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GRAINS RESEARCH UPDATE

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GRDC Grains Research Update MAITLAND

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PROGRAM

9:00 am	**Announcements and GRDC welcome**	***GRDC representative***
9:15 am	**Canadian Farming Systems – building farm resilience**	***Dr Sheri Strydhorst,*** *Ag Consulting*
9:55 am	**Strategies for post amelioration sowing and crop establishment on sandy soils**	***Mel Fraser,*** *Soil Function Consulting*
10:35 am	**Morning tea**	
11:05 am	**The market and agronomic challenges of carbendazim usage**	***Panel of industry experts***
11.45am	**The economics of fungicides in lentils**	***Sara Blake,*** *SARDI*
12:25 am	**Future proofing herbicide efficacy**	***Sam Kleeman,*** *Plant Science Consulting*
1.05 pm	**Close and evaluations**	***GRDC representative***
1.10 pm	**LUNCH**	

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TOP 10 TIPS

FOR REDUCING SPRAY DRIFT

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01 **Choose all products in the tank mix carefully**, which includes the choice of active ingredient, the formulation type and the adjuvant used.

02 **Understand** how product uptake and translocation may impact on coverage requirements for the target. Read the label and technical literature for guidance on spray quality, buffer (no-spray) zones and wind speed requirements.

03 **Select the coarsest** spray quality that will provide an acceptable level of control. Be prepared to increase application volumes when coarser spray qualities are used, or when the delta T value approaches 10 to 12. Use water-sensitive paper and the Snapcard app to assess the impact of coarser spray qualities on coverage at the target.

04 **Always expect** that surface temperature inversions will form later in the day, as sunset approaches, and that they are likely to persist overnight and beyond sunrise on many occasions. If the spray operator cannot determine that an inversion is not present, spraying should NOT occur.

05 **Use weather forecasting** information to plan the application. BoM meteograms and forecasting websites can provide information on likely wind speed and direction for 5 to 7 days in advance of the intended day of spraying. Indications of the likely presence of a hazardous surface inversion include: variation between maximum and minimum daily temperatures are greater than 5°C, delta T values are below 2 and low overnight wind speeds (less than 11km/h).

06 **Only start spraying** after the sun has risen more than 20 degrees above the horizon and the wind speed has been above 4 to 5km/h for more than 20 to 30 minutes, with a clear direction that is away from adjacent sensitive areas.

07 **Higher booms increase drift**. Set the boom height to achieve double overlap of the spray pattern, with a 110-degree nozzle using a 50cm nozzle spacing (this is 50cm above the top of the stubble or crop canopy). Boom height and stability are critical. Use height control systems for wider booms or reduce the spraying speed to maintain boom height. An increase in boom height from 50 to 70cm above the target can increase drift fourfold.

08 **Avoid high spraying speeds**, particularly when ground cover is minimal. Spraying speeds more than 16 to 18km/h with trailing rigs and more than 20 to 22km/h with self-propelled sprayers greatly increase losses due to effects at the nozzle and the aerodynamics of the machine.

09 **Be prepared** to leave unsprayed buffers when the label requires, or when the wind direction is towards sensitive areas. Always refer to the spray drift restraints on the product label.

10 **Continually monitor** the conditions at the site of application. Where wind direction is a concern move operations to another paddock. Always stop spraying if the weather conditions become unfavourable.
Always record the date, start and finish times, wind direction and speed, temperature and relative humidity, product(s) and rate(s), nozzle details and spray system pressure for every tank load. Plus any additional record keeping requirements according to the label.

The WeedSmart Big 6

Weeding out herbicide resistance in winter & summer cropping systems.

The WeedSmart Big 6 provides practical ways for farmers to fight herbicide resistance.

How many of the Big 6 are you doing on your farm?

We've weeded out the science into 6 simple messages which will help arm you in the war against weeds. By farming with diverse tactics, you can keep your herbicides working.

Rotate Crops & Pastures

Crop and pasture rotation is the recipe for diversity

- Use break crops and double break crops, fallow & pasture phases to drive the weed seed bank down.
- In summer cropping systems use diverse rotations of crops including cereals, pulses, cotton, oilseed crops, millets & fallows.

Mix & Rotate Herbicides

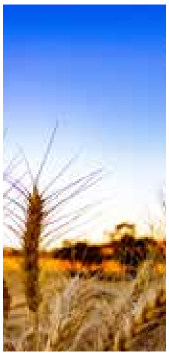
Rotating buys you time, mixing buys you shots.

- Rotate between herbicide groups.
- Mix different modes of action within the same herbicide mix or in consecutive applications.
- Always use full rates.
- In cotton systems, aim to target both grasses & broadleaf weeds using 2 non-glyphosate tactics in crop & 2 non-glyphosate tactics during the summer fallow & always remove any survivors (2 + 2 & 0).

Increase Crop Competition

Stay ahead of the pack

Adopt at least one competitive strategy (but two is better), including reduced row spacing, higher seeding rates, east-west sowing, early sowing, improving soil fertility & structure, precision seed placement, and competitive varieties.



Double Knock

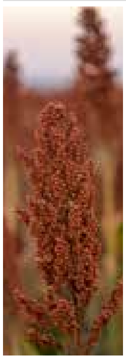
Preserve glyphosate and paraquat

- Incorporate multiple modes of action in the double knock, e.g. paraquat or glyphosate followed by paraquat + Group 14 (G) + pre-emergent herbicide
- Use two different weed control tactics (herbicide or non-herbicide) to control survivors.

Stop Weed Seed Set

Take no prisoners

- Aim for 100% control of weeds and diligently monitor for survivors in all post weed control inspections.
- Crop top or pre-harvest spray in crops to manage weedy paddocks.
- Consider hay or silage production, brown manure or long fallow in high-pressure situations.
- Spray top/spray fallow pasture prior to cropping phases to ensure a clean start to any seeding operation.
- Consider shielded spraying, optical spot spraying technology (OSST), targeted tillage, inter-row cultivation, chipping or spot spraying.
- Windrow (swath) to collect early shedding weed seed.



Implement Harvest Weed Seed Control

Capture weed seed survivors

Capture weed seed survivors at harvest using chaff lining, chaff tramlining/decking, chaff carts, narrow windrow burning, bale direct or weed seed impact mills.

WeedSmart Wisdom

Never cut the herbicide rate – always follow label directions
Spray well – choose correct nozzles, adjuvants, water rates and use reputable products.
Clean seed – don't seed resistant weeds.
Clean borders – avoid evolving resistance on fence lines.
Test – know your resistance levels.
'Come clean. Go clean' – don't let weeds hitch a ride with visitors & ensure good biosecurity.

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Adopting innovative agronomic practices and research – a Canadian experience

Sheri Strydhorst.

Sheri's Ag Consulting Inc.

Keywords

- crop rotation, nitrogen use efficiency, on-farm research, western Canada.

Take home messages

- Western Canadian grain growers are trying to balance enhanced nitrogen use efficiency (NUE), reduced greenhouse gas (GHG) emissions and on-farm profitability. However, agronomic solutions do not achieve all three simultaneously and the most profitable solution is the most widely implemented.
- Grain growers are faced with an overwhelming number of 'quick fixes' that distract them from putting enough time and attention towards foundational agronomic practices. On-farm trials take considerable time and effort, but they are an excellent tool to understand the frequency and magnitude of benefits associated with 'quick-fixes'.
- Simple crop rotations dominate western Canada as they are easy to implement on large acres and are generally profitable. However, countless research studies document the benefits of diversified rotations. Scientific findings alone do not provide enough incentive for many growers to diversify their crop rotations. Grain growers should consider starting with small changes to their crop rotations to experience the benefits first-hand.
- Decisions based on peer-reviewed research and/or on-farm testing help grain growers to invest in profitable agronomic practices and not throw good money after 'quick fixes'. To achieve long-term sustainability, grain growers should start small and slowly increase the diversity of their rotations.

Background

Canada, Australia and all grain-producing regions are facing a myriad of abiotic and biotic stresses that limit crop yields, marketability and profitability. Producers may compromise foundational agronomic practices, such as nutrient management and crop rotation, while spending too much time, effort and money on 'quick-fixes'. Navigating this complicated space can be aided by on-farm trials and unbiased, peer-reviewed research.

Balancing NUE, GHG emissions and farm economics

Improving NUE is critically important to achieve improved profitability and reduce the environmental footprint of food production. In Canada, there is growing public and political pressure to improve NUE and reduce GHG emissions. However, adoption of enhanced efficiency fertilisers (EEF) and biologicals is limited due to their lack of profitability at the farmgate. Peer-reviewed research highlights that, on some soil types, the use of foundational nitrogen (N) management practices negates the on-farm benefits of EEF and highlights the need for other economic incentives to increase EEF adoption if the sole benefits are reduced GHG emissions.

Sorting out the truth of 'quick-fixes'

There are an overwhelming number of 'quick fix' solutions being marketed to grain growers. It becomes more and more complicated to sort through worthwhile products and products that are a waste of time and resources. To benefit a farm, a product must work consistently year after year and produce enough yield benefit to cover the cost of the product and its application.

Academic and government researchers do not run product comparison research trials. In the absence of third party, independent research, on-farm trials provide an ideal platform to test the frequency of a product's benefit (is the benefit seen once every three years or every year?) and the magnitude of the product's benefit (is the yield increase 2% or 10%?).

Balancing logistic ease with complex crop rotations

In western Canada, crop rotations are primarily two-year, spring wheat-canola rotations, which are profitable and easy to implement on large acreages. However, there are increasing examples of soil-borne disease and low NUE that could be managed with more diverse rotations. Furthermore, numerous research studies repeatedly find that inclusion of N fixing pulse crops and/or winter cereal crops provide numerous system health improvements.

A recent survey of western Canadian grain growers indicated 62.5% agree or strongly agree they need to diversify their current crop rotation. The same survey found that having a crop rotation with better net economic returns would be the number one reason convincing them to change their current crop rotation. Given the profitability of current crop choices, diversification is challenging for western Canadian grain growers.

Method

Balancing NUE and farm economics through the lens of small plot research

A recently published study from Fast et al. 2023 tested the benefits of EEFs on spring wheat grain yield and quality at eight locations, representing three different soil types, over four growing seasons. The five N sources tested were:

- urea
- urea + urease inhibitor, N-(n-butyl) thiophosphoric triamide (NBPT)
- urea + nitrification inhibitor, Nitrapyrin
- urea + dual-inhibitors, (NBPT + Dicyandiamide)
- polymer-coated urea, Environmentally Smart Nitrogen®.

Each N source was tested at four N rates (60, 120, 180 and 240kg N/ha) with all N fertiliser applied at planting in either a mid- or side-row band.

Balancing the benefits of N fixing foliar bacteria with yield through the lens of on-farm research

Alberta Grains, a commodity organisation funded through a refundable producer levy, has built a robust program for on-farm research to evaluate agronomic questions related to the performance of genetics and/or management practices on individual producer farms. In 2022, four on-farm trials tested the performance of two biological products (Utrisha-N™ and Envita®) with an untreated control on spring wheat for their ability to increase yield and quality.

Balancing logistic ease with complex crop rotations by implementing small plot research

A diverse team of experts collaborated on a four-year research project to evaluate yield and yield stability, NUE and net economic returns of six crop rotations in the Southern Prairies, Northern Prairies and Red River Valley ecozones of western Canada. Six crop rotations tested in the study were:

- the traditionally recommended rotation in each ecozone
- pulse or oilseed intensified rotation
- a diversified rotation with multiple pulse species and/or winter cereals
- a market driven rotation based on crop types selected for their high commodity prices
- a high-risk rotation
- a soil health rotation.

Results and discussion

Balancing NUE, GHG emissions and farm economics

The Fast et al. 2023 study found that N source affected grain yield in the Dark Brown soils only. Here, the dual-inhibitor treatment increased grain yield relative to urea and polymer-coated urea. However, on the Black Chernozem and Dark Grey Luvisol soils, there was no improvement in yield or grain quality with the EEFs compared to untreated urea.

The use of a dual-inhibitor resulted in higher net returns ($62 CAD/ha) than urea in the Dark Brown soils (Figure 1). However, on the other soil types, there was no economic incentive for grain growers to use an EEF product.

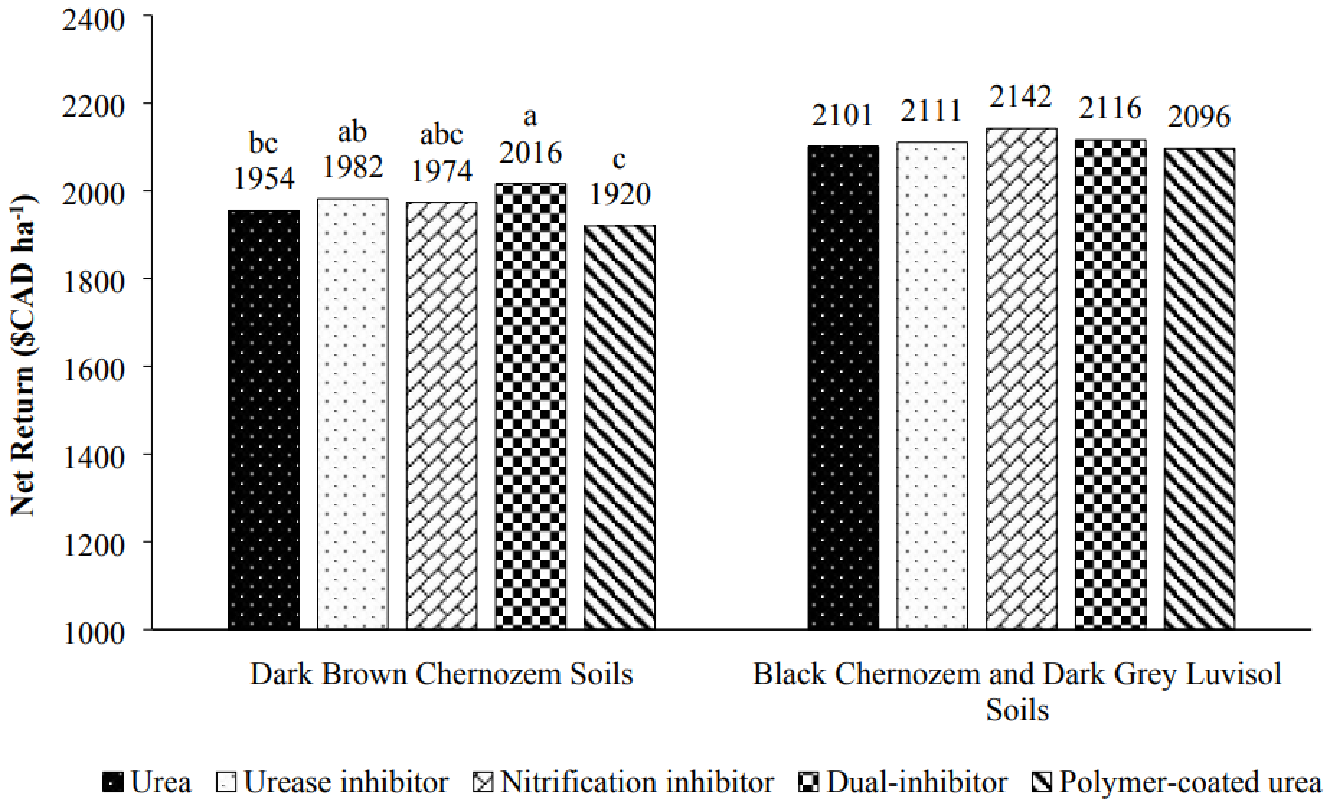

Figure 1. Net return response to N source in both Dark Brown Chernozem and Black Chernozem (combined) with Dark Grey Luvisol Soils. Values are least square means. Different letters above means indicate significant differences between N sources at $p \leq 0.05$. Source: Fast et al. 2023.

The lack of yield response to the EEFs in the Black Chernozems and Dark Grey Luvisols may be attributed to the use of N fertiliser best management practices. For example, the foundational agronomic practices of N application at the 'Right TIME' and the 'Right PLACE' are thought to be mitigating the benefits of the 'Right SOURCE' on these two soil types.

Sorting out the truth of 'quick-fixes'

At all four on-farm testing locations, there was no statistical difference in yield or quality parameters when Utrisha-N™ and Envita® *foliar* N fixing bacteria treatments were applied under these trial conditions, compared with the check (Table 1). In comparison, advertisements to growers cite a 2.2bu/ac (0.12mt/ha) yield increase, which occurs 67% of the time (based on data from 12 responsive field trials in 2021). When assessing the likelihood of an economic response, growers need to proceed cautiously, as the company advertised revenue from the 0.12mt/ha of increased grain sales (based on spring wheat at $364 CAD/mt) is $43.68 CAD but the product sells for approximately $16 CAD/ac ($39.54 CAD/ha). Given that there is also an application cost, it is very challenging for this practice to be profitable, especially when this yield increase cannot be counted on annually.

Table 1: Spring wheat yields in response to N fixing biologicals, from Alberta Grain's four on-farm testing locations in 2022.

	Spring Wheat Yield (t/ha)			
Treatment	**Irrigated** **Dark Brown Chernozem**	**Dark Brown Chernozem**	**Black Chernozem**	**Dark Gray Chernozem**
Control	5.65 a	2.48 a	4.64 a	6.61 a
Biological Product 1	5.58 a	2.52 a	4.80 a	6.62 a
Biological Product 2	5.53 a	2.51 a	n/a	6.58 a
p-**value**	0.6023	0.7954	0.3709	0.5481
CV%	3.88%	4.99%	4.54%	1.13%

Within each site, yields followed by the same letter are not significantly different based on a Tukey mean separation at p=0.05.

On-farm implementation of more diverse rotations

In the Northern Prairies, the higher net returns often associated with the market driven rotation are attributed to the high frequency of canola in the rotation and the high canola crop prices. This market driven rotation often has canola being grown in three of four years, which is an agronomically risky practice due to the long-term impacts of canola disease build up in short rotations. The soil health rotation consistently has some of the lowest net returns, due to the lack of yield in the green manure year of the rotation resulting in no saleable grain in one of four years.

Table 2: Net economic returns of the crop rotation treatments at the four locations in the Northern Prairies ecozones of the Canadian Prairies.

	Net Economic Returns (CAD/ha)			
Rotation Treatment	**Beaverlodge**	**Lacombe**	**Scott**	**Melfort**
Control	$40.11 ab	$264.65 bc	$60.34 b	$175.32 a
Intensified	-$72.65 bc	$297.02 b	-$52.44 c	$163.51 a
Diversified	$141.79 a	$283.78 b	-$76.31 c	$155.90 a
Market Driven	$46.04 ab	$577.56 a	$270.73 a	-$7.76 b
High Risk	$55.60 ab	$264.70 bc	-$47.44 c	$18.83 b
Soil Health	-$125.01 c	$132.65 c	-$81.62 c	$32.91 b

Within each site, net economic returns followed by different letters are significantly different based on a Tukey mean separation at p=0.05. Adapted from: Strydhorst and Liu, 2023.

When assessing trends from all site-years, the intensified rotation (POS) had relatively high yields combined with a low CV, giving it some of the most consistent yields over time and growing environments (Figure 2).

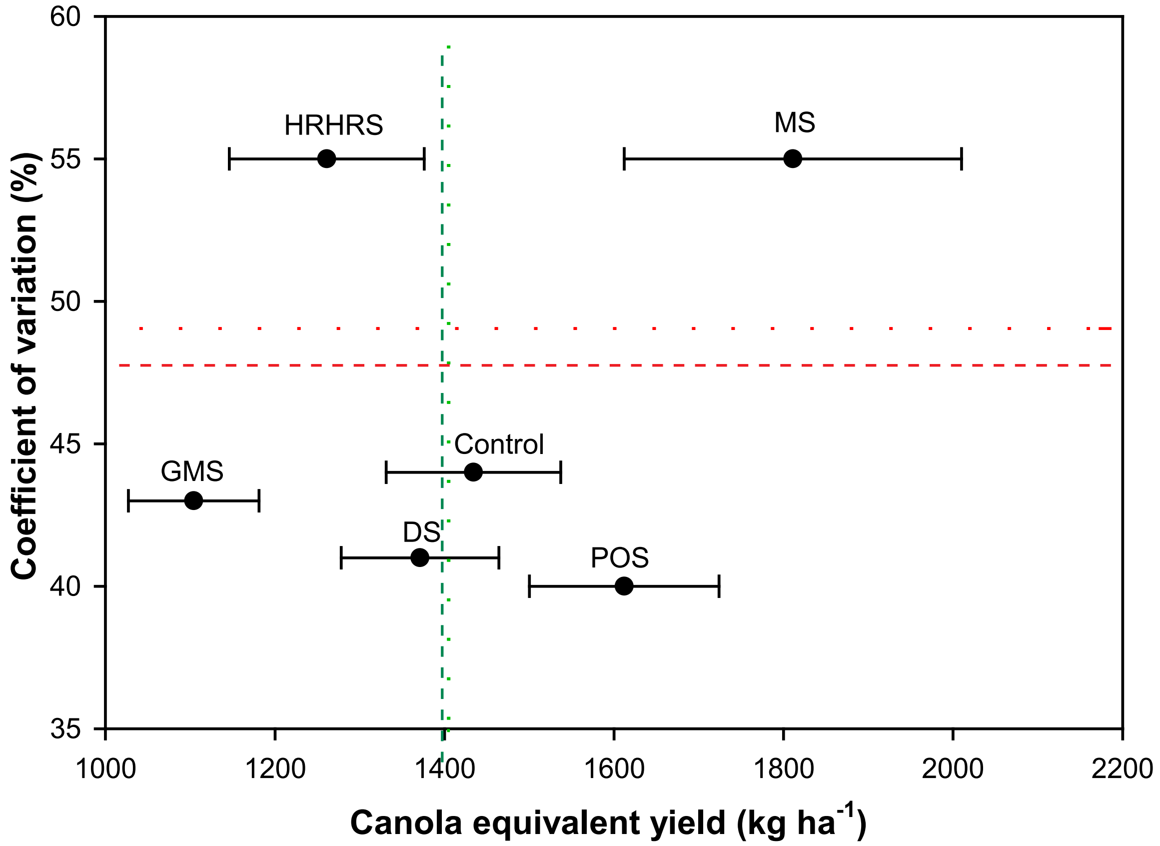

Figure 2. Yield stability of the crop rotation treatments over 27 site years. The horizontal black bars represent the standard error of the mean. The vertical dashed line indicates the Canola Equivalent Yield averaged across all six crop rotation treatments: Control; POS, Pulse- or Oilseed- Intensified System; DS, Diversified System; MS, Market Driven System; HRHRS, High Risk System; and GMS, Green-Manure, Soil Health System. The horizonal dashed line is the average CV across all six crop rotations. Adapted from: Strydhorst and Liu, 2023.

If a grower has been adhering to a wheat-canola rotation across all their fields (i.e. 2023ha farm with 31 fields), grain growers need to give serious thought to taking a small step beyond their comfort level and diversify their rotations. This could take the form of a wheat-barley-canola rotation on one of the 31 fields. Then, the following year, a feasible goal would be to introduce a pea-wheat-canola rotation on a second field. The idea is not to become overwhelmed by the changes but to gradually incorporate them into the routine. Diversity can be achieved by gradually adding winter cereals, pulse crops and other cereal species. Over time, the small steps accumulate and lead to a more diversified rotation across the entire farm.

Conclusion

- When foundational best management practices are used, such as 'Right TIME' and 'Right PLACE', the benefits from Right 'SOURCE', such as EEFs, might be limited on some soil types. Grower adoption of EEFs will depend on profitability.
- Caution must be used when deciding to apply products which are not 'tried and true', and profitability may not be guaranteed. On-farm testing is a platform to assess product profitability when third-party independent research is lacking.
- While the benefits of more diverse crop rotations have been documented in research studies, the operational logistics and the lack of rotations with better net returns make it challenging for growers to diversify their rotations. However, grain growers should consider slowly implementing more diverse rotations on a small portion of their farms. This will allow them to capture some of the yield stability and long-term system health benefits.
- While foundational agronomic practices take more time, planning, and knowledge, they present growers with the opportunity to harvest some low hanging fruit while maintaining yields and profitability.

Acknowledgements

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Notes

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ANALYTICAL SERVICES

Strategies to improve crop establishment and yield on repellent sandy soils after amelioration

Melissa Fraser[1], Jack Desbiolles[2], Amanda Pearce[3] and Nigel Wilhelm[3].

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GRDC project code: MFM2106-001RTX

Keywords

- amelioration, crop establishment, sandy soil, water repellence.

Take home messages

- Crop establishment can be improved following amelioration by adequately consolidating the seed-bed pre-sowing, which reduces seeder sinkage and excessive soil throw.
- Combining seed broadcasting with in-row seeding in vulnerable paddock zones can increase early ground cover and reduce in-crop wind erosion risks.
- When amelioration of water repellence is successful, sowing rates can be reduced, with seed cost-savings and no penalty to grain yield, providing adequate nutrition is supplied to meet the new crop potential.
- Despite successful amelioration of constraints (clay spreading, delving, spading), crop yields are rarely consistent across different soil types, both spatially and temporally, hence zone-based approaches to soil sampling and in-crop nutrition are still needed to achieve potential yields in different soil types.

Background

Sandy soils that have been deep tilled to eliminate water repellence often have soft seedbeds, face high wind erosion risks and have diluted or re-distributed nutrients through the profile. These consequences of amelioration can hinder crop establishment in the first year and limit grain yield and quality in subsequent years.

A paddock scale trial at Coomandook in the Upper Southeast of South Australia was set up on a water repellent sandy soil to test responses to different deep tillage types and seeding strategies. Results presented here outline the impact of treatments on barley crop establishment in the same year as amelioration (2022), and agronomic strategies to enhance canola yield in the second year (2023).

Data are also presented for two sites at Sherwood, also in the Upper SE. The first site sought to quantify the new yield potential in different paddock zones after amelioration (clay spread deep sand versus delved heavy flat) and to identify economically viable agronomic strategies to 'close the yield gap' in each zone. This site was established in 2022 and monitored for a second year in 2023 to measure legacy effects of different nutrient packages. The second site was set up in 2023 and sought to build on 2022 results by further exploring nitrogen demand and attainable yields in two paddock zones.

Method

Coomandook year 1

Two tillage-based soil amelioration treatments were contrasted against an unmodified control: topsoil inversion to 350mm depth (Plozza Plow, conducted on the day of sowing; the soil was at field capacity following rain); or chisel ploughing to 550mm depth with topsoil dilution from sublayer lifting (Bednar Terraland, conducted in dry soil 10 weeks prior to sowing, including 5 weeks of surface consolidation via grazing). Treatments were applied in strips 24m wide and 850m long, separated by controls; both tillage strips were rolled just before sowing using a 1.5m diameter straight-rib roller.

Commodus[⊕] barley (medium coleoptile length) was sown on 22nd June 2022 at 73kg/ha using the following techniques.

- Furrow seeding: John Deere 1870 Conserva-Pak (30cm row spacing) operated at 8.5km/h, set for 3cm seeding depth in the control area and kept the same across the ripped/ploughed strips to monitor their impact.
- Seed broadcast: An additional 50kg/ha of seed was broadcast pre-seeding to 20m x 12m subplots over both tillage strips in an exposed section of a deep sandy rise. The broadcast seeds were then incorporated by the seeder during the sowing pass.

Sowing depth and crop establishment were recorded for both rear and front seeder rows (replicated x 3). Grain yield was measured using a plot harvester for each tillage type (replicated x 3).

Coomandook year 2

A small plot trial was sown across the Plozza, control and Bednar strips on 9 May 2023 in a semi-randomised split plot design, replicated three times. Three sowing rates of 44Y94CL canola (162 200 seeds/kg) were used: 1.6kg/ha, 2.8kg/ha and 4.0kg/ha, targeting plant populations of 20, 35 and 50 plants/m2 respectively, assuming 96% germination and 80% field emergence. Two nutrition strategies were applied to split plots: baseline nutrition, reflecting district practice (target yield of 1.8t/ha) and improved nutrition that was designed to accommodate the economic water limited yield potential of 2.3t/ha (Table 1), a target supported by pre-sowing soil test data.

Table 1: Nutrition treatments applied at Coomandook in canola in 2023. Nitrogen (N) was supplied as urea at three different timings, phosphorus (P) as MAP, potassium (K) as muriate of potash and copper (Cu) as fluid copper sulphate, banded below the seed. Note, sulphur (S) was supplied across the whole site pre-sowing as gypsum (800kg/ha = 100–110kg/ha of S).

Treatment	N kg/ha				P	K	Cu
	Sowing	1–4 leaf	Early stem elongation	Total	kg/ha	kg/ha	kg/ha
Baseline	8	40	46	94	16.4	10	0
Improved	30	80	40	150	16.4	15	1

Sherwood a, 2022 and 2023

Two identical small plot trials were sown across a delved flat and clay spread hill that had both been spaded in 2020. Nutrition treatments were designed to reflect district practice or to accommodate the economic water limited yield potential of 3.9t/ha (Table 2).

Table 2: Nutrition treatments applied to wheat at Sherwood in 2022.

Treatment		Nutrients supplied (kg/ha) from fertiliser				
#	Name	N	P	K	S	Cu
T1	Nil fertiliser	0	0	0	0	2
T2	District practice	100	18	0	11	2
T3	T2 + N	200	18	0	11	2
T4	T2 + P	100	27	0	11	2
T5	T2 + K	100	18	20	11	2
T6	T2 + N + P + K shallow	200	27	20	11	2
T7	T2 + N + P + K deep	200	27	20	11	2

Nutrients were supplied in either of two positions: banded with and below the seed (shallow); or banded with, below the seed and at 15–20cm (deep). Scepter[⊕] wheat was sown on 24 May 2022 and the trials were oversown with 44Y94CL canola on 26 May 2023. In 2023, all plots received the same nutrient package to test the legacy effects of 2022 fertiliser additions.

Sherwood b, 2023

Two identical small plot trials were sown across a delved flat and clay spread sandhill that had both been spaded in 2021. Nitrogen rates of 0kg/ha, 50kg/ha, 75kg/ha, 100kg/ha, 125kg/ha, 150kg/ha and 200kg/ha were tested, along with a treatment allowing for starting soil N and K status, supplying 75kg N/ha and 20kg K/ha on the delved flat, and

125kg N/ha and 20 kg K/ha on the clay spread hill. The trials were sown to RockStar⍉ wheat on 26 May 2023.

Results and discussion

Crop establishment after amelioration at Coomandook, 2022

Average sowing depth in the control was 50mm (Table 3) and the crop established at 120 plants/m2 (71% of seed sown; Table 4). The seeder front rows were 9mm deeper than the rear rows due to soil throw. Under the Bednar Terraland treatment, which was consolidated by grazing prior to sowing, the sowing depth was similar (59mm), with no impact on crop establishment. Conversely, under the Plozza disc treatment, which still had a soft seedbed post-rolling, the sowing depth was strongly affected by seeder sinkage and excessive soil throw. The greatest impacts were measured on the seeder front rows (+94mm), leading to a reduction in plant population (-19 plants/m2). Even more plant losses would be expected if a shorter coleoptile variety and pre-emergence herbicides had been used.

Table 3: Barley seeding depth (mm) at Coomandook in 2022 by treatment and seeder row position.

Seeder row position	Unmodified control		Plozza		Bednar	
	mean	s.e.	mean	s.e.	mean	s.e.
Rear row	45.3	4.2	78.4	7.8	52.7	6.0
Front row	54.1	6.4	148.0	13.0	65.3	8.4
Average depth	**50**	**5.3**	**113**	**10.4**	**59**	**7.2**

Seed broadcasting combined with seeder sowing added an extra 41 plants/m2 on the Bednar plots (Table 4) and an extra 34 plants/m2 in Plozza plots and displayed greater protection during a high wind event in August that caused substantial drift damage in surrounding areas.

Table 4: Year 1 barley crop establishment (plants/m2) at Coomandook.

Seeder sowing	Unmodified control		Plozza		Bednar	
	mean	s.e.	mean	s.e.	mean	s.e.
Rear row p/m2	113	4.9	115	6.2	113	9.6
Front row p/m2	127	5.7	108	6.2	140	4.4
Average p/m2	**120**	**5.3**	**112**	**6.2**	**126**	**7.0**
% seed rate	71%	-	66%	-	74%	-
Combined seeder + broadcast sowing						
Mean row p/m2	-	-	123	5.8	121	3.1
Inter row p/m2	-	-	23	3.3	46	2.7
Average p/m2	-	-	146	4.6	167	2.9

Optimised year 2 agronomy at Coomandook

Treating water repellence at Coomandook via inversion or chisel ploughing in 2022 resulted in average canola plant populations of 18 plants/m^2, 32 plants/m^2 and 56 plants/m^2 in 2023, for the low, medium and high sowing rates respectively (Figure 1), achieving 72%, 73% and 90% field establishment. In contrast, the unmodified control only achieved 34–40% field establishment, with populations of 9 plants/m^2, 18 plants/m^2 and 25 plants/m^2 for the low, medium and high sowing rates respectively. Even with the highest sowing rate of 4kg/ha, the target plant population of 35 plants/m^2 was not achieved and produced only 1.43t/ha of grain with district practice agronomy, improving to 1.73t/ha of grain with extra N and K applied (Figure 2).

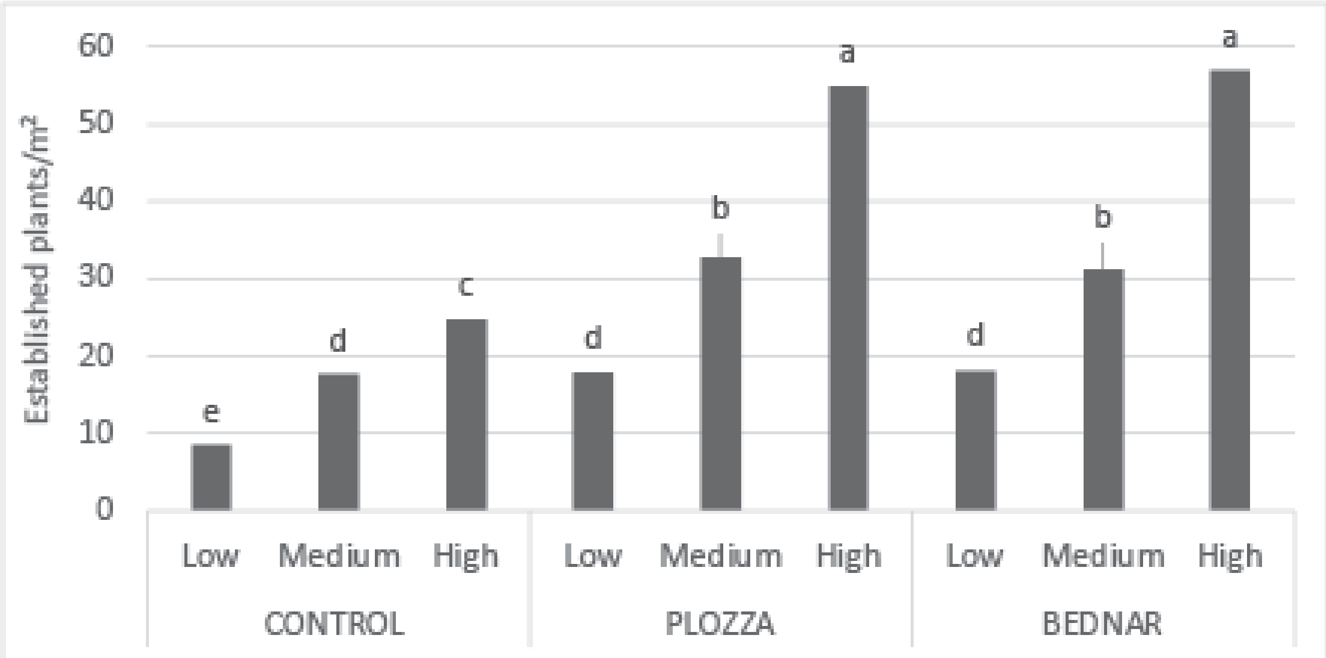

Figure 1. Canola crop establishment at Coomandook in 2023 for each tillage type and sowing rate (low=1.6kg/ha, medium=2.8kg/ha, high=4kg/ha), showing higher sowing rates are needed to achieve the target plant population (dashed line) when water repellence is present (control). Letters denote significance (p<0.001, Lsd=6.2).

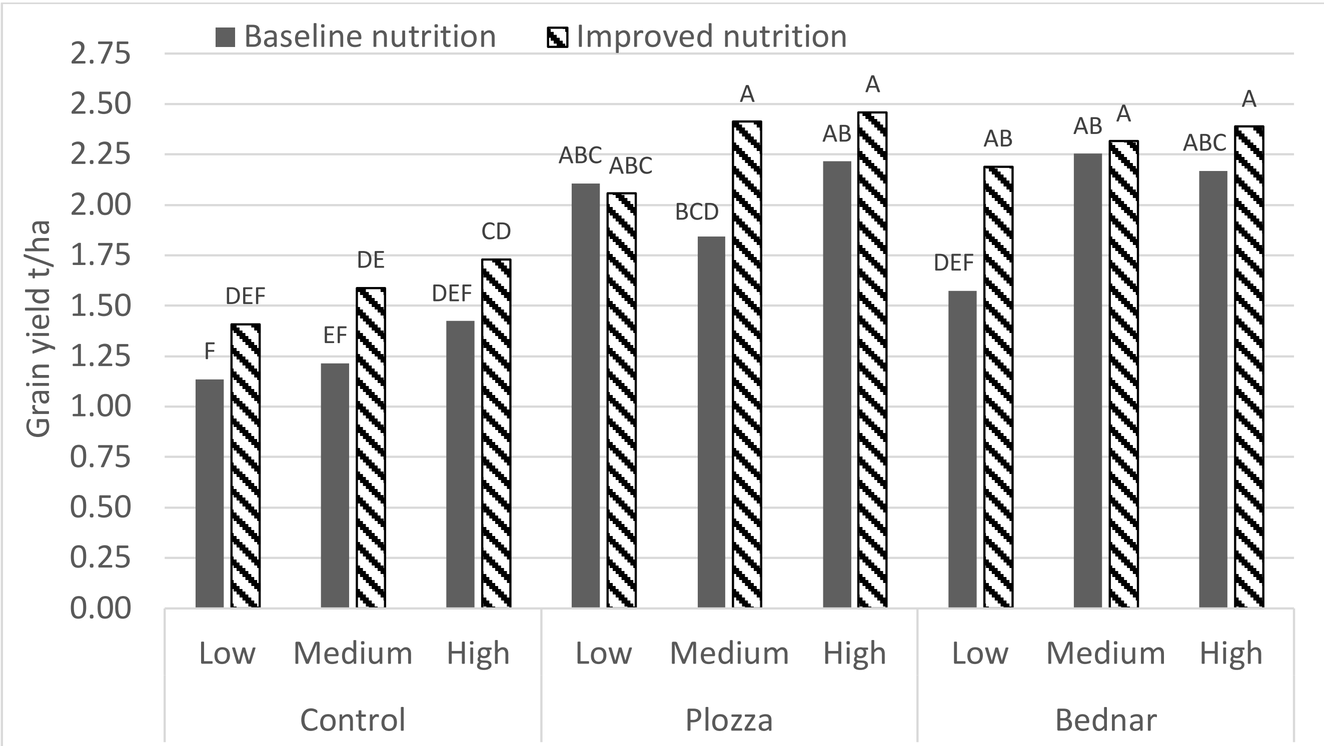

Figure 2. Canola grain yield at Coomandook in 2023 for each tillage type, sowing rate (low, medium and high, as per Fig. 1) and nutrition strategy (solid columns = baseline nutrition, N@93kg/ha; dashed columns = improved nutrition, N@150kg/ha). Letters denote significance (p<0.05, Lsd=0.40).

The improved nutrition treatments performed the most consistently across the Plozza and Bednar treatments, yielding 2.3t/ha on average (0.3t/ha above the district practice at 2.0t/ha; Figure 2). There was no benefit to increasing the sowing rate >2.8kg/ha. These results show that sowing rates can be substantially reduced when water repellence is treated and that yields can be improved, even with plant populations <20/m2. At $35/kg for the latest hybrid seeds, lower seeding rates can deliver substantial savings.

Nutrition response – Sherwood a 2022 and 2023

Nitrogen was the major driver of wheat yield responses to nutrition additions in 2022, achieving an average of 4.5t/ha on the delved flat and 3.9t/

ha on the clay spread hill for all treatments that contained 200kg N/ha, more than 1.3t/ha better than the district practice treatment (3.1t/ha and 2.6t/ha respectively; Table 5). Canola yields in 2023 were also consistently improved by the extra N applied in 2022, achieving 3.9t/ha and 3.2t/ha, more than 1t/ha better than district practice. There was no response to extra P or K fertiliser in either location.

Table 5: Wheat (2022) and canola (2023) yields (t/ha) at Sherwood, showing higher yields on the delved flat than on the clay spread hill in both years. A different letter in the Lsd group indicates a significant difference between treatments.

	Delved flat				Clay spread hill			
	Wheat 2022		Canola 2023		Wheat 2022		Canola 2023	
Treatment	Yield	Lsd group	Yield	Lsd group	Yield	Lsd group	Yield	Lsd group
Nil fertiliser	1.62	a	0.88	a	1.17	a	0.98	a
District practice	3.12	b	2.61	b	2.87	b	2.19	b
T2 + N	4.36	c	3.73	c	3.78	c	3.17	d
T2 + P	3.49	b	2.85	b	3.01	b	2.52	c
T2 + K	3.03	b	3.16	bc	2.98	b	2.49	c
T2 + N + P + K shallow	4.62	c	3.66	c	3.94	c	3.21	d
T2 + N + P + K deep	4.37	c	3.65	c	3.86	c	3.23	d
P Value	<.001	-	<.001	-	<.001	-	<.001	-
Lsd (0.05)	0.55	-	0.73	-	0.32	-	0.27	-

Nitrogen response – Sherwood b 2023

Wheat at Sherwood in 2023 yielded 4t/ha on the delved flat and 1.7t/ha on the clay spread hill with no N fertiliser applied, following beans in 2022 (Figure 3). The crop on the hill suffered severe moisture stress in late spring and no N response was recorded. Down on the flat however, yields were improved by >0.5t/ha with the addition of 100kg N/ha and maximised at 125kg/ha, resulting in improved grain quality via higher protein (Table 6). Although screenings were elevated, particularly for N rates >150kg/ha, all N treatments achieved a grade of AUH2. There was no benefit to grain yield by applying more than 125kg N/ha, but the data presented above (Sherwood a) show that residual N may benefit subsequent crops.

Results from these trials confirm that yields can be improved by matching N additions to water limited yield potential and starting soil chemistry, but that yield gaps still exist between different soil types/zones both spatially and temporally, even after amelioration. Adopting strategic zone-based soil sampling and variable rate fertiliser technology is the next step to enhance grain yields and optimise economic returns after amelioration.

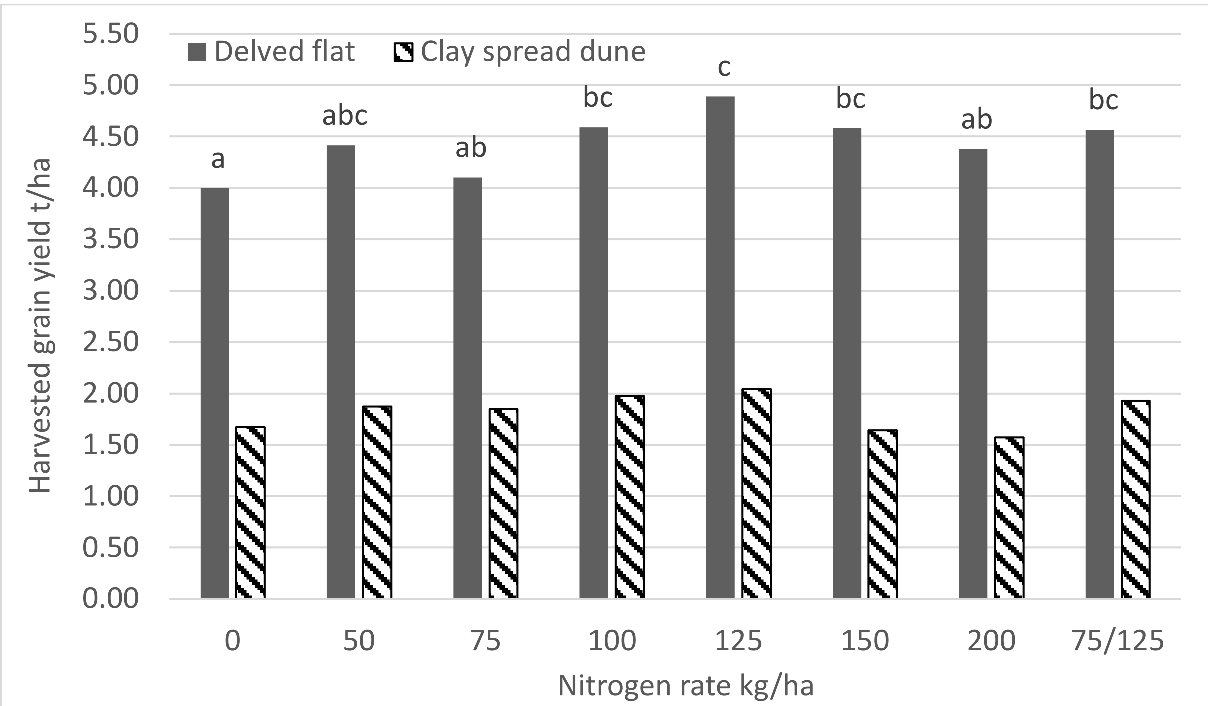

Figure 3. Wheat grain yield (t/ha) at Sherwood in 2023 in response to increasing rates of nitrogen fertiliser. Solid columns = delved flat; dashed columns = clay spread dune (not significant). Letters denote significance (p<0.05, Lsd=0.5).

Table 6: Grain quality at Sherwood in 2023 for different nitrogen (N) application rates.

Treatment kg N/ha	Test Weight kg/hl	Protein		Screenings		Receival grade
		%	Lsd group	%	Lsd group	
0	77.03	11.3	a	6.0	a	**AGP1**
50	77.48	12.7	b	8.6	bc	**AUH2**
75	77.52	13.0	bc	7.3	ab	**AUH2**
100	76.79	13.3	bcd	7.4	ab	**AUH2**
125	77.65	13.7	cd	7.9	abc	**AUH2**
150	76.64	13.7	cd	8.9	bc	**AUH2**
200	77.26	13.9	d	9.3	c	**AUH2**
75N + 20 K	77.79	13.1	bc	7.5	abc	**AUH2**
P Value	0.338	<.001	-	0.045	-	**-**
Lsd (0.05)	NS	0.8	-	1.9	-	**-**

Conclusion

Crop establishment can be improved following amelioration by adequately consolidating the seed-bed pre-sowing, which reduces seeder sinkage and excessive soil throw. Combining seed broadcasting with in-row seeding in vulnerable paddock zones can increase early ground cover and reduce in-crop wind erosion risks. Options to 'spade and sow' in one pass or broadcast seeds pre-spading also exist to minimise soil erosion risks and these techniques have been shown in other projects (CSP1606-008RMX) to achieve uniform crop establishment where there is moisture within the soil profile.

When amelioration of water repellence is successful, sowing rates can be reduced, with substantive seed cost savings and no penalty to grain yield, providing adequate nutrition is supplied to meet the new crop potential. Nitrogen has proven to be the major driver of yield responses after amelioration.

Despite successful amelioration of constraints (clay spreading, delving, spading), attainable yields are rarely consistent across different paddock zones, both spatially and temporally, hence zone-based approaches to soil sampling and in-crop nutrition are still needed to achieve potential yields in different soil types and topography.

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Notes

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Emerging strategies for managing pulse foliar disease

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Keywords

- ascochyta pathotype, botrytis, disease management, sclerotinia.

Take home messages

- Foliar disease in pulses was infrequently reported in 2023, likely due to the dry spring. Foliar fungicides were likely unnecessary unless disease was observed, as most pulse foliar diseases require high humidity or recurring rain events.
- The first step to good disease management is choosing a resistant variety.
- Integrated disease management (IDM) practices also serve to minimise the risk of fungicide resistance developing.
- Sclerotinia disease in pulses was rare in 2023. However, severe Sclerotinia was reported in canola crops, reflecting a legacy effect of soil inoculum in paddocks sown to pulses in 2022.
- There were early reports of Botrytis disease in lentil and faba bean in July 2023. This is due to high inoculum load from 2022, coupled with above average June rainfall. Disease did not progress in the dry spring.
- Manage lentil varieties for Ascochyta blight based on pathotype 2 (Hurricane-virulent) ratings, as this pathotype is dominant in South Australia. A shift away from pathotype 1 (Nipper-virulent) towards dual pathotype 1 and 2 virulence has occurred.

Integrated disease management

To reduce the risk of foliar pulse disease and the risk of fungicide resistance developing, implement as many of the following practices each season.

- Maintain a 3–4-year gap between crops of the same type in the same paddock to reduce disease carryover from stubble and soil.
- Sow disease-resistant varieties to help reduce disease and the number of fungicide applications required.
- Sow clean seed or apply seed treatments to protect emerging seedlings. Seed and soil testing before sowing helps informs growers of disease risk.
- Avoid sowing near the previous year's pulse crop, including neighbour's stubble, to avoid infection by stubble-borne diseases.
- Monitor early for disease, especially near neighbouring stubble, in over-sown areas of the paddock and under trees or powerlines.
- Plan your foliar fungicide strategy early. Always mix and rotate fungicide groups, avoid consecutive use of the same group, and adhere to label restrictions. Spray ahead of rain, if disease is present.
- A pre-canopy closure spray will protect the base of the plant before the canopy closes over. Podding sprays may be required to protect the developing grain.
- Consider economics of continued disease management and crop end use (withholding periods, minimum residue levels).

For information on minimising the risk of fungicide resistance, including workshops, podcasts and the fungicide resistance management guide, visit the Australian Fungicide Resistance Extension Network (AFREN) at afren.com.au.

Disease ratings for pulse varieties are reviewed annually in the National Variety Trial (NVT) disease ratings review. This is usually finalised by early March and updated ratings are available from nvt.grdc.com.au/nvt-disease-ratings.

Sclerotinia white mould in pulses

Sclerotinia white mould (SWM) poses an increasing threat in southern Australian grain growing regions. SWM is caused by the soilborne fungus, *Sclerotinia* spp., and produces durable survival structures (sclerotia) that survive in the soil for many years, creating a legacy effect for future pulse or canola crops. High sclerotia populations can lead to basal stem infection and seedling death. Symptoms include bleaching or cottony white fungal growth on and in foliage, stems, pods and grain, and flowers are susceptible. Sclerotia on/in plant foliage can contaminate harvested grain, acting as a future inoculum source if the grain is not screened.

Prevalence of SWM in 2022 vs 2023

The 2022 season was highly conducive for SWM and several lentil paddocks were severely affected in SA (Blake et al. 2023) and Vic (Fanning 2023), whereas SWM was sporadically reported in 2023 likely due to the drier conditions and decile 1/2 rainfall (BOM). Surveys of lentil crops conducted in SA in spring revealed disease incidence in four of six paddocks of 88–95% in 2022 (Blake et al. 2023), compared to disease incidence in four of five paddocks of 2–9% in 2023. In Victoria during 2022, 60% of paddocks had Sclerotinia with a greater proportion in the Mallee compared to the Wimmera. Despite a high risk moving into 2023, no Sclerotinia was observed in the paddock surveys due to environmental conditions. The legacy effect of SWM in lentil in SA was also shown through reports of severe Sclerotinia stem rot in canola in 2023 that occurred in paddocks sown to lentil in 2022.

Lentil trials examining yield loss, agronomic factors and varietal response to SWM

In 2023 at Long Plains in SA, trials were conducted to examine the yield loss from SWM in different lentil varieties (Table 1) and under different crop canopies manipulated by two times of sowing (Table 2). This site was selected as it had a high level of soil inoculum and high disease severity in 2022 (Blake et al. 2023). A low level of SWM symptoms were rated in the trials on 26 September 2023. Grain yield of lentil varieties was poorly correlated with their disease severity (R^2=0.203); however, higher grain yield was achieved at the earlier time of sowing despite the higher level of disease symptoms. These trials will be repeated in 2024 in anticipation of more conducive environmental conditions for SWM disease at the site.

Table 1: Grain yield (t/ha) and SWM disease severity (% of wilted plants per plot) of lentil varieties at Long Plains SA in 2023. Least significant difference of means (5% level) shown for each variable.

Variety	Grain yield (t/ha)	% wilted plants/plot
PBA HighlandXT⦶	2.46 a	24.17 b
PBA Hallmark XT⦶	2.40 a	15.00 c
GIA Lightning⦶	2.35 a	25.00 b
PBA Hurricane XT⦶	2.20 b	34.17 a
GIA Leader⦶	2.08 bc	27.50 ab
PBA KelpieXT⦶	1.96 c	24.17 b
p	<.001	0.008
Lsd (5%)	0.1462	9.0

Table 2: Grain yield (t/ha) and SWM disease severity (% of wilted plants per plot) of PBA Hurricane XT⦶ at two times of sowing at Long Plains SA in 2023. Least significant difference of means (5% level) shown for each variable.

Time of Sowing	Grain Yield (t/ha)	% wilted plants/plot
TOS1 - 2 May	2.27 a	32.22 a
TOS2 - 5 June	1.93 b	0.33 b
p	0.042	0.003
Lsd (5%)	0.305	13.24

In 2022 at Wagga Wagga, NSW, a lentil variety trial was conducted to assess yield loss from SWM and a high level of SWM developed. Unfortunately, continued wet weather through spring compromised results. Yields were highest in the Complete Control (fortnightly fungicide) treatments, but this was not always significant and yield response to a single foliar fungicide application at canopy closure did not always increase yields over the Nil treatment (Table 3). Plant infection was lowest in the Complete Control treatment, but there were no significant differences between the Nil and Canopy Closure treatments (Table 4). A single application of foliar fungicide at canopy closure did not provide adequate periods of protection under conditions of prolonged disease pressure. Interestingly, total sclerotia weight was highest in the Complete Control treatment, likely due to the retention of green leaf within the canopy (Table 5).

Table 3: Effect of foliar fungicide treatment to manage Sclerotinia disease (SWM) on grain yield averaged across five lentil varieties sown at Wagga Wagga, NSW 2022.

Treatment	Grain weight (t/ha)	SE	Test 5% Lsd
CANOPY_CLOSURE	1.44	0.196	A
COMPLETE_CONTROL	2.07	0.196	B
NIL	1.36	0.196	A
SED	0.166		
5% Lsd	0.3294		

Table 4: Effect of foliar fungicide treatment on the incidence of Sclerotinia disease (SWM) (% plants infected along 2m row) averaged across five lentil varieties sown at Wagga Wagga, NSW 2022.

Treatment	% infected per 2m row	SE	Test 5% Lsd
CANOPY_CLOSURE	58.2	3.65	B
COMPLETE_CONTROL	26.3	3.64	A
NIL	57.2	3.64	B
SED	4.024		
5% Lsd	8.127		

Table 5: Effect of fungicide treatment to manage Sclerotinia disease (SWM) on production of sclerotia averaged across five lentil varieties sown at Wagga Wagga, NSW 2022.

Treatment	Sclerotia weight (kg/ha)	SE	Test 5% Lsd
CANOPY_CLOSURE	4.11	0.067	A
COMPLETE_CONTROL	5.44	0.067	B
NIL	3.13	0.067	A
SED	0.566		
5% Lsd	1.12E-01		

Management of SWM in pulses

Crop rotation and careful paddock selection to avoid SWM infection are the most effective control measures. High risk paddocks are those with canola or pulses in the rotation, a history of previous outbreaks of Sclerotinia, and where high growing-season rainfall is forecast. Note that pasture and broadleaf weed species are also hosts. PREDICTA B testing of *Sclerotinia* spp. soil inoculum levels after harvest will inform growers of disease risk. The new GRDC investment (DPI2206-023RTX) is showing that behaviour of Sclerotinia disease in each crop species is unique. The behaviour of SWM in pulses is very different to that in canola and should be managed as such, as the plant to plant spread of the disease, for example, is unique to lentil.

Foliar fungicides will go part way to managing the disease, but basal infections cannot be managed. There are a limited number of fungicides registered for control of Sclerotinia disease in pulse and canola crops. For more information: extensionaus.com.au/FieldCropDiseasesVic/sclerotinia-in-victorian-pulses/

For information on Sclerotinia in canola: grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/07/managing-sclerotinia-stem-rot-of-canola-in-2022

Botrytis disease of lentil and faba bean

Botrytis grey mould (BGM) of lentil and chocolate spot (CS) of faba bean were infrequently reported during 2023 in SA. Early reports of BGM on lentil in SA and Vic in mid-July 2023 following the decile 9/10 rainfall in June (BOM) did not progress in spring, likely due to the dry seasonal conditions.

Botrytis disease is favoured by mild temperatures (15–25°C) and high humidity (>70%). It can also develop slowly in cool conditions, particularly with a high inoculum load, humidity, or a full soil moisture profile. Early sowing or high seeding rates can create a warm humid microclimate under dense canopies, ideal for rapid disease development in spring. In lentils, symptoms start as pale grey to light tan leaf lesions without black spots in the centre. Severe infections may result in easily liberated fluffy grey fungal material when the canopy is parted and eventual crop collapse. Faba beans show initial symptoms as red-brown discrete scattered spots over leaves and flower petals. With severe infection, lesions merge causing rapid defoliation and flower abortion within a few days.

The development of cost-effective IDM strategies for control of Botrytis disease (and Ascochyta blight, AB) of lentil and faba bean is the focus of a new national three-year GRDC investment led by Agriculture Victoria (DJP2304-004RTX; 2023-2026). This will complement validation research being conducted in the SARDI/UoA-led state-wide Grain Legume Validation project (GRDC investment UOA2105-013RTX, 2021-2025). However, due to the dry spring in 2023, Botrytis disease did not develop in these trials at Maitland, Riverton or Tarlee in SA.

Growers are encouraged to implement IDM best practice (see above). Sowing disease resistant varieties helps reduce disease severity and preserve or increase grain yield (Blake et al. 2023;). Ensure that varietal selections are compatible with the disease risk profile, paddock history, local climate, soil type, and agronomic management. Disease risk will be higher in regions where canopy closure is achieved, as often climatic conditions in these regions are more disease conducive.

Managing BGM in lentil with foliar fungicides

Several fungicides are registered for control of BGM in lentil. Newer fungicides with dual modes of action, as well as Filan® and Sumisclex®, show superior disease control and grain yield preservation in a high disease situation (Blake et al. 2023). However, judicious use of fungicides along with cultural practices and crop rotation, is critical to protect the current chemistries.

Two new coformulations (DMI+SDHI and DMI+QoI) of three new active ingredients not currently registered on pulses are anticipated for registration in the next 12–24 months by BASF (I. Francis, *pers. comm*.).

For medium to high rainfall regions, apply a pre-canopy closure spray regardless of the BGM resistance rating. Varieties rated MRMS and less may require additional sprays before rain in high-risk situations every 2–3 weeks. Follow-up sprays may be necessary in MR varieties or during highly conducive disease seasons. A podding spray may also be required to protect the developing grain from both BGM and AB. Always follow label directions. In low rainfall zones, the economic justification for fungicide sprays should consider the likelihood of achieving canopy closure and of ongoing humid conditions that favour the disease. This is particularly important with early sown crops.

In 2023, Agricultural Innovation & Research Eyre Peninsula (AIR EP) and South Australian Grain Industry Trust (SAGIT) co-funded research to examine the effectiveness and economic benefit of different fungicide strategies on lentil in a warm, low rainfall climate with short, mild winters. Trials were conducted at Mount Cooper and Mount Damper on the Eyre Peninsula, however no disease developed as conditions were not conducive. Fungicide spray(s) were uneconomical in a decile 1 rainfall spring in this region.

Managing CS in faba bean with foliar fungicides

PBA Amberley^ϕ^, rated MRMS, is the most resistant faba bean variety to CS but still benefits from foliar fungicide application. Several fungicides are registered or permitted for control of CS in faba bean, however application timing is critical. During 2022, reports of a mistimed spray(s), often due to persistent rain restricting paddock access, were associated with moderate to severe CS, crop lodging, and occasional crop failure. Proactively control CS with early-mid flowering sprays before symptoms appear. Follow-up sprays are needed in high rainfall situations and high biomass crops. Crop areas around trees and under power lines can be CS hot spots if not reached by spray equipment.

Monitoring the lentil Ascochyta blight pathogen population

Annual controlled environment testing of 29 *Ascochyta lentis* isolates collected from SA in 2022 was conducted in 2023 on an expanded lentil differential host set that included alternative sources of resistance to AB (Table 6). This is the second year in a row that no isolates were characterised as pathotype 1 (Nipper-virulent). A shift towards pathotype 2 (Hurricane-virulent), and dual virulent isolates that combine both pathotypes 1 and 2, has occurred (Figure 1). Of the isolates tested, 90% were capable of infecting PBA Hurricane XT$^{\phi}$ which is currently rated MRMS to AB pathotype 2. Twelve of 29 isolates (41%) were capable of infecting PBA HighlandXT$^{\phi}$ and five of 29 (17%) were capable of infecting PBA Jumbo2$^{\phi}$.

Monitor and proactively manage lentil varieties for AB based on the current NVT rating for pathotype 2. If disease occurs, plan to spray before rain, mixing and rotating modes of action. Where AB is present with persistent wet weather before harvest, pod infection may cause seed staining and quality downgrades. Podding sprays may be necessary in a wet spring; always adhere to withholding periods and follow label directions for use.

Table 6: Twenty-nine *Ascochyta lentis* isolates collected in 2022 from SA were inoculated onto a lentil host differential set in controlled environment conditions in 2023. Entries in the table are the number of isolates per category.

Test reaction	Cumra (susceptible check)	Nipper⫯	PBA Hurricane XT⫯	PBA HighlandXT⫯	PBA Jumbo2⫯	AK Mercimek (landrace from Turkey)	ILL2024 (elite breeding line with boron tolerance)	ILL7537 (elite breeding line)
R	3	14	3	17	24	21	6	29
MR	4	9	7	8	4	8	7	0
MRMS	5	5	8	4	1	0	12	0
MS	15	1	10	0	0	0	4	0
S	2	0	1	0	0	0	0	0
Total	29	29	29	29	29	29	29	29

Key: R = resistant, MR = moderately resistant, MRMS - moderately resistant moderately susceptible, MS = moderately susceptible, S = susceptible

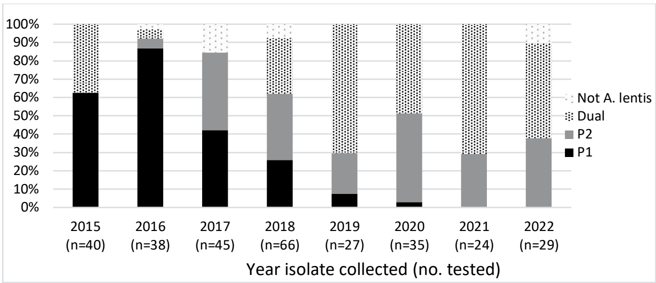

Figure 1. Annual testing of *Ascochyta lentis* isolates (n) collected from 2015 to 2022 from SA and VIC and their pathotype characterisation. Legend: P1 = pathotype 1, Nipper-virulent; P2 = pathotype 2, Hurricane-virulent; dual = combined pathotype 1 and 2; Not *A. lentis* = did not infect susceptible lentil check line.

Diseased samples of Ascochyta blight and Sclerotinia sought

Diseased samples of pulses with AB, and pulses and canola with Sclerotinia, are sought by SARDI for GRDC investments monitoring pathogen populations and changes in varietal resistance. If you can help, please contact Sara Blake (**sara.blake@sa.gov.au**) or Mohsen Khani (**mohsen.khani@sa.gov.au**) for a collection kit that includes sample envelopes and a return Express Post envelope.

Diagnostic plant samples

Send by Express Post to Pulse Pathology Plant Diagnostics SARDI, Locked Bag 100, Glen Osmond, 5064. Dig up whole symptomatic and asymptomatic plants and send with roots wrapped in damp (not wet) paper towel. Send at the beginning of the week, so the parcel does not get held up in the post. Please email PIRSA.SARDIPulsepathology@sa.gov.au to notify the team that the plants are coming.

Crop protection products for pulses

For current registrations including minor use permits, visit Grain Producers Australia (**www.grainproducers.com.au/industry-pesticide-permits**) or APVMA (www.apvma.gov.au).

Acknowledgements

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Fanning J (2023) Pulse disease guide 2023. Agriculture Victoria, March 2023 (https://agriculture.vic.gov.au/__data/assets/pdf_file/0004/847354/VIC-Pulse-disease-guide-2023.pdf)

Resources

Seasonal disease reports – subscribe to SA Crop Watch e-newsletter (bit.ly/CropWatchSA)

2024 South Australian Crop Sowing Guide (bit.ly/2024SASowingGuide)

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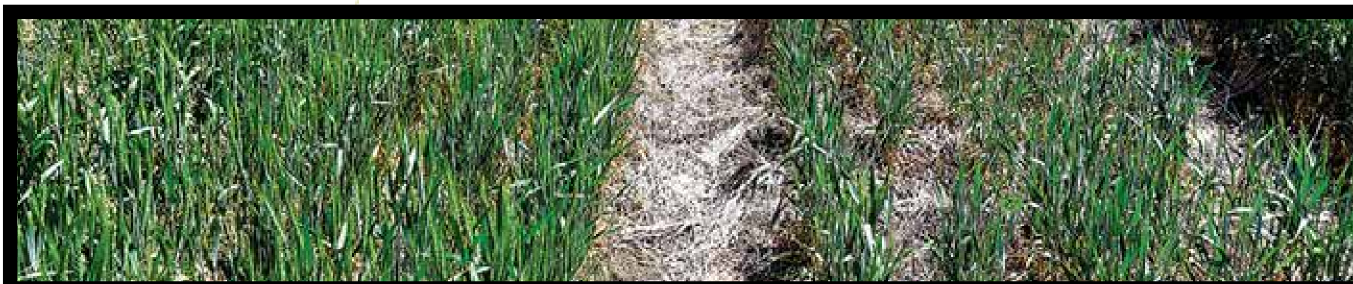
Notes

KNOW BEFORE YOU SOW

PREDICTA® B and PREDICTA® rNod

PREDICTA B DNA Soilborne disease tests

PREDICTA rNod Rhizobia test



Cereal root diseases and poor rhizobia inoculation decisions in grain legumes cost grain growers in excess of $300 million annually in lost production.

PREDICTA® B and PREDICTA® rNod soil testing services and your accredited agronomist can help you to identify before seeding, the soil borne disease risk in cereals, and whether an appropriate rhizobium inoculant should be applied to grain legume crops.

Enquire with your local agronomist or visit http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

PREDICTA® B has tests for most soil-borne diseases of cereals and some pulse crops:

- Crown rot (cereals)
- Rhizoctonia root rot
- Take-all (including oat strain)
- Root lesion nematodes
- Cereal cyst nematode
- Stem nematode
- Blackspot (field peas)
- Yellow leaf spot
- Common root rot
- Pythium clade f
- Charcoal rot
- Ascochyta blight of chickpea
- White grain disorder
- Sclerotinia stem rot

New PREDICTA® rNod has tests for rhizobia:

- Group E and F (lentil, faba bean, pea and vetch)
- Group N (chickpea)
- Groups G and S (lupin and serradella)

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SARDI
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GRAINS RESEARCH & DEVELOPMENT CORPORATION

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Herbicide-resistant ryegrass & future proofing herbicide efficacy

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**Plant Science Consulting P/L*

#School of Agriculture, Food & Wine, University of Adelaide

GRDC project code: UCS00020 and UCS2008-001RTX

Keywords

- Random weed survey, resistance, ryegrass, testing

Take home messages

- Random weed surveys have been undertaken since 1998 to identify the incidence of herbicide resistance across South Australia and the Yorke Peninsula
- Resistance to key MoA herbicides has increased for ryegrass; Group 2 herbicides no longer work (i.e. Hussar® and Intervix®) and resistance to trifluralin is widespread, but fortunately most populations remain susceptible to clethodim (Select®), glyphosate (Group 9) and many of the pre-emergent options (pyroxasulfone (i.e. Sakura®), propyzamide)
- Ryegrass resistant to paraquat and glyphosate has recently been detected from a fence-line
- Using residual herbicides in conjunction with double knocking, spray-topping and cultural practices (i.e. HWSC and crop competition) will continue to be pivotal in the long-term management of ryegrass and resistance
- Commercial testing continues to provide growers and advisors with informed herbicide choices

Ryegrass herbicide resistance on the Yorke Peninsula

The University of Adelaide has conducted annual weed surveys across South Australia and the Yorke Peninsula since 1998 with the financial assistance of GRDC. Originally these surveys were done on a 5-year sampling rotation (i.e. 1998, 2003, 2008, 2013 & 2018) with paddocks randomly sampled approximately every 5-10 km and weed seeds collected of different species prior to harvest. However, the most recent survey commissioned by GRDC in 2020, was done nationally with the entire Southern wheat-belt sampled via coordinated efforts involving UA (University of Adelaide), CSU (Charles Sturt University) and AHRI, UWA (University of Western Australia). A couple of key differences with the new survey approach was that consultants and agronomists were asked to provide grower map files from which paddocks were randomly selected and sampled, and seeds of targeted weed species were sent to 1 of the 3 organisations for testing. For example, UA tested the entire ryegrass and mustard collection, whereas CSU tested wild oats and sowthistle, and UWA brome, barley grass and wild radish.

In total 350 sites were sampled across South Australia in 2020 with 50 sampled from the Yorke Peninsula alone. Testing was done the following winter to key herbicides at recommended label rates with 2 key aims: a) determine the incidence and shifts in resistance to existing chemistry, and b) identify new cases of resistance to recently registered herbicides. The results from the surveys are shown as the percentage of paddocks containing resistant weeds where survival following testing was ≥20% (i.e. obvious failure in the field). Samples with less than 20% survival were classed as developing resistance (1-19% survival).

Table 1. Percentage of paddocks on the Yorke Peninsula containing herbicide resistant ryegrass to post-emergent herbicides. Paddocks were scored as resistant if samples exhibited ≥20% survival. Samples showing 1-19% survival were classed as developing resistance and are shown in parenthesis (). Data shown in bold represents testing results across SA in 2020.

	∇Herbicides					
	Pinoxwaden	Clethodim	Iodosulfuron	Imazamox + Imazapyr	Glyphosate	Paraquat
Year	MoA 1	1	2	2	9	22
1998	-	*	15	-	-	-
2003	36	*	75	-	-	-
2008	59	*	73	44	0	-
2013	65	*	71	83	1	-
2018	68	3	70	73	2	-
2020	74 (20)	11 (20)	93 (7)	76 (18)	0 (20)	0 (0)
South Australia (350 samples)						
2020	**66**	**14**	**85**	**68**	**14**	**0**

*Abbreviation: MoA, mode-of-action; *Tested to old registered field rate of 250 mL/ha*
Herbicides applied at recommended field rates with recommended adjuvants
∇Pinoxaden (Axial®), clethodim (Select 240®), iodosulfuron (Hussar®), imazamox + imazapyr (Intervix®), glyphosate (Wipe-Out Pro®), paraquat (Gramoxone®)

Table 2. Percentage of paddocks on the Yorke Peninsula containing herbicide resistant ryegrass to pre-emergent herbicides. Paddocks were scored as resistant if samples exhibited ≥20% survival. Samples showing 1-19% survival were classed as developing resistance and are shown in parenthesis (). Data shown in bold represents testing resu

	∇Herbicides					
	Trifluralin	Prosulfocarb + S-metolachlor	Pyroxasulfone	Propyzamide	Cinmethylin	Bixlozone
Year	MoA 3	15	15	3	30	13
1998	9	-	-	-	-	-
2003	49	-	-	-	-	-
2008	40	-	-	-	-	-
2013	66	0	0	0	-	-
2018	62	2	0	0	-	-
2020	52 (31)	3 (13)	0 (0)	0 (0)	0 (0)	0 (0)
South Australia (350 samples)						
2020	**38**	**1**	**0**	**0**	**0**	**0**

Abbreviation: MoA, mode-of-action
Herbicides applied at recommended field rates
∇Trifluralin (Treflan®), prosulfocarb + S-metolachlor (Boxer Gold®), pyroxasulfone (Sakura®), propyzamide (Edge®), cinmethylin (Luximax®), bixlozone (Overwatch®)

Resistance to post-emergence herbicides

Resistance in ryegrass was most prevalent for Group 2 sulfonylurea herbicides (i.e. Glean/Oust/Hussar = 93%) and imidazolinone herbicide Intervix (76%). Unfortunately these herbicides are no longer effective on most ryegrass populations on the YP, a consequence of their prolonged use, strong selection pressure, and the common occurrence of the target site mutations that naturally arise giving resistance (i.e. initial gene frequency = 1 in 20,000 plants resistant). The rise in resistance to Intervix is not entirely surprising given the strong adoption of imi-tolerant lentils in the region. Most populations are also resistant to pinoxaden (Axial®)(76%) and therefore most fop herbicides (Hoegrass®, Targa® and Verdict®) belonging to the Group 1 MoA (i.e. ACCase inhibitors) because of cross-resistance. Fortunately, many of these populations remain susceptible to clethodim (Select®) (11% resistance at 500 mL/ha of 240 EC formulation), although an increasing number of samples (20%) are developing resistance. Poor control with clethodim (Select) is often blamed on resistance, however these results still tend to suggest that factors other than resistance (namely cold conditions and growth stage) are contributing to failures in the field. Where resistance has been suspected and samples sent to Plant Science Consulting for testing of recent (2020 to 2023), levels of resistance to clethodim (Select) (41% resistant with 38% developing resistance) and clethodim + butroxydim (Select + Factor®) mixtures (31% resistant with 26% developing resistance) have been much higher (Table 3). If herbicide failures are observed in the field testing should be undertaken to confirm whether the poor control is a result of resistance or conditions at application (i.e. cold temperatures, poor coverage, large growth stage).

Herbicide (Product)	Product rate/ha	Samples tested	% resistant (>20% survival)	% developing R (1-19% survival)
Clethodim (Select 240®)	500mL	29	41	38
Clethodim (Select 240®) + Butroxydim (Factor®)	500mL + 180g	72	31	26
Glyphosate (Wipe-Out Pro®)	1.5L	64	33	28
Glyphosate (Wipe-Out Pro®)	3L	14	29	14
Paraquat (Gramoxone®)	2L	9	0	0
Trifluralin (Treflan®)	1.5L	70	93	6
Trifluralin (Treflan®) + Tri-allate (Avadex® X)	1.5L + 1.6L	65	23	25
Prosulfocarb + S-metolachlor (Boxer Gold®)	2.5L	74	7	20
Pyroxasulfone (Sakura®)	118g	76	0	16
Propyzamide (Edge®)	1L	72	0	0
Carbetamide (Ultro®)	1.7L	51	0	0

Herbicides applied with recommended adjuvants

Despite the random survey not detecting any glyphosate resistance >20% survival, more than 20% of populations were found to be developing resistance (i.e. 1-19% survival; Table 1). Further several samples sent to Plant Science Consulting from the YP have recently been confirmed resistant with more than 33% of samples resistant to 1.5 L glyphosate and as many as 29% of samples resistant to rates as high as 3L/ha. Given that both the random weed survey and commercial testing has failed to detect paraquat resistance (0%), paraquat is an obvious option to combat glyphosate resistance and should be utilised for both double knock strategy and for spray-topping lentils. Note best practice for the double knock approach is glyphosate followed by a robust rate of paraquat 1-5 days later (Figure 1). This approach reduces the selection pressure on paraquat as glyphosate still does most of the "heavy lifting". Mixing with other fast acting herbicides (i.e. Group 14) such as 700 g/kg tiafenacil (Terrad'or®) or (Voraxor®) 250 g/L saflufenacil + 125 g/L trifludimoxazin (Voraxor®) can further reduce the selection pressure on paraquat.

Despite no paraquat resistance being detected in the field, a sample recently submitted for commercial testing from a YP fence-line was confirmed resistant to both paraquat and glyphosate. Over reliance of both herbicides on fence-lines could be the ignition point for dual resistance (glyphosate and paraquat) emerging in the field. Several residual options are now registered for fence-lines (i.e. indaziflam (Alion®), bromacil (Uragan®), flumioxazin (Terrain®)) and should be utilised with contact products.

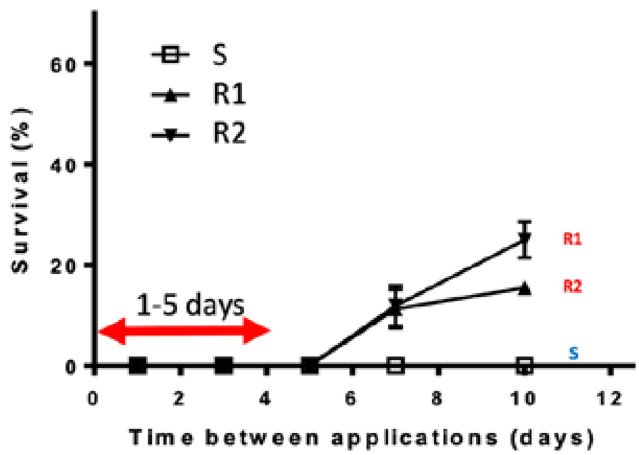

Figure 1. Double knock timing. Glyphosate applied to a susceptible (S) and two glyphosate resistant ryegrass biotypes (R1 and R2) followed by paraquat 1, 3, 5, 7 and 10 days after application. Source Professor Chris Preston (UA).

Resistance to pre-emergence herbicides

Significant resistance to trifluralin was identified both from the random weed survey (52%) and samples submitted for commercial testing (93%) with Plant Science Consulting (Table 3). Low level resistance was also detected for s-metolachlor + prosulfocarb (Boxer Gold) (3% survey; 7% commercial testing). In contrast, no resistance was detected to pyroxasulfone (Sakura) from the random weed survey, and only a handful of samples (16%) sent for testing with Plant Science Consulting identified as developing resistance (Table 3). Despite this, pyroxasulfone (Sakura) should still be rotated or mixed with other herbicides, bixlozone (Overwatch®) is an excellent alternative provided it is used correctly in wheat, canola or barley, and pyroxasulfone (Sakura) mixtures with tri-allate

(Avadex® Xtra) continue to be a cost-effective option. Pyroxasulfone the active ingredient of Sakura has recently come off patent, and consequently several new products (n=40, source APVMA PubCRIS) have been registered for release in the Australian market this season. This will undoubtably result in a significant price decline and therefore potential overuse which may accelerate resistance development. A strong suggestion would be to keep these pyroxasulfone products for use in wheat or at worst limit their use in lentils substituting for pulse options like propyzamide and 900 g/kg carbetamide (Ultro®). Also given the number of pyroxasulfone products soon to be available if you have any uncertainty regarding product quality then stick to the reputable brands. There is no known resistance to propyzamide, and all YP populations tested susceptible to latest pre-emergent chemistry (i.e. bixlozone (Overwatch) and cinmethylin (Luximax®)).

Latest pre-emergent residual mode-of-action (MoA) herbicides

Several new pre-emergent herbicides with diverse mode-of-action have recently been released to the Australian market and provide an effective alternative to old chemistry. These include aclonifen + diflufenican + pyroxasulfone (Mateno Complete®), cinmethylin (Luximax), bixlozone (Overwatch), and carbetamide (Ultro) which collectively have registration for use in a range of crops. Use of these herbicides, particularly in combination with older chemistry such as trifluralin or tri-allate (Avadex), can provide strong control of multiple-resistant ryegrass and other important weed species. include aclonifen + diflufenican + pyroxasulfone (Mateno Complete®) can also be applied in an alternate use pattern with early post-emergent (EPE) timing now registered for both wheat and barley. If used as part of an integrated weed control strategy, these alternative MoA herbicides are likely to reduce selection pressure on any one MoA.

Harvest weed seed control

Harvest weed seed control is an important strategy to destroy weed seeds that are remaining at the end of the season. Surviving plants can comprise of late germinators or resistant survivors that are likely to have accumulated resistance mechanisms and possess higher levels of resistance than the parent plants. Harvest weed seed control is a critical component to WeedSmart big 6 (herbicide and non-herbicide tactics) and should be implemented as a key herbicide resistance management strategy.

Conclusion

Several pre-emergent herbicide options remain to control multiple-resistant ryegrass as identified by recent national random weed survey. There are several factors that can contribute to poor weed control with resistance being only one of them. If poor control arises don't assume its resistance, it could be application related; have the population tested to verify and determine which herbicides are "effective" and which are "not" so that an optimised weed control strategy can be implemented. Also be aware of the strengths and weaknesses of the wheat/lentil rotation for ryegrass management and make the most of any opportunity to reduce seed production (spray-topping and HWSC), often it's the resistant individuals that remain.

Acknowledgements

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December 2023

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Rutherglen, Victoria

Andrew is the managing director and a shareholder of Lilliput Ag, and a director and shareholder of the affiliated Baker Seed Co, a family owned farming and seed-cleaning business. He has served on GRDC's medium rainfall zone Regional Cropping Solutions Network and has held leadership roles with Riverine Plains Inc, Victorian Farmers Federation and the Rutherglen Group of fire brigades.

PRU COOK, DEPUTY CHAIR

Dimboola, Victoria

Raised on a mixed farm in Victoria's Wimmera region, Pru has spent her professional career working in extension for the grains industry. Starting her career at the DPI, she has worked at GRDC and the Birchip Cropping Group, managing a number of extension projects. She has recently started her own business specialising in extension, project development and project management.

TIM MCCLELLAND

Birchip, Victoria

Tim farms with his wife, father and aunt on a 6500-hectare mixed property in the southern Mallee. After completing his Bachelor of Agriculture and Commerce at the University of Melbourne in 2006, he took on work at Advisor Edge, Birchip Cropping Group (BCG) and RMCG. In 2011, he moved back to Birchip to become formally involved in the family farm and continue his role with BCG.

RUTH SOMMERVILLE

Burra, South Australia

Ruth is an agroecologist who runs a consulting business. She has a Bachelor of Science in Ecology and Master of Applied Science in Wildlife Management from the University of Sydney, and has worked in sustainable agriculture research, development and extension and property management since 2002. Ruth has been the Upper North Farming Systems Group executive officer and project manager since 2013.

ANDREW WARE

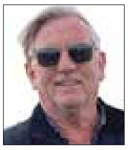
Port Lincoln, South Australia

Andrew is a research agronomist who started his career with the South Australian Research and Development Institute (SARDI) and then spent time at CSIRO in Adelaide. This was followed by 10 years away from research, managing the family farm on the Lower Eyre Peninsula, before returning to SARDI. In 2019, he started his own research company, EPAG Research, delivering applied research across the Eyre Peninsula.

MICHAEL TRELOAR

Cummins, South Australia

Michael is a third-generation grain grower who produces wheat, barley, canola, beans, lupins and lentils on a range of soil types. He has been involved in a number of research organisations, including the South Australian Grain Industry Trust (of which he was chair for four years), the Lower Eyre Agricultural Development Association and the South Australian No-Till Farmers Association (both of which he has been a board member).



NEIL FISHER

Adelaide, South Australia

Neil's family grain farming legacy dates back to 1889, giving him an extensive understanding of the challenges faced by grain growers in SA and Victoria across the Mallee, Wimmera and Riverina regions. With his wife Jenny, he retains a cropping/grazing property at Bordertown, producing wheat, canola, barley, beans and hay. He has held chief executive and board roles in organisations including Sugar Research Australia, Grains Council of Australia, Grape and Wine Research and Development Corporation and Plant Health Australia. Neil has previously worked for GRDC managing a large portfolio of research projects.

PETER DAMEN

Kindred, Tasmania

Peter is a grower from north-western Tasmania with more than 10 years' experience growing and processing commercial grain crops. He holds a degree in agricultural science from the University of Tasmania. Peter has production, research and development experience in quinoa, oats, buckwheat, spelt, hemp, adzuki beans, wheat, barley, ryegrass and more. He is working at Tas Stockfeed, focusing on technical support, sales and grain procurement and processing. In 2017, he was recognised as the Young Farmer of the Year.

DR KATHY OPHEL-KELLER

Adelaide, South Australia

Kathy is a strategic science leader with a strong track record in developing and leading national research programs with industry co-investment, including GRDC. Her own research background is in plant biosecurity and molecular detection of plant pathogens and she has a strong interest in capacity building and succession planning. Kathy is a former acting executive director of SARDI and a research director at Crop Sciences, covering applied research on plant biosecurity, crop improvement, climate risk management, water use efficiency and crop agronomy.

DR PATRICIA FLYNN

Douglas, Victoria

Patricia is a grower in the southern Wimmera, Vic. She holds a Bachelor of Science (Honours) from the University of Western Australia and a PhD from the Australian National University. Her expertise lies in farming systems research with a specific interest in soils management and farm business profitability. Patricia is the financial manager of a family mixed cropping and Merino sheep enterprise – Kwangaloo Pastoral. She held research and development positions at the WA Department of Agriculture, CSIRO, and what was the Department of Primary Industries in Victoria.

CRAIG BAILLIE

GRDC Executive Manager

Craig Baillie is GRDC's general manager of applied research, development and extension. He has oversight of research areas including sustainable cropping systems (agronomy and soils) and crop protection (pests, weeds and diseases). He also has responsibility for GRDC's grower and stakeholder engagement at a national level.

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Stories include seasonally and regionally relevant information on topics ranging from advances in plant breeding and biotechnology, new varieties and agronomic best practice, through to harvest and on-farm grain storage.
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LOOK AROUND YOU.

1 in 5 people in rural Australia are currently experiencing mental health issues.

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

The GRDC supports the mental wellbeing of Australian grain growers and their communities. Are you ok? If you or someone you know is experiencing mental health issues call *beyondblue* or Lifeline for 24/7 crisis support.

beyondblue
1300 22 46 36
www.beyondblue.org.au

beyondblue
Depression. Anxiety.

Lifeline
13 11 14
www.lifeline.org.au

Lifeline
13 11 14

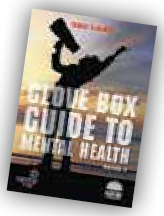
Looking for information on mental wellbeing? Information and support resources are available through:

www.ifarmwell.com.au An online toolkit specifically tailored to help growers cope with challenges, particularly things beyond their control (such as weather), and get the most out of every day.

www.blackdoginstitute.org.au The Black Dog Institute is a medical research institute that focuses on the identification, prevention and treatment of mental illness. Its website aims to lead you through the logical steps in seeking help for mood disorders, such as depression and bipolar disorder, and to provide you with information, resources and assessment tools.

www.crrmh.com.au The Centre for Rural & Remote Mental Health (CRRMH) provides leadership in rural and remote mental-health research, working closely with rural communities and partners to provide evidence-based service design, delivery and education.

Glove Box Guide to Mental Health
The *Glove Box Guide to Mental Health* includes stories, tips, and information about services to help connect rural communities and encourage conversations about mental health. Available online from CRRMH.



www.rrmh.com.au Rural & Remote Mental Health run workshops and training through its Rural Minds program, which is designed to raise mental health awareness and confidence, grow understanding and ensure information is embedded into agricultural and farming communities.

www.cores.org.au CORES™ (Community Response to Eliminating Suicide) is a community-based program that educates members of a local community on how to intervene when they encounter a person they believe may be suicidal.

www.headsup.org.au Heads Up is all about giving individuals and businesses tools to create more mentally healthy workplaces. Heads Up provides a wide range of resources, information and advice for individuals and organisations – designed to offer simple, practical and, importantly, achievable guidance. You can also create an action plan that is tailored for your business.

www.farmerhealth.org.au The National Centre for Farmer Health provides leadership to improve the health, wellbeing and safety of farm workers, their families and communities across Australia and serves to increase knowledge transfer between farmers, medical professionals, academics and students.

www.ruralhealth.org.au The National Rural Health Alliance produces a range of communication materials, including fact sheets and infographics, media releases and its flagship magazine *Partyline*.

ifarmwell growing farmers' wellbeing | Black Dog Institute | Centre for Rural & Remote Mental Health | CORES™
Rural & Remote Mental Health | Heads up Better mental health in the workplace | National Centre for Farmer Health | National Rural Health Alliance Ltd

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WE LOVE TO GET YOUR FEEDBACK

Choose your preferred way to give feedback:

- access the digital form by scanning the QR code below
- leave feedback as you go - click 'Next' to save responses before exiting the survey.
- fill out the hardcopy survey overleaf. Tear out the pages and leave at the rego desk at the end of the event.

2024 Maitland GRDC Grains Research Update Feedback

Name

ORM and/or GRDC has permission to follow me up in regards to post event outcomes.

1. **Industry role?** *(choose one only)*

- ❑ Grower
- ❑ Agronomic adviser
- ❑ Farm business adviser
- ❑ Financial adviser
- ❑ Communications/extension
- ❑ Grain marketing
- ❑ Farm input/service provider
- ❑ Banking
- ❑ Accountant
- ❑ Researcher
- ❑ Student
- ❑ Other* (please specify)

Your feedback

Please rate each presentation you attended in terms of relevance and quality

(10 = totally satisfactory, 0 = totally unsatisfactory).

2. **Canadian Farming Systems – building farm resilience.** ***Sheri Strydhorst***

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

3. **Strategies for post amelioration sowing and crop establishment on sandy soils.** ***Mel Fraser***

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

4. **The market and agronomic challenges of carbendazim usage. Panel of industry Experts**

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

5. **Emerging strategies for managing pulse foliar disease.** ***Sara Blake***

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

6. **Future proofing herbicide efficacy.** ***Sam Kleeman***

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

Your next steps

7. Please describe at least one new strategy you will undertake as a result of attending this Update event

8. What are the first steps you will take?

e.g. seek further information from a presenter, consider a new resource, talk to my network, start a trial in my business

Your feedback on the Update

9. This Update has increased my awareness and knowledge of the latest in grains research

Strongly agree	Agree	Neither agree nor Disagree	Disagree	Strongly disagree
❑	❑	❑	❑	❑

10. Do you have any comments or suggestions to improve the GRDC Update events?

GRDC Grains Research Update MAITLAND

Acknowledgements

We would like to thank those who have contributed to the successful staging of the Maitland GRDC Grains Research Update:

- The local GRDC Grains Research Update planning committee that includes growers, advisers and GRDC representatives.

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GRAINS RESEARCH
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