LOCAL RESEARCH AND DEVELOPMENT RESULTS

RESULTS FROM THE 2023 SEASON

Liebe Group

Working together in Agriculture

2023/24

Dear Liebe Group Members and Supporters,

The Liebe Group team are proud to present the annual Local Research and Development Results Book for 2024. This publication contains the results from research trials and demonstrations conducted in the Liebe Group region from the 2023 season, as well as summaries of current Liebe Group projects.

We would like to sincerely thank the Liebe Group board members, sub-committee members and staff for their hard work and effort. It is with the contributions made by the team of dedicated staff and respected volunteers that kept the group pushing through its 27th year of research, development and extension activities.

Many thanks are also extended to Boyd, Keith and Rosemary Carter, as well as Heather Knowles and employees for hosting the 2023 Main Trial Site at their property in Jibberding, along with all other members who have hosted or contributed towards research, trial and demonstration efforts throughout the region.

All partners and supporters play a vital role in ensuring the continued success of the Liebe Group. The Liebe Group acknowledges the invaluable support received from the Grains Research and Development Corporation (GRDC), the Department of Primary Industries and Regional Development (DPIRD), the Farm Weekly, the Shire of Dalwallinu and the Grower Group Alliance. We would also like to thank our long term Diamond Partners Rabobank, RSM, CSBP and CBH Group, along with our valued Gold and Silver Partners.

The Liebe Group team are anticipating a fantastic year ahead, with the Main Trial Site being hosted by the McAlpine's (Elserae Agriculture) at their property in Maya.

Please note that the majority of results presented in the book are from one season, and therefore should be interpreted with caution. Guidelines to understanding the results and statistics are included on page 14. Please contact the Liebe Group office if you have any further queries and we encourage you to get in touch with our research partners if you would like any further information on a particular trial.

We wish you all the best for a successful 2024 season and look forward to working with you throughout the year.

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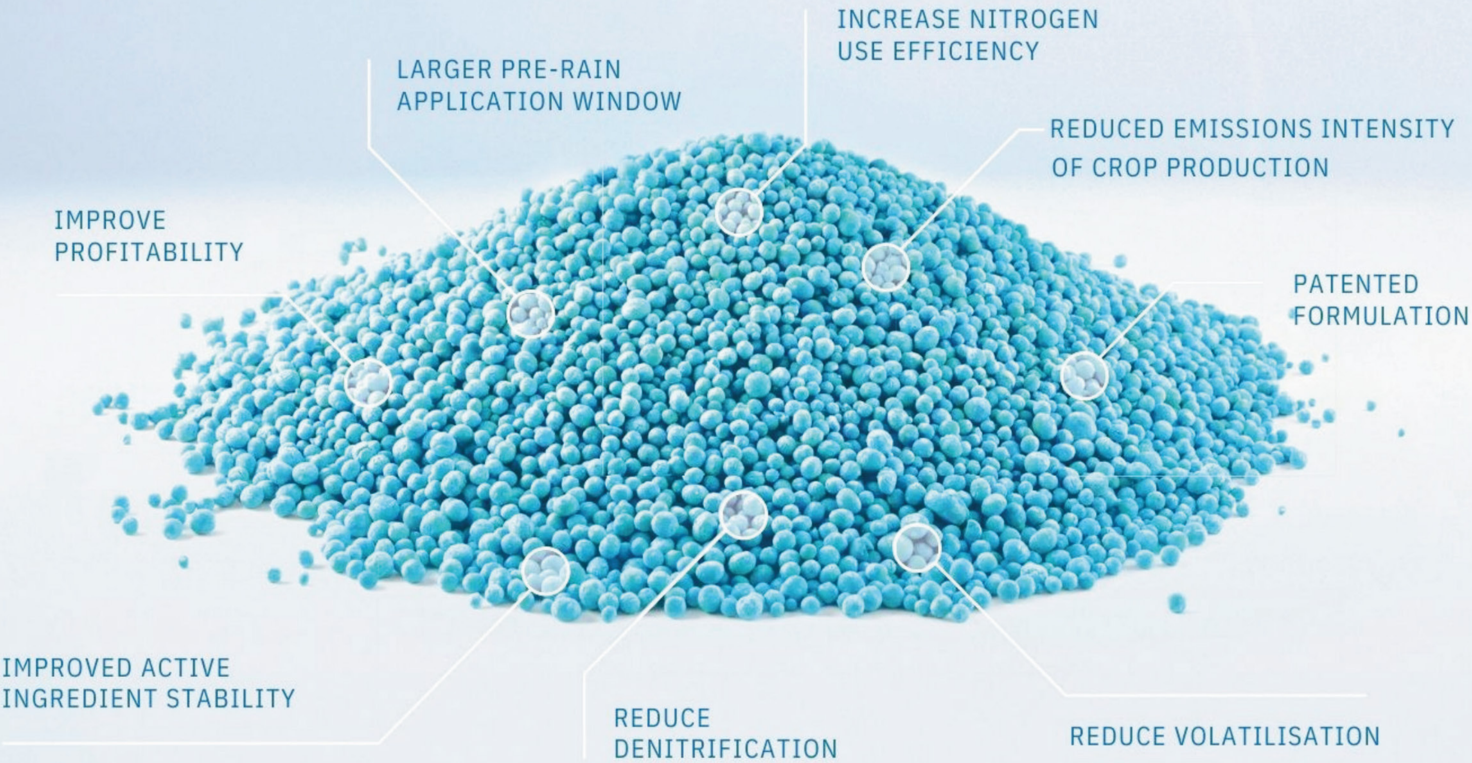

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The development of Urea Sustain reflects our commitment to innovation and new product developments resulting from our trials and research program.

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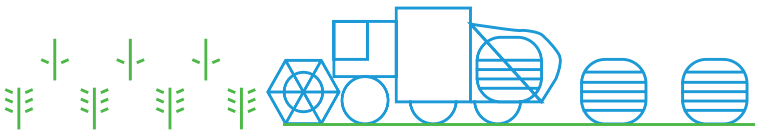

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LIEBE GROUP EVENTS 2024

ANNUAL GENERAL MEETING & TRIALS REVIEW DAY

Thursday 7th March | Dalwallinu Rec Centre

The Annual General Meeting (AGM) invites all Liebe Group members and sponsors to nominate and elect committee members for the coming year.

A members-only event, Trials Review Day links growers with industry representatives, allowing them to obtain first-hand detail and information around local trials and research.

WOMEN'S FIELD DAY

Tuesday 11th June | Dalwallinu Recreation Centre

The Liebe Group Women's Field Day is an event designed to build the management capacity of rural women to make a difference to their family, farm business and the agricultural industry.

POST SEEDING FIELD WALK

Wednesday 24th July | Main Trial Site (Maya)

This annual event provides a comprehensive overview of the trials being conducted at the Main Trial Site for the season, including trial research progress and predictions. The following sundowner provides great networking and social opportunities for growers and industry.

SPRING FIELD DAY

Thursday 5th September | Main Trial Site (Maya)

The Spring Field Day is an interactive field day that showcases the latest local research and development, which has been coordinated on one convenient location at the Liebe Group Main Trial Site. This Main Trial Site is rotated annually to different farming properties in the Liebe area.

UNDERSTANDING TRIAL RESULTS & STATISTICS

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

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

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

Standard Error (SE)
The standard error is a statistical term that measures the accuracy with which a sample distribution represents a population by using standard deviation. In statistics, a sample mean deviates from the actual mean of a population; this deviation is the standard error of the mean or the SE. The standard error tells us how confident we can be in the observed sample mean. A larger sample size usually results in a smaller standard error, and a more accurate sample mean.

The Least Significant Difference (LSD) test
To determine if there is a significant difference between two or more treatments, a least significant difference (LSD) is often used. If there is a significant difference between two treatments, their difference will be greater than the LSD. For example when comparing the yield of five wheat varieties (Table 1), the difference in yield between variety 4 and 5 is greater than 0.6 t/ha (LSD), therefore it can be said there is a significant difference. This means its is 95% ($p = 0.05$) certain that the difference in yield is a result of variety not soil type or some other factor. Whilst there is a difference in yield between variety 1 and 2, it is less than 0.6 t/ha, therefore the difference is unable to be determined as a result of variety; it may be due to subtle soil type change or other external factors.

Letters are often used to indicate which varieties are significantly different, using the LSD value (Table 1), so in this example, there is no significant different between varieties 1, 2 and 3, whereas varieties 4 and 5 are significantly different to each other and the rest of the varieties. Where the LSD result reads as 'NS' this represents that the values are not significantly different from each other.

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

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

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

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

Glossary of Terms

DAA	Days After Application
ToS	Time of Sowing
NSD	No significant difference
GSR	Growing Season Rainfall
IBS	Incorporated by Sowing
PSPE	Post Seeding Pre Emergent
EPE	Early Post Emergent
ANA	Analysis not Applicable

Disease Ratings

Disease ratings in Australia are developed by plant pathologists in a nationally co-ordinated program of both field and controlled environment testing. The work is funded by the GRDC through its NVT program with the work undertaken by specialist plant pathologists across Australia.

VS = Very susceptible, SVS = Susceptible to very susceptible, S = Susceptible, MSS = Moderately susceptible to susceptible, MS = Moderately susceptible, MRMS = Moderately resistant to moderately susceptible, MR = Moderately resistant, RMR = Resistant to moderately resistant, R = Resistant. No score '-' = no rating is currently available. p = Provisional assessment. * = some races in eastern Australia can attack these varieties, including races with Yr17 virulence for stripe rust and races with Lr24 virulence for leaf rust. Combined P. neglectus ratings from DPIRD, SARDI, AgVic and USQ data. Not all varieties have been tested in WA. P. quasitereoides ratings are from DPIRD glasshouse and field trials. Provisional ratings provided for varieties with fewer than three observations or where there has been no field trial verification of the glasshouse rating. CCN ratings from GRDC NVT data. R = resistant – nematode numbers will decrease when this variety is grown. MR = Moderately resistant – nematode numbers will slightly decrease when this variety is grown. MS = Moderately susceptible – nematode numbers will slightly increase when this variety is grown. S = Susceptible – nematode numbers will increase greatly when this variety is grown. Crown rot ratings from SARDI, USQ and DPI NSW data.

2023 SEASON OVERVIEW

Dylan Hirsch, Liebe Group R&D Committee Chair

2023 was a shocker for farmers and trials within the Liebe region, especially in comparison to the record yields of 2022. It started with a dry summer, where minimal storm activity combined with previous high yields left many farmers concerned about poor nutrient availability for the 2023 crop. The exception was for some areas in the north-east and south-east part of the region, where March rain fell and allowed some early plantings of canola. Crop residue management was a hot topic going into seeding, with many paddocks burnt or tilled for the first time in a while. In addition to this, we wanted to know how much moisture had carried over from 2022's wet finish. How can we get herbicide and nitrogen to where it needs to be? And in April many of us started optimistically dry seeding, something we haven't done since 2020.

The R&D committee started optimistically also, with new R&D Coordinator Daenia Dundon, and Project Officer Aeneva Poulish joining us for 2023. Their enthusiasm was notable, with the main trial site at Carter's in Jibberding successfully planned and in the ground as if they'd been with us for years. One of our largest projects was also established in 2023, with Aeneva taking control of our new RiskWi$e Project at McIlroy's in Pithara. This project was established in response to member queries around the long-term economics of chemical fallow and legumes in a rotation. The popular Early Sown Canola trial was also reiterated for 2023 following moderate rainfall at our MTS. However, as a sign of what was to come in the rest of 2023, the early April sown canola had poor germination and the later 'normal' sown canola didn't get up and about until early June, much like the rest of the regions crop.

The dry summer was joined by a dry autumn, winter and spring culminating in an extremely poor season across the region. Many areas in the north and east experienced their driest growing season and calendar year rainfall on record. For the Carter's and the Liebe team, the main trial site was no different. It is a testament to modern cropping systems and technology that farmers could grow a harvestable crop at all on such little rainfall, even if we had to speak in kilograms per hectare instead of tons. At the post-seeding field walk many crops appeared to be in fair condition, indicating they had potential to yield well if we had a finishing rain. Whilst yields were low, the quality of grain was largely very good, with very high protein and reasonable screenings across cereals.

For a drought year, the trials implemented at the main trial site and across our projects did extremely well. The early sown canola trial showed significant yield differences between sowing time (again), the dry conditions showed up herbicide limitations, and in accordance with 'Murphy's Law' we saw fertiliser toxicity in cereals where we didn't expect to see it, but not in canola where we expected to see it! Despite many trials being terminated before harvest, all had reasonable germination which enabled meaningful observations by the Liebe team and our trial partners.

In 2024 the Main Trial Site will head to another repeat host, being McAlpine's home farm in Latham/Maya, just west of the main road. The site is located on yellow sandplain, typical of many areas within the region and will have a range of crops and trials. The McAlpine's last hosted the main trial site in 2000, where we looked at the effect of stubble, seeding technique and seed size on canola establishment. Oh how things change but stay the same! For those interested in soil amelioration, you will not be disappointed, with Brendon McAlpine keen to investigate a variety of machines and techniques in 2024. If you have a suggestion or query please get in touch with one of our R&D committee members.

Onwards and upwards for 2024.

CANOLA & PULSES RESEARCH RESULTS

Evaluating Different Legume Crops and Inoculation Options

Daenia Dundon, R&D Coordinator, Liebe Group

Key Messages

- All three crops (lupin, faba bean and chickpea) had significantly higher nodulation scores on the light acidic loam compared to the red loam trial.
- For chickpea, two new acid-tolerant rhizobia strains, developed by Murdoch University, had significantly higher average nodulation formation over the other inoculants.
- No significant differences were observed between the inoculate types (granular, peat and liquid) for any of the crops.
- The trial could not be harvested due to poor performance in a dry year.

Aim

This trial aims to demonstrate and assess the benefits of growing legumes and provide a better understanding of how to maximise gross margins and nitrogen recovery.

Background

The cultivation of grain legumes provides nutritious food, improves soil health, and reduces nitrogen fertiliser in farming systems. Significant increases in domestic and international demand for West Australian grain legumes are forecast due to burgeoning global populations, improvements in market access, as well as our geographic advantage.

Grain legumes currently contribute in a small and diminishing way to the profitability of West Australian farming systems. GRDC analysis indicates farmers have a good awareness of the benefits of growing a legume in their rotation but have concerns about pulse reliability and profitability. There have been recent advances in grain legume genetics, acid-tolerant rhizobia, management strategies, and weed and disease protection products.

These trials are part of a large-scale collaborative project led by the Grower Group Alliance, which includes 13 grower groups that are demonstrating different legume options and management techniques.

This trial specifically looks at the performance of three legume varieties, when using different inoculation products. This trial has been conducted on a light acidic sandy loam and a red loam. The three inoculation products in the trial were ALOSCA (granular), BASF Nodulaid (peat) and New Edge Microbial Ezi Rhi (liquid). Three experimental peat lines have been included, specifically designed by Murdoch University with tolerance to acid soils.

Trial Details

Trial location	KL Carter & Co., Jibberding
Plot size & replication	10m x 1.5m x 3 replications
Soil type	Sand (light) and sandy clay loam (red)
Paddock rotation	2020 wheat, 2021 wheat, 2022 wheat
Sowing date	19/05/2023
Sowing rate	86 kg/ha Jurien lupin (target 45 plants/m^2), 222 kg/ha PBA Bendoc faba bean (target 30 plants/m^2, 115 kg/ha CBA Captain chickpea (target 45 plants/m^2)
Fertiliser	19/05 - 80 kg/ha MacroPro Extra
Herbicides, Insecticides & Fungicides	19/05 - 1.5 L/ha trifluralin, 1.0 L/ha glyphosate, 1.1 kg/ha simazine, 1 L/ha chlorpyrifos, 150 ml/ha bifenthrin, 27/07 - 330 ml/ha clethodim 360 EC, 150 ml/ha quizalofop-p-ethyl, 10/08 - 20 ml/ha gamma-cyhalothrin, 600 ml/ha bixafen/prothioconazole
Harvest date	Trial was unable to be harvested

Treatments

Treatment	Chickpea	Faba Bean	Lupin
1	WSM5041 (peat 1)*	Alosca Gp F	Alosca Gp G
2	WSM5043 (peat 2)*	EziRhi Gp F	EziRhi Gp G
3	541B1 (peat 3)	Nodulaid Gp F	Nodulaid Gp G
4	Alosca Gp N	Control	Control
5	EziRhi Gp N		
6	Nodulaid Gp N		
7	Control		

*Treatment only occurs on light soil trial.

Soil Composition- Light Soil Trial

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.1	27	72	5.8	2	4	0.040	0.57
10-20	5.8	24	50	8.1	< 1	2	0.034	0.33
20-30	5.0	9	43	17.4	< 1	2	0.033	0.19

Soil Composition- Red Soil Trial

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.7	11	462	8.7	2	2	0.226	0.68
10-20	7.1	9	386	7.6	2	1	0.264	0.51
20-30	7.4	7	411	11.5	2	1	0.353	0.43

Results

Table 1. Predicta B soil testing (pre-seeding) showing resident rhizobia levels. Rhizobia numbers are shown as log(rhizobia)/g soil. (BD) = below detection, (L) = low and (M) = medium levels of rhizobia in the soil.

Trial	Rep	Rhizobia Group N (Chickpea)	Rhizobia Group F (Raba Bean)	Rhizobia Group G (Lupin)
Light Soil	2	0 (BD)	3.28 (M)	2.64 (L)
Light Soil	3	0 (BD)	2.99 (M)	2.95 (L)
Red Soil	1	0 (BD)	1.57 (L)	2.18 (BD)
Red Soil	2	0 (BD)	0 (BD)	2.37 (L)
Red Soil	3	2.36 (L)	0 (BD)	2.23 (BD)
20-30	7.4	7	411	11.5

Table 2. Establishment counts (plants/m²) were conducted on 15 June, approximately four weeks post-seeding.

	Chickpea		Faba Bean		Lupin	
Inoculant	Light	Red	Light	Red	Light	Red
Ezi Rhi	29	34	24	27	43	27
Nodulaid	32	34	31	24	39	54
Alosca	33	24	29	26	39	24
Control	27	35	28	31	43	43
Peat 3	26	24				
Peat 2	29					
Peat 1	23					
Average	28	30	28	27	41	37

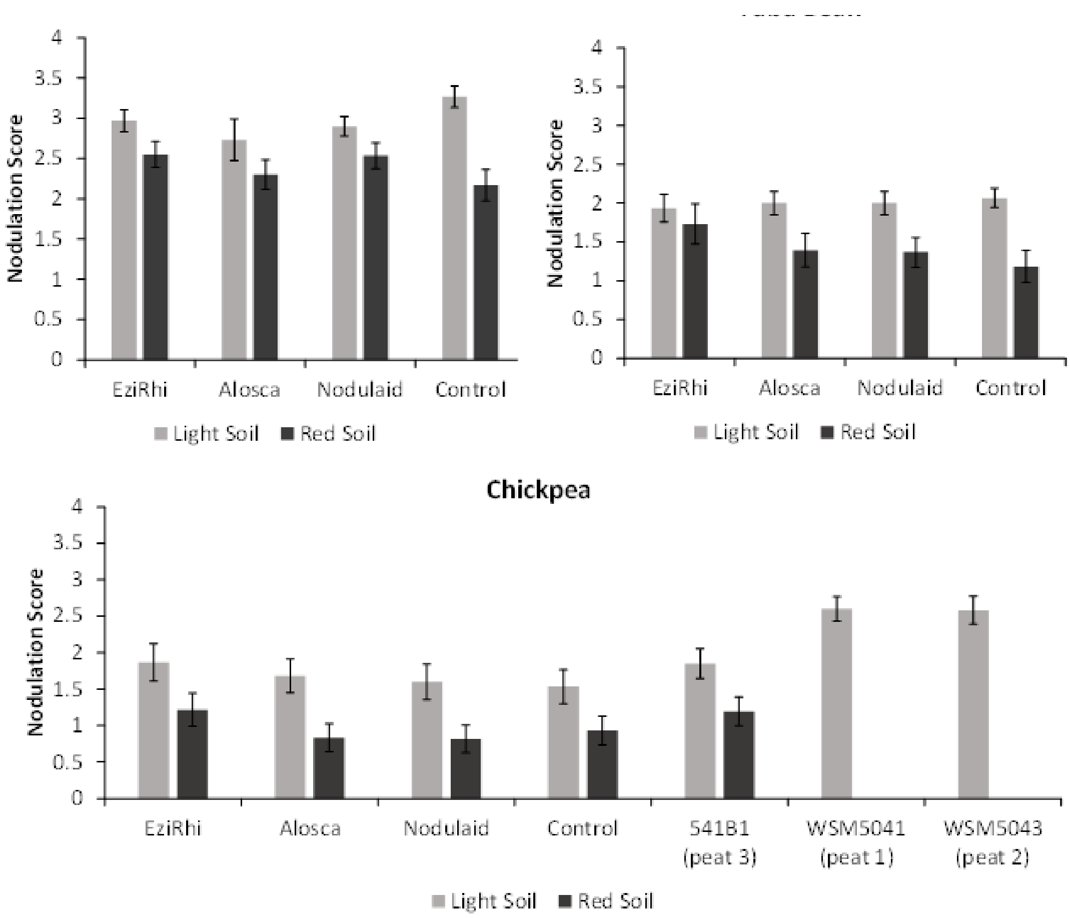

Figure 1. Average nodulation score (0-10) for all treatments of inoculants on lupin, faba bean, chickpea crops for both the light and red soil trials. Treatments are shown with standard errors of the means.

Background rhizobia soil testing shows low levels of Group G rhizobia strain (lupin) in both the light and red soil. Group F rhizobia strains (faba bean) had a medium presence in the light soil, and a low or below detection level in the red soil. Group N rhizobia strains were only present in rep 3 of the red trial at low levels.

Across all crops and treatments, there were significant differences between the light and red soil trials, in terms of average nodulation score ($p < 0.05$). Within the crops, only Murdoch University's experimental chickpea rhizobia peat lines, WSM5041 and WSM5043, had significantly higher average nodulation scores compared to all other inoculates ($p < 0.05$). The freeze-dried liquid inoculant, EziRhi, had the highest average nodulation scores for all crops on the red soil trial, however not significantly ($p > 0.05$).

Comments

Legumes can play a pivotal role in farm rotations due to their dual benefits: serving as a break crop and their ability to fix nitrogen. To ensure optimal nitrogen fixation, it is essential to understand the biology of rhizobia-legume symbioses and inoculation options to improve productivity and sustainability.

The three legume crops examined in this trial exhibit varying soil pH preferences: lupin can tolerate acidity (soil pH of 4.5–8.0), faba bean slightly less so (soil pH of 5.5-8.0), and chickpea prefer a more neutral/alkaline soil (soil pH of 6.0-8.5) (O'Hara, et al. 2012). This was reflected in the establishment counts, with lupin having significantly higher establishment counts in the light soil ($p < 0.05$) with plant numbers closer to the target of 45 plants/m^2 compared to the red soil trial (Table 2). Faba bean maintained similar rates in both soil types (n.s.) and was the closest crop to approach its target of 30 plants/m^2. Chickpea had slightly higher establishment counts in the red soil trial (characterised by a more neutral pH) compared to the light soil trial (n.s.), however chickpea was notably below the target of 45 plants/m^2 in both soil types.

Through-out the growing season, especially as the conditions became dry, the light soil plots were observed to be in a 'healthier' condition than the red soil trial. This may be attributed to deeper penetration of the root systems, enabling access to sub-soil moisture. Consequently, the light soil plots had significantly higher average nodulation scores than their red soil counterparts (Figure 1).

In terms of the inoculants, no single standout option emerged from the commercial options for any crop on either soil type. In the red soil trial, the EziRhi inoculant treatments had the highest average nodulation score for all crops, however this was not statistically significant (Figure 1). New Edge's EziRhi inoculant is a freeze-dried powder that was mixed with water to coat the seed. This method contains a higher cell count of rhizobia compared to granular and peat products (Denton, et al. 2018). Further field testing is required to determine the efficacy of the different inoculation options, with a focus on rhizobia survival.

For lupin and faba bean in the light soil trial, no significant difference was observed between treatments, with the control having the highest average nodulation score. Background rhizobia soil testing conducted prior to sowing shows a low and medium presence of lupin and faba bean rhizobia strains in the light soil, respectively, which could explain the result (Table 1). However, this unexpected result could also suggest a potential limitation of the trial with possible contamination within the seeding box during implementation. Additionally, the trial was dry sown, which is suboptimal for rhizobia survival, serving as another limiting factor.

Despite these results, within the chickpea treatments on light soil, two of Murdoch University's experimental peat lines, WSM5041 and WSM5043, had significantly higher average nodulation scores compared to all other inoculants (Figure 1). Those two strains were specifically developed for their acid tolerance, suggesting higher rhizobial survival in the light acid soil, which would explain the increased formation of nodules.

Acknowledgements
Thank you to Boyd Carter for hosting the site and Living Farm for seeding and managing the trial. This trial is part of a GRDC investment into grain legume extension being led by the Grower Group Alliance. Thanks to BASF, New Edge Microbials, Elders Dalwallinu, Yvette Hill (Murdoch University) and Rob Nankivell for supplying products and advice.

References
Denton, M., Farquharson, L., Ryder, M., Rathjen, J., & Ballard, R. (2018). Best options for optimal performance from rhizobial inoculants. *Ground Cover, Grains Research and Development Corporation.*
O'Hara, G., Howieson, J., Drew, E., Ballard, R., Herridge, D., Gemmell, G., & Hartley, E. (2012). Inoculating Legumes: A Practical Guide. Canberra: *Grains Research and Development Corporation.*

Peer Review
Mark Seymour, Senior Research Scientist, DPIRD

Survey
GGA has created a survey to better understand growers' opinions of legumes. It would be greatly appreciated if you could please complete the survey, using the QR code.

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Risks and Rewards of Sowing Canola Early

Daenia Dundon, R&D Coordinator, and Chris O'Callaghan, Executive Officer, Liebe Group

Key Messages

- All six canola varieties sown at the start of April (time of sowing 1, 3 April 2023) had significantly higher yields than all varieties sown at the start of May (time of sowing 2, 2 May 2023).
- The early maturing varieties, Emu and Battalion, performed the best overall.
- 2022 and 2023 trials demonstrate the significant effect time of sowing has on yield and the rewards associated with sowing canola early (if the opportunity arises).

Aim

To understand the risks and rewards of sowing canola early, in particular, the impact on yields and profitability.

Background

The past few seasons have provided early seeding opportunities, particularly in 2021 and 2022 off the back of tropical weather systems. In response, growers have sought to investigate the risks and rewards of sowing canola earlier in the season. Those who have taken these early opportunities have observed phenological variances with the earlier sowing conditions, as indicated by variety phenology work done by NSW DPI (NSW DPI, 2021).

Liebe growers have also identified a gap in experimental data, particularly on the consequences of sowing canola in the region before mid-April. While previous research conducted by the Department of Primary Industries and Regional Development in Mullewa and Wongan Hills in 2019 and 2020 showed no yield penalty for seeding in March, further investigation was required to understand the specific implications for the Liebe region.

To address this knowledge gap, Liebe Group's R&D Committee designed a trial wherein six varieties of Roundup Ready canola, with varying maturity lengths, were sown on two different dates: 3 April (time of sowing 1) and 2 May (time of sowing 2). The two early maturing varieties were Nuseeds' Emu and Pacific Seeds' Battalion, with maturity ratings of 3 and 3.5, respectively. The mid-maturing varieties, both with a rating of 4, were BASFs' Invigor 4022P and NuSeeds' Raptor. The longer maturing varieties were, BASFs' R4520P and NuSeeds' Eagle, with ratings of 4.5 and 5, respectively. This specific selection of varieties was chosen to assess the performance and adaptability of canola to early sowing conditions, aiming to provide valuable insights for Liebe members in optimising their sowing strategies.

Trial Details

Trial location	KL Carter & Co, Jibberding
Plot size & replication	10m x 1.5m x 3 replications
Soil type	Sandy loam
Paddock rotation	2022 wheat, 2021 canola, 2020 wheat
Sowing date	Time of sowing 1 - 03/04/2023 (sown wet, after ~36mm rain); Time of sowing 2 - 02/05/2023 (sown dry, no rain in month preceding);
Emergence date	Time of sowing 1 - ~08/04/2023 Time of sowing 2 - ~15/06/2023
Sowing rate	Battalion 4.4 kg/ha, Emu 2.3 kg/ha, Eagle 4.0 kg/ha, Invigor R4022P 2.9kg/ha, R4520P 2.9kg/ha, Raptor 1.8kg/ha. (Target of 40 plants/m2)
Fertiliser	60 kg/ha MacroPro Extra, 60 kg/ha Urea, 180 L/ha Flexi-N
Herbicides, Insecticides & Fungicides	2 L/ha glyphosate, 100 g/ha clopyralid, 1 L/ha propyzamide, 1.5 L/ha trifluralin, 1.8L/ha glyphosate, 300 ml/ha flutriafol, 600 ml/ha prothioconazole + bixafen, 1 L/ha chlorpyrifos, 100 ml/ha bifenthrin, 50 g/ha sulfoxaflor, 300 ml/ha emamectin.
Harvest date	10/11/2023

Results

Table 1. Average plants/m² for time of sowing 1 and 2, at four, six and ten weeks after seeding (approximately).

	4WAS Average		6WAS Average		10WAS Average	
Count date	**TOS1 2/5**	**TOS2 14/7**	**TOS1 18/5**	**TOS2 27/7**	**TOS1 15/6**	**TOS2 29/8**
Emu	13	63	11	56	30	62
Battalion	16	58	15	56	34	56
Eagle	10	54	8	54	30	56
Invigor 4022P	8	53	8	51	24	51
R4520P	12	51	10	44	28	48
Raptor	15	54	13	44	25	47
Average	12	56	11	51	29	53

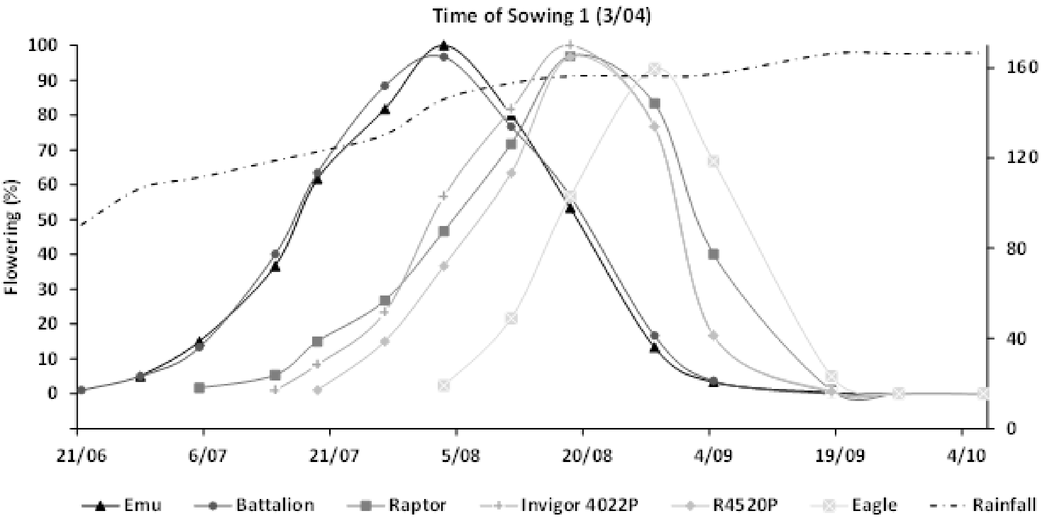

Figure 1. The number of flowering plants (%) for each variety over the flowering period for time of sowing 1. The secondary axis shows accumulated rainfall (mm) at the site for the year. Six varieties were used: Emu, Battalion, Raptor, Invigor 4022P, R4520P and Eagle, all were sown on 3 April.

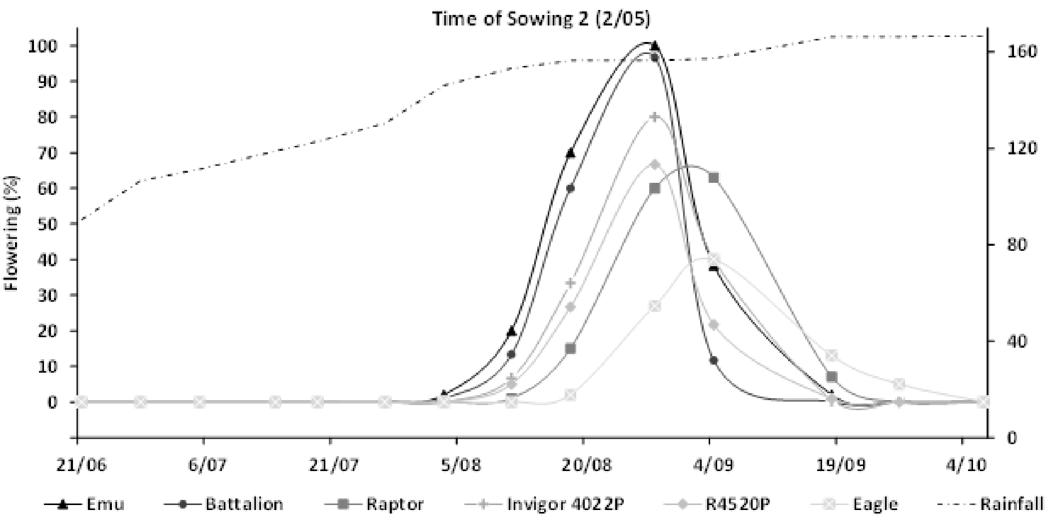

Figure 2. The number of flowering plants (%) for each variety over the flowering period for time of sowing 2. The secondary axis shows accumulated rainfall (mm) at the site for the year. Six varieties were used: Emu, Battalion, Raptor, Invigor 4022P, R4520P and Eagle, all were sown on 2 May.

Table 2. Harvest results for each variety in time of sowing 1 and time of sowing 2, including average yield (t/ha), protein, oil, moisture and admix (%).

	Average Yield t/ha		Protein		Oil		Moisture		Admix (%)	
Variety	TOS1	TOS2	TOS1	TOS2	TOS1	TOS2	TOS1	TOS2	TOS1	TOS2
Emu	0.62	0.30	20.87	23.7	46.77	44	3.9	5.7	0.80	1.38
Battalion	0.56	0.19	20.83	24.5	47.33	41.9	5.4	5.7	2.46	1.68
Eagle	0.34	0.08	23.2	23.7	44.2	44	5.4	5.7	3.14	1.38
Invigor 4022P	0.43	0.21	21.7	24.9	46.1	41.6	5.1	5.2	1.38	1.83
R4520P	0.43	0.19	22.5	23.9	42.6	40.8	5.5	5.8	1.78	1.85
Raptor	0.35	0.15	22.4	24.1	43	40.5	5.5	5.5	1.7	2.1

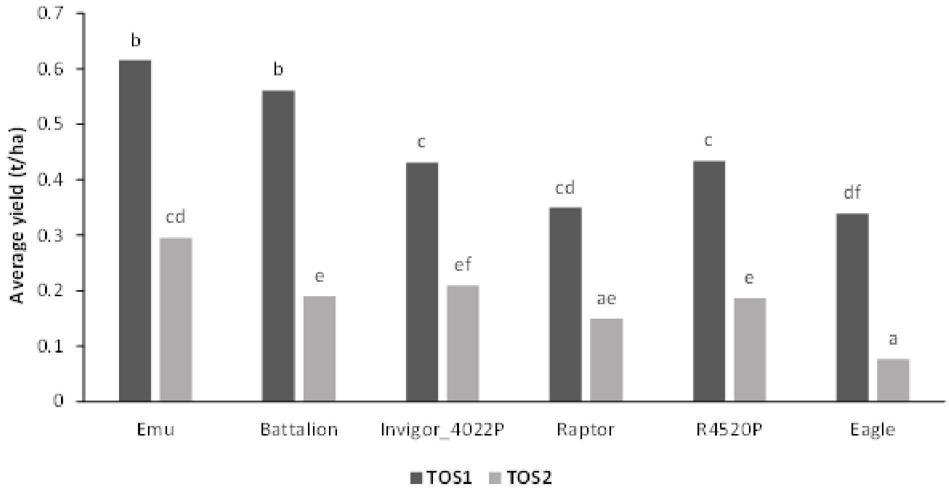

Figure 3. Average yield for each variety for time of sowing 1 and time of sowing 2. Bars annotated with the same letter have average yields that were not significantly different (P > 0.05) according to a LSD test.

Comments

Time of sowing 1 (TOS 1) canola was sown into wet soil conditions on 3 April after the site received ~36mm between 25 and 31 March, enough to achieve germination. Whereas time of sowing 2 (TOS 2) was sown on the 2 May and germinated approximately six weeks later, at the start of June, after a 12mm rainfall event.

In both time of sowing treatments, the early season varieties had the highest plant counts (Table 1). Battalion consistently had the highest plant counts in TOS 1, whereas in TOS 2, Emu had the highest. Additionally, TOS 2 had higher plant density at all stages indicating increased initial germinations and minimal plant mortality.

Time of sowing 1 started flowering approximately three months after germination, due to the cooler than average June which potentially delayed the varieties reaching their required number of degree days. The two early varieties, Emu and Battalion, were the first to flower in late June, and the longest variety, Eagle, started flowering 6 weeks later (3 August) (Figure 2). On average the varieties in TOS 1 were flowering for 9.5 weeks, with most reaching full flower around the six-week mark. TOS 1 had three distinct full-flower stages, which were dependent on the maturity length of the variety.

The seasonal conditions impacted the flowering opportunities for TOS 2 with cool and dry conditions in May delaying germination until 6 weeks post-seeding, in mid-June. Rainfall then decreased through July and August whilst temperatures rose, delaying varieties reaching the reproductive stage by not meeting their vernalisation requirements. All varieties in TOS 1 reached full flower, however, in TOS 2 only the early maturing varieties, Emu and Battalion, managed full flower, with the longer variety, Eagle, only having a maximum of 40% flowering for the season (Figure 3). On average, the TOS 2 treatments were flowering for five weeks, with the peak flowering stage at three weeks; a substantially shorter flowering period than the TOS 1.

Average yield was significantly higher in TOS 1 compared to TOS 2, with the early varieties performing the best overall (Table 2 and Figure 3). Early April seeding had significantly lower plant counts, with an average of 17 plants/m² compared to early May seeding's 53 plants/m². Despite the low plant density, TOS 1 yields were double the yield of TOS 2, demonstrating that the time of sowing significantly affects yield ($p < 0.05$). The extended growing period of TOS 1 allowed the treatments to reach full flower before the hot and dry spring resulting in increased pod production and enhanced overall performance.

In terms of grain quality, protein and moisture increased for all varieties in TOS 2 from TOS 1, whereas oil decreased. This pattern is expected as TOS 1 had a longer growing window, allowing it to utilise increased nitrogen from the system to produce higher yields and therefore higher oil content and lower protein (DPIRD 2019). Whereas TOS 2 had a shorter growing season, limiting nitrogen usage, which is reflected in the higher protein levels and lower oil content.

Due to the dry year resulting in low-yielding crops, treatments had to be combined in order to conduct grain quality testing. This is a limiting factor of the 2023 trial as a single measurement only provides a snapshot and does not capture potential variability within each variety or time of sowing treatment.

Although the 2022 and 2023 seasons were starkly different, a consistent theme emerged across both trials: all TOS 1 treatments outperformed their TOS 2 counterparts. These trials demonstrate that sowing canola before mid-April can result in significantly higher yields within the Liebe region, and given the right conditions, can be a reliable practice to optimise crop performance.

Acknowledgements
Thank you to Boyd Carter for hosting the site and Living Farm for seeding, harvesting and managing the trial. This trial is a GRDC investment through the National Grower Network. Thanks to Nuseed, Pacific Seeds, BASF and Living Farm for supplying seed. Lastly, thank you to AAGI for conducting all statistical analyses.

References

DPIRD. (2019). *Tactical Break Crop Agronomy Project: Canola and Pulse Agronomy Trials and Information.* Department of Primary Industries and Regional Development.
NSW DPI. (2021). *Canola Phenology - targeting varieties to dlowering dates in different environments.* Grains Research and Development Corportaion.

Peer Review
Jackie Bucat, DPIRD

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Nitrogen Recovery Under Various Legume Strategies

Daenia Dundon, R&D Coordinator, Liebe Group

Aim

This demonstration aims to investigate long-term gross margins and nitrogen recovery under various legume strategies in canola and subsequent cereal crops.

Background

The cultivation of grain legumes provides nutritious food, improves soil health and reduces nitrogen fertiliser in farming systems. Burgeoning global populations and incomes, improving market access, and our geographic advantage are forecast to significantly increase domestic and international demand for Western Australian grain legumes. However, grain legumes currently contribute in a small and diminishing way to the profitability of Western Australian farming systems. In the Liebe Group region, grain legumes in general have declined in popularity due to issues around weed control, performance in acid soils and profitability when compared to alternative break crops such as canola.

This trial is a farmer-scale demonstration part of GRDC investment into improving the adoption of grain legumes in Western Australia. This trial involves farmer-size strips of lupin, brown manure lupin, brown manure vetch and fallow, which were sown in 2023, followed by canola in 2024 and a cereal crop in 2025.

Trial Details

Trial location	BA JM Hirsch, Bunjil
Plot size & replication	12m x 600m x 2 replications
Soil type	Sandy loam
Paddock rotation	2022 cereal, 2021 canola, 2020 lupin
Sowing date	07/05/2023 lupin, 08/05/2023 vetch
Sowing rate	40 kg/ha vetch, 60 kg/ha Jurien lupin
Fertiliser	N/A
Herbicides, Insecticides & Fungicides	N/A
Harvest date	25/10/2023

Treatment

Treatment	
1	Lupins (grain)
2	Brown manure lupin
3	Brown manure vetch
4	Chemical fallow

Results

Treatment 1, lupins (grain) yielded on average 0.3 t/ha in 2023.

Comments

The difference in yield of the subsequent crop seeded over the four treatments will help farmers understand potential rotational strategies, by determining which are most effective and profitable. Data collection in 2024 will include soil sampling, plant tissue sampling and yield.

Acknowledgments

Thank you to Dylan Hirsch for hosting and implementing the trial. This trial is part of a GRDC investment into grain legume extension being led by the Grower Group Alliance.

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NATIONAL VARIETY TRIAL RESULTS

Wheat and Barley National Variety Trial – Jibberding

Aim

The aim of the National Variety Trials (NVT) is to generate independent information for growers and industry about newly released varieties of field crops to the current commercial varieties grown in the area.

Background

The NVT program has been designed to identify the highest yielding varieties, free from the constraints of nutrition and disease. As a result, the nutrition and crop protection packages applied to NVT trials are typically higher than what may be applied by the average grower. Management is the same for all plots with no differences in timing for crop protection or nutrition. All trials have three replicates of each variety and all plots are sown (and subsequently harvested) on the same day. Timing of sowing is dependent upon the season but is typically done within an average district "best practice" window and located on a typical soil type for the area.

Trial Details

Trial location	KL Carter & Co., Jibberding
Plot size & replication	10m x 1.72m x 3 replications
Soil type	Sandy loam
Paddock rotation	2020 wheat, 2021 wheat, 2022 canola
Sowing date	18/05/2023
Sowing rate	200 seed/m2
Fertiliser	18/05/23 – Urea 100 kg/ha, K Till Extra 130 kg/ha, 04/07/23 – Flexi-N 150 L/ha
Herbicides, Insecticides & Fungicides	Knockdown pre-seeding, broadleaf and grass spray, insecticide and fungicide. Details of chemicals used and rates available at nvtonline.com.au
Harvest date	11/09/2023

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.7	11	462	8.7	2	2	0.226	0.68
10-20	7.1	9	386	7.6	2	1	0.264	0.51
20-30	7.4	7	411	11.5	2	1	0.353	0.43

Results

1	18Q4H0262	14	H16Q3x0336.SCI-011D	27	LRPB Havoc	40	Scepter
2	Ballista	15	H16Q3x0336.SCI-097D	28	LRPB Matador	41	Sting
3	Borlaug 100	16	Hammer CL Plus	29	LRPB Nyala	42	Supreme
4	Brumby	17	IGW6754	30	Mace	43	Valiant CL Plus
5	Calibre	18	IGW6783	31	Magenta	44	Vixen
6	Catapult	19	IGW6884	32	Ninja	45	Wedin
7	Chief CL Plus	20	IGW8192	33	OAGT0049R	46	Yitpi
8	Cutlass	21	Kinsei	34	OD2965-001	47	Zen
9	Denison	22	LPB18-3055	35	RAC3146		
10	Devil	23	LPB19-12826	36	RAC3260		
11	EDGE16Q-0155	24	LPB19-12888	37	RAC3261		
12	Emu Rock	25	LRPB Anvil CL Plus	38	Razor CL Plus		
13	H16Q3x0138.SCI-102D	26	LRPB Avenger	39	RockStar		

Figure 1. List of wheat varieties included into the Buntine Main Season Wheat (WMaA23BUNT6) NVT Trial for the 2023 season.

1	AGTB0415	14	CA22-517	27	Litmus	40	Zena CL
2	AGTB0530	15	Combat	28	Maximus CL		
3	AGTB0532	16	Commander	29	Minotaur		
4	AGTB0659	17	Commodus CL	30	Neo		
5	AGTB0660	18	Compass	31	RGT Planet		
6	AGTB0667	19	Cyclops	32	Rosalind		
7	AGTB0669	20	Fathom	33	RP22054		
8	AGTB0671	21	IGB22012T	34	SCA21-Y003		
9	Alestar	22	IGB22014T	35	SCA23-Y004		
10	Bass	23	IGB22015T	36	SCA23-Y005		
11	Beast	24	La Trobe	37	Scope CL		
12	Buff	25	Laperouse	38	Spartacus CL		
13	CA22-228	26	Leabrook	39	Titan AX		

Figure 2. List of barley varieties included into the Buntine Main Season Barley (BMaA23BUNT6) NVT Trial for the 2023 season.

Acknowledgments
Thank you to Living Farm for implementing and managing the NVTs. Also thank you to Boyd Carter for providing the site for the trial as well as participating companies, GRDC and the NVT program coordinators.

References
DPIRD. (2023). 2024 Western Australian Crop Sowing Guide. Perth: State of Western Australia.

To view results or for more information scan the QR code below or visit the GRDC NVT webpage.
https://nvt.grdc.com.au/

WEEDS RESEARCH RESULTS

Alion® Herbicide for Fence Line Weed Control

Matt Willis, Market Development Agronomist (WA North), Bayer Crop Science

Key Messages

- Agricultural fence lines have become hotspots for developing herbicide resistance across Australia, particularly annual ryegrass to glyphosate.
- Alion is a soil-applied herbicide that provides long-lasting control against a range of grass and broadleaf weeds. With a low use rate and excellent safety beneath established trees, it is ideal to be used along agricultural fence lines.
- Alion herbicide is available for Australian growers for the 2024 growing season.

Aim

To evaluate the length of control achieved by Alion when used as a pre-emergent herbicide on fence lines, and to compare it with current industry standards.

Background

With increasing levels of herbicide resistance being detected across Australia in recent years, it is important to try and preserve the existing herbicide chemistry for as long as possible. Notably, fence line weeds have been managed less than optimally by many Australian growers with substandard application methods and herbicide choice being prevalent (i.e. no rotation of chemistry and “glyphosate plus whatever is left in the chemical shed”).

Alion herbicide (indaziflam) has been registered ahead of the 2024 season, and with its long residual activity across a range of weed species, and unique mode of action (Group 29, formerly ‘O’), it will be an ideal alternative to herbicides that are currently being used in-crop. Alion will also be registered under vineyards and orchards, which demonstrates how safely it will perform under trees and shrubs along fence lines.

Trial Details

Trial location	KL Carter & Co., Jibberding
Plot size & replication	6m x 2m x 3 replications
Soil type	Red sandy loam
Paddock rotation	Long-term tree line
Application date	25/05/2023
Herbicides, Insecticides & Fungicides	As per treatment list
Harvest date	N/A

Treatments

1	Untreated Control
2	2.5 L/ha Roundup Ultra®MAX (570 g/L glyphosate)
3	2.5 L/ha Roundup UltraMAX + 150 ml/ha Alion (500 g/L indaziflam)
4	2.5 L/ha Roundup UltraMAX + 730 ml/ha Terrain® Flow (480 g/L flumioxazin)
5	2.5 L/ha Roundup UltraMAX + 3.5 kg/ha atrazine 900
6	3.2 L/ha paraquat 250 + 150 ml/ha Alion

A planned Uragan® (bromacil) treatment was not applied due to the presence of trees adjacent to the trial site.

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.7	27	72	5.8	2	4	0.226	0.57
10-20	7.1	24	50	8.1	< 1	2	0.264	0.33
20-30	7.4	9	43	17.4	< 1	2	0.353	0.19

Results

Table 1. Weed control ratings (%) for each treatment 62 days after application (62 DAA) and 105 days after application (105 DAA). ARG = annual rye grass, Capew. = Capeweed, Ice Pl. = Ice plant and PatCur = Pattersons curse.

Assessment Date	26-Jul-23 (62 DAA)				07-Sep-23 (105 DAA)			
	ARG (%)	Capew. (%)	Ice Pl. (%)	PatCur. (%)	ARG (%)	Capew. (%)	Ice Pl. (%)	PatCur. (%)
Untreated	0	0	0	0	0	0	0	0
2.5 L/ha Roundup UltraMAX	57	37	67	93	40	23	82	90
2.5 L/ha Roundup UltraMAX + 150 ml/ha Alion	96	90	93	98	95	47	93	95
2.5 L/ha Roundup UltraMAX + 730 ml/ha Terrain Flow	93	96	99	98	93	47	99	95
2.5 L/ha Roundup UltraMAX + 3.5 kg/ha atrazine	95	99	99	99	43	90	99	96
3.2 L/ha paraquat + 150 ml/ha Alion	98	47	96	81	95	33	96	80

At the 105 days after application (DAA) assessment, there was high control (>93%) of annual ryegrass (Lolium rigidum) achieved by both Alion treatments and the Terrain Flow treatment. Both the standalone Roundup UltraMAX (40%) and atrazine (43%) treatment had less control, with the atrazine treatment having seemingly run out of residual after good control being recorded 62 DAA.

Atrazine was the only treatment to display good control (90%) of capeweed (Arctotheca calendula) at the 105 DAA assessment, with all other treatments less than 50% control.
Common ice plant (Mesembryanthemum crystallinum) was controlled by all treatments at the 105 DAA assessment, with high levels (>92%) achieved by the atrazine, Terrain Flow, and both Alion treatments.

All treatments containing Roundup UltraMAX provided high control (>90%) of Paterson's curse (Echium plantagineum), whereas the paraquat + Alion treatment only recorded 80% control. Further assessments will be conducted 12 months after application.

Discussion

Despite the low rainfall received at the trial site (less than 100mm recorded from June to September), all three residual products (Alion, Terrain Flow and atrazine) were incorporated into the soil and activated by the early June rains; enabling them to provide good control of a wide range of weed species that germinated after the initial weed population was controlled by their glyphosate or paraquat knockdown partner.

The higher residual control of Alion and Terrain Flow over older triazole chemistry such as atrazine, was evident with the difference in performance on annual ryegrass by the 105 DAA assessment, but there was an unexpected, inverted response with the results on capeweed at the same timing.

It will be important to revisit this trial in autumn of 2024 to see whether there is still any residual activity present 9-12 months after application. Having good residual chemistry to complement our existing knockdown herbicides is critical going forward to minimise the risk of herbicide resistance, with the goal of reducing weed seed numbers and potentially being able to apply to bare soil or on smaller weeds the following season.

Acknowledgements

Thanks to Boyd Carter for hosting the Main Trial Site, and the Liebe Group for organising the event.

Peer Review

Grant Thompson, Crop Circle Consulting

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Pre-and Post-Emergent Options for Broadleaf Weed Control in Wheat

Tristan Clarke, Agronomist, Elders Dalwallinu

Key Messages

- Pre-emergent treatments have significantly reduced germination of early radish and continue to provide good control all season.
- Most pre-emergent options provided similar levels of control, except Terrain Flow which performed poorly due to conditions.
- Early Post-Emergent (EPE) application of Mateno Complete performed well with 5mm of rain falling shortly after application, helping substantially.
- Post-emergent mixes containing Picolinafen performed worse when applied to large weeds late in the season under high light intensity conditions.
- All mixes with Group 27 herbicide worked slowly but did result in best overall control.

Aim

With a range of new broadleaf weed control options and a shift in the use pattern on many existing post-emergent options, this trial seeks to investigate the control of wild radish in wheat. The trial also aims to investigate how new products will tank mix with existing herbicides to potentially provide a one-pass control of broadleaf and grass when seeking to clean up problematic paddocks.

Background

Wild radish is a major issue for WA grain growers with its presence in paddocks continuing to be one of the key weed species requiring control every year. As farm scale increases, there is a never-ending pursuit for efficiency and as such, many products are often tank mixed to gain control of multiple weeds. This trial will investigate how new products can fit into this system and their broadleaf weed control efficacy.

Trial Details

Trial location	KL Carter & Co., Jibberding
Plot size & replication	10m x 2m, 3 replications
Soil type	Sandy loam
Paddock rotation	2021 wheat, 2022 wheat, 2023 canola
Sowing date	25/05/2023
Sowing rate	Calibre wheat 70 kg/ha
Fertiliser	25/05/23: 120 kg/ha Macropro Xtra + 100 kg/ha Urea 04/07/23: 180 L/ha Flexi-N
Herbicides, Insecticides & Fungicides	All plots received 2.5 L/ha glyphosate + 0.15 L/ha bifenthrin + 0.8 L/ha chlorpyrifos + 2 L/ha trifluralin + 3 L/ha tri-allate IBS followed by treatments listed below.

Treatment	Timing	Description
1		Untreated Control
2	A	Callisto 200 ml/ha
3	A	Voraxor 200 ml/ha
4	A	Terrain Flow 125 ml/ha
5	A	Mateno Complete 1000 ml/ha
6	B	Mateno Complete 1000 ml/ha
7	C	Triathlon 1000 ml/ha
8	C	Quadrant 1000 ml/ha
9	C	Flight 720 ml/ha
10	C	Velocity 1000 ml/ha; Hasten 1.0 % V/V
11	C	Frequency 200 ml/ha; Bromoxynil 1000 ml/ha; Hasten 1 % V/V
12	C	Galaxy 500 ml/ha; Hasten 1 % V/V
13	C	Triforto 1000 ml/ha
14	C	Priority 25 ml/ha; MCPA LVE 570 500 ml/ha; Uptake .5 % V/V
15	C	Galaxy 500 mL/ha; Bromoxynil 1000 ml/ha; Hasten 1 % V/V
16	C	Infinity Ultra 140 ml/ha; Bromoxynil 1000 ml/ha; Hasten 500 ml/ha
17	C	Infinity Ultra 140 ml/ha; Arcade 2500 ml/ha; Hasten 1 % V/V
18	C	Galaxy 500 ml/ha; Arcade 2500 ml/ha; Hasten 1 % V/V

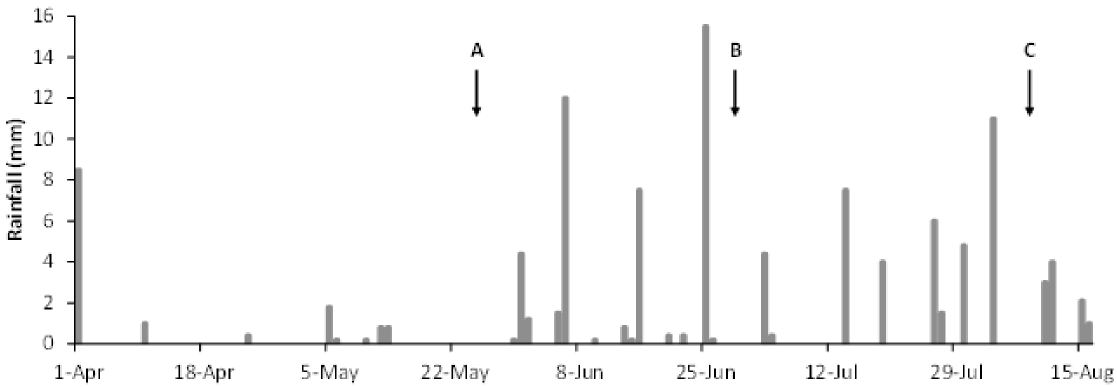

Figure 1. Rainfall (mm) data at the trial location from April to September. Arrows indicate treatment timing: 'A' treatments were applied on 25/05, 'B' treatments were applied on 29/06 and 'C' treatments were applied on 08/08.

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.1	27	72	5.8	2	4	0.040	0.57
10-20	5.8	24	50	8.1	< 1	2	0.034	0.33
20-30	5.0	9	43	17.4	< 1	2	0.033	0.19

Results

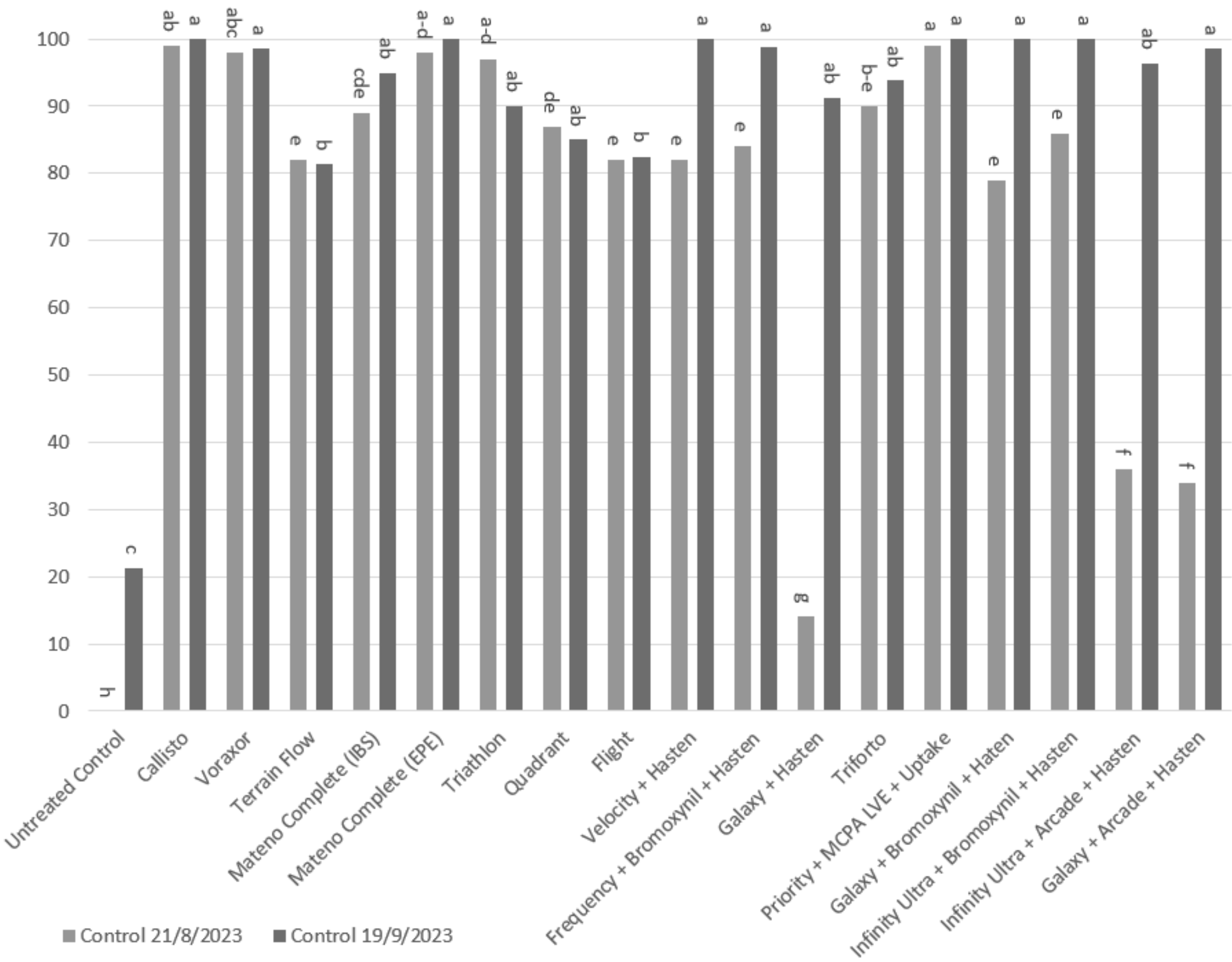

Figure 2. Wild radish and volunteer canola control ratings (%) recorded on 21st of August and 19th of September for all treatments. Letters signify statistical differences.

Discussion

Results from pre-emergent control options of Callisto and Voraxor both showed comparable high levels of control while Terrain Flow was nearly 20% behind, primarily due to lack of rain following application. This trend remained evident all season with later ratings of Terrain also behind. Flumioxazin has a very low solubility (0.8 mg/L) and as such would require good levels of moisture post-application to get adequate root uptake for good levels of control. Mateno Complete showed overall good levels of control both pre and post-emergent, however, the step up in control from IBS to EPE was visually apparent in the plots, particularly early in the season.

Control from any of the premixed 6/12/4 brews in Triathlon/Quadrant and Triforto were standout performers for control of the canola and radish at the first rating, however stayed around the 80-90% control range when the second rating was completed a month later. It was noticeable that products containing Picolinafen had a slightly lower overall control rating as the application of these products was past the advisable time frame (applied on 08/08/23 early stem elongation) where there was a period of high sunlight intensity, and it is suspected that the quicker burndown of Picolinafen resulted in lower overall uptake of the MCPA and bromoxynil components resulting in lower overall control. This is a consideration when applying common brews and is often overlooked.

Priority + LVE provided very good overall control at both ratings primarily due to the canola being the main weed type present, this is a very good control option for RR canola volunteers and can be a handy clean-up option where group 2 chemistry still works.

All products containing Pyrasulfotole showed lower levels of control early and increased dramatically by the time the last rating was completed. Group 27 products in Frequency + Bromoxynil and Velocity provided similar levels of control at both ratings and performed very well at the final rating.

Galaxy, a standalone Pyrasulfotole product without Bromoxynil to allow flexible tank mixing, provided a poor result early and was only marginally better with the addition of Arcade. The second assessment timing for Galaxy was significantly better. If there had been follow-up rain, however, it is expected that the poorly controlled early weeds would have re-shot and potentially continued growing. It must be noted that Galaxy is not registered standalone and should never be applied without a tank mix partner. When Galaxy is mixed with Bromoxynil, control is significantly improved but was still slightly behind Velocity standalone at the first assessment timing. However, it was on par by the time the second rating was completed, and was in line with all of the group 27 based products.

When mixed with Bromoxynil, Infinity Ultra, a combination of Pyrasulfotole and DFF provided slightly higher level of broadleaf control than Galaxy + Bromoxynil. Efficacy was closer to the level of the 6/12/4 mixes at the first rating and not significantly different from the highest control options at the final rating showing its fit when used as a mix with Bromoxynil. This trend is also seen in the mix with Arcade where, although not significant, the level of control early is slightly higher when DFF is added to the mix. If there had been subsequent germinations of canola/radish we would have expected the Infinity + Bromoxynil treatment to provide a level of residual control that would be from any Velocity/Frequency type.

Acknowledgements
Thank you to Living Farm for the implementation and maintenance of the site, Syngenta, BASF, Bayer, ADAMA, Nufarm and Titan Ag for the supply of the product and to the Carter family for hosting the site.

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Efficacy of a Rate Range of Reflex® Herbicide on Wild Radish in Lupins

Owen Langley, Broadacre Development Lead, Syngenta

Key Messages

- Reflex® herbicide was released in 2021 providing a unique mode of action (group 14) for the control and suppression of key broadleaf weeds in a range of pulse crops.
- Reflex® has proven to provide a step-change level of control of key broadleaf weeds for Australian pulse growers compared to previous industry standards.
- Higher rates of Reflex®, whilst providing excellent weed control, are proving to be a challenge in managing the risk to sensitive crops the following year, particularly in lighter soil types and lower rainfall zones.
- Pulses will continue to be an important rotational tool in Western Australian cropping systems, and Reflex® will play a crucial weed control role in these crops.
- Studies have shown that reducing the rate of Reflex® used in these higher risk paddocks is one tool that can be used to minimise the risk on the following crop, however, to optimise weed control other weed management techniques must be employed in support.
- This study demonstrated how a lower use rate of Reflex® can effectively control wild radish and reduce the carryover risk.

Aim

1. What can be expected from a range of Reflex® rates, both standalone and in tank mix combinations, for the control of wild radish when applied IBS or PSPE?
2. What can we expect in overall control, length of residual from reduced Reflex® rates?

Background

Since its release in 2021, Reflex® by Syngenta has provided Australian pulse growers with a new herbicide option to manage a range of hard to kill broadleaf weeds in various pulse crops, including narrow leaf lupin. Whilst it has proven to provide excellent weed control, there are some challenges with managing the risk to sensitive crops the following year particularly in lighter, hostile soil types or in low rainfall zones.

Reducing the rate of Reflex® is one tool that growers can use to minimise the risk the following year, however, that comes with the prospect of a reduction in the length of residual activity and overall weed control. In 2023, Syngenta conducted a series of trials designed to evaluate a range of Reflex® rates and timings, along with tank mix partners, to determine the most appropriate use rate for these higher risk situations.

Unfortunately, three of the five trials conducted did not have adequate weed populations to generate any data. These trials were located at the Liebe Group's Main Trial site at Jibberding, the Mingenew Irwin Group's Main Trial Site at Irwin, and another at Tenindewa. This report is a summary of trials done at Doodenanning and Regans Ford.

Trial Details

Trial location	Doodenanning, York	Regans Ford
Rotation	2021 – wheat, 2022 - canola	2021 – canola, 2022 - wheat
Plot size & replication	10m x 2.3m x 4 reps	12m x 2m x 4 reps
Soil type	White sand	White sand
Stubble Cover	Low (<10%)	Low (<10%)
Variety	Jurien lupins	Jurien lupins
Seeding Rate	100 kg/ha	100 kg/ha
Application Information	100 L/ha, Handboom @ 6 km/hr, Lechler IDK 120-015 A.I. @ 2.1bar	100 L/ha, Handboom @ 6 km/hr, Billeracy 015 @ 2.5bar
Sowing Date	30 May 2023	11 July 2023
Time to Incorporation	<3hr	<3hr
Seeder Type	Depth: 3cm, plot seeder knife point with press wheels at 4 km/hr	Depth: 3cm, plot seeder knife point with press wheels at 4 km/hr
Rainfall Notes	46.6mm in March, 51.8mm in April, 9.7mm in May. 48mm fell in the 2 weeks after seeding (total of 60mm in June), 23mm in July, 21mm in August and 37mm in September.	65mm fell in Jan-June, 103mm in June and 19mm in the week prior to seeding. A further 52mm fell in July post seeding, 35mm in August and 27mm in September.
Herbicides : Knockdowns and Pre-Emergent Treatments	1.3L Trifluralin, 1L propyzamide, 2L glyphosate, 800ml chlorpyrifos and 150ml bifenthrin	2L glyphosate f/b 1L propyzamide, 2L paraquat, 750ml chlorpyrifos
Post-Emergent Herbicide Applications	PSPE treatments were applied day of sowing. 330ml clethodim and 150ml quizalofop-P-ethyl was applied at post-emergence to control the grass weeds.	PSPE treatments were applied day of sowing. 400ml clethodim and 150ml quizalofop-P-ethyl was applied at post-emergence to control the grass weeds.

Results

Table 1. Wild radish weed control (%) vs UTC at various timings by treatment at Doodenanning and Regans Ford.

Location	Doodenanning		Regans Ford	
Untreated Wild Radish per m2	2 plants per m²		26 plants per m²	
Assessment Timing (days after planting)	21DAP	62DAP	21DAP	65DAP
Untreated	0 d	0 g	0d	0 g
Reflex® 500ml IBS	94 c	83.3 de	83.3 bc	75 ef
Reflex® 750ml IBS	96.3 abc	83.3 de	88.3 abc	83.3 c-f
Reflex® 1000ml IBS	98 ab	92.3 abc	88.3 abc	94.3 abc
Reflex® 1500ml IBS	99 a	94.3 ab	95 a	97 ab
Reflex® 500ml + Simazine 550gm IBS	97 abc	80 ef	91.7 ab	80 def
Reflex® 500ml + Metribuzin 180gm IBS	98.7 a	80 ef	86.7 abc	73.3 f
Reflex® 750ml + Simazine 550gm IBS	97 abc	81.7 de	88.3 abc	90 a-d
Reflex® 750ml + Metribuzin 180gm +IBS	98 ab	86.7 cde	86.7 abc	86 b-e
Simazine 550gm + Metribuzin 180gm IBS	95.3 bc	73.3 f	78.3 c	85 cde
Reflex® 500ml + Simazine 550gm + Metribuzin 180gm IBS	94.7 c	88.3 bcd	88.3 abc	86.7 bcd
Simazine 550gm + Metribuzin 180gm IBS fb Reflex® 500ml PSPE	96 abc	91.7 abc	95 a	98.3 a
Simazine 550gm + Metribuzin 180gm IBS fb Reflex® 750ml PSPE	99 a	96.7 a	86.7 abc	97 ab
Reflex® 750ml PSPE	99 a	94 abc	88.3 abc	93.3 abc

Trial Site Background
The two trials had populations of naturally occurring wild radish present under different pressures, with an average of 2.4 plants per m² (low) at Doodenanning and 26 per m² (high) at Regans Ford. Both sites had a light sandy soil profile, with organic carbon below 0.6%. As seen in the rainfall notes in the trial details, the locations experienced similar rainfall conditions before and after seeding which is an influence on herbicide performance. Whilst the sowing date at Doodenanning was commercially relevant, the sowing at Regans Ford was much later than what may normally be expected. In the 45 days leading up to seeding, the Regans Ford site received a total of 130mm resulting in an effective knockdown program.

Reflex® Dose Response on Residual Activity
One of the main strengths of Reflex® has been the long residual activity. One of the aims of this trial was to determine what could be expected in the way of early seasonal control and residual activity from lower use rates under different conditions. Four rates of Reflex® from 500 to 1500 ml/ha were evaluated across the trials under IBS (incorporated by sowing) use patterns.

At the earliest assessment timing, 21 days after planting (21DAP), under a lower pressure weed density scenario at Doodenanning the differences, whilst noticeable, were not significant across all treatments. A high level of control at the earlier timing was achieved by all treatments, although there were some statistical differences and an overall trend towards better performance from higher rates. Reflex® at 500 and 750 mL/ha resulted in 94% and 96% control respectively at the Doodenanning trial. Whereas under higher weed burden (Regans Ford), 500 to 750 ml/ha rates only resulted in 83% and 88% control. The top label rate at 1500 ml/ha revealed consistent efficacy across different weed pressures, resulting in 99% and 95% control at Doodenanning and Regans Ford sites respectively (Figure 1, Figure 2).

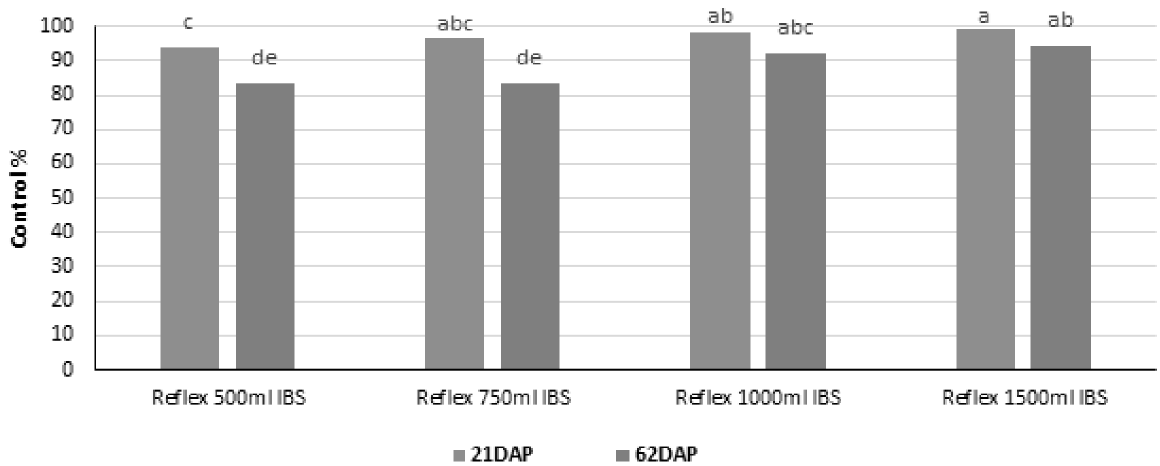

Figure 1. Wild radish weed control (%) vs UTC at 21DAP and 65DAP by Reflex® IBS rates at Doodenanning (low weed pressure).

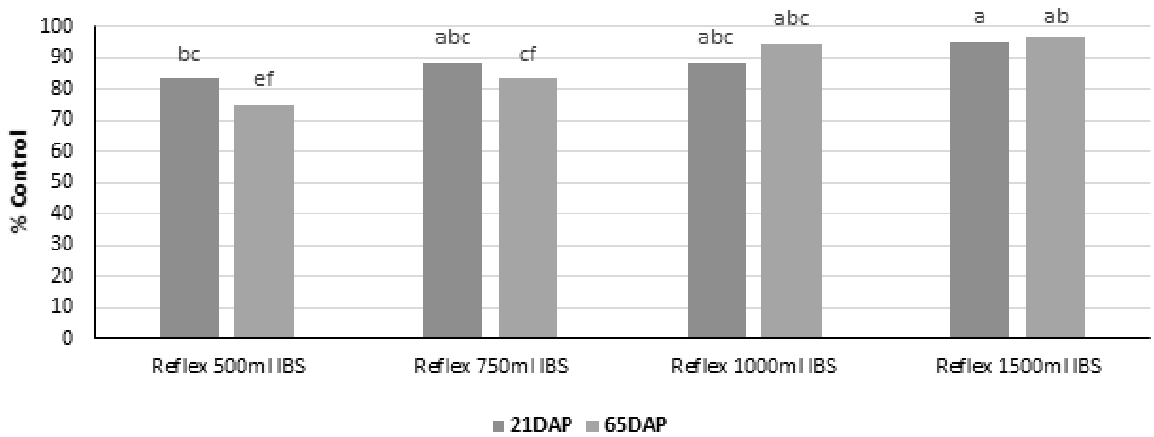

Figure 2. Wild radish weed control (%) vs UTC at 21 DAP and 65DAP by Reflex® IBS rates at Regans Ford (high weed pressure).

At the late assessments, 65 days after planting (65DAP), Reflex® applied at 1000 ml/ha IBS provided 92% and 94% control at Doodenanning and Regans Ford sites. When the rate was increased to 1500 ml/ha IBS, the control at each trial site increased to 94% and 97% respectively. When applied at 750ml/ha at IBS, the control reduced to 83% across both trials. At 500ml/ha, the performance dropped to 84% at Doodenanning and to 75% at Regans Ford under higher weed pressure.

As expected, there was a trend towards better weed control at the higher rates due to improved residual activity. Reflex® at 1000-1500 ml/ha rates provided consistent control (92-97%) across early and late assessment timings. Reflex® at 500-750 ml/ha rate provided similar levels of control at 21DAP, however reduced to 75-83% at 65DAP across both locations. Final assessments also indicated that higher rates of Reflex® are beneficial under higher weed pressure. At the Doodenanning site, there was no rate response between 500 and 750 mL of Reflex® at final assessment. However, at Regans Ford where there was a higher density population, Reflex® at 750 ml (83%) was significantly better than 500ml (75%).

Reflex® used in tank mix

The addition of simazine or metribuzin to Reflex® rates of 500ml or 750ml IBS only improved the outcome in some instances. At Doodenanning, the addition of Simazine to Reflex® at 750ml was significantly better than metribuzin at the same Reflex® rate, and both treatments with Reflex® at 500ml (Table 1).

The addition of both simazine and metribuzin to the lower rates of Reflex, whilst not significant, consistently resulted in a better performance across both trials. By comparing treatments 11, 12 and 13 to 10, the addition of Reflex®500-750 ml/ha improved the final efficacy across IBS and PSPE. A rate response of Reflex® was observed when used as a tank mix. The 750 mL/ha rate of Reflex® consistently resulted in better final control than 500 ml/ha when added into standalone simazine, metribuzin or simazine and metribuzin mix (Table 1).

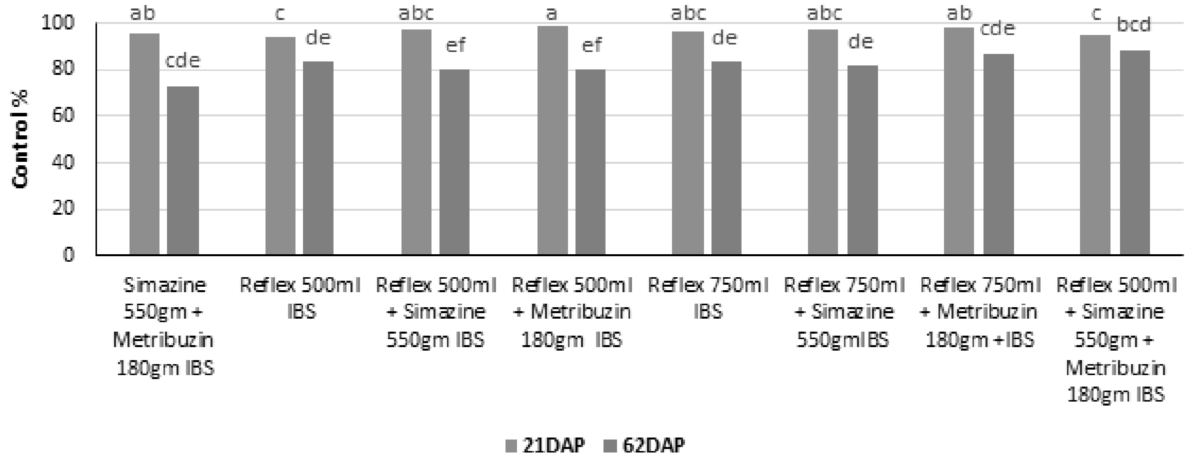

Figure 3. Wild radish weed control (%) vs UTC at 21 DAP and 65DAP by Reflex® IBS rates with Simazine and Metribuzin at Doodenanning (low weed pressure).

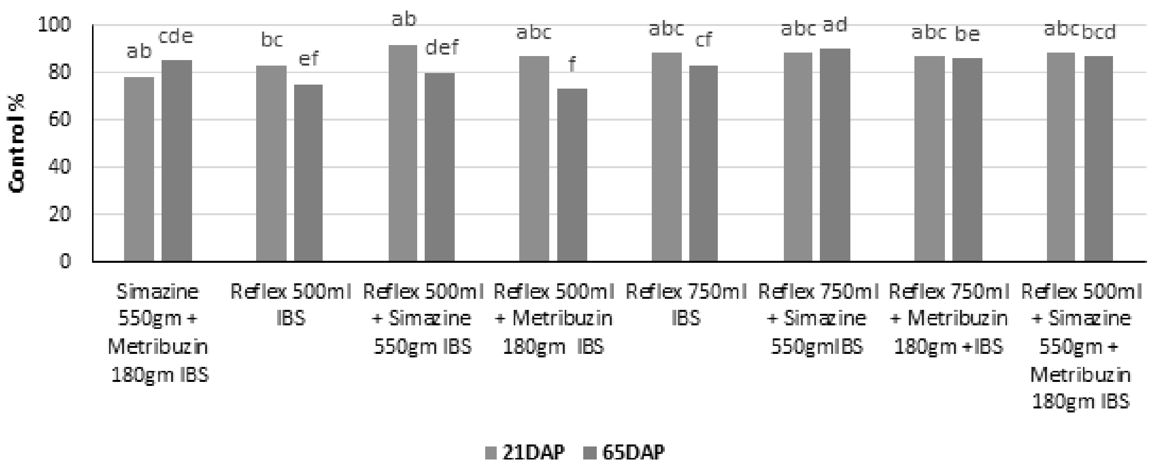

Figure 4. Wild radish weed control (%) vs UTC at 21 DAP and 65DAP by Reflex® IBS rates with Simazine and Metribuzin at Regans Ford (high weed pressure).

Reflex® IBS vs PSPE

Applications of Reflex® PSPE were superior to similar rates applied IBS. When compared at 750 ml/ha rates, the PSPE application of Reflex® outperformed IBS standalone at the later assessments. There was a significant difference at Doodenanning and whilst not significant at Regans Ford, there was a trend. The same could be said when Reflex® was applied in combination with either simazine or metribuzin, with treatment 12 providing significantly better control than treatment 11 at Regans Ford (Table 1). The addition of simazine and metribuzin IBS prior to the application of Reflex® PSPE, resulted in better performance across both sites.

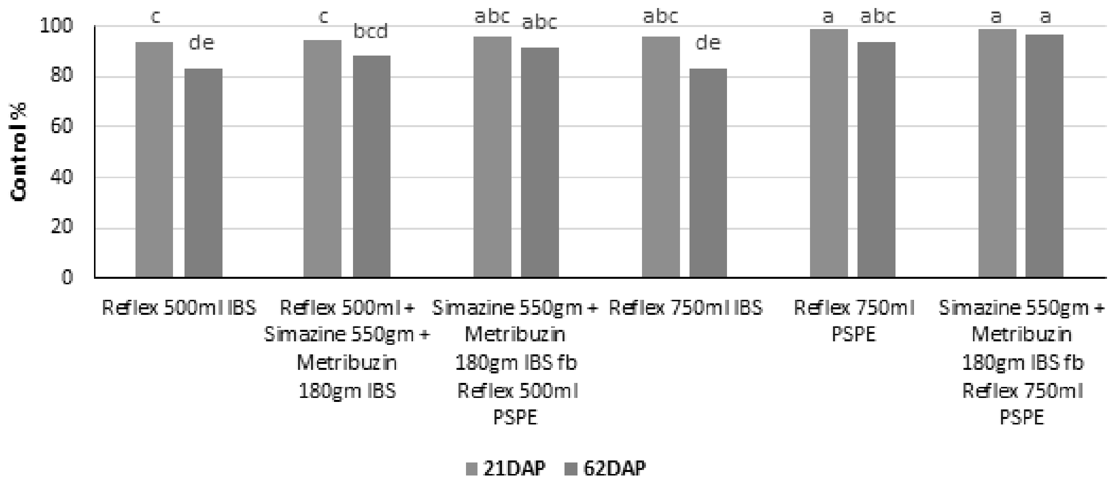

Figure 5. Wild radish weed control (%) vs UTC at 21 DAP and 65DAP by Reflex® IBS and PSPE rates at Doodenanning (low weed pressure).

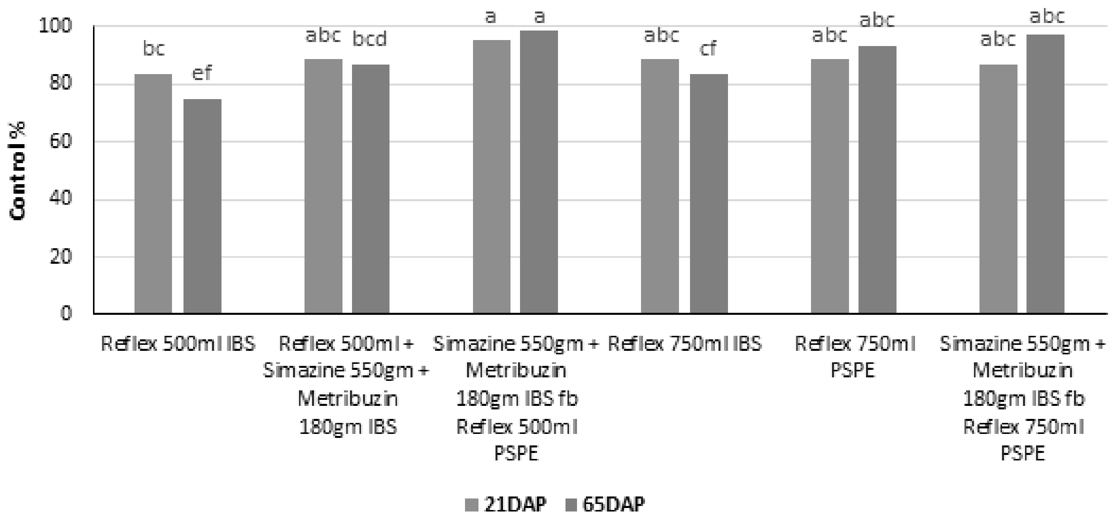

Figure 6. Wild radish weed control (%) vs UTC at 21 DAP and 65DAP by Reflex® IBS and PSPE rates at Regans Ford (high weed pressure).

Seasonal conditions at both trials were ideal to allow PSPE application of Reflex® to perform the way they did. The applications went onto moist soil following seeding, and both sites received at least 40mm of rain in the 14 days after application. This resulted in adequate activation and movement of the herbicide to the root zone of germinating weeds.

Comments

Whilst pulses form a smaller part of overall cropping hectares in Western Australia, the value they offer to the broader cropping system is critical. One of the limitations of pulse production in Western Australia has been robust weed control options to ensure cleanliness in the current crop, plus a reduced weed seed set for future crops in the rotation. Reflex® herbicide has been demonstrated to address this issue by having powerful activity on key weeds challenging pulse production in WA.

Using Reflex® at high rates (750-1500 mL/ha) may increase carry over risk in the following year. To minimise the risk, Syngenta recommends using lower rates of Reflex® (500-750 mL/ha) if the organic carbon content of the intended paddocks soil is between 0.5-1.5%. In situations where soil organic carbon is below 0.5%, Syngenta does not recommend the use of Reflex®.

Standalone, Reflex® has shown itself to be a step change in weed control for wild radish vs current standards, these trials again were a demonstration of that. More importantly, it has proven to be a valuable and robust partner for protecting and extending the life of existing chemistries. Reflex® tank mixed with a group 6 (C) herbicide offers improved levels of weed control compared to existing options and offers a cost-effective IBS option for broad spectrum weed control. Additionally, it has improved the performance of group 12 (F) and 6 (C) applications post-emergent by reducing the early weed pressure and improving coverage of post-em sprays through reduced shading and numbers. For research purposes, no post-emergent broadleaf spray was done in the trials. However, as an integrated weed management approach, post-emergent spray is required. The 75-83% residual control displayed by lower Reflex® rates at these trials up to 10 weeks after seeding will significantly reduce the weed coverage, maximising the efficacy of post-emergent spray.

The addition of a tank mix partner to Reflex® will be critical in improving overall control, particularly on other weeds such as capeweed and doublegee (suppression activity only). It will also be an important tool in managing resistance.

The decision to apply Reflex® IBS or PSPE is one of logistics. The user's ability and capacity to come back post-sowing and pre-emergent, without disrupting the rest of their spraying program, should ultimately dictate the application timing of Reflex®. There are also risks associated with PSPE applications that do not necessarily apply to IBS. Conditions around the time of application will greatly influence the performance of both applications timings, however, it does have a greater effect on PSPE. These trials are a great example where sufficient rainfall before and after application result in excellent PSPE performance. Receiving this amount of rainfall and the timing is not always the case. There are also some crop safety risks if a high amount of rainfall or events that move treated soil back into the crop occur following the application of Reflex® PSPE. These are all factors which should be considered when deciding on the most appropriate timing of Reflex® application on paddocks.

In summary, these trials have shown that the addition of a lower rate of Reflex® into pulse herbicide programs will continue to offer growers with robust, residual control of wild radish in a range of pulse crops. Even in situations where the rate needs to be reduced to manage the plant-back risk to the following crop, growers and advisors should continue to experience robust weed control. However, a shortened length of activity and reduced performance in high density situations should be expected. An integrated approach to weed management, incorporating appropriate rates of Reflex® for the situation, along with robust rates of a tank mix partner, combined with a well-timed post-emergent strategy will provide the best results.

Acknowledgements
Thanks to all the collaborators/managers of the various trial sites. The biggest thanks of all to the growers who kindly donated the use of their properties in order for us to conduct this research. Also, to the Liebe Group and Mingenew Irwin Group for hosting trials. To Living Farm and Kalyx for their management at Doodenanning and Regans Ford. Also, a big thank you to all who attended field walks during the year.

Peer Review
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DISEASE & PEST RESEARCH RESULTS

Are Chickpeas Resistant to Root Lesion Nematode Species Pratylenchus neglectus?

Carla Wilkinson, Senior Research Officer, and Mark Seymour, Senior Resesarch Scientist, DPIRD

Key Messages

- Current and upcoming chickpea varieties show some resistance to the root lesion nematode species *Pratylenchus neglectus*.
- Chickpeas are a much better rotation option for management of *P. neglectus* than a susceptible wheat variety.
- Chickpea varietal resistance ratings specific for our WA environment will be published in the 2025 edition of the Western Australian Crop Sowing Guide.

Aim

1. Determine resistance of current popular and emerging chickpea varieties to the root lesion nematode species *Pratylenchus neglectu*s in Western Australian growing conditions.
2. Determine if chickpeas are a better rotation option than cereals to manage *P. neglectus*.

Background

Root lesion nematodes (RLN) enter crop roots to feed and lay eggs. This activity damages the plant roots and affects the uptake of nutrients and water and also impacts yield. In resistant plants, RLN are either unable to enter the root system or are not able to multiply. This results in a reduction in nematode levels over a growing season whereas susceptible plants offer a good food source to the nematode, promote RLN reproduction, and nematode numbers will significantly increase over a season. Crops or varieties that reduce RLN levels over a season in multiple trials (multiplication less than 1) are classified as resistant (R) or moderately resistant (MR).

Pratylenchus neglectus is a RLN found in 70% of WA broadacre paddocks and can cause yield loss in a wide range of crops including wheat, barley, and canola. To reduce the potential for P. neglectus to impact yields of current and future crops, it is best to choose crops and varieties that result in the lowest end-of-season nematode levels. Resistance of chickpeas to *P. neglectus* has not been tested in Western Australia (WA) since the early 2000s, when all varieties screened were rated susceptible (S), to very susceptible (VS) (Perth Crop Updates, 2005). However, recent testing in eastern Australia of the newer chickpea varieties has shown that they are more resistant to *P. neglectus* than the older varieties and, in some seasons, may reduce *P. neglectus* nematode levels. This needed to be tested in Western Australia as our physical soil structure, soil biology, and environment are different to Victorian, South Australian and Queensland environments, where this screening was conducted.

In 2022, a trial was established in Dalwallinu. This site was chosen as the farmer was interested in hosting a nematode trial and the paddock (i) was suitable for growing chickpeas - chickpeas prefer well drained loamy sands to clay loams with a pH above 5.5, (ii) had low to medium starting levels of *P. neglectus* and (iii) had low levels of Rhizoctonia solani AG8.

In this experiment, commercial chickpea varieties and new breeding lines were compared to varieties of wheat, barley, and triticale with known resistance or susceptibility to *P. neglectus.* Bare fallow plots were also included in the trials to assist in the assessment of RLN nematode multiplication rates. We used the following controls, shown in increasing order of resistance; Calingiri (SVS), Scepter (S), La Trobe (MS), Yenda (MRMS), Fusion RMR and a weed free fallow. Yenda is included in our trials as it is the most resistant wheat or barley variety that we have tested in WA. It is an old AGT variety that is no longer commercially available. Fusion triticale was included as it is the most resistant cereal that has been tested.

Trial Details

Trial Location	HJ Hyde & Co., Dalwallinu
Plot size & replication	2m x 10m x 6 reps
Pratylenchus neglectus	23/05/2022 site average 4 /g soil; plot levels ranged from below detection to 14 /g soil
Soil type	Red cracking clay
Soil pH (CaCl2)	0-10 cm: 7.4 10-20 cm: 8 20-30 cm: 7.9
Paddock rotation	2019 fallow, 2020 Mace wheat, 2021 Mace wheat
Sowing date	16/05/2022 chickpeas and cereals 3-4cm depth (aimed to sow chickpeas at 5-7cm but soil too dry to get to depth)
Sowing rate	Chickpeas 90-130 kg/ha depending on varietal seed weight and germination. Target was 30 plants/m2
Rhizobia inoculum	Group N - ALOSCA (10 kg/ha) packed with seed and Tag Team granular (4.6 kg/ha) with seed at day of sowing
Fertiliser	16/05/2022 Agstar extra (100 kg/ha); cereals only - Urea (50 kg/ha); cereals only - 30/06/2022 FlexiN (50 L/ha)
Herbicides, Insecticides & Fungicides	11/05/2022 glyphosate (1.5 L/ha) 16/05/2022 paraquat + diquat (2 L/ha), bifenthrin + chlorpyrifos (0.5 L/ha); chickpeas only – pyroxasulfone (0.12 L/ha), terbuthylazine (860 g/ha), fomesafen (1 L/ha), isoxaflutole (100 g/ha); cereals only - mesotrione 480 (0.2 L/ha), trifluralin (2 L/ha), tri-allate (2.4 L/ha) 16/06/2022 azoxystrobin + tebuconazole (0.88 L/ha); cereals only – prosulfocarb + s-metolachlor (2.5 L/ha) 06/07/2022 cereals only - MCPA (0.45 L/ha), bromoxynil (0.8 L/ha); chickpeas only - butroxydim (0.02 L/ha), clethodim (0.5 L/ha) 12/09/2022 chickpeas only - azoxystrobin + tebuconazole (0.88 L/ha)
Harvest Date	22/11/2022

Results

P. neglectus multiplication in chickpeas during the growing season ranged from just over 1.3x in CBA 2042 to 3.6x in Genesis 090 (Figure 1). Multiplication in the cereal controls ranged from 1x in Fusion and Yenda to 14.3x in Calingiri and 11.7x in Scepter. This is a promising result as it shows that chickpeas have more resistance to *P. neglectus* than susceptible wheat varieties Scepter and Calingiri and have a similar resistance as La Trobe barley which is moderately susceptible.

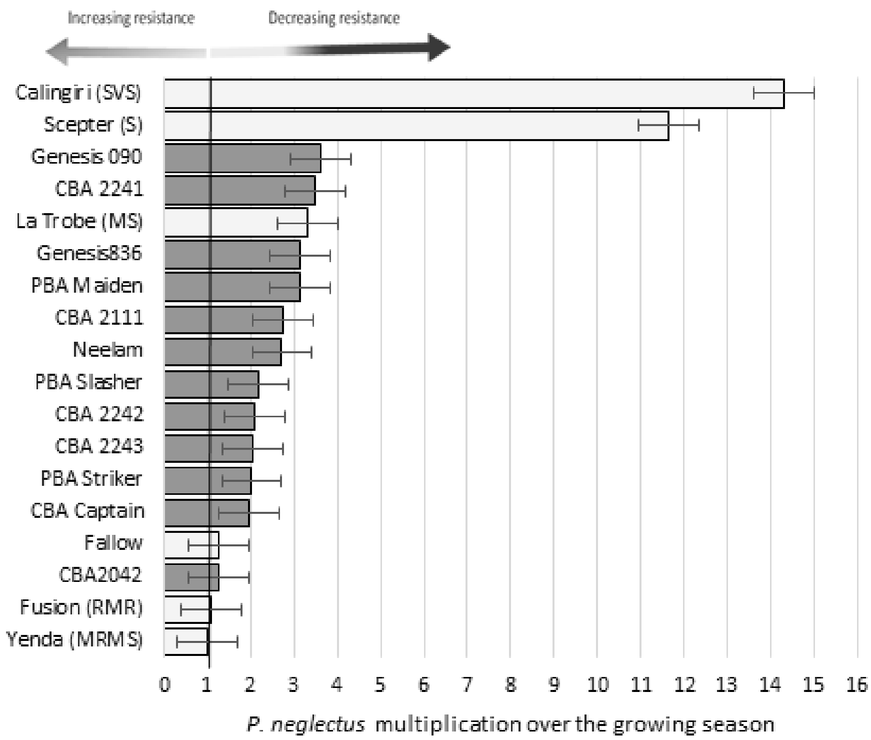

Figure 1. Root lesion nematode species *Pratylenchus neglectus* multiplication after growing different chickpea varieties at Dalwallinu in 2022. Yellow is cereal controls or fallow, and green bars are chickpea test varieties (+/- LSD). Letters after the control variety name shows their resistance to P. neglectus – SVS = susceptible to very susceptible, S = susceptible, MS = moderately susceptible, MRMS = moderately resistant to moderately susceptible and RMR = resistant to moderately resistant.

Ratings for resistance of chickpeas to *P. neglectus* at Dalwallinu were combined with ratings from a sister trial at Doodlakine, to give an average rating for each variety (Figure 2). From provisional ratings PBA Striker is the most resistant chickpea variety screened. While it was MS at Dalwallinu and resulted in an increase in *P. neglectus* levels, it reduced nematode levels 0.6x at Doodlakine and currently has a provisional rating of MR. The popular new chickpea variety, CBA Captain, is currently rated as MS and may only cause a small increase in nematode levels over a season. Please note - a robust rating for *P. neglectus* resistance requires at least five successful screening tests (with at least three in the field).

Crop	Variety	Resistance rating[1]
N/A	Fallow	RMR
Triticale	Fusion	RMRp
Chickpea	PBA Striker	MRp
Chickpea	CBA 2042	MRMSp
Chickpea	PBA Slasher	MRMSp
Wheat	Yenda	MRMS
Chickpea	CBA Captain	MSp
Chickpea	CBA 2111	MSp
Chickpea	CBA 2242	MSp
Chickpea	Neelam	MSp
Barley	LaTrobe	MS
Chickpea	CBA 2241	MSSp
Chickpea	CBA 2243	MSSp
Chickpea	Genesis 090	MSSp
Chickpea	Genesis 836	MSSp
Chickpea	PBA Maiden	Sp
Wheat	Scepter	S
Wheat	Calingiri	SVS

Table 1. (left) Provisional resistance ratings of chickpea varieties to root lesion nematode species *Pratylenchus neglectus*, based on field screening at Dalwallinu and Doodlakine in 2022. 1R = resistant - nematode numbers will decrease when this variety is grown. MR = Moderately resistant - nematode numbers will slightly decrease when this variety is grown. MS = Moderately susceptible - nematode numbers will slightly increase when this variety is grown. S = Susceptible - nematode numbers will increase greatly when this variety is grown and p = provisional rating.

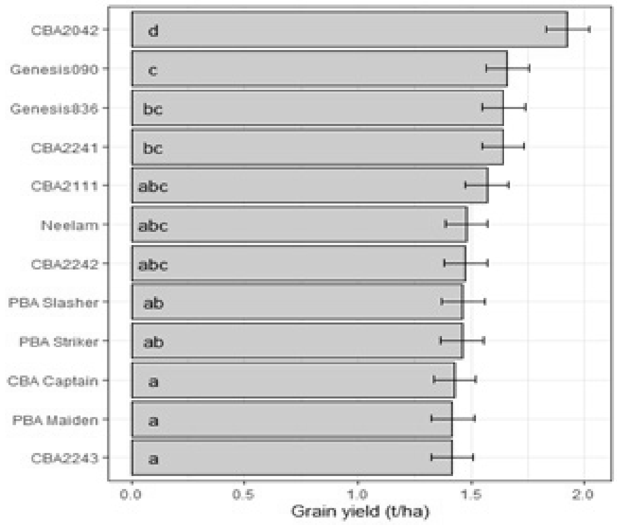

Figure 2. (above) Chickpea yields in a trial testing the resistance of chickpea varieties to root lesion nematode species *P. neglectus,* Dalwallinu 2022. Different letters indicate a significant difference ($p < 0.05$) in yields e.g. Genesis 090 yielded significantly more grain than CBA 2243 or PBA Slasher.

Average chickpea yields in 2022 ranged from 1.42 to 1.92 t/ha at Dalwallinu. CBA 2042 and Genesis 090 yielded the highest (Figure 2). These are expected yields for this area and are comparable with average chickpea NVT yields in Agzone 2 of 1.13 t/ha in 2022 (nvt.grdc.com.au).

Comments

This trial has shown the importance of variety and crop choice in managing RLN. In this trial average end of season *P. neglectus* levels were 32 nematodes/g soil in susceptible wheat variety, Scepter, versus 4 nematodes/g soil in CBA Captain chickpea plots (data not shown). If these levels of nematodes are still present at the beginning of next growing season, then yield loss in a cereal may be 20-40% after Scepter and only 0-5% after CBA Captain.

Based on our recent WA field trials at Dalwallinu and Doodlakine, provisional resistance ratings for chickpeas range from MR to S. This shows that some chickpea varieties have some resistance to *P. neglectus* and that there is a difference in resistance between chickpea varieties. Once sufficient trials have been conducted chickpea resistance ratings will be included in the DPIRD WA Crop Sowing Guide.

In previous research, we have shown that reduced nematode levels under more resistant varieties and crops can still be detected for at least two years post-harvest. As there is no commercially available chemical for managing RLN in broadacre cropping, the most effective management is through crop rotation. Lupin, field pea, and serradella are crops that reduce *P. neglectus* levels while wheat, barley, oats and canola will likely increase levels of this nematode species. Variety choice also plays a big role with Scepter, which accounted for 50% of WA's wheat crop in 2023, rated S (susceptible) to *P. neglectus* whilst Chief CL and Vixen, which are the next most grown wheat varieties, are MRMS (moderately resistant to moderately susceptible). This trial has demonstrated that there are varietal and crop differences in resistance which can be utilised to make a difference in nematode levels and reduce the risk of yield loss in the next crop.

In 2023, the farmer planted Scepter wheat after our 2022 chickpea trial. Scepter is S to *P. neglectus*, and in a conducive season may support 10x multiplication of *P. neglectus* over the 2023 growing season.

We will take beginning and end of season soil samples and yield cuts to determine if chickpeas (grown in 2022) have had a residual effect in limiting nematode multiplication and Scepter yields in 2023 when compared with cereals with a range of resistances or a fallow. Results for this research will be reported next year.

Acknowledgments
This research has been funded by DPIRD. Thanks to Matthew Hyde for hosting this trial. DPIRD staff; Tanzi Carpenter and Lucas Cooke for trial management, Sean Kelly for technical support, Sarah Collins for nematology expertise and biometrician Karyn Reeves.

References
Shackley, B., Power, S., Paynter, B., Troup, G., Seymour, M., & Dhammu, D. (2023). 2024 Western Australian crop sowing guide. https://www.agric.wa.gov.au/grains-research-development/2024-wa-crop-sowing-guide.
South Australian Research and Development Institute. (2022). Broadacre soilborne disease manual.
National Variety Trials. (2023). GRDC National Variety Trials Disease Ratings. https://nvt.grdc.com.au/nvt-disease-ratings

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Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

2023 Survey of the Summer/Autumn Brassica Refuges for Diamondback Moth to Predict Early Season Risk of Infestation

Andrew Phillips, Christiaan Valentine and Rebecca Severtson, Research Scientists, DPIRD

Key Messages

- Low summer rainfall and lack of a significant green bridge may have contributed to low diamondback moth (DBM) numbers observed during the 2023 canola growing season.
- Pre-season brassica refuges provided a minimal source of colonising moths prior to canola seeding this year.
- DBM populations this year did not reach threshold levels and were lower than experienced in the previous four years.
- It is important to monitor DBM populations by sweep netting as numbers can quickly increase above thresholds.
- Similarly, it is important to monitor DBM populations to avoid unnecessary spray applications.

Aim

1. To determine whether pre-season brassicas harbouring DBM contribute to early crop colonisation and/or higher populations of larvae in spring.
2. To monitor DBM populations during the canola growing season by pheromone-based trapping and determine if there is a correlation between moths caught in traps and larvae detected in the field.

Background

DBM has unpredictable population dynamics both spatially and temporally, and is known for its ability to reduce crop yields significantly over short periods of time after explosive outbreaks, as seen in WA in some years. Canola growers are encouraged to monitor crops regularly during late winter and spring, and target their sprays according to the sweep net thresholds of larvae.

This year was the final year of a four-year research project looking at the influence of a late summer, early autumn green bridge at predicting growing season DBM numbers across the WA grainbelt. Our approach encompassed:

1. March/April green bridge surveillance of brassicas and pre-season DBM populations across the WA grainbelt to investigate any potential impact this may have for the growing season. Pheromone-baited moth traps were used to trap moths at sites with actively growing brassicas.
2. Growing season surveillance for DBM populations from June until harvest to investigate if early moth numbers led to higher larvae numbers. Surveillance was undertaken at 49 focus canola crop sites across the five GRDC port zones using pheromone-baited moth traps and sweep-netting.

Results

Below-average summer rainfall in 2023 across the WA grainbelt reduced the presence of green bridges to several isolated pockets. Of the 425 green bridge sites surveyed in March/April, only 47 had brassicas (volunteer canola and wild radish) present (Figure 1). Pheromone-baited moth traps set at the 47 brassica sites for four weeks in March/April did not record any moths and larvae were present at only seven sites in March (Figure 2). In contrast, green bridge surveys in previous years recorded more widespread DBM populations: 24 sites with moths and three sites with larvae in 2022, 57 sites with moths and 11 sites with larvae in 2021, and 10 sites with moths and 26 sites with larvae in 2020.

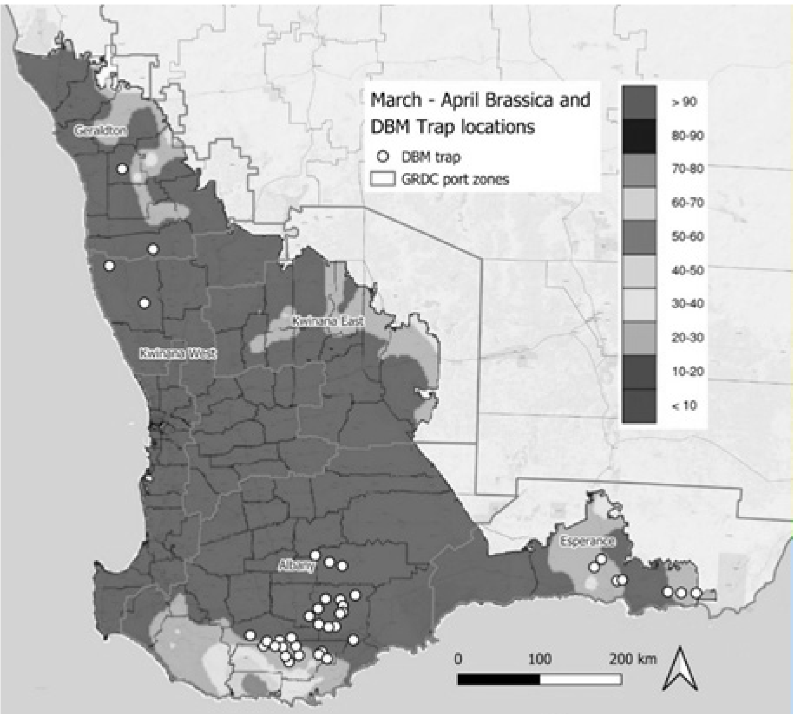

Figure 1. 2023 summer rainfall received (mm) from 1 January to 20 March in the WA grainbelt, and locations of DBM pheromone traps installed at green bridge sites with brassicas. No moths were caught in traps. GRDC port zone boundaries are shown in green.

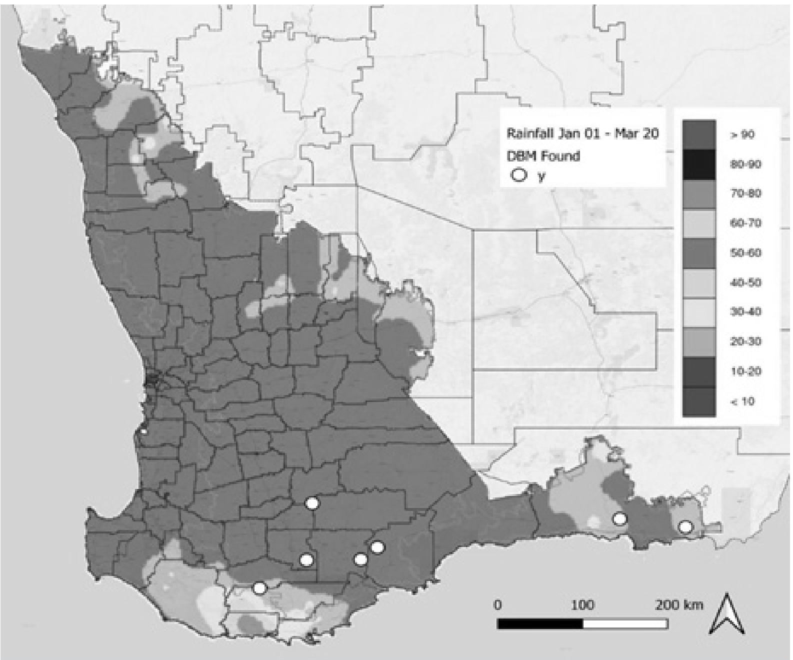

Figure 2. Positive DBM larvae sites recorded during March 2023 green bridge surveillance, over 2023 summer rainfall received (mm) in the WA grainbelt.

DBM moth and larvae numbers recorded fortnightly from focus crops during the 2023 growing season were low and didn't reach outbreak or economic threshold levels at any stage in any location (Figure 3).

DBM moths began colonising crops in late July in the Esperance port zone, and in late August to September in the Geraldton, Kwinana West, Kwinana East and Albany port zones. Moth numbers continued to be low throughout the season across the Kwinana East and Kwinana West zones, and south of Geraldton (central and eastern margins of the grainbelt). In mid-September, moths suddenly increased (100-200 moths) at isolated locations north of Geraldton and a focus crop in Dalyup, Shire of Esperance. In October, some sudden localised increases in moth numbers (>200) occurred in the northern and southern fringes of the Albany port zone (Takalarup, Shire of Takalarup, Woogenellup, Perillup, and Shire of Plantagenet).

Larvae were first detected in very low numbers in early July and continued to appear in low numbers at focus crops in Kwinana East, Kwinana West and Geraldton zones. DBM larvae appeared in greater numbers in October when canola crops were nearing harvest and desiccation.

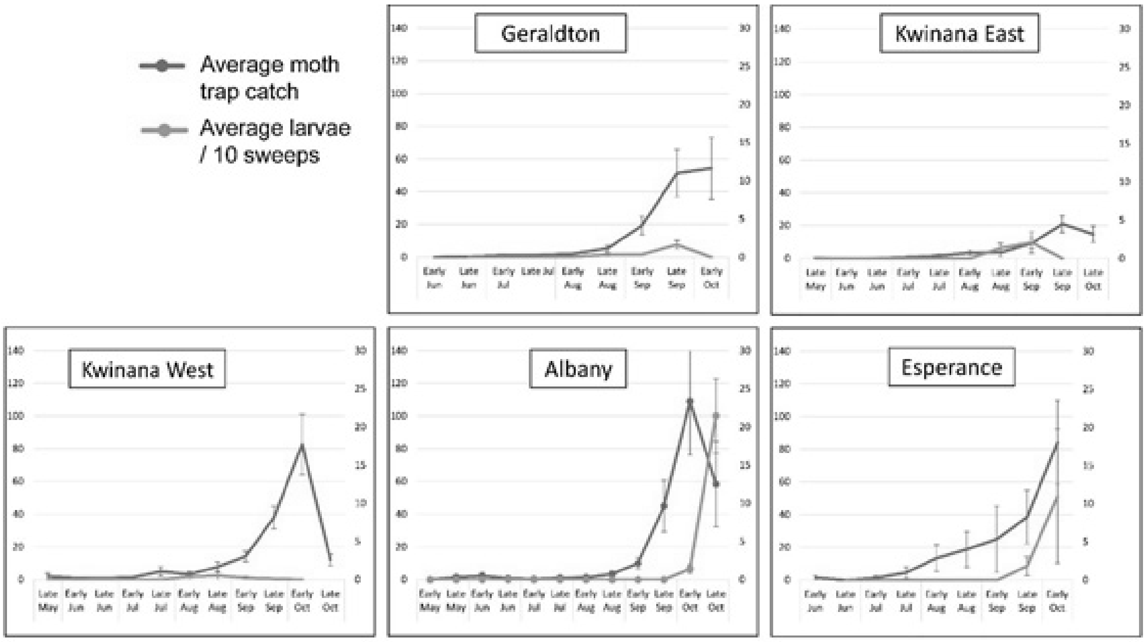

Figure 3. Average bimonthly DBM moth and larvae (+/- SEM) numbers for canola focus crops assessed from May to October 2023, and grouped by geographical port zone. The left y-axis represents moth numbers, right y-axis represents larvae numbers.

There did appear to be a relationship between higher moth numbers and an increase in larvae numbers in some areas, particularly the Esperance and Albany port zones. However, this trend wasn't uniform across the grainbelt.

Comments

The green bridge surveillance results have provided a foundation for assessing the role of brassicas in the presence of pre-season DBM regionally, and relate pre-season DBM presence with canola crop colonisation timing and potential for populations to increase above threshold levels.

The negligible 2023 summer/autumn green bridge likely offered little opportunity for early-season DBM moth colonisation across the WA grainbelt. Limited colonisation of winter canola crops by moths occurred regardless of whether the crop was close to one of the few DBM positive green bridge locations. Low moth numbers detected in moth traps were followed by low larvae numbers during the season.

Overall, DBM moth and larvae numbers were low in 2023 and had little impact on canola crops throughout the growing season. Results from surveillance in previous years indicate that timing of moth migration into crops is potentially an important factor on DBM numbers during the season. Early detection of moths in the field in July or August may potentially indicate problem DBM populations building up in September and October.

Acknowledgments

This research was a co-investment by DPIRD and GRDC, project DAW1905-010RTX, Survey of the Summer/ Autumn Brassica Refuges for Diamondback Moth in the Western Region to Predict Early Season Risk of Infestation. Technical and survey support from DPIRD staff, The Liebe Group, West Midlands Group, Mingenew Irwin Group, Facey Group, and South East Agronomy Services.

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Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

NUTRITION RESEARCH RESULTS

Nitrogen Sources, Placement and Timings on Canola

Lois Kowald, Senior Account Manager – Nutrition and Sales, CSBP

Key Messages

- Banding Flexi-N increased early-season crop vigour without any detrimental effects on crop establishment, indicating an increase in yield potential.
- Urea Sustain was more effective at supplying N to the crop based on oil content.
- Due to low rainfall, no significant difference was seen in yield.

Aim

To (1) compare the effectiveness of banding Flexi-N at seeding compared to topdressing Flexi-N, Urea or Urea Sustain at the 4-5 leaf stage, and (2) to determine if there are productivity gains from applying Urea Sustain post seeding compared to urea.

Background

High yielding canola crops can have a high demand for nitrogen (N) fertiliser. CSBP canola trials have shown the benefits of banding Flexi-N at seeding. This trial will compare the effectiveness of banding Flexi-N compared to applying Flexi-N, Urea and Urea Sustain at the 4-6 leaf stage. Urea Sustain contains urease and nitrification inhibitors which can potentially reduce losses of N to the environment and increase returns from fertiliser applications.

Trial Details

Trial Location	KL Carter & Co., Jibberding
Plot size & replication	15m x 1.83m x 3 replicates
Soil type	Sandy loam/loam, clay loam at 40-60cm
Paddock rotation	2020 wheat, 2021 wheat, 2022 wheat
Sowing date	09/05/2023
Sowing rate	NuSeed Emu canola, dry seeded at 2.5 kg/ha, 2cm depth
Fertiliser	30/03- 150 kg/ha SoP basa 09/05- 70 kg/ha Big Phos banded, Flexi-N rates banded to select plots 04/07- Urea, Urea Sustain and Flexi-N treatments 17/08- 60 L/ha Flexi-N (Trt 14)
Herbicides, Insecticides & Fungicides	08/05- 1.8 L/ha glyphosate, 300 ml/ha chlorpyrifos, 900 g/ha propyzamide 30/06- 1.2 L/ha SeedShield and 20 ml/ha gamma-cyhalothrin
Harvest Date	20/10/2023

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)	PBI
0-10	6.3	33	62	6	4	3	0.06	0.6	21
10-20	5.1	20	50	12	1	2	0.04	0.3	30
20-30	4.5	6	50	30	1	1	0.04	0.2	28
30-40	4.7	3	50	29	1	1	0.04	0.1	34
40-50	4.9	3	23	19	1	1	0.04	0.2	33

Results

Plant establishment counts indicated no difference between treatments.

Tissue test results on 1 August showed an increase in plant weights in treatments where up to 120 L/ha of Flexi-N was banded (Figure 1).

Crop yields were limited to 0.2 t/ha in all treatments (Table 1). Oil concentrations were between 37 and 41%. There was a trend to lower oil concentrations with Urea Sustain (the difference was statistically significant with 76 kg N/ha applied).

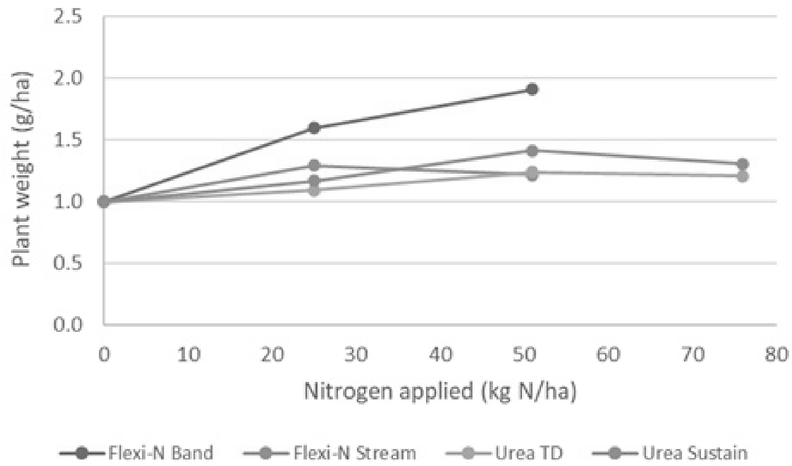

Figure 1. Average plant weight as of 1st August 2023 (4 weeks after post-seeding treatments were applied).

Table 1. Harvest results of the different treatments, including yield (t/ha) and oil content (%).

Trt	Description	Seeding Banded (L/ha)	4 Leaf Topdress (kg/ha)	4 Leaf Streamed (L/ha)	Flower Streamed (L/ha)	N (kg/ha)	Yield (t/ ha)	HSD	Oil (%)	HSD
1	Nil N					0	0.2	a	41	a
2	60 Flexi-N (Banded)	60 Flexi-N				25	0.2	a	40	abc
3	120 Flexi-N (Banded)	120 Flexi-N				51	0.2	a	40	ab
4	60 Flexi-N (Streamed)			60 Flexi-N		25	0.2	a	40	ab
7	120 Flexi-N (Streamed)			120 Flexi-N		51	0.2	a	40	abc
10	180 Flexi-N (Streamed)			180 Flexi-N		76	0.2	a	41	a
5	55 Urea (TD)		55 Urea			25	0.1	a	39	abc
8	110 Urea (TD)		110 Urea			51	0.2	a	41	a
11	165 Urea (TD)		165 Urea			76	0.2	a	41	a
6	55 Urea Sustain (TD)		55 Urea Sustain			25	0.2	a	38	bc
9	110 Urea Sustain (TD)		112 Urea Sustain			51	0.3	a	39	abc
12	165 Urea Sustain (TD)		166 Urea Sustain			76	0.2	a	39	bc
13	High N	60 Flexi-N				101	0.2	a	38	bc
14	Very High N	60 Flexi-N			60 Flexi-N	127	0.2	a	37	c
						Prob(F)	0.263		0.0001	
						LSD	0.085		2.05A	

Comments

While there were no yield effects this year, banding Flexi-N clearly increased early season crop vigour without any detrimental effects on crop establishment, which could indicate an increase in yield potential. The trial seeder is set up to band Flexi-N 4-5cm below and to the side of the seed with splitter boots (27cm row spacings).

Yields were obviously limited by low rainfall but comparisons between post-seeding N treatments showed a trend towards lower oil concentrations where Urea Sustain was used. This indicates that Urea Sustain was more effective at supplying N to the crop.

Acknowledgements

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CSBP Field Research and Agronomy team.

Peer Review

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Factorial Nitrogen x Potassium Rates for Wheat

Saritha Marais, Wongan Hills Area Manager, Summit Fertilizers

Key Messages

- Wheat establishment was impacted by urea banded at seeding and low soil moisture, but all plant counts were low.
- Vegetative growth and grain yield responded significantly, only to increasing N from nil to 30 kg/ha.
- Yield results indicated no response to applied K.
- Yields averaged 0.7 t/ha, illustrating the limited effect of N and K in low rainfall years.
- Protein gradually increased with increasing N rates, influencing receival grades along with varied screenings.
- Gross margins were only positive at N rates below 90 kg/ha.
- The most profitable treatment was nil K and 30 kg N/ha, with a gross margin of $145/ha.

Aim

To assess the response of Calibre wheat under a factorial nitrogen (N) and potassium (K) fertiliser application trial design in the Wubin area. To improve understanding of the value of optimal N and K for wheat yield, grain quality and profitable returns.

Background

The task of managing wheat nutrient inputs is an ongoing challenge, intensified by seasonal rainfall variability, improved agronomic practices – particularly those addressing soil constraints – and the advancement of modern varieties with continually increased yield potential. There is an emerging thought process that traditional approaches to nitrogen (N), phosphorus (P) and potassium (K) management may no longer be applicable, with the added complexity of soil amelioration operations changing soil profiles and available nutrients. This trial will investigate the response of wheat to N and K fertiliser rates in the Wubin area, on a soil with elevated K content as requested by growers in the district.

Trial Details

Trial Location	KL Carter & Co., Jibberding
Plot size & replication	10m x 1.54m x 4 replications
Soil type	Red loamy sand
Paddock rotation	2020 wheat, 2021 wheat, 2022 canola
Sowing details	18/05/2023: Calibre wheat sown at 80 kg/ha
Rainfall	Summer (Jan-Mar) 31mm; growing season 104mm; decile 1; 102mm below average
Herbicides (pre-em)	120 g/ha clopyralid, 250 g/ha diuron, 210 ml/ha pyroxasulfone, 2 L/ha trifluralin, 1.5L/ha glyphosate
Fungicides (pre-em)	Tebuconazole + triflumuron 100 mL/100 kg (seed treatment)
Insecticides (pre-em)	Imidacloprid 150 mL/100 kg (seed treatment), 1 L/ha chlorpyrifos, 100 mL/ha bifenthrin.
Harvest Date	09/11/2023

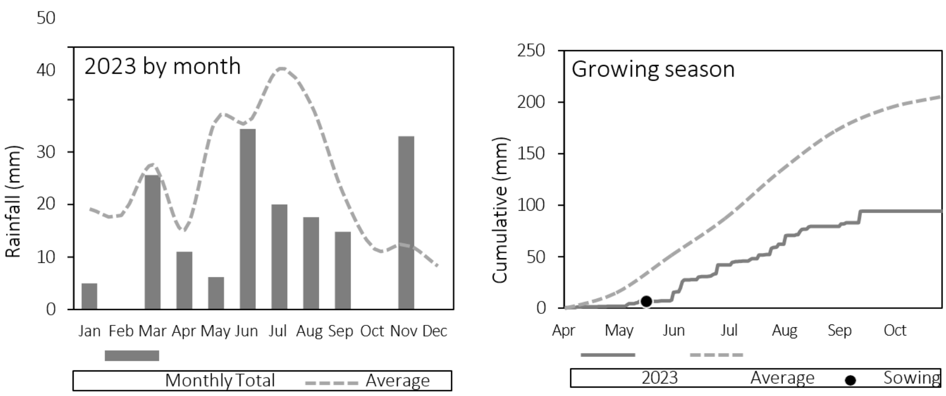

Figure 1. 2023 monthly rainfall data from Kalannie DPIRD weather station (35km SE). 30-year average rainfall data is from Dalwallinu North BOM Station (15km SW).

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N(NO_3) (mg/kg)	N(NH_4) (mg/kg)	EC	OC (%)	PBI	Exch K (mg/kg)	Org C (%)	Cu (mg/kg)	CEC (cmol/kg)	Mn (mg/kg)	Zn (mg/kg)
0-10	7.9	13	493	8	4	1	2.2	0.6	48	446	0.6	0.2	18	3.2	0.2
10-20	7.9	6	390	6	3	1	2.8	0.3	81	332	0.7	0.3	25	2.1	0.1
20-30	8.0	5	317	4	3	1	2.8	0.2	87	340	0.6	0.3	26	1.6	0.1

Treatments

Trt	Treatment	Seeding Product Banded (kg/ha)	5WAE (L/ha)	10WAE (L/ha)	N	P	K	S
1	N0 K0	50 TSP, 50 SSP			0	15	0	6
2	N30 K0	65 MAP, 20 MAXam, 40 Urea			30	15	0	6
3	N60 K0	65 MAP, 20 MAXam, 40 Urea	70 UAN		60	15	0	6
4	N90 K0	65 MAP, 20 MAXam, 40 Urea	140 UAN		90	15	0	6
5	N120 K0	65 MAP, 20 MAXam, 40 Urea	140 UAN	70 UAN	120	15	0	6
6	N120 K0 (+S)	65 MAP, 20 MAXam, 40 Urea	215 MxFlo	70 UAN	120	15	0	23
7	N0 K15	50 TSP, 50 SSP, 30 MOP			0	15	15	6
8	N30 K15	65 MAP, 20 MAXam, 40 Urea, 30 MOP			30	15	15	6
9	N60 K15	65 MAP, 20 MAXam, 40 Urea, 30 MOP	70 UAN		60	15	15	6
10	N90 K15	65 MAP, 20 MAXam, 40 Urea, 30 MOP	140 UAN		90	15	15	6
11	N120 K15	65 MAP, 20 MAXam, 40 Urea, 30 MOP	140 UAN	70 UAN	120	15	15	6
12	N120 K15 (+S)	65 MAP, 20 MAXam, 40 Urea, 30 MOP	215 MxFlo	70 UAN	120	15	15	23
13	N0 K30	50 TSP, 50 SSP, 60 MOP			0	15	30	6
14	N30 K30	65 MAP, 20 MAXam, 40 Urea, 60 MOP			30	15	30	6
15	N60 K30	65 MAP, 20 MAXam, 40 Urea, 60 MOP	70 UAN		60	15	30	6
16	N90 K30	65 MAP, 20 MAXam, 40 Urea, 60 MOP	140 UAN		90	15	30	6
17	N120 K30	65 MAP, 20 MAXam, 40 Urea, 60 MOP	140 UAN	70 UAN	120	15	30	6
18	N120 K30 (+S)	65 MAP, 20 MAXam, 40 Urea, 60 MOP	215 MxFlo	70 UAN	120	15	30	23

*5WAE in-season fertiliser applied on 2 June at 3-leaf. 10WAE fertiliser applied on 28 July at early tillering.

In-Season Results

Plant emergence counts were recorded at the three-leaf growth stage on 28 June. Emergence was low across the trial and indicated that N banded at seeding as urea had a negative effect on wheat establishment ($p < 0.001$) (Figure 2). Treatments that received 30kg N/ha at seeding had an average establishment of 40 plants/m², while treatments that did not receive N had an average establishment of 65 plants/m². Both were well below the target emergence of 100 plants/m².

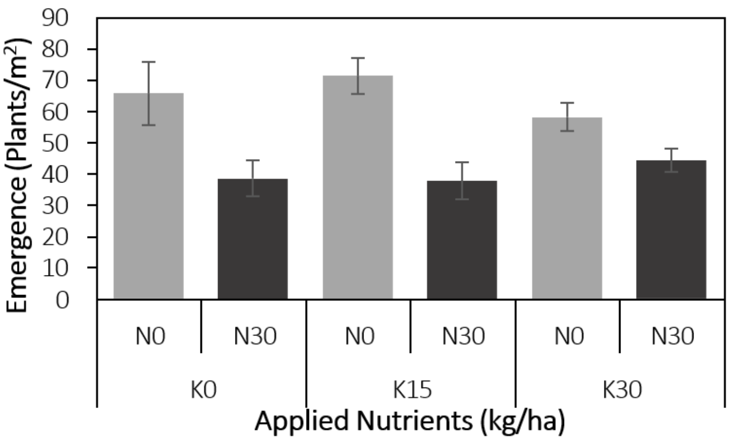

Figure 2. Emergence counts (plants/m²) recorded at three-leaf stage.

Biomass as Normalised Difference Vegetation Index (NDVI) recorded on 21 August (late tillering) showed no response to increasing rates of applied K, across all N rates (p = 0.799) (Figure 3). There was a significant increase in biomass where N was applied compared to where no N was applied (p = 0.002), although no significant differences between 30kg N/ha and all the higher N rates (p > 0.05).

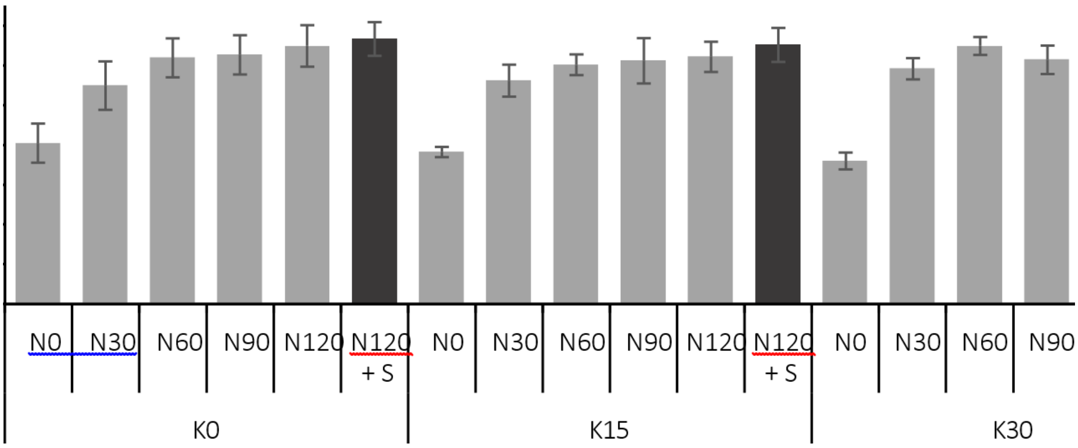

Figure 3. Wheat shoot biomass (NDVI) at late tillering for all treatments

Harvest Results

Decile 1 growing season rainfall resulted in a very low average yield of 0.66 t/ha. Yields ranged from a low of 0.42 t/ha with no N and 30 kg K/ha applied, to a high of 0.79 t/ha with 60 kg N/ha and 30 kg K/ha applied (Figure 4). Yields were significantly affected by the rate of N applied (p < 0.05), but not by K rate (p = 0.85). However, further analysis shows that N was only significantly influenced by yields when at least 30kg N/ha was applied compared to where no N was applied (p < 0.05). Grain yield from N rates above 30 kg/ha was relatively consistent, ranging from 0.68 t/ha to 0.73 t/ha. The additional treatments of 120kg N/ha with extra S gained no yield advantage over the treatments without the S.

Grain protein was high across most treatments, with an average of 12.6%. There was a noticeable trend of grain protein increasing with increasing N rates, irrespective of applied K.

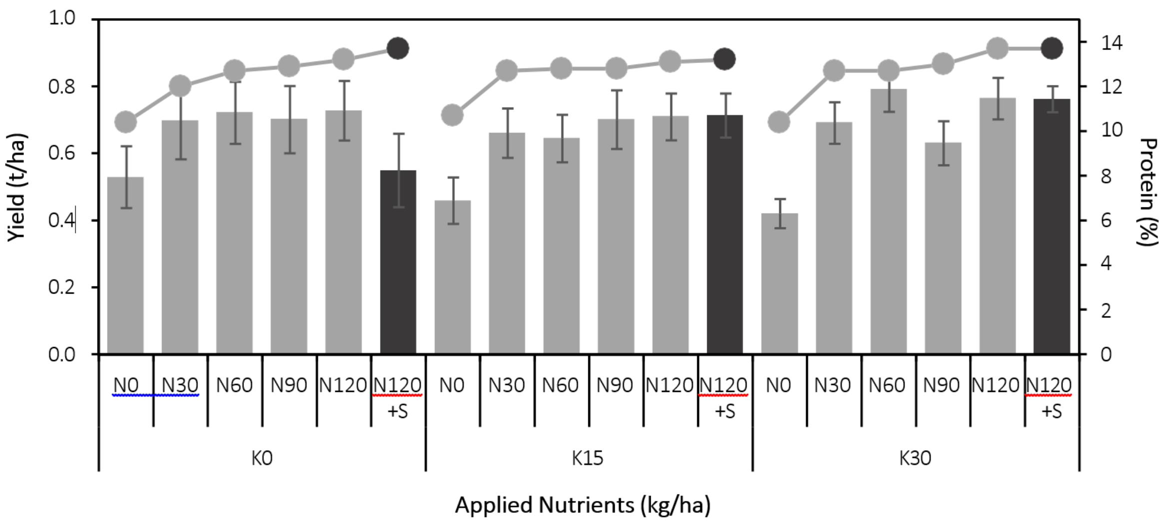

Figure 4. Harvest yield (bars, t/ha) and grain protein (lines, %) for all treatments.

Hectolitre weights all exceeded 74 kg/hL, with some screenings exceeding 5% (Table 3). Grain protein levels were also quite varied throughout the treatments, resulting in four different wheat receival grades across the trial (Figure 5). The only treatment to achieve a higher gross margin than the nil control was the 30kg N/ha with nil K, resulting in a 40% increase in returns compared to nil N and K. Half of the individual treatment gross margins showed an overall loss. On average across the trial, applying up to 60 kg N/ha remained profitable. Applying any K on soil with this high of a Colwell and exchangeable K status, combined with the decile 1 season of 2023, resulted in a break-even or loss when averaged across the N rates.

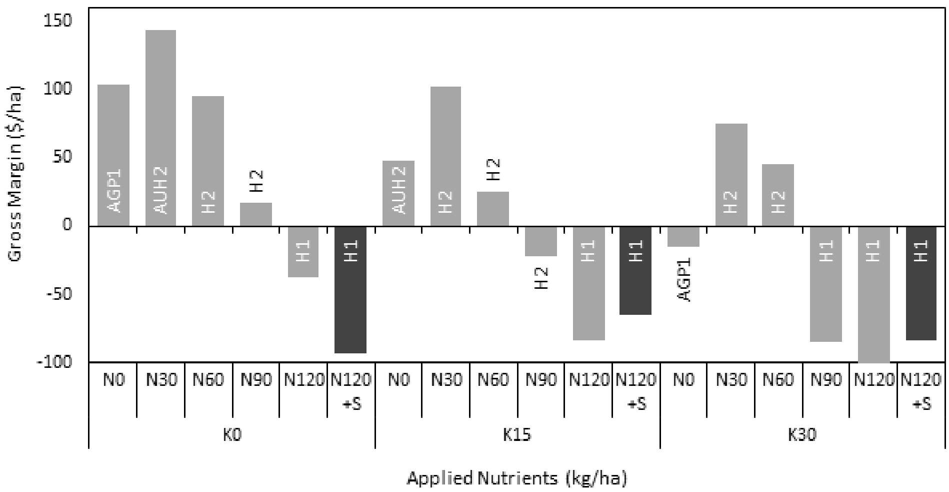

Figure 5. Individual treatment gross margins ($/ha) and receival grades between treatments.

Considering the dry conditions at Wubin in 2023, especially during grain fill, these findings are to be expected. Additional K was not likely needed in the soil at this site even if there had been more rainfall, based on the soil test results indicating that the soil had sufficient levels of total and exchangeable K. Only a minimal amount of applied N increased margins, but this is unlikely to be the case in a season with rainfall closer to the long-term average.

Table 3. Summary Table

	Treatment	Fertiliser Cost ($/ha)	Yield (t/ha)	Protein (%)	Hectolitre Weight (kg/hL)	Screenings below 2mm (%)	Grade	Grain Value ($/ha)	Gross Margin ($/ha)
1	N0 K0	90	0.53	10.4	77.7	5.8	AGP1	195	105
2	N30 K0	125	0.70	12	76.2	5.3	AUH2	271	145
3	N60 K0	195	0.72	12.7	77.7	3.8	H2	293	95
4	N90 K0	270	0.70	12.9	77.2	4.3	H2	285	15
5	N120 K0	340	0.73	13.2	76.8	4.2	H1	302	-35
6	N120 K0 (+S)	320	0.55	13.7	79.1	3.7	H1	228	-95
7	N0 K15	130	0.46	10.7	78.4	5.9	AGP1	179	50
8	N30 K15	165	0.66	12.7	79.0	4.0	APW1	268	100
9	N60 K15	235	0.65	12.8	77.7	4.0	H2	262	25
10	N90 K15	305	0.70	12.8	78.5	4.0	H2	285	-20
11	N120 K15	380	0.71	13.1	75.1	4.3	H1	294	-85
12	N120 K15 (+S)	360	0.71	13.2	74.0	4.5	H1	296	-65
13	N0 K30	170	0.42	10.4	77.0	5.8	AGP1	155	-15
14	N30 K30	205	0.69	12.7	79.0	4.4	H2	281	75
15	N60 K30	275	0.79	12.7	77.1	3.1	H2	321	45
16	N90 K30	345	0.63	13	78.5	3.9	H1	261	-85
17	N120 K30	415	0.76	13.7	77.3	3.5	H1	317	-100

Fertiliser cost based on Summit Fertilizers May 2023 retail list pricing ex Kwinana.
Grain value based on delivery grade grain prices from GrainCorp for the 09/11/2023 at Kwinana.
Gross margin is a basic representation of grain value minus the cost of fertiliser input.

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SOIL HEALTH RESEARCH RESULTS

Deep Lime Incorporation with a Rotary Spader Boosts Yield Over Surface Application of Lime But Not in a Dry Season

Gaus Azam, Research Scientist, DPIRD, and Bob Nixon, Liebe Group Grower

Key Messages

- Surface liming significantly increased wheat (up to 169%), canola (up to 55%) and barley (up to 22%) grain yield from the first year of the experiment compared to the ripped control.
- Shallow incorporation of lime to 0.2m with a one-way-plough had no yield benefit over the surface application of lime during the 2017-2020 seasons.
- Spading ~0.3m depth over the one-way ploughed plots in 2021 to allow deeper lime incorporation resulted in an extra gain in wheat yield in 2021 and 2022 seasons compared to the surface-applied lime; however, no such yield advantage was measured in the 2023 dry season.
- The relative magnitude of the yield difference was the greatest (169% increase) between lime incorporation and the control in the 2021 frost-affected season.

Aim

1. To assess the value of surface lime and gypsum application for ameliorating subsoil acidity in a low rainfall environment.
2. To assess the value of incorporating lime and gypsum into acidic soil in a low rainfall environment.

Background

Subsurface soil acidity (low pH) is a widespread phenomenon in the Mediterranean-type climatic region of southwestern Western Australia (WA) (Gazey et al., 2013). At low soil pH, toxic forms of aluminium (Al) increase in the soil solution and significantly limit root growth and crop yield (Rengel, 1992). Incorporation of agricultural lime into acidic soil can increase soil pH quickly, which reduces the concentration of toxic Al (Azam and Gazey, 2020). However, lime is usually applied to the soil surface, and it can take several years to increase subsurface soil pH (Li et al., 2019; Azam & Gazey, 2020).

Previous work suggests that the physical incorporation of lime in the subsurface soil increases the rate of change of subsurface soil pH (Azam & Gazey, 2020). However, the cost of physical incorporation using tillage equipment may make the liming process too expensive for many growers. Another suggested method for quick amelioration of acidic subsoil is the application of gypsum on the soil surface. Surface-applied gypsum rapidly moves into the subsoil and may reduce toxic forms of Al, as well as supply additional calcium (Ca) and sulphur (S) where it is deficient (Sumner et al.,1986). The addition of extra Ca may play a role in reducing Al activity by increasing the electrical conductivity and ionic strength of the soil (Rengel, 1992). McLay et al. (1994) reported an initial, large increase in wheat grain yield due to gypsum application in the eastern wheatbelt of WA. However, there was a negative effect of gypsum on grain yield after the second year of the trial. Treatment with gypsum alone produced inconsistent results in improving crop yield in acidic soil. Therefore, there is confusion amongst growers about the value of applying gypsum as part of management strategies for acidic soil. There is also a large gap in understanding the underlying mechanism of how gypsum brings beneficial chemical changes in soil (Zoca & Penn, 2017).

Initially, this experiment was conducted to evaluate the interactive effect of lime and gypsum application, with or without incorporation, on subsoil acidity, Al toxicity and grain yield. After the first four years, when insignificant effects of gypsum and shallow incorporation were identified, the shallow lime-incorporated plots were spaded to a deeper depth to evaluate the effect of deep lime incorporation in a semi-arid environment. The experiment was designed to address the amelioration of acidic soil under semi-arid conditions; hence, we chose a paddock near Kalannie (annual rainfall ~250mm), Western Australia.

Trial Details

Trial Location	Robert Nixon & Co, Kalannie
Plot size & replication	20m x 1.8m x 3 replications
Soil type	Acidic (Wodjil) sand
Soil pH (CaCl2)	0–0.10m: 4.4 0.10–0.20m: 3.9 0.20–0.30m: 3.9
Paddock rotation	2017 wheat, 2018 wheat, 2019 canola, 2020 barley, 2021 wheat, 2022 wheat, 2023 wheat
Sowing date	Wheat and barley 60 kg/ha, canola 2.2 kg/ha
Fertiliser	MAP 37 kg/ha and urea 57 kg/ha at sowing; 109 kg urea as a top up at tillering (2023)

Results

Due to the insignificant and inconsistent response of gypsum in this experiment this report will mostly focus on the results of lime application and incorporation.

Seasons: The growing season weather data are presented in Table 1. The first four seasons (2017, 2018, 2019 and 2020) were average in terms of rainfall for Kalannie; however, 2017 and 2019 had an extremely dry spring, causing poor crop growth and yield. The following two seasons (2021 and 2022) were very wet while 2023 became the driest season of all with an extremely dry spring. Although the 2021 season was the wettest, there was a severe frost event on 3 September. This frost event caused a significant yield loss for the experimental site and the region.

Table 1: Crop type, yield potential and site weather data for the duration of the experiment (2017-2023).

Parameters	2017	2018	2019	2020	2021	2022	2023
Crop type and variety	Wheat (Mace)	Wheat (Mace)	Canola (Bonito)	Barley (La Trobe)	Wheat (Scepter)	Wheat (Scepter)	Wheat (Scepter)
Annual rainfall (mm)	256	317	204	237	484	385	184
GSR (May-Oct, mm)	141	211	176	150	273	253	93
Jan-Apr (mm)	94	88	28	87	181	132	58
Available moisture (mm)	56	123	76	65	247	196	17
Temperate below 0°C (hr)	5	6	5	0	20	1	6
Temperate below -2°C (hr)	0	0	0	0	3*	0	0
Yield potential (t/ha)	1.12	2.45	0.99	1.31	4.94	3.91	0.34

*3 September 2021, 4-7am

Grain yields (pre-spading 2017-2020): During the 2017-2020 growing seasons, the interaction of lime, gypsum and shallow tillage did not significantly influence grain yield (Figure 1). Gypsum treatment itself did not affect the grain yield of wheat (in 2017 and 2018) and barley (in 2020), but increased grain yield of canola in 2019 compared to the zero-gypsum treatment, with higher rates of gypsum having a greater impact (data not shown). Shallow tillage treatments had no effect on wheat grain yield in 2017 and 2018 but significantly decreased barley grain yield in 2020. Shallow tillage had no effect on canola grain yield in 2019. Lime treatments increased the grain yield of wheat, canola, and barley crops (Figure 1a). In 2017, 2018 and 2020, lime treatment increased cereal (wheat and barley) grain yield by 12–22% compared to the unlimed control, but there was no difference among 2, 4, and 6 t/ha lime rates (Figure 1a). The barley yield increase in response to lime was greater (22%) than that for wheat (up to 15%). In 2019 canola, the effect of lime rates was significant where higher lime rates (4 and 6 t/ha) had greater yield increase compared to 0 and 2 t/ha lime rates (Figure 1a).

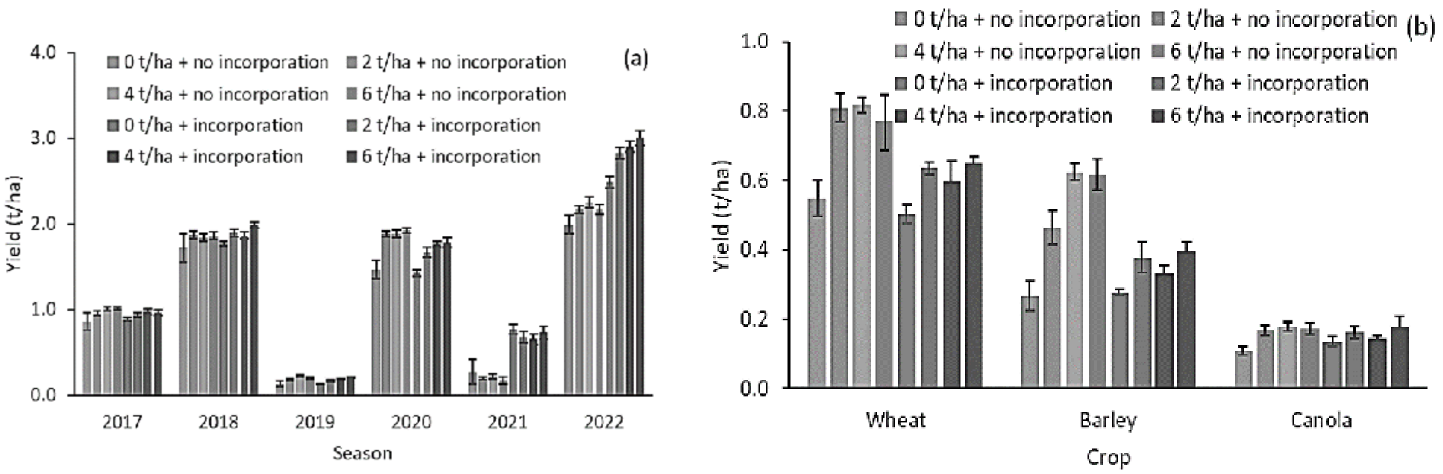

Figure 1: Effect of lime and incorporation on grain yield of wheat (2017, 2018, 2021, 2022), barley (2020) and canola 2019 (a) when a single crop (2017-2022) was grown annually, or (b) multiple crops (2023) were grown in the experiment. Incorporation consisted of one-way plough in 2017 to ~0.2m for the 2017-2020 seasons, but these same treatments were incorporated deeper in 2021 with a rotary spader to ~0.3m.

Grain yields (post-spading 2021-2023): In the 2021 and 2022 seasons, the interaction of lime and re-incorporation with spader was significant despite both seasons having above average rainfall (Figure 1a, Table 1). The wheat crop was severely damaged by frost in 2021, but the effect of spading was still significant. The relative magnitude of the difference (169%) between lime incorporation and the control was the greatest in 2021, despite not being the highest yielding season due to frost. The highest wheat response to lime and spading was observed in the 2022 season, where there was 1 t/ha extra yield in the 6 t/ha lime-incorporated plots compared to the control. The results from lime incorporation were different in the 2023 season. The surface application of lime yielded significantly higher than the control. However, the benefit of lime incorporation was not observed in 2023 due to very dry conditions in this season. There was no yield penalty in the spaded plots compared to the control (Figure 1b).

Economic analyses: The cost of treatments increased with increasing rates of lime as well as the use of a one-way plough and rotary spader for incorporation. Therefore, treatments that had higher lime rates (4 and 6 t/ha lime), were economically less beneficial than that of 2 t/ha lime rate within the seven seasons of this study (Figure 2b). Almost all treatments involving incorporation of lime produced a positive net present value (NPV) compared to the surface liming or the control in first seven years of the experiment.

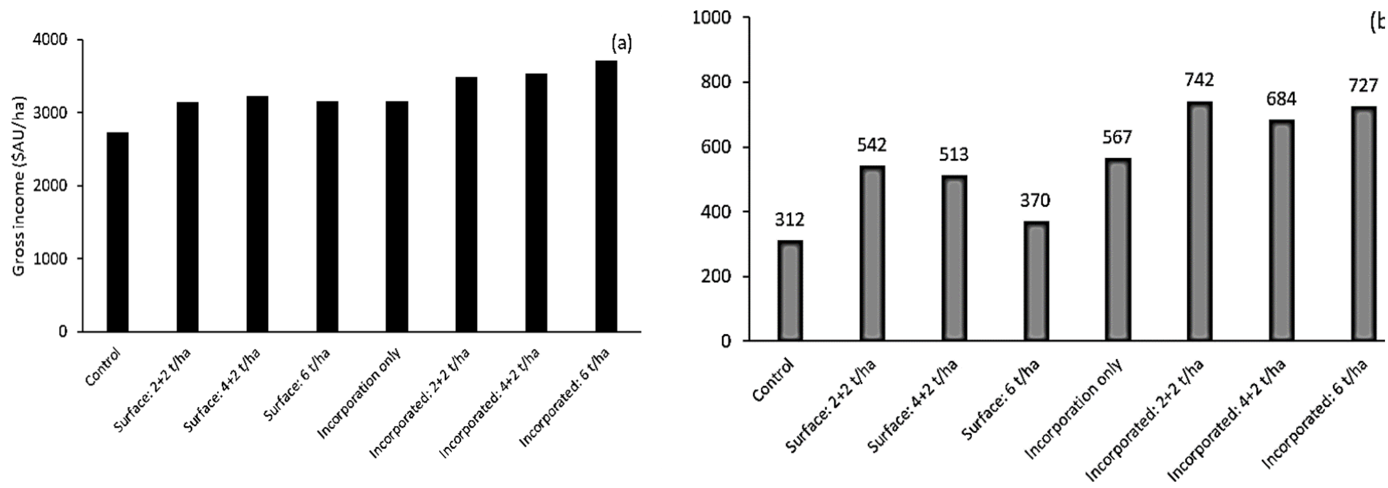

Figure 2: (a) Gross income ($/ha) and (b) net present value (NPV, $/ha) for different treatments over seven years (2017-2023).

Amelioration of soil acidity: Lime application to the surface significantly increased soil pH in the 0-0.10m depth, while incorporation increased it to 0–0.40m depth (Table 2). However, subsurface soil pH was raised over the recommended target pH of 4.8 only at 0.10–0.20m where lime was incorporated. There was also an increase of 0.3 units pH in the 0.20–0.30 and 0.30–0.40m depths where lime was incorporated. No changes were recorded in soil pH at depths below 0.40m.

Table 2: Soil pH (measured in 0.1 M CaCl2) profiles seven seasons after lime application at different rates with and without incorporation.

Depth (cm)	**Lime applied in 2017 (t/ha)**							
	Surface				Spaded			
	0	2*	4*	6	0	2*	4*	6
0 – 0.10	4.60	5.80	6.07	6.07	4.60	5.50	5.53	5.17
0.10 – 0.20	4.33	4.57	4.50	4.53	4.47	5.17	4.90	5.43
0.20 – 0.30	4.20	4.27	4.30	4.27	4.23	4.50	4.53	4.37
0.30 – 0.40	4.17	4.17	4.17	4.27	4.20	4.50	4.30	4.37
0.40 – 0.50	4.20	4.13	4.17	4.20	4.23	4.20	4.17	4.17
0.50 – 0.60	4.23	4.17	4.23	4.13	4.17	4.13	4.13	4.23

*****2 t/ha extra lime was surface applied to these treatments after rotary spading in 2021

Comments

In this field experiment liming significantly increased grain yield. This effect was consistent across seven contrasting seasons and three crop species. This yield improvement was related to an increase in soil pH and, hence, a decrease in Al toxicity. Increased soil pH also led to improved uptake of major macronutrients, as reported in 2018.

Lime incorporation using a one-way plough increased soil pH within 0–0.20m soil depth, but grain yield did not improve over surface-applied lime treatments. However, when those plots were reincorporated in 2021 using a rotary spader, soil pH increased to a depth of 0.40m. Grain yield increased in spaded plots compared to the surface-limed and control plots in both the 2021 and 2022 seasons. In the 2021 season, the benefit of spading as a frost mitigation strategy was also observed. However, the benefit of lime incorporation by a spader was not observed in the 2023 season due to the dry nature of this season.

We recommend liming as an essential soil management tool, while the incorporation of lime to 0.30-0.40m depth (e.g. spading) can further improve grain yield in most years, except if the season is very dry (e.g. 2023). We would not recommend shallow incorporation (e.g. ploughing with a one-way plough) of lime, which would be an ineffective tool for managing subsoil acidity.

References
Azam, G., Gazey, C. (2020). Slow movement of alkali from surface-applied lime warrants the introduction of strategic tillage for rapid amelioration of subsurface acidity in south-western Australia. Soil Research, 59, 97-106.
Gazey, C., Andrew, J., Griffin E. (2013). Soil acidity. In: Report card on sustainable natural resource use in agriculture, Department of Agriculture and Food, Western Australia.
Li, G. D., Conyers, M. K., Heylar, K. R., Lisle, C. J., Poile, G. J., Cullis,B. R. (2019). Long-term surface application of lime ameliorates subsoil acidity in the mixed farming zone of south-eastern Australia. Geodarma, 338, 236-246.
Mclay, C. D. A., Ritchie, G. S. P., Porter, W. M. (1994). Amelioration of subsurface acidity in sandy soils in low rainfall regions .1. Responses of wheat and lupins to surface-applied gypsum and lime. Soil Research, 32, 835-846.
Rengel, Z. (1992). Role of calcium in aluminium toxicity. New Phytologist, 121(4), 499-513.
Sumner, M. E., Shahandeh, H., Bouton, J., & Hammel, J. (1986). Amelioration of an Acid Soil Profile through Deep Liming and Surface Application of Gypsum. Soil Science Society of America Journal, 50, 1254-1258.
Zoca, S. M., & Penn, C. (2017). An important tool with no instruction manual: a review of gypsum use in agriculture. Advances in Agronomy, 144, 1-44.

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GOVERNMENT OF WESTERN AUSTRALIA

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Effect of Soil Amelioration and Organic Amendments on Water Use Efficiency and Soil Carbon

Amber Martin, Project Support, Daenia Dundon, R&D Coordinator and Chris O'Callaghan, Executive Officer, Liebe Group

Aim

This project aims to investigate the use of living plant systems and modern farming methods to sequester soil organic carbon, reduce greenhouse gas emissions and improve soil fertility.

Background

The west Coorow region is characterised by deep coarse sands and sandy loams, many of which have low water and nutrient holding capacity. Increasing soil carbon provides an energy source for microbes, increases nutrient storage, improves soil structure and increases water-holding capacity (Hoyle & Murphy, 2018).

This particular paddock has no cropping or pasture history and is a deep yellow coarse sand. The site is covered with tussocky weeds and needs rejuvenating to bring it back into production. Soil analyses of the site indicate a clay content of between 3-5%, organic carbon levels of 0.2% and a low nutrient status.

Trial Details

Trial Location	Wass Holdings West Coorow
Plot size & replication	50m x 15m
Soil type	Deep yellow coarse sand
Paddock rotation	No cropping history

Treatments

	Treatment
1	Control
2	80 t/ha bentonite clay
3	80 t/ha bentonite clay + chicken manure
4	160 t/ha bentonite clay
5	160 t/ha bentonite clay + chicken manure
6	3 m^3 bentonite chicken manure

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)	Clay (%)	Sand (%)
0-10	5.1	7	25	1.6	<1	1	0.013	0.24	5.73	94.26
10-30	5.1	4	24	1.7	<1	<1	< 0.010	0.15	3.95	95.04
30-50	5.5	2	17	1.1	<1	<1	< 0.010	0.08	5.81	92.24
50-70	5.7	5	22	0.8	<1	<1	< 0.010	0.06	5.92	94.07

Comments

Research has shown that by increasing the clay content within a soil, the organic carbon holding capacity of the soil should increase in turn (Hoyle et al., 2011). The two treatments of 80 t/ha and 160 t/ha of bentonite clay have been hypothesised to increase the clay content by around 2-4%.

Another factor influencing soil organic carbon levels is biomass production. Chicken manure has been added as a treatment to provide an organic matter and nutrient boost, however maximising crop water use efficiency will be key to achieving measurable increases.

The clay has been added in 2022, with chicken manure spread in 2023. These amendments have been ploughed into the soil to around 30cm, using a one-way 'plozza' plough during the winter of 2023. The dry conditions experienced in 2023 meant that the site was not sown, however, this trial is ongoing into 2024 with an aim to establish as much biomass as possible to maximise organic matter inputs.

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References

Hoyle, F. C., Baldock, J. A., & Murphy, D. (2011). Soil organic carbon - role in rainfed farming systems. *Rainfed Farming Systems*, 339-361.
Hoyle, F. C., & Murphy, D. (2018). Soil Quality: Soil Organic Matter. Perth: *SoilsWest*.

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Use of Inert Stone Mulch to Improve Yield on Sodic, Alkaline Soil

Wayne Parker and Chad Reynolds, Research Scientists, DPIRD Geraldton

Key Messages

- Stone mulch on the surface of a sodic alkaline soil reduces surface evaporation to increase crop yield.
- Given the finish of the 2022 season, full stubble retention did not improve crop yield over nil stubble retention.

Aim

This two-year trial aims to determine the benefit or detriment of stone mulch applied to a soil surface in comparison to full height stripper stubble retention.

Background

Clay soil has the capacity to store more moisture than loam and sand but more of it is unavailable to the plant. While the plant available water is greatest in clay, the water retained by the soil is also the greatest. In low rainfall years the amount of plant available water by percent of rain is lower than in sand and loam. The greatest fluctuations in yield occur in clay soil with both very high yields possible with high rainfall and next to no yield with low rainfall. In an environment strongly conducive to evaporation, gains are to be made by preventing moisture leaving from the surface without first going through a crop.

Surface mulch prevents moisture evaporation from the soil. In current farming systems, most surface mulch takes the form of stubble. The type of stubble, the height, the percentage cover, and the volume all influence the rate of evaporation. Increased stubble volume, percentage cover and height all reduce the levels of evaporation. The stripper header front removes only the grain and husk from the head of the cereal plant leaving the stubble in its entirety. This is the maximum height and volume possible for any stubble mulch. Current harvest practice sees the stubble cut, chopped and spread which decreases the height of stubble, and creates smaller particles sooner broken down by weathering and digestion.

Other forms of mulch do already exist in broadacre agriculture, they include water repellent sand and stone. Mulches work through increasing pore size on the surface and breaking capillary rise as well as reducing surface temperature. Inert stone mulch has been used to positive effect when applied to the surface of sodic, alkaline clay soil (Hall et al., 2022). This trial seeks to determine the yield benefit of stone mulch and stripper stubble when compared to bare soil.

Trial Details

Trial Location	Prowaka Spring, Carnamah	
Plot size & replication	20m x 4m x 4 replications	
Soil type	Sodic, alkaline clay	
Paddock rotation	2021 barley 2022 canola	2021 barley 2022 canola 2023 barley
Sowing date	10/05/2022,	2023*
Sowing rate	2 kg/ha Hyola Battalion XC canola	barley*
Fertiliser	Sowing 65 kg/ha Agflow extra, Post 120 kg/ha Urea	Sowing 60 kg/ha Aglfow extra, Post 100 kg/ha Urea
Herbicides, Insecticides & Fungicides	Pre Treflan, Post Roundup early, 6 leaf and late. Mouse off, Affirm for DBM.	Pre 2 l/ha Treflan, 2.5 l/ha Boxer Gold, Post 1 l/ha Jaguar, 450 ml/ha LVE MCPA,
Harvest Date	01/11/2022	Hand cuts taken only
Rainfall	Dec – Mar 80mm, Apr - Oct 385mm	Dec - Mar 26mm, Apr - Oct 103mm

*Sowing date not provided for 2023. Seeding rate for barley not provided.

Treatments

	Treatment
Stone mulch	14mm blue metal stone applied to surface to depth of 3-4cm. Same stone as is applied to bituminised road surfaces
Full stripper stubble	Stubble harvested with stripper front
½ height stripper stubble	Stripper stubble cut to half height with whipper snipper to simulate cut and spread of current header front operation
Bare soil	Stripper stubble and trash burnt prior to seeding leaving bare soil

Table 1. Soil composition.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	pH (H2O)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO3) (mg/kg)	N (NH4) (mg/kg)	EC (ds/m)	OC (%)	ESP (%)
0-10	63	15	21	7.38	23.8	730	7.2	1.87	6.70	0.24	4.9	3
10-20	42	15	42	8.37	6	621	3.5	1.25	2.95	0.15	2.6	6
20-30	42	14	42	8.85	5	456	4.0	0	1.63	0.22	2.2	12
30-40	41	15	41	9.17	<5	405	8.7	0	1.80	0.36	1.5	20
40-50	40	17	40	9.31	<5	388	21.0	0	1.63	0.55	1.2	27
50-60	40	17	70	9.38	<5	419	47.0	1.20	1.55	0.75	1.0	33

Results

Table 2. 2022 and 2023 establishment numbers and harvest quality parameters from the trial.

Treatment	Plants/m2		Yield (t/ha)		Oil (%)		Protein (%)		1000 grain weight (g)	
	2022	**2023**	**2022**	**2023***	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
Bare	54b	106a	1.70a	0.11a	43.6	-	19.0	-	2.93a	24.4a
Stone mulch	46a	109a	1.81b	0.85b	44.2	-	18.4	-	3.28b	29.4b
Stripper stubble	56bc	85b	1.66a	0.17a	43.8	-	18.8	-	3.03a	25.5a
Half stubble	62c	95ab	1.71a	0.15a	44.0	-	18.6	-	3.04a	25.8a
LSD ($p < 0.05$)	4	20	0.07	0.16	NS	-	NS	-	0.13	3.0

2023* yield estimated from handcuts, 3m2, taking grain weights from these handcuts and scaling up to t/ha.

The stone mulch provided an additional 100 and 680 kg/ha over the next best treatment, though no differences in oil or protein were achieved. The stone mulch treatment also provided the largest grain size.

In 2022, the soil moisture profile was measured at one time only, 30 August, and was not altered by either treatment (data not presented). Variability was large enough to cancel any trends. Stone mulch and stripper stubble had significantly greater percentages of water in the top ten centimetres than bare soil.

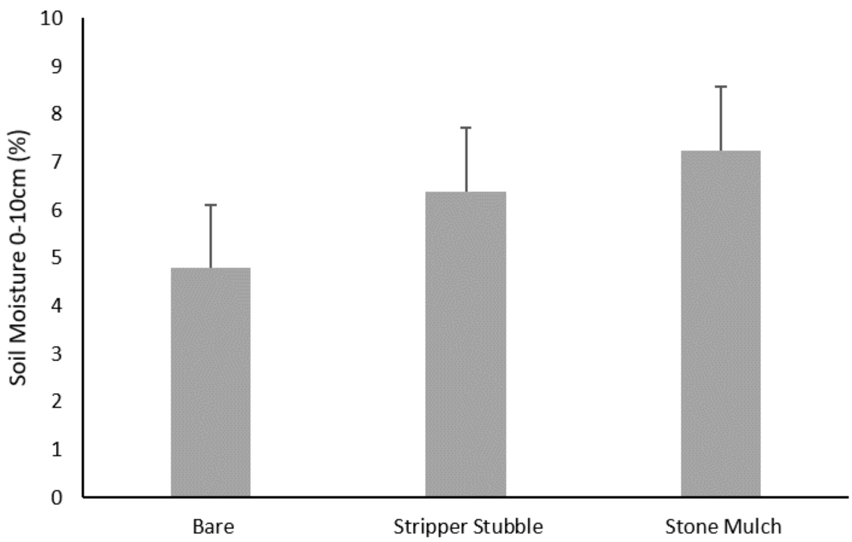

Figure 1. Percentage moisture from volumetric water assessments taken at the 0-10cm layer, on 30 May 2023. T bar represents LSD of 1.3%.

Table 3. 2022 and 2023 establishment numbers and harvest quality parameters from the trial.

Treatment	Bo	Cl-	Cu	Mn	K	Na	S
Bare	29.4a	3.39b	7.51b	96a	5.79a	0.560b	0.595b
Stone Mulch	35.6b	3.42b	8.41c	122b	6.68b	0.583b	0.575ab
Half Stubble	28.2a	2.85a	7.15ab	80a	5.40a	0.365a	0.548a
Stripper Stubble	28.9a	2.96ab	6.88a	84a	5.91ab	0.405a	0.54a
LSD ($p < 0.05$)	2.9	0.48	0.38	22	0.84	0.133	0.04

Table 4. 2023 leaf tissue test results, elements provided are significant effects only.

Treatment	Bo	Ca	Cl	Cu	Mg	Mn	NO_3-	K	S	Tot N
Bare	15.6a	0.39a	2.54a	11.5a	0.20a	93.1a	492a	4.88a	0.37a	4.39a
Stone Mulch	11.2b	0.42a	2.08b	8.25b	0.16b	65.7b	69b	3.72b	0.25b	3.09b
Half Stubble	12.5ab	0.26b	2.37ab	10.8a	0.19a	74.0a	601a	4.81a	0.35a	4.28a
Stripper Stubble	10.6b	0.42a	2.41a	10.4a	0.17ab	75.4a	474a	4.63a	0.33ab	4.07a
LSD ($p < 0.05$)	3.4	0.07	0.31	1.2	0.018	9.0	418	0.25	0.03	0.45

Stone mulch had large influence over the levels of many nutrients in the leaf during late tillering. Stone mulch was directly responsible for reduced levels of nitrate, total nitrogen, potassium, copper and manganese. Biomass of stone mulch treatments was visibly greater than any other treatment for the entire season.

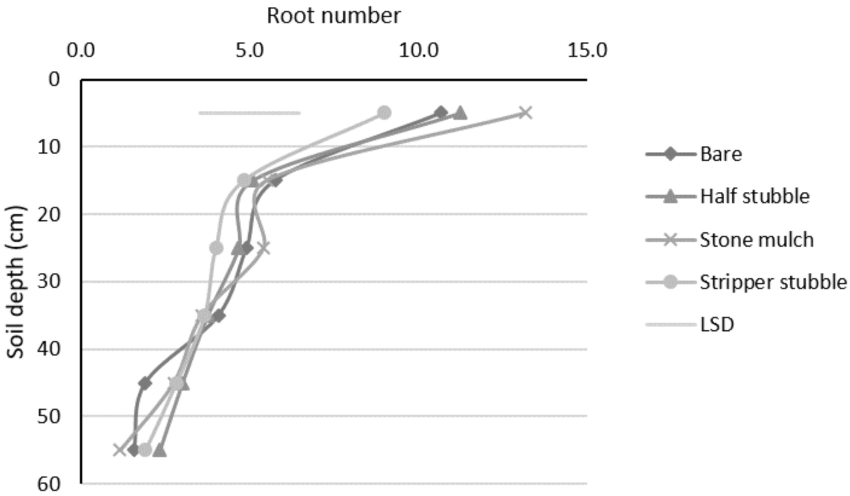

Figure 2. Root number as assessed using core break method (Bennie et al., 1987), LSD ($p < 0.05$), 2022.

Comments

The yield difference in 2022 is reflective of the long, wet, cool finish to the season. There was a statistically significant improvement in canola yield from stone surface treatments. This increase of 100 kg/ha was not as large an increase as anticipated, only 6% over that of the remaining treatments. The seed weight of the stone mulch treatments accounts for this difference at 8% greater than the half stubble treatments.

The two to three weeks following pollination is the time pod number and seed within pod survival is determined (Mendham & Robertson, 2004). In this period water was not limiting and all treatments set, retained and filled an equivalent number of pods. During the season canola in the stone mulch treatments had larger biomass and were taller plants. It is probable that the increased biomass of these plants provided the additional substrates to fill seed at the end of the season as seen in the larger seed weight.

Root number is greatest in the surface 10cm beneath the stone mulch plots. Significantly more were present in this treatment than in the stripper stubble plots. Early vigour observations had the stone mulch plots with greater plant size when compared to all other treatments.

Total rainfall at the site from 23 March to final rain on 14 September was 116mm in 2023. Harvest of plots was not possible as grain head height was too low to machine harvest without significant loss. Handcuts were required to provide yield estimates in 2023. However the results were again significant.

Currently stone mulching is cost prohibitive and logistically challenging. Each plot was covered with approximately 5.2 ton of stone to give a depth of 3cm which equates to 650 t/ha. In this trial the stone mulch was 14mm screened blue metal, as used for road surface, which is more expensive than a screened gravel or sand and not recommended outside of trial scale. To spread such rates as this may be possible with modified clay spreaders though most likely no other agricultural equipment exists today. These results are consistent with results from Moorine rock and Devils Creek, where sister trials have been conducted. It is necessary to investigate how such measures can be taken to prevent surface evaporation at a broader scale.

In a cereal season there is potential for full length stubble to reduce evaporation during the summer months, keep the surface cooler and retain more moisture for the beginning of the season. Unfortunately, this trial was unable to answer those questions as season 2023 saw a carryover of canola stubble, harvested conventionally. At the time of early season sampling soil moisture stripper stubble had comparable moisture levels to the stone mulch while the stone mulch plots were approximately 2.5% greater than the bare plots. Inert stone mulch has the capacity to reduce evaporation and improve yield within exceptionally dry seasons on high clay soil (Hall et al., 2022).

Acknowledgments
Thanks to Scott Bowman for sowing and managing this trial throughout both seasons, also for his generosity in hosting the many field walks during 2022.

References
Bennie, A., Taylor, H., & Georgen, P. (1987). An assessment of the core break method for estimating rooting density of different crops in field. Soil and Tillage Research, 9, 347-353.
Hall D., Daw P., Burrell L., Parker W., & Munir R. (2022). Mineral mulches improve water relations and yields on sodic clay soils. Proceedings GRDC Research Updates, Crown, Perth, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/03/mineral-mulches-improve-water-relations-and-yields-on-sodic-clay-soils accessed 30/11/2022
Mendham N. & Robertson M. (2004). Canola: Agronomy in Encyclopedia of grain science, editor in chief Wrigley C., Elsevier, 144-154 http://hdl.handle.net/102.100.100/186437?index=1

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GOVERNMENT OF WESTERN AUSTRALIA

Farmer Demonstrations of Soil Extension Activities to Enhance Productivity and Sustainability

Daenia Dundon, R&D Coordinator, and Chris O'Callaghan, Executive Officer, Liebe Group

In the Northern Agricultural Region of Western Australia, many farmers have adopted soil testing on an annual basis to guide their liming programs and fertiliser decisions. However, there has been limited uptake of testing to depth, >30cm to investigate soil parameters such as microbial biomass, organic carbon, and soil nutrition, and how these indicators can contribute to the overall health and economic potential of the soil.

This project has focused on supporting farmers in the Liebe Group region to optimise their soil testing investment and understand the situations where soil testing could provide a greater return on investment and support their decision-making in managing soil constraints. Through the engagement of an agricultural professional, growers were supported in implementing on-farm demonstrations that aimed to improve the health of the soil including developing variable rate maps, removal of subsoil constraints and building soil carbon levels.

Four focus sites, located around the Liebe Group region, have been soil sampled for various reasons, detailed below. These demonstrations are a part of the Soil Extension project funded by the National Landcare Program.

Managing Soil Nutrition Post-Reefinating

Aim

This demonstration aims to gain an understanding of how reefinating may affect soil composition and thus how fertiliser management may change post-soil amelioration.

Background

The reefinator works by digging up common laterite rock or limestone and then crushing it to create topsoil. It is made up of four leading tines at the front, followed by five tines at the back which work to break up the rock, followed by a ribbed roller which weighs 30 tonnes (when full of water) to crush the rocks brought to the surface by the tines. The roller leaves an indented surface to stabilise the topsoil and has anecdotally been found to improve crop germination.

This form of soil amelioration is aimed at relieving the constraint of compaction and improving trafficability and seedability with farm equipment. There has been limited independent research on the impacts of reefinating on soil composition, and if the soil needs to be managed differently post-reefinating.

Results

Table 1. Soil sample results from 0-40cm pre and post-reefinating at site 1.

Site 1	**0-10cm**		**10-20cm**		**20-30cm**		**30-40cm**	
Measurement	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Gravel	5	25-30	25-30	35-40	25-30	35-40	25-30	35-40
P Colwell	17	29	6	19	4	9	3	5
K Colwell	36	40	16	27	< 15	31	16	37
Sulfur	5.8	10.3	39.0	18.8	61.6	32.5	64.2	60.5
Organic Carbon	0.77	0.65	0.38	0.47	0.25	0.43	0.30	0.23
DTPA Copper	0.40	0.60	0.09	0.30	0.08	0.19	0.13	0.15
DTPA Iron	18.10	18.80	9.40	14.20	4.60	7.70	5.30	7.50
DTPA Manganese	0.93	1.71	0.22	0.71	< 0.10	0.61	0.14	0.23
DTPA Zinc	0.48	1.44	0.12	0.32	0.07	0.30	0.13	0.10

Table 2. Soil sample results from 0-50cm pre and post-reefinating at site 2.

Site 2	0-10cm		10-20cm		20-30cm		30-40cm		40-50 cm	
Measurement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Gravel	25-30	35-40	35-40	45-50	45-50	45-50	25-30	55-60	25-30	45-50
P Colwell	30	42	12	24	4	5	2	3	2	< 2
K Colwell	68	87	58	54	39	48	30	34	24	22
Sulfur	21.2	16.3	49.2	31.3	78.0	48.5	81.1	56.6	82.8	58.1
Organic Carbon	0.75	0.97	0.58	0.70	0.32	0.40	0.25	0.34	0.15	0.25
DTPA Copper	0.77	0.43	0.46	0.45	0.27	0.26	0.19	0.43	0.19	0.29
DTPA Iron	28.90	21.10	16.10	23.40	8.70	11.50	6.60	9.60	5.10	6.50
DTPA Manganese	1.18	1.82	0.65	1.07	0.33	0.65	0.20	0.61	< 0.10	0.69
DTPA Zinc	0.21	2.63	0.03	0.74	0.02	0.10	0.09	0.08	0.01	0.04

Comments

Understanding the impacts of soil amelioration practices can be challenging given the complexity and diversity of soil systems. To fully comprehend the impacts, a comprehensive and interdisciplinary approach is required. However, for this project, we are simply comparing soil samples pre and post-reefinating to begin investigating if and how growers may need to alter soil management decisions and strategies following soil amelioration.

The soil samples from both sites show that post-reefinating, sulfur (S) had decreased overall, although in site 1 there was a slight increase in the top 10cm. Whereas, potassium (K), phosphorus (P) and trace elements have all increased overall throughout the soil profile (Table 1 and Table 2). A potential explanation for these observations is that the soil amelioration practices may increase the mineralisation rate, and accelerate the decomposition of organic matter increasing nutrient availability. It is also feasible that the reefinating operation has released nutrients previously held in the rock. The decrease in S levels could be attributed to the decomposition of organic matter resulting in the metabolic conversion of sulfates to sulfides by anaerobic bacteria (Patrick et al., 2015).

Changes in the percentage of gravel in the pre and post-samples indicate that the reefinator effectively breaks up rocks and gravel (as advertised). Currently, gravel greater than 2mm in size is excluded from soil analyses, however, new research is investigating how porous gravel might impact nutrient availability and its potential to bind fertilisers (GRDC, 2020). This suggests that reefinating could potentially release nutrients stored in porous gravel, making them accessible to plants.

This dataset is limited as it is a single measurement that only provides a snapshot and does not capture various factors such as sampling method, paddock variation, or seasonal variance that could be impacting the results. However, it does show the value of soil sampling post-soil amelioration to ensure optimal management of soil and plant nutrition.

Variable Rate Mapping to Improve Farming Efficiencies Through Grid-Based Soil Sampling

Aim

This demonstration aims to show how soil sampling can aid in variable rate mapping for various applications.

Background

With the widespread adoption of precision farming, there are now greater opportunities to target the application of amendments. Fertiliser efficiency can be greatly improved through the use of nutrient mapping and variable rate technology. This practice can optimise farm performance by increasing yield potential through identifying and targeting areas whilst simultaneously decreasing input costs.

In this demonstration, a variable rate map of potassium (K) based on grid soil sampling results is presented. The map considers multiple factors including soil type, baseline K levels and crop requirements.

Results

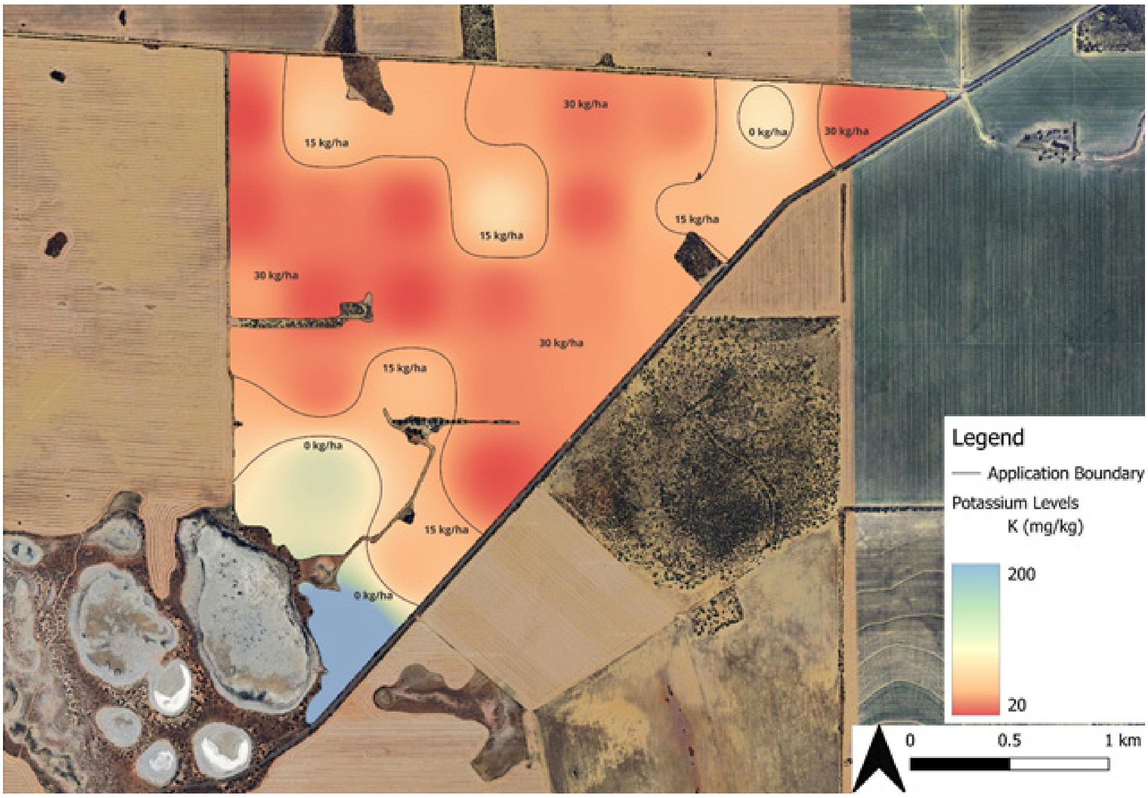

Figure 1. A variable rate potassium (K) application map constructed on grid-based soil sampling results. Potassium levels ranged from <25 to 200, with the lowest levels represented as red and the highest levels as blue. Differing application rates of muriate of potash (MOP) are delineated by the black lines. Low K levels require 30 kg/ha of MOP, moderate K levels require 15 kg/ha of MOP for maintenance, and areas of high K levels require no additional K.

Comments

Understanding soil nutrient levels through systematic soil sampling enables farmers to modify product outputs to adequately represent the paddock requirements. By conducting soil sampling in a grid format across the whole paddock, farmers can assess nutrient levels throughout the area. This data is then combined with soil characterisation mapping and associated yield potentials to create a variable rate map for nutrients such as potassium (K) (Figure 1).

Several factors influence plant K uptake and use efficiency, including soil types, crop species and rotations, seasonal conditions, and K management practices (Ma et al., 2022). In terms of soil types, heavier soils such as clays have a greater capacity to hold onto nutrients such as K, due to their smaller particle size and higher cation exchange capacity (CEC). Therefore, clay soils often naturally exhibit higher baseline levels of K. In Figure 1, the green zones, which require no additional K, corresponded with areas of higher clay content. Conversely, areas requiring additional K were on sandy soils which are known to leach nutrients due to their larger particle size and lower CEC.

The guideline for K rates, as demonstrated by Brennan & Bell (2013), indicates that wheat grown on tenosol soils requires 32-51 mg/kg of K to achieve 90% maximum yield. Based on this, areas that tested below 30 mg/kg were estimated to require 30 kg/ha of muriate of potash (MOP) to increase K rates to be within optimal ranges. Similarly, areas showing base K levels below 50 mg/kg required 15 kg/ha of MOP, and areas above 50 mg/kg were deemed to not require additional K. Comprehensive paddock scale soil sampling allows farmers to vary the rate of outputs such as potassium, nitrogen, phosphorus and lime to adequately supply the paddock requirements.

Note, that this is an example of variable rate mapping and potential rates required. A comprehensive understanding of soil types and base nutrition levels is required to make variable rate maps specific to individual circumstances.

Demonstration of a Rotary Spader's Ability to Alleviate Soil Constraints and Enhance Soil Quality

Aim

This demonstration aims to gain an understanding of how rotary spading affects soil composition.

Background

Rotary spader's were introduced to Australia from Europe in 2009, and have since gained traction as an effective soil amelioration tool for growers to harness. Spader's use their winged-blades to mix the soil top-to-bottom, incorporating any surface-applied amendments to a depth of 350-400mm. This mixing ability has been shown to produce significant and sustained yield improvements through alleviating constraints such as compaction layers and non-wetting soil surfaces in sandy soils (Fraser et al., 2016). This farmer-scale demonstration investigates if changes in soil composition are present 1.5 years after spading has occurred.

Results

Table 3. Soil sample results from sampling of the same location in April 2022 (pre-spading) and November 2023 (post-spading) from 0 -50cm.

	Colour		Gravel (%)		pH (Cacl2)		Organic Carbon (%)		Nitrate Nitrogen (mg/kg)		Ammonium Nitrogen (mg/kg)	
Depth	**2022**	**2023**	**2022**	**2023**		**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
0 – 10cm	GRYW	GRBR	0	0	7.3	6.2	1.27	0.87	3	10	1	2
10 – 20cm	YWGR	GRYW	5	5	5.7	6.0	0.72	0.62	4	4	2	<1
20 – 30cm	YWGR	YWGR	0	5	4.8	4.8	0.34	0.31	4	3	2	<1
30 – 40cm	YWGR	YWBR	5-10	5	4.5	4.5	0.40	0.32	3	2	1	<1
40 – 50cm	YWGR	YW	5-10	5	4.4	4.2	0.29	0.15	2	2	<1	3

Comments

The soil sampling results corroborate that the rotary spader is successfully mixing the soil to depth. This is most evident with changes in soil characteristics such as colour and gravel (%). The 2022 samples show a rather uniform colour throughout the soil profile, whereas the 2023 sample has much more variance. Likewise, gravel distribution has shifted, with a reduction in depth-specific gravel content and a more even distribution across depths, indicative of effective mixing even 1.5 years after spading has occurred.

In the 2022 samples, pH levels were neutral within the top 10cm, followed by a substantial drop in pH to an acidic nature in the 10-20cm depth. Whereas, in the 2023 samples, a more uniform pH level is observed across the top 20cm. This uniformity suggests that lime has been effectively dispersed throughout the top soil profile, by the mixing action of the rotary spader.

Notably, the organic carbon levels have decreased from 2022. This could potentially be due to sampling being conducted post-harvest or could also be indicative that the mixing from the rotary spader has amplified decomposition rates meaning increased breakdown of organic matter, lowering the organic carbon levels in the soil. This breakdown of organic matter by micro-organisms also releases nitrogen through the mineralisation process, which is evident in the higher nitrate nitrogen levels in the soil post-spading in 2023.

One limitation of this demonstration is its reliance on single soil measurements which does not capture various factors such as sampling method, paddock variation, or seasonal variance that could be impacting the results. However, these observations still highlight the potential role of mechanical intervention in promoting the movement and distribution of soil, alleviating various constraints, and ultimately enhancing soil health and crop productivity.

‘Building Soil Carbon’ Soil Biology Trial Almost 10 Years On

Aim
To investigate if organic matter applied to plots over eight years ago still has elevated organic carbon levels.

Background
This long-term trial was established in 2003 to investigate how agronomic factors such as yield and grain quality are affected by organic matter (OM) breakdown and cycling. The trial consisted of six treatments: tilled (offset discs), organic matter (20 t/ha applied every three years), organic matter run down (20 t/ha chaff applied twice only), burnt (March every year), brown manure (every three years) and minimum tillage (control). Although the application of 20 t/ha of organic matter is not practical in a commercial farming enterprise, this treatment was designed to demonstrate the potential upper limit of organic carbon for sandy soils in our environment. The organic matter treatment received a total of 100 t/ha of organic matter across five separate applications (2003, 2006, 2010, 2012 and 2015).

In 2016, the last year of the trial, results showed that over the course of the trial (13 years), the organic matter treatment added an extra 10.9 t/ha of organic carbon into the soil over the control. These two treatments were re-sampled in 2022 to investigate organic carbon levels eight years on.

Results
Soil sampling in 2022 showed organic matter treatments held an average of 0.85% organic carbon in the top 10cm, compared to the controls’ 0.56%, which is a significant difference ($p < 0.05$).

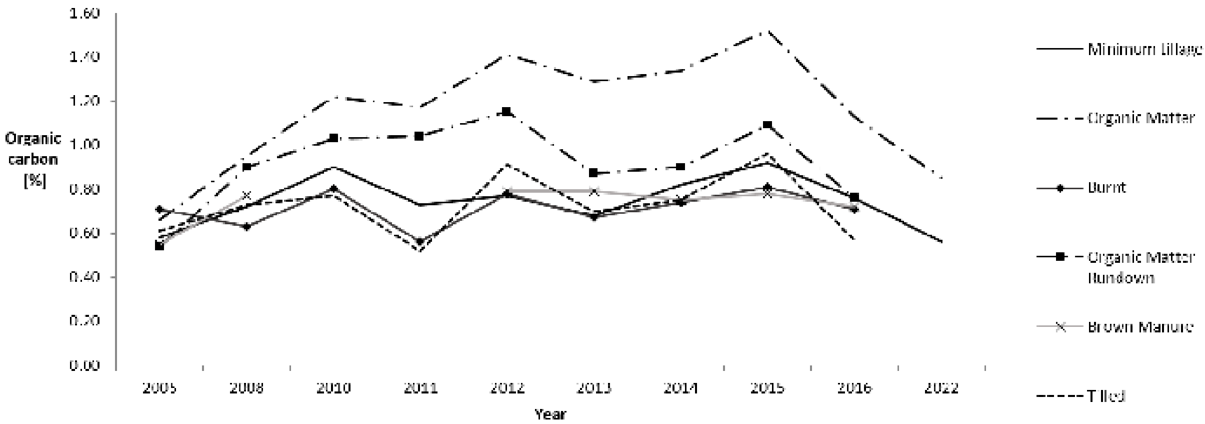

Figure 2. Organic carbon in topsoil (%, 0-10cm) for all treatments from 2005 to 2016. Organic carbon percentage was not recorded for brown manure treatment in 2010 and 2011. In 2022 organic carbon was tested in the organic matter and minimum tillage treatments only.

Comments
Organic carbon content results from the balance between organic inputs and losses, with strong influences of soil type and climate (Hoyle & Murphy, 2018). In Western Australian grains-based cropping systems, organic carbon levels continue to be in decline (Kopittke et al., 2022). A soil's ability to hold stable forms of organic carbon depends on its composition and climatic conditions, particularly rainfall and average daily temperatures (Hoyle et al., 2013). Sandy soils in the northern ag region inherently have some of the lowest natural organic carbon levels due to the strong influence of climate on the amount of organic inputs, the rate of decomposition and also because sandy textured soils offer little protection to organic matter compared to higher clay content soils (Hoyle et al., 2013).

In 2016, this trial demonstrated that it is possible to build soil carbon levels in sandy soils with the addition of significant amounts of organic material, however, this is not seen as an economically viable option, rather an opportunity to validate theoretical limits. Re-sampling the plots in 2022 has shown that the previous additional organic matter applied has continued to result in significantly elevated levels of organic carbon. This shows that organic carbon can be built over long periods of time and can have lasting effects into the future. Further research is required into a viable option for building soil carbon in broad-acre agriculture systems.

Acknowledgements
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References
Brennen, R., & Bell, M. (2013). Soil potassium—crop response calibration relationships and criteria for field crops grown in Australia. CSIRO Publishing: Crop and Pasture Science 514-522.
GRDC. (2020). New research key to unlocking secrets of underperforming gravel soils. Ground Cover.
Hoyle, F., & Murphy, D. (2018). Soil Quality: Soil Organic Matter. Perth: SoilsWest.
Hoyle, F., Antuono, M., Overheu, T., & Murphy, D. (2013). Capacity for increasing soil organic carbon stocks in dryland agricultural systems. CSIRO Publishing 657-667.
Kopittke, P., Berhe, A., Carrillo, Y., Cavahnaro, T., Chen, D., & Chen, Q. (2022). Ensuring planetary survival: the centrality of organic carbon in balancing the multifuctional nature of soils. Environmental Science and Technology 4308-4324.
Ma, Q., Bell, R., Scanlan, C., & Neuhaus, A. (2022). Long-term rundown of plant-available potassium in Western Australia requires a re-evaluation of potassium management for grain production: a review. CSIRO Publishing: Crop and Pasture Science 981-996.
Patrick, S., M.,Fitzpatrick, R., & Reid, R. (2015). The role of organic matter in ameliorating acid sulfate soils with sulfuric horizons. Geoderma 42-29.

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Managing Dryland Salinity

Daenia Dundon, R&D Coordinator and Chris O'Callaghan, Executive Officer, Liebe Group

Aim

This project aimed to investigate dryland salinity issues and to find potential land management interventions.

Background

In Western Australia, dryland salinity is a major cause of land degradation, with widespread implications on rural infrastructure, water resources, biodiversity and productive land. Furthermore, the industry is also seeing a new generation of landholders taking on the primary decision making roles in their enterprises. It has been identified that although these landholders have strong values as custodians of the land for future generations, there is perceived conflict between production efficiencies of modern farming systems and the salinity management practices implemented by previous generations (ie contour banks, deep drainage). These are ongoing issues within the Liebe region, which led to a three-year project, funded by the State NRMProgram, which investigated dryland salinity within the Moore Catchment.
Highlights of the project include a catchment review and management plan that addresses the challenges of dryland salinity and discusses practical solutions, four farmer case study videos, as well as a series of workshops that facilitated knowledge-sharing and collaborative problem-solving.

Historically, farmers in the region have implemented deep drains, contour banks, tree plantings and fences to combat salinity. Going forward, these measures are likely to continue but with added guidance from innovative technology and advanced knowledge to inform decision-making. This report provides a snapshot into how dryland salinity can be monitored using EM38 scanning and how the measurements should be interpreted. Full project results can be found on the Liebe Group website.

Results

Figure 1. Transect of EM38 readings (dS/m) from the current cropping area to a saline valley floor. Readings were taken in ECa (apparent soil electrical conductivities) and were converted to ECe (soil saturation extract) by the following calculation for deep sands: ECe = 4.72ECa + 112. The yellow line indicates where cropping may expect to show yield penalties.

Comments

Previously, farmers and agronomists have relied on soil sampling to determine salinity levels through electrical conductivity (EC) measurements, however, advancements in technology offer alternatives that are more efficient, less labour intensive and with fewer logistical constraints. One such innovation is the EM38 by Geonics Ltd, which measures the apparent bulk soil electrical conductivity. The instrument induces a small current within the soil via a primary electromagnetic field from a transmitting coil and a secondary coil receives the resultant current, giving a reading of electrical conductivity. The EM38 offers dual depth readings; when placed horizontally on the soil it measures 0-0.5m, and while in the vertical position, it measures deeper from 0.5-1.5m. The device is simple to use and gives an instant measurement of electrical conductivity, making it ideal for transect monitoring of salinity as seen in Figure 1. Understanding the gradient of change in salinity is valuable for determining potential productive areas and strategic placements of deep drains and/or tree plantings.

Research has shown that as electrical conductivity increases, maximum yield decreases due to salinity stress which hinders a plant's ability to uptake water, causes ion imbalances and reduces photosynthesis activity; impacting plant growth and final yield (Hussain et al., 2019). Specifically, Hussain et al. (2019) identified threshold EC values for wheat to be between 6 – 8 dS/m. Within this range, a 25% yield loss is anticipated at an EC level of 6.3 dS/m, escalating to 50% at 10 dS/m, and zero germination above 15 dS/m. Based on this, farmers could delineate areas where productive land is unattainable. For instance, in Figure 1, a yellow line represents the wheat threshold boundary; the west of it is too saline for cropping, while the land to the east could potentially be brought back into production.

The EM38 device measures the apparent soil electrical conductivities (ECa), which soil salinity has the most dominant effect. However, other factors such as clay content, soil moisture and soil temperature also affect ECa (Bennett et al., 1995). Additionally, soil type can influence the readings as well as the conversion method of ECa to ECe. Therefore, it's important to understand these factors within the soil and their potential influence on the EM38 results, to ensure accurate interpretation for informed management decisions.

Acknowledgements

Thank you to all the farmers who assisted with this project. This project is funded through the Western Australian Governments State NRM Program.

References

Bennett, D., George, R., & Ryder, A., (1995). Soil salinity assessment using the EM38: Field operating Soil salinity assessment using the EM38: Field operating instructions and data interpretation instructions and data interpretation . *Soil Science Commons* - DPIRD.

Hussain, S., Shaukat, M., Ashraf, M., Zhu, C., Jin, Q., & Zhang, J.(2019). Salinity Stress in Arid and Semi-Arid Climates: Effects and Management in Field Crops. *Climate Change and Agriculture* 197-222.

Peer review

Lizzie King, Yarra Yarra Catchment Management Group

To read the full Catchment Management Review and vidoes please visit: https://www.liebegroup.org.au/drylandsalinity

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FARMING SYSTEMS RESEARCH RESULTS

RiskWi$e: To Fallow or Not to Fallow: Soil Moisture Management and Cover Crop Risks and Rewards

Aeneva Poulish, Project Officer, and Chris O'Callaghan, Executive Officer, Liebe Group

Key messages
- This is the first year of a five-year factorial crop sequence x nitrogen management trial.
- Decile 1 season meant yields were low across the trial.
- There was a small yield and protein benefit to applied nitrogen.

Aim
The aim of this trial is to fill the knowledge gaps around crop sequencing and nitrogen management, in order to help growers identify risk and assist in the decision making process. This trial is part of the RiskWi$e project, which is a five year national initiative that seeks to involve Australian grain growers in the identification of on-farm decisions that have unknown components of risk-reward.

Background
During fallow, growers forfeit production in one season in anticipation that there will be partial compensation by increased crop production the following season. Growing cover or break crops can also increase yields in subsequent years and improve soil nitrogen fixation (McBeath et al., 2015). Some of the main benefits of fallow, cover, and break crops are; soil moisture conservation, disease, and weed break. Having stored soil moisture at seeding helps in growing seasons when rainfall is less than 280mm (Liebe Group region). The risk-benefits of fallow, cover, and break crop management are not often well understood.

In 2023, the Liebe Group designed and implemented a small plot trial in Pithara, with the aim to compare the soil chemical and physiological characteristics between; (i) continuous wheat, (ii) chemical fallow with stubble, (iii) legume crop and (iv) legume cover crop (worked into the soil as brown manure). The basic template for this experiment is a factorial crop sequence x nitrogen management strategy with full phasing of crop sequences over a four year period to simulate farmer practice.

The crop sequences consist of the following: continuous wheat; low risk, N mining (fallow incorporated into wheat crop rotation); low risk, N building (brown manure legume incorporated into wheat crop rotation; high risk, high return (grain legume incorporated into wheat crop rotation). Three nitrogen treatments (nil, low risk and high risk) were randomised and applied to each crop sequence strategy. The low risk nitrogen treatment relates to sufficient nitrogen fertiliser applied to achieve water limited potential yield given the starting soil water, soil nitrogen, timing of break, rainfall to date and assuming a median season finish from the point at which the decision was made (decile 5). The high risk nitrogen treatment relates to sufficient nitrogen fertiliser applied to achieve water limited potential yield given the starting soil water, soil nitrogen, timing of break, rainfall to date and assuming a top quartile season finish from the point at which the decision was made (decile 7/8).

Trial Details

Trial Location	DW & GD McIlroy, Pithara
Plot size & replication	8.1m x 1.75m x 3 replications
Soil type	Loam over gravel
Paddock rotation	2020 canola, 2021 wheat, 2022 wheat
Sowing date	19/05/2023
Sowing rate	75 kg/ha Calibre wheat, 110 kg/ha Jurien lupins
Harvest date	29/11/2023

Treatments

Inputs/ha	Wheat	Lupins	Lupins (Brown Manure)	Fallow
Pre-Emergent	210 ml Sakura Flow	210 ml Sakura Flow	210 ml Sakura Flow	210 ml Sakura Flow
	1.5 L Trifluralin	1.5 L Trifluralin	1.5 L Trifluralin	1.5 L Trifluralin
	1.5 L Avadex Xtra	1.5 L Avadex Xtra	1.5 L Avadex Xtra	1.5 L Avadex Xtra
	1 L Chlorpyrifos	1 L Chlorpyrifos	1 L Chlorpyrifos	1 L Chlorpyrifos
	100 ml Bifethrin	100ml Bifethrin	100 ml Bifethrin	100 ml Bifethrin
	1.5LWeedmaster DST	1.5 L Weedmaster DST	1.5 L Weedmaster DST	1.5 L Weedmaster DST
PSPE		50 ml Brodal	50 ml Brodal	
Post-Emergent	2.5L BoxerGold	330 ml Clethodim 360	330 ml Clethodim 360	330 ml Clethodim 360
	800mL Velocity	180 g Factor	180 g Factor	180 g Factor
		200 ml Brodal	200 ml Brodal	200 ml Brodal
		100 g Metribuzin	100 g Metribuzin	100 g Metribuzin
		20 ml Trojan	20 ml Trojan	20 ml Trojan
Spray Out			2.5 L Weedmaster DST	2.5 L Weedmaster DST

Crop Sequence

Sequence Name	Crop Rotation
Continuous wheat	Wheat (1 phase)
Low risk, low return, N mining	Fallow – Wheat (3 phases)
Low risk, low return, N building	Brown Manure Legume – Wheat (3 phases)
High risk, high return	Grain Legume – Wheat (3 phases)

Nitrogen Treatments

Strategy	Treatment
Nil	No N fertiliser applied (other than 20 kg/ha urea at sowing)
Low Risk	50 kg/ha of N applied, based on decile 5 from Yield Prophet predictions. (Date applied)
High Risk	70 kg/ha of N applied, based on decile 7/8 from Yield Prophet predictions.

*Nitrogen applied to wheat phase only.

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	5.9	23	51	25.4	6	1	0.100	0.59
10-20	6.1	7	39	19	1	< 1	0.048	0.22
20-30	5.5	16	43	18.3	3	1	0.071	0.41

Pithara Monthly Rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
2023	6.0	0.0	25.8	5.8	21.2	38.8	23.8	17.4	3.6	0.0	26.0	14.0	182.4

Results

The Yield Prophet crop model was used as a tool to determine the most appropriate rates of nitrogen for the treatments in this trial. Based on a Yield Prophet report generated on 22 June 2023 (Figure 1), for a decile 5 (50% probability) finish, a rate of 50 kg/ha N was applied to the low risk treatments to achieve a 1.6 t/ha yield and for the decile 7/8 (25% probability) finish, a rate of 70 kg/ha N was applied to the high risk treatments to achieve 2 t/ha. As a visual demonstration, a rate of 90 kg/ha was applied to the buffer plots in the event the season turned favourable and a decile 9 (10% probability) finish was achieved.

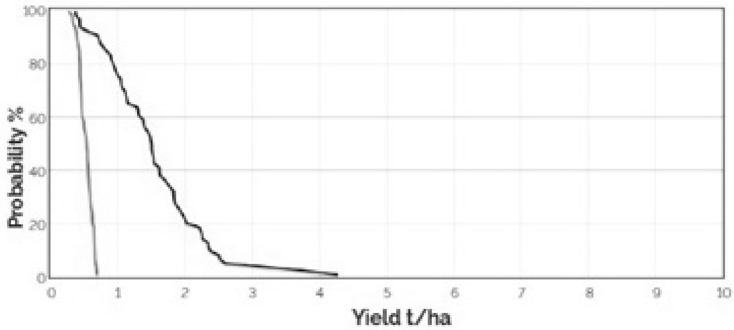

Figure 1. Yield Prophet crop report for Pithara on 22 June 2023.

The green line in Figure 1 represents the predicted yield when no nitrogen is applied (nitrogen limited yield), compared to the blue line which represents nitrogen unlimited yield (water limited yield). Given this is year one of the five year trial, there are no rotational effects at play at this stage of the trial. A yield and protein benefit to applied nitrogen is noted across the trial.

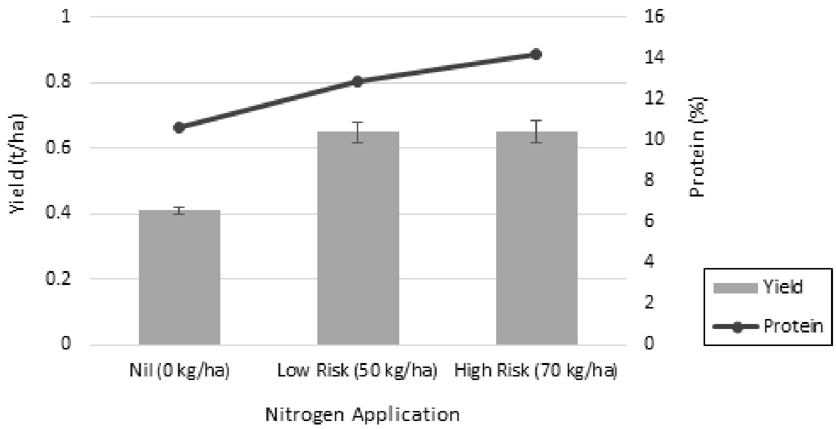

Figure 2. Average yield (t/ha) and protein (%) for wheat across all crop sequence strategies in year one of the trial.

Being the first year of the trial, it is important to note that there will be no rotational influence at play. However, the nil nitrogen treatment yielded slightly lower than the low and high risk treatments (Figure 2). There is a corresponding trend between the three nitrogen treatments in the harvest index results (Figure 3), with the nil nitrogen treatment having the highest harvest index.

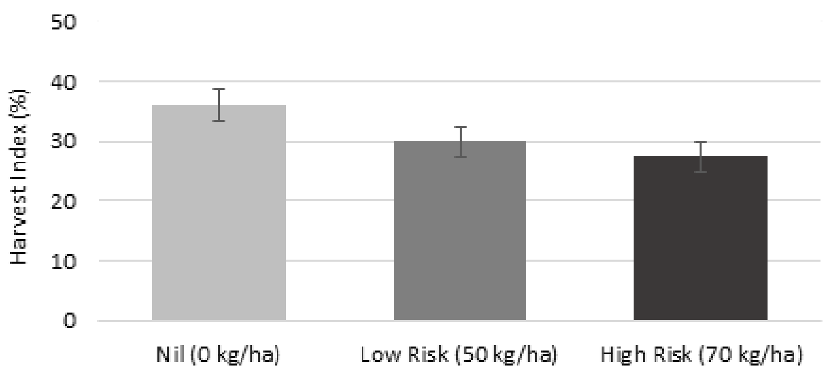

Figure 3. Average harvest index (%) for wheat across all crop sequence strategies in year one of the trial. (Note: this is year one of the trial and thus there will be no rotational influence at play).

Comments

This was the first year of a five-year trial and as such can only be considered as a set-up year. There was a yield benefit to additional nitrogen applications however the rainfall for the year did not increase past decile 1, so it is likely these treatments were over-fertilised for their potential yield. This is supported by the lower harvest index results for the high nitrogen treatments.

Harvest index refers to the ratio of grain produced to the total above-ground biomass of the plant. It is a measure of the crop's reproductive efficiency. A higher harvest index indicates a more efficient conversion of plant biomass into the harvested product.

During a dry season like 2023, nitrogen application and crop rotations become pivotal factors in agricultural management. The scarcity of water in a dry season can affect the availability and uptake of nitrogen by plants, making precise nitrogen management crucial. Growers carefully consider the timing and method of nitrogen application to maximise its efficiency and minimise losses through leaching or volatilisation. Crop rotations, on the other hand, play a crucial role in optimising resource use and managing potential pest and disease pressures.

Growers are undeniably confronted with a multitude of decisions, with the primary risks faced by grain growers are yield (impacted by weather) and price volatility, both of which are unpredictable from one season to another. Over the next three years, the RiskWi$e project will involve grain growers in the identification of on-farm decisions that have unknown components of risk-reward, which will be studied to elucidate new insights. In 2023, there was a whole-of-system approach to help growers assess nitrogen decision strategies encompassing fertiliser and legume use.

Acknowledgments

This is a GRDC invested project that forms part of the RiskWi$e initiative, led by the Grower Group Alliance. Thank you to Brad McIlroy for hosting the trial.

References

McBeath, T. M., Gupta, V. V. S. R., Llewellyn R. S., Davoren C. W., & Whitbread A. M. (2015). Break-crop effects on wheat production across soils and seasons in a semi-arid environment. Crop and Pasture Science, 66(6), 566-579.

Survey

As part of the participatory action research component of the RiskWi$e project, we encourage growers and advisors to complete the national baseline survey to allow us to understand how Liebe Group growers are identifying risks and making decisions. To access the survey, scan the QR code below.

Peer Review

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The Impact of Stubble Height on Cropping Systems in the Western Region

Aeneva Poulish, Project Officer, and Chris O'Callaghan, Executive Officer, Liebe Group

Key Messages

- Strip and disc system yielded the least out of all treatments in 2023.
- Striper stubble may have provided protection to the growing crop which led to a longer flowering period in a hot finish.
- Less weeds were present in the disc seeding system in comparison to the tyne seeder.

Aim

Grain growers will have the knowledge and understanding of how differing stubble architectures contribute value to their farming system, understand the differing costs involved, acknowledge the risk/reward profile and use this knowledge to apply the step changes required for profitability.

Background

Since 2021, the Liebe Group have collaborated with Stirlings to Coast Farmers, Facey Group, Corrigin Farm Improvement Group as well as Farmanco, DPIRD and Charles Stuart University to research the "Impact of Stubble Height on Cropping Systems in the Western Region". This GRDC investment came about due to an increased interest in the 'strip and disc' system and to understand the benefits in water use efficiencies, reduced wind erosion and increased yields.

Four farmer-scale demonstration sites have been designed and implemented in the Wheatbelt and Great Southern regions of WA, with various treatments including: stripper front + disc seeder, draper front + tyne seeder, and other combinations. This report focuses on the Liebe Group site at Bunjil, which was the first year of the trial at this location.

Trial Details

Trial Location	BA JM Hirsch, Bunjil
Plot size & replication	36.6m x 1000m (1 strip) x 4 replications
Soil type	Sandy loam
Paddock rotation	2021 lupins, 2022 wheat, 2023 wheat
Sowing date	15/05/2023
Sowing rate	62 kg/ha Rockstar wheat
Fertiliser	15/05 – 40 L/ha UAN, 02/06 – 100 kg/ha Urea Sustain
Herbicides	20/06 – 1 L/ha Mateno Complete
Harvest date	29/11/2023

Treatments

T1	Draper Front + Tyne Seeder
T2	Stripper Front + Disc Seeder
T3	Draper Front + Disc Seeder

Soil Composition- Pre Seeding (Average)

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.2-6.6	29.2-38.7	56.0-70.7	11.5-31.5	4.7-5.0	2.5-3.7	0.07-0.09	0.60-0.65
10-30	4.7-4.9	27.2-28.2	33.7-47.0	10.6-13.3	1	1	0.02-0.03	0.21-0.25
30-50	5.2-5.4	3.75	31.0-36.7	12.4-14.5	<1	<1-1	0.01-0.02	0.10-0.14
50-70	5.4-5.9	2.5-3.0	25.7-32.5	13.1-15.4	<1	<1	0.02	0.09-0.13

Bunjil Monthly Rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
2023	0.4	0.0	9.4	1.0	6.8	27.5	23.1	22.4	4.1	0.0	18.4	2.6	115.7

Results

Harvest Losses

Harvest Losses were not taken in 2023, as the stripper front was not used during harvest as crops were too short.

Moisture Conservation

Soil moisture at seeding was measured using a volumetric probe in the top 10cm. Results show that the strip and disc system (treatment 2) had the greatest % of volumetric moisture on the day of sowing (figure 1). Stripper stubble has the ability to conserve soil moisture due to its retention of standing crop residue, whereas draper stubble may result in greater soil exposure and potentially lower moisture conservation (Schillinger & Wuest, 2021).

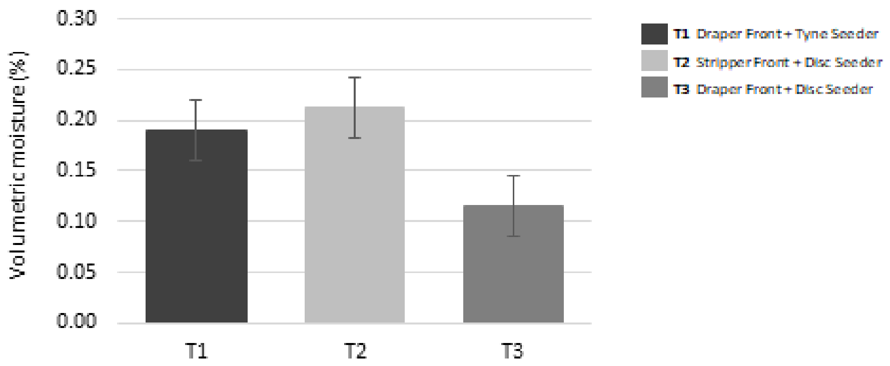

Figure 1: Pre-seeding volumetric soil moisture readings measured on 15/05/2023.

Crop Establishment

Wheat plant counts were collected four weeks after sowing (4WAS) (22/06/2023), with treatment 3 (draper front + disc seeder) having the highest average plant count of 33 plants/m². By growth stage 30 (GS30) (after stem elongation) (04/08/2023), plant counts decreased by 30% to an average of 23 plants/m² across all treatments. At GS30, treatment 3 also had the highest plant count of 24 plants/m².

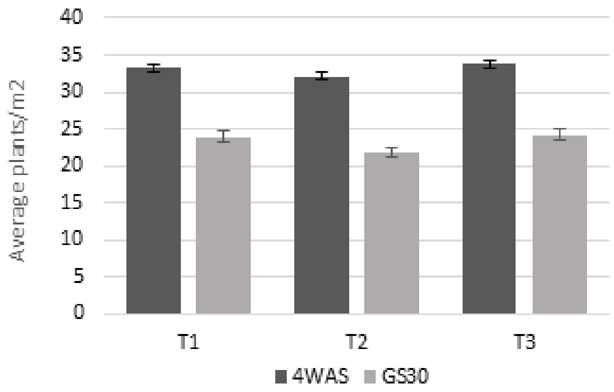

Figure 2: Average plants/m² 4 weeks after sowing (4WAS) and growth stage 30 (GS30).

Crop height was measured three weeks prior to harvest, when crop had reached full maturity. Results demonstrate that treatment 2 (striper front + disc seeder) had the greatest crop height with an average of 46cm. Due to the increased wind protection, greater soil moisture and reduced weed competition, the stripper stubble provided a more favourable growing environment in the dry conditions.

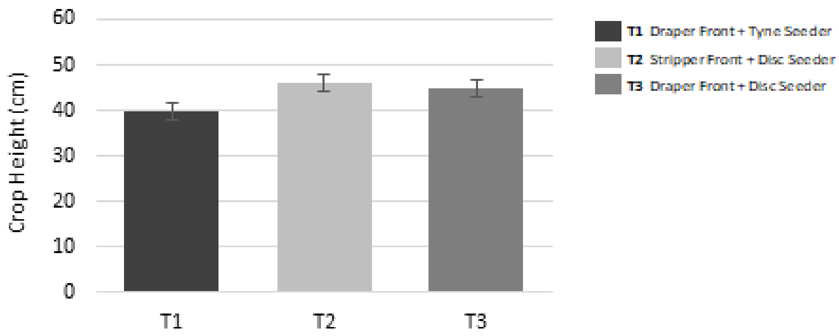

Figure 3: Average crop height (cm) across all treatments at full maturity (30/10/2023).

Weed Density

Weed counts were taken four weeks after sowing (4WAS), and no weeds were present across all treatments (data not shown). The next weed assessment was taken in late October when the crop reached full maturity. Treatment 1 had the highest weed count with an average of 3 across all plots. Treatment 2 and treatment 3 had an average of less than 1 weed across all plots (Figure 4).

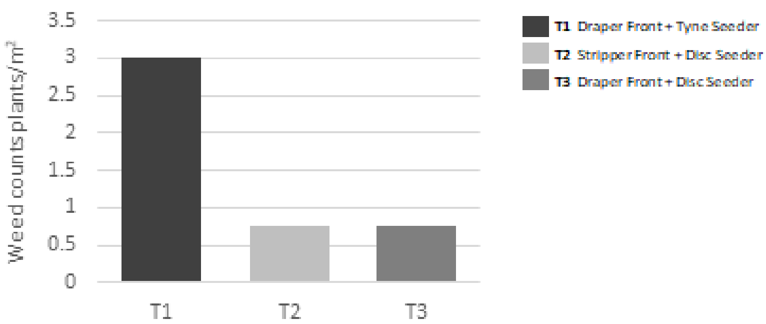

Figure 4: Average weed counts (plants/m^2) across all treatments recorded at full maturity (30/10/2023).

Yield

Yield data from 2023 showed that treatment 3 (draper front + disc seeder) had the highest yield, with an average of 0.40 t/ha, followed by treatment 1 (draper front + tyne seeder), with an average of 0.37 t/ha. Treatment 2 (stripper front + disc seeder) had the lowest yield, average of 0.30 t/ha.

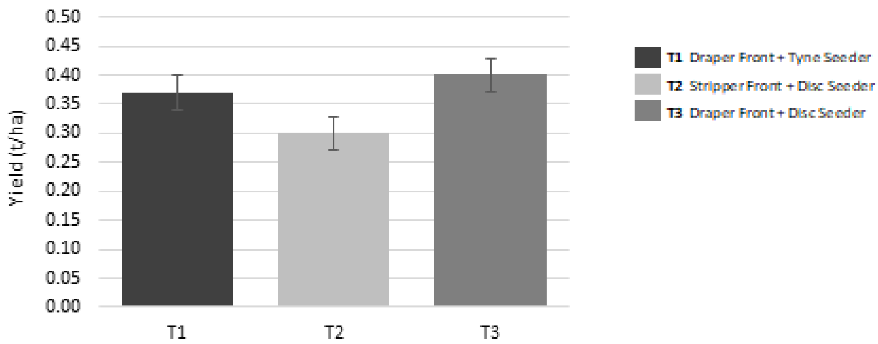

Figure 5: Average yield (t/ha) across all treatments.

Grain Quality

In terms of grain quality, the average protein was 13.1 and hectolitre weight averaged 78.5% across all treatments. There is no significant difference between treatments in the protein and hectolitre weight.

Table 1: Grain quality per treatment.

	Protein (%)	Hectolitre (%)	Screenings (%)
T1	12.80	79.12	3.06
T2	13.78	77.82	3.32
T3	12.90	78.54	3.04

Comments
Stubble heights from the 2022 harvest were measured at the start of the season. Heights for the draper treatments averaged 33.93cm in treatment 1 and 28.35cm in treatment 3, whereas the stripper stubble height averaged 47.43cm (Data not presented). The site was extremely dry at sowing across all treatments.

Conditions at this site were unfavourable due to the below-average rainfall for the 2023 season, which was evident in the low yields across all treatments. The site was sown on 15 May, and did not receive a follow up rainfall event until 1 June.

Observations were made during spring, that the crop sown into the stripper front stubble was greener and flowered for longer, however this did not translate into a yield benefit. The trial was harvested on 27 of November and due to the dry conditions, all plots were harvested with a draper front. The yield penalty associated with the stripper stubble was counter-intuitive to what was expected. Potentially this can be explained by the stripper stubble providing greater heat protection over the other treatments, which has potentially slowed the growth rates of the plants, causing a delay in flowering into the hotter climate and resulting in heat stress.

Full results from this project are still being analysed and will be released later in the year.

Acknowledgments
This project is an investment by the Grains Research & Development Corporation. Thank you to Dylan and the Hirsch family for hosting, seeding and harvesting the trial this year.

References
Schillinger, W. F., & Wuest, S. B. (2021). Wheat stubble height effects on soil water capture and retention during long fallow. Agricultural Water Management, 256

Peer Review
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Growing Wheat on Faba Bean Stubble Compared to Barley Stubble

Daenia Dundon, R&D Coordinator, and Chris O'Callaghan, Executive Officer, Liebe Group

Key Messages
- Wheat on faba bean stubble yielded significantly higher than wheat on barley stubble.
- Faba beans are another potential break crop option for growers in the northern/central ag region.

Aim
This trial aims to investigate the potential yield benefits of growing cereals on a faba bean stubble compared to a cereal stubble.

Background
In the northern and central agricultural regions, the most common break crops in a cereal-dominated cropping system are lupins, canola, or both. However, there is potential for other pulse crops, such as faba beans, to become a part of the rotation strategy. Faba beans are a beneficial break crop compared to canola for a few reasons; they fix nitrogen into the system, they are a break from root lesion nematode and are registered for higher rates of butroxydim (DPIRD, 2021). In some soil types, faba beans may be used where lupins are not performing as well, for instance in alkaline soils or heavier clay loam soil types (DPIRD, 2021). This trial involved farmer scale strips of faba bean in 2022 next to barley, with wheat seeded over the top in 2023. The faba bean strips yielded an average of 1.7 t/ha and the barley yielded an average of 4.8 t/ha in 2022. This demonstration is part of the GRDC investment, Closing the Economic Yield Gap of Grain Legumes in WA.

Trial Details

Trial Location	KL Carter & Co., Jibberding
Plot size	37m x 800m
Soil type	Red loam, pH 7.4 (0-10cm)
Paddock rotation	2023 wheat, 2022 barley/faba bean, 2021 wheat
Sowing date	09/06/2023
Sowing rate	50 kg/ha Scepter wheat and Tomahawk CL Plus wheat
Fertiliser	01/06/2023 – 50 L/ha UAN, 80 kg/ha NPK, 28/07/2023 - 70 L/ha Flexi-N.
Herbicides, Insecticides & Fungicides	09/06/2023 – 1.8 L/ha trifluralin, 0.1 L/ha diuron, 0.1 L/ha clopyralid. 04/07/2023 – 2 L/ha 800 g/L prosulfocarb + 120 g/L s-metolachlor, 27/07/2023 – 0.8 L/ha 250 g/L bromoxynil + 25 g/L diflufenican, 0.4 L/ha MCPA
Harvest Date	27/11/2023

Results

Table 1. Starting Gravimetric Soil moisture from the demonstration of wheat on faba bean stubble and barley stubble taken on 2 May 2023.

Depth	Scepter wheat on barley stubble	Tomahawk CL Plus wheat on faba bean stubble
0cm - 10cm	3.90%	3.20%
10cm- 20cm	6%	4.06%
20cm - 30cm	5.60%	5.20%

Table 2. Starting Nitrogen (mg/kg) from the demonstration of wheat on faba bean stubble and barley stubble.

Treatment	0 – 10 cm		10 – 20 cm		20 – 30 cm	
	Ammonium Nitrogen	Nitrate Nitrogen	Ammonium Nitrogen	Nitrate Nitrogen	Ammonium Nitrogen	Nitrate Nitrogen
Scepter wheat on barley stubble	5	5	3	3	1	1
Tomahawk CL Plus wheat on faba bean stubble	11	9	1	4	2	4

Table 3. Harvest results, average yield (t/ha) from the demonstration of wheat on faba bean stubble and barley stubble.

Treatment	Average Yield (t/ha)
Scepter wheat on barley stubble	0.76
Tomahawk CL Plus wheat on faba bean stubble	0.93

The difference in average yield between the two treatments was significant ($p < 0.05$).

Comments

There are two well-known benefits of growing crops on legume stubble; serving as a break crop and their ability to fix nitrogen which reduces nitrogen fertiliser costs for the current and subsequent crop rotation. This practice has been researched thoroughly, however, in the Liebe Group region, is most often focused on lupins. This demonstration shows that faba bean stubble is another potential break crop option in a cropping system.

‘CL Plus’ varieties have two resistance genes for imidazolinone (IMI) herbicides, which are not known to reduce growth or cost yield, however, IMI-tolerant wheats have lagged behind the highest yield wheat varieties in the past (DPIRD, 2023). Tomahawk CL Plus, released by Australian Grains Technology in 2023, is closely related to Scepter and yielded very similarly at the Jibberding wheat National Variety Trial, 0.80 and 0.77 t/ha, respectively (DPIRD, 2023).

With the NVT being located in the adjacent paddock, caution must be applied when comparing the results of this farmer demonstration to the NVT, however, the NVT does provide a benchmark for variety comparison and does provide a level of confidence that both varieties should yield somewhat similarly in this environment. This was the case for the Scepter on barley stubble, which mirrored the performance of the Scepter plots in the NVT, yielding 0.76 and 0.77 (t/ha) respectively. Whereas, the Tomahawk CL Plus on faba bean stubble yielded slightly higher (0.93 t/ha) than the Tomahawk CL Plus plots in the NVT (0.8 t/ha) and the Scepter on barley stubble (0.76 t/ha). The starting soil moisture levels and Nitrogen levels were higher in the faba bean stubble compared to the barley stubble which may explain the minor yield benefit. This highlights the positive impact of a faba bean rotation on the subsequent crop, which aligns with previous studies on legume rotations (Denton et al., 2017; Peoples & Baldock, 2001).

This trial will continue in 2024, with a barley rotation planned. It will be interesting to see if the benefits are observed in the second subsequent crop, and if 2023 being a dry year, left more nitrogen in the system for this year.

Please note this is an unreplicated farmer demonstration and results should be interpreted with caution.

Acknowledgments

Thank you to Boyd Carter for hosting and implementing the trial. Additionally, thank you to AGT for supplying the cereal grain. This trial is part of a GRDC investment into grain legume extension being led by the Grower Group Alliance.

References

Denton, M., Phillips, L., Peoples, M., Pearce, D., Swan, A., Mele, P., & Brockwell, J. (2017). Legume inoculant application methods: effects on nodulation patterns, nitrogen fixation, crop growth and yield in narrow-leaf lupin and faba bean. Plant and Soil 25-39.
DPIRD. 2023. 2024 Crop Sowing Guide. Perth: State of Western Australia.
GRDC. 2023. NVT Results. 02 09. https://nvt.grdc.com.au/trials/results.
Peoples, M., & Baldock, J. (2001). Nitrogen dynamics of pastures: nitrogen fixation inputs, the impact of legumes on soil nitrogen fertility, and the contributions of fixed nitrogen to Australian farming systems. Australian Jounal of Experimental Agriculture 327 - 346.

Peer review

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Evaluation of Row Spacing and Sowing Speed

Daenia Dundon, R&D Coordinator, and Chris O'Callaghan, Executive Officer, Liebe Group

Key Messages

- Due to below average rainfall, yields at this site were low overall.
- Narrower row spacings had slightly higher yields than wider row spacing.
- The narrow row spacing (10") at the fast speed (11 km/h) yielded statistically significantly higher than all other treatments.

Aim

This trial is a farm-scale demonstration that looks at different sowing speeds at different row spacings.

Background

The depth of seed placement and the distance from the adjacent row both play pivotal roles in crop performance. With the widespread adoption of no-till and precision farming, there are now greater opportunities to vary row spacing and seeding depth. In this trial, the farmer varied both speed (8 km/h, 9.5 km/h and 11 km/h) and row spacing (10" and 12"), to explore their potential impacts on crop performance.

Trial Details

Trial Location	KL Carter & Co., Jibberding
Plot size	18m x 500m
Soil type	Sandy clay loam
Paddock rotation	2020 wheat, 2021 wheat, 2022 canola
Sowing date	15/05/2023
Sowing rate	50 kg/ha Calibre wheat
Fertiliser	15/05/2023 – 50 L/ha UAN, 84 kg/ha NPK, 04/07/2023 – 60 kg/ha Urea
Herbicides, Insecticides & Fungicides	12/05/2023 – 0.8 L/ha paraquat dichloride, 1.5 L/ha 800 g/L prosulfocarb,0.8 L/ha 120 g/L S-metolachlor, 0.5 L/ha prosulfocarb, 1.8 L/ha 480 g/L trifluralin, 15/05/2023- 0.2L/ha azoxystrobin + metalaxy-M, 20/07/2023 – 0.4 L/ha MCPA, 1 L/ha bromoxynil
Harvest Date	27/11/2023

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.7	11	462	8.7	2	2	0.226	0.68
10-20	7.1	9	386	7.6	2	1	0.264	0.51
20-30	7.4	7	411	11.5	2	1	0.353	0.43

Results

Table 1. Starting gravimetric soil moisture from the demonstration of wheat on faba bean stubble and barley stubble taken on 2 May 2023.

Treatment	Average depth of seed (cm)	Average (plants/m²)	Average (weeds/m²)	Average yield (t/ha)
12" at 8 km/h	3.2 (ab)	100 (a)	8 (a)	0.43 (a)
10" at 8 km/h	2.1 (a)	104 (a)	2 (a)	0.52 (b)
12" at 9.5 km/h	3.3 (ab)	95 (a)	4 (a)	0.42 (a)
10" at 9.5 km/h	3.1 (ab)	130 (a)	2 (a)	0.55 (bc)
12" at 11 km/h	3.9 (b)	105 (a)	0 (a)	0.59 (c)
10" at 11 km/h	3.5 (ab)	120 (a)	2 (a)	0.65 (d)

Comments

Average yield increased as speed rose, with narrow row spacing yielding higher than their wider row spacing counterpart. The narrower row spacing can provide greater coverage of the soil surface, potentially improving water use efficiencies (GRDC, 2011). Additionally, in a dry year, the decrease in competition from weeds in the narrow rows and at higher sowing speeds potentially aided the crop throughout the grain fill period (Ahsan Bajwa et al., 2017;Scott et al., 2013). The 10-inch row spacing at 11 km/h sowing speed had a statistically significantly higher yield than all other treatments, indicating narrow rows at high speeds can result in optimal crop performance.

The increase in yield as sowing speed rose could be due to the increased soil throw providing more nutrients and moisture to the furrow, as well as a softer soil for the crop to establish in, however, no data was collected on this aspect. Increased soil throw can also reduce crop emergence due to chemical interactions, however, this effect was not observed in this trial (GRDC, 2011).

Another component of this demonstration was to investigate if increasing sowing speed resulted in deeper seed placement, however, the results show no statistical difference. Whereas another study found that raising the sowing speed from 8 km/h to 12 km/h led to a 6mm increase in seeding depth (depending on the seeding setup), indicating further research is required (Barr et al., 2019).

This data set is limited due to no replication of treatments, therefore, further investigation into the interaction between sowing speed and row spacing is required for a more comprehensive understanding.

Acknowledgments

Thank you to Boyd Carter for hosting and implementing this trial and harvesting this trial.

References

Ahsan Bajwa, A., Walsh, M., & Chauhan, B., S. (2017). Weed management using crop competition in Australia. Crop Protection 8-13.

Barr, J., Desbiolles, J., Fielke, J., & Ucgul, M. (2019). Development and field evaluation of a high-speed no–till seeding system. Soil and Tillage Research.

GRDC. (2011). Grains Research and Development Corporation. Research Papers. January. https://grdc.com.au/__data/assets/pdf_file/0018/210294/crop-placement-and-row-spacing-northern-fact-sheet.pdf.pdf.

Scott, B., Martin, P., & Riethmuller, G. (2013). Row spacing of winter crops in broad scale agriculture in southern Australia . Adelaide: NSW Department of Primary Industries.

Peer Review

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MACHINERY & TECHNOLOGY

Electric Weed Control Efficacy with Varying Topsoil Moisture

Miranda Slaven and Catherine Borger, Research Scientists, DPIRD

Key Messages

- Electric weed control is an effective non-chemical weed control alternative, it functions through the conversion of PTO power into a high voltage current that bursts weed cells.
- Simulated rainfall events of two, three and 10mm did not reduce electric weed control efficacy on a range of weed species. However, rainfall of 20mm reduced the control efficacy of annual ryegrass.
- To obtain full weed control of dense and mature weeds, lower application speeds of electric weed control would be more appropriate.

Aim

1. To investigate the effect of varying levels of soil surface moisture on the efficacy of electric weed control.
2. To determine if there is variation in the efficacy of electric weed control according to weed species.

Background

The Department of Primary Industries and Regional Development (DPIRD) and AGXTEND Europe (a brand of CNH Industrial) have commenced an Australian-first project on electric weed control. Electric weed control (or electroweeding) offers an alternative non-selective weed control method to reduce chemical use. It can be used across a variety of industries with the technology already utilised across Europe. DPIRD and AGXTEND are seeking to prove the concept of its applicability in Australian systems with the hope it will be certified for use here in the coming years.

In this project, the XPower electric weed control machine is being used (Figure 1). The machine utilises the power take off (PTO) to generate high voltage electric current in the power unit mounted on the rear linkage of the tractor. The current is then transferred to the applicator unit which contains electrodes. There are multiple applicator units which can be used with this machine, but for the trials discussed in this report, the XPU (urban) applicator was used at 1.2m width on the front of the tractor. As the tractor moves forward, the electrodes in the applicator unit touch the weeds and transfer the electric current through their shoots and roots. The current transforms into heat energy and bursts the weeds' cells, killing it or suppressing growth. The current then travels into the soil and a second row of electrodes of the opposite charge pull the current back up, closing the circuit.

Figure 1. The AGXTEND XPower electric weed control machine, powered by Zasso™. Mounted on the rear linkage is the power unit with XPS (viticulture application unit), and the XPU (urban application unit) is mounted on the front. Note that a tractor can carry either applicator, in varying configurations.

Electric weed control efficacy is dependent on achieving the right application conditions, as it also needs to occur with herbicide applications. This year, DPIRD has tested a range of different application conditions that may influence efficacy. Manufacturer recommendations for electric weed control include application speeds of 2-4 km/hrfor broadleaf weeds and 1-3 km/hr for grass weeds. Field tests in Europe have also indicated that control is reduced where weeds are mature or dense, as for any other weed control tactic (Vigneault et al., 1990). Control is also thought to be optimised when plants are dry and when surface soil moisture is low (i.e. not to be used during or directly after rainfall). Studies have established that the damage to the weeds' root system from electric weed control is more severe when the soil is dry (reviewed by Vigneault & Benoit, 2001). In wet conditions, the electrical current may travel out of the roots of the target plant into the surrounding soil (i.e. electrical 'spray drift') whereas, in dry soil the current stays in the roots. For example, a study by Vigoureux (1981) found that complete control of weed beet in sugar beet crops ranged from 29-67% when electric weed control was applied in moist soil conditions, but increased to 80-92% in dry conditions. However, the water content of these soils was not specified, the soil type had a greater clay content than generally occurs in Australian agricultural soils and little research has occurred into this effect since. Therefore, research is needed to determine the optimum soil conditions under which electric weed control should occur.

Trial Details

Trial Site	Site 1	Site 2
Trial Location	DPIRD Field Research Station, Northam	DPIRD Field Research Station, Wongan Hills
Plot size & replication	4m x 2m x 3 replications	5m x 2m x 6 replications
Soil type	Brown sand (5% gravel)	Yellow grey sandy loam (15-20% gravel)
Paddock rotation	NA	NA
Sowing date	26/05/2022	16/05/2023
Sowing rate	Safeguard annual ryegrass and Turbocote kikuyu - 200 seeds m^2, Wild radish - 100 seeds m^2	Safeguard annual ryegrass - 200 seeds m^2
Harvest Date	30/08/2022	8/7/2023

Treatments

	Weed control	Weed species	Rainfall simulated (mm)
Site 1	Untreated control	Ryegrass	0, 2 or 3
		Kikuyu	0, 2 or 3
		Wild radish	0, 2 or 3
	Electric weed control (at 3 km/h)	Ryegrass	0, 2 or 3
		Kikuyu	0, 2 or 3
		Wild radish	0, 2 or 3
Site 2	Untreated control	Ryegrass	0, 10 or 20
	Electric weed control (at 2 km/h)	Ryegrass	0, 10 or 20

Soil Composition

	Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
Site 1	0-10	4.4	51	161	3.7	11	2	0.037	0.83
Site 2	0-10	6.5	36	159	6.7	9	4	0.082	1.16

Results

With the application of the simulated rainfall events at Site 1, the volumetric water content (VWC) of the soil at a 12cm depth was increased from 16.54% in the 0mm treatment, 19.46% in the 2-mm treatment and 18.97% in the 3mm treatment. The VWC of the 0mm treatment was significantly lower than the 2- and 3mm treatments ($p < 0.05$), but there was not a significant difference between the 2 and 3mm treatments. Despite this increase in VWC, there was no impact of simulated rainfall events before electric weed control applications on weed density or dry shoot biomass (Table 1). Electric weed control effectively reduced the density ($p < 0.001$; LSD: 1.599) and biomass ($p < 0.001$; LSD 0.124) of all weed species compared to the untreated control. However, the efficacy of the weed control was dependant on the weed species, with the greatest biomass occurring in the wild radish plots ($p < 0.001$; LSD: 0.152). This is expected as wild radish is a larger plant than the grass species.

Table 1. The effect at Site 1 of topsoil moisture on electric weed control efficacy on weed density and above ground dry biomass of weeds two weeks after application.

Treatments			Weed density	Col K (mg/kg)
Weed control	Weed species	Rainfall simulated (mm)	(plants per m²)	Dry shoot biomass
Electric weed control	Kikuyu	0	14.0 (2.94)	2.0 (0.301)
		2	0.7 (0.47)	0.5 (0.068)
		3	1.3 (0.94)	0.3 (0.000)
	Ryegrass	0	44.0 (6.47)	34.7 (1.497)
		2	52.7 (7.25)	119.3 (1.766)
		3	63.3 (7.71)	49.3 (1.169)
	Wild radish	0	54.0 (7.18)	210.7 (2.304)
		2	38.0 (5.99)	565.3 (2.235)
		3	26.7 (4.58)	237.3 (2.125)
Untreated control	Kikuyu	0	87.3 (9.29)	15.3 (1.163)
		2	104.0 (10.15)	28.7 (1.396)
		3	106.0 (10.24)	28.7 (1.392)
	Ryegrass	0	90.0 (9.46)	121.3 (1.959)
		2	69.3 (8.13)	166.0 (2.121)
		3	84.0 (9.08)	135.3 (1.978)
	Wild radish	0	57.3 (7.53)	388.0 (2.574)
		2	72.0 (8.45)	337.3 (2.479)
		3	64.7 (7.96)	261.3 (2.403)
P (and LSD)			0.254 (1.385)	0.898 (0.810)

*Note that a square root transformation was applied to the density data and a logarithmic (base 10) transformation to the biomass data to normalise residual distribution prior to analysis. The back-transformed means are presented with the transformed means in brackets. The LSD value should be applied to the transformed means in brackets.

The application of the 0-, 10- and 20mm simulated rainfall events at Site 2 resulted in significantly different soil VWCs of 3.05%, 7.51% and 10.26%, respectively. This change in topsoil moisture increased the survival of annual ryegrass following electric weed control, with plant density and biomass significantly greater following 20mm of rain compared to 0mm of rain (Figure 2).

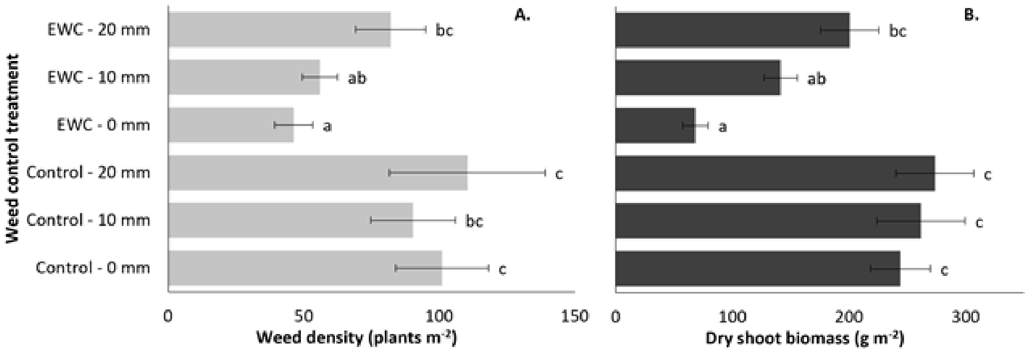

Figure 2. The effect at Site 2 of topsoil moisture on electric weed control (EWC) efficacy on weed density (A, p = 0.023, LSD = 2.184) and above ground dry biomass (B, $p < 0.001$, LSD = 74.20) of annual ryegrass two weeks after application. Bars annotated with the same letter have means that were not significantly different at p = 0.05 according to an LSD test.

Comments

Soil moisture did affect the efficacy of electric weed control when rainfall was simulated at high levels of 20mm. This finding is in line with manufacturer recommendations to avoid treatment directly after rainfall, on moist plants. However, rainfall events of 2, 3 or 10mm, which are commonly seen in Western Australia, did not significantly decrease weed control efficacy. This is a positive result and highlights that electric weed control can be applied after a light rainfall event, on slightly damp weeds, with no impact on the weed control achieved.

It should be noted that the weeds at both sites were mature and dense. The electric weed control application speeds of 2 or 3 km/hr were too fast to effectively control all plants, even where soil moisture was low. These speeds were selected to ensure a range of different control levels, as it would not be possible to assess the impact of topsoil moisture if complete weed control was achieved. Mature broadleaf species should be treated at 1-2 km/hr and mature grasses at 1 km/hr (manufacturer recommendations). Slower application speeds would improve control regardless of soil moisture. While application speeds of 1-2 km/hr are not applicable to broadscale cropping, electric weed control is likely to be a viable option for fence line, roadside or fire break weed control.

Acknowledgments

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References

Vigneault, C., & Benoit, D. (2001). Electrical weed control: Theory and applications, 174 - 188 In Vincent, C., Panneton, B., & Fleurat-Lessard, F., (Eds), Physical control methods in plant protection. New York, USA: Springer-Verlag Berlin, Heidelberg.

Vigneault, C., Benoit, D.L., & McLaughlin, N.B., (1990). Energy aspects of weed electrocution. Reviews of Weed Science, 5, 15-26.

Vigoureux, A. (1981). Results of trials carried out in Belgium in 1980 about killing weed beets by electric discharge. Mededelingen van de Faculteit Landbouwwetenschappen Rijksuniversiteit Gent 46, 163 - 171.

Peer review

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Agtech Decoded: Growers Critically Analysing the Role of New Technology in On-Farm Decision Making – What Are the Possibilities?

Aeneva Poulish, Project Officer, and Chris O'Callaghan, Executive Officer, Liebe Group

Aim

This project aimed to critically assess modern data analytics' ability to address farming system challenges and improve in-season decision-making when faced with a variable climate.

Background

Technology has always been at the forefront for Western Australian grain growers to increase profitability, sustainability and efficiency. In recent years, the importance of growers utilising data analytics to enhance their farming enterprises has significantly increased. Integrating modern technology such as real-time soil moisture sensors and satellite imagery, when combined with in-season paddock data and evaluated with advanced analytic techniques, can change the face of farmer-driven research and development in Australia.

Over the past 18 months, Liebe Group growers have invested in a network of 14 soil moisture probes and weather stations to improve the overall understanding of soil water dynamics and water use efficacy in the region. The Agtech Decoded project commenced in June of 2022 to explore the use and integration of this technology and the opportunity it may provide to improve farming practices. Monthly reports generated through Yield Prophet provided growers with a predicted final yield based on rainfall to date as well as stored soil moisture and characterisation. Furthermore, this project allowed growers to assess the use of this tool critically, provide feedback on its value and give researchers valuable insight into the shortcomings and improvements that can be made.

Results

Yield Prophet

Yield Prophet is a crop modelling interface based on the CSIRO Agricultural Production Simulator (APSIM). This tool has been around for 20 years and is the standard modelling tool used to predict yield potential based on soil type, moisture and historical climate data. In 2022, the tool was used in conjunction with the Liebe Group's weather station network, and reports were sent out to farmers.

Table 1 outlines what the model was predicting in 2022 at different times through the growing season across the 14 sites in the network, and what the average actual yields were when they came to harvest. This table suggests that growers got their N decisions pretty right based on how the season was tracking. There was potentially some yield left out in the paddock, however this was mainly due to an unexpected soft finish, and the risk of applying extra Nitrogen at a late stage was high.

Table 1. Yield gap analysis of modelled versus actual yields from the 2022 season, averaged across 14 sites.

Model Timing	Average Decile	Modelled Nitrogen Limited Yield (NLY) (t/ha)	Modelled Water Limited Yield (WLY) (t/ha)	Probability (%)
29 June	3	1.7	2.6	76
26 July	3	2.0	2.8	70
18 August	4	2.4	3.2	84
15 September	6	2.7	4.4	100
			Actual Yield Average	2.7 t/ha

Survey Results

In collaboration with Stirlings to Coast Farmers (STCF), the Liebe Group partnered with CSIRO to build on growers' current knowledge and awareness of agricultural technologies. On-farm surveys conducted with host growers in January 2023 identified that, on average, growers in the Liebe Group and STCF regions use up to seven different sources of digital technology. It was found that weather information and climate forecasts were the most sought-after, closely followed by information regarding crop yield and soil moisture. The Bureau of Meteorology (BOM) was the most frequently used weather forecast platform.

Table 2. Results from survey question: “What farm management/technology apps are you currently using?”

Technologies Currently in Use	Liebe Group (%)	STCF (%)
My John Deere (Operations Centre)	80	75
AgriMaster	70	50
CSBP Decipher or Summit Fertilizer App	60	75
AgWorld	60	25
SMS Basic or Advanced	50	50
AFS Connect/PLM (Case or New Holland)	40	0
PCT AgCloud	20	25
Xero	20	0
BackPaddock	10	25
AgriWebb	0	25
Other: CBH Load Net, Safe_Ag_Systems, Agritrack, Excel, Production Wise	50	0

Weather forecasting reliability was deemed 'fairly reliable' (75%) by five respondents and 'somewhat reliable' (50%) by four respondents. No respondents identified the weather forecasting as 'reliable' (100%), supporting anecdotal evidence of growers' hopes for greater accuracy and reliability in forecasting, particularly long-term forecasts. Furthermore, when asked what growers feel the most significant challenges with technology use and adoption are, they most commonly reported interoperability, time, machine setup, compatibility, and value (Table 2).

Table 3. Results from the survey question: “What are the key challenges identified with technology adoption/use?”

Key Challenges Identified	Liebe Group (%)	STCF (%)
Interoperability - dealing with different platforms (machinery, software providers)	90	75
Time - just not enough hours in the day to do it	80	50
Machine setup and compatibility - getting my data in or out of machines	60	50
Value - is it financially worth doing it?	50	25
Experience - just not sure what is out there?	10	50
Support - not sure where to start or how things work?	10	0
Knowledge - I'm just not tech savvy enough	0	25
Other: STCF participants relate to practices of livestock industries (stock and pasture).	0	25

Workshops
In addition to the on-farm surveys, both grower groups held interactive workshops in Dalwallinu and Albany to determine the major concerns and frustrations involved with adopting new digital technologies. Growers were interested in interpreting soil water information and relating it to a critical management decision. To do this, it was determined that better conceptualisation of the data's meaning would allow it to be used more effectively in decision-making. In terms of time, growers hoped to understand the changes in soil water data, specifically comparing it to previous seasons.

While technology can be employed to assess production benchmarks, assist in identifying if crops are reaching yield potential, and aid in nitrogen management decisions, the use of systems such as Yield Prophet and crop models does not appear to have made it into conventional practices for most growers. The workshops highlighted the importance of integrating technology with grower-specific data, such as yield maps, to maximise its on-farm use. For growers to optimise their advantages from crop models, this project determined that more targeted applicability for larger farm scales was necessary, as well as further training in data use and interpretation of the models.

Case Study
Despite the rise in agricultural technologies, there is still an opportunity for more tools to be developed in the agricultural industry. Discussions with Dylan Hirsch (Liebe Group grower and R&D Committee Chair) reiterated key findings from both the project workshops and surveys, where it was noted that growers are most interested in technology that is used to make critical management decisions such as crop planting, crop nutrition, soil amelioration, weed detection and management. Dylan reported that many of the existing technologies do not provide clear value propositions; "I think if we are talking about building an interface to be as intuitive as possible for everyday use, that's where those numbers need to start, to at least be easily customisable so that they reflect what the grower sees." This again reinforces a need for integration between crop modelling programs and grower data for maximum efficiency of technology use, and bridging the gap between "gut feel decisions" and crop model data. Additionally, Dylan spoke of a need for a greater understanding of the bounds of the technology, where he says "as a farmer, I'd not be scared to try new things, but I'd be scared of relying on those things because I don't know what its limitations are."

Comments
Agricultural technology has always been at the forefront for Western Australian grain growers to increase profitability, sustainability and efficiency. Growers put a significant amount of value and trust into technology; however, there appears to be a distinct gap between the practical applicability of available technologies and growers' decision-making trends. Technology has significantly improved in the last decade, and in coming years it is expected to continue to develop and bridge the gap to support growers in their critical management decisions.

Acknowledgments
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Deep Soil 'Re-engineering' to Optimise Grain Yield Under Low Rainfall Conditions: 2018-2023

Gaus Azam, Research Scientist, DPIRD (Northam)

Key Messages

- Wheat and barley grain yields were at least doubled, and water use efficiency (WUE) was as high as 56 and 30 kg/mm for wheat and barley, respectively, due to deep amelioration of soil compaction and acidity in the low rainfall region of WA.
- Deep incorporation of lime increased subsoil pH closer to the minimum target pH of 4.8, and decreased Al concentration to below toxic levels within two months of lime incorporation. This was maintained over the five-season duration of the experiment.
- Deep amelioration of either compaction, or compaction and acidity together, helped wheat plants to produce root systems to 60–65cm depth compared to 20–25cm depth for the untreated control. Deeper roots allowed plants to extract soil water from deeper soil layers and avoid moisture stress in the absence of sufficient rainfall during grain-filling.

Aim

The experiment was conducted in a paddock near Kalannie, Western Australia, where wheat, canola and barley crops were grown in small plots under no soil constraints (to an approximate depth of 45cm) to quantify the yield potential and WUE of wheat, canola and barley on a re-engineered sandy soil.

Background

More than 70% of topsoil (0-10cm depth) and almost 50% of subsoil (10–20 and 20–30cm) samples collected from the WA Wheatbelt were below the minimum recommended pH targets of 5.5 and 4.8 respectively (Gazey et al., 2013). These soils are acidic due to the historical contribution of the leguminous native plants and/or due to the intensive use of ammonium-based fertilisers and the export of food and fibre from the farmland. Conventional surface application of agricultural lime to treat acidic soil takes many years to improve soil pH deeper in the soil profile and increase crop yield (Azam & Gazey, 2020). The number of years that elapse before yield improves, and economic benefit is realised after surface application of lime, is a barrier for many growers. Therefore, growers look for more efficient methods to correct subsurface soil acidity.

A large proportion of acidic sandplain is also compacted (van Gool, 2016). Literature suggests that the physical incorporation of lime using strategic tillage could be the most effective way of improving soil pH while reducing soil compaction (Davies, 2015). Scanlan et al. (2014) suggested that if an efficient tillage operation is used to mix the lime to the depth where the soil pH constraint occurs, then an immediate payback on lime and cultivation is possible. However, current soil amelioration practices, including deep ripping and liming are found to remediate soil acidity and compaction partially. Moreover, such soil renovations generate variable crop yield responses, as observed from various long-term field experiments (Davies, 2015).

Most crop roots are confined within the top 20–30cm from the surface in paddocks where multiple soil constraints, such as compaction and subsoil acidity, are present (Azam & Gazey, 2020). With such shallow roots, a large proportion of growing season rainfall quickly drains away beyond the root zone. This field experiment aimed to test whether 'Re-engineering' (deep loosening and thorough lime incorporation) a soil profile with multiple constraints can significantly improve the rooting depth of grain crops towards optimising water use efficiency (WUE), water-limited yield potential and grain yield.

Trial Details

Trial Location	Robert Nixon & Co, Kalannie
Plot size & replication	3m x 2m, 3 replications
Soil type	Acidic (Wodjil) sand
Soil pH (CaCl2)	0-10cm: 4.4 10-20cm: 3.9 20-30cm: 3.9
Paddock rotation:	2017 wheat, 2018 wheat, 2019 canola, 2020 barley, 2021 wheat, 2022 wheat, 2023 wheat
Sowing rate	Wheat and barley 60 kg/ha, canola 2.2 kg/ha
Fertiliser	MAP 37 kg/ha at sowing; urea 57 kg/ha at early tillering (cereal) or stem elongation (canola)

Treatments

T0	Zero grading, zero lime
T1	Grade 0.10m, then 0.10–0.30m, keep soils from each layer separately, rotary hoe 0.30–0.45m without spreading lime; back-fill the plots layer-by-layer without adding any lime.
T2	Grade 0.10m, then 0.10–0.30m, keep soils from each layer separately, rotary hoe 0.30–0.45m without spreading lime; back-fill the plots without adding any lime to the 0.10–0.30m subsoil; back-fill topsoil (0–0.10m) and incorporate 1.5 t/ha lime with a manually operated rotary hoe.
T3	Grade 0.10m, then 0.10–0.30m, keep soils from each layer separately, rotary hoe 0.30–0.45m without spreading lime; back-fill 0.10–0.30m and incorporate 3.0 t/ha lime with a rotary hoe; back-fill topsoil (0–0.10m) and incorporate 1.5 t/ha lime with a rotary hoe.
T4	Grade 0.10m, then 0.10–0.30m, keep soils from each layer separately, incorporate 1.5 t/ha lime with a rotary hoe to 0.30–0.45m; back-fill 0.10–0.30m and incorporate 3.0 t/ha lime with a rotary hoe and back-fill topsoil (0–0.10m) and incorporate 1.5 t/ha lime with a rotary hoe.

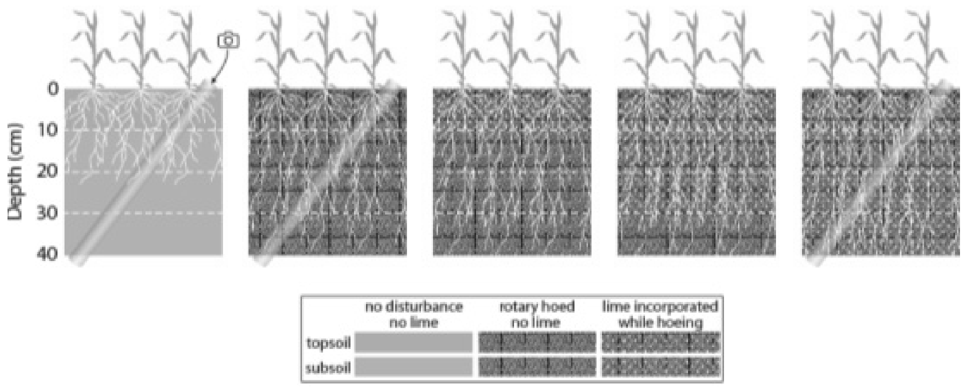

Figure 1: A schematic diagram of the soil re-engineering treatments. From left to right: Control; T1 loosened to 0.45m, no lime; T2 loosened to 0.45m, lime to 0.10m; T3 loosened to 0.45m, limed to 0.30m; T4 loosened to 0.45m, limed to 0.45m.

Results

Seasons

The growing season weather data are presented in Table 1. The first three seasons (2018, 2019 and 2020) were average for Kalannie; however, 2019 had an extremely dry spring causing near failure of the canola crop. The following two seasons (2021 and 2022) were very wet, while 2023 was the driest season with an extremely dry spring. Although the 2021 season was the wettest, there was a severe frost event on 3 September. This frost event caused a significant yield loss at the experimental site and across the region.

Longevity of Soil Amelioration

Soil excavation completely removed compaction to the depth of excavation and the low soil resistance achieved was sustained below the threshold level over six growing seasons (Figure 2a, b &c). Lime incorporation raised the soil pH of the treated soil layers well above the minimum recommended pHCa of 5.5 in the surface and 4.8 in the subsurface within two months from amelioration and maintained or further improved as the seasons progressed (Figure 2d, e & f). Liming also decreased total Al from a very toxic range (18–27 mg/kg in the control subsoil) to a non-toxic level of <5 mg/kg (Figure 2g, h & i).

Table 1: On-site climate data and yield potential for the duration of the experiment (2018-2023).

Parameters	2018 (wheat)	2019 (canola)	2020 (barley)	2021 (wheat)	2022 (wheat)	2023 (wheat)
Annual rainfall (mm)	317	204	237	484	385	184
GSR (May-Oct, mm)	211	176	150	273	253	93
Jan-Apr (mm)	88	28	87	181	132	58
Effective available moisture (mm)	123	76	65	247	196	17
Temperate below 0°C (hours)	6	5	0	20	1	6
Temperate below -2°C (hours)	0	0	0	3*	0	0
Yield potential (t/ha)	2.45	0.99	1.31	4.94	3.91	0.34

* 3 September 2021, 4-7am

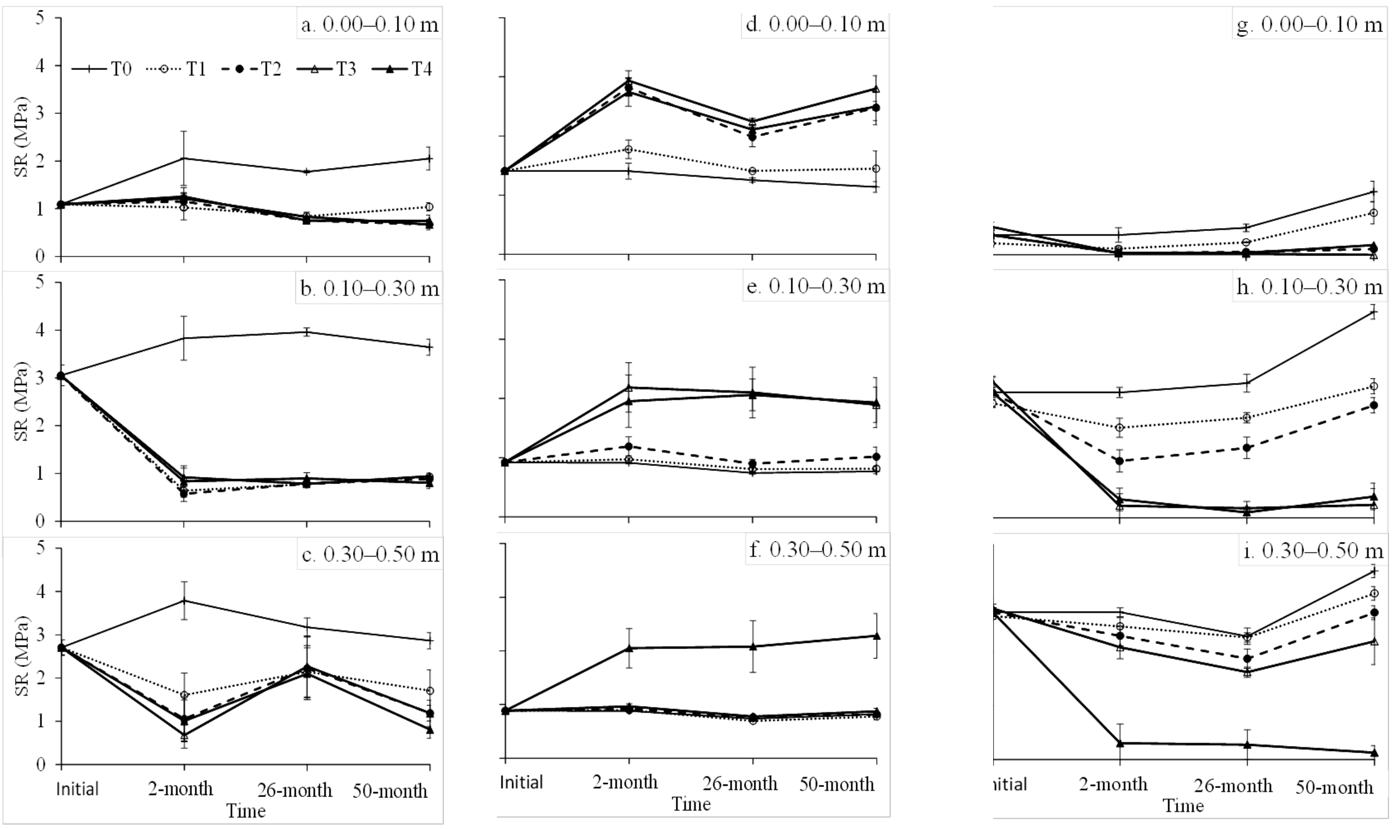

Figure 2. (a–c) Soil Resistance (SR), (d–f) pH and (g–i) extractable aluminium concentration (EAC) in different soil layers and treatments at four different sampling times during the experiment. Measurements were taken at 0, 2, 26 and 50 months after the establishment of the experiment. Vertical error bars represent the standard error of the mean values of the respective variables. Values on the Y-axis are at different scales. Treatments were: T0 - untreated control, T1 - decompaction at 0–0.45 m, T2 – decompaction at 0–0.45 m plus amelioration of acidity at 0–0.10 m by incorporation of 1.5 t/ha lime, T3 - decompaction at 0–0.45 m plus amelioration of acidity at 0–0.30 m depth by incorporation of 4.5 t/ha lime, and T4 - decompaction at 0–0.45 m plus amelioration of acidity.

Yield and WUE

Grain yields were significantly different between various treatments in most of the growing seasons, including a more than 3-fold increase in grain yield in T4 compared to T0, the control (Figure 2). A higher wheat grain yield was recorded in T1, decompaction alone, compared to the control in every wheat growing season (2018, 2021, 2022 and 2023). No difference in grain yield was observed between T0 control and T1 for barley in 2020.

A higher grain yield was measured in T3 and T4 compared to T0 and T1. No yield difference was observed between T3 and T4. In most cases, higher grain yield was also recorded in T2, loosened to 0.45m and limed to 0.1m, compared to the control. There was no yield difference between T1 and T2, except in the 2022 season where T2 had higher wheat yield than T1 control. Grain yield in T4 was 2.5 times higher than the control in 2018, 1.9 times higher in 2020, 2.5 times higher in 2021, 2.2 times higher in 2022 and 3.7 times higher in 2023.

Significant differences were observed between various treatments in WUE of wheat and barley crops (Figure 3). A higher WUE of wheat was recorded in T1 (in the range of 9.2–38.9 kg grain/ha/mm rainfall) compared to the control (6.2–15.3 kg grain/ha/mm rainfall), however no difference was observed between T0 and T1 in WUE of barley in the 2020 season.

A higher WUE of wheat and barley was found in T3 and T4 compared to T0 and T1. In most cases, higher WUE was recorded in T2 compared to the control. There was no significant difference in the WUE of any crop between T1 and T2, except in the 2022 season, where T2 had higher WUE than T1. WUE of wheat and barley were up to 56.1 and 30.4 kg grain/ha/mm rainfall, respectively, in T4, which was up to 3.7-fold higher compared to the control.

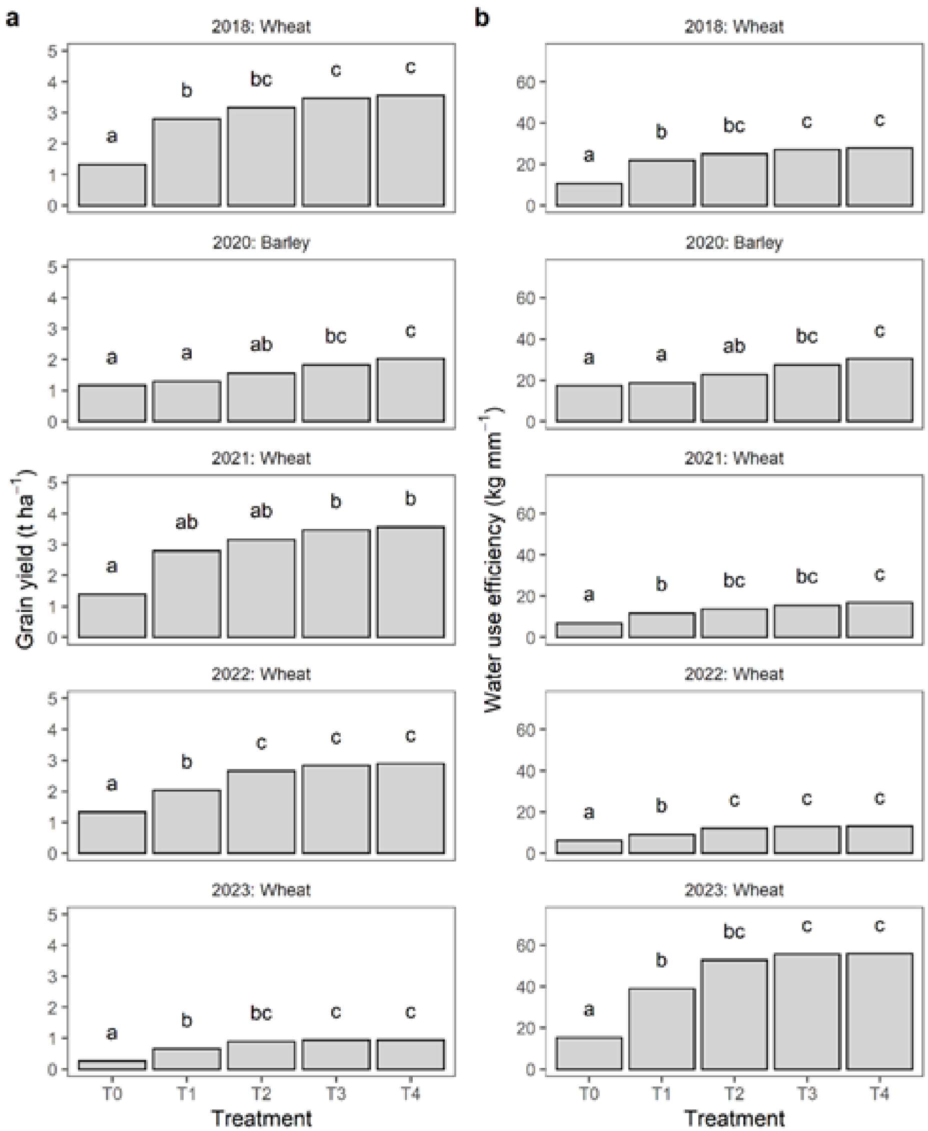

Figure 3: Long-term (2018–2023) effect of soil re-engineering on grain yield (A) and water use efficiency (B) of wheat, barley and canola crops grown on an acidic sand near Kalannie, Western Australia. Treatments were: T0 - untreated control, T1 - decompaction at 0–0.45 m, T2 – decompaction at 0–0.45 m plus amelioration of acidity at 0–0.10 m by incorporation of 1.5 t/ha lime, T3 - decompaction at 0–0.45 m plus amelioration of acidity at 0–0.30 m depth by incorporation of 4.5 t/ha lime, and T4 - decompaction at 0–0.45 m plus amelioration of acidity at 0–0.45 m soil depth by incorporation of 6.0 t/ha lime. Different letters indicate statistically significant differences ($p \leq 0.05$).

Comments

Results show that deep incorporation of lime (to a depth of 30cm and/or 45cm) increased soil pH by more than a unit (fully ameliorated) within two months of lime application. This improvement in soil pH also reduced available Al concentration to a non-toxic level. Complete removal of compaction (by grading and back-filling), coupled with lime incorporation facilitated the development of deep root systems for both wheat and barley (with fine roots and root hairs) over six growing seasons. This allows plants to extract soil water and nutrients from deeper soil horizons (Scanlan et al., 2014). With the improvement in soil chemistry as well as water and nutrient uptake, plant growth was improved significantly. Furthermore, plants grown in ameliorated treatments were less impacted by the dry finish of the season in 2018, 2020, 2021 and 2023 as reflected in the grain yields. Despite severe frost damage in 2021, the deep amelioration of compaction and acidity treatments yielded more than the untreated control.

Wheat yield improved in most seasons with soil loosening to 0.45m alone with deep incorporation of lime further improving yield. Barley, which is more sensitive to soil acidity and toxic aluminium, only had a yield increase when lime was added along with soil loosening.

This experiment demonstrated that deep amelioration of soil compaction and acidity can double wheat and barley grain yield, exceeding the modelled yield potentials for the low rainfall region of WA. The WUE of the wheat and barley crops were up to 56 and 30 kg/ha/mm rainfall, respectively, which surpassed the expectation of the local grower. The benefits of deep soil amelioration were sustained for six growing seasons, showing the potential for long-lasting effect once these soil constraints are corrected effectively. Although it is currently difficult to replicate these soil re-engineering treatments where the soil is thoroughly loosened and lime is homogeneously incorporated at a farmer's paddock scale, the findings from this experiment set the benchmark to maximise yield potential.

References

Azam, G., & Gazey, C. (2020). Slow movement of alkali from surface-applied lime warrants the introduction of strategic tillage for rapid amelioration of subsurface acidity in south-western Australia. Soil Research 59, 97-106. https://www.agronomyaustraliaproceedings.org/index.php/special-publications

Davies, S., Hagan, J., Reynolds, C., Smee, V., Lefroy, W., Andrew, J., & Newman, P. (2015). Long-term responses to soil amelioration – benefits will last more than 10 years! GRDC Agribusiness Crop Updates 2015.

Gazey, C., Andrew, J., & Griffin, E. (2013). Soil acidity. In 'Report card on sustainable natural resource use in agriculture,' Department of Agriculture and Food, Western Australia. https://www.agric.wa.gov.au

Scanlan, C., Brennan, R., & Sarre, G. (2014). Shifting investment from nutrients to lime and cultivation on acid soils: is an immediate payback possible? GRDC Updates Papers available at https://grdc.com.au.

Whitten, M. (2002). Amelioration and prevention of agriculturally generated subsurface acidity in sandy soils in Western Australia, PhD Thesis, University of Western Australia, Crawley, Australia.

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Peer Review

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Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

GENERAL INFORMATION

Benchmarking with Aglytica

Aglytica is a specialist benchmarking company providing farm financial and production analysis to hundreds of businesses across Australia. Aglytica's annual publication, Farm Profit SeriesTM, is designed to help producers compare results to other businesses and has been produced (as the Farmanco Profit Series) for nearly 25 years.

Benchmarking is a process that uses key performance indicators to better understand how the management activities of a farming business impacts its profitability. It is a tool used to compare your business externally to similar businesses or to make comparisons within the business itself. This comparison can then be used to identify business strengths and areas for improvement to help make decisions to achieve the desired outcomes.

Benchmarking can be used to improve the understanding of the physical and financial performance of your business, increase motivation to improve your efficiency, identify trends, create best practice, improve the business bottom line, improve awareness, and allow farm owners and managers to better align their performance with their business objectives.

The following data has been extracted from the 2022/2023 edition and is based on the shires covered by the Liebe Group. For further information or if you are interested in joining the Liebe Group benchmarking, please contact Hilary Bunny on 0439 448 159 or hilary@aglytica.com.au. You can also learn more on the Aglytica website - www.aglytica.com.

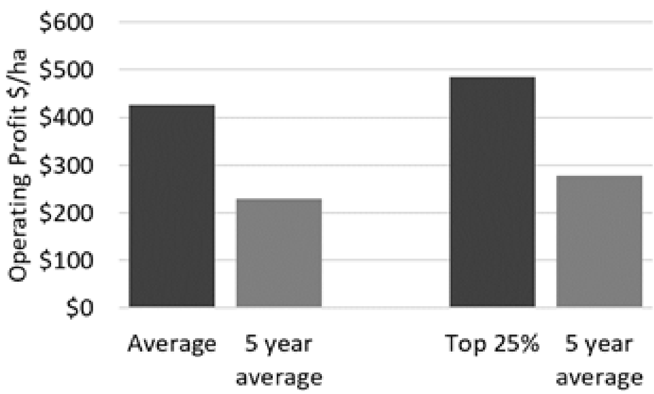
Whole Farm

2022 was another highly profitable year for the Liebe Group zone. Yields were once again exceptional, overtaking the 2021 season convincingly. Yields and subsequent income was not the only increase in 2022, significant rises in farm expenses made matching the 2021 profits difficult, but not impossible.

Table 1: Liebe Group Zone average ROAM figures divided into average annual rainfall zones. Low rainfall zone (L) is 150-300mm, Medium rainfall zone (M) is 300-450mm, High Rainfall zone (H) is 450-600mm.

Rainfall Zone	Return On Assets Managed	Effective Rainfall (mm)
L	17.65%	274mm
M	11.36%	342mm
H	5.73%	462mm

Figure 1: 2022 Operating profit $/ha compared to the 5-year average in the average and top 25% cohorts.



Profitability measures were historically high in the 2022 period. The top 25% generated a return on assets managed (ROAM) average of 23.86%. ROAM is a profitability measure determining how efficiently a business uses its resources. It is one of the best benchmark measures to assess the ability of a business to expand and grow its profits into the future.

ROAM is calculated by dividing the business earnings before interest and tax by the value of the total asset base (including infrastructure and lease values). It is important to note that ROAM generally has a much stronger correlation with profit than with land values. However, ROAM figures will be influenced by extreme movements in land valuations, which will be coming through in the benchmarked period. So, whilst ROAM is an important measure to track, it should be coupled with other key performance indicators to get a robust view of the season.

This is an important point in 2022 where the top 25% managed only $60 of extra operating profit per hectare compared to the average ($486/ha compared to $426/ha) but their ROAM nearly doubled due to land prices being half the value per hectare. The majority of Top 25% have been skewed towards the Low Rainfall Zone with two exceptional seasons in a row which is why the profit per hectare difference is small however the difference in ROAM is very large.

Nearly all the additional profit in the top 25% was made up by savings in variable costs. Fertiliser, chemical and R&M accounted for most of the savings.

Being in the top 25% cohort consistently, requires a level of management that knows where the best return on investment is and how to achieve it in the most efficient manner. This was particularly noticeable in the 2022 season where key expenses were 40-50% greater than the five-year average. Fertiliser and Fuel and Oil were the worst offenders when it came to key production expenses. It was also clear that farm infrastructure over machinery was the key investment coming out of the historic returns of 2021.

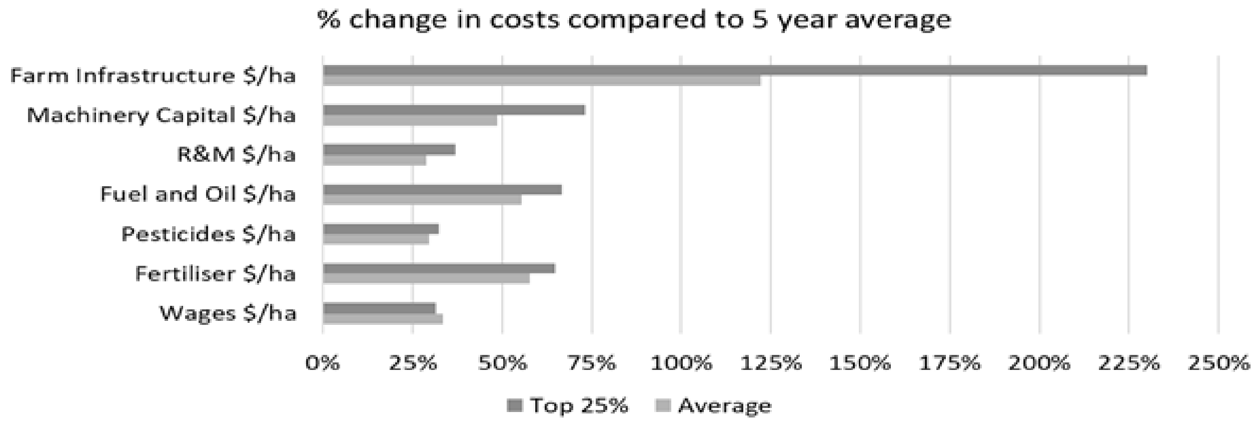


Figure 2: 2022 breakdown of key costs in the Liebe Group zone, comparing the top 25% and average producers to the 5-year average.

Whole Farm

2022 crop yields were exceptional for the Liebe Group zone, represented across all crop yields as well as all water use efficiency (WUE) figures.

Across the major crops, yields were up greater than 0.5t/ha on the five-year average, wheat was 0.75t/ha greater and barley was 1.03t/ha greater.

Wheat operating profit was clearly correlated with price received in 2022. A large spread of over $100/tonne across the Liebe Group illustrated the impact wet harvest conditions and the downgrade of some deliveries.

Barley operating profit had the strongest correlation with WUE. This indicates that the Liebe Group zone had the seasonal advantage to generate high yields, whether it was capitalised on or not was dependent on management.

Canola was the weakest crop when compared to historical yield averages in 2022 for the Liebe Group zone, in saying that, operating profits were still exceptional. Whilst price received ranged from less than $750/t to over $1000/t the greatest impact on profitability was WUE. Constraints to WUE include soil acidity, non-wetting soils, compaction, waterlogging, timing of rainfall and operations, weeds, and frost.

Table 2: Individual cropping Yield, Profit and WUE figures for the Liebe Group Zone, divided into average annual rainfall zones. Low rainfall zone (L) is 150-300mm, Medium rainfall zone (M) is 300-450mm, High Rainfall zone (H) is 450-600mm.

Rainfall Zone	Effective Rainfall (mm)	Wheat Yield (t/Ha)	Wheat Op Profit	Wheat WUE
L	274mm	2.94/Ha	$367/Ha	16kg/mm
M	342mm	3.86/Ha	$569/Ha	17kg/mm
H	462mm	3.94/Ha	$674/Ha	12kg/mm

Rainfall Zone	Effective Rainfall (mm)	Barley Yield (t/Ha)	Barley Op Profit	Barley WUE
L	275mm	3.12/Ha	$254/Ha	17kg/mm
M	345mm	4.11/Ha	$427/Ha	18kg/mm
H	461mm	3.74/Ha	$231/Ha	12kg/mm

Rainfall Zone	Effective Rainfall (mm)	Canola Yield (t/Ha)	Canola Op Profit	Canola WUE
L	272mm	1.43/Ha	$651/Ha	8kg/mm
M	358mm	2.15/Ha	$860/Ha	9kg/mm
H	461mm	1.75/Ha	$510/Ha	5kg/mm

Rainfall Zone	Effective Rainfall (mm)	Lupin Yield (t/Ha)	Lupin Op Profit	Lupin WUE
L	275mm	2.24/Ha	$134/Ha	12kg/mm
M	329mm	2.39/Ha	$108/Ha	11kg/mm
H				

Livestock
Increases in production in both wool and lamb indicators was not enough to buffer the steep drop in income in the 2022 sheep operations. Income of $75 per dry sheep equivalent (DSE) compared to $140/DSE in 2021 left little in terms of profit when $66/DSE in expenses was removed.

Everything was against the WA sheep industry in 2022 with a drop in the wool market, an increase in feed costs as a result of the above average grain prices and a significant depreciation in closing sheep values. The graph below demonstrates the stark opportunity cost of running livestock, comparing sheep to wheat operating profits over the last five years in the Liebe Zone. Whilst this comparison does not take into account the fact that better country is often cropped and management is geared towards optimising crop profits over sheep (for good reason!), it does serve as a reminder to continuously keep enterprises accountable.

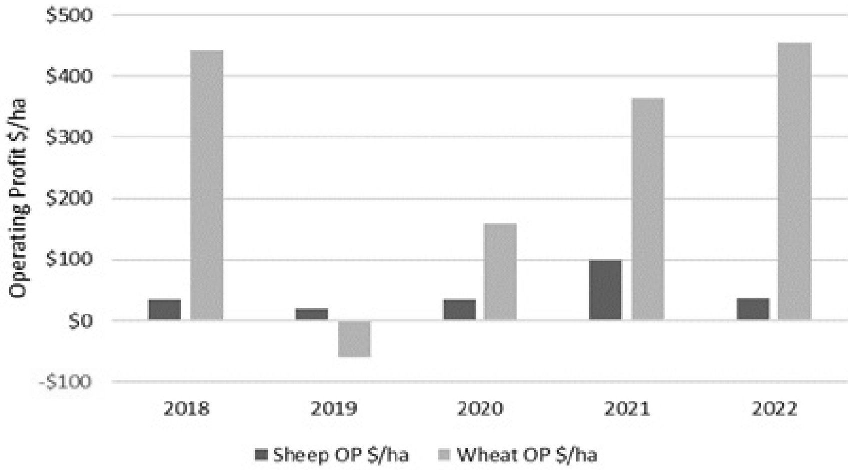


Figure 3: Sheep operating profit compared to wheat operating profit over the past 5 years in the Liebe Group zone.

Machinery
Machinery efficiency is a key profit driver of cropping enterprises. Crop, Plant, Machinery and Labour (CPML) is the ratio that indicates the efficiency of owning and operating machinery at an enterprise level. Scale is a big driver of this indicator, and a top 25% performance is not always attainable for smaller operations however, managers should be monitoring this indicator within businesses across years and always be aiming to lower it.

Table 3: 2022 Total Machinery Costs which include Capital, Running Costs, Management and Contract

2022 Total Machinery Costs $/ha

	Average	Top 25%
Machinery Replacement Allowance	$63	$60
Management Allowance	$45	$32
Wages, F&O, R&M, Contract	$157	$134
CPML (Total Cost of Machinery)	$265	$226
CPML as a % of Income	21%	18%
Crop Income ($/ha)	$1,297	$1,269
Crop Area (ha)	5346	8256

As seen in the graph below, over the last five years in the Liebe zone the top 25% have managed to nearly double their cropping area whilst maintaining crop profits, efficient labour systems and machinery turnover. The difference in management allowance when comparing the top 25% to the average is a function of increased scale in the top 25%. It takes the same number of management units to run the larger businesses, and as they expand it brings down the cost per hectare. The magnitude of the difference is also influenced by the very good years in the Low Rainfall Zone where scale is essential.

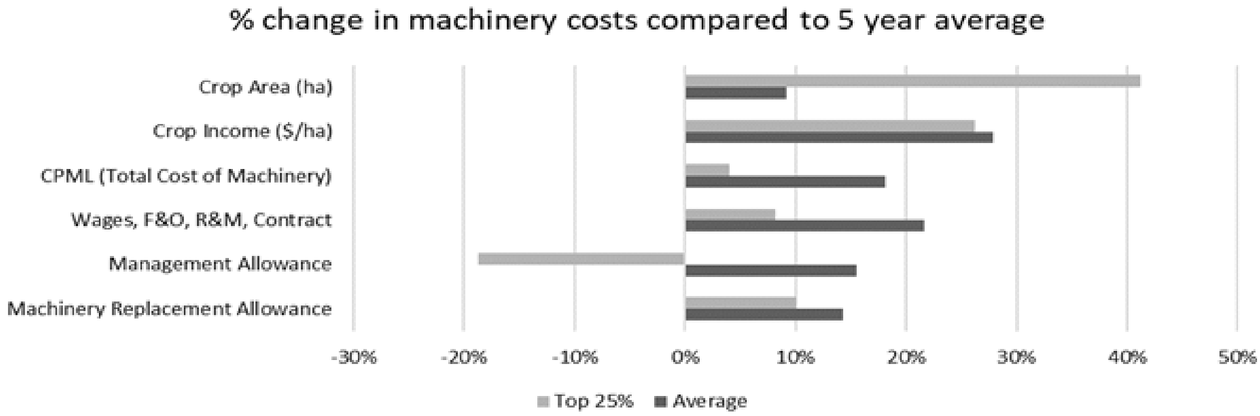


Figure 4: 2022 breakdown of machinery costs in the Leibe Group zone, comparing the top 25% and average producers to the 5-year average.

Carbon Benchmarking

Emissions of carbon dioxide (CO2), methane (NH4) and nitrous oxide (N2O) are benchmarked as tonnes of CO2 equivalent (CO2e). Emissions are categorized into scopes to capture all emissions on farm. These are classified as scope 1, 2 and 3 emissions.

Scope 1: All emissions on-farm from agricultural activity

Scope 2: Emissions from the production of purchased electricity

Scope 3: All emissions associated with producing inputs such as fertilisers, herbicides etc.

The graph below (Figure 5) demonstrates the scope 1 emissions in CO2e per tonne, from the crops benchmarked by the Liebe Group. Emissions per tonne of Canola are generally higher because the yields per hectare tend to be around half the cereal yields. Conducting an emissions audit for your business allows you to benchmark your results against the largest database of its kind in Australia. Like all aspects of farming, in order to make the best decisions, you need to understand where you currently stand.

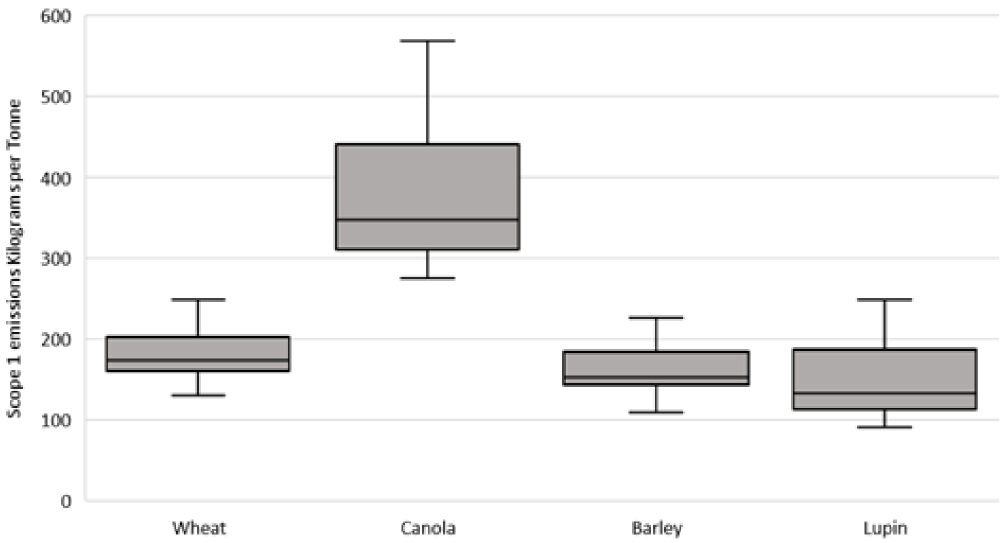


Figure 5: 2022 Scope 1 emissions for each crop enterprise.

2023 RAINFALL REPORT

	Dalwallinu	Kalannie	Coorow	Carnamah	Latham	Perenjori	Wongan Hills	Goodlands	Watheroo^	Main Trial Site (Jibberding)^
Jan	13.6	3.6	1.6	26.3	15.4	3.4	17.6	13.4	11.4	7.6
Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
Mar	21.0	25.0	21.7	11.8	37.2	16.6	17.2	34.2	14.2	40.8
Apr	18.4	16.2	5.5	3.6	4.8	1.0	10.6	10.6	5.8	9.9
May	13.0	7.2	22.5	19.0	10.5	6.6	14.0	3.2	25.0	8.4
Jun	41.6	39.4	43.5	34.9	39.2	23.4	53.0	30.6	31.0	39.9
Jul	26.0	23.6	27.1	31.3	22.6	23.1	28.6	19.0	26.8	28.6
Aug	13.2	17.6	18.9	19.9	20.8	23.7	19.8	17.8	12.6	21.1
Sep	14.2	11.2	18.2	8.8	11.8	4.0	31.6	15.8	15.4	10.0
Oct	1.8	1.2	0.9	0.0	2.8	0.0	3.4	0.0	2.0	0.6
Nov	29.8	33.8	9.0	7.1	39.8	11.4	33.4	21.8	13.4	23.6
Dec	0.2	2.0	-*	0.0	3.8	-*	3.4	0.6	0.0	2.2
GSR (Apr - Oct)	128.2	116.4	136.6	117.5	112.5	81.8	161	97	118.6	118.5
Total	192.8	180.8	168.9	162.7	208.7	113.2	232.6	167.4	157.6	192.7

* Rainfall data not available for some months.
^ Data gathered from Liebe Group rain gauges (manual & digital).

Unless otherwise specified, data were gathered from the Bureau of Meteeorology at www.bom.gov.au

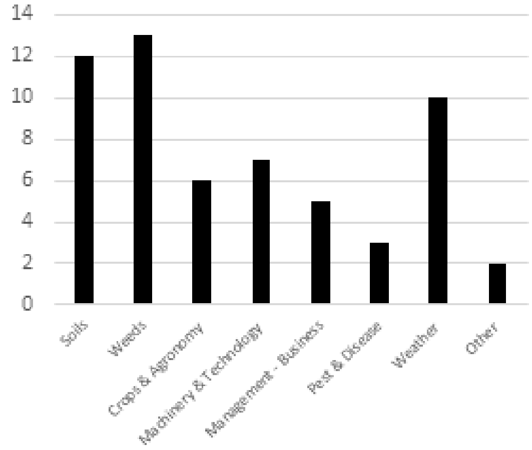
Contact the Bureau of Meteorology by phone (08) 9263 2222, by fax on (08) 9263 2233 or by email at climate.wa@bom.gov.au

The Liebe Group have taken all due care but cannot provide any warranty nor accept any liability for this information.

2023 LIEBE GROUP R&D SURVEY RESULTS

Conducted September 2023 at the Liebe Group Spring Field Day.

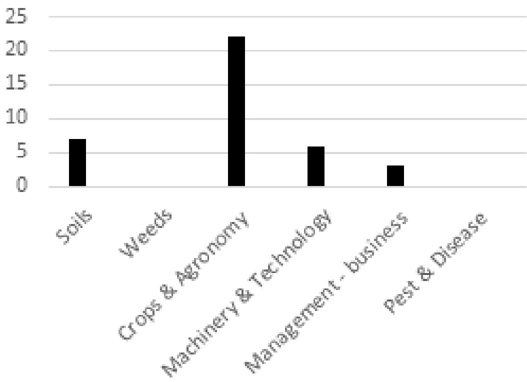
What are the key challenges affecting your farm business?



What are the key areas in relation to weeds?

- Chemical resistance
- The most effective chemicals taking into account resistance

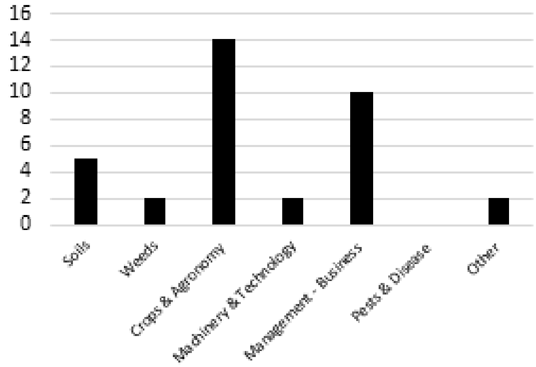
What farming system concepts or practices would you like to see demonstrated at a local level by the Liebe Group?



What are the key areas in relation to crops and agronomy?

- Crop protection decision-making
- Fertiliser decision-making and application
- Fallow management
- Sowing decisions- different seeding systems, speeds, spacing and risk vs. reward of early and late sowing

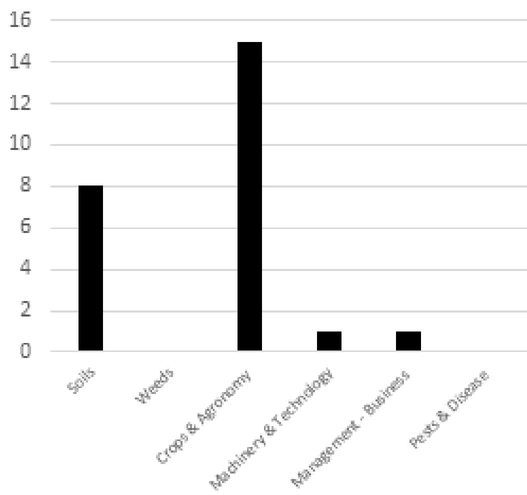
What skills or knowledge would you (or your staff members) like to build on in the next 12 months?



What are the key areas in relation to crops and agronomy?

- Break crops and fallow management
- Precision agriculture including green on green technology
- Chemical application and drift management
- Agronomy skills

What long term research would you like to see the Liebe Group invest in?



What are the key areas in relation to Crops and Agronomy?

- Long term rotational trials
- Rotational cropping and fallow economics
- Future of chemical use with chemical resistance
- Non-conventional cropping methods

LIEBE GROUP STRATEGIC PLAN 2022 - 2026

PURPOSE
Collective local knowledge that advances, unites and reduces risks for our members

VISION
Vibrance and Innovation for Rural Prosperity

MISSION
To facilitate grower prioritised research, development and extension to support our members to be profitable and sustainable.

COMMITMENT TO MEMBERS

- We are a welcoming, inclusive and forward thinking grower group
- We are focused on supporting members and providing an enjoyable member experience
- Research, development, extension and adoption will have local significance and relevance to members
- We collaborate for mutually beneficial outcomes
- We will protect the integrity and professionalism of our research, development and extension
- We will deliver value and return on our investments (people, resources, projects)
- We will support our staff to help us deliver upon our purpose, mission and vision
- We will have a professional and capable Board

STRATEGIC OBJECTIVES	STRATEGIES
Membership 1.1 Members are engaged and active in the Liebe Group	• Communication Strategy developed and implemented • Diverse engagement opportunities are offered • Members have timely access to R,D,E and A as well as other services that will benefit their farm business
Research, Development, Extension and Adoption 2.1 Skilled, professional and capable team that can deliver R,D,E and A 2.2 Our R,D,E and A is leveraged for member benefit	• Organisational structure reflects member and industry priorities in R,D,E and A • Liebe Group team is up-skilled and exposed to new experiences and learnings to be able to deliver locally significant R,D,E and A • R&D Sub Committee prioritise and present ideas and concepts to the Board to consider • Work towards a Liebe Group collaborative R and D hub
Partnerships 3.1 Our partners deliver value to our members	• Partnership Strategy is developed and implemented • Identify and approach new partners that help us deliver upon our purpose and vision
Governance 4.1 We demonstrate best practice not for profit governance	• Investment into the capacity and capabilities of the Liebe Board • Active succession planning by the Board and Executive Officer • Sub Committees are active and communicate strategic and operational challenges and opportunities to the Board • Highly skilled finance sub committee to oversee finances

BACKGROUND

The Liebe Group Board endorsed the 2022-2026 Strategic Plan in October 2021, following several months of comprehensive consultation with members, partners and the wider agricultural industry. With assistance from experienced consultant Caroline Robinson, this new plan marks the sixth strategic planning exercise that the Liebe Group has conducted.

Taking on a more concise format, the 2022-2026 plan highlights future opportunities for the group which will be guided by four main strategic objectives. The plan will assist the group in achieving its vision of farming communities and family businesses that are vibrant, innovative and prosperous. Our strategy will be reinforced by continual improvement and evaluation of impact and success, and will continue to provide the guidance to staff in operations and planning.

ROLE OF THE LIEBE GROUP

The Liebe Group is a dynamic, grower-driven, not for profit organisation that operates within the Dalwallinu, Coorow, Perenjori and Wongan-Ballidu Shires in the West Australian Wheatbelt. As a leading 'grass roots' group, the Liebe Group provides its members with access to innovative, timely and relevant research along with grower and industry network opportunities from all over Australia. The group ensures regular consultation with members and industry to guarantee the group remains relevant. Liebe is governed by a central Board which is informed by a range of operational sub-committees that are comprised of local growers and industry partners.

The group conducts valuable research, development and extension through trials, demonstrations and workshops, and provides information to over 100 farming businesses in the local region, encompassing a land area of over 1,000,000ha.

OUR VALUES

The following are a set of evolving philosophies and values that the group maintains for members and employees. By accepting these values it enables us to build trust in order to make effective and efficient decisions and reach our potential.

Member Driven
Primarily, the Liebe Group is here to create value for its members through R&D, technology and capacity building extension. It is local and relevant, and prioritized by the membership.

Innovation and Progression
The group is innovative and progressive and this is encouraged and valued. An ethos of constant review is adhered to, to ensure we are on track and achieving best practice.

Professionalism
The group is professional which is encouraged and nurtured in the membership. The group is driven by the decision-making capacity of the Board and its supporting sub-committees which use accountable and transparent processes. We expect staff to be confidential in their dealings within the group.

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.

Respect
The group values and respects its members and partners, and their resources and experience. We expect people to be open and honest, and build processes that reflect the transparency of the administration and processes used in the group.

Independence
The group is independent and acts under direction from the 'grass roots.' The group is objective in its views and stance.

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.

Collaborative
Effective networking and links to beneficial partnerships is encouraged to add value and opportunities. The group works collaboratively within the agricultural industry to value add. The group maintains an ethos of team work and cooperation within the group and values peer to peer learning.

Empowerment
Empowerment and capacity building is encouraged of members and staff to ensure everyone reaches their potential and supports their personal development.

Enjoyment
There is a social and fun philosophy within the group.

ACKNOWLEDGEMENTS

The Liebe Group would like to thank those who contributed to this Strategic Plan, and for continuing to support the group with passion and enthusiasm. We look forward to continuing this journey with you all.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