, Velocity® 670 mL/ha, Triathlon® 1 L/ha.

Application of in-crop herbicides (Triathlon® Z12 fb Velocity® at Z30 or Velocity® at Z12 fb Triathlon® at Z30) has controlled wild radish in the crop by 97% to 100%. However, the plots treated with knockdown herbicides only (with no in-crop herbicides) provided 90% to 93% wild radish control, leading to some radish plants producing seeds in wheat crops. The effect of harvest weed seed removal and windrow burning are yet to be determined.

Seed rate of wheat (60 and 120 kg/ha) did not influence wild radish control and wheat screenings. However, grain yield and 1000-grain weight were greater at 60 kg/ha than 120 kg/ha at this site in 2014 season.

Economic Analysis

Variable costs included costs of herbicides, wheat seed and weed seed collection at harvest. Cost of windrow burning was not included in 2014 treatment costs. Since cultivation was not performed as a knockdown weed control option in 2014 season, cost of cultivation was not included in the variable costs.

Regardless of treatments, highest gross margin was obtained from 60 kg seed rate (average gross margin $198/ha) than 120 kg (average gross margin $110/ha) mainly due to greater grain yield and lower seed costs at 60 kg/ha.
Regardless of seed rate, higher gross margin came from treatment 1 where no post-emergence herbicide was applied and cost of windrow burning was not included. Gross margin in treatment 4 was also similar to Treatment 1 where cost of cultivation is not included in the variable costs.

Table 2: Economic analysis of wild radish control treatments based on wheat price at $300/t at the wild radish IWM trial site, Dalwallinu in 2014[1].

Treatments		Gross Return ($)	Variable Cost ($)	Gross Margin ($)
1	Roundup® fb Alliance® + 60 kg/ha + windrow burning	315	99	216
2	Roundup® fb Alliance® + 60 kg/ha + Triathlon® Z12 fb Velocity® at Z30	312	135	178
3	Roundup® fb Alliance® + 60 kg/ha + Velocity® at Z12 fb Triathlon® Z30	327	135	193
4	Cultivation fb Para-Trooper® + 60 kg/ha + Velocity® at Z12 fb Triathlon® Z30	324	108	217
5	Roundup® fb Alliance® + 60 kg/ha + Velocity® Z12 fb Triathlon® Z30 + HWSR	339	145	195
6	Roundup® fb Alliance® + 60 kg/ha + Velocity® at Z12 fb Triathlon® Z30 + windrow burning.	324	135	190
7	Roundup® fb Alliance® + 120 kg/ha + windrow burning	276	159	117
8	Roundup® fb Alliance® + 120 kg/ha + Triathlon® Z12 fb Velocity® at Z30	291	195	97
9	Roundup® fb Alliance® + 120 kg/ha + Velocity® Z12 fb Triathlon® Z30	309	195	115
10	Cultivation[2] fb Para-trooper® + 120 kg/ha + Velocity® Z12 fb Triathlon® Z30	291	168	124
11	Roundup® fb Alliance® + 120 kg/ha Velocity ®Z12 fb Triathlon® Z30 + HWSR	309	205	105
12	Roundup® fb Alliance® + 120 kg/ha + Velocity® Z12 fb Triathlon® Z30 + windrow burning	297	205	93

[1]fb = followed by; Windrow burning cost was not included in 2014 variable cost; cost of HWSR (Harvest weed seed removal) = $10/ha; Price of herbicides ($/ha): Alliance®= $25, Roundup®= $14, Para-trooper®= $12, Velocity® =$20, Triathlon® = $15.5; cost of wheat seed = $1/kg. Cost of cultivation is not included as seasonal conditions did not allow for pre-sowing cultivation in 2014.

Comments

This is the first year of the three-year trial plan of this wild radish IWM trial at three locations of Western Australian Wheatbelt. Based on the results of 2014 season, double knockdowns and application of in-crop herbicides from diverse mode of action (for example, Triathlon® and Velocity®) provided 100% control of wild radish. Higher seed rate did not result in greater weed control or grain yield in 2014 season probably due to lower rainfall July and August. Further success in 100% radish control in subsequent 2-3 years should deplete the radish seed bank to a low level. The efficacy of weed seed catching and wind row burning in reducing the radish seed will be available at the end of 2015 season.

Wild radish has developed resistance to most of the available selective and non-selective herbicides including glyphosate in WA. It is important that wild radish is managed by IWM approach including as many weed control options as possible. It is also important that 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 are thankful to GRDC for funding the project (UA00149). Thanks are due to Department of Agriculture and Food, Western Australia (DAFWA) Research Support Unit at Wongan Hills and Geraldton and DAFWA Technical Officers Barb Sage and Chris Roberts. Special thanks are due to Michael Sawyer's Family for providing the land and allowing for access to their farm for the trial, and Liebe Group for their kind collaborations.

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Sakura® 850WG Influence of Rainfall After Sowing for Annual Ryegrass Control at Three Locations Across Western Australia

Rick Horbury, Technical Advisor north, Bayer CropScience

Aims

1. Compare the influence of rainfall on the efficacy of Sakura 850WG vs. commercial standards for annual ryegrass (ARG) control across three different soil types at three locations in Mingenew, Warradarge and Meckering.
2. Highlight the importance of effective knockdowns coupled with sowing timing to maximise weed control and crop yield in Mace wheat.

Background

- Time of sowing (TOS) dates were selected to ensure that treatments were applied after a germination event (significant rainfall ≥10mm) had occurred but prior to significant emergence of ARG.
- Sakura 850WG like other root uptake herbicides i.e. propyzamide works best when activated within a moist soil profile prior to or as weeds germinate.
- All pre-emergent herbicides are impacted by surface stubble especially under high grass weed numbers.
- The value of an effective knockdown in taking the pressure off pre-emergent herbicides cannot be underestimated when trying to drive a seed bank down.
- Pre-emergent herbicides should only form part of a full Integrated Weed Management program with harvest weed seed practices strongly recommended to reduce numbers and delay the onset of resistance.

Trial Details

Property	WE04 – Mingenew	WE05 – Warradarge	WE06 – Meckering north
Plot size & replication	2.5m x 20m x 3 replications		
Soil type	red loam	sand plain, gravel 20%	non wetting sand
Soil pH ($CaCl_2$)	5.1	6.3	~5
Stubble cover	Mostly standing ~40%	4-5 t/ha thick trash 50-100%	Light surface trash ~40-60%
Sowing date	Early (A) – 02/05/2014, Grower timing (B) – 16/05/2014, Late (C) 30/05/2014		
Seeding rate	60 kg/ha Mace treated with 80 mL/100 kg EverGol® Prime		
Paddock rotation	2012: wheat, 2013: lupin	2012: wheat, 2013: lupin	2012: serradella, 2013:wheat
Fertiliser	02/05/2014: 60 kg/ha Gusto® Gold banded + 60 kg Urea top-dressed 04/08/2014: Urea 75 kg/ha		
Herbicides: knockdown and pre-emergent	02/05/2014: Early – 2 L/ha Spray.Seed®, Grower – 2 L/ha Spray.Seed, Late- 2 L/ha Spray.Seed 2 L/ha Glyphosate 16/05/2014: 2 L/ha Glyphosate , 2 L/ha Spray.Seed 30/05/2014: 2 L/ha Spray.Seed		
Herbicides and fungicides post-emergent	27/06/2014: 800 mL/ha Velocity®, 420 mL/ha MCPA LVE 570, 150 mL/ha Prosaro® 420SC ,1% Hasten®		
Growing Season Rainfall	378mm	393mm	316mm

Results

For all three locations whilst the actual rainfall figures varied slightly the timings of the significant rainfall events were on similar days. To help visualise the influence of rainfall events across the three trials conducted in 2014 the rainfall and temperature data for Mingenew is included in Figure 1. The early application timing on the 2nd May followed the season break on the 25th of April by a week allowing significant ryegrass emergence to take place albeit only around ~50% of the germination had broken the soil at application of knockdown and pre-emergent herbicides especially at Meckering. This was followed by another ~25 mm of rainfall or more at all sites which activated all the herbicides including Sakura which relies on soil moisture for root uptake.

The "grower" timing on the 16th April was closest to the district seeding date and allowed time for a further emergence of ryegrass and ensured that the second knockdown applied at sowing was very effective at all sites. This timing also was also followed by enough rainfall to activate all the herbicides. The final late sowing on the 30th May recorded excellent control from the third knockdown at all sites. At Mingenew and Warradarge there was sufficient soil moisture to keep Sakura active however, on the non-wetting sand at Meckering there was a 19 day break from seeding to the first significant rainfall which influenced the uptake of Sakura and reduced control of the first germination. However, as June continued there were excellent falls ensuring Sakura worked well at controlling subsequent germinations.

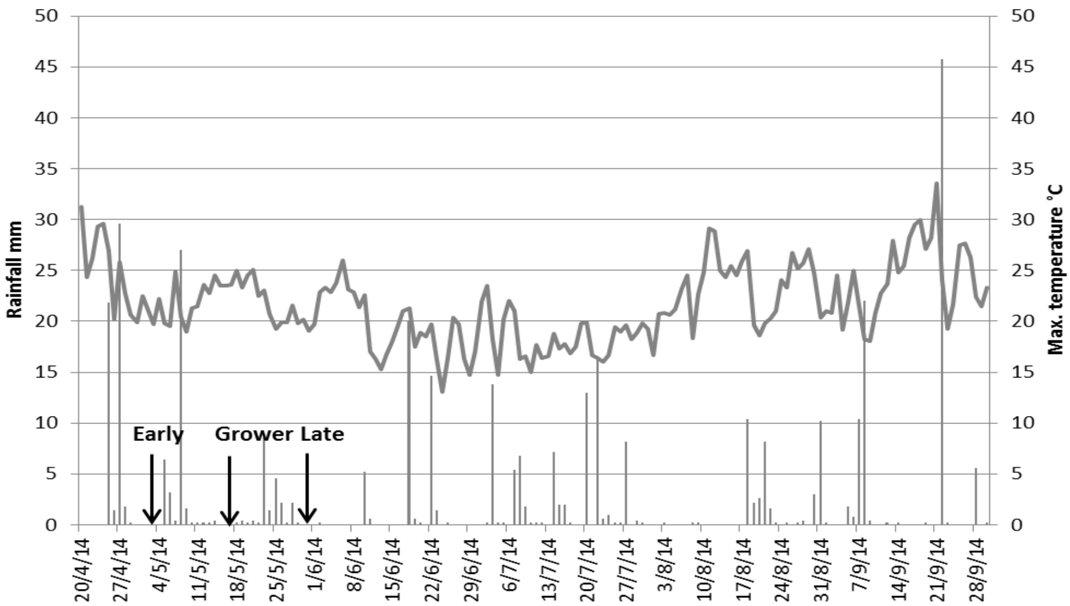

Figure 1: Mingenew daily rainfall and max temperature during the main 2014 growing season.

Weed control ratings – early and late season

It is important to note that early weed control in July does not equate to final ARG control at the end of the growing season which is what really counts for seed bank management. A reduction in average percent control of ARG rating was recorded for all pre-emergent herbicides in the three trial sites in 2014 between July and September assessments. The Sakura treatments with their longer residual activity were more stable at the early and late ARG control ratings than trifluralin and Boxer Gold treatments at all three times of sowing.

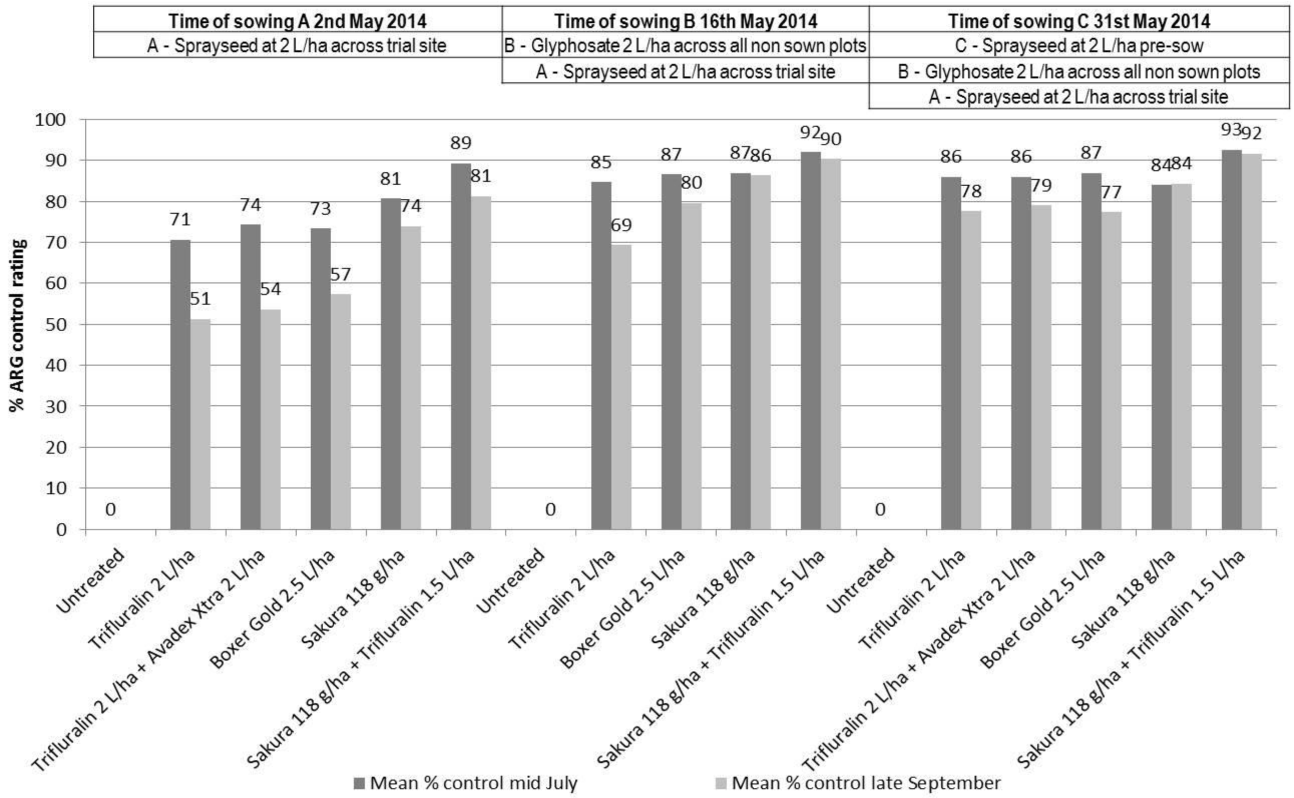

Figure 2: Average pre-emergent ARG control by herbicide across three TOS and three locations across WA in 2014.

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

Panicle counts are the most reflective measure of the effectiveness of a herbicide programs impact on how much seed is being set and contributing to the seed bank of the paddock for future rotations.

TOSA: All pre-emergent herbicides struggled to provide acceptable control of ARG panicles at TOSA due to very high weed numbers (panicle count in brackets in Figure 3 below are for untreated at TOSA) across all three locations following a poor initial knockdown which placed heightened pressure on the herbicides. Sakura recorded a higher % ARG panicle control than the trifluralin, trifluralin + Avadex Xtra or Boxer Gold treatments although it was still below commercially acceptable levels (≥80%). The addition of trifluralin to Sakura was of particular benefit on the non-wetting soil at Meckering (12% increase) due to it being active while the top soil was dry with germinated weeds unable to take Sakura up through the roots at initial establishment. However, in the heavy stubble at Warradarge and on the red loam at Mingenew trifluralin provided minimal increase in efficacy to Sakura.

TOSB: The effectiveness of the second knockdown was evident with a 37% reduction in ARG in the untreated and an increase in control from all herbicides across the three trials. The longer residual activity observed in the Sakura treatments (86 and 89%) resulted in a higher level of ARG control compared to trifluralin (74%) although Boxer Gold recorded useful suppression (80%).

TOSC: The application of third knockdown in this timing resulted in an increase in control from all herbicides with the untreated alone recording an average 57% reduction in ARG numbers with 76% at Meckering. On average both trifluralin treatments and Boxer Gold recorded useful suppression (80-84%) of ARG while both Sakura treatments recorded excellent control (≥90%). However, at Warradarge where the high stubble load was present all herbicides recorded reduced control compared to Mingenew and Meckering where better soil contact was achieved. This highlights the importance of stubble management to get the best efficacy from pre-emergent soil active herbicides.

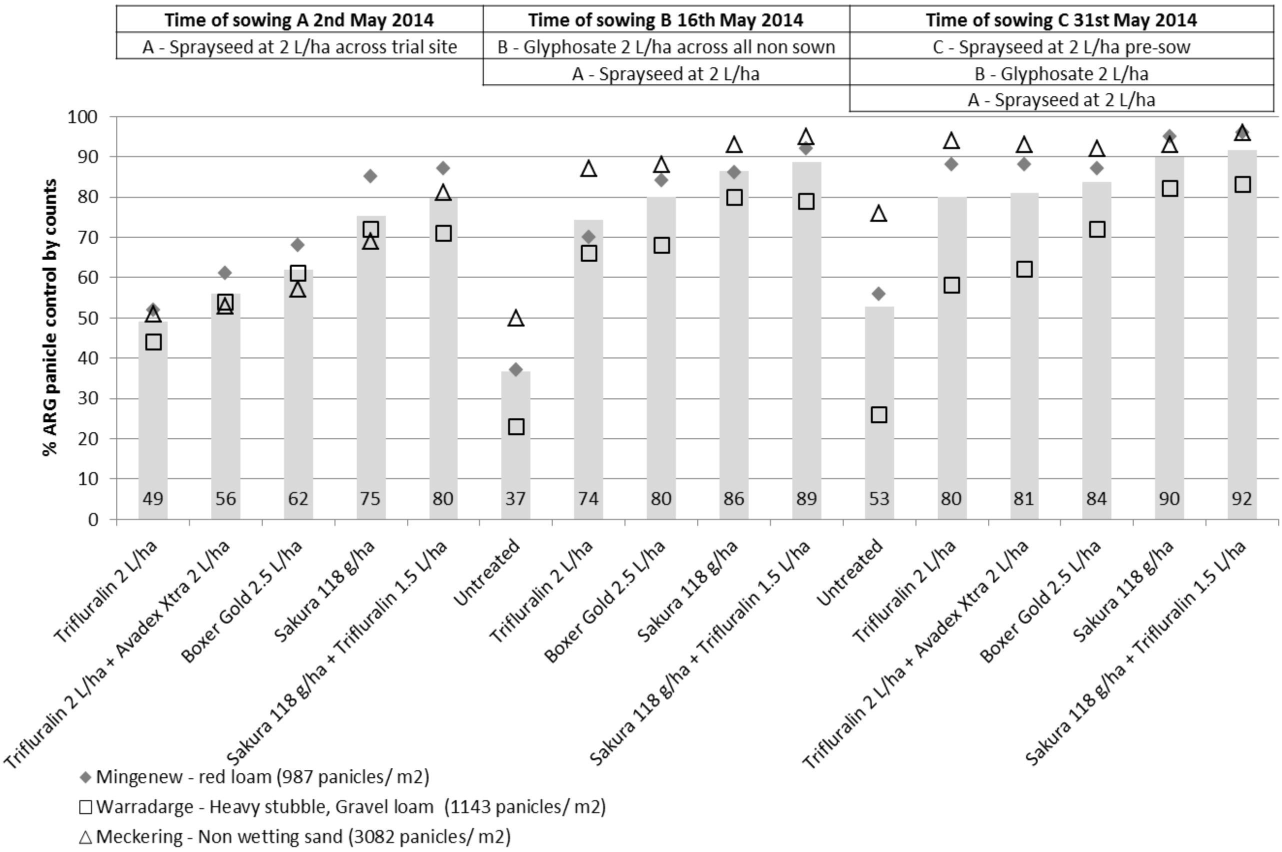

Figure 3: Average % ARG panicle control by herbicide across three TOS and three locations across WA in 2014.

Weed control comments

The value of an effective knockdown or even a double knock cannot be underestimated for reducing the pressure on all herbicides and allowing for more options to remain in the rotation for longer. Reduced weed competition improves the water and nutrient use by the crop resulting in increased yield potential. The addition of trifluralin (+5%) a shoot uptake volatile herbicide to Sakura a long lasting residual root uptake product can be an excellent insurance option in challenging non-wetting soil types like at Meckering. On heavier soils or where heavy stubble is an issue only comparable or a slight improvement (2-3%) are observed.

Grain yield – What time of sowing and herbicide worked best in 2014?

TOSA: The knockdown was not fully effective at any of the sites as all weeds had not emerged from the initial germination. Therefore with maximum weed competition yields were well below yield potential for the season. Sakura recorded an increase of 140 kg/ha over Boxer Gold and 390 kg/ha over trifluralin at this timing. The addition of trifluralin to Sakura increased weed control and delivered an increase of 170 kg/ha over Sakura alone averaged across the three trials.

TOSB: All sites benefited from an effective double knockdown strategy and additional weed control. This resulted in the average yield for the pre-emergent herbicides in TOSB recording an 880 kg/ha yield increase over TOSA and 550 kg/ha over TOSB. Sakura recorded an average increase of 120 kg/ha over Boxer Gold and 280 kg/ha over trifluralin across the three trials. The addition of trifluralin to Sakura resulted in a yield increase of 350 kg/ha on the non-wetting sand at Meckering but comparable yields at Warradarge and Mingenew.

TOSC: Weed control was at its highest for all herbicides due to a triple knockdown, however, conditions at establishment were much cooler and less favourable which coupled with a dry hot August (especially Mingenew) led to significant reductions in yield potential. In a longer softer season like 2013 this timing may have been different. Sakura recorded a small average increase of 70 kg/ha over Boxer Gold and 60 kg/ha over trifluralin across the three trials. The addition of trifluralin to Sakura did not increase yield apart from at Meckering.

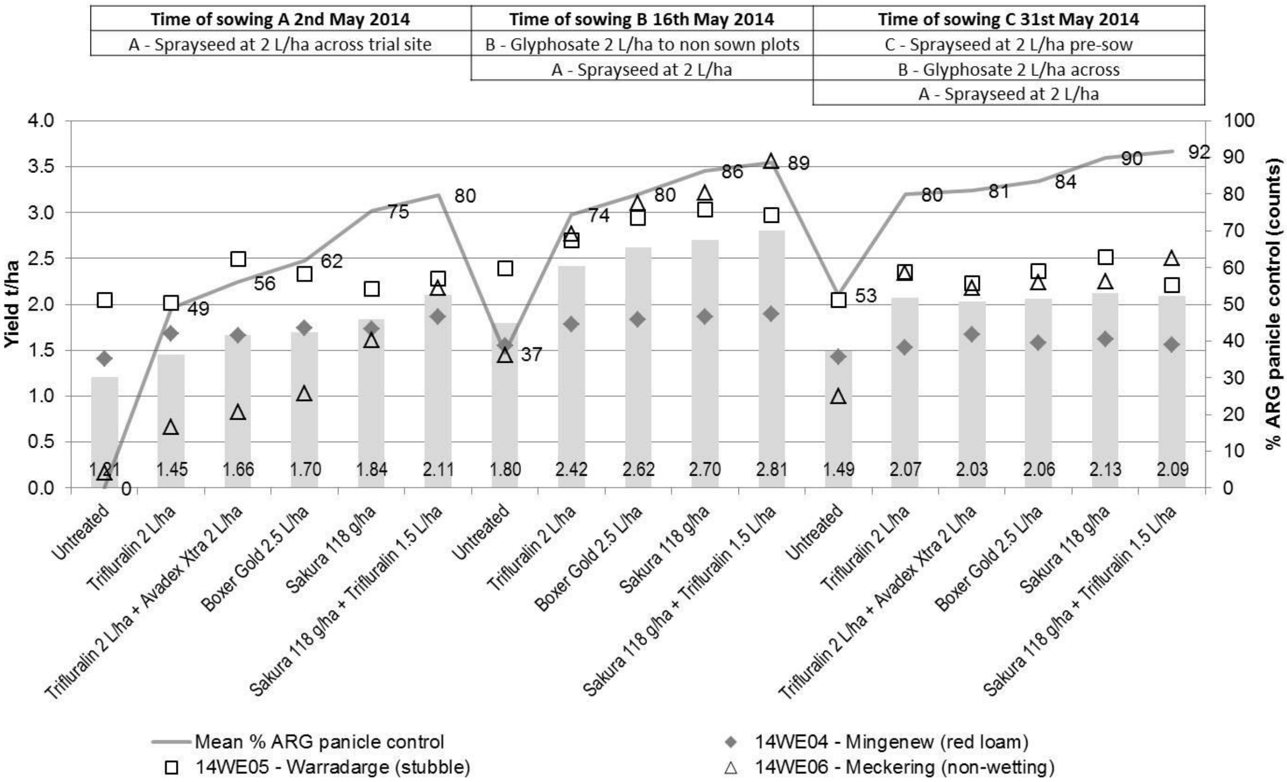

Figure 4: Average yield and % ARG panicle control by herbicide across three TOS and three locations across WA in 2014.

Comments on yield

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 excellent knockdowns and a long residual activity product like Sakura can deliver quality yields and returns across a variety of sowing timings and locations as seen across the three trial locations in 2014. Always remember the importance of harvest weed seed management in the year before to also set things up.

Acknowledgements

Kalyx for sowing the Mingenew and Warradarge trials and Living Farm for their excellent work at Meckering. Additional thanks to the host grower's at each of the three trial sites whom without their permission research like this isn't possible.

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Soil Health Research Results

Mouldboard Plough Demonstration – West Buntine

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages

- This is the 3rd wheat crop where there has been no benefit in yield or quality due to mouldboard ploughing.

Aim

To determine if there are any benefits to increased productivity and carbon cycling on a yellow sandplain soil through mechanical incorporation.

Background

Mouldboard ploughing involves a one-off inversion of the topsoil. In this trial the plough was able to invert the top 30cm, larger ploughs can get deeper. Mouldboard ploughing can help control weed, bury water repellent topsoil and incorporate lime at depth. Cost of the operation is approximately $100-120/ha (Davies et al, 2012).

The trial was mouldboard ploughed on the 17th June 2012, after receiving 55mm of rain in the previous week. This allowed the soil profile to fill up at least the top 30cm of soil, which is required for best inversion.

The deep ripping treatment also conducted in 2012 was included to take into account the ripping effect of mouldboard ploughing and if that was the reason a yield improvement was produced. The whole paddock was last deep ripped in 2009, therefore it was predicted that there wouldn't be a significant difference in yield between deep ripped and control plots.

Trial Details

Property	Michael & Narelle Dodd, west Buntine
Plot size & replication	100m x 18m x 2 replications
Soil type	Yellow sand
Soil pH ($CaCl_2$)	0-10cm: 6.2 10-20cm: 4.8 20-40cm: 5.0
EC (dS/m)	0.045
Sowing date	27/05/2014
Seeding rate	80 kg/ha Corack
Paddock rotation	2013: wheat, 2012: wheat, 2011: pasture
Fertiliser	27/05/2014: 55kg/ha Agstar Extra, 15 kg/ha MOP, 30 L/ha Flexi-N, 10 L/ha CalSap, 20 L/ha Flexi-N
Herbicides & Insecticides	18/05/2014: 1.5 L/ha Roundup, 0.25% LI700, 100 mL/ha Goal 27/05/2014: 1 L/ha Spray.Seed, 1.8 L/ha Treflan 14/07/2014: 680 mL/ha Velocity
Growing Season Rainfall	187mm

Results

Over the life of the trial 2012-2014 there has been no significant crop response to the deep ripping or the mouldboard ploughing in terms of yield and quality. This is the third wheat crop since tillage occurred in June 2012.

Table 1: Wheat yield, quality and grade 28 months after mouldboard ploughing and deep ripping occurred on yellow sand at Buntine. The trial was set up with a no tillage plot termed "Control" next to each tillage treatment to act as a comparison point for this non replicated demonstration.

Treatment	Yield (t/ha)	Nearest Neighbour Control (%)	Protein (%)	Screenings (%)	Hectolitre Weight (%)	Grade
Control	2.30	100	13.3	2.60	81.28	AGP1
Deep ripped	2.60	113	12.0	1.13	82.68	APW1
Mouldboard	2.28	102	12.6	2.27	81.89	APW1
Control	2.22	100	12.3	2.04	82.72	AGP1
Deep ripped	2.28	102	12.1	2.05	82.45	AGP1
Mouldboard	1.85	95	12.5	4.40	80.44	AGP1
Control	1.93	100	12.0	3.45	80.84	AGP1

Note: There was a very high amount of speargrass in the downgraded wheat samples.

This paddock has issues with hard pans and compaction at of 15-50cm depth (Hollamby and Davies, 2014). The deep ripping did remove the compaction where the tyne passed through.

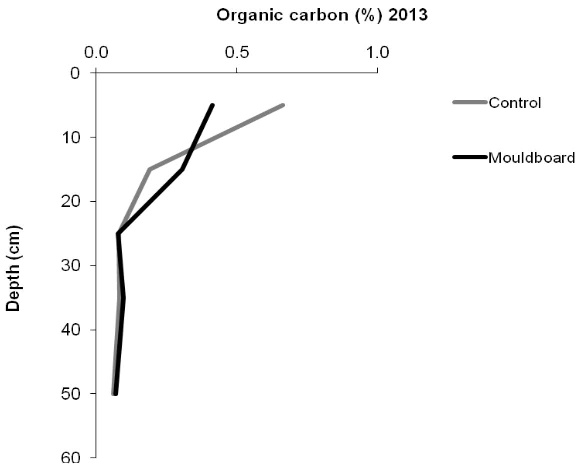

Figure 1: Soil organic carbon as a percentage of soil after cereal rye has been incorporated by ploughing (grey line) compared to no ploughing (black line), Buntine, May 2013. Ploughing occurred in 2012.

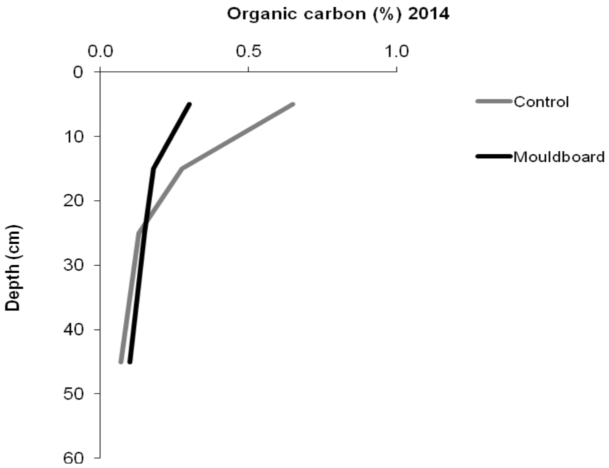

Figure 2: Soil organic carbon as a percentage of soil after cereal rye has been incorporated by ploughing (grey line) compared to no ploughing (black line), Buntine, December 2014. Ploughing occurred in 2012.

In 2014 the mouldboard ploughing decreased the topsoil organic carbon % from 0.41% in 2013 to 0.3% in 2014, see Figure 1 and 2. The soil organic carbon % in the control treatment has remained relatively the same from the 2013 and 2014 results in the topsoil but is increasing in the subsoils, moving from 0.19% in 2013 to 0.275% in 2014 in the 10-20cm depth and from 0.08% to 0.13% in the 20-30cm level.

Economic Analysis

Over the course of the trial to date the most economically profitable treatment has been the control with a cumulative gross margin for 2012 and 2013 of $870/ha. However, this year the deep ripped treatment has returned the highest cumulative gross margin at $1204/ha. This is the first year that the implementation cost ($50/ha) of the deep ripping treatment has begun to be repaid. The mouldboard treatment has yet to repay the cost of implementation ($125/ha).

Table 2: Gross margins of mouldboard ploughing compared to deep ripping and control (minimum tillage) on deep yellow sand at Buntine. Determined by grain income minus cost of production, fixed costs are not included in this analysis. The cost of deep ripping $50/ha and mouldboard ploughing $125/ha was incurred in 2012 only.

	Gross Margin ($/ha)			
Treatment	**2014**	**2013**	**2012**	**Cumulative Total**
Control	318	350	520	1188
Deep ripped	394	340	470	1204
Mouldboard plough	295	370	340	1005

Grain price used were: 2012 season - $340/t, 2013 - $300/t, 2014 - $295/t.

Comments

This is not a fully replicated trial but a farmer demonstration that has nearest neighbour controls. This is the first year of the trial in which the control treatment has had a lower cumulative gross margin than one of the cultivation treatments; this means that the cultivation treatment (deep ripping) is finally beginning to return dividends to the farmer, three years after the cultivation occurred.

The farmer has noted that this site was seeded and sprayed as per normal program. This was somewhat detrimental to the mouldboard site as the seed depth and establishment was compromised due to the softness of the top soil. Another factor to consider was that the normal rates of chemical, Trifluralin in particular, almost became toxic due to the low organic matter created by the mouldboard treatment. This also contributed to the mouldboard plots poor performance.

Acknowledgements

This project is funded by the Australian Government Department of Agriculture. Thank you to the Department of Agriculture and Food, WA for the use of their mouldboard plough and Colin Cail for the use of his tractor in 2012 and Justin Laycock and Frances Hoyle (DAFWA) for their help with bulk density testing in 2014.

Paper reviewed by: Michael Dodd, Grower

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Deep Ripping Dry Compact Sand in Two Bites

Paul Blackwell and Glen Riethmuller, DAFWA, Phil Ward, CSIRO

Key Messages

- Deep ripping dry sand was more effective with two passes (or shallow leading tines); less cloddy.
- Yield benefits of 410 kg/ha (18%) from deep ripping were mainly due to better head fill. Better head fill was probably due to better cooling of the crop in hot weather due to better supply of moisture.
- Extra moisture seemed to be from rain which infiltrated deeper in the ripped soil to avoid more evaporative loss than the unripped soil.
- A controlled traffic system will better protect the investment in deep ripping and extend the benefits. Deep ripping costs will also be reduced when the permanent tramlines are left unripped; seeding can also be easier with better flotation on permanent tramlines.

Aim

To demonstrate more efficient deep ripping of a dry compact sandy soil and to assess any benefits of improved rain infiltration and crop yield.

Background

Compression stresses from cropping machinery are becoming greater and deeper in our cropping soils as farm machinery increases in size and capacity to improve efficiency. This is due to increasing loads on axles, wheels and tracks. Such effects are of most concern on sandy soils which need depth to compensate for relatively low water holding capacity, compared with soils of higher clay content. Deep ripping provides a method of breaking up compacted soil, but greater depth of ripping encounters the problem of soil overburden pressure. Soil overburden pressure is the weight and tightness of soil above the penetrating point of a ripper, which can restrict the bursting out of soil towards the surface and restrict soil failure to a slot. Shallow leading tines that rip at two depths in one pass minimise this problem. Deep ripping when the soil is dry is also a convenient time in the cropping cycle, compared with when rain occurs and other operations will become a priority. Previous research has found shallow leading tines can reduce fuel use and minimise large clods when deep ripping, especially to depths below 300mm.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	3m x 40m x 4 replications
Soil type	Sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 4.5 10-20cm: 4.1 20-40cm: 4.7
EC (dS/m)	0.117 dS/m
Soil Amelioration	24/04/2014: Deep ripped in dry conditions using a Yeomans farm ripper (centre section) with towed rubber tyred roller; subsoil moisture content 5-7% v/v. The Case Steiger 435 HD used 40-45 L/h of fuel (41-46% engine power and 5-7% slip at 4.5kph) when ripping to 350-400mm in one pass. For the 2 bite system the tractor used 42-45 L/h of fuel (42-45% engine power and 4-5% slip at 4.5 kph) in a second pass to 400-450mm after a first pass using 28-30 L/h (30-38% power and 2-3% slip at 4.5 kph) ripping to 250-275 mm depth. 5 tines at 500mm spacing were used in all cases. No shear pins failed when ripping the plots. The front rank of tines was set at about 40mm shallower than the rear tines to reduce draft on the leading tines in all runs.
Sowing date	03/05/2014 with farm Morris airseeder
Seeding rate	50 kg/ha Calingiri
Paddock rotation	2010: wheat, 2011: wheat, 2013: lupin
Fertiliser	03/05/2014: 30 kg/ha DAPSCZ, 5.3 L/ha CalSap®, 1% Sulphate of Ammonia 05/06/2014: 40 L/ha UAN 09/07/2014: 30 L/ha UAN
Herbicides	03/05/2014: 1.8 L/ha Trifluralin, 1.5 L/ha Gramoxone, 275 g/ha Diuron, 0.3% LI 700 05/06/2014: 350 mL/ha Paragon, 50 mL/ha Alpha-cypermethrin, 30 g/ha Lontrel, 4 g/ha Metsulfuron
Growing Season Rainfall	180mm

Results

Table 1: Yield, screenings and some yield components at east Buntine, 2014.

Treatment	Biomass (t/ha)	Yield (t/ha)	Screenings (%)	Heads (m^2)	Yield/head (g)	1000 grain weight (g)
Unripped	4.95^a	2.27^a	0.50^a	67.0^a	0.034^a	41.42^a
One Rip	5.59^a	2.69^b	0.79^b	70.4^a	0.039^b	42.83^a
Two Rips	5.51^a	2.67^b	0.45^a	70.7^a	0.038^b	42.79^a
LSD (95%)	0.64	0.34	0.29	9	0.0027	2.028

Deep ripping by either method increased yield by 410 kg/ha or 18%. Most of this yield improvement came from more grains being filled in the heads of the deep ripped crop, shown in the 13% increase in yield/head. This probably came from better water supply to cool the crop in hot weather than from water to fill the grains. Grain weights and screenings in unripped and ripped treatments were not as different as yield/head; probably helped by grain fill from rain late in the growing season.

Surface Cloddiness

The two bite ripping showed less surface clod and the one bite more surface clod, as found in the previous research: http://www.giwa.org.au/_literature_125845/Hamza,_Mohammad_et_al_-_Significant_reduction_in_specific_draft_when_ripping

Plant Establishment

There were 147 plants/m^2 established in the nil treatment, 96 in the two rip treatment and 97 in the one rip treatment (standard error 13). Thus there were significantly less plants in the ripped treatments, but enough for a profitable yield, although there were some bare patches that would enable weed development. This was caused by the ripped soil being softer and supporting the seeder presswheels less than the unripped soil.

Soil Strength (at field capacity)

Penetration resistance measured on 11th July showed the pattern in Figure 1.

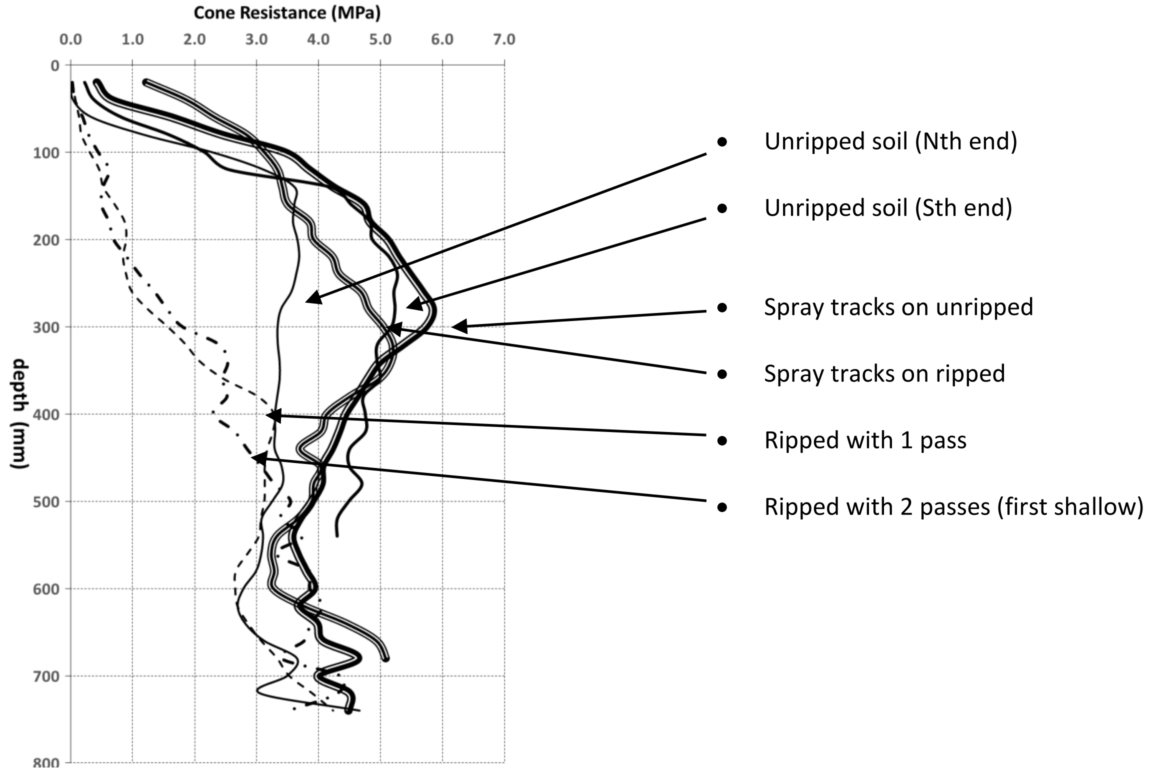


Figure 1: Cone resistance profiles.

A cone resistance of about 3.5MPa is usually enough to stop wheat root growth. Much of the crop roots in the paddock may be constrained to about 200mm depth at best. Either method of ripping has removed the constraint within 400mm depth, but a few passes of normal spraying traffic is enough to reverse the benefits in the first season and compromise long term benefits of deep ripping. Controlled traffic can help to maximise the benefits of investing in deep ripping by minimising recompaction in subsequent seasons. These earthy sands can also show ability to recompact over a number of seasons by the forces induced by wetting and drying but controlled traffic will minimise the need to use deep ripping to correct this.

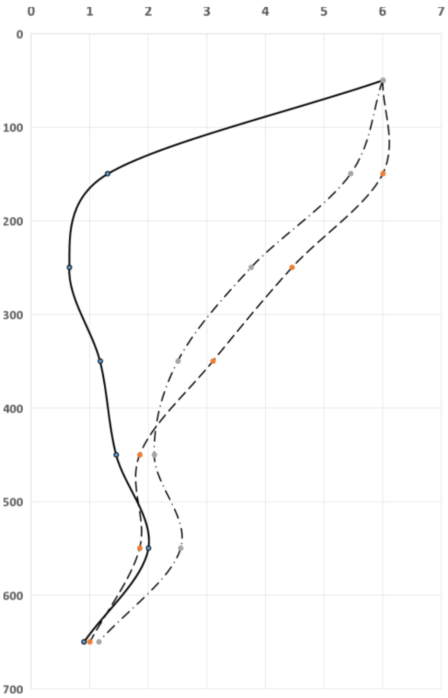
Root Distribution (from visual estimates in trench 12th August)

The side of the trench was exposed to view roots and a weldmesh guide was used to estimate root abundance at 70mm intervals. The photos in Figure 2 show an unripped plot and a deep ripped plot from each of the two deep ripping treatments. There did tend to be more topsoil incorporation with the shallow leading tine (two pass treatment), but the effect did not seem as extreme as can be achieved by a spader or deep working discs.

Unripped | Deep ripped one pass | Deep ripped shallow then deep

Figure 2: Root abundance profile photographs.

The root estimate is shown below for mean values of the four replicates; 6 = abundant roots, 3 = common roots, 1 = few roots, 0 = no roots. In the unripped soil most of the visible roots from 10 - 20cm were in biopores.



Root abundance estimate by depth in mm.

Solid line = unripped
Broken line = ripped in one pass
Dash and dot line = deep ripped with shallow first pass

There is no real difference between the estimated root abundance of the two methods of deep ripping.

Figure 3: Root abundance graph.

Soil Moisture Changes

CSIRO installed recording soil moisture sensors (FDR probes) on June 12th. Each probe consisted of two metal wires 300mm long and 3.2mm in diameter installed horizontally from a pit face at depths of 5, 20, 40, 60 and 80cm. Probes were installed in two replicates of each treatment. Soil moisture was monitored in each probe at 15 minute intervals commencing on June 12th and continued until probe removal on October 22nd to help analyse soil moisture extraction patterns. The early data collected up to August 13th showed evidence of more uptake from the two ripped plots compared with the unripped plot at a soil depth of 20cm. From July 8th to August 13th, uptake was 1.4, 7.0 and 3.6mm from the unripped, ripped once and ripped twice plots respectively. However, there were no differences between the treatments in terms of their water uptake from soil depths of 40cm or deeper. These differences are generally consistent with differences in root abundance (Figure 3).

Despite the differences in yield, differences in patterns of soil water uptake over the whole growing season were difficult to discern (Figure 4). Whilst there was some evidence of lower water content in the ripped plots at depths of 60 and 80cm, the parallel lines for the unripped and ripped plots suggests that this is more likely due to random differences in soil texture and gravel content, rather than a genuine treatment difference. Another interesting difference was observed for soil at 5cm from the surface, where water content was higher in the unripped plots than in the ripped plots. This is probably due to soil disturbance affecting the ability of the topsoil to hold water, which is supported by the lack of response to rainfall events at 20cm in the unripped plots. In other words, rainfall penetrated deeper into the soil in the ripped plots, which could potentially affect evaporation losses and may partly explain the observed yield differences.

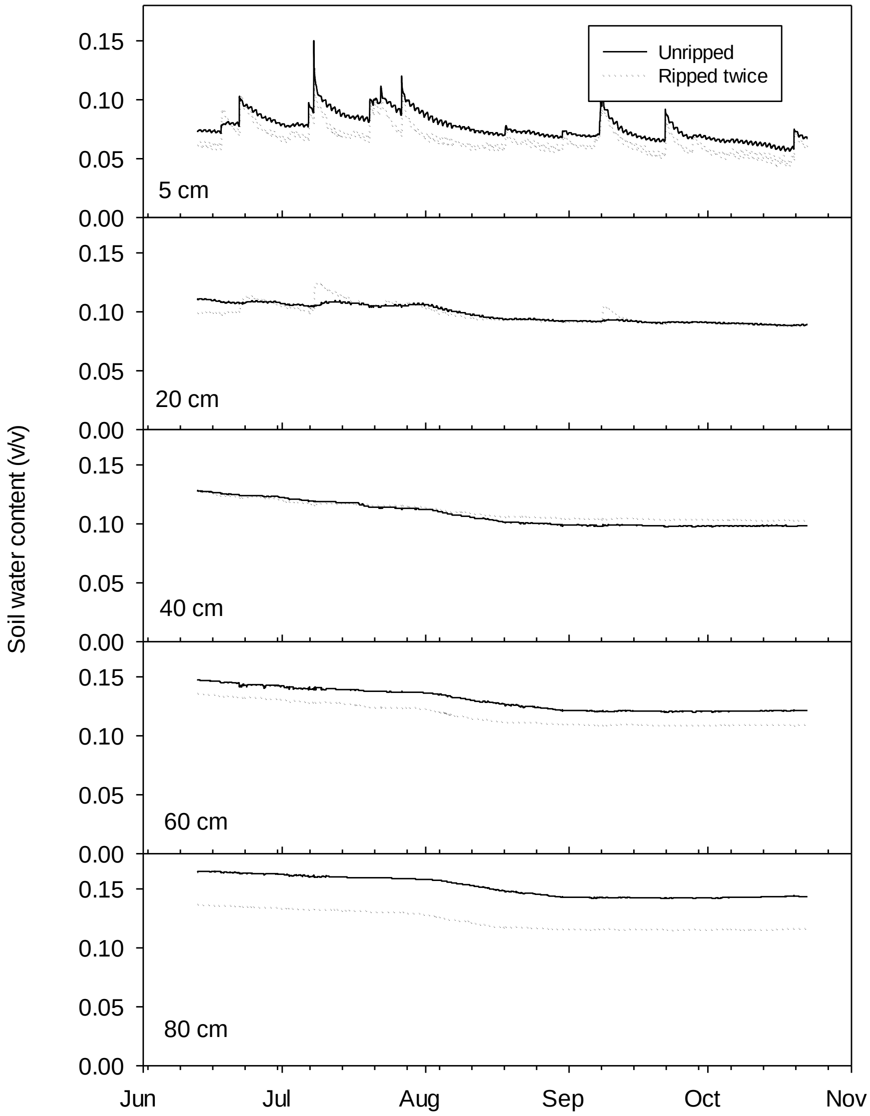


Figure 4: Soil water content changes with time at different depths.

Comments

- Deep ripping dry sand was more effective with two passes (or shallow leading tines) because the surface finish was less cloddy, allowing more reliable seed placement. Deeper seed placement in the trial was due to trying to use a common setting of presswheel pressure and frame height for the airseeder. In a whole deep ripped paddock the air seeder would be set up for optimum seed depth in just one condition. From previous research we already know shallow leading tines reduce cloddiness and fuel use; both are challenges to effective deep ripping of dry sand.
- Yield benefits of 410 kg/ha (18%) from deep ripping were mainly due to better head fill. About 12% more yield per head was found. The fewer plants in the deep ripped soil produced more tillers to provide about the same head population as the unripped treatment. Screenings and grain size were about the same, probably due to late rains. Larger yield improvements were found by deep ripping last season at the Liebe site (approx. 1 t/ha or 40%), probably because there was a more severe winter drought then and the benefits of improved water supply from the subsoil were more valuable to reducing drought stress and minimising yield losses.
- Better head fill was probably due to better cooling of the crop in hot weather due to better supply of moisture from rain which infiltrated deeper into the deep ripped soil to avoid more evaporative loss than the unripped soil. The water supply to the crops looked alike in all treatments but there was evidence of rain penetrating deeper in the deep ripped soil. This would be more difficult to lose by evaporation through the soil surface.

- A controlled traffic system will better protect the investment in deep ripping and extend the benefits. Deep ripping costs will also be reduced when the permanent tramlines are left unripped. Seeding can also be easier with better flotation with more of the seeding equipment wheels on permanent tramlines.

Acknowledgements
Ross and Shaun Fitzsimons for setting up the ripper, doing the ripping and recording the tractor performance, as well as the Liebe Group, for helping choose the site. The funding for this work comes from the new DAFWA project DAW00234 "Minimising the effect of soil compaction on crop yield" funded by GRDC.

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Evaluation of Spading x Lime Incorporation in Low pH, Non-Wetting Sand

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages

- Spading has buried the non-wetting layer of soil in this paddock, resulting in an increase in crop yield in two of the past three years.
- Using a spader to mix lime and dolomite into the subsoil has improved soil pH soil and increased yield.

Aim

To examine whether deep cultivation by spading can be used to manage water repellence and subsoil acidity on non-wetting sand.

Background

This demonstration was established in 2010 to assess the impact of a one-off deep soil cultivation using a rotary spader to dilute water repellent soils and ameliorate subsurface acidity through the incorporation of lime.

The trial was spaded in May 2010 to a depth of 30cm. The 'spade' on a rotary spader tyne can carry topsoil down into the subsoil and also bring subsoil up to the surface, mixing to a depth of 25-30cm. It is estimated that the rotary spader buries at least two-thirds of the topsoil. In 2011 the rest of the paddock was spaded to a depth of 34cm and lime and dolomite was incorporated giving us a side by side comparison of incorporation to depth.

Water repellence in soils is caused by waxes from plant residues which coat the sand particles. These waxes are hydrophobic and can cause slow and uneven infiltration of water into the soil. The mixing action of a spader reduces water repellence in sandy soils by diluting the organic matter rich, repellent topsoil through the top 30cm of the soil profile and by lifting seams of subsoil to the surface that can act as preferred pathways for water movement. As a consequence of the mixing action some of the topsoil can remain slightly water repellent after spading. The fate of the buried water repellent topsoil is not yet clear, and there is a risk that cultivation of this type may ultimately increase the depth of non-wetting. Current findings are mixed with severity of water repellence in the buried topsoil declining by half after three years at one site but no measureable change at another site after five years (S. Davies pers. comm.). Research to assess this further is ongoing. In poor sands with low clay content the buried topsoil and associated organic matter can hold more soil moisture than the bulk soil so it can increase the amount of water held in the root zone, albeit by a relatively small amount.

Surface applied lime in a no till system is slow to move down the profile. To significantly increase the subsoil pH below 10cm the lime must be incorporated. Spaders can effectively incorporate surface applied lime into acid subsoils to depths of up to 30-35cm thereby significantly speeding up the amelioration of subsoil acidity.

Trial Details

Property	Hunt Partners, Marchagee
Plot size & replication	22.5m x 1000m x no replications
Soil type	Deep yellow sand
Soil pH ($CaCl_2$)	0-5cm: 6 5-10cm: 5.2 10-20cm: 5.1 20-30cm: 4.8
EC (dS/m)	0.022
Sowing date	08/05/2014
Seeding rate	70kg/ha Calingiri
Paddock rotation	2010: lupins, 2011: wheat, 2012: wheat, 2013: lupins, 2014: wheat
Soil Amelioration	2010: (Spading plot only) 1 t/ha Lime and 1 t/ha Dolomite 2011: 1 t/ha Lime and 1 t/ha Dolomite
Fertiliser	08/05/2014: 42 kg/ha Agflow Extra, 18 kg/ha Muriate of Potash, 65 L/ha Flexi-N 01/07/2014: 34 L/ha Flexi-N
Herbicides	08/05/2014: 1.5 L/ha Spray.Seed, 2.5 L/ha Trifluralin, 35 g/ha Triasulfuron 01/07/2014: 25 g/ha Monza, 1.5 L/ha Precept
Growing Season Rainfall	240mm (April to end September)

Results

The 'spade' on rotary tynes, mixes soil to a depth of 25-30cm allowing the opportunity for mixing lime if pH is an issue. In Figure 1, a bulge in soil pH can be seen in the sub-soil where surface applied lime and dolomite lime was incorporated. The bulge corresponds with the maximum working depth of the spader. There is a difference where the bulge is between the 2010 and the 2011 spaded treatments which demonstrates that the lime/dolomite is moving down through the profile.

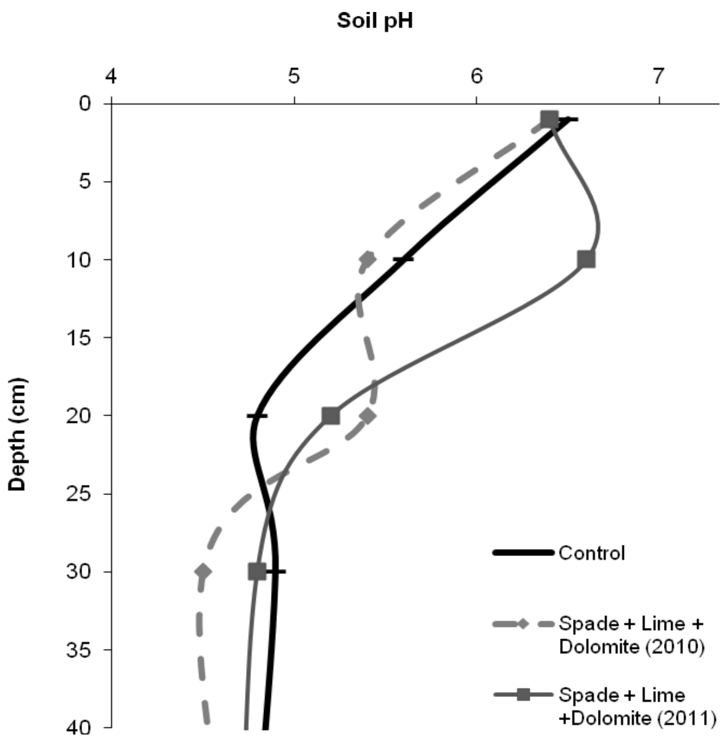

Figure 1: Soil pH ($CaCl_2$) profile changes as a result of spading and incorporating lime and dolomite measured in December 2014. Note all the treatments received a surface application of 1t/ha lime and 1t/ha dolomite in 2011.

In 2011 the whole trial was top dressed with 1 t/ha lime and 1 t/ha dolomite, this second application was not incorporated, but through the soil pH analyses carried out in December 2014 it has shown an increase in pH in the subsurface soil (10-20cm) which has led to an increase in yields over the control treatments as shown in Table 1 and Figure 2.

Table 1: Crop yields sown at Marchagee, incorporation of 1 t/ha lime and 1 t/ha dolomite using a rotary spader was carried out in 2010 and 2011 respectively.

Treatment	2014 Wheat Yield (t/ha)	2012 Wheat Yield (t/ha)	2011 Wheat Yield (t/ha)	2010 Lupin Yield (t/ha)
Control (No tillage)	1.57	0.8	1.3	0.7
Deep Ripped	1.58	1.0	1.4	0.7
Spade	1.67	1.0	1.5	0.5
Spade + Lime + Dolomite (2010)	2.15	1.2	1.7	0.5
Spade + Lime + Dolomite (2011)	2.26	-	-	-

Crop yields have been collected 2010 - 2012 and again in 2014 and are displayed in Table 1. In 2010, the year the spading was conducted, spading caused yields to decrease compared to the control as a result of the lupins being sown too deep and sand-blasted due to the lack of soil cover, greatly reducing plant numbers. In 2011 and 2012 spading (no lime or dolomite) increased yield by 0.2 t/ha above the control however, in 2014 the increase in yield was only 0.1 t/ha.

The farmer observed the infiltration of rainfall has improved on spading treaments. Using the spader to mix lime through the soil in an attempt to ameliorate soil acidity has improved yield beyond the initial gain of spading alone. The addition of lime and dolomite increased yield by an additional 0.2 t/ha compared to spading in both 2011 and 2012 and increased yield by 0.48 t/ha in 2014, which is the greatest increase in yield to date.

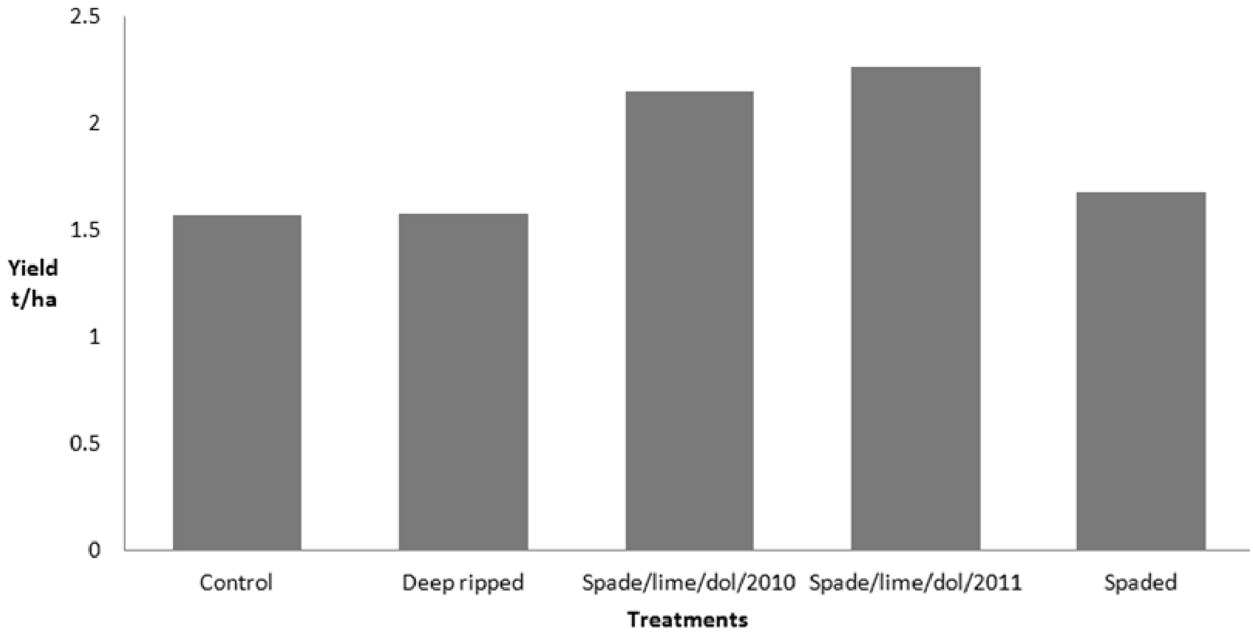

Figure 2: Wheat yield at Marchagee across all treatments in 2014. Note: All treatments were top dressed with 1 t/ha lime and 1 t/ha dolomite in 2011, bringing the total lime and dolomite on the spaded 2010 treatment to 2 t/ha lime and 2 t/ha dolomite.

Comments

Over the life of the trial the Hunt's have observed a difference over the treatments with the spading/lime/dolomite treatment attaining the desired results, leading them to full adoption of the practice in 2011 when they implemented the treatment over the rest of the paddock. The Hunt's are still reaping the benefits of adopting this method of incorporation to deal with the two issues that the paddock was presenting.

The implementation of this practice has been proven to attain increased results in yield but it is not without its own issues as the Hunt's experienced in 2010. Wind erosion risk is at its maximum in the first year with limited stubble cover allowing erosion which impacted final yield in 2010. Spading has the added benefit of reducing compaction in a similar method to deep ripping by physically breaking down any compacted layers in the top 30cm, although this benefit may only last a few years if a controlled traffic system is not implemented to sustain the benefit. In this demonstration there was no lasting impact of deep ripping or spading on their own on crop yield, indicating that the cultivation benefit of these has disappeared, however, the improved soil pH from incorporated lime and dolomite appears to be showing longer lasting benefits.

Acknowledgements
Thanks to Clint and Ian Hunt and Simon Meyer for implementing the trial and Stuart McAlpine for carrying out soil pH tests.

Paper reviewed by: Stephen Davies, Research Officer, DAFWA and Stuart McAlpine, Grower

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Mouldboard Plough and Cereal Rye Incorporation Demonstration

Lilly Martin, Research and Extension Agronomist, Liebe Group

Australian Government

LIEBE GROUP Working together in Agriculture

Key Messages

- Cereal rye has done an excellent job of providing ground cover on poor windblown sand.
- Approximately 4 t/ha of biomass was produced by the cereal rye.
- Using a mouldboard plough to incorporate cereal rye has increased soil organic carbon in the subsoil but decreased topsoil levels.

Aim

To evaluate the effects of mouldboard ploughing and its ability to increase carbon on a poor yellow sand.

Background

Cereal rye can be used to stabilise eroded land as it can tolerate infertile sandy soils, withstanding sand blasting much better than other cereals. The straw is tough both when growing and when mature, providing good protection for poor soil throughout the summer.

Mouldboard ploughing is a complete inversion of the soil, in this case to approximately 30cm. It can help with weed control, water repellent soils, placing lime at depth as well as having a deep ripping effect. Many farmers are considering using mouldboard ploughing as a once off paddock renovation to overcome one or more of these issues. Cost of operation is approximately $100-120/ha (Davies et al, 2012).

The trial is on a problem area of land that has been identified by the farmer as relatively unproductive with poor organic carbon levels and low pH at depth. In 2011 the area was planted to cereal rye in an effort to create some cover, preventing erosion. In 2012 the mouldboard plough was used to invert the top 30cm of soil, burying the rye stubble. 1 t/ha lime was later applied to the top soil.

Trial Details

Property	Bwlch Hendreff (G&H Pearse Pty Ltd), west Wubin
Plot size & replication	80m x 15.3m x 2 replications
Soil type	Yellow sand
Soil pH ($CaCl_2$)	0-10cm: 5.1 10-20cm: 4.5 20-30cm: 4.5 30-40cm: 4.5
EC (dS/m)	0.028
Sowing date	05/06/2014
Seeding rate	80 kg/ha top dressed + self sown cereal rye
Paddock rotation	2010: canola, 2011: cereal rye, 2012:cereal rye, 2013: cereal rye
Soil amelioration	21/06/2012: 1 t/ha lime
Fertiliser	50 kg/ha Macro Pro Extra
Herbicides	None
Growing Season Rainfall	210mm

Results

This season as well as being self sown the farmer also top dressed with another 80 kg/ha of seed. The farmer estimated that there is approximately 4 t/ha of biomass. The cereal rye has done the job that it was intended for, in that it has stabilised the poor windblown soil by providing exceptional ground cover. Grain yield and quality results are displayed in Table 1. There was almost no difference in yield between the mouldboard and the control plots.

Table 1: Yield, quality and grade of cereal rye sown at west Wubin.

Treatment	Hectolitre weight (%)	Protein (%)	Yield (t/ha)
Control	348.59	11.8	0.320
Mouldboard	351.50	12.1	0.315

Soil nutrient levels are low in both treatments as can be seen in Table 2, this is as a result of only having a small amount of fertiliser applied over the duration of the trial. The pH has dropped in the control plots from 5.5 to 5.1 whilst in the mouldboard treatments the pH has increased from 5.1 to 5.4.

Table 2: Comparison of soil nutrients from 0-10cm from the 2013 and 2014 seasons.

Treatment	Ammonia Nitrogen (mg/kg)	Nitrate nitrogen (mg/kg)	Phosphorus (Cowell mg/kg)	Potassium (Cowell mg/kg)	Sulphur (mg/kg)	Organic Carbon (%)	EC (dSm)	pH ($CaCl_2$)
Control 2013	0.9	1	9	18	2.7	0.46	0.021	5.5
Control 2014	2.5	4	16.5	39.5	3.95	0.53	0.031	5.15
Mouldboard 2013	0.9	0.9	9	22	2.4	0.21	0.017	5.1
Mouldboard 2014	1.5	3	17.5	48.5	3.25	0.25	0.035	5.4

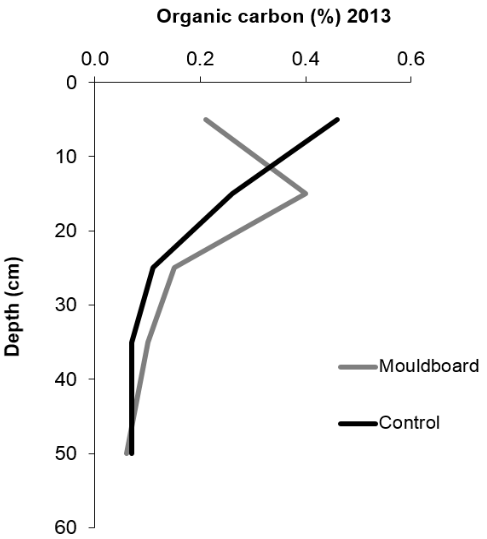

Figure 1: Soil organic carbon as a percentage of soil after cereal rye has been incorporated by ploughing (grey line) compared to no ploughing (black line), west Wubin, October 2013. Ploughing occurred in 2012.

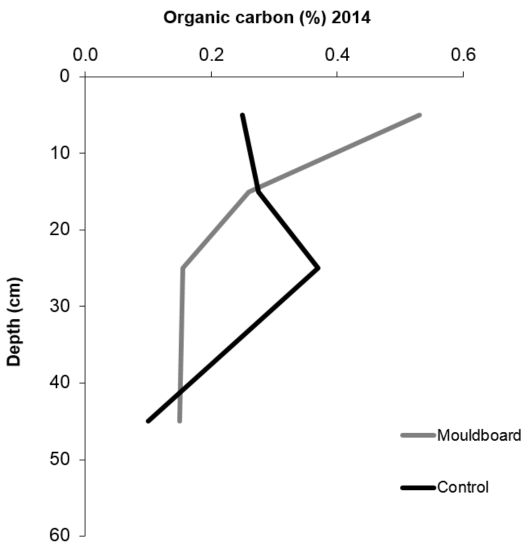

Figure 2: Soil organic carbon as a percentage of soil after cereal rye has been incorporated by ploughing (grey line) compared to no ploughing (black line), west Wubin, December 2014. Ploughing occurred in 2012.

Comments

This is not a fully replicated trial but a farmer demonstration that has nearest neighbour controls. In 2013 mouldboard ploughing increased subsoil organic carbon but decreased the topsoil levels, see Figure 1. In Figure 2 you can see that the mouldboard treatments topsoil organic carbon has improved slightly from 0.21% to 0.25%, this is as a result of the topsoil beginning to recover with the aid of the cereal rye. The control has seen a similar increase from 0.46% to 0.53%.

Results show that the soil organic carbon % has increased over both treatments since 2013. The total soil organic carbon has increased from 0.18% to 0.27% in the control treatment and 0.19% to 0.25% in the mouldboard treatment (measurements taken as an average of soil organic carbon % from 0-60cm). This indicates that the increase in soil organic % has come as a result of the cereal rye treatment and not from the mouldboard treatment. This tells us that as a short term investment mouldboard ploughing is not the answer in increasing soil organic carbon %. It is hypothesised that over a longer period of time the mouldboard plough treatment will continue to build organic carbon in the topsoil at a quicker rate than the control due to the current low levels. The trial will be continued to be monitored to see if it has an impact over a longer period.

Acknowledgements
Thank you to the Pearse family for hosting this trial. This project is funded by the Australian Government Department of Agriculture. Thank you to Justin Laycock and Frances Hoyle, Department of Agriculture and Food, WA for their help with bulk density testing in 2014.

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Bioprime: Impact on Yield, Soil Carbon Accumulation and Nitrogen Use

Peter Keating, Managing Director, Bioscience Pty Ltd

Aim

Trials from over four years are examining different rates and timing of application of Bioprime, a liquid soil amendment which changes soil microbiology. The aim is to relate measured plant growth and yield improvement to changes in microbial populations in the soil around roots, and to show how these changes and different ways of applying nitrogen (N) impact on soil carbon accumulation.

Background

This is the third year of Bioprime trials at the long term site. A review of the last two years led to a revision of the trial design, with fewer treatment types and more replicates.

In the previous two years, rainfall was poor in the first year, but relatively good in the second. Insufficient N caused a significant yield decline in the first year, but there was no decline in the second, possibly due to increased mineralisation of N following deep ripping of the soil in the second year. The decision was made to not test different N rates and application times, but rather to lower all fertiliser to 2/3 standard practice.

In 2014 Bioscience developed a new seed dressing form of Bioprime. The 2014 trials examined the impact of this new product on grain yield, with and without subsequent application of the standard liquid Bioprime.

Trial Details

Property:	Long Term Research Site, west Buntine
Plot size & replication	12m x 1.83m x 9 replications per treatment
Soil type	Sand/sandy loam
Soil pH ($CaCl_2$)	0-10cm: 5.1
EC (dS/m):	0.082
Soil carbon (%)	0.64
Sowing date	07/06/2014
Seeding rate	75 kg/ha (Mace)
Fertiliser	07/06/2014: 30 kg/ha Superphosphate, 17kg/ha Potassium sulphate, 30 kg/ha Urea
Paddock rotation	2011: wheat, 2012: wheat, 2013: wheat
Herbicides	05/06/2014: 118 g/ha Sakura, 2.5 L/ha Avadex, 400 mL/ha Diuron, 2 L/ha Spray.Seed
Growing Season Rainfall	185mm

Trial Design

Half the trial used seed treated with Bioprime Seed Treatment at 3 L/tonne of grain, and the other half used untreated seed. Standard Bioprime was applied at 3 rates (3 L/ha and 6 L/ha at the 2 leaf growth stage, and 3 L/ha at both 2 leaf and tillering). Including untreated controls, this meant 8 treatments were tested in 9 replicate blocks.

Data Collection

Bioscience visited the site at tillering and undertook visual rating. Plant roots were collected from healthy and unhealthy plants in the four treated and four untreated areas which showed signs of Rhizoctonia and compared to areas free of Rhizoctonia. This complemented trials undertaken elsewhere looking at the impact of Bioprime on Rhizoctonia. Root samples were recovered and the adhering rhizosphere soil was analysed by extracting DNA and undertaking ARISA profiling of microbial diversity.

Throughout the growing season, visual rating by both Living Farm and Bioscience did not show any significant differences between treatments.

2014 Yield Results

Table 1: Average yield (converted to tonnes per hectare) from 9 replicates of each of 8 treatments.

Trt No.	Type	Treatment Name	Yield (t/ha)
1	CHK	Untreated	1.61[cd]
2	SDTR FERT	Seed Treated No Foliar	1.73[a]
3	SDTR FERT	No Seed Treatment 3 L/ha Bioprime @ Tillering	1.58[d]
4	SDTR FERT	Seed Treated 3 L/ha Bioprime @ Tillering	1.69[abc]
5	SDTR FERT	No Seed Treatment 6 L/ha Bioprime @ Tillering	1.66[a-d]
6	SDTR FERT	Seed Treated 6 L/ha Bioprime @ Tillering	1.71[ab]
7	SDTR FERT FERT	No Seed Treatment 3 L/ha Bioprime @ Tillering 3 L/ha Bioprime @ Anthesis	1.64[a-d]
8	SDTR FERT FERT	Seed Treated 3 L/ha Bioprime @ Tillering 3 L/ha Bioprime @ Anthesis	1.62[bcd]
		LSD	0.088
		CV	5.64
		F Prob	0.022

Seed treatment without additional Bioprime produced a 7.5% increased grain yield. Treatment with foliar Bioprime caused a small (3%) but not significant increase in grain yield (treatment 5 compared to treatment 1).

The DNA results demonstrated no clear difference in root colonisation between treated and untreated seed, whereas application of liquid Bioprime to soil produced the expected changes in diversity within the different microbial groups tested (See Figure 1). Five of the groups, Dikarya (higher fungi), Firmicutes (formerly called gram positives), gamma Proteobacteria, Bacteroidetes and Archea showed significant increases in species diversity.

It was noteworthy that the Rhizoctonia patches were more evident in plots within the central block. We analysed the rhizosphere DNA from affected and unaffected plants within the same treatment plots. The analysis suggested Rhizoctonia is not correlated with the microbial diversity as measured by ARISA.

Complete data and statistical analysis can be viewed online at: www.biosciencewa.com/agriculture/trial results2014/Liebe.pdf

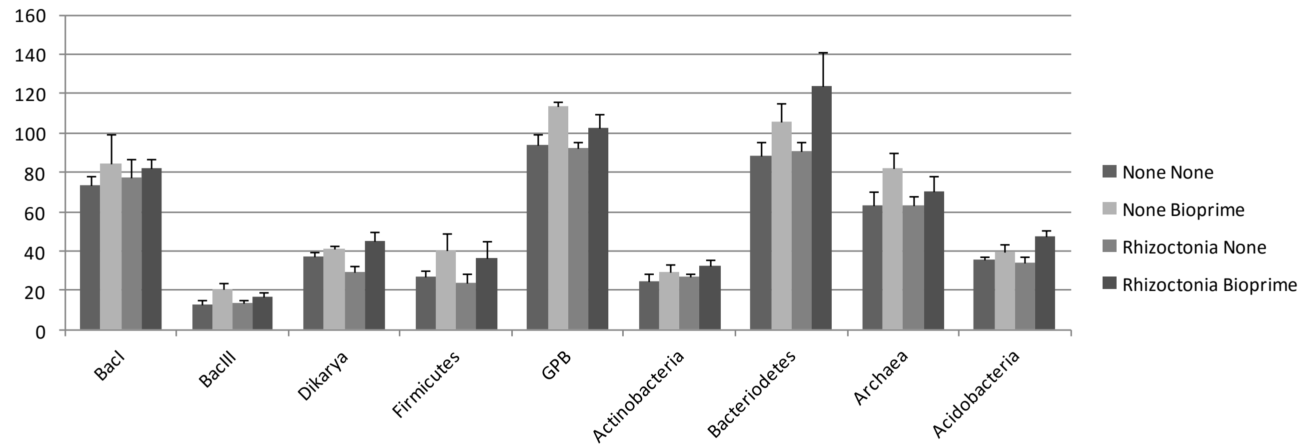

Figure 1: Graph of Operational Taxonomic Units (OTU) of 9 microbial groups from wheat rhizosphere soil.

Treatment with Bioprime changed biodiversity in 7 of the 9 groups, but the incidence of Rhizoctonia was not evident from ARISA data.

Discussion

The 2014 growing season had reasonable rainfall at 190mm, compared to 162mm in 2012 and 228mm in 2013. However, there was an unusually hot and dry August which is thought to have reduced tillering and ultimately, grain yield, to an average of 1.66 t/ha (compared to 1.45 t/ha in 2012 and 2.51 t/ha in 2013).

Under these conditions the seed treatment form of Bioprime produced a better yield outcome than the foliar application. Based on $280 per tonne for wheat, and a cost of $24 per tonne to treat seed, the treatment provided a net benefit of $31.80/ha.

The DNA evidence was that seed treatment did not produce a change in rhizosphere microbial diversity as measured using the ARISA assay. Contrasting this, post emergence treatment with Bioprime produced significant changes in five of nine groups tested and smaller, but not significant changes in another two groups. This suggests different mechanisms are operating with seed dressing and soil application of Bioprime. There did not seem to be any synergistic interaction between seed treatment and later applications, suggesting the changes in root colonisation did not have an impact on grain yield in 2014.

Acknowledgements

Richard Devlin and Living Farm staff.

Paper Reviewed by: Dr Margaret Roper, CSIRO

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Effects of Cultivation on Yield

Joe Delaney, Agronomist, Elders Scholz Rural

Key Messages

- Reduced yield experienced on cultivation treatment with the drying out effect at seeding.
- More root biomass in the early part of the season with cultivation.
- With no sub soil moisture cultivation did not have the desired effects on yield.

Aim

To compare and evaluate the yield effect from cultivation, before seeding versus a full cut system in a wheat crop.

Background

Cultivation farming, considered the traditional practice of farming, is the process by which paddocks are ploughed on several occasions before seeding. This step of prior cultivation helps in airing the soil, allowing good root growth and aiding the penetration and infiltration of rainfall deeper into the soil profile. It also helps in incorporating organic matter such as stubble and trash from the previous year and can also be used to incorporate lime quicker into the profile. However, the disadvantage of cultivating is soil erosion and increased water evaporation.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	3m x 15m x 3 replications
Soil type	Sand over gravel
Soil pH (CaCl2)	0-10cm: 4.5 10-20cm: 4.1 20-40cm: 4.7
EC (dS/m)	0.117
Soil amelioration	Off set disc before seeding
Sowing date	09/06/2014
Seeding rate	60 kg/ha Corack
Fertiliser	06/06/2014: 50 kg/ha DAP
Paddock rotation	2011: wheat, 2012: wheat, 2013: lupins
Herbicides	09/06/2014: 1 L/ha Paraquat, 1.2 L/ha Trifluralin, 200 g/ha Diuron pre-seeding 18/07/2014: 1 L/ha Velocity, 5 g/ha Ally, 1% Hasten
Growing Season Rainfall	180mm

Results

Table 1: Full cut and cultivation differences.

	Full Cut	**Cultivated**
Plants/m^2 @ 3WAS	173	83
Volunteer Lupins/m^2	30	2
Grasses/m^2	5	1
	15% more root biomass in the cultivated treatment	
Yield t/ha	0.87 t/ha	0.74 t/ha

Comments

The offset discs went in at a depth of 6 inches into good moisture. To simulate full cut we ran the seeder over the seeded plots again to be the same as full cut. With the cultivation it did dry out the soil before the seeding. This slowed emergence of seedling for 3-5 days against the non-cultivated treatments. The off-set discs also had a negative effect on germination numbers due to the drying effect of the cultivation. I believe this was the reason for the yield difference. Another reason for the low germination numbers was the depth of seeding. It was hard to get the depth right on the trial seeder in the cultivated strips as it did tend to dig in making the seeding depth uneven. In general the cultivation did have a good effect on weed control as it did bury seeds and could be used for the mechanical control of weeds.

Acknowledgements
Thanks to Summit for the trial seeder and to the Fitzsimons family for hosting the trial.

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Does Increasing Soil Organic Carbon in Sandy Soils Increase Soil Nitrous Oxide Emissions from Grain Production?

Louise Barton and Dan Murphy, UWA, and Frances Hoyle, DAFWA, South Perth

Key messages

- Crop production is often a source of greenhouse gas (GHG) emissions including nitrous oxide (N_2O).
- Increasing organic carbon (C) in the surface soil increased N_2O emissions from a cropped soil in the Western Australian grainbelt, however, losses were low by international standards.
- Greatest N_2O emissions occurred in response to summer-autumn rainfall events.

Aim

To investigate if increasing soil organic carbon (SOC) increases N_2O emissions.

Background

Crop production is often a source of greenhouse gas (GHG) emissions including N_2O, which is almost 300-times more potent than carbon dioxide (CO_2), as well as a sink for CO_2 via soil C sequestration. Understanding the interactions between soil organic carbon (SOC) and N fertiliser, and its influence on GHG emissions and crop yield is critical when assessing the effectiveness of soil organic carbon (C) sequestration to abate GHG emissions from the agricultural land sector.

The effect of increasing SOC via tillage practises on GHG emissions varies depending on soil type. A review of international studies showed for a well-aerated soil (e.g. sands), increasing soil C abated soil GHG emissions via soil C sequestration plus decreased soil N_2O emissions. Increasing SOC by the same amount in poorly aerated soils (e.g. clay) was less effective at abating GHG emissions, as increased soil N_2O emissions from the poorly aerated soil offset soil C sequestration. These findings were mainly derived from agricultural systems in the Northern Hemisphere, and their applicability to southern Australian cropping systems is unknown.

Experimental Approach

We are investigating if increasing SOC alters soil N_2O emissions at the Liebe Group's Long Term Research Site at Buntine (Table 1). The site was established in 2003, and includes a variety of replicated treatments aimed to alter SOC. The current study is utilising field plots that have either been tilled annually with or without the addition of organic matter (OM) every three years. In May 2011, the OM+tillage plots contained 1.2% C in the surface 100mm, while the Tillage treatment contained 0.5% C. Two blocks (Tillage, OM+tillage) have been divided into six plots, with half the plots in each block receiving no nitrogen (N) fertiliser and the remaining plots receiving N fertiliser (100 kg N/ha as urea in 2013 and 2014).

Soil N_2O emissions will be measured for approximately 2.5 years, and commenced 6 June 2012 following seeding. Fluxes are measured using soil chambers (one per plot) connected to a fully automated system that measures N_2O emissions using gas chromatography. Chambers (500mm x 500mm in area) made of clear perspex are placed on metal bases inserted into the ground. The chamber height is progressively increased to accommodate crop growth, with a minimum height of 150mm and a maximum height of 900mm. Four bases are located in each treatment plot to enable the chambers to be moved to a new position every week so as to minimise the effect of chambers on soil properties and plant growth. In addition, grain yield is estimated at harvest each year by collecting hand-cuts collected from each treatment.

Trial Details

Property	Long Term Research Site, west Buntine
Experimental design	2 OM treatments x 2 N fertiliser rates x 3 replicates
Treatments	*OM treatments:* 1. Tillage only (annual tillage using offset disks) 2. OM+tillage (OM applied every 3 years, last applied 2012 at rate of 20 t/ha; annual tillage using offset disks) *Nitrogen fertiliser treatments* 1. No N fertiliser 2. N fertiliser (100 kg N/ha applied 4 weeks after seeding)
Plot size	10.5m x 3.6m
Soil type	Deep yellow sand (Basic Regolithic Yellow-Orthic Tenosol)
Sowing date	06/05/2014
Seeding rate	100 kg/ha oats (cv. Brusher)
Fertiliser	03/06/2014: see above "Treatments" for details
Paddock rotation	2011: wheat, 2012: canola, 2013: barley
Herbicides	03/04/2014: 1 L/ha Glyphosate, 300 mL/ha Ester 680, 100 mL/ha Garlon 06/05/2014: 0.5 L/ha Diuron, 0.5 L/ha Dual Gold 30/06/2014: 2 L/ha Spray.Seed, 500 g/ha Diuron, 140 g/ha Cadence, 1.5 L/ha Precept, 1% Hasten
Harvest date	04/11/2014
Growing Season Rainfall	185mm

Results

Hourly N_2O fluxes ranged from -9 to 108 µg N_2O -N/m^2/h in the first two years of the study (7 June 2012–7 June 2014). Losses appeared to be greater from the OM+tillage treatment, especially in response to summer-autumn rainfall (Figure 1). The total amount of N_2O emitted during the first two years of the study varied in response to both the OM treatment and the application of N fertiliser. Consequently, total N_2O losses after two years were ranked: OM+tillage, plus N fertiliser (413 g N_2O-N/ha) > OM+tillage, no N fertiliser (203 g N_2O-N/ha) > Tillage, plus N fertiliser (42 g N_2O-N/ha) = Tillage, no N fertiliser (11 g N_2O-N/ha) (Figure 1). The proportion of N fertiliser emitted as N_2O, after correction for the 'background' emission (no N fertiliser applied) was 0.1% for the OM+tillage treatment. An emission factor for the Tillage treatment was not calculated as the annual N_2O emission did not differ between the plus and no N fertiliser treatments.

Comments

Increasing soil C contents in the surface soil appears to increase the risk of N_2O emissions from a cropped soil in the Western Australian grainbelt. Annual N_2O emissions were 20-times greater from the OM+tillage treatment than the Tillage treatment in the absence of N fertiliser, and almost 10-times greater when N fertiliser was applied. This finding is not unexpected as increasing soil C is known to increase the size of soil microbial biomass, including the microorganisms responsible for N_2O emissions.

Despite N_2O emissions increasing in response to the OM additions, the range of annual N_2O emission at the present study site (0–0.27 kg N_2O-N/ha/yr) are conservative in comparison to values reported for other cropped sites in Australia and overseas. Globally, and across a variety of climatic regions, annual N_2O losses from cropped mineral soils have ranged from 0.3 to 16.8 kg N_2O-N/ha/yr. The annual N_2O emission reported for Buntine is also within the range of values that have been reported for other cropped soils in the Western Australian grainbelt (Table 1).

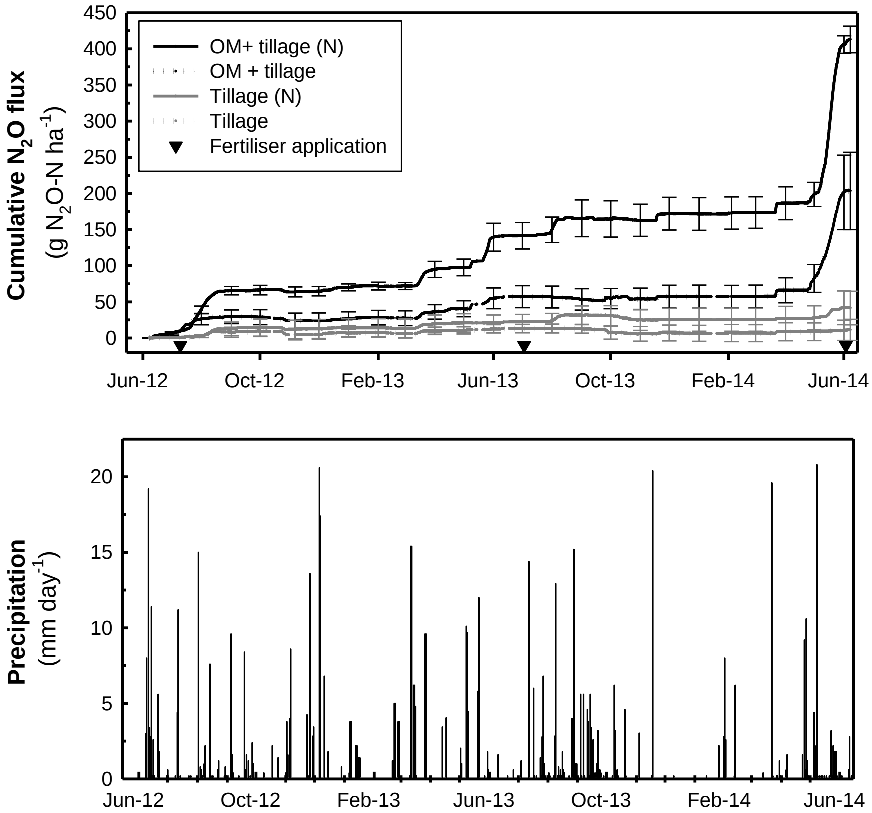

Figure 1. Cumulative N_2O emissions for each OM treatment (a) and daily precipitation (b) after two years of investigations at the Long Term Research Site, Buntine, (7 June 2012 – 14 June 2014). Cumulative N_2O fluxes represent means (± standard errors) of three replicates. The triangle indicates the timing of N fertiliser applications.

Table 1. Annual N_2O emissions from cropped soils in Western Australia.

Location, year	Crop	N application (kg/ha/yrN)	Annual N_2O emission (kg/ha/yrN)	Emission Factor (%)
Cunderdin, 2005	Wheat	0	0.09	0.02
		100	0.11	
Cunderdin, 2006	Wheat	0	0.07	0.02
		75	0.09	
Cunderdin, 2007	Canola	0	0.08	0.06
		75	0.13	
Cunderdin, 2008	Lupin	0	0.13	NA*
Wongan Hills, 2009	Lupin	0	0.04	NA
	Wheat	75	0.06	
Wongan Hills, 2010	Wheat	20	0.06	NA
	Wheat	50	0.07	

*Not applicable

The N_2O emission factor for the application of N fertiliser to land for the OM+tillage treatment (0.1%) was less than the both the international default value (1.0%) and the value used by the Australian Government for dryland agriculture (0.3%), but slightly greater than values previously reported for the Western Australian grainbelt (Table 1).

Largest hourly N_2O emissions occurred in response to summer-autumn rainfall events. This is consistent with previous observations in the central grainbelt, where a large proportion of annual N_2O emissions occurred between crop growing seasons, when the soil was fallow, and in response to soil wetting following summer–autumn rainfall. Elevated N_2O emissions following summer-autumn rainfall have been attributed to the rapid release of readily decomposable OM to viable microorganisms following wetting of dry soil. These substrates can be derived from non-living organic matter already present in the soil, and from the death of microorganisms due to rapid changes in water potential.

Acknowledgements

Debra Donovan for maintaining the automated gas chambers and field site at Buntine, and Chris Swain for coordinating soil and plant analyses. The Liebe Group for allowing access to the Long Term Research Site and assisting with the establishment and maintenance of the study site. This project is supported by funding from the Australian Government and the Grains Research and Development Corporation.

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Bentonite Clay and Tillage to Improve Soil and Yield

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages

- Crop germination was poor on the mouldboard plots and compaction is still a big issue on these plots.
- Bentonite clay has shown no effect on organic carbon %.

Aim

To determine if the inclusion of Bentonite clay improves crop yields on non-wetting sandy soils and their ability to store more carbon.

Background

Bentonite clay, also known as smectite, can be found near Watheroo and is used by home gardeners to increase water and nutrient holding capacity in sandy soils. This trial examines if 6 t/ha of Bentonite clay can improve water and nutrient holding capacity of agricultural soil sufficiently to increase crop yield. The 'A' grade Bentonite sourced from Watheroo costs $130 per tonne and has 82% clay content.

Three methods of incorporating the Bentonite (mouldboard plough, deep ripping and tandem discs) were also compared.

Mouldboard ploughing involves a one-off inversion of the topsoil. The plough in this trial was able to invert the top 30cm of soil. Mouldboard ploughing can help in the control of weeds, burying water repellent topsoil, incorporating lime at depth as well as having a deep ripping effect. Cost of the operation is approximately $100-150/ha (Davies et al, 2012). The deep ripping cost was $60/ha and the tandem disc operation was $30/ha.

Trial Details

Property	Manji Spring, Miling
Plot size & replication	50m x 20m not replicated
Soil type	Yellow sand
Soil pH ($CaCl_2$)	0-10cm: 6 10-30cm: 4.7
EC (dS/m)	0-10cm: 0.04
Sowing date	30/04/2014
Seeding rate	3 kg/ha Benito canola
Paddock rotation	2011: wheat, 2012: wheat, 2013: barley
Fertiliser	30/04/2014: 75 kg/ha Mallee Extra, 25 kg/ha Muriate of Potash, 50 L/ha Flexi N 28/06/2014: 80 kg/ha NS51 25/07/2014: 40 L/ha Flexi N
Herbicides & Insecticides	30/04/2014: 3 L/ha Atrazine, 1 L/ha Propyzamide, 25/05/2014: 2 L/ha Atrazine, 200 mL/ha Talstar 11/06/2014: 500 mL/ha Select, 240 mL/ha Targa, 100 mL/ha Alpha Cypermethrin
Growing Season Rainfall	225mm

Results

This is a large scale farm demonstration which is not replicated and results should be treated with caution. The soil type improves down the paddock from the Bentonite to the non-Bentonite plots which was reflected in increasing yields down the paddock rather than treatment results. This was evident in no significant differences between all treatments on yield in 2013 and 2014. The mouldboard plots had severe compaction issues and several wheel tracks where there was very poor emergence which has impacted the plot yield.

Table 1: Yield and quality of Benito canola on the no Bentonite treatment sown at Miling, 2014.

Tillage type	Treatment	Yield (t/ha)	Protein (%)	Oil (%)
Mouldboard	No Bentonite	0.94	22.4	42.4
None	No Bentonite	0.79	22.1	41.6
None	No Bentonite	1.24	22	42.8
Mouldboard	No Bentonite	1.47	21.9	44.5
Deep rip	No Bentonite	1.94	19.9	45.7
None	No Bentonite	1.61	19.8	45.8
Disc	No Bentonite	1.19	22	43.5

Table 2: Yield and quality of Benito canola on the Bentonite treatment sown at Miling, 2014.

Tillage Type	Treatment	Yield (t/ha)	Protein (%)	Oil (%)
Mouldboard	Bentonite	0.52	21.9	42.5
None	Bentonite	0.63	22.7	41.9
None	Bentonite	0.85	22.2	42.6
Mouldboard	Bentonite	0.87	21.8	44.2
Deep rip	Bentonite	1.22	22	43.7
None	Bentonite	1.45	18.9	46.2
Disc	Bentonite	1.86	20.2	46.6
None	Bentonite	1.93	22.1	43.8

Table 3: Average soil organic carbon as a percentage of soil two years after treatment at Miling, December 2014. Incorporation occurred in 2012.

Cultivation Type	Ameliorant	Soil organic carbon % (0-60cm)
Mouldboard	Bentonite	0.19
Control	Bentonite	0.24
Deep Ripped	Bentonite	0.23
Tandem Disc	Bentonite	0.29
Mouldboard	No Bentonite	0.23
Control	No Bentonite	0.32
Deep Ripped	No Bentonite	0.47
Tandem Disc	No Bentonite	0.27

Comments

In the first year of the trial there was no change in yield or grain quality after the incorporation of Bentonite clay. However, it's important to note that there is an improvement in soil type in the non-Bentonite plots. With this in mind the results from 2014 should also be treated with caution. The soil organic carbon percentage is greater on the plots that were untreated with Bentonite (Table 3) but again we feel that this is more a reflection of paddock variation than treatment effect.

The trial has made the farmer realise that mouldboard ploughing is not practical for their farm unless they can strip down their seeding rig as it is currently too heavy (approximately 70 tonne loaded) and left 18cm deep ruts on the mouldboard plots where the liquid cart followed. There was no plant establishment on these ruts. Another comment was on the narrow window of opportunity there is to implement mouldboard ploughing without the detrimental effects such as wind erosion and compaction. With these factors in mind the farmer has decided that in their particular system deep ripping is the most effective tool they currently have at their disposal. The grower also observed that if the Bentonite has been mixed better in the 20 to 30cm layer that it may have shown a better result.

Acknowledgements

Thank you to the Seymour Family for hosting the trial, Justin Laycock and Frances Hoyle, Department of Agriculture and Food, WA for their help with bulk density testing in 2014. Thanks to Shari Dougall and Bruce Thorpe from DAFWA Wongan Hills for conducting the mouldboard ploughing. This demonstration is funded by the Australian Government Department of Agriculture's Action on the Ground project.

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Liebe Group Soil Biology Trial

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages

- Organic matter treatments showed greater early vigour, but this was not reflected in yield due to the dry season.

Aim

To investigate the potential of 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 level of organic carbon for sandy soils in our environment. The plots have now received a total of 80 t/ha of organic matter across four separate applications (2003, 2006, 2010, 2012) of chaff. Future modelling will determine whether the soil is nearing its upper soil organic carbon capacity.

Trial Details

Property	Long Term Research Site, west Buntine
Plot size & replication	10.5m x 80m x 3 replicates
Soil type	Deep yellow sand
Soil pH ($CaCl_2$)	Topsoil: 6.0 Subsoil 4.6
EC (dS/m)	0.1
Sowing date	06/05/2014
Seeding rate	78 kg/ha
Paddock rotation	2010 wheat, 2011 wheat, 2012 canola, 2013 barley
Fertiliser	None
Herbicides & pesticides	03/04/2014: 1 L/ha Roundup UltraMAX, 300 mL/ha Ester 680, 100 mL/ha Garlon 06/05/2014: 2 L/ha Spray.Seed, 0.5 L/ha Diuron, 0.5 L/ha Dual Gold 30/06/2014: 500 g/ha Diuron, 140 g/ha Cadence, 1.5 L/ha Precept, 1 % Hasten
Growing Season Rainfall	185mm

2013 Treatment List

1. Control (minimum till with knife points and full stubble retention).
2. Tilled soil using offset discs.
3. Organic matter (chaff is applied once every 3 years last applied 2012 at rate of 20 t/ha; tilled with offset discs).
4. Organic matter run down (plots were chaff was previously applied in 2003 & 2006 but not since).
5. Burnt (stubble burnt annually in March; minimum till).

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, brown manure.
2007	Wheat – sprayed out	None recorded	
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.
2010	Wheat (cv. Magenta)	2.5-1.9 t/ha	20 t/ha 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	20 t/ha chaff applied.
2013	Barley (cv. Hindmarsh)	2.3-3.6 t/ha	Addition of organic matter increased yield.

Results

In 2014, the only results of significance are for the hectolitre weight of the oats from the 'Control'. This is possibly more a reflection of the dry season than a true reflection of the treatments. In previous years the OM treatments have resulted in over 1 t/ha yield increases as shown in Table 2 as the OM has made the soil more resilient.

Table 1: Quality for oats comparing different tillage and stubble retention methods west of Buntine, 2014. Results followed by the same letter do not significantly differ from each other (P= 0.05).

Treatment	Protein (%)	Screenings (%)	Hectolitre Weight (%)
Brown Manure	12.2[a]	5.72[a]	51.34[b]
Burnt	11.63[a]	5.47[a]	50.05[b]
Control	11.27[a]	4.2[a]	53.25[a]
Organic matter run down	12.3[a]	5.7[a]	49.85[b]
Tilled soil	12.4[a]	6.17[a]	50.89[b]
Organic matter	12.17[a]	4.2[a]	50.43[b]
F - probability	0.095	0.151	0.022
LSD	0.874	1.828	1.869

Table 2: Yield results comparing different tillage and stubble retention methods west of Buntine from 2010 to 2014. Results followed by the same letter do not significantly differ from each other (P= 0.05).

Treatment	Yield Oats 2014 (t/ha)	Yield Barley 2013 (t/ha)	Yield Canola 2012 (t/ha)	Yield Wheat 2011 (t/ha)	Yield Wheat 2010 (t/ha)
Brown manure	0.49[a]	2.74[ab]	Brown manured	-	-
Control	0.68[a]	2.62[ab]	0.71[a]	3.31[a]	2.5[a]
Tilled	0.54[a]	2.88[b]	0.78[ab]	3.41[a]	2.4[a]
Tilled + OM	0.60[a]	3.69[c]	0.97[b]	4.23[a]	1.9[a]
OM rundown	0.52[a]	3.03[b]	0.87[ab]	4.00[a]	2.5[a]
Burnt	0.63[a]	2.35[a]	0.78[ab]	3.78[a]	2.4[a]
LSD	NS	0.48	0.25	NS	NS

Comments

On an average rainfall year the Soil Biology Trial has proven that increased amounts of OM in the soil has increased the soils buffering ability by improving the soils water and nutrient holding capacity, leading to higher yielding crops. At the beginning of the season there was visually greater biomass at the site leading us to hypothesize that the crop fell over due to the extra biomass running out of moisture with the extreme heat stress in August.

This biomass could not be sustained during the dry period in August; as such there was no difference in the treatments come harvest. This underlines that although in some of the previous dry seasons the added OM sites have shown significant yield increase compared to the control in extreme dry conditions that extra buffering ability can also reach critical levels and effect production.

It is probable that the OM treatments may have caused more N mineralisation in the soil, pushing the crop biomass, explaining how the 'Control' (0N) has a greater yield in this instance.

Acknowledgements
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Changes in Soil Organic Carbon and Yield in Response to Compost and Spading on a Sand

Frances Hoyle, Natalie Hogg, Justin Laycock, Liam Ryan (DAFWA); Liebe Group staff

Aim

To assess the effects of physical (spading), chemical (fertiliser) and biological (compost) treatments on soil organic carbon (SOC) in relation to changes in long term crop yields and quality.

Background

Growers are constantly assessing the long term profitability and sustainability of their farming systems. Often growers look to target an optimum gross margin rather than highest yield. This demonstration trial was established in 2013 and carried on into 2014 to determine whether measureable changes in soil organic carbon (SOC) and productivity could be associated with physical disturbance and/or higher levels of either chemical or biological inputs applied to the soil.

In this instance the influence of physical disturbance compared plus and minus spading, chemical inputs were compared by high and low chemical fertiliser inputs, and biological inputs compared plus and minus compost. The impact of different inputs was assessed by considering any changes in SOC storage, yield and/or profitability.

Trial Details

Property	Long Term Research Site, west Buntine
Plot size & replication	50m x 18.2m x 4 replications
Soil type	Deep yellow Sand (Tenosol, 13% clay 0-30 cm)
Soil pH ($CaCl_2$)	0-10cm: 6.0 10-30cm: 4.7
EC (dS/m)	0-10cm: 0.10 10-30cm: 0.04
Sowing date	06/05/2014
Seeding rate	78 kg/ha Brusher oats
Fertiliser	06/05/2014: All treatments 10 L/ha Flexi-N; 9 L/ha CalSap, Low treatment 25 kg/ha Urea, High treatment 50 kg/ha urea (top-dressed) 07/05/2014: Low treatment 34 kg/ha TSP, High treatment 80 kg/ha TSP (top-dressed) 18/07/2014: Low treatment 25 kg/ha Urea, High treatment 50 kg/ha Urea (top-dressed)
Herbicides	06/05/2014: 2 L/ha Spray.Seed, 0.5 L/ha Diuron, 0.5 L/ha Dual Gold 30/06/2014: 500 g/ha Diuron, 140 g/ha Cadence, 1.5 L/ha Precept, 1% Hasten
Paddock rotation	2010 wheat, 2011 wheat, 2012 canola, 2013 barley
Soil amelioration	17/05/2013: Rotary spading
Growing Season Rainfall	159mm (May-October); 129mm (includes consideration of summer rainfall and losses due to evaporation and run-off)

Results

2013

Soil (baseline)

In March 2013, soils were marginal for inorganic nitrogen (N) and below 10cm were low in pH with low level compaction in the 10-20cm layer (Table 1). Water holding capacity (0-10cm) was approximately 29%. The microbial biomass (mass of microorganisms) in surface soil to 10cm measured 92 kg/ha (63 mg/kg soil).

Table 1: Selected soil properties (0-30cm) for soil collected in March 2013 at the Buntine experimental site prior to treatments being imposed.

Depth	Phosphorus (Colwell, mg/kg)	Potassium (Colwell, mg/kg)	Sulfur (mg/kg)	Organic carbon (%)	Organic carbon (t C/ha)	pH ($CaCl_2$)	Bulk density (g/cm^3)	C/N ratio
0-10 cm	29	73	25	0.86	12.9	6.0	1.45	12
10-20 cm	18	51	15	0.50	8.7	4.7	1.76	10
20-30 cm	7	53	20	0.26	1.9	4.7	1.63	8

Grain Yield

In 2013 control (non-spaded) plots yielded 15% more than spaded treatments (2.2 t/ha versus 1.9 t/ha) but grain protein was lower (9.6% versus 11.3%) – resulting in a similar uptake of nitrogen (35kg N/ha). Compost showed no yield response with a nominal increase in grain protein, compared to fertiliser treatments which demonstrated higher N uptake due to both increased yield and protein (42kg N/ha). High screenings on the spaded treatments (42% screenings < 2.5mm) suggests the spaded areas may have experienced higher water stress later in the season and may explain the slightly lower grain weight compared to non-spaded areas (30% screenings < 2.5mm). This would be supported by seasonal observations that crop height and biomass were greater in spaded treatments than non-spaded treatments.

2014

No change in nutrient status was measured in 2014 following treatments imposed in 2013 (Table 2). Cation exchange capacity (CEC) was evenly distributed across all soil layers in spaded treatments as compared to non-spaded treatments where more than 50% was in the surface 0-10cm indicating changes in CEC associated with the burial of organic matter.

Table 2: Soil properties (0-30cm) in March 2014 – 12 months after treatments were imposed at Buntine. Data is the average of all treatments.

Depth	Nitrogen (NH_4, NO_3; mg/kg)	Phosphorus (Colwell, mg/kg)	Potassium (Colwell, mg/kg)	Sulphur (mg/kg)	Cation exchange capacity (meq/100g)	Organic carbon (%)	Organic carbon (t C/ha)	pH ($CaCl_2$)	Bulk density (g/cm^3)	C/N ratio
0-10cm	10	23	66	31	2.8	0.6	9.1	5.8	1.5	10
10-20cm	6	23	56	25	2.0	0.5	8.7	5.1	1.7	10
20-30cm	3	12	58	21	1.5	0.3	5.1	4.8	1.6	8

Changes in soil pH were evident as a result of spading across all soil depths and resulted in a profile which should arguably support higher productivity (Figure 1). Surface (0-10cm) pH decreased by approximately 0.5 units in spaded treatments, but increased at 10-20cm (0.7 pH units) and 20-30cm (0.5 units) taking these layer above the minimum pH of 4.8 recommended for these soil layers.

A large ($p<0.05$) decline in dissolved organic carbon of 39% was observed in spaded treatments, as well as a 60% decline in microbial biomass carbon (81 kg/ha) and 57% decline in potentially mineralisable nitrogen (6 kg/ha) compared to area that were not spaded.

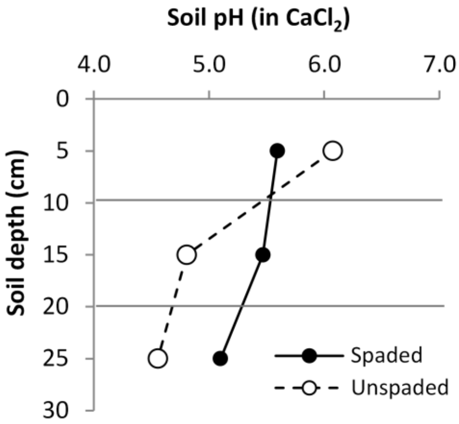

Figure 1: Effect of spading applied in 2013 on the soil pH profile (as measured in $CaCl_2$) to 30cm of in 2014 (data is the average of all treatments).

SOC stocks (0-30cm depth) averaged 22.4t C/ha in treatments which had no spading applied and 19.0t C/ha in spaded treatments indicating a significant decrease of approximately 15%. The surface layer (0-10cm) where most organic matter is located experienced the greatest losses with the spaded treatment approximately half that of unspaded treatments (SOC 0.4% versus SOC 0.8%). It appears a component of this was lost and the remainder redistributed to the 20-30cm soil layer which measured an increase in SOC (0.4% SOC versus 0.2% in unspaded areas).

No other treatment differences were measured as a result of either increased fertiliser or from applying compost (Figure 2).

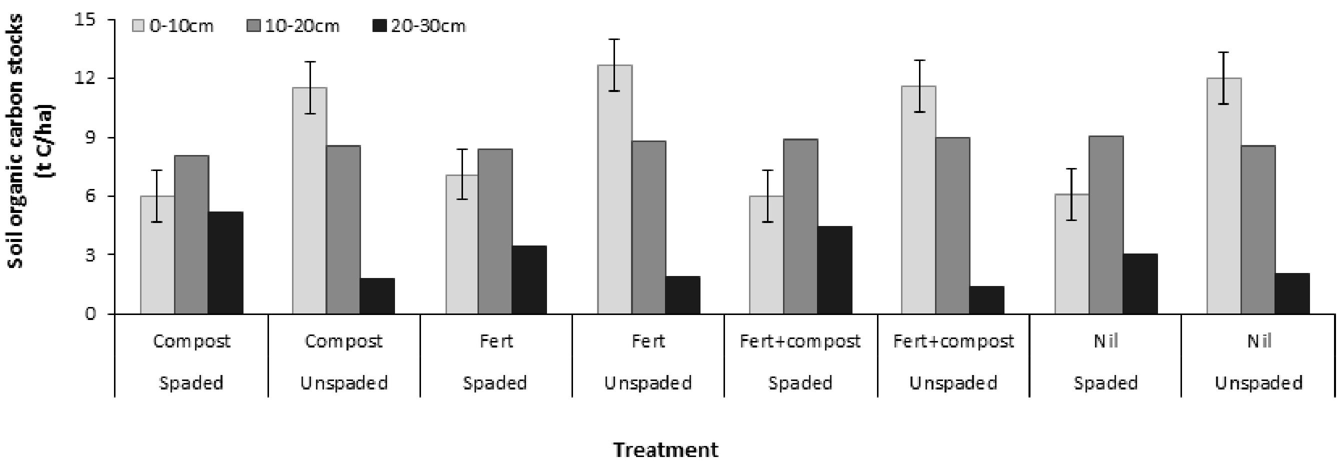

Figure 2: Effect of spading, compost and fertiliser application on soil organic carbon (t C/ha) measured in 2014 at depths of 0-10, 10-20, 20-30cm.

Hay Yield

No significant changes in hay yield were measured at this site associated with treatments in 2013/2014. A rainfall to yield conversion suggests approximately 15kg of hay yield per mm of growing season rainfall (May to October rainfall, plus one third of January-April rainfall) was achieved taking into consideration some loss of water through run-off and evaporation (one third of total growing season rainfall).

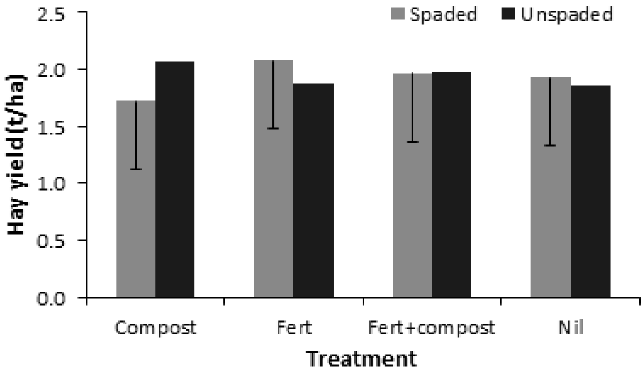

Figure 3: Effect of treatments applied in 2013 on hay yields in 2014.

Economic Analysis
In 2013 the application of 2 t/ha compost did not result in higher returns and the response under compost plus fertiliser treatments could be attributed to the application of fertiliser. Spading did not return any further gains in terms of yield or quality at this site in 2013 (Figure 4). The high cost of spading and compost has negatively influenced profit outcomes. Short term yield responses observed in both 2013 and 2014 suggest these treatments are unlikely to pay for themselves over the longer term at this site.

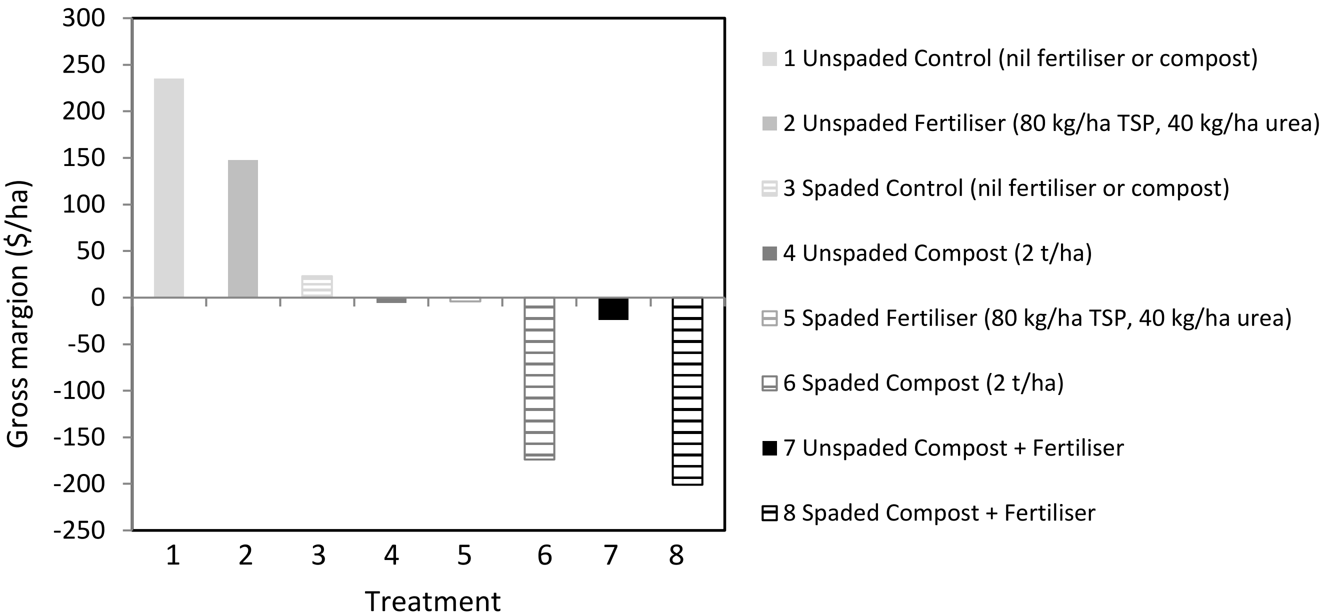

Figure 4: Gross margins ($/ha) for soil treatments applied to barley in 2013 on a deep sand at Buntine. Light shaded areas represent spaded treatments; dark shaded areas are non-spaded treatments. Treatment numbers are on the bottom axis of graph. Source: Nadine Hollamby Liebe Group.

Thus in this instance the most profitable treatments would have been the non-spaded control (Treatment 1) and the non-spaded fertiliser (Treatment 2; Figure 1). This is likely to reflect analyses of 2014 yield and quality results (not yet complete). The only measureable changes in soil condition noted in 2014 that would add value to the potential long term profit of this site was increasing soil pH at depth associated with spading.

Comments
Machinery used for composting caused some compaction and under dry post-sowing conditions as experienced in 2013 can cause patchy germination. In 2013 the trial site experienced significant moisture stress early in the season and may not be representative of seasons experiencing an average or wetter start. Extended moisture in spring supported good yields associated with high grain weights. In 2014 the site had good starting moisture and rainfall but experienced dry post sowing conditions through June and July.

This site has not responded greatly to fertiliser suggesting N was not a limiting factor in either season. Soil tests taken in March also suggest there would be no other limiting major nutrients (P, K, S) to crop growth. The control treatments which had a minimum fertiliser and background turnover of SOC (assumed at 3% per year) could have been expected to supply between 65 and 80kg N/ha.

Application of compost at 2 t/ha is nominal given the background SOC stocks of approximately 20 t/ha (0-30cm). To have an impact on soil function the rate of application required is likely much greater and would need to be maintained and applied at regular intervals to avoid losses.

Acknowledgements
Thanks to the Liebe Group and their growers for continued interest and support for this project and management of the trial site. Also thanks to Natalie Hogg (DAFWA), Richard Bowles (UWA) and Justin Laycock (DAFWA) for enabling this trial site to be implemented and sampled. This project is led by the Department of Agriculture & Food, WA in collaboration with the Liebe Group and is supported by funding from the Australian Government.

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Managing Acidity

Stuart McAlpine, Contract Research, Development and Extension, Optima Agriculture

Key messages

- In furrow remediation could be useful in managing acidity generated by fertiliser placement.
- CalSap® is a liquid product which can be used to manage acidity generated by fertiliser in the furrow.

Aim

Examine the effect of variable rates of fertiliser on acidity in the furrow and how CalSap® interacts with soil pH over a period of time at different locations in the profile.

Background

CalSap® is a liquid product designed to prevent further acidification from banded fertiliser in the soil. In this case the liquid was banded at seeding with liquid nitrogen (N). The suggested application rates for a sandy soil is 4-5 L/ha. In this farmer demonstration the Dodd's compared different rates of CalSap® (0, 5 and 10 L/ha) and different rates of fertiliser.

Optima CalSap® is 6% calcium, fully soluble, and has an organic chemistry base that makes the product reactive. With a pH of 12.5 this process also makes the product soil and plant safe.

Previous trial data has demonstrated that CalSap® is high reactivity and alkalinity is a useful tool in changing pH levels where the seed and fertiliser is placed. The management of furrow pH will lead to better nutrient recovery and therefore improved efficiency from the applied fertiliser. An improved pH in the root zone will allow for potential increases in biological activity and less root pruning. Soluble calcium provides additional benefits to plants and soil over simple acid neutralization when applied to the root zone. Optima CalSap® should not be seen as a lime replacement to remediate existing acidity but one component of a strategy to address acidity on the farm.

Trial Details

Property	Mike and Narelle Dodd, west Buntine
Plot size & replication	300m x 14m x no replications
Soil type	Yellow Sand (pear tree)
Soil pH ($CaCl_2$)	0-15cm: 4.5 15-40cm: 4.3
EC (dSm)	0.05
Sowing date	30/05/2014
Seeding rate	3 kg/ha Stingray
Fertiliser	30/05/2014: 35 kg/ha AgFlow, 10 kg/ha Muriate of Potash, Flexi-N as per protocol (Table 1) 20/07/2014: 30 L/ha of Flexi-N at cabbage
Soil Amelioration	27/03/2013: 2 t/ha Limesand, full cut cultivation
Paddock rotation	2010: pasture, 2011: wheat, 2012: wheat, 2013: wheat
Herbicides	29/05/2014: 1.1 L/ha Glyphosate, 1.1 kg/ha Atrazine, 1 L/ha Propyzamide 01/06/2014: 1.1 kg/ha Atrazine 28/06/2014: 500 mL/ha Clethodim
Growing Season Rainfall	185mm

Results

The highest yielding treatment was 0.75 t/ha and received 30 L/ha Flexi-N and 10 L/ha CalSap® (Table 1). The lowest yield recorded was 0.59 t/ha for 30L/ha of Flexi-N and no CalSap®. This was an un-replicated farmer demonstration so it is difficult to tell if a difference in yield is random paddock variation or caused by application of product.

Table 1: Canola yield and quality grown with three rates of CalSap® and different fertiliser rates applied at seeding, west Buntine 2014.

Plot #	Flexi-N (L/ha)	CalSap® (L/ha)	Yield (t/ha)	Oil (%)	Protein (%)
1	30	0	0.69	42.4	23.2
2	0	0	0.65	43.3	23.3
3	30	10	0.75	42.7	22.7
4	60	10	0.68	41.8	23.2
5	30	5	0.74	43.1	23.1
6	60	0	0.69	41.3	24.4
7	60	5	0.64	41.5	24.1
8	30	0	0.59	41.9	24.4
9	0	0	0.71	43.2	22.1

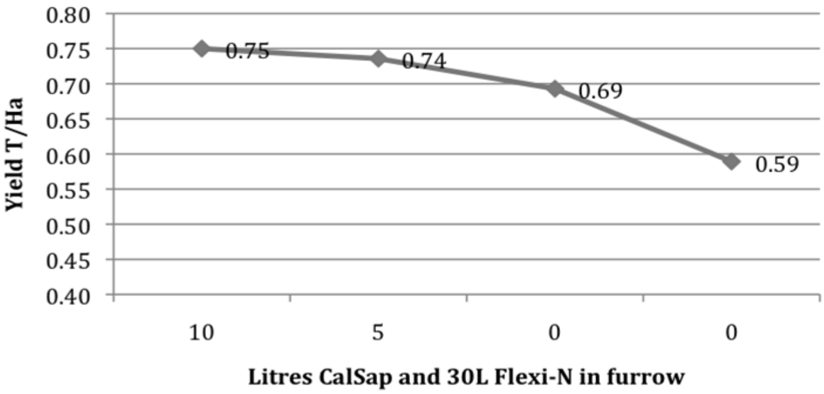

Figure 1: Yield comparisons at 30 L/ha of Flexi-N in furrow at Buntine.

Economic Analysis

Table 2: Input costs for treatments compared to income generated from grain yield for trial west of Buntine in 2014 (Includes treatment costs and oil bonuses).

Plot	CalSap® (L/ha)	Flexi-N (L/ha)	Flex-N Post (L/ha)	Yield (t/ha)	Total Costs ($/ha)	Gross ($/ha)	Net ($/ha)
1	0	30	30	0.69	74.49	346.43	271.94
2	0	0	30	0.65	61.46	323.21	261.75
3	10	30	30	0.75	90.00	375.00	285.00
4	10	60	30	0.68	103.03	339.29	236.25
5	5	30	30	0.74	86.31	367.86	281.55
6	0	60	30	0.69	86.04	342.86	256.82
7	5	60	30	0.64	94.16	317.86	223.70
8	0	30	30	0.59	70.79	294.64	223.85
9	0	0	30	0.71	60.72	355.36	294.64

Table 3: Input costs for treatments compared to income generated from grain yield for trial west Buntine in 2014 (Includes treatment costs and oil bonuses), ranked by return and showing treatment $/ha difference to highest ranked plot.

Treatment #	CalSap® (L/ha)	Flexi-N (L/ha)	Flex-N Post (L/ha)	Yield (t/ha)	Net ($/ha)	$/ha difference to highest ranking treatment
9	0	0	30	0.71	294.64	0.00
3	10	30	30	0.75	285.00	-9.64
5	5	30	30	0.74	281.55	-13.09
1	0	30	30	0.69	271.94	-22.70
2	0	0	30	0.65	261.75	-32.89
6	0	60	30	0.69	256.82	-37.82
4	10	60	30	0.68	236.25	-58.39
8	0	30	30	0.59	223.85	-70.79
7	5	60	30	0.64	223.70	-70.94

Comments

The demonstration site was sown with favourable conditions continuing into May and June. July was dry and August was drier with some really high temperatures when soil moisture was all but exhausted. The higher applications of N have suffered from the production of biomass that has affected yield in the hot dry conditions. Mike has commented that in retrospect the post application of N would have been better left out. CalSap® at the lower rates of N seem to have been worthwhile economically but as the trial is not replicated and there are some inconsistencies in plots of the same treatments results should be treated with caution. It is hoped that the trial can be continued next year. Closer evaluation of soil pH through the profile will be investigated to determine changes.

Acknowledgements

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Sustainable Farming through Improved Understanding of Soil Quality

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Aim

To understand how agricultural and mining practices alter soil quality through collaboration with local farmers, in order to enable land management practices to progress towards more sustainable systems.

Background

With a growing global population, food demands are increasing worldwide and it is therefore required that there is increased and ongoing agricultural production (Lemenih et al., 2005). Soil is a fundamental resource for agricultural production; however, management practices of this industry have the potential to have adverse effects on the quality and health of the soil (Lemenih et al., 2005). The extraction of mineral resources is an obtrusive process, where the overlying vegetation is cleared and topsoil is removed. Rehabilitation is required to return the area to its natural state. For soil to be productive and stable the physical, chemical and biological properties must be robust (Department of Environment and Primary Industries, 2006).

Assessing soil quality through investigation of the chemical and biological properties is an approach widely used across Western Australia. These properties are assessed as they react effectively to soil disturbance. Assessment of these properties can also indicate how capable a soil is of recovery from these disturbances. Fundamental knowledge of how soils biological and chemical properties have been altered through land management practices will enable steps towards possible improvements in practices to retain optimum microbial functioning.

The overall objective of this study was to determine if and how agricultural and mining land management practices have altered soil quality in the grain belt of Western Australia, focusing specifically in the Liebe Group area. This was done by comparing soil chemical and biological properties between anthropogenically altered land (through agriculture or post-mining rehabilitation) with adjacent remnant vegetation. The study was based on the hypothesis that soil microbial indicators will differ as a consequence of agricultural production and rehabilitation following mining operations. Specifically, it was hypothesised that soil microbial biomass would be greater in remnant areas compared to altered areas, whereas CO_2 emissions (microbial respiration) would be lower. Understanding changes in soil chemical and biological properties can assist in the continuing development of sustainable farming practices and best practice rehabilitation strategies.

Methodology

Soil samples were taken from five study sites that had a paired altered and a remnant bush land area (Figure 1). Sites 1 to 4 were paired agricultural and remnant bush sites. Land holders provided information of previous management of the sampled areas. Site 1 had gypsum applied in 1994 and lime in 2006. Cropping rotation for the past 5 years was pasture, wheat, wheat, pasture and wheat in 2013, 2012, 2011, 2010 and 2009 respectively. Site 2 had no gypsum applied, but lime was applied in 1999. It has been most recently been cropped with wheat in 2013, which followed on from pasture, pasture, wheat and pasture in 2012, 2011, 2010, and 2009 respectively. Site 3 cropping history was lupins, barley, wheat, wheat and lupins in 2013, 2012, 2011, 2010 and 2009, respectively and lime was applied in 2009. Site 4 had no gypsum applied, but lime was applied in 2010. The site was most recently cropped with canola in 2013 and previously in wheat, lupins and wheat in 2012, 2011 and 2010 respectively.

Site 5 was a paired rehabilitation and remnant bush site within the Mount Gibson mine site. The Mount Gibson mine site, of Extension Hill Limited, has been in operation since 2011. The study site was subject to the removal of 26,429m^3 of gravel and subsequently rehabilitated. Rehabilitation occurred in 2011 and included reshaping and ripping of the land, and the respreading of topsoil. There was no application of fertiliser to the rehabilitated site.

Study sites were visually assessed before soil sampling for suitable pairing of the bush land and altered land. This involved assessing if there were differences in landscape (e.g. presence of rocky outcrops), colour of soil, and slope between paired sites. All sites selected passed this preliminary assessment.

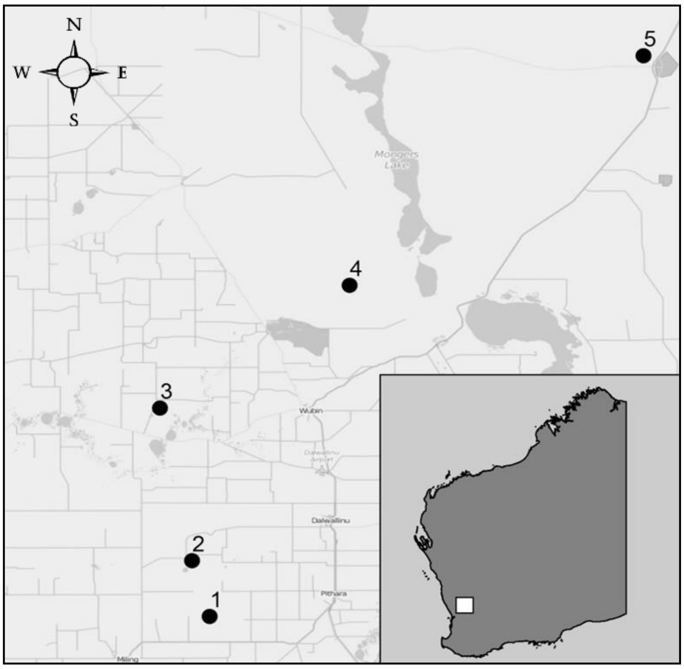

Figure 1: Map displaying sites where soil samples were collected within the Liebe focus area.

Soil cores were taken from the depths of 0–10cm, 10–20cm, and 20–30cm at every site and were transferred to the University of Western Australia for further analysis. Standard methods were used to assess soil texture (by particle size analysis), soil pH ($CaCl_2$) and soil salinity (EC). Total carbon (C) and nitrogen (N) were analysed by dry combustion (Elementar CHN analyser). Inorganic N (NO_3^- and NH_4^+) was analysed spectrophotometrically on soil extracts using an auto analyser.

Soil microbial biomass carbon was measured by the fumigation-extraction technique using the k_{EC} correction factor of 0.45. This provides a measure of the mass of living microorganisms (mostly bacteria and fungi) within the soil. Soil microbial respiration, a measure of the heterotrophic activity of the living microorganisms, was analysed by incubation of soil in sealed glass jars with measurement of the headspace CO_2-C concentration using an infrared gas analyser three times with three day intervals.

Results

Soil Texture

Particle size analysis in the laboratory determined that soil texture at sites 2, 3, 4 and 5 did not vary between the altered agricultural/rehabilitated areas and remnant bushland areas (Table 1). However, soil textures at site 1 were different between the altered and remnant areas indicating that this site was not well paired. Therefore, comparisons based on site 1 were not included when drawing overall conclusions drawn from this study.

Table 1: Texture of each site at the depths of 0-10, 10-20, and 20-30cm.

Depth (cm)	Site 1		Site 2		Site 3		Site 4		Site 5	
	Altered	Bush	Altered	Bush	Altered	Bush	Altered	Bush	Altered	Bush
0-10	Sandy loam	Loamy sand	Sand	Sand	Sand	Sand	Sand	Sand	Loamy sand	Loamy sand
10-20	Sandy loam	Loamy sand	Sand	Sand	Sand	Sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand
20-30	Sandy loam	Loamy sand	Sand	Sand	Sand	Sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand

Biological properties

Overall microbial biomass carbon did not change in response to disturbances from agriculture or rehabilitation with no significant differences between altered samples and remnant bushland samples. Microbial biomass carbon from the surface soil (0-10cm; 355 mg/kg) of site 1 bushland was 3 times greater than the average value for the remaining sites (127 mg/kg) (Figure 2). Sites 2, 3, 4 and 5 had no significant change between study areas (Figure 2). There is clear stratification between depths with significantly increased microbial biomass carbon at shallow depths (0-10cm, 10-20cm) at sites 1, 2, 3 and 4 (P≤ 0.05, Figure 2). Microbial biomass carbon in the subsoil (20-30cm) did not exceed 100 mg/kg^{-1}, with most sites (site 2, 3 and 4) having between 0-27 mg/kg^{-1} microbial biomass carbon (Figure 2).

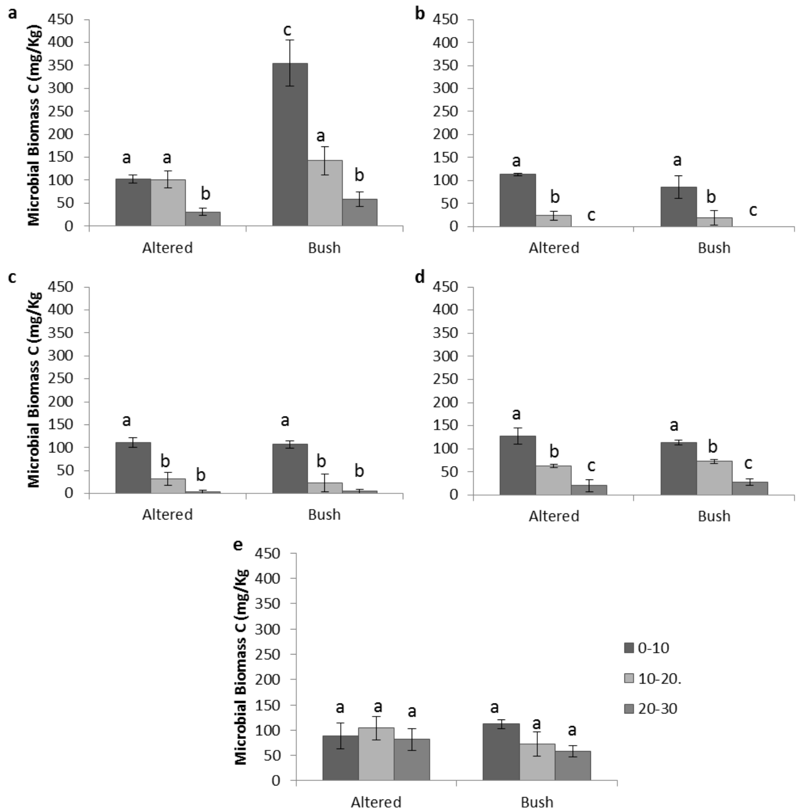

Figure 2: Average microbial biomass C with standard error bars, at each depth, 0-10cm, 10-20cm and 20-30cm, at each site: (a) site 1, (b) site 2, (c) site 3, (d) site 4 and (e) site 5, in anthropogenically altered areas and remnant bushland areas. Different letters above bars indicated significance at P≤ 0.05.

Microbial respiration was greater in the altered samples at sites 2 and 4 than in the remnant bushland samples, reaching averages of 100 and 84 mg/kg dry soil/day (P ≤ 0.05 Figure 3). The highest microbial respiration (activity) was found at site 1 in the remnant bushland samples, with an average of 112.26 mg/kg dry soil/day, respiration in the altered samples averaged 62.4 mg/kg dry soil/day (Figure 3). No significant difference in respiration was found at site 3 and 5 between the altered and remnant bushland samples.

Metabolic quotients (a ratio of the respiration rate per unit of microbial biomass) revealed significantly higher activity per unit biomass at sites 1, 4 and 5 from the altered samples (P≤ 0.05 Table 2). Sites 2 and 3 did not have significantly different metabolic quotients between the altered and bushland samples (Table 2).

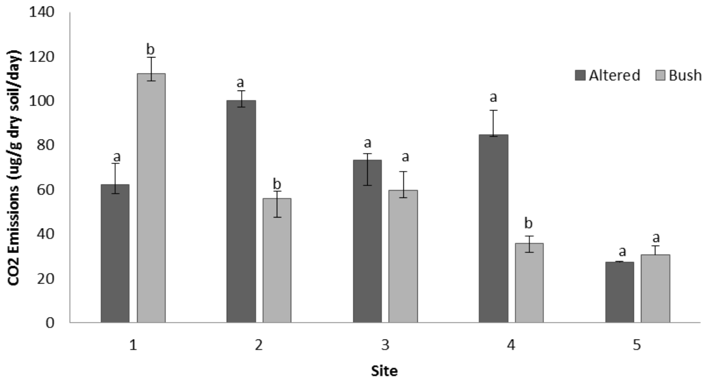

Figure 3: Average microbial respiration, as CO_2 emissions, with standard error bars, in the top 10cm of the soil profile at each site for altered and remnant bushland samples. Different letters above bars indicate significance at P≤ 0.05.

Table 2: Metabolic quotients (rate of respiration per unit biomass) of altered and remnant bushland samples from the top 10cm samples at each site with standard error.

	Site 1		**Site 2**		**Site 3**		**Site 4**		**Site 5**	
	Altered	**Bush**	**Altered**	**Bush**	**Altered**	**Bush**	**Altered**	**Bush**	**Altered**	**Bush**
Metabolic Quotient	0.64	0.33	0.88	0.84	0.69	0.55	0.66	0.31	0.40	0.25
Standard Error	(0.13)	(0.41)	(0.03)	(0.22)	(0.09)	(0.04)	(0.00)	(0.01)	(0.06)	(0.02)

All sites within the study were found to be nitrate (NO_3^-) dominant with NO_3^- ranging between 41 mg/kg^{-1} and 8 mg/kg^{-1} (Figure 4). Inorganic N present as ammonium (NH_4^+) ranges between averages of 2.4 mg/kg^{-1} and 0 mg/kg^{-1} of dry soil (Figure 4). There was no difference between the amount of inorganic N as NO_3 altered and remnant bushland areas for sites 1, 3, 4, and 5 (Figure 4). There was increased NO_3 in the altered samples at site 2 with a mean of 29.17 mg/kg^{-1} compared to 9.85 mg/kg^{-1} within the remnant bushland samples after 23 days of incubation (P≤0.05, Figure 4). Low NH_4^+ concentrations were measured throughout the incubation of soils from all sites.

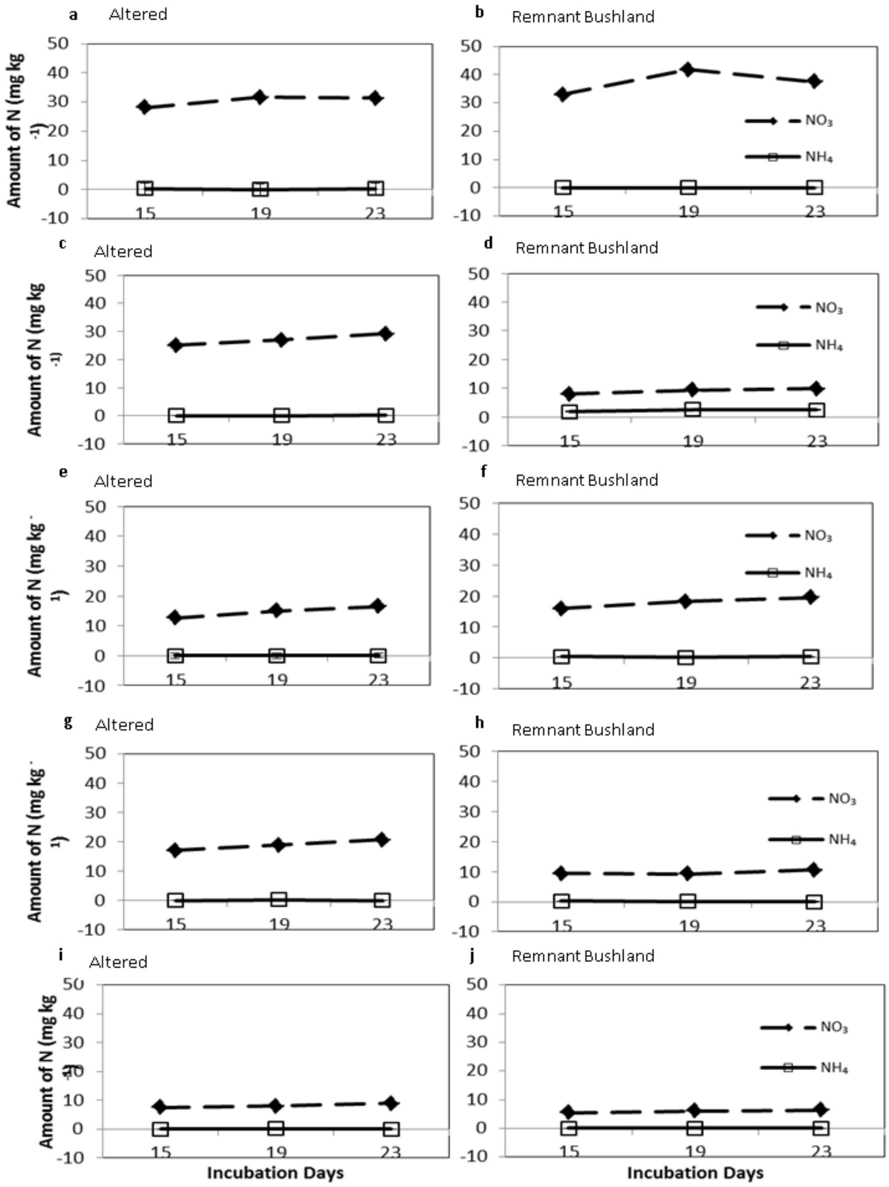

Figure 4: Average NO_3^- and NH_4^+ with standard error bars, at each depth, 0-10cm, 10-20cm and 20-30cm, at each site: (a) site 1, (b) site 2, (c) site 3, (d) site 4 and (e) site 5, in anthropogenically altered areas and remnant bushland areas.

Chemical properties

Total C and N were greatest in the remnant bush land samples from site 1 with 1.98% and 0.125% respectively at 0-10cm (Figure 5). All other sites had total C ranging between 0.2 – 0.8% and total N between 0.01 – 0.06% (Figure 5). Percentage of total C and N behave in the same pattern as each other at all sites (Figure 5). No difference was found between altered samples and bush land samples at Sites 4 and 5 of total C and N. Site 1 only had significantly increased total C in altered samples compared to bush land samples at 20-30cm ($P \leq 0.05$, Figure 5). Sites 2 and 3 have significantly higher total C and N in altered samples compared to bush land samples in the top 20cm ($P \leq 0.05$, Figure 5). Total C and N decreased with depth at sites 1, 2 and 3 in both altered and remnant bush land samples ($P \leq 0.05$, Figure 5).

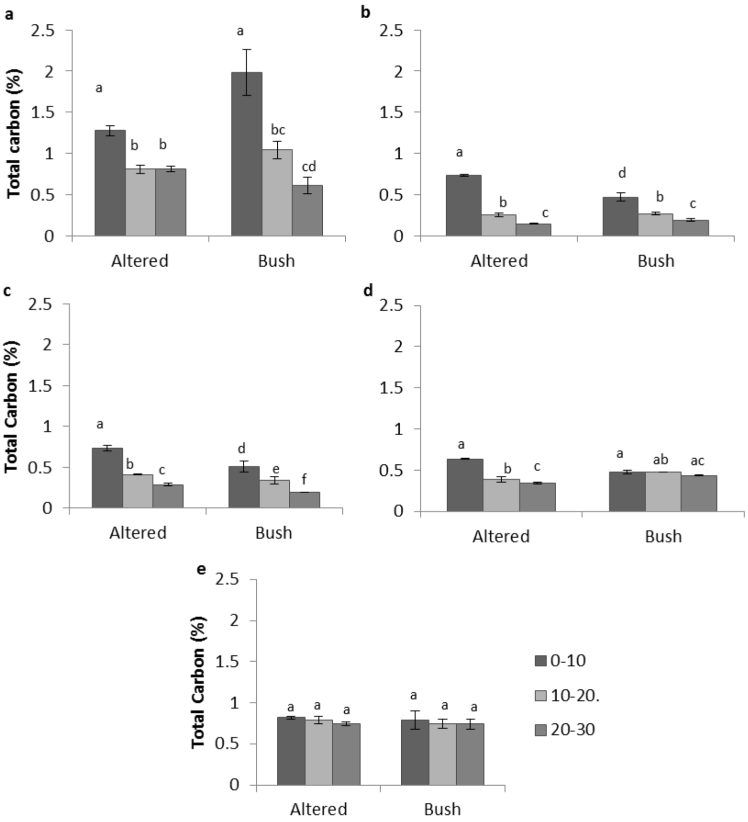

Figure 5: Mean total carbon as a percentage, with standard error bars, at each depth, 0-10cm, 10-20cm and 20-30cm, at each site: (a) site 1, (b) site 2, (c) site 3, (d) site 4 and (e) site 5, in anthropogenically altered areas and remnant bushland areas. Different letters above bars indicate significance at P≤ 0.05.

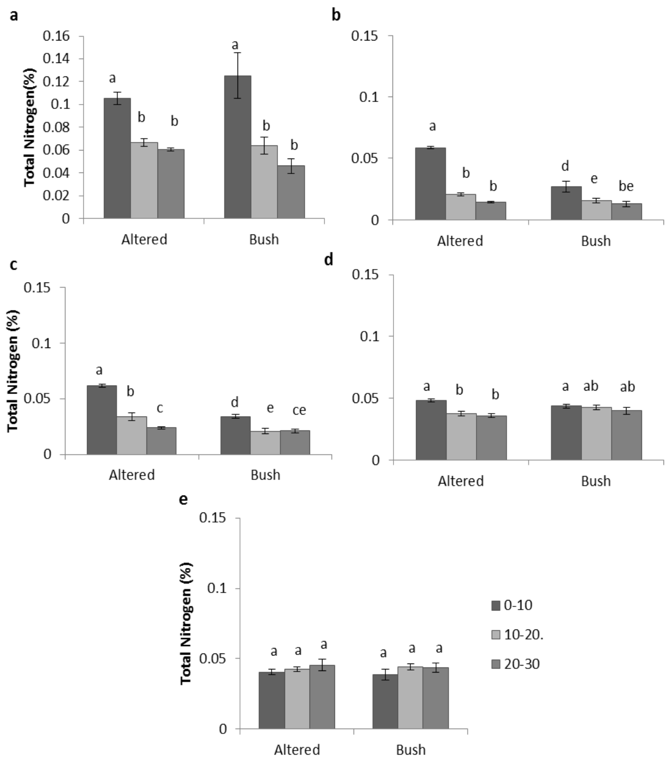

Figure 6: Mean total nitrogen (N) as a percentage, with standard error bars, at each depth, 0-10cm, 10-20cm and 20-30cm, at each site: (a) site 1, (b) site 2, (c) site 3, (d) site 4 and (e) site 5, in anthropogenically altered areas and remnant bushland areas. Different letters above bars indicate significance at P≤ 0.05.

Soil pH varied between 3.97 – 5.76 at most sites, however, site 1 had higher pH, reaching 8.17 (Table 3). Anthropogenically altered areas at sites 3 and 4 had greater pH in the top 10cm compared to remnant bushland areas ($P \leq 0.05$, Table 3). There was no difference between soil pH in the altered area and remnant bushland area at site 5 (Table 3). Site 1 increases in pH between depths in altered samples, however, not in the remnant bushland samples ($P \leq 0.05$, Table 3). Altered samples had a decrease in pH with depth at site 2, whereas there was no change with depth in bushland samples.

Table 3: Average pH ($CaCl_2$) with standard error, of each depth (0-10cm, 10-20cm and 20-30cm depth), in anthropogenically altered areas and remnant bushland areas at each site.

Depth	Site 1		Site 2		Site 3		Site 4		Site 5	
(cm)	Altered	Bush	Altered	Bush	Altered	Bush	Altered	Bush	Altered	Bush
0-10	5.42 (0.12)	5.76 (0.06)	5.72 (0.23)	4.82 (0.16)	5.92 (0.16)	4.95 (0.06)	5.56 (0.11)	3.97 (0.02)	4.20 (0.04)	4.29 (0.06)
10-20	7.52 (0.40)	6.37 (0.17)	4.76 (0.36)	4.97 (0.14)	5.13 (0.13)	4.98 (0.08)	4.35 (0.35)	3.99 (0.02)	4.16 (0.06)	4.05 (0.11)
20-30	8.17 (0.59)	6.89 (0.17)	4.29 (0.43)	4.81 (0.06)	5.13 (0.19)	5.03 (0.28)	4.35 (0.28	4.09 (0.00)	4.16 (0.06)	3.65 (0.11)

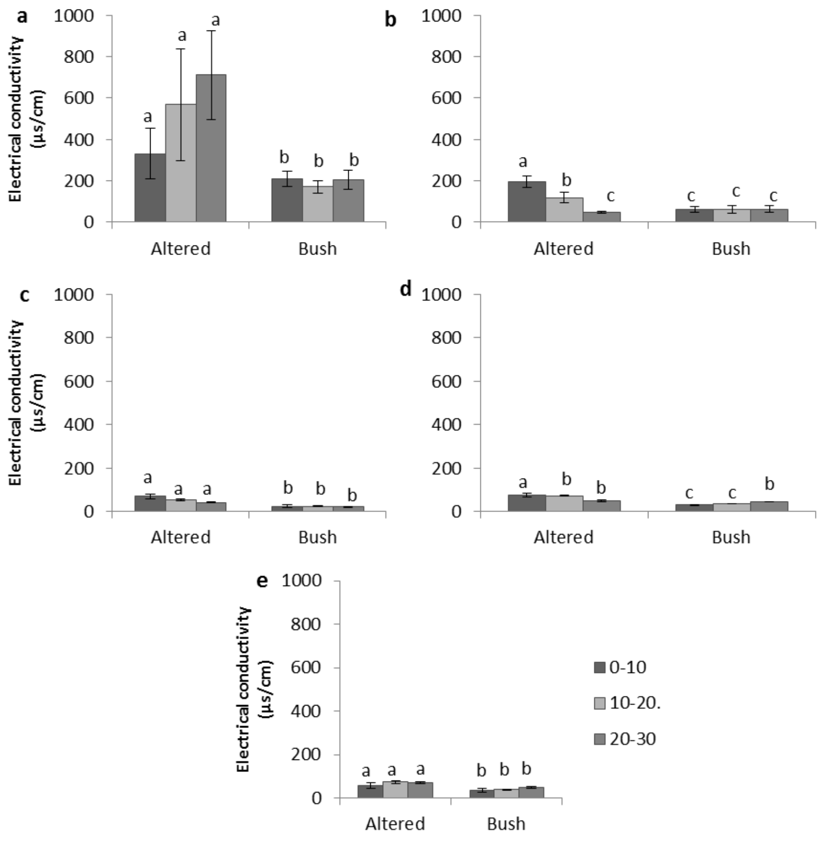

Figure 7: Electrical conductivity of anthropogenically altered areas and remnant bushland areas samples at 3 depths: 0-10cm, 10-20cm and 20-30cm, at each site: (a) site 1, (b) site 2, (c) site 3, (d) site 4 and (e) site 5, in. These are mean across each site with standard error. Different letters above bars indicate significance at $P \leq 0.05$.

Electrical conductivity ranged from 30-200 µs/cm in most sites; however, at site 1 it was as high as 701 µs/cm at a depth of 20-30cm (Figure 7). Anthropogenically altered areas had a greater EC than remnant bushland at all sites ($P \leq 0.05$, Figure 7). The observed increase occurred at all depths at sites 1, 3 and 5 whereas this only occurred in the surface 20cm at site 2 and 4 ($P \leq 0.05$, Figure 7b and 7d). Soil EC did not consistently vary with depth across all sites (Figure 7). For example, sites 1, 3 and 5 did not change with depth in either altered or bushland samples (Figure 7a, 7c, 7e). By contrast EC decreases with depth at site 2 (altered area only), and increased with depth at site 4 (bush area only), (Figure 7b and 7d).

Discussion and conclusion

This study demonstrated that soil under agricultural land-use and post-mining rehabilitation at the selected sites did not differ in key chemical and biological properties in comparison with adjacent remnant bush land. Land management practices such as no till farming, 'precision' fertiliser application and liming may have been important factors contributing to the lack of major differences between the remnant bush land soils and the altered soils. No till farming can allow greater organic matter build-up near the surface and reduce the incorporation of this organic matter into the subsoil (Feng et al., 2003). Liming has the ability to counteract increased acidity, in the already naturally acidic soils, caused by the application of fertiliser and precision management techniques can reduce the excess application of N fertilisers (Chen et al., 2009).

In conclusion, this study indicated that land management practices within the agricultural industry in the studied region, have resulted in little to no detrimental effects in the microbial properties of the soil. Rehabilitation processes undergone at the Extension Hill mine of Mt Gibson Iron Limited have returned the studied site to near remnant bushland state in regards to soil chemical and biological properties. This research has been critical in understanding how these land uses have affected the soil as an ecosystem. Analysis of a wider range of study sites would help to gain a greater understanding of anthropogenic impacts on soil on a regional scale.

Acknowledgements

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Paper reviewed by: Natasha Banning and Louise Barton, UWA

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In-furrow Liquid Lime Demonstration

Elly Wainwright, R&D Coordinator, Liebe Group

Aim

To assess the effect of different rates of CalSap® applied in-furrow on an acidic sand over gravel.

Background

CalSap® is a liquid lime product being used to remediate acidification in the mid soil (10-20cm). It can be easily applied in banded liquid fertiliser treatments, potentially neutralising some of the acidity associated with these fertilisers. The paddock where this demonstration was conducted is acidic and exhibited the lower pH in the mid soil. It was also used because it was part of the Liebe Group's Main Trial Site. This demonstration was designed and implemented by the farmer to address his assumptions about what this product is able to do for amelioration of mid soil acidity and the rates required to achieve this.

Trial Details

Property	Fitzsimons Property, east Buntine
Plot size & replication	800m x 18.5m not replicated
Soil type	Sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 4.5 10-20cm: 4.1 20-40cm: 4.7
EC (dS/m)	0-10cm: 0.117
Sowing date	03/05/2014
Seeding rate	50 kg/ha Calingiri
Paddock rotation	2011: wheat, 2012: wheat, 2013: lupin
Fertiliser	03/05/2014: 30 kg/ha DAPSCZ, 5.3 L/ha CalSap®, 1% Sulphate of Ammonia 05/06/2014: 40 L/ha UAN 09/07/2014: 30 L/ha UAN
Herbicides	03/05/2014: 1.8 L/ha Trifluralin, 1.5 L/ha Gramoxone, 275 g/ha Diuron, 0.3% LI 700 05/06/2014: 350 mL/ha Paragon, 50 mL/ha Alpha Cypermethrin, 30 g/ha Lontrel, 4 g/ha Metsulfuron
Growing Season Rainfall	180mm

Results

Table 1: Yield, quality and grade of Calingiri sown at east Buntine.

Treatment	Yield (t/ha)	Protein (%)	Hectolitre Weight (kg/hL)	Screenings (%)	Grade
5.0 L/ha CalSap®	1.87	11.1	83.27	0.35	ANW1
No Treatment	1.71	12.9	81.26	0.68	ANW2
5.3 L/ha CalSap®	1.73	11.1	83.15	0.37	ANW1
9.0 L/ha CalSap®	1.76	12.9	82.63	0.65	ANW2
No Treatment	1.80	11.2	83.95	0.33	ANW1
8.8 L/ha CalSap®	1.78	11.9	82.48	0.46	ANW2
5.0 L/ha CalSap®	1.78	11.6	83.53	0.33	ANW2

Table 2: End of season pH results (10-20cm).

Treatment	pH ($CaCl_2$) at 10-20cm
5.0 L/ha CalSap®	4.3
No Treatment	4.3
5.3 L/ha CalSap®	4.4
9.0 L/ha CalSap®	4.1
No Treatment	4.3
8.8 L/ha CalSap®	4.2
5.0 L/ha CalSap®	4.2

Comments

The mid soil (10-20cm) pH levels were sampled from in-furrow. Results varied across the demonstration and should therefore be treated with caution as the variation in pH ($CaCl_2$), yield and quality may be due to natural paddock variation or other factors. This site was subjected to wind damage prior to harvest, introducing more variability across the large plots further reducing the reliability of the yield results.

Acknowledgements

Thanks to the Fitzsimons family for implementing and maintaining the trial.

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Impact of Biochar on Crop Yield and Nitrogen

Lilly Martin, Research and Extension Agronomist, Liebe Group

Key Messages

- 4 t/ha of biochar applied in 2010 has not influenced yield this season.

Aim

- To determine the impacts of biochar on crop yield and quality.
- To compare the effectiveness of different methods of applying biochar to the soil.

Background

Biochar is a carbon rich product created when organic matter is heated to temperatures greater than 250°C in low oxygen conditions (Antal and Grønli 2003). During the conversion of organic matter to biochar, volatile compounds are released. These compounds can be combusted to produce energy; hence it can be considered a carbon negative method of producing energy. Biochar is also very stable in soils. It can remain in soils for many hundreds, or thousands of years, providing a method of carbon sequestration (Ascough et al. 2009).

From an agronomic perspective it is suggested that biochar could improve soil health by improving nutrient retention, particularly in coarsely textured soils (Chan et al. 2008). As most biochar is alkaline, it may also provide a neutralising effect similar to liming. From a biological perspective, biochar is also a potential habitat for microbes to avoid predation by nematodes and protozoa. Some biochars can also supply nutrients. The aim of this experiment is to examine the interaction between biochar (made from wheat chaff) and nitrogen (N). From this we hope to determine whether biochar changes N fertiliser use efficiency.

The Experiment

If biochar does prove to be a beneficial soil ameliorant, growers will need to consider how to apply the product. In this trial biochar was either banded or applied on the soil surface at a rate of 4 t/ha using the Department of Agriculture and Food's trial seeder. The biochar was applied in April 2010 and therefore this is the fourth cropping year after biochar application to the site. To investigate the claim that biochar increases fertiliser efficiency the trial compares 3 N rates (0, 20 or 40 units of N) applied as urea at seeding. No further N was applied.

Trial Details

Property	Long Term Research Site, west Buntine
Plot size & replication	20m x 2m x 4 replications
Soil type	Deep yellow sand
Soil pH ($CaCl_2$)	0-10cm: 5.5 10-20cm: 4.6
EC (dS/m)	0.04
Sowing date	22/05/2014
Seeding rate	70 kg/ha
Paddock rotation	2010: wheat, 2011: wheat, 2012: canola, 2013: barley
Fertiliser	22/05/14: As per treatment (N), 40kg/ha Triple Super
Herbicides	06/05/2014: 2 L/ha Spray.Seed, 0.5L/ha Diuron, 0.5L/ha Dual Gold 22/05/2014: 2 L/ha Spray.Seed 250 26/06/2014: 25 mL/ha Glean, 1% wetter
Growing Season Rainfall	185mm

Results

Table 1: Yield and quality of oaten hay sown at Buntine 2014, standard error for yield ±0.23.

Fertiliser Rate and Treatment	Yield (t/ha)	DEMD* (%)	NDF* (%)	ME* (%)	WSC* (%)	ADF* (%)
Nil Rate (0N)						
Banded	1.97	70.87	51.7	10.53	16.4	28.07
None	1.78	70.13	52.37	10.43	14.53	28.57
Top Dressed	1.75	70.93	52.43	10.60	15.60	28.27
Half N Rate (20 N)						
Banded	1.88	72.40	50.73	10.83	15.53	27.27
None	2.12	71.27	52.23	10.63	14.87	27.90
Top Dressed	2.29	71.20	51.37	10.63	14.60	27.60
Full N Rate (40 N)						
Banded	2.38	73.07	49.80	10.93	16.50	26.10
None	1.99	72.47	50.43	10.83	15.37	26.70
Top Dressed	1.99	71.27	51.37	10.63	13.73	27.03
Significance	NS	NS	NS	NS	NS	NS
CV	19.7					

NS = Fertiliser and biochar treatments both not significant ($p>0.05$).
***Note:** Dry Energy Matter Digestibility (DEMD) is the proportion of forage that is digestible (high is better).
Neutral Detergent Fibre (NDF) is the structural component of the plant, it provides bulk or fill (low is better).
Metabolise Energy (ME) is the net energy available to the animal (high is better).
Water Soluable Carbohydrate (WSC) are the sugars such as sucrose, glucose and fructose (high is better).
Acid Detergent Fibre (ADF) is the least digestible plant components, including cellulose and lignin (low is better).

The application of 4 t/ha of biochar (2010) had no statistical significance on yield or hay quality in 2014. There was no interaction between the biochar and fertiliser treatments. The three differing N rates also had no significant impact on yield or quality; this could be due to the dry/hot August as in all other years that the trial has been monitored fertiliser rates have had an impact on yield.

Comments

Two factors (along with a host of others) that influence hay palatability are the Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF). The ADF and NDF were low, indicative of highly palatable hay. These two factors are controllable by seeding date and rate, the lower the ADF and NDF the more palatable the hay becomes.

All the hay samples where on track for top grade but the Water Soluable Content (WSC) was the result that let the quality down (see Appendix 1). This is controlled more by the weather and due the dry August all of Western Australia's oaten hay was low in WSC. The hay was valued at $210/t (Grade: OH1QV).

Another factor to note was that these hay samples were dried indoors and if this hay crop had a serious rain event on it whilst in the windrow curing, we would expect the hay quality to be damaged; as all hay in the growing area was affected by rain this year.

The biochar has been in the soil for five years and the trial results collected for four years (2010, 2011, 2013 and 2014) have shown no major impacts on yield. Biochar is considered to be a long term soil ameliorant and is largely untested in broadacre agriculture.

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Appendix 1

Table: Hay Receival Standards 2014.

Grade	DEMD	ADF	NDF	WSC	Green (%)	Brown (%)	Weather Damage	Chaff (%)	Aroma	Stem (mm)
OH1QQQV	>60	<30	<52	>23	>70	<10	Nil	<25	Bland	<6
OH1QQQ	>60	<30	<52	>23	>70	<10	V. Minor	<25	Bland	<6
OH1QQV	>60	<32	<54	>20	>50	<15	Nil	<25	Bland	<6
OH1QQ	>60	<32	<54	>20	>50	<15	Minor	<25	Bland	<6
OH1QV	>58	<33	<56	>18	>50	<20	Nil	<25	Bland	<6
OH1V	>56	<36	<59	>12	>50	<20	Nil	<25	Bland	<7
OH1	>56	<36	<59	>12	>30	<20	Moderate	<25	Bland	<7
OHMINV	>54	<39	<64	>6	>30	<20	Nil	<25	Bland	<7
OHMIN	>54	<39	<64	>6	>30	<25	Moderate	<25	Bland	<7

Liebe Group Projects

Profitable Crop Sequencing Project

Wayne Parker, Development Officer, DAFWA

Key Messages

- Weed numbers are declining in the Focus Paddocks, therefore current crop and pasture sequences are working for weeds.
- Observation of soil nitrogen (N) content implies that Liebe paddocks are well managed for fertiliser inputs.
- Nematodes and root disease continue to build under high intensity wheat rotations.

Aim

To track the real situation of break crops over a wide range of farms in WA to determine where and when they deliver a benefit.

Background

Should I grow wheat or canola? Is my legume crop more economical than applying N fertiliser? Should I keep sheep in the farming system? These are some of the questions being investigated in the Profitable Crop Sequencing Project.

While the possible benefits of a break crop are known it can be difficult to put a dollar value on these benefits or identify situations where a break crop will provide maximum benefit to cereal cropping. A survey of farmers in 2014 indicated they rate break crops of major importance to the future of farming. So by following the paddock rotation decisions of farmers across the state and collecting extensive agronomic and financial information the project aims to determine when and where break crops deliver a benefit.

How it works

Over the previous five seasons the project has been monitoring 30 paddocks in the Liebe area, which are part of 184 across the state, to determine the strength and weakness of break crops in the rotation. Vigorous field monitoring, economic modelling and captured farmer experience are all being used to develop the understanding of the role of the break crop.

The project is led by the Department of Agriculture and Food, Western Australia and incorporates eight grower groups across the state. In order to include the wide range of farming systems, rainfalls and soil types in the Liebe area paddocks were selected in the following areas:

- Coorow
- Dalwallinu
- East Maya
- East Buntine
- Kalannie
- Pithara

The project began in 2010 with all paddocks sown to wheat. Paddocks will continue to be monitored until the middle of 2015 with no restriction on the use of the paddock. Each paddock is visited 4 times a year to measure:

- Soil health and type
- Soil and plant nutrition
- Plant disease
- Soil disease via PreDicta B
- Weed populations and herbicide resistance

Results

2014 season:

July and August delivered little rain and exceptionally hot temperatures putting the yield ceiling on the majority of crops throughout the region. Yields for canola were particularly influenced during this hot period as crops lost flowers before setting seed. Late sown wheat crops lost tillers and yield, unfortunately not enough pleasant surprises during harvest this year.

The pressure on canola in the rotation continues as it is expected to reduce high numbers of weeds generated by the wheat phase. Further concern is the increasing disease levels that canola host to be revisited on the wheat in follow seasons, root lesion nematode in particular, see Figure 4.

Roundup Ready hybrid canola has made a place for itself in the rotation. The yield potential of these hybrid varieties and the relatively low cost of required herbicide have kept it in the market. With Roundup Ready in the rotation it is worth remembering the pressure put on the herbicides given the positive result of trifluralin resistance detected by the project in the Liebe Group region in 2013.

In a recent survey conducted by the project, 203 growers throughout WA, 98% of those surveyed rate the break crop of moderate/major importance to the future of farming. Just how and when can be answered using the information derived by the Profitable Crop and Pasture Sequencing project. Below is a snap shot of the important results from the last five seasons of monitoring.

Weeds

Liebe focus paddocks have a higher average number of grass weeds in paddocks, plants/m^2, than the state average. It is important to note that the range for number of grass weeds in 2013 is 0 to 17 plants/m^2. There are still a number of paddocks with large numbers of ryegrass that are keeping the average up. Results for 2014 grass and broadleaf weed are still being analysed at time of print.

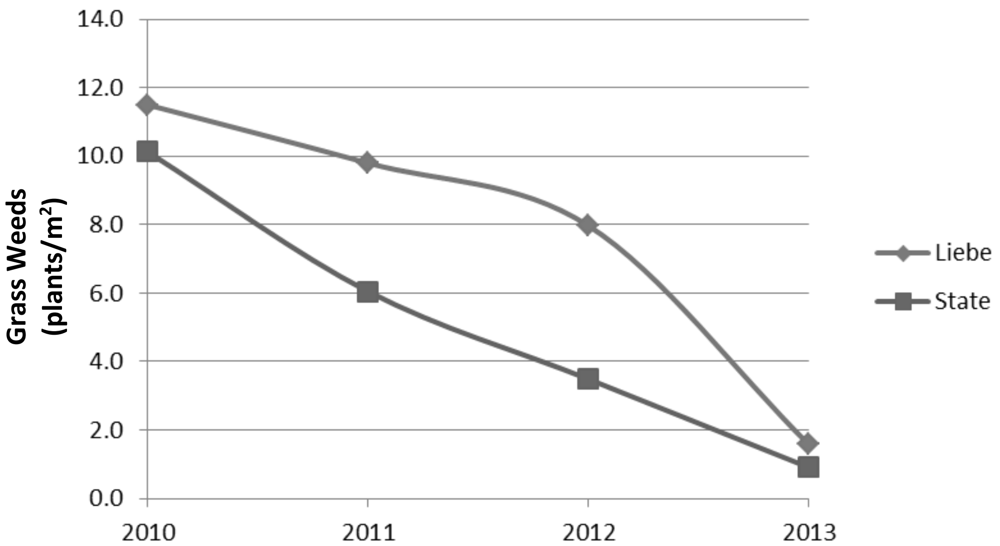

Figure 1: The trend in grass weed numbers, plants/m^2, from Liebe Focus Paddocks as compared to the Focus Paddocks throughout the state, spring observation.

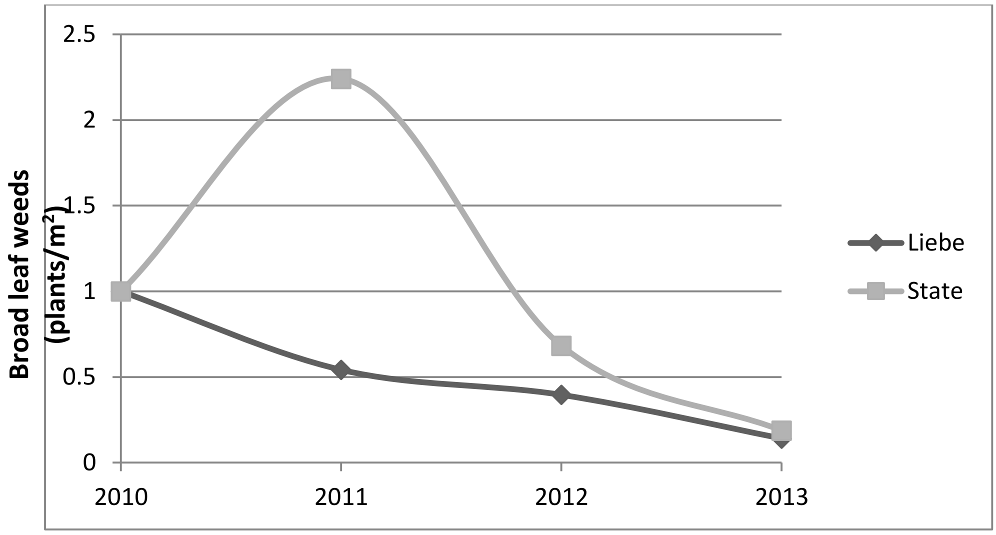

Figure 2: The trend in broadleaf weed numbers, plants/m^2, from Liebe Focus Paddocks as compared to the Focus Paddocks throughout the state, spring observation.

In the measurements taken by the project; weed numbers, both grass and broadleaf continue to build throughout the season when the paddocks are in wheat, see Figure 3.

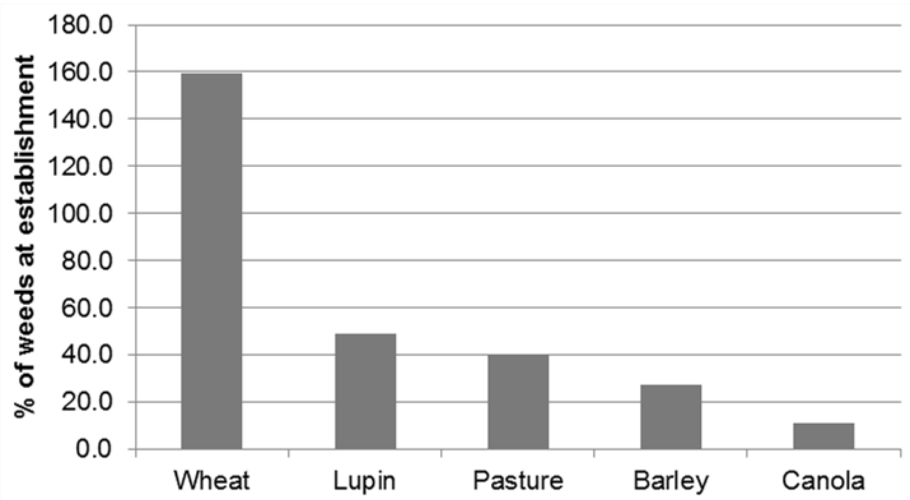

Figure 3: Change in grass weed numbers achieved, in crop, during each crop phase, determined from two measurements taken annually before seeding and at anthesis prior to harvest.

Table 1: Change in grass weed numbers.

Sequence	n	Grass weeds in paddocks 1-146 at establishment
WCaW	22	-5.1 (1.9)
WWW	22	11.6 (5.4)
WWCa	21	-11.1 (4.5)
WLW	20	-4.1(2.2)
WPW	11	-5.5 (1.6)

In terms of rotation, canola continues to be used to manage grass and broadleaf weeds. Years following canola have significant reductions in both grass and broadleaf weed numbers, see Table 1.

Disease

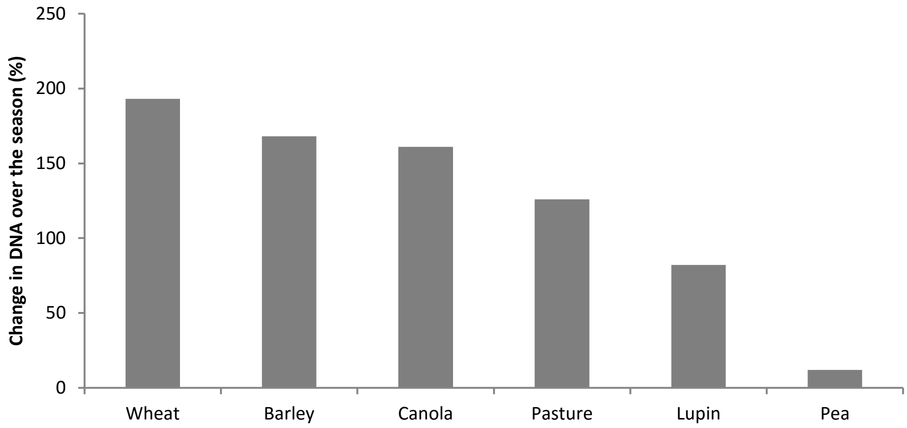

Figure 4: The in season change in levels of nematode *Pratylenchus neglectus* under break crop as measured by the project.

The problems of root lesion nematode continues to grow with the reliance on cereal crops and those break crops that harbour grass weeds. Canola is a susceptible host for *P. neglectus* and numbers of the nematode continue to increase under this, see Figure 4. *P. neglectus* numbers are significantly reduced with the addition of either a lupin or field pea crop.

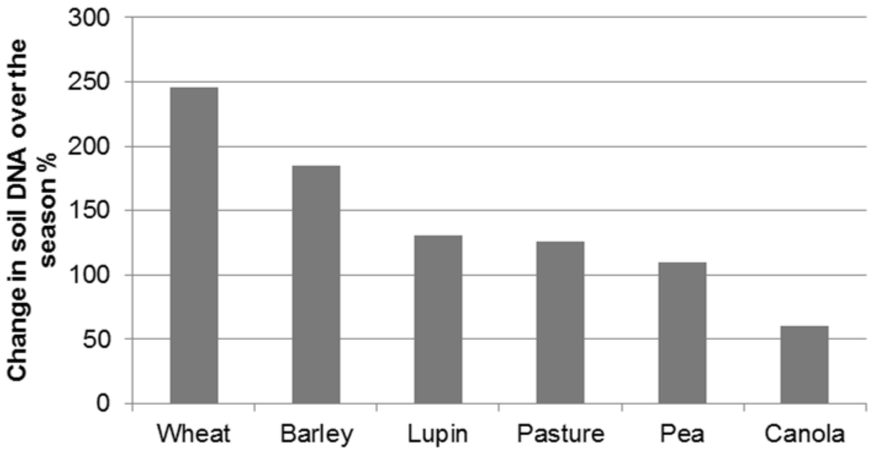

Figure 5: The percentage change in soil DNA of *Rhizoctonia solani* AG8 change following a break crop.

Weed free canola is reducing the amount of rhizoctonia DNA present in the paddock unlike a pasture or barley crop. It is suspected that the level of Rhizoctonia in lupin and pea crops is maintained through the grass weeds contained within. Further, the R. solani AG8 strain has a very wide host range which includes lupins which is why the levels under lupin do not decrease during the break crop phase as would be expected.

Nutrition

Given the lack of legume crops in the rotation there is a dependence on the mineralisation of N during summer from the previous crop and additional N via bag. These results are testament to the quality of the season in the southern half of the state during 2013 with huge reductions in available N in WANTFA, Facey, Holt Rock and Southern DIRT. Conversely, the poor season in 2013 in the Liebe area meant that soil N was okay before sowing in 2014 despite the dry summer, hence the relative consistency in N levels throughout the last five years of measurement in the Liebe Focus Paddocks.

Table 4: The average levels of soil N, (nitrate and ammonium profiles to 90cm) from focus paddocks, as found in the respective farming groups.

Grower Group	2010	2011	2012	2013	2014	5 year average
Yuna	80	119	58	66	54	75
MIG	66	103	57	61	41	66
Liebe	77	85	90	80	85	83
WANTFA	108	104	105	108	50	95
Facey	122	101	80	102	42	89
Holt Rock	-	50	77	127	68	81
Southern Dirt	88	-	73	83	48	73

Comments

The data obtained from the last five seasons of monitoring will be analysed in the coming season. It will contribute to work and be the foundation of future funding submissions for break crops.

A 2013 results report is available at the Focus Paddocks webpage http://focuspaddocks.ning.com/, look for the blog posts that contain it. An updated report covering all the data is being prepared to be made available in February.

The results from the survey, Grower Attitudes to Break Crop Sequences and the Future of Break Crops 2014, conducted by Ipsos will be contained in the proceeding for the Agribusiness Crop Updates 2015.

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Working Together to Deliver Multiple Benefit Messages to Growers Through a Whole Systems Approach to Soil Management

Lilly Martin, Research and Extension Agronomist, Liebe Group

Aims

- Give growers in Western Australia the capacity to understand and better manage the economic and environmental impacts on acidic soils.
- Give growers the knowledge and awareness of tools and information available to manage soil acidity.
- Growers to become better equipped through development of new tools and information to make effective adoption decisions to manage soil acidity.
- Growers maintaining viable farming systems through optimum management of their systems.

Background

The Liebe Group is leading a grower driven initiative and has formed an alliance to work collaboratively with Mingenew-Irwin Group (MIG), West Midlands Group (WMG), Southern Dirt and Aglime Australia. Funding has been awarded from GRDC to begin research into the most appropriate liming strategy to maximise return on investment and increase knowledge around the economics of different soil pH management, products and techniques utilising the Lime Economic Calculator.

Farmers in the Northern Agricultural Region have experienced extreme climate volatility over the last 15 years including three severe droughts and a number of below average rainfall years. As a response to this farmers are looking to improve their farming systems through increasing water and nutrient use efficiencies and developing flexible farming systems. Managing soil acidity in this volatile environment is a key component in improving the system.

As part of Liebe Group's previous GRDC funded projects 'Growers critically analysing new technologies for improved farming systems' 2006-2009 and 'Improved stubble soil management practices for sustainable systems in the Liebe area' 2009-2012, surveys of 60 growers in the Liebe area were conducted. This included around 50 members and 10 non-members each time. These surveys asked questions around liming including 'Do you lime?' and 'How many years ago did you start liming?' In 2006, 94% farmers surveyed limed, with that number increasing to 100% in 2012, (Liebe Group Technical Audit Results 2012 Executive Summary). The average number of years since liming was first used is 16 years.

However, when asked what major issues are impacting their farming system, soil acidity is still one of the highest ranking issues. With the uptake of liming 100% but the issue continuing, there is research required to find out what is the best method to overcome soil acidity and barriers to full adoption.

The project team, in consultation with the Regional Cropping Solutions Network, local growers, key researchers and NRM agencies will determine an appropriate development and extension plan to improve soil pH. This will include field trials to provide validation of the economic model against different lime products and rates and will also utilise existing research trials where possible, including an extensive lime x incorporation trial established by the West Midlands Group through the GRDC agribusiness trial extension network and a lime x deep ripping trial established by the Mingenew-Irwin Group in March 2013. By utilising existing research trials, the project adds value to previous investments in this field by ensuring continuity of data and extension messages.

To aid in the extension of liming messages, a Lime Economic Calculator will be used. The Lime Economic Calculator was a grower driven initiative developed after they had seen trials reporting improvements from liming but had trouble quantifying the return on investment. As a result of long term below average seasons, lime has often been the first input taken off the budget, further compounding both financial and environment problems in the longer term.

Environmental benefits will occur through increasing the soil pH, leading to improved soil health. The improved soil health will result in greater economic benefits compounding the improvements as growers are able to further invest in their soil health. A lack of adoption will result in soil pH continuing to decline.

Activities:

1) Develop and implement four new trials (Liebe Group, MIG, WMG and Southern Dirt) and revisit five old trials (Aglime Australia).
2) Conduct three workshops designed to increase knowledge around the economics of different soil pH management products and techniques utilising the Lime Economic Calculator.
3) Conduct six case studies throughout WA featuring growers who have adopted various soil acidity management practices (Liebe Group, MIG, WMG and Southern Dirt).
4) Deliver annual reports to communicate results.
5) Extend results on a state and national level.

Outputs

1) Six detailed case studies on improved soil acidity management practices will be produced and will include an economic analysis of the practice. Extension of information will be via each groups networks to ensure over 500 businesses throughout WA are exposed to the case studies.
2) Annual results and trial reports produced based on the assessment and economics of best management practices for soil acidity management. Nine trial reports, one each by WMG, Southern Dirt, MIG and Liebe Group and five by Aglime Australia, produced annually (2016 & 2017) and extended to farm businesses across WA.
3) A series of three workshops looking at addressing the issue of soil acidity and discussing economics of different ways to ameliorate acidic soils.

Acknowledgements
This project is funded by GRDC.

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Innovative Carbon Storage and Nitrogen Management Strategies in the WA Wheatbelt

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Aim
This project has two main objectives:
1) To demonstrate innovative on-farm practices that can reduce nitrous oxide emissions, through the rotational use of leguminous crops in order to reduce the use of nitrogenous (N) based fertilisers whilst maximising net primary production (biomass).

2) The project will trial and demonstrate innovative on-farm practices that can increase the sequestration of carbon (C) in soil, through the use of biochar, soil amendments, biological amendments and use of additional composting materials to develop economically viable farming practices that sustainably store and build soil carbon.

Background
C is an important part of maintaining soil health and the productivity of the soil. It provides an energy source for many functions considered important for soil biological health, including: the transformation of nutrients to more plant available forms, increasing soil pH buffering capacity, increasing cation exchange capacity, stabilisation of soil structure and the degradation of soil pollutants.

Building soil C is a product of soil type, climate and management factors. The soil organic content that can be achieved depends not only on the potential of the soil to protect C but also on the productivity of the crop or pasture. Theoretically, there is a soil C upper and lower limit in all soils. Previous research conducted by the Liebe Group shows that in the low rainfall environment in the Northern Wheatbelt of Western Australia, over time the upper and lower limits of soil carbon will reach an equilibrium, that is where the microbial decomposition of organic C is lower (upper limit) or higher (lower limit) than the input of new C inputs.

The challenge for our farming system is to find ways that can push our current C storage equilibrium more towards the upper limit and thus improve the soils potential and keep it at that equilibrium.

Hoyle, Baldock & Murphy (2009), indicate that there are a number of management options for farmers to sequester soil C, centring on increasing inputs of soil C, improving soil structure and supplying adequate amounts of nutrients to the soil. This project aims to demonstrate practices that cover all three of these areas.

In the area of addition of soil C, growing more biomass such as perennial pastures, eliminating fallow or adding biochar to the soil, all present a viable way to add soil C. Improving soil structure, through improved stubble management and reducing wind erosion through cover cropping, decreases the loss of organic residues from the soil and thus the loss of soil C from the soil. Finally, by supplying nutrients through brown manuring crops, utilising the N fixing ability of leguminous crops and adding organic soil amendments, ensures that crop biomass and root growth is maximised, thus increasing C in the soil. As organic materials decompose, nutrients can be released (mineralised) or taken up (immobilised) by soil organisms.

This project is funded by the Australian Government Department of Agriculture Action on the Ground program. The project commenced in July 2012 and will be completed by June 2015 with the exception of the Practice for Profit trial which will be completed by July 2016.

Project Activities
1. Practice for Profit Trial - Mills Property, east Dalwallinu
The long term Practice for Profit trial will be continued through this project to compare high and low fertiliser use under the following crops; wheat, canola, volunteer pasture and field peas. Total C will be measured under different rotations. The trial will demonstrate the profitability of using legumes and low levels of N fertiliser in

the farming system. To take seasonal variability and rotation effects into account the trial will run from 2014 to 2016 inclusive. The information provided from this research will allow growers to better manage the use of N fertiliser leading to improved gross margins.

2. Demonstration of Perennial Legume Tedera - Martin Property, north Watheroo
The project will demonstrate how using perennial legumes can increase nitrogen carbon stored in the soil. To achieve this, tedera seeds and seedlings were planted in low fertility soils which the host grower has prioritised for C management.

3. Soil Amendment Trials - Buntine, north Miling and Wubin
A series of soil amendment trials were conducted to amend soil issues with the physical, chemical and biological status of the soil, in turn increasing productivity and C cycling on that soil.

- Growing cereal rye - Pearse Property, west Wubin
- Removing soil compaction - Dodd Property, west Buntine
- Incorporating Bentonite clay - Seymour Property, north Miling

4. Biochar Trial - Long Term Research Site, west Buntine
The project will investigate if biochar is a suitable option for storing C in WA's Wheatbelt and how it affects crop yield and C storage.

5. Crop Manuring Trial - Long Term Research Site, west Buntine
The Liebe Group's Soil Biology Trial will be utilised to assess how crop manuring can be used to increase the amount of C in the soil. Manuring refers to sacrificing a crop in order to put organic matter back into the soil to improve soil health, weed control and subsequent crop yield. Soil C levels, biomass and the economic and agronomic factors of how crop manuring fits into the farming system will be recorded.

Collaboration with Other Projects
The Liebe Group is also collaborating with other organisations on projects funded through the Australian Government's Carbon Farming Futures program. These projects are summarised below.

"Economies of Managing Soil Organic Carbon" - Department of Agriculture and Food, WA
This project involves field-based and grower managed demonstration sites implementing innovative methods for improving both soil organic carbon (SOC) stores in conjunction with their production base; and monitoring of previously established soil quality sites will provide information to landholders on beneficial/perverse outcomes associated with changing SOC levels in grain production systems. This will enable landowners to determine the profitability and risk of managing C from a sequestration vs. production perspective. These trials began in 2013.

Does Increasing Soil Carbon in Sandy Soils Increase Soil Nitrous Oxide Emissions from Grain Production?" - University of Western Australia
This project will investigate if varying soil organic matter content and quality alters the crop response to applied N fertiliser. The field sites include the Liebe Group's long term Soil Biology Trial where there is a gradient of soil organic matter. The crop and soil response to different N fertiliser rates would be measured to determine the influence of soil organic matter on N fertiliser response and estimate changes in nitrogen use efficiency. The project will also measure nitrous oxide emissions in response to the changing soil organic matter and applied nitrogen regime.

Contact
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(08) 9661 0570

General Information

Planfarm Bankwest Benchmarks 2013 – 2014 Season

Both Planfarm and Bankwest – producers of the two dominant and most respected farm business benchmarking surveys in Western Australia, have decided to join forces to create the Planfarm Bankwest Benchmarks.

The Planfarm Bankwest Benchmarks are derived mostly from the information supplied by clients of Planfarm Pty Ltd, Bankwest and Bedbrook Johnston Williams, 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 ($Eff/ha) – 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.

May – October Rainfall (mm) – growing season rainfall (May-Oct) 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 2013/2014'.
For more information please contact the Bankwest Agribusiness Centre on (08) 9420 5175.

Figure 1: The regions used in the Planfarm Bankwest Benchmark survey.

Table 1: Farm Group Statistics - Medium Rainfall Zone, Region 2 from the 2013/2014 season.

Variables	Unit	Top 25%	Average	Bottom 25%
Effective Area	ha	3865	3955	3568
May – October Rainfall	mm	243	243	250
Permanent Labour	person	2.4	2.3	2.2
Casual Labour	wks	21.5	19.1	12.7
Effective Area/Perm Labour	ha	1408	1533	1534
Income/Perm Labour	$	$1,253,329	$995,337	$680,656
Operating Surplus/Perm Labour	$	$596,200	$402,480	$224,069
Gross Farm Income (GFI)	$/eff ha	$902	$661	$461
Operating Costs (OPEX)	$/eff ha	$472	$393	$313
Farm Operating Surplus	$ eff ha	$431	$268	$147
Farm Oper. Surplus/mm GSR Rainfall*	$/eff ha	$2.22	$1.39	$0.72
OPEX as % GFI	%	52%	59%	68%
Return on Capital	%	10.8%	6.5%	3.3%
Total Crop Area	ha	3530	3143	2476
% Effective Area Crop	%	91%	81%	70%
% Of Crop as Legumes	%	4%	6%	6%
% Of Crop Oil Seed	%	25%	20%	16%
% Effective Area Pasture	%	9%	21%	31%
Wheat Yield	t/ha	3.26	2.63	2.11
Wheat Area	ha	1923	1884	1658
Wheat kg/mm Average	kg/mm	16.84	13.66	10.50
Lupin Yield	t/ha	1.62	1.63	1.89
Lupin Area	ha	311	314	384
Barley Yield	t/ha	4.01	3.11	2.87
Barley Area	ha	617	416	246
Canola Yield	t/ha	1.68	1.38	1.06
Canola Area	ha	946	772	623
N Use on Cereals	kg/ha	57.01	47.93	47.38
P Use on Whole Farm	kg/ha	10.93	9.62	8.77
Herbicide Costs	$/ha crop	$70	$67	$59
Plant Investment	$/ha crop	$457	$428	$376
Opening Sheep Number	hd	2597	3128	3550
Closing Sheep Number	hd	2329	3065	3391
Number of Ewes Mated	hd	1295	1605	1729
Lambs/WG ha	no.	3.8	1.8	1.5
Wool Price	$/kg net	$6.43	$6.21	$6.43
Wool Cut/Grazed Area	kg/wgha	18.80	19.77	20.65
Stocking Rate	dse/wgha	3.79	3.84	3.50
Wool Production	kg greasy	12139	14194	14959
Average kg/Sheep Shorn	kg	4.65	4.42	4.40

*Top and bottom 25% groups are sorted by Farm Operating Surplus/Effective ha/mm Growing Season Rainfall.

Table 2: Farm Group Statistics - Low Rainfall Zone, Region 2 from the 2013/2014 season.

Variables	Unit	Top 25%	Average	Bottom 25%
Effective Area	ha	5893	6189	5999
May – October Rainfall	mm	184	168	152
Permanent Labour	person	2.3	2.2	2.4
Casual Labour	weeks	14.7	21.0	6.7
Eff Area/Perm Labour	ha	2287	2397	2505
Income/Perm Labour	$	$972,547	$703,017	$460,516
Op Surplus/Perm Labour	$	$442,319	$252,991	$83,781
Gross Farm Income (GFI)	$/eff ha	$428	$308	$186
Operating Costs (OPEX)	$/eff ha	$235	$199	$151
Farm Operating Surplus	$/eff ha	$193	$109	$35
Farm Oper. Surplus/mm GSR Rainfall*	$/eff ha	$1.33	$0.78	$0.27
OPEX as % GFI	%	55%	65%	81%
Return on Capital	%	9.4%	4.6%	-0.9%
Total Crop area	ha	4871	4472	3685
% Effective area crop	%	83%	73%	61%
% Of crop as legumes	%	3%	2%	2%
% Of crop oil seed	%	15%	8%	5%
% Effective area pasture	%	17%	28%	39%
Wheat Yield	t/ha	1.73	1.35	1.01
Wheat Area	ha	3704	3657	3080
Wheat kg/mm ave	kg/mm	11.80	9.86	8.14
Lupin Yield	t/ha	1.14	0.82	0.40
Lupin Area	ha	304	256	242
Barley Yield	t/ha	2.01	1.51	1.02
Barley Area	ha	421	411	356
Canola Yield	t/ha	0.88	0.73	0.51
Canola Area	ha	745	585	292
N Use on Cereals	kg/ha	23.31	18.54	13.59
P Use on Whole Farm	kg/ha	7.21	5.67	4.00
Herbicide Costs	$/ha crop	$47	$48	$43
Plant Investments	$/ha crop	$331	$317	$325
Opening Sheep Numbers	hd	1892	2603	3216
Closing Sheep Numbers	hd	1873	2444	2869
No. of Ewes Mated	hd	909	1313	1584
Lambs/WG Ha	no.	0.8	0.7	0.6
Wool price	$/kg net	$6.05	$6.06	$6.04
Wool cut/grazed area	kg/wgha	11.51	7.88	6.65
Stocking rate	dse/wgha	2.10	1.42	1.12
Wool production	kg greasy	10295	12821	15886
Ave kg/sheep shorn	kg	4.69	4.63	4.80

*Top and bottom 25% groups are sorted by farm operating surplus/effective ha/mm growing season rainfall.

2014 Rainfall Report

	Dalwallinu	Kalannie	Coorow	Carnamah	Latham	Perenjori	Wongan Hills	Goodlands	MTS East Buntine	West Buntine LTRS
Jan	3.8	8.6	4.0	2.4	7.0	16.2	3.2	8.8	0	5.2
Feb	5.0	18.2	4.6	6.9	6.2	11.2	2.0	56.4	22.0	17.0
Mar	6.4	7.6	3.8	7.5	16.8	3.5	3.3	7.4	0	22.0
Apr	22.8	28.4	32.8	29.9	38.4	48.8	26.2	39.0	44.5	25.6
May	43.8	54.9	47.4	48.2	38.4	29.1	44.4	41.0	42.5	41.0
June	25.0	16.8	27.5	31.3	23.0	14.6	27.2	19.2	20.0	25.8
July	48.2	46.0	49.8	40.1	32.8	19.0	68.8	36.2	37.0	36.6
Aug	18.2	22.0	22.1	31.1	18.6	7.8	25.6	9.4	13.0	15.4
Sep	43.4	30.6	49.3	46.6	38.4	14.6	41.4	27.4	20.0	33.2
Oct	8.0	10.1	5.2	2.3	3.4	-	9.5	12.6	3.0	7.2
Nov	18.6	5.4	9.4	4.0	26.0	-	30.2	8.0	4.0	5.0
Dec	0.2	-	-	0	-	-	7.0	-	0	-
GSR (Apr-Oct)	209.4	208.8	234.1	229.3	193.0	133.9	243.1	184.8	180.0	184.8
Total	243.4	248.6	255.9	250.3	249.0	164.8	288.0	265.4	206.0	234.0

*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.

2014 Liebe Group R & D Survey Results

Conducted September 2014 at Spring Field Day

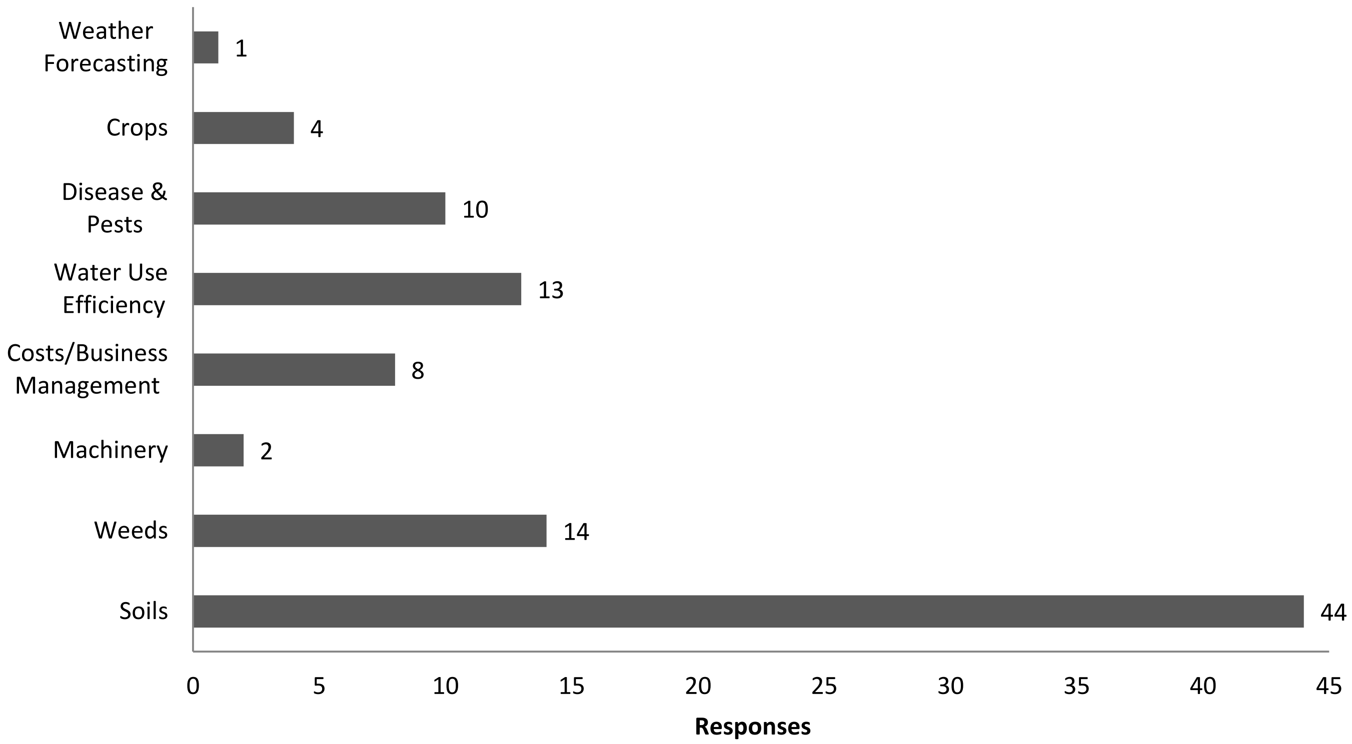

Figure 1: Farmers' responses when asked about key problems affecting their farm business that could be addressed through research, recorded at the Liebe Group Spring Field Day 2014.

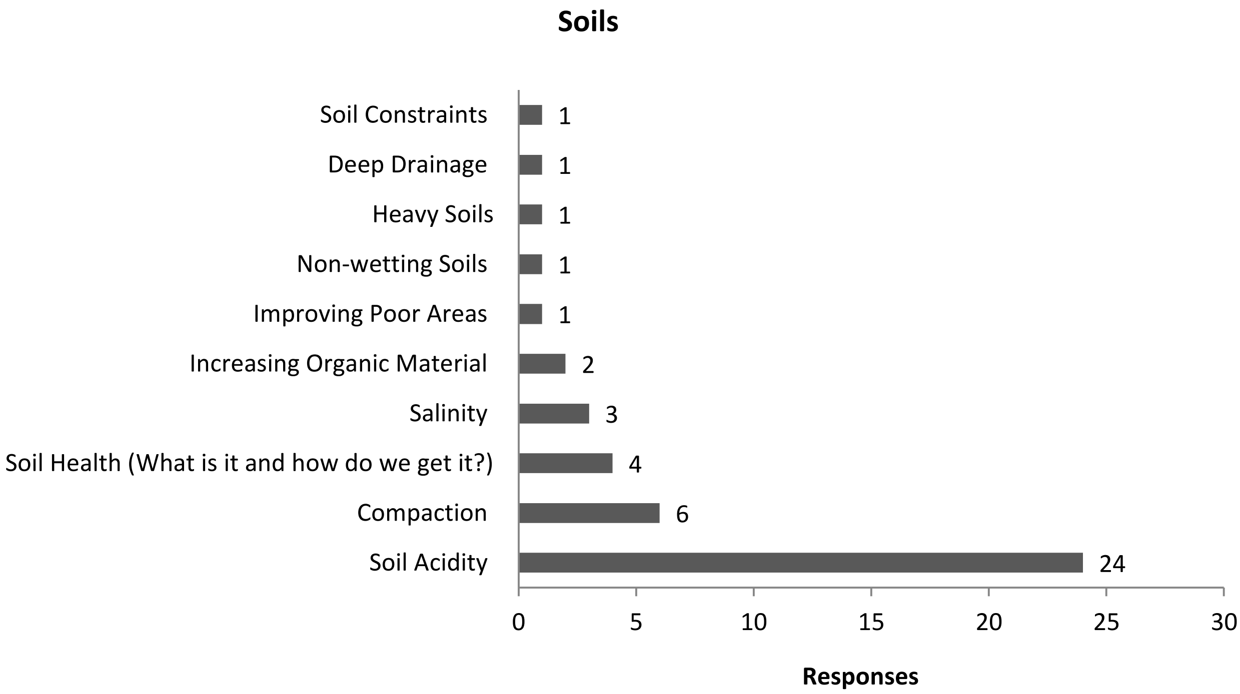

Figure 2: Areas of interest in soils recorded at the Liebe Spring Field Day 2014.

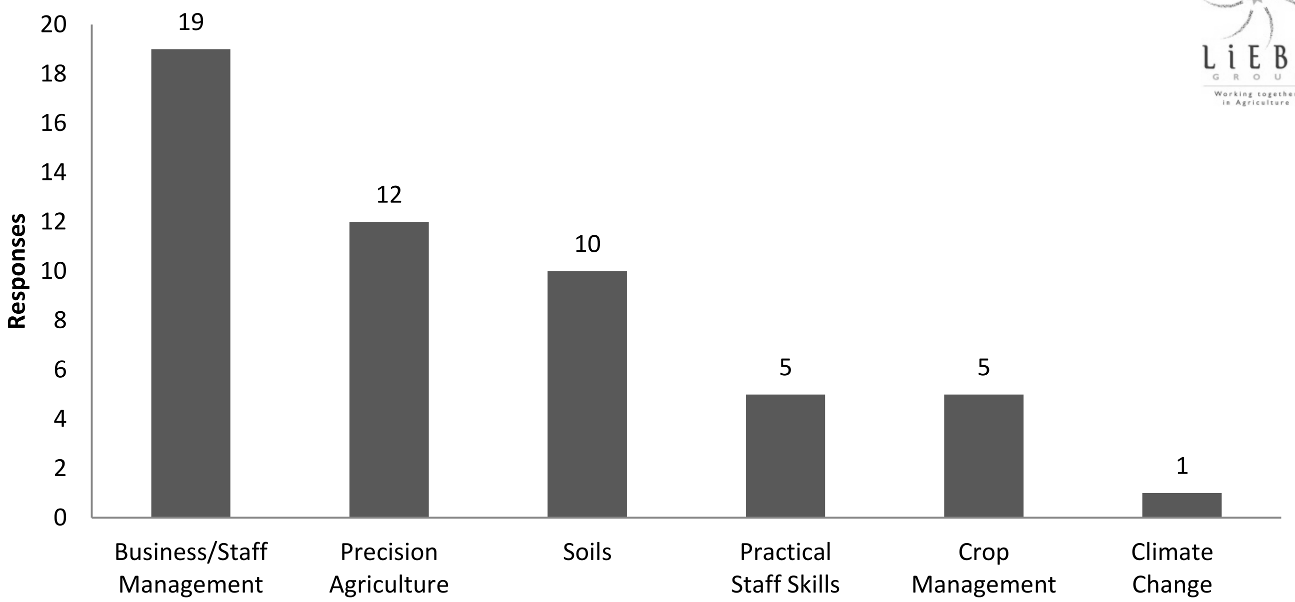

Figure 3: Farmers' responses when asked what key issues could be address in the training, workshops or other communication activities organised through the Liebe Group, measured at the Liebe Group Spring Field Day 2014.

Business/Staff Management Interest Areas Based on Grower Responses at the Liebe Group Spring Field Day 2014 (see Figure 3)

- Grain marketing
- IT workshops
- Farm safety
- Networking
- Staff training and professional development
- Economic analysis on costs per hectare
- Finance
- Training farm workers on safety issues
- Budgeting in low rainfall zones

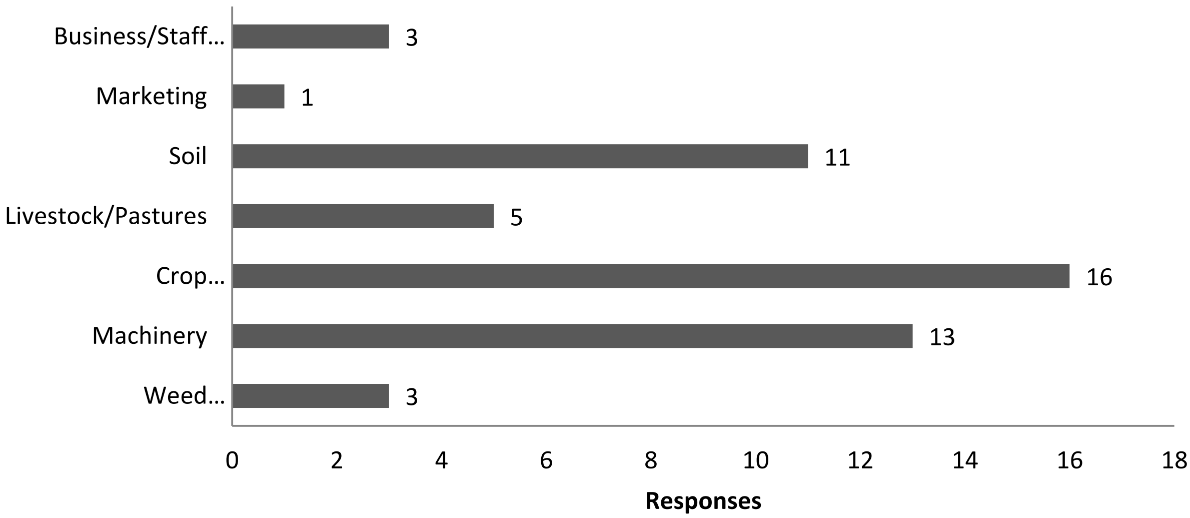

Figure 4: Farmers' responses when asked what concepts/products/practices they'd like to see demonstrated, measured at the Liebe Group Spring Field Day 2014.

Machinery Interest Areas Based on Grower Responses at the Liebe Group Spring Field Day 2014 (see Figure 4)

- Leading tyne deep ripper
- Long term effects of deep ploughing using 40” discs to 30-40cm deep, one-way plough, deep offset disc, spading
- Variable rate technology – seed, fertiliser, spraying concepts
- Sowing tyne configuration
- Tillage under seed at various depths
- Ideal fertiliser setups - down the tube or top-dressed
- Machinery demonstrations

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.

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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 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 groups' inception in 1997 and has become part of the groups' 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 i.e. 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 the 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, 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 monthly newsletters.
- 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 3 major events annually.
- Conduct 3 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 farmers 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 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 and internationally to foster innovation.
- Utilise new ways of interacting (i.e. 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 years 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 officers 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 employees 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 an 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 Committee and Women's 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, subcommittee 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

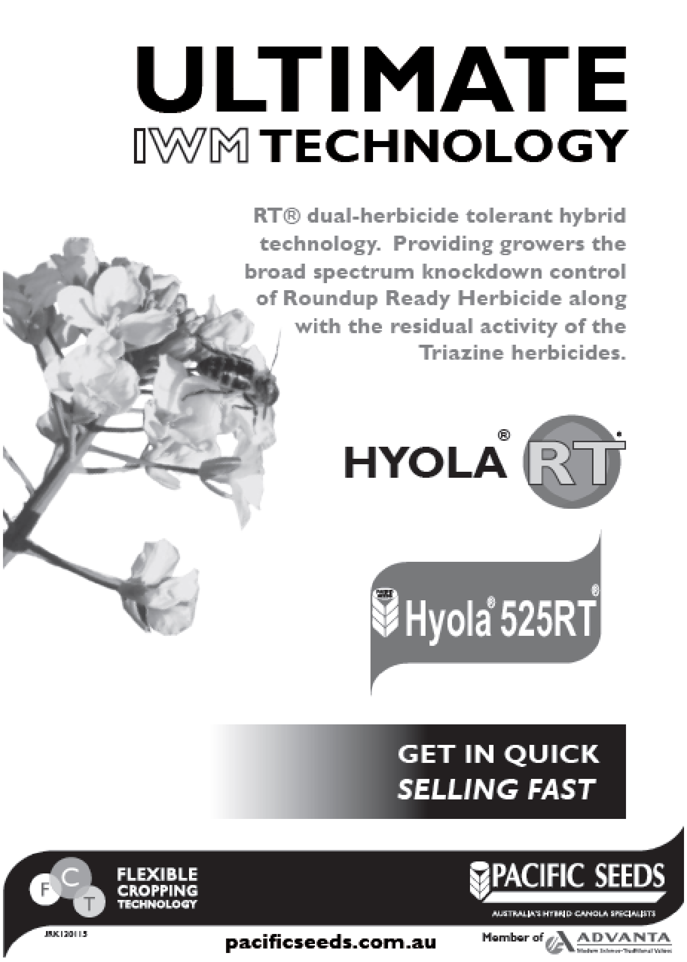
- Develop 5 year strategic plan and review objectives annually as a working document.
- Committee members understand their roles and responsibilities.
- Communicate Liebe Group strategy to Liebe Group stakeholders.
- Ensure inclusive processes are always used.
- Maintain transparency in processes.
- 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 – 2015

EVENT	DATE	LOCATION	CONTACT
February General Meeting	9th February 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
Liebe Group Trials Review Day	17th February 2015	Dalwallinu Bowling Club	Elly Wainwright (08) 9661 0570
Liebe Group AGM	17th February 2015	Dalwallinu Bowling Club	Clare Johnston (08) 9661 0570
R & D Meeting	27th February 2015	Dalwallinu Discovery Centre Performing Arts Room	Elly Wainwright (08) 9661 0570
Liebe Group Crop Updates	4th March 2015	Dalwallinu Recreation Centre	Sarah Tholstrup (08) 9661 0570
March General Meeting	16th March 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
April General Meeting	20th April 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
June General Meeting	8th June 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
Women's Field Day	17th June 2015	Dalwallinu Recreation Centre	Sarah Tholstrup (08) 9661 0570
July General Meeting	20th July 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
Post Seeding Field Walk & Beer 'n' Burger Night	23rd July 2015	Main Trial Site – Hood's Property, Ballidu	Elly Wainwright (08) 9661 0570
August General Meeting	10th August 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
Liebe Group Annual Dinner	12th August 2015	TBA	Alieske van der Schyff (08) 9661 0570
Spring Field Day	10th September 2015	Main Trial Site – Hood's Property, Ballidu	Elly Wainwright (08) 9661 0570
September General Meeting	14th September 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
October General Meeting	12th October 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570
December General Meeting & Christmas Drinks	14th December 2015	Dalwallinu Discovery Centre Performing Arts Room	Clare Johnston (08) 9661 0570



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