VICTORIA CROP TECHNOLOGY CENTRE

FAR AUSTRALIA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

FIELD DAY

INCREASING PRODUCTIVITY IN THE HRZ OF VICTORIA

Thursday 27th October 2022

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The GRDC Hyper Yielding Crops project is led by FAR Australia in collaboration with:

MFMG, Stirlings to Coast Farmers, FAR Australia, Riverine Plains, SFS, Department of Primary Industries and Regional Development, CSIRO, CeRDI, Federation University Australia, BRILLAG Agronomy & Research, TechCrop

Victoria CTC trial site courtesy of: Ewen Peel

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- Practice social distancing:
  - Keep a distance of 1.5 metres between you and other people.
  - Avoid crowds and large public gatherings.
  - Avoid shaking hands or any other physical contact.

Thank you for your cooperation.

INCREASING PRODUCTIVITY IN THE VICTORIA HRZ

FEATURING THE GRDC'S HYPER YIELDING CROPS AND PULSE AGRONOMY PROJECTS

On behalf of our investor, the **Grains Research & Development Corporation** along with the associated project teams, I am delighted to welcome you to our 2022 Victoria Crop Technology Centre Field Day featuring Hyper Yielding Crops (HYC) and Pulse Agronomy projects.

To make the programme as diverse as possible, I would like to thank all our speakers who have helped to put today's programme together; in particular, our keynote speaker Prof. James Hunt who joins us today from the University of Melbourne.

Finally I would like to thank the GRDC for investing in these research programmes. Also a big thanks to Ewen Peel, our host farmer for his tremendous practical support given to the team and to today's Keynote speaker sponsor SeedForce, our lunch sponsor Western Ag and event sponsor AGF Seeds – please support them in supporting us.

Should you require any assistance throughout the day, please don't hesitate to contact a FAR Australia staff member. We hope you find the day informative, and as a result, take away new ideas which can be implemented in your own farming business.

Nick Poole
Managing Director
FAR Australia

Hyper Yielding Crops

Hyper Yielding Crops (HYC) builds on the success of the GRDC's four-year Hyper Yielding Cereals Project in Tasmania which attracted a great deal of interest from mainland HRZ regions. The project demonstrated that increases in productivity could be achieved through sowing the right cultivars, at the right time and with effective implementation of appropriately tailored management strategies. The popularity of this project highlighted the need to advance a similar initiative nationally which would strive to push crop yield boundaries in high yield potential grain growing environments.

With input from national and international cereal breeders, growers, advisers and the wider industry, this project is working towards setting record yield targets as aspirational goals for growers of wheat, barley and canola.

In addition to the research centres, the project also includes a series of focus farms and innovative grower networks, which are geared to road-test the findings of experimental plot trials in paddock-scale trials. This is where in the extension phase of the project we are hoping to get you, the grower and adviser involved.

HYC project officers in each state (Ashley Amourgis of Southern Farming Systems here in Victoria) are working with innovative grower networks to set up paddock strip trials on growers' properties with assistance from the national extension lead Jon Midwood.

Another component of the research project is the HYC awards program. The awards aim to benchmark the yield performance of growers' wheat paddocks and, ultimately, identify the agronomic management practices that help achieve high yields in variable on-farm conditions across the country. This season, HYC project officers are seeking nominations for 50 wheat paddocks nationwide (about 10 paddocks per state) as part of the awards program.

For more details on the project contact:

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Rohan Brill – HYC canola research lead, Brill Ag
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Jon Midwood - HYC extension coordinator, TechCrop
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Ashley Amourgis – HYC Project Officer, Southern Farming Systems
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Pulse Agronomy

A Grains Research & Development Corporation (GRDC) Investment across eastern Australia aims to close the economic gap in grain legume production. Victoria is led by Agriculture Victoria (Jason Brand), South Australia by SARDI (Penny Roberts), and Brill Ag (Rohan Brill) in NSW along with other regional partners including FAR Australia across all states at spoke sites focusing on Faba Beans.

Faba bean is the most dominant pulse in this region. The key point about Faba Beans is that they are not limited in yield potential. For example, if every flower on every faba bean plant produced a pod, and every pod produced between 2 – 3 seeds their yield potential would far exceed that of the 10t/ha of wheat and barley. The explanation for this has not been fully explored in the higher production regions but we believe aspirational yields exceeding 8t/ha should be possible in Faba Beans.

For more details on this project contact:

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Hyper Yielding Crops: Victoria

Scan the QR code to download the 2021 results

Victoria (Gnarwarre) Crop Technology Centre 2022 Climate Update

Growing Season Rainfall to date

The current 2022 rainfall at Winchelsea has been tracking below average with long term trends up until October, unlike much of the wheat belt north. However recent rainfall over the past week has significantly increased rainfall totals. Up until the start of October the April – October rainfall was 277 mm compared to long term median of 306 mm for the same time period. This is still less than the 2016 season which was renowned for being the wettest season on record.

Long-term growing season rainfall and yield potential

The long-term median rainfall for Winchelsea from April – November is 355 mm of rain. Using a French and Schulz equation, assuming 60mm is lost to evaporation, and incorporating 25% of fallow rainfall as water supply, and a water use efficiency of 25kg/ha/mm in cereals a yield potential of > 8 t/ha should be possible in more than 50% of years. However, this assumes other climate factors light and temperature are non-limiting.

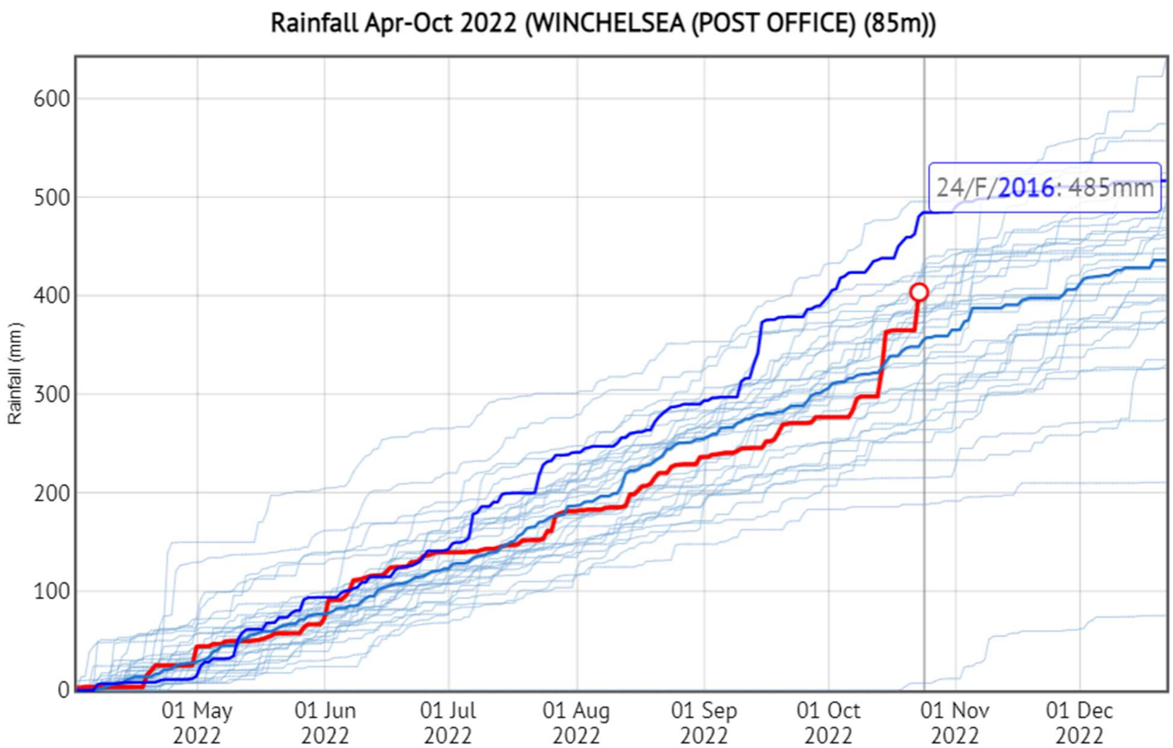

Figure 1. Long term rainfall (mm) trends for Winchelsea in the period from Apr – Dec. The dark line represents the **long-term median,** and red line the 2022 season tracking relative to other seasons light blue deciles. 2016 is highlighted. (DATA Source: Australian CLIMATE online 2022).

Solar Radiation and Temperature (figures 1 and 2)

In parts of the high rainfall zone solar radiation and temperature during the critical period (20 Sep – 20 Oct) are the limiting factors to yield more often than water supply. This was a defining feature of 2021, with temperature consistent or slightly warmer than long term trends, however solar radiation lower than average leading to reduced photosynthesis and grain number potential. As of Oct 1 in 2022 temperatures are consistent with long term trends, however solar radiation is significantly lower in 2022 see paper discussing this.

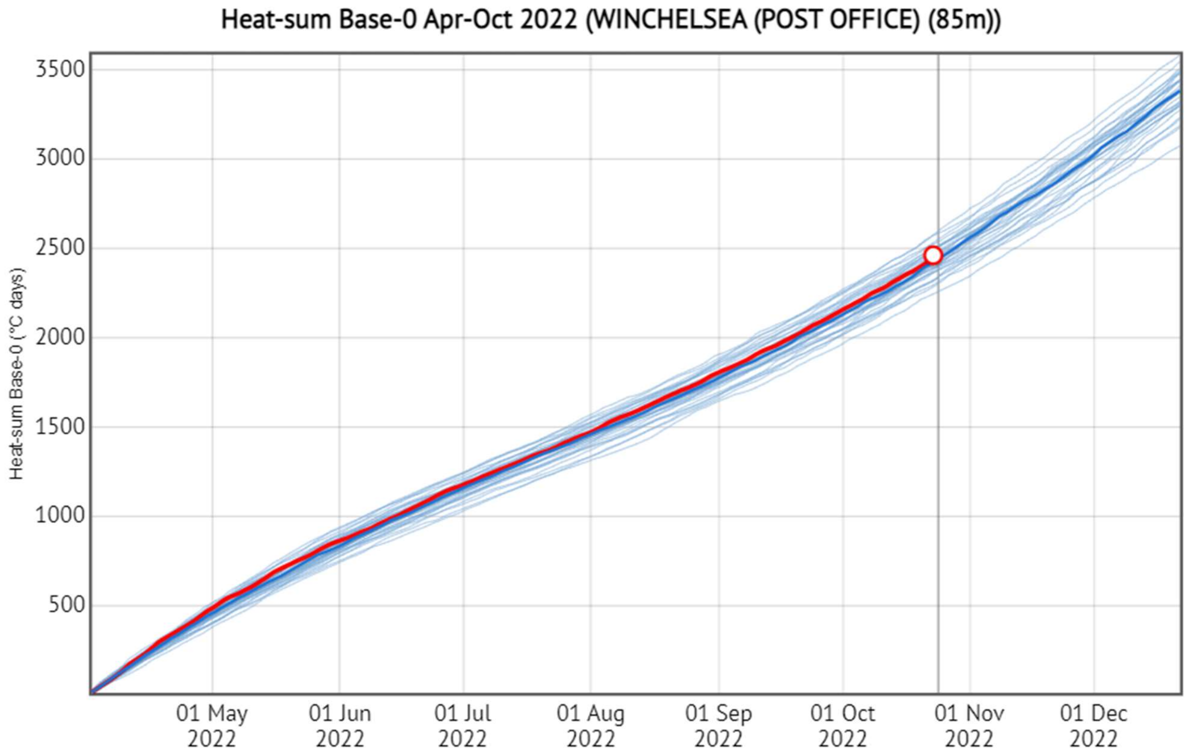

Figure 2. Long term **accumulated temperature** trends for Winchelsea in the period from Apr – Nov. The dark line represents the **long-term median,** and red line the 2022 season tracking relative to other seasons light blue deciles. (DATA Source: Australian CLIMATE online 2022).

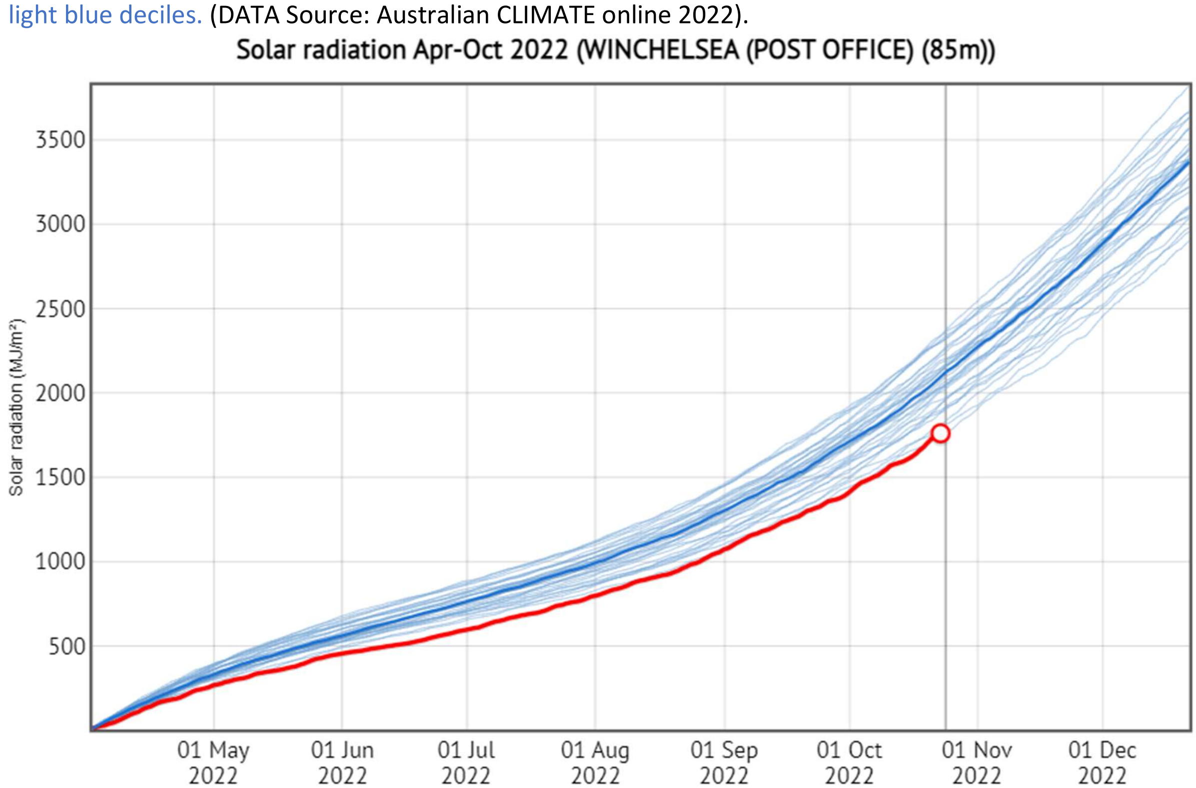

Figure 3. Long term **accumulated Solar Radiation** trends for Winchelsea in the period from Apr – Nov. The dark line represents the **long-term median,** and red line the 2022 season tracking relative to other seasons light blue deciles. 2021 is marked for comparison (DATA Source: Australian CLIMATE online 2022).

Hyper Yielding Canola – more than just urea and fungicide

Rohan Brill, Brill Ag

Key Points

- 2020 and 2021 Hyper Yielding Canola trials have shown that yield potential can be raised through increased attention to nutrient management and variety choice.
- At Hyper Yielding Canola sites in four states in 2021, canola yield was improved where animal manure (chicken or pig) was applied. This response was observed where 225 kg/ha N and >30 kg/ha P was applied.
- At Gnarwarre in 2021, the extra nutrition in pig manure increased yield in both winter and spring canola (0.6 and 0.8 t/ha respectively).
- 2022 trials will provide a better understanding of the reasons for the manure response and if the response can be replicated with the application of inorganic nutrition alone.
- 45Y28 RR was the highest yielding variety in the spring Genotype * Environment * Management (GEM) trial with a yield (averaged across treatments) of 4.7 t/ha. Hyola Feast CL yielded 4.3 t/ha in the winter GEM trial.
- Where an Intensive fungicide protection program (seed treatment plus foliar fungicides at 4-leaf, 20% bloom and 50% bloom) was used, grain yield increased by 0.8 t/ha in 45Y28 RR compared to nil fungicide. The best value single application was at the 20-30% bloom stage with a benefit of ~0.4 t/ha.

Importance of nutrition for Hyper Yielding Canola

The aim of the canola component of the Hyper Yielding Crops project is to determine management practices that achieve 5 t/ha canola grain yield in high yield potential environments. Nitrogen management has been prioritised as one management strategy that is important for canola yield. At Gnarwarre in 2021, nitrogen response plateaued at a rate of 150 kg/ha of applied N, with a yield benefit of 0.9 t/ha compared to nil N. There was no response to N in the winter canola trial. Over and above N and P application (225 kg/ha N and 35 kg/ha P) there was a response to the application of pig manure at 6.7 t/ha. This supplied 169 kg/ha N and 85 kg/ha P and increased yield by 0.8 t/ha and 0.5 t/ha in the spring and winter canola nutrition trials, respectively. Animal manure may not be readily available and/or the cost may be prohibitive, so 2022 trials are looking further into the reasons for the response to manure. The trials will determine if a similar response can be achieved by matching the nutrition supplied in manure with inorganic inputs. Is it a matter of simply increasing the NPK inputs to match or is there a benefit from manure beyond just the nutrient content? Does the manure increase nutrient supply when it is most required, i.e., through the crop critical period?

The positive response from manure application was mirrored at all four HYC Canola sites in 2021, including:

- Millicent, SA (pig manure)
- Wallendbeen, NSW (chicken litter)
- Kojonup, WA (chicken manure)

There was a range in yield response from 0.5 t/ha at Wallendbeen to 0.8 t/ha at Gnarwarre and Kojonup.

Variety Choice 2021

Once nutrition is optimised, a variety needs to be chosen that will capitalise on the investment in soil fertility. In a Genotype * Environment * Management (GEM) Trial at Gnarwarre in 2021 the standout for grain yield was 45Y28 RR, being at least 0.6 t/ha higher yielding than all other varieties (Table 1). In a nearby variety screen trial, 45Y95 CL yielded 5.5 t/ha. It has been included in the 2022 HYC YieldMax Trials along with Hyola Blazer TT which also performed well in the variety screen trials.

45Y28 RR had 14.3 t/ha of biomass at maturity, which was 3 t/ha above the TT varieties included in 2021. As well high biomass it had a high harvest index with 34% of biomass at maturity being grain.

In the nearby Winter GEM trial, Hyola Feast CL yielded 4.3 t/ha.

Table 1. *Yield of spring canola varieties at four national HYC canola sites in 2021.*

	Gnawarre Vic	**Kojonup WA**	**Millicent SA**	**Wallendbeen NSW**
ATR Wahoo	3.5	1.8	3.3	3.6
HyTTec Trifecta	3.9	2.7	4.4	5.2
45Y95 CL	*	*	6.4	6.4
45Y93 CL	*	*	5.7	5.6
45Y28 RR	4.5	2.9	5.1	4.9
Condor XT	3.9	3.4	5.1	5.2
l.s.d. (p<0.05)	0.21	0.13	0.34	0.36

YieldMax Trial 2022

The YieldMax Trial has been included in 2022 which gives an opportunity to evaluate the best varieties with a strong nutrition package. The nutrition treatments include:

- High Input – 40 kg/ha P, 225 kg/ha N + Chicken Manure
- Low Input – 15 kg/ha P, 150 kg/ha N.

And the varieties include:

- Triazine Tolerant
  - Hyola Blazer TT
  - HyTTec Trifecta
- Clearfield
  - 45Y93 CL
  - 45Y95 CL

- Glyphosate Tolerant
    - Nuseed Condor TF
    - 45Y28 RR

HYC Canola Disease Management

With large biomass canola crops in high yield potential environments, it might be expected that growers would need to increase fungicide inputs to protect crops from disease. However, across the project in 2021 the yield response to fungicide (difference between Intensive and Nil fungicide program) ranged from nil in four (of seven) trials to 0.9 t/ha in a trial at Wallendbeen in 45Y28 RR canola (Figure 3). Intensive fungicide program included Saltro Duo on seed, Prosaro at 4-leaf stage, Aviator Xpro at 20% bloom stage and a follow up Prosaro at 50% bloom stage. The single best value fungicide application in 2021 (across the project area) was the use of an SDHI product (e.g. Aviator Xpro, Miravis Star) at 20-30% bloom stage. There was an overall benefit of 0.8 t/ha for the Intensive versus nil fungicide treatments at Gnarwarre in 2021, and like other sites the best value single fungicide was a foliar application at 20-30% bloom stage.

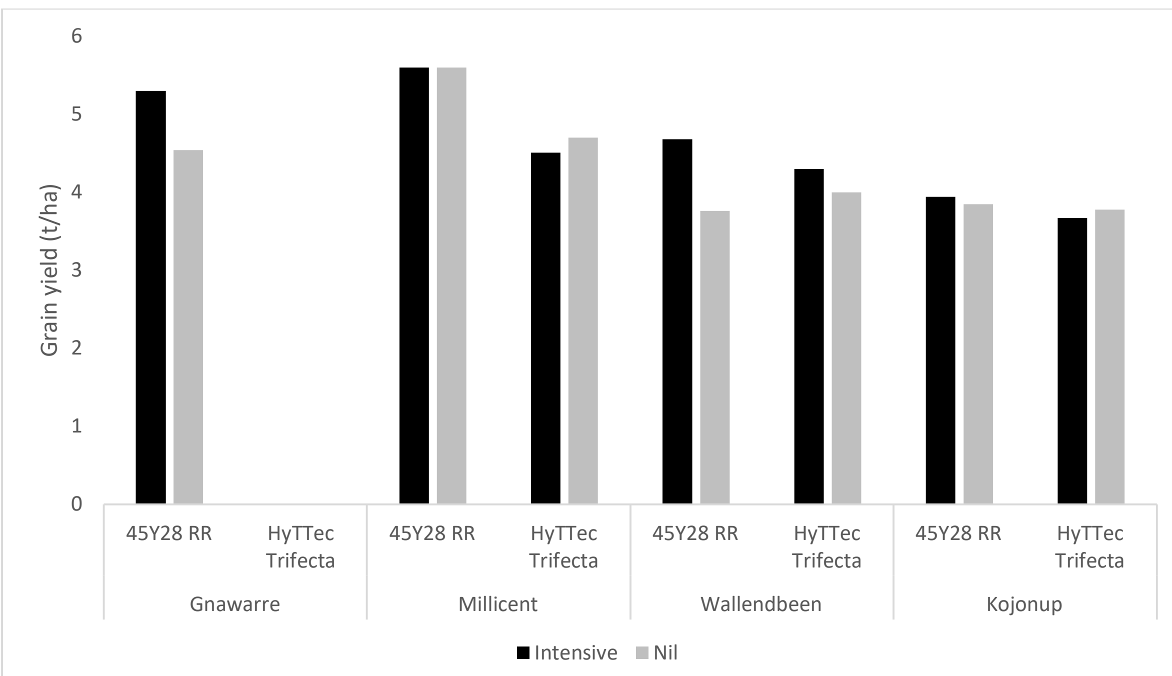

***Figure 1**: Effect of fungicide program (Intensive versus Nil) on grain yield of 45Y28 RR at Gnarwarre, Millicent and Wallendbeen and on HyTTec Trifecta at Millicent and Wallendbeen in 2021.*

Hyper yielding canola results

Full results from 2021 are available at https://faraustralia.com.au/wp-content/uploads/2022/04/HYC-2021-Results-FINAL.pdf. Results from 2022 will also be made available through the FAR Australia website and various other channels such as through social media and GRDC Updates.

Hyper-yields need hyper-fertility

Prof. James Hunt - University of Melbourne

To achieve hyper-yields, grain crops need hyper-performing soils. A key attribute of hyper-performing soils is their fertility, or their ability to retain and cycle nutrients and make them available to crops. Nitrogen (N) is the nutrient required in the greatest amount by crops and is often the major limit to grain yield in Australia and will be the focus of this discussion.

Soil is the most important source of N to crops

On average, grain crops derive only 30-40% of their N requirement from fertiliser applied during their life cycle, with the majority being taken up from the soil. Soil sources of N are thus the most important source of N to a crop, and include mineral N accumulated prior to sowing, and N that mineralises from soil organic matter while the crop is growing.

In any given year, it is difficult to compensate for poor soil N fertility (low mineral N and soil organic matter) with high rates of N fertiliser because it is difficult to get more than 30-40% of total crop N uptake as fertiliser into a crop. To support high yields, it is essential that soil N fertility is maintained.

How can N fertility be maintained?

N fertility in cropping systems is maintained by ensuring that N inputs either equal or exceed N outputs in grain and losses. That is, the cropping system needs to have a neutral or positive N balance. If system N balances are consistently negative, N in soil organic matter is mined, and the ability of the soil to provide mineral N to crops (and yield) declines.

In continuous cropping systems, N fertility can only be maintained by inclusion of grain or forage legumes in the crop rotation and/or addition of sufficient N fertiliser or manure to compensate for N exported in grain or lost to the environment. Only ~50% of applied fertiliser (and less of manure) is used by crops in the year of application, and the remainder is either carried over in the soil as mineral N, immobilised into soil organic matter or lost to the environment through stubble burning, volatilisation, run-off, leaching or denitrification.

Cropping systems with an overly positive N balance are at risk of higher N losses but running a positive N balance may be necessary to build fertility in paddocks that are run down.

In mixed farming systems, legume-based pastures can make a significant contribution to maintaining soil N fertility. Decades of legume-based pastures were responsible for building N fertility in many of Australia's high rainfall zones.

Call to action

Change N management from trying to supply enough fertiliser N to crops in the year they are growing to achieve a yield target, to supplying the cropping system with enough N (and other nutrients) to maintain fertility and allow the soil to provide crops with the N they need.

Keep managing N fertiliser to try and minimise losses to the environment – make sure N fertiliser application is aligned with crop demand and use all other techniques available (e.g. mid-row banding, inhibitors, variable rate application). Burning stubble is a major loss of N, retaining crop residues helps immobilise mineral N, keeping it safe from loss and building soil organic matter.

Calculate N budgets over your crop sequence (how many kg/ha of N have gone in from fertiliser, legumes and manure vs. taken out in grain, hay, burnt stubble and losses?). Measure soil fertility regularly – mineral N and soil organic carbon are best indicators of N fertility.

Don't get hung up about poor NUE and response to fertiliser N in year of application, manage to minimise losses and unused N will make an important contribution to system fertility.

Canopy management in barley for higher yields in HYC Research – keeping crops green and standing

Dr Kenton Porker, FAR Australia

Take home messages

- 10.4t/ha was achieved in Pixel and 6 row winter barley in 2021 while Planet achieved 8.0t/ha, however winter cultivars are not yet as stable across seasons and yielded 7.1t/ha (Pixel), and 8.7t/ha (Planet) in the 2020 season.
- Planet⌽ barley remains the benchmark cultivar for achieving high yields across all higher production environments; higher yields can be achieved from early sowing with winter types, and with Laureate from later sowing, but these are both not as stable as Planet and Rosalind.
- In the barley cultivar Planet, **disease management is the number one factor to achieve high yields.**
- Fertile soils in the high rainfall zone (HRZ) limit the ability to manage yield and early biomass production with applied nitrogen in wetter environments. Mineralised N timing, and other canopy management factors such as plant growth regulators (PGR) and fungicide are equally or more important.
- Canopy management benefits of PGR and fungicides extend beyond the growing season and limit pre harvest yield losses (lodging, brackling, head-loss) and improve harvest logistics.
- Waterlogging tolerance of barley compared to wheat is poor in wetter seasons, however earlier sowing and slow developing cultivars increases the chances of improved yield recovery.

Canopy management is key to building and protecting high yielding crops

Canopy management is a broad term but fundamentally relies upon adopting techniques that allow crops to intercept more radiation (sunlight) and transpire more water into biomass at the right time in the season to contribute to yield. This is achieved by ensuring flowering is matched to environment and a high proportion of the upper crop canopy leaves remain intercepting light (green leaf area) during the 'critical period' for grain number formation (the month prior to flowering in cereals). Unlike low rainfall environments, excessive growth prior to stem elongation is unproductive and leads to lodging, shading and poorer light interception in the critical period. Equally nitrogen (N) limitation, and/or poor disease control during this period will lower grain number potential and yield either by limiting biomass production or its conversion into yield (harvest index). Harvest indices of greater than 50% should be possible with good management. Therefore, to achieve 10t/ha cereal grain yields, the final biomass needs to be greater than 20t/ha.

Management is as important as Germplasm from early sowing

Feed winter barley is yet to achieve the same adoption as feed winter wheats in the SE. European introductions have demonstrated superior disease resistance to all spring cultivars, however, they grow too tall, and are more prone to yield losses from lodging, head loss and grain shattering. These production constraints can be managed with principles of canopy management in both contrasting cultivar types highlighting the importance of disease resistance and fungicide lessons.

The summary of two seasons (three experiments) at Millicent SA, and Gnarwarre Vic of earlier sowing barley is below (Figure 1). A key finding was that the addition of a SDHI fungicide in the susceptible cultivar Planet⏀ increased yield by 1.2t/ha (6.1 – 7.3t/ha) irrespective of any other management factor. Whereas in the winter barley, yields were 6.6 and 6.7t/ha under standard and increased disease management respectively. The addition of plant growth regulators or defoliation by grazing, or an extra 80kg of applied N did not increase yield and demonstrates in the barley variety Planet⏀, that **disease management is the number one factor to achieving high yields.**

Essential role of disease management in better seasons: Irrespective of whether it's medium or high rainfall zone (M-HRZ), it's essential growers and advisers consider disease management as one of the most important components of growing high yielding cereal crops in seasons with higher yield potential. While other management techniques can improve harvest index, they should not come at the expense of reduced final biomass. For example, grazing (mowing) spring and winter barley increases harvest index (HI) but yields were not increased due to lower biomass in both Planet and Winter barley (Figure 1).

In winter barley the use of plant growth regulators (PGRs) to reduce height, lodging and head loss increased yield and was more important than extra fungicide application alone, however in combination they both increased yield. Under standard management, grain yield increased by 0.4t/ha (6.6 – 7.0t/ha) with the application of a PGR, whereas the more robust fungicide strategy did not increase yield unless it was combined with the PGR, and then increased yield by 0.7 t/ha (6.6 – 7.3t/ha). Grazing or extra N didn't further increase yield. This demonstrates the improved flexibility in fungicide management within cultivars of greater disease resistance.

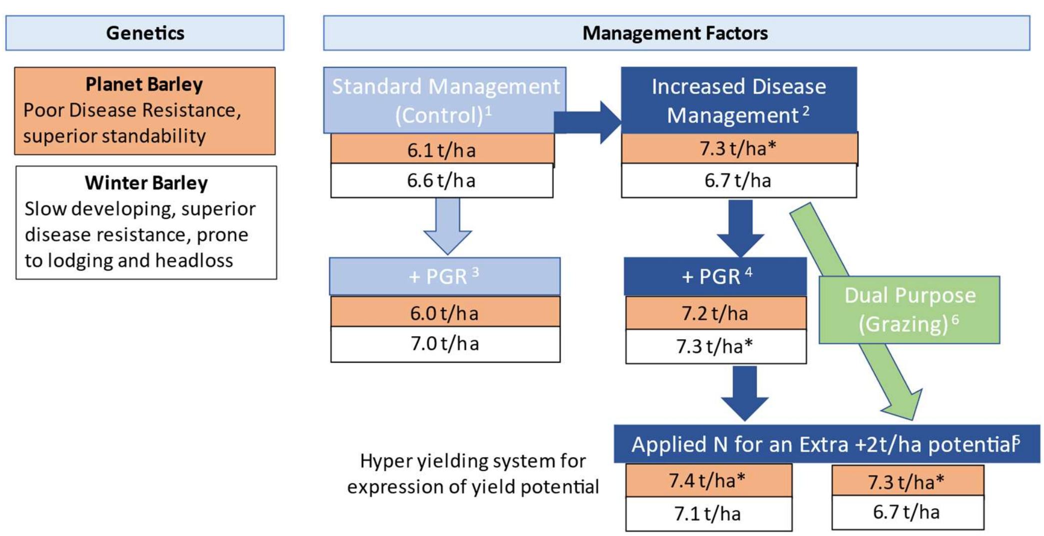

Figure 1. *Mean yields and response to canopy management factors, fungicide, plant growth regulators (PGR), nitrogen, and grazing in two contrasting barley cultivars across 3 earlier sown experiments (~20 April) in the HRZ of SA, Vic (2020/2021).*

Definitions of management factors

[1] Standard Management Control – 2 x cheaper foliar fungicide propiconazole (Tilt® 250 EC at 500mL/ha) @ GS31 and tebuconazole(Folicur® 430 SC 290 mL/ha) @ GS39-49. Nitrogen managed for 8 t/ha yield potential.

[2] Increased disease management – Systiva® seed treatment, 2 x foliar fungicides including QoI (strobilurin) & SDHI combinations with DMIs) with third fungicide if required.

[3,4] Plant growth regulator (PGR) (Moddus® Evo 200 mL/ha @ GS30 & Moddus Evo 200 mL/ha @ GS33-37).

[5] Extra applied nitrogen (N) = Additional 80 units (kg of N) applied @ GS31.

[6] Defoliation = simulated grazing @ GS16 and GS30 or before Aug 15 in winters.

All other inputs of insecticides and herbicides were standard across the trial. Timings of PGRs and fungicides were adjusted to take account of the differences in spring and winter barley phenology (development).

Achieving stable high barley yields

High yields and malt can be achieved in spring barley, particularly RGT Planet and Rosalind. However, introduction of higher potential winter feed barley cultivars could raise yield expectations.

The spring barley cultivar RGT Planet has been consistently higher yielding (8.5t/ha) across the four experiments on average 0.2t/ha higher than Rosalind (8.3t/ha) and 1.4t/ha higher than the winter cultivar Cassiopee (7.1t/ha).

While Planet⊕ barley remains the benchmark cultivar for achieving high yields across all higher production environments, the new cultivar Laureate has yielded similar to Planet, but has demonstrated slightly higher yield potential than Planet from later planting dates (and spring sowing in TAS). Experiments and observations in 2022 will provide another season to confirm these findings.

Table 1. *Grain yield of selected spring and winter barley cultivars sown at Millicent across two sowing dates, and seasons under high yielding management conditions[1] Shaded cells represent the highest yielding cultivars.*

Cultivar Controls	Type	2020 Millicent TOS1 (Sown 17 Apr)		2020 Millicent TOS2 (Sown 11 May)		2021 Millicent TOS1 (Sown 21 Apr)		2021 Millicent TOS2 (Sown 12 May)		Mean	+/- SD#
RGT Planet	2R Spring	8.7	abc	9.6	abc	8.0	de	7.9	b	8.5	0.8
Rosalind	2R Spring	8.4	bcd	9.0	a-e	8.0	de	8.0	b	8.3	0.5
Cassiopee*	2R Winter	6.4	h-k	7.3	fg	7.9	e	6.7	c	7.1	0.7
Laureate*	2R Spring	7.8	b-g	9.8	a	8.0	de	8.4	b	8.5	0.9
Other Lines											
Minotaur	2R Spring	6.8	e-i	8.2	c-g	-		9.0	ab	-	
HV8 Nitro	2R Spring	7.7	b-h	9.8	ab	-		8.3	b	-	
Laperouse	2R Spring	7.3	c-h	8.7	a-f	-		8.1	b	-	
Madness*	2R Winter	6.8	f-i	-		8.7	cd	-		-	
Newton*	2R Winter	7.1	d-h	-		9.7	ab	-		-	
Pixel*	6R Winter	7.4	c-h	-		10.4	a	6.1	c	-	
Memento*	2R Winter	6.3	h-k	-		8.9	c	-		-	
Urambie	2R Winter	6.5	g-j	6.9	g	-		-		-	
AGTB0244*	2R Spring	-		9.3	a-e	7.9	e	6.2	c	-	
IGB1844*	2R Spring	-		9.6	abc	-		9.3	a	-	
Fpr Value		<0.001		<0.001		<0.001		<0.001			
LSD (5%)		1.34		1.40		0.75		0.62			

[1] *High yielding management conditions include a robust fungicide strategy, plant growth regulators and extra N described in the flow diagram below. *Lines are experimental and yet to be commercialised in Australia or receive a quality classification. #SD=standard deviation, a low SD indicates that the values tend to be close to the mean (ie stable) a high SD indicates that the values are spread out over a wider range and may indicate a cultivar has greater up and downside risk (less stable)*

Making plant growth regulators pay in barley?

Canopy management benefits extend beyond the growing season – disease control and the combined application of PGRs and timely harvest ensures pre harvest yield losses are reduced, particularly in barley (e.g., head loss and brackling).

In the cultivar Planet there is little evidence to suggest an economic response to plant growth regulators in the high rainfall zones when crops are harvested on time compared to untreated (Figure 2). This suggests Planet is relatively non-responsive to PGRs and there has been little evidence of pre-flowering lodging in this cultivar. Importantly, at least in the case of Planet, there is also little evidence that PGRs are causing yield penalties in the absence of lodging and not overregulating the crop. **When harvest was delayed there was no additional benefit of PGRs in Planet (data not shown).**

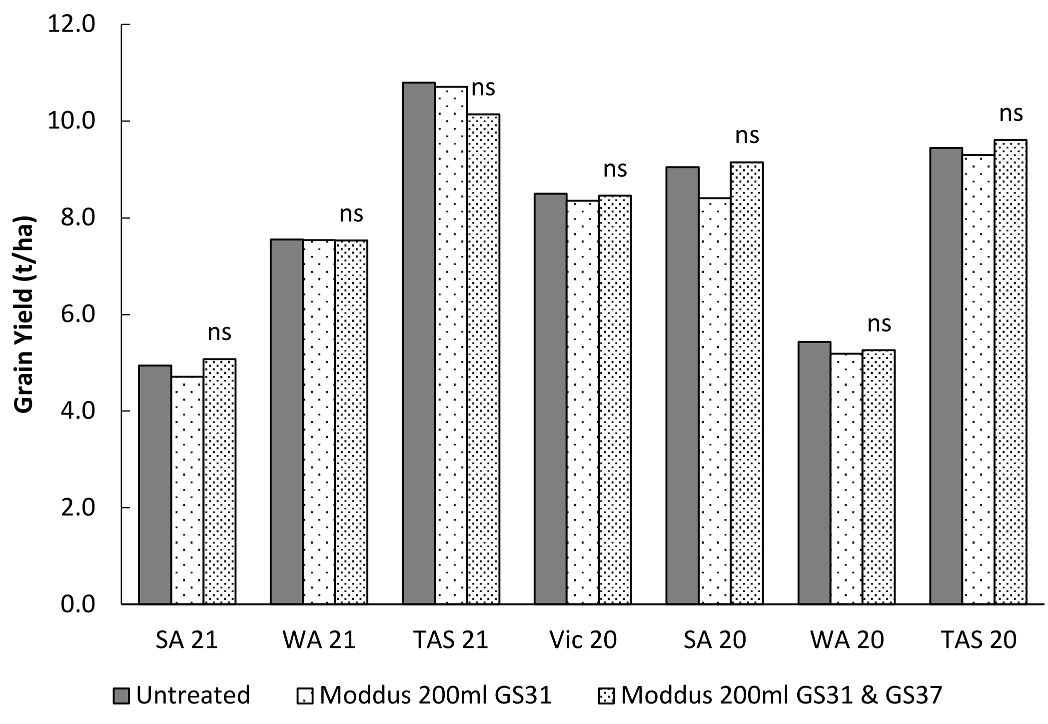

Figure 2. The yield responses to plant growth regulation (Moddus Evo) in barley in the Australian High rainfall Zone for Planet Barley when harvested on time.

Cultivars more susceptible to head loss such as winter barley and Compass types are more likely to benefit from late applications of a PGR to retain heads and improve harvest logistics. For example in 2021 at Millicent the sequence PGR treatment that included a later application of Moddus achieved yields closer to when harvesting on time. However, harvesting on time was still more important but PGRs may assist in harvest logistics (Figure 3).

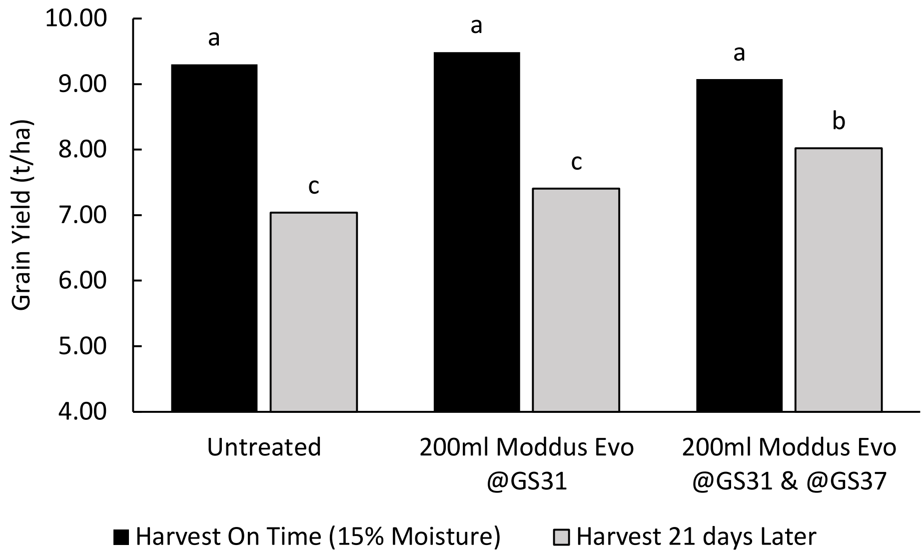

Figure 3. The yield responses to plant growth regulation in Pixel winter barley at Millicent in 2021 when harvested on time and when delayed by three weeks.

2021 Victoria Crop Technology Centre - Gnarwarre, Victoria
Barley Waterlogging Damage: What can we learn?

- Water logging during late stem elongation (the critical period) reduced grain number significantly in early sown Planet barley and severe stress resulted in complete crop failure.
- 6 row slower developing winter barley had more viable stems and more grains per spike making recovery better from waterlogging.
- 6 row winter barley achieved 9.9t/ha in the absence of significant water logging and 3.1t/ha under severe water logging stress.
- RGT Planet yielded 7.8t/ha in the absence of significant water logging and 0.3t/ha under severe water logging stress.
- Apart from sowing earlier and using slower developing genetics, there was little evidence of genetic differences in field waterlogging tolerance.
- Water logging was more detrimental to barley than wheat on site.
- Little evidence to suggest more N recovered yield from water logging and/or later sowing, the lowest N treatment (10 units of N) yielded 5.65, 50 Units of N yielded 7.11t/ha and the highest N treatment (290 units of N) yielded 6.32t/ha.

Trials at the Victoria Crop Technology Centre were badly affected by waterlogging throughout the winter of 2021 making yield results variable and interpretation more difficult. Unfortunately, most of the barley experiments were completely submerged. However, there were sections of the site that were slightly elevated and it was possible to evaluate enough replicates of a 6 row winter variety Pixel and RGT Planet side by side in non-water logged conditions through to completely stressed and submerged. This enables us to test what yields were possible in the absence of water logging and what yields are possible when subject to different water logging stress levels. The plots were scored based on % plot affected based on water submersion and visual symptoms during stem elongation and the peak period of damage (Table 1). All plots were harvested by machine harvest and hand cuts were taken for yield components.

Table 1. *Summary of treatments used for yield analysis of water logging damage from 27 April sowing, side by side analysis of Winter vs Planet spring barley*

Water Log Scale	1 Non limited	2 Mild Stress	3 Moderate Stress	4 Severe Stress
% Plot Affected	<20%	20-40%	40-60%	>60%
No of Reps per variety*	4	4	6	6
Winter Barley vs Spring Barley Planet				

Figure 1 demonstrates the difference in growth responses reflecting different development types and sowing times. Early sown (27 April) Planet reached stem elongation earlier than the winter barley or the later sown Planet. Treatments that developed later and remained vegetative during waterlogging survived waterlogging better.

Figure 1. *Picture of Severely stressed waterlogged plots at the start of October at Gnarwarre.*

The differences in response to water logging were reflected in biomass, % viable stems, the number of grains per spike and final grain yield. Grain weights were similar across all water logging stresses in Planet and slightly lower in Pixel when waterlogged. The majority of yield loss differences came from the proportion of stems that had a viable head and the number of grains per spike. Increasing water logging stress decreased grains per spike significantly as this coincided with the critical period for grain number determination (30 days prior to flowering). The 6 row winter barley had more grains per spike under all conditions and highlights the importance of delayed development and more potential grain sites (Table 2).

Table 2. *Differences in yield components in 6 row Pixel barley and Planet barley under moderate and non-limited conditions*

	Viable Heads/m^2	**Actual Grains/spike**	**Grain Weight**	**Grain Yield (t/ha)**
Non Limited				
Planet	646a	27.9b	44.9a	7.8b
Pixel	481c	53.5a	44.3a	9.9a
Moderate Stress				
Pixel	506bc	29.6b	42.3b	5.7c
Planet	448cd	7.5c	44.9a	1.5d

Biomass numbers were similar between cultivars under mild and moderate stress levels, however slow developing barley had greater biomass under significant stress. 6 row winter barley achieved greater yields of 9.9t/ha when water logging was absent and 3.1t/ha under severe water logging stress. Whereas RGT Planet yielded 7.8t/ha when water logging was absent and 0.3t/ha under sever water logging stress (Figure 2 and Figure 3).

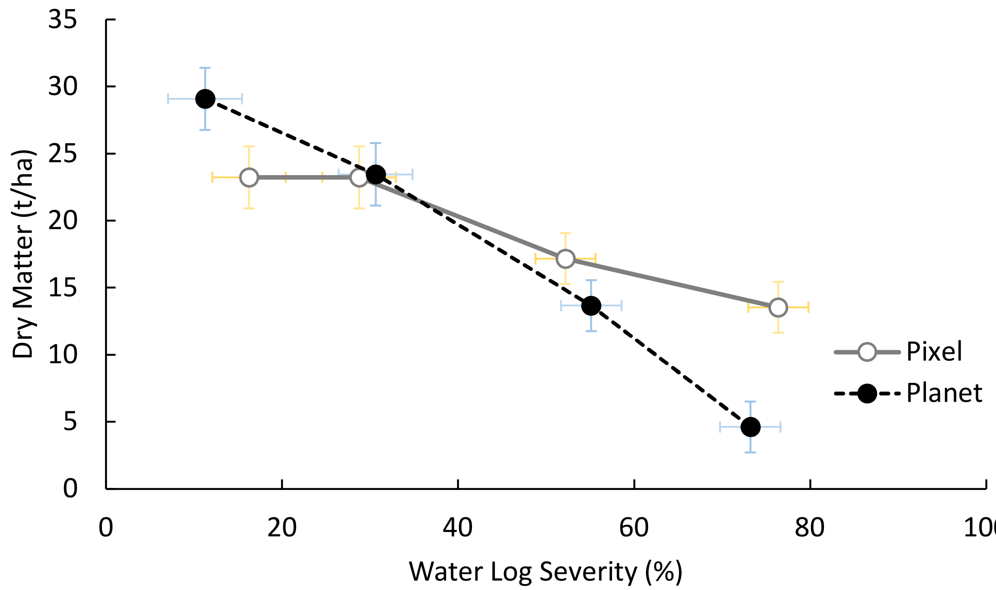

Figure 2. *Relationship between dry matter and water logging severity in Pixel (6 row winter barley) and Planet barley.*

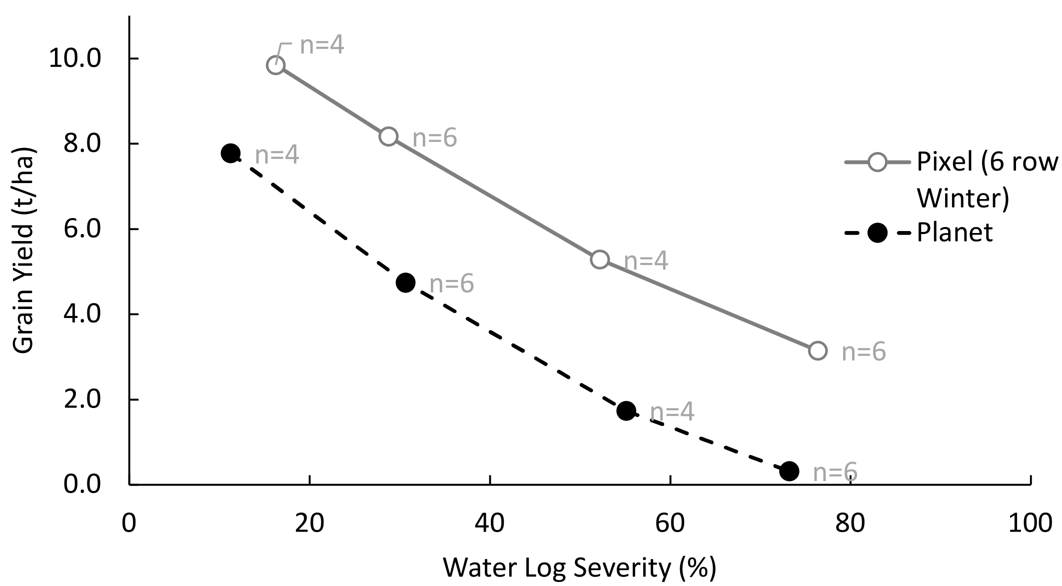

Figure 3. *Relationship between dry matter and water logging severity in Pixel (6 row winter barley) and Planet barley.*

What about delaying sowing and more N?

A separate experiment was located on the site that was sown to RGT Planet barley later (28 May) see Figure 1. This experiment also suffered significant water logging stress and extra N was applied as Urea. 100kg MAP was drilled at sowing (to supply 10 kg N) to the lowest N treatment and in crop applications included 50% at tillering and 50% at the onset of stem elongation. While results were variable, the lowest N treatment yielded 5.65t/ha, and an additional 40 units of N yielded 7.11t/ha. However, increasing N application over and above 50 units to 290 units of N did not further increase yield under water logging conditions Table 3. There was no significant effect on grain quality parameters.

Table 3. *Responses to increasing N application in RGT Planet sown later at Gnarwarre (28 May 2021)*

Nitrogen Applied (kg/ha)	Yield t/ha,	Protein %	Test Weight kg/hl	Retention %,	Screenings %
1 10N	5.65 c	11.7 -	66.6 -	89.4 -	3.4 -
2 50N	7.11 a	11.7 -	68.0 -	89.5 -	3.1 -
3 95N	6.32 ab	12.1 -	67.0 -	88.2 -	3.7 -
4 160N	6.23 ab	11.3 -	67.7 -	91.1 -	2.7 -
5 225N	6.23 ab	11.7 -	67.2 -	89.6 -	3.3 -
6 290N	6.32 ab	11.5 -	67.7 -	90.1 -	3.0 -
LSD P=.05	0.87	1.1	1.2	3.7	1.4
Treatment Prob(F)	0.050	0.750	0.232	0.728	0.761
CV	10.5	6.95	1.39	3.15	33.88

Genetic differences in tolerance to water logging?

For less severe waterlogging, the use of nitrogen can sometimes help mitigate the damage. When waterlogging is very severe, sometimes delaying sowing is the only option such as in spring, this has been shown to work well in Tasmania. The most obvious and effective methods is to use different engineering solutions to improve drainage, including the use of raised bed, surface drainage, controlled traffic farming and tillage. Combining genetic solutions and some of the ideas of winter barley with the engineering controls have the potential to assist in reducing waterlogging damage. We also included the waterlogging tolerant Planet (Planet WL) developed by Prof Meixue Zhou, Tasmanian Institute of Agriculture, University of Tasmania. The trial was significantly damaged by water logging and plots were harvested by hand to get a dry matter and yield estimate, the yield component data has not yet been processed. However, based on the dry matter data, the slower developing winter cultivars had more biomass, and there was no difference between spring cultivars and the waterlogging tolerant Planet (Planet WL). At other sites less exposed to waterlogging this line has yielded similar to Planet.

Table 4. *Final maturity dry matter of selected cultivars in the elite variety screening trial sown on 28 May and subjected to water logging at Gnarwarre. (P value <0.05, LSD 2.1)*

Cultivar	Maturity Dry Matter (t/ha)
Cassiopee (winter)	11.75a
Laureate (Spring)	10.35ab
Pixel (winter)	12.76a
Planet (spring)	8.42b
Planet WL (spring)	**9.73b**
Rosalind (spring)	9.44b

The primary role of Field Applied Research (FAR) Australia is to apply science innovations to profitable outcomes for Australian grain growers. Located across three hubs nationally, FAR Australia staff have the skills and expertise to provide 'concept to delivery' applied science innovations through excellence in applied field research, and interpretation of this research for adoption on farm.

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SOWING THE SEED FOR A BRIGHTER FUTURE

VICTORIA HYC
RESEARCH CENTRE

2022 SITE MAP:

Featuring the GRDC's Hyper Yielding Crops

Lunch and post event drinks kindly sponsored by:

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Event Sponsor:

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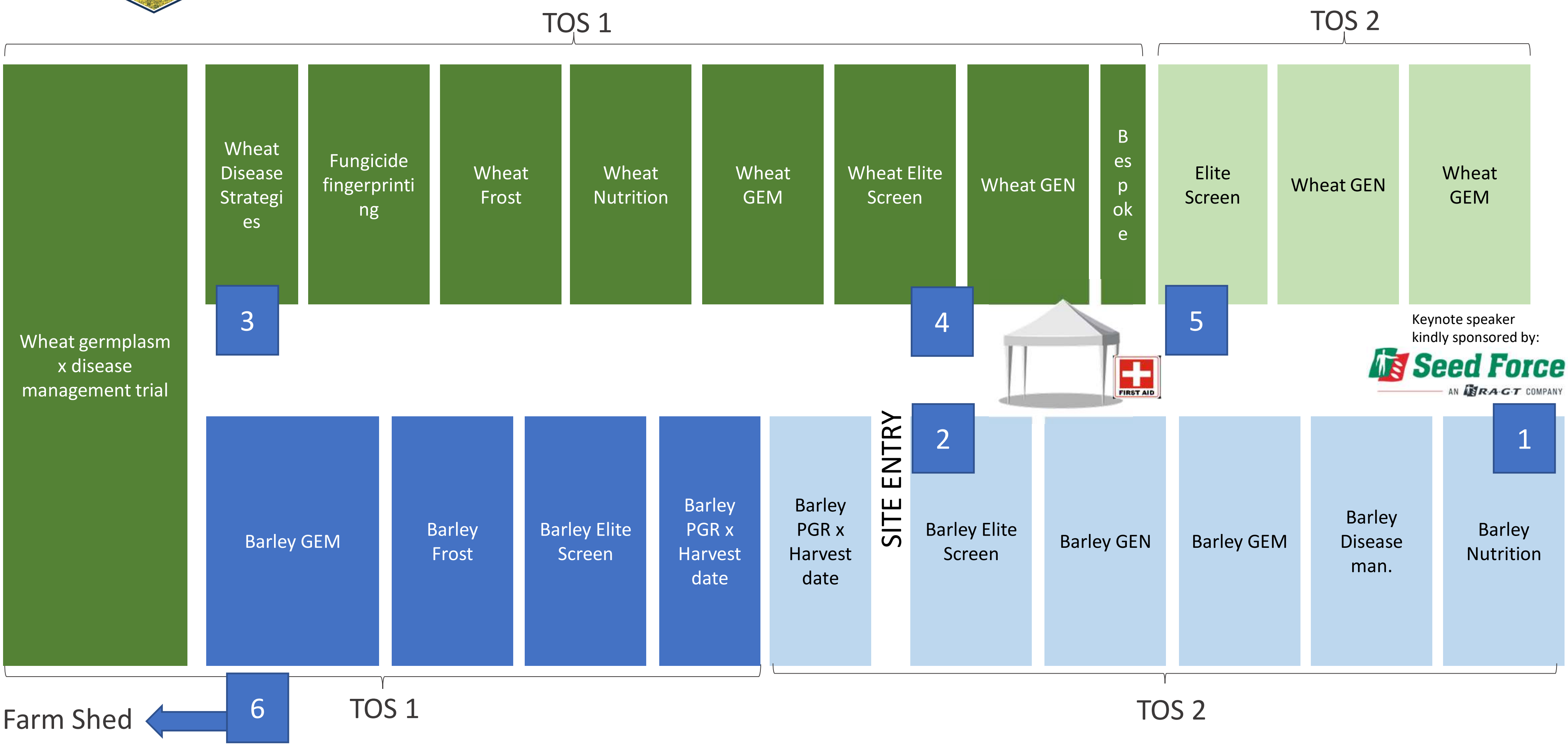

VICTORIA HYC RESEARCH CENTRE

TIMETABLE

VICTORIA CROP TECHNOLOGY CENTRE FIELD DAY (GNARWARRE): THURSDAY 27 OCTOBER 2022

Featuring the GRDC's Hyper Yielding Crops and Pulse Agronomy

Thanks to our keynote speaker sponsor: Seed Force – AN RAGT COMPANY

In-field presentations	Station No.	10:15am-12:00noon	12:30	1:15	1:30	2:00	2:30	3:00	3:30	4:00	4:30
Rohan Brill, Brill Ag and HYC Canola Research Lead will be joined by Nick Poole (FAR Australia) to discuss *Hyper yielding canola in Victoria what have we learnt so far?*	Canola research site	ALL	Lunch kindly sponsored by westernAG	Opening address by Andrew Russell, GRDC Southern Panel Chair and Nick Poole, FAR Australia's Managing Director for an introduction to the cereal research programme.							Closing address followed by refreshments kindly sponsored by westernAG
Prof. James Hunt, University of Melbourne *Removing N limitation in the HRZ, N Banks and fertile farming systems.* Seed Force	1										
Kenton Porker & Daniel Bosveld, FAR Australia *Is early sowing winter barley and waterlogging tolerant barley going to close the gap to wheat in the HRZ?*	2										
Darcy Warren, FAR Australia *Achieving wheat yield potentials greater than 10t/ha more sustainably with new genetics & management.*	3										
Nick Poole, FAR Australia *Canopy management in high rainfall wheat and barley crops.*	4										
Jon Midwood, TechCrop and Ashley Amourgis, Southern Farming Systems *Hyper Yielding Crops: Capturing yield potential through innovation and benchmarking.*	5										
Aaron Vague and Kenton Porker, FAR Australia *Canopy Management in Faba Beans - keeping 8t/ha potential bean crops green and standing.*	6 Farm Shed										
In-field presentations	Station No.	10:15am-12:00noon	12:30	1:15	1:30	2:00	2:30	3:00	3:30	4:00	4:30

Thanks also to event sponsor AGF seeds SMYTH SEEDS

It's been wet and cool, but this doesn't always mean that SW Vic 2022 is on target for 10 tonne yields – how does this compare to other seasons?

Kenton Porker, Nick Poole, John Kirkegaard, Darcy Warren

2022 has been extremely wet and the water supply for a 12.5t/ha cereal crop has already been achieved based on water use efficiency metrics. However, this doesn't mean that >10t/ha yields are attainable due to other climatic constraints solar radiation and temperature in the critical period.

Solar radiation and temperature drives yield when water and N is non-limiting.
All crops have a "critical period" in which the number of grains is set, and increasing grain number is the key to higher yields. In cereals, the critical period is occurring in the three weeks before flowering. The importance of the critical period for crop management must be given greater attention in high rainfall environments.

Minimising stress and maximising growth in this critical period are the key to high yields. To minimise stress, flowering should be timed to minimise the risk of frost, heat and drought and ensure water and nutrients are in good supply. Other factors that limit photosynthesis such as disease and lodging also need to be managed. Other papers will discuss this.

To maximise growth, the crop requires cool temperatures – which increase the duration of the critical period - and sunny days which increase photosynthesis for growth. A common way to measure this effect is the photo-thermal quotient (PTQ) which is simply (total radiation/average temperature) in the critical period. A high PTQ means more photosynthesis for more days and in turn more grain and more yield. Crop yield is proportional to the duration of the critical period, and the critical period shortens with a lower photothermal quotient. This is why higher yields can be achieved in Tasmania, and other places like NZ which have high PTQ with crops flowering in long summer days, with cool temperatures more similar to those experienced in September at Gnarwarre Vic.

Based on long term data and own experience the 15 – 20th October is considered the most optimal time to be flowering at Gnarwarre to achieve this goal.

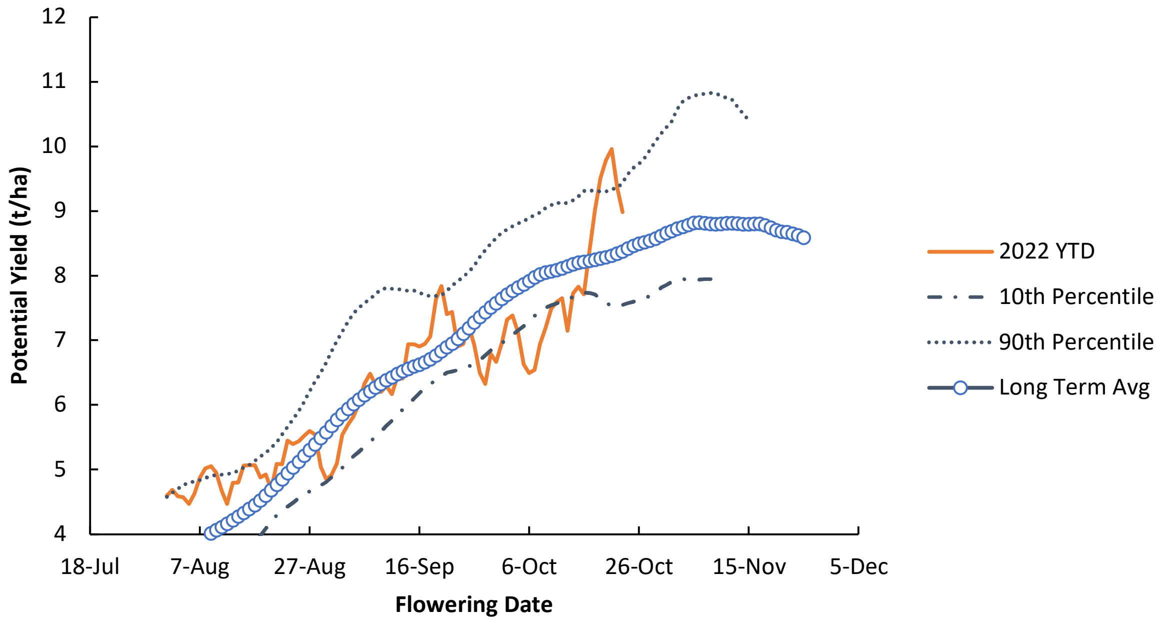

Figure 1. Long Term (last 10 years) yield potential and relationship with flowering date at Gnarwarre based on the photothermal quotient compared to 2022 YTD. Note this is the upper ceiling of yield potential and does not factor in frost and heat risk and assumes water is non limiting.

The PTQ puts an upper limit on the potential yield in any environment and can vary from season to season. This is highlighted above with solar radiation currently being lower than the long-term average at the start of October despite the extra rainfall. This means the only likely way to achieve 10t/ha in 2022 will be if later flowering crops experience conditions of higher PTQ in the next few weeks and remain stress free (late October). Similar trends were observed in 2021 yield results with a mild and wet finish, with later flowering cultivars like Reflection for example achieving higher yields due to a higher PTQ (figure 2) in South Australia Millicent.

- In SA in 2021 PTQ improved in mid-October favouring late sown crops and late flowering European wheats.
- The UK wheat Reflection (which is usually too long for Millicent) was the highest yielding wheat at 12.74t/ha
- It is now acknowledged in Millicent that we may be more limited by solar radiation than water limited in the majority of seasons if flowering in early spring at Millicent.

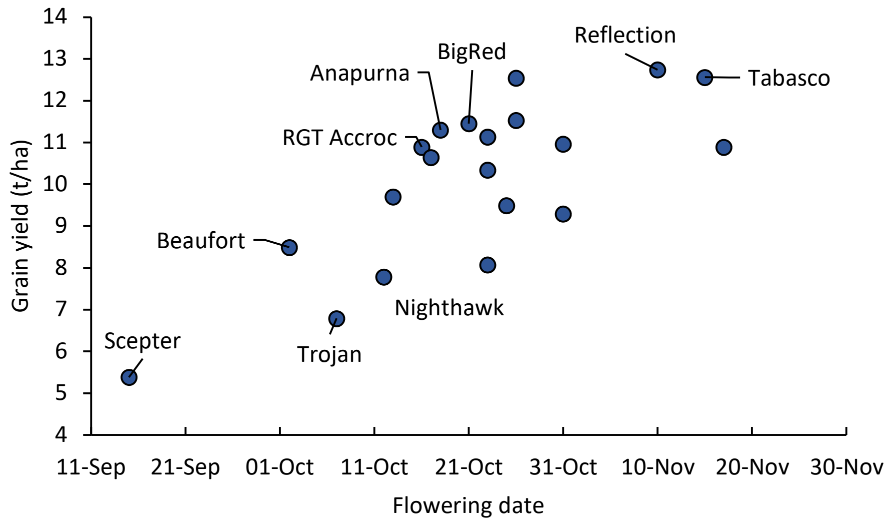

Figure 2. Grain yield and flowering time relationship from Millicent HYC 2021.

Long Term Yield Potentials at Gnarwarre Vic

Based on simple water use efficiency metrics, and the photothermal quotient calculations outlined these data demonstrate that yields are likely to be water limited in most seasons, and limited by solar radiation and temperature in three of the last 10 seasons when flowering in late October. PTQ begins to limit yield more often at sites west of Gnarwarre when water supply increased.

Table 1. Grain Yield potentials based on water use efficiency, and photothermal quotient equations for Gnarwarre over the last 10 years (using SILO Bom Data) shaded cells indicates the seasons where PTQ was the limiting factor.

Year	Water Limited Yield Potential (t/ha)	Photothermal Quotient Yield Potential (t/ha)#
2010	9.4	10.2
2011	7.7	8.7
2012	7.9	9.4
2013	8.8	8.3
2014	6.1	7.6
2015	5.0	7.9
2016	9.2	8.5
2017	8.5	8.5
2018	6.0	6.2
2019	6.8	8.2
2020	9.1	6.6
2021	8.0	8.9
*2022 YTD**	9.1	9.8

**year to date*
#based on a flowering date of 20th October

Choosing a cultivar and sowing date to achieve 10 tonne potential?

New genetics offer improved yield and may convert light and water into yield more efficiently than older genetics in the high rainfall zones. In particular, cultivars that are coming out of Europe where breeding for high yield potential is a greater focus.

Breeding programs in Australia are understandably more focused on breeding for improved water use efficiency for the wheat belt. However, as this data highlights in many parts of the HRZ yield may be limited by solar radiation and temperature in 50% of years, and top end yield potential rather than water. For a cultivar to achieve 10t/ha, it needs to have the genetic yield potential to do so, but it must also have the correct flowering behaviour to align its critical period with the environment. Some of the slower developing winter feed wheats have realised this potential in the southern states and when sown in the high rainfall environments, such as Tasmania. However, our data suggests that cultivars such as BigRed, RGT Cesario, RGT Accroc and Anapurna are equally as well adapted to Gnarwarre particularly when sown in April and mid may in seasons like 2020, 2021, and 2022 when yields are not water limited. This is because their critical period is aligned with the most optimal conditions to achieve 10t/ha and they flower during the start of the 3rd week of October. Based on long term data, this date is the period in which highest yields could be achieved based on the photothermal quotient (light and temperature in the critical period) (figure 1). While it must be noted high yields can be achieved by flowering later than this in some seasons, the heat risk is considerably higher and will reduce yields.

Grain yields from 2020 at Gnarwarre reflect these differences in flowering time when disease is controlled (table 2). However, when the crop canopy was not managed the crop failed to achieve its potential, as outlined in the FAR Australia disease results.

Table 2. Flowering responses and yield data (when disease is controlled) at Gnarwarre HYC 2020.

Cultivar	Flowering date	2020 Yield
Trojan (spring)	29-Sep	7.71
Scepter (spring)	29-Sep	9.03
Nighthawk (facultative)	18-Oct	8.55
Anapurna (winter)	24-Oct	9.25
RGT Acrocc (winter)	24-Oct	10.42
RGT Calabro (winter)	28-Oct	9.41
Tabasco (winter)	2-Nov	7.88
DS Bennett (winter)	22-Oct	8.96
Variety (LSD)		0.689

Fungicide resistance update - national situation and issues

Nick Poole[1], Tracey Wylie[1], Kat Fuhrmann[1], Ben Morris[1], Kejal Dodhia[2], Steven Chang[2], Fran Lopez-Ruiz[2], Steven Simpfendorfer[3] and the AFREN team[4]

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GRDC code

CUR00023, AFREN project (Australian Fungicide Resistance Extension Network) CUR1905-001SAX

Keywords

wheat powdery mildew (WPM), net blotch, Septoria tritici blotch (STB), Integrated Disease Management (IDM), fungicide resistance, DeMethylation Inhibitors (DMI)

Take home messages

- Monitoring and analysis of pathogen populations by CCDM in 2021 revealed new resistance mutations affecting fungicide performance for the first time in Australia and in other cases existing mutations being more widespread and affecting more states
- In a field trial in NE Victoria which combined field efficacy with laboratory analysis, testing has revealed significant differences in DMI (Group 3, triazole) performance for control of wheat powdery mildew (WPM)
- The results illustrated that the weaker compounds (triadimefon, epoxiconazole, tebuconazole, cyproconazole and propiconazole) provided less than 50% control of WPM
- Fungicide resistance and reduced sensitivity can be slowed down by using integrated disease management (IDM) approaches that reduce the number of fungicide applications required
- To 'slow the train that's heading to fungicide resistance', growers and advisers need to adopt fungicide resistance management strategies that avoid repeated applications of the same modes of action and active ingredients
- IDM strategies can include crop rotation, stubble management, green bridge control, sowing more disease resistant (avoid susceptible) cultivars, nutrition and canopy management (e.g. grazing) to minimise disease pressure.

Background

Fungicide resistance is a major concern for Australian growers as it potentially reduces the efficacy of fungicides and their ability to protect grain yield and profit potential. To minimise the yield gap on cropping farms, it is essential to maintain impact of these agrichemicals through fungicide resistance management strategies.

The first step in recognising the significance of this problem is to understand which pathogens are developing issues and to which fungicide actives.

The research reported in this paper includes fungicides that may not be registered in Australia either alone or in combination with other actives for the diseases mentioned. Their use was necessary for the express purpose of determining the resistance profile for specific mode of action groups and actives. Only products that are registered for use in Australia should be used and in accordance with directions for use on their respective labels.

What is the current status of fungicide resistance and reduced sensitivity in Australia?

Over the last decade the Fungicide Resistance Group (FRG) at the Centre for Crop and Disease Management, (CCDM at Curtin University) has been working with industry and other researchers to establish a fast and cost-effective monitoring system for fungicide resistance of common fungal pathogens of broad acre grain crops. Current cases of fungicide resistance and reduced sensitivity in Australian broadacre grain crops are outlined in Table 1.

Table 1. Fungicide resistance and reduced sensitivity cases identified in Australian broadacre grains crops.

Disease	Pathogen	Fungicide Group	Compounds affected	Region (status*)	Industry implications
Barley powdery mildew	*Blumeria graminis* f.sp. *hordei*	3 (DMI)	Tebuconazole Propiconazole Flutriafol	WA (R), Qld, NSW, Vic, Tas, (L)	Field resistance and reduced sensitivity to some actives
Wheat powdery mildew	*Blumeria graminis* f.sp. *tritici*	3 (DMI)	Propiconazole Tebuconazole	NSW, Vic (R), Tas, SA (L)	Field resistance to some actives in NSW and Vic. The gateway mutation is the first step towards resistance. This mutation does not seem to reduce efficacy in the field but combined with other mutations can affect DMI efficacy
		11 (QoI)	Azoxystrobin Pyraclostrobin	Vic, Tas, SA & NSW (R)	Field resistance to all Group 11 fungicides
Barley net-form of net blotch	*Pyrenophora teres* f.sp. *teres*	3 (DMI)	Tebuconazole Epoxiconazole Propiconazole Prothioconazole	WA (R), VIC, SA (RS)	Field resistance and reduced sensitivity to some actives
		7 (SDHI)	Fluxapyroxad Bixafen Benzovindiflupyr	SA (R & RS), VIC (L)	Reduced sensitivity or resistance depending on the frequency of resistant population
Barley spot-form of net blotch	*Pyrenophora teres* f.sp. *maculata*	3 (DMI)	Tebuconazole Epoxiconazole Propiconazole Prothioconazole	WA (R, RS) VIC (L)	Field resistance to some actives
		7 (SDHI)	Fluxapyroxad Bixafen Benzovindiflupyr	WA (R, RS)	Field resistance and reduced sensitivity

Wheat septoria tritici blotch	*Zymoseptoria tritici*	3 (DMI)	Tebuconazole Flutriafol Propiconazole Cyproconazole Triadimenol Epoxiconazole	NSW, Vic, SA, Tas (RS)	Reduced sensitivity
		11 (QoI)	Azoxystrobin Pyraclostrobin	SA, (Millicent region) (R)	Frequency of A143 mutation in Millicent region unknown. 32 STB samples collected from 29 locations across Victoria, South Australia and NSW in 2021 did not detect the mutation associated with resistance to QoI fungicides
Canola Blackleg disease	*Leptosphaeria maculans*	3 (DMI)	Tebuconazole Flutriafol Prothioconazole Fluquinconazole	VIC, NSW, SA, WA (RS)	Reduced sensitivity

***Table 1 definitions:**

Reduced sensitivity (RS): Fungi are considered as having reduced sensitivity to a fungicide when a fungicide application does not work optimally but does not completely fail. In most cases, this would be related to small reductions in product performance which may not be noticeable at the field level. In some cases, growers may find that they need to use increased rates of the fungicide to obtain the previous level of control. Reduced sensitivity needs to be confirmed through specialised laboratory testing. Note that mutations that cause field failure (full resistance) present at lower frequencies in a pathogen population would give similar field symptoms to mutations that cause small reductions in field performance but which do not cause field failure.

Resistant (R): Resistance occurs when the fungicide fails to provide an acceptable level of control of the target pathogen in the field at full label rates. Resistance needs to be confirmed with laboratory testing and be clearly linked with an unacceptable loss of disease control when using the fungicide in the field at full label rates.

Laboratory detection (L): Measurable differences in sensitivity of the pathogen to the fungicide when tested in the laboratory. Detection of resistance in the lab can often be made before the fungicide's performance is impacted in the field.

Fungicide reduced sensitivity and resistance in NSW/SA/Victoria in 2021

The following section carries results from three states. Although resistance results from Vic and SA may seem less relevant to the northern GRDC region, they give us an early warning of potential issues in southern NSW where farming systems are more similar to SA and Victoria.

Wheat powdery mildew in the northern grains region

Wheat powdery mildew (WPM) was particularly problematic in NSW in 2020 but was less damaging in 2021.

Steven Simpfendorfer (NSW DPI) co-ordinated 22 samples of WPM for testing with CCDM over the last two seasons and the results revealed widespread fungicide reduced sensitivity in the DMIs and resistance in the QoIs (Table 2). The F136 mutation in WPM is a gateway mutation that doesn't confer field resistance but in combinations with other mutations (which are still being characterised) in the same gene does confer reduced sensitivity in the field.

Table 2. Location of 22 wheat powdery mildew samples; 19 collected across NSW in 2020 and 3 in 2021 along with frequency of DMI (triazole) gateway and QoI (strobilurin) mutations.

Location	Year	Region	Variety	DMI F136	QoI A143
Katamatite	2020	NE Vic	Scepter	100%	90%
Katamatite	2020	NE Vic	Scepter	100%	90%
Cobram	2020	NE Vic	Scepter	100%	46%
Cobram	2020	NE Vic	Scepter	100%	28%
Balldale	2020	SE NSW	Scepter	100%	98%
Walbundrie	2020	SE NSW	Scepter	100%	5%
Rennie	2020	SE NSW	Suntop	85%	27%
Rennie	2020	SE NSW	Scepter	85%	20%
Jerilderie	2020	SE NSW	Scepter	100%	37%
Corowa	2021	SE NSW	Scepter	100%	94%
Deniliquin	2020	SW NSW	Scepter	99%	35%
Deniliquin	2020	SW NSW	Scepter	99%	20%
Deniliquin	2020	SW NSW	Scepter	83%	20%
Hillston	2020	SW NSW	Vittaroi	96%	21%
Hillston	2020	SW NSW	Vixen	94%	3%
Hillston	2020	SW NSW	Vixen	85%	6%
Yenda	2020	SW NSW	Cobra	100%	44%
Yenda	2020	SW NSW	Vixen	100%	12%
Finley	2021	SW NSW	Scepter	100%	38%
Edgeroi	2020	NE NSW	Lillaroi	82%	29%
Wee Waa	2020	NW NSW	Bindaroi	62%	51%
Wee Waa	2021	NW NSW	Aurora	100%	20%

FAR working in collaboration with CCDM and NSW DPI ran an irrigated trial at Katamatite in NE Victoria in 2021 to determine the field performance of different modes of action and DMI active ingredients for control of WPM. The results illustrated some interesting differences in field performance which, whilst not all statistically significant, illustrated that the weaker compounds of triadimefon, epoxiconazole (Opus), tebuconazole, cyproconazole plus propiconazole (Bumper) were giving less than 50% control (Figure 1). Isolates from this trial were taken in October (post application) and the samples sent to CCDM for fungicide resistance testing. Analysis for the presence of the A143 mutation that affects WPM control globally when using group 11 QoIs (strobilurins) was present in all treatments (Figure 2) but as might be expected was highest in the experimental treatment that received straight strobilurin alone (azoxystobin - Mirador®). Therefore, although the WPM control within this experimental treatment was not the poorest (still less than 50% control) it indicates that the population that remains post application will be less effectively controlled. Clearly, we don't apply this fungicide alone in Australia but in mixtures with DMIs, however it demonstrates the selection pressure that can occur in a season when we use fungicide actives that are at higher risk of resistance development in the pathogen. Significant differences to the untreated in the level of the QoI mutation in plots treated with DMIs and the Group 5 fungicide Prosper® (spiroxamine) will be investigated further.

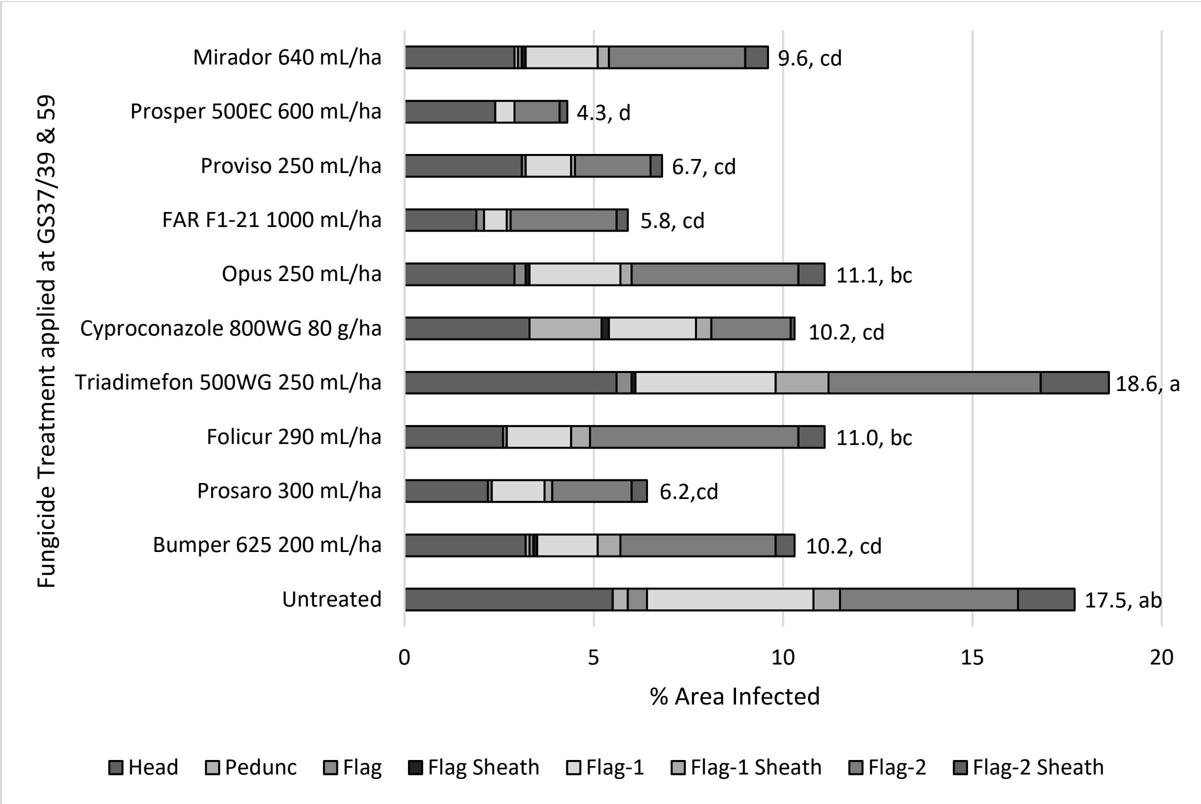

Figure 1. Influence of two spray fungicide application (GS37/39 and GS59) on wheat powdery mildew (WPM) infection on different components of upper canopy – cv Scepter⏀, Katamatite, Vic 2021.

Notes: Data labels and statistical significance based on total WPM infection of all plant components listed

Notes: Please be aware that cyproconazole, FAR F1-21, Prosper and Mirador have been included in this experimentation as experimental treatments that currently cannot be used commercially in this form. These treatments were included to test the full range of available individual fungicide actives some of which are only approved in mixtures

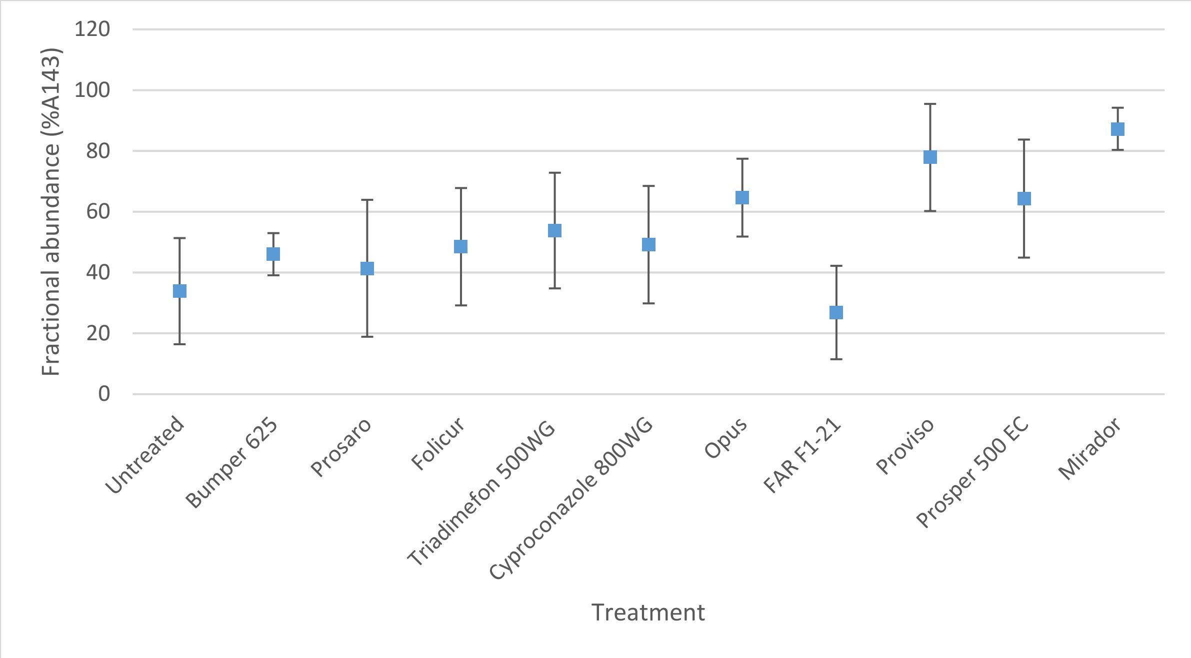

Figure 2. Fractional abundance of the A143 mutation in the different fungicide treatments applied for WPM control – cv Scepter⦶, Katamatite, Vic 2021. (CCDM analysis)

Note: When the mutation at G143A occurs the G amino acid in the wild type is replaced with an A amino acid

SDHI resistance and reduced sensitivity in net form of net blotch (NFNB) in barley

The *SdhC*-H134R mutation in the SDHI (Group 7) target site, was detected in six samples from Victoria and one sample from South Australia in 2021. This mutation was first observed in Australia in NFNB from the Yorke Peninsula of South Australia in 2019 and is associated with the highest resistance factors affecting the key SDHI compounds such as fluxapyroxad, bixafen and benzovindiflupyr.

Four other samples from Victoria and one sample from South Australia in 2021 were associated with low resistance factors for SDHI compounds and classed as the mutations conferring reduced sensitivity. These mutations have been detected previously. In the case of the SdhD-D145G mutation it was first observed in Australia in NFNB from the Yorke Peninsula of South Australia in 2019 and in the case of SdhC-N75S in spot form of net blotch (SFNB) in the Cunderdin region in WA in 2020.

DMI reduced sensitivity in net form net blotch (NFNB) in barley

The F489L-2 mutation in the DMI (Group 3) target, *Cyp51A*, was detected in six samples from Victoria and one sample from South Australia in 2021. This mutation was previously observed in Australia in NFNB from the Yorke Peninsula of South Australia in 2019 and is associated with reduced sensitivity to DMI compounds.

Genetic changes in the region that controls the DMI target were detected in one sample from South Australia in 2021. This different type of mutation has been previously observed in Australia in spot form net blotch (SFNB) from Western Australia since 2016 and is associated with reduced sensitivity to DMI compounds.

QoI resistance in septoria tritici blotch (STB)

Fungal cultures isolated from two STB samples collected in South Australia in 2020, were found to carry the fungicide resistance mutation A143, which is associated with full resistance to QoI (Group 11) fungicides. *In vitro* analysis of two STB resistant isolates obtained from these samples showed a

200-fold increase in azoxystrobin resistance compared to sensitive reference isolates. Subsequent molecular analysis of 32 STB samples collected from 29 locations across Victoria, South Australia and NSW in 2021 did not detect the mutation associated with resistance to QoI fungicides.

So what does this mean for growers and advisers

Fungicide resistance management strategies which should be used within broader IDM include:

- With wheat and barley crops where two to three fungicide applications occur within a season, avoid repeat applications of the same product/active ingredient and where possible also avoid the same mode of action in the same crop. This is particularly important when using Group 11 QoI (strobilurins) and Group 7 SDHIs, which preferably would only be used once in a growing season
- Avoid using the seed treatment fluxapyroxad (Systiva®) year after year in barley without rotating with foliar fungicides of a different mode of action during the season
- Avoid applying the same DMI (triazole) Group 3 fungicide twice in a row, irrespective of whether the DMI is applied alone or as a mixture with another mode of action
- Avoid the use of tebuconazole alone and flutriafol for Septoria tritici blotch (STB) pathogen control in regions where reduced sensitivity is problematic, as these Group 3 DMIs are more affected by reduced sensitivity strains than other DMIs
- Group 3 DMIs such as epoxiconazole (Opus®) or triazole mixtures \such as prothioconazole and tebuconazole (Prosaro®) when used alone are best reserved for less important spray timings, or in situations where disease pressure is low in higher yielding scenarios.
- With SDHI seed treatments such as fluxapyroxad (Systiva®) or QoI fungicides used in-furrow such azoxystrobin (Uniform®), consider using a subsequent foliar fungicide with a different mode of action, and therefore avoiding, if possible, a second application of SDHI or QoI fungicide active.

Clearly, the best way to avoid fungicide resistance is not to use fungicides! However, in high disease pressure regions, this would be an unprofitable decision. When a cultivar's genetic resistance breaks down or is incomplete, it is imperative that growers and advisers have access to a diverse range of effective fungicides (in terms of mode of action) for controlling leaf disease. Hence, we need to protect their longevity. In order to protect them, one of the most effective measures is to minimise the number of fungicide applications applied during the season. Therefore, consider all aspects of an Integrated Disease Management (IDM) strategy when putting your cropping plans together at the start of the season, since this will help reduce our overall fungicide dependency.

Principle components of IDM

Rotations – where possible avoid high risk rotations for disease, for example, barley on barley or wheat on wheat.

Seed hygiene – minimise the use of seed from paddocks where there were high levels of disease that could be seedborne (e.g. Ramularia, net form net blotch).

Use less disease susceptible cultivars, particularly when sowing early. Where this is not possible delay the sowing of the most susceptible cultivars to reduce disease pressure where the phenology of the cultivar is adapted to the later development window.

Cultural control such as stubble management, where disease risks are high and the penalties for stubble removal are not as high.

Grazing early sown cereal crops up to GS30 to reduce disease pressure.

AFREN (Australian Fungicide Resistance Extension Network)

The Australian Fungicide Resistance Extension Network (AFREN) was established to develop and deliver fungicide resistance resources for grains growers and advisers across the country. It brings together regional plant pathologists, fungicide resistance experts and communications and extension specialists.

AFREN wants to equip growers with the knowledge and understanding that they need to reduce the emergence and manage the impacts of fungicide resistance in Australian grains crops.

As members of AFREN, the authors of this paper are keen to hear if you believe you are encountering reduced sensitivity or resistance in your broad acre crops.

Acknowledgements

FAR Australia would like to acknowledge the assistance of Andrew McPherson and James Reilly in sourcing and managing the field trial conducted near Katamatite in 2021. The research undertaken as part of this project is made possible by the significant contributions of growers and their advisers through their support of the GRDC.

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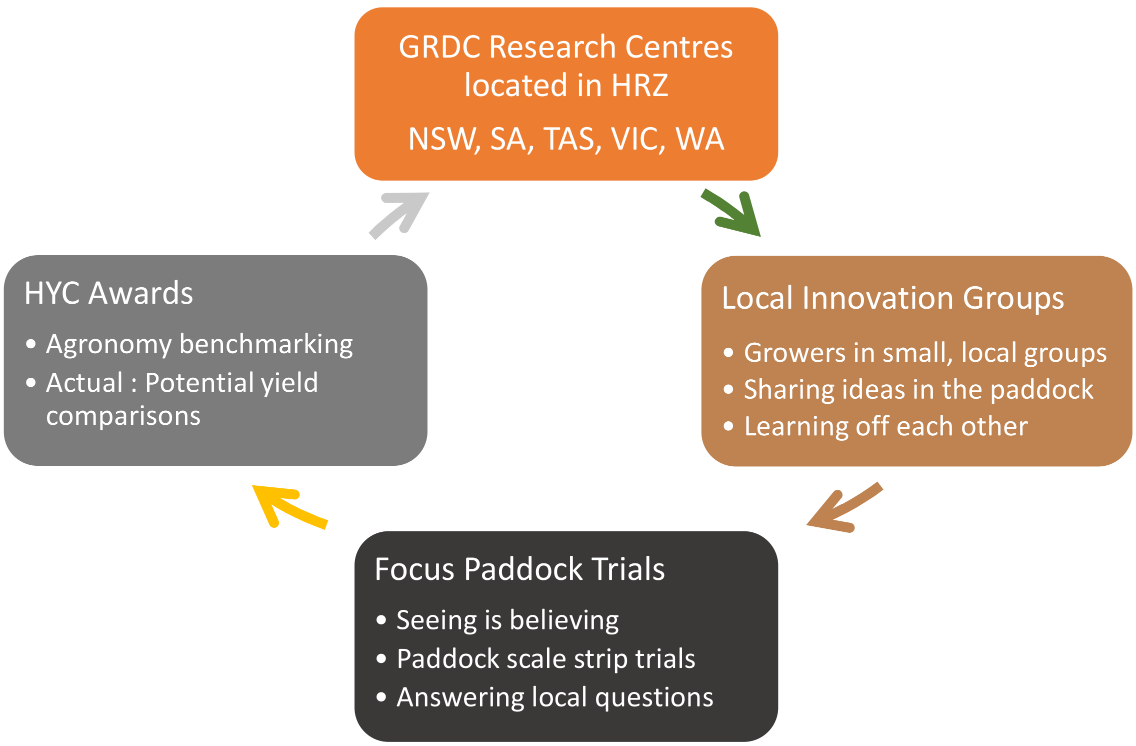
GRDC Hyper Yielding Crops VIC

Jon Midwood, TechCrop

In 2020 the GRDC Hyper Yielding Crops project started. The project is being conducted in Victoria, Tasmania, South Australia, New South Wales, and Western Australia, with each state hosting a GRDC Centre of Excellence. These sites have been selected to run research trials to help determine some of the major factors growers and advisors can use, in their specific environment, to achieve optimum yields through variety and agronomic management of wheat, barley and canola. The following graphic shows the various outputs from the project and how they are inter related with each other:



In combination with the research centres there is a large emphasis on local grower involvement in the project and so in the HRZ of VIC, Southern Farming Systems (SFS) have been contracted to run this part of the project. As the graphic above shows, this involves the setting up of local grower led innovation groups, facilitating and setting up Focus paddock scale trials and gathering information and measurements for the local HYC Award paddocks. Jon Midwood (TechCrop) oversees this part of the project, in a national role, alongside Nick Poole as project leader.

Innovation groups

In 2021 SFS ran four innovation groups in the SW VIC region. All groups had a spring crop walk during August, where the groups met out in a paddock and discussed not only the crops they looked at on the day, but also the specific questions the groups had and whether they could answer the question with a simple paddock strip trial. The layout, assessments and treatments of these strip trials were facilitated by the SFS project officer and as a result a number of different trials were setup.

The following are details from one of these Focus paddock trials.

Focus paddock trials:

1. ***Fungicide timing paddock trial***

Research question: What is the impact on yield from a third foliar fungicide application at GS60 on extending disease control, increasing green leaf area retention and controlling any head diseases.

Paddock details

Crop	Cereal: Wheat
Variety	Accroc
Sow Rate	150.00 kg/ha
Sow Date	16-05-20
Harvest Date	31-01-21
Harvest Yield	10.93 T/ha
Stubble Management	Incorporated
Previous crop	Beans
Row spacing	229mm

Fungicide Treatments

Treatment	Product	Actives	Rate/ha	Growth Stage
1. Control - Grower practice	Prosaro	PTZ + TEB (Gp 3 + 3)	0.3	GS32
	Aviator Xpro	PTZ + Bixafen (Gp3 + 11)	0.5	GS39
2. Trial treatments	Prosaro	PTZ + TEB (Gp 3 + 3)	0.3	GS32
	Aviator Xpro	PTZ + Bixafen (Gp3 + 11)	0.5	GS39
	Avior Gold	EPZ + Amistar (Gp3 + Gp7)	0.32	GS60

Results

Measurement type	Control (Grower)	Treatment 2	Sig Diff (p<0.05)
Yield (t/ha)	10.93	11.84	Yes
Protein (%)	9.5	9.0	No
Screenings (%)	1.94	2.18	No
Test weight (kg/hL)	76.6	76.6	No

Conclusion

The season was a decile 6 and rainfall exceeded the long term average in each month during the spring. The application of Avior Gold (Azoxystrobin and Epoxiconazole) at the start of flowering gave a significant yield increase of nearly a tonne per ha.

HYC Awards

Award paddocks were nominated from the Innovation groups initially, with the aim being to collect and record specific wheat paddock information and to provide an agronomic benchmarking report which compares that paddock to all the others entered, both regionally and nationally. Nominated paddocks had their validated yields compared to a biophysical 'potential yield' for that paddock, which allows for the variability of soil types, rainfall, temperature and radiation across all regions. All agronomic information such as sowing dates, variety, crop development timings, soil data – pH, soil organic carbon, N, P, K etc., and in-season applications were collected by the project officer from SFS. Paddock yields, harvest maturity samples, harvest index calculations and grain samples were also collected for analysis. Reports were sent out to all participating growers allowing them to benchmark their agronomy from over 50 factors and compare it to other growers in their region.

The winner for the highest yield in VIC in 2021 was Will Langley from Winchelsea with a 10.1 t/ha crop of Beaufort wheat sown on 15 May, following a two year break of Beans followed by Canola in 2020.

Will also won the award for the highest yield as a percentage of the potential yield in VIC. His 10.1 t/ha crop of Beaufort wheat was 109% of the 9.22 t/ha calculated potential for his paddock.

The following are an example of some of the agronomic benchmarks produced in the HYC Awards report for VIC in 2021:

Agronomic Factor	Top 20% Award paddocks	Remaining 80%
Yield (t/ha)	9.73	7.43
N applied (kg N/ha)	247	163
N applied per tonne yield kg N/ha)	25	24
Fungicides ($/ha)	$44	$36
Fungicides ($/t)	$4.6/t	$4.8/t
Crop biomass (t/ha)	21	20
Harvest index	53%	49%
Head count (m2)	491	460
Grains per head	35	38
1000 grain weight	46	47

Key take home messages from VIC Award data 2021:

- Highest yielding paddocks targeted appropriate sowing date and variety phenology to achieve GS61 at the optimum timing
- In 2021 top 20% yielding group sowed between 11th – 18th May. In 2021 this was very season dependent!
- Accroc and Beaufort sown at the optimum time in 2021 gave higher yields than Revenue and Rockstar
- Wheat following canola or beans were approx. 0.5t/ha higher yielding than following a wheat.
- On average 2nd wheats received 40kg N/ha more N than those following canola or ~80kg N/ha more than those following beans.
- The higher yielding group spent a little more per ha on fungicides and used higher rates on average than those in the remaining 80%. Their cost/tonne was less!
- The higher yielding group had slightly higher crop biomass at harvest and 4% higher harvest index. They also had higher head counts by ~30/m2

Please contact Ash Amourgis (0439 005071) for information about being part of this exciting project or to enter a wheat crop as a HYC award paddock in 2022.

GRDC Southern Grain Legume Agronomy:
Learnings from 2021 Med – High rainfall production zones

Aaron Vague, Tom Price, Ben Morris, Darcy Warren, Nick Poole, Kenton Porker

Background

A Grains Research & Development Corporation (GRDC) investment across eastern Australia aims to close the economic gap in grain legume production. NSW is led by Brill Ag, Victoria by Agriculture Victoria, and South Australia is led by SARDI. Other regional partners are contributing to the investment, including FAR Australia who managed a pulse spoke site at Buraja/Coreen, Bundalong, and Gnarwarre in the HRZ in 2021. As part of the GRDC Southern grain legumes project we are targeting 6-8t/ha dryland yields in faba beans in NE Victoria and SW Vic, and 4 – 6t/ha at Buraja in NSW.

Disease Management for Faba Beans

This is the key component FAR Australia is addressing in the GRDC Grain Legumes projects in SA, Vic, and NSW. Fungicide products and timing should target the leaves most critical to yield determination. Given beans are indeterminate, pod number is determined in the period prior and post flowering, whereas the number of seeds per pod are determined post flowering (Figure 1). It is important to think about the difference between growth and development and how this links with disease management. Development rate of branches and leaves, the progression towards flowering, pod set and disease development are all influenced by temperature, whereas humidity and rainfall influences disease development. A key feature of the NSW, and Vic NE environment is that humidity and frequency of rainfall events are typically lower than the South, and thus the grower may be able to apply a more practical and flexible approach to disease management. This should include protecting segments of the canopy that are most likely to contribute to yield. The key question we will address in the fungicide trials is **When should we apply fungicides in the canopy to offer the greatest return on yield?**

Here we present disease management results from three contrasting environments across Vic and NSW.

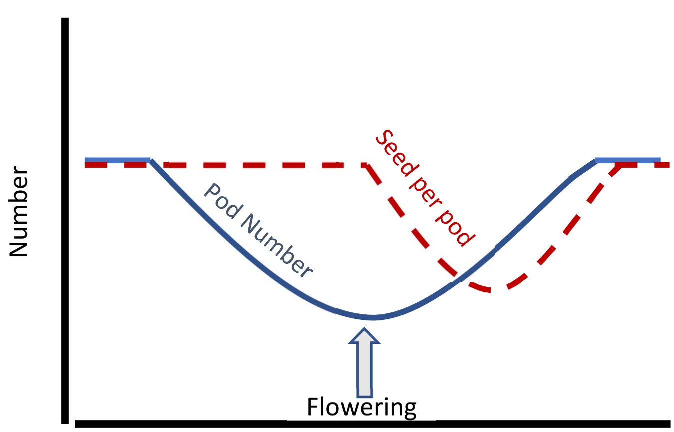


Figure 1. Effect on the timing of stress on (a) pod number and (b) seed per pod. Adapted image and based on shading experiments conducted and published by Lake et al 2019.

Faba Bean Disease Management Trials: Key Learnings from 2021

- Bendoc showed higher levels of chocolate spot due to its poorer genetic resistance to the disease.
- PBA Amberly has improved genetic resistance to disease and at the lower rainfall Buraja site showed no yield response to fungicide.
- At the HRZ SW Vic site untreated yields were 4.43t/ha, and disease managed treatments yielded as high as 7.5t/ha.
- Under high disease pressure similar (similar to 2022) at SW Vic.
  - Working backwards a 1 spray unit 28 days post flower yielded 6.03t/ha, 2 units at 14 days and 28 days post flower yielded 6.42, and 1 at 1st flower, 14 days and 28 days post flower yielded 7.18t/ha.
  - The addition of tebuconazole to at an earlier timing did not further increase yield to a 3 spray strategy.
  - A two-spray strategy combining a SDHI fungicide at 14 days after the first flower yielded similar to a 4 and 3 spray strategy combining cheaper fungicides highlighting the efficacy of this chemistry.

Disease management under higher disease pressure in SW Vic

Table 1. Influence of faba bean cultivar and disease management on grain yield (t/ha) at Gnarwarre 2021.

					Grain Yield (t/ha)					
Trt	4th node	**1st flower**	**1st flower +14 days**	**1st flower +28 days**	**PBA Amberly (MR)**		**PBA Bendoc (S)**		**Mean**	
1	---	---	---	---	4.29	-	4.57	-	**4.43**	**d**
2	---	---	---	Chlorothalonil +Carbendazim	6.01	-	6.05	-	**6.03**	**b**
3	---	---	Chlorothalonil +Carbendazim	Chlorothalonil +Carbendazim	6.25	-	6.59	-	**6.42**	**b**
4	---	Mancozeb	Chlorothalonil +Carbendazim	Chlorothalonil +Carbendazim	7.50	-	6.86	-	**7.18**	**a**
5	Tebuconazole	Mancozeb	Chlorothalonil +Carbendazim	Chlorothalonil +Carbendazim	7.34	-	6.85	-	**7.10**	**a**
6	---	---	Miravis Star	Veritas	7.45	-	6.70	-	**7.08**	**a**
7	---	---	---	Veritas	5.56	-	5.18	-	**5.37**	**c**
Mean					**6.34**	**-**	**6.11**	**-**	**6.23**	
Cultivar LSD p=0.05					ns		P val		0.101	
Fungicide Strategy LSD p=0.05					0.48		P val		<0.001	
Cultivar x Fungicide LSD p=0.05					ns		P val		0.125	

Tebuconazole applied at 145ml/ha, Mancozeb 750 at 2.00L/ha, Chlorothalonil at 2.30L/ha, Carbendazim at 0.50L/ha, Miravis Star at 0.75L/ha and Veritas at 0.75L/ha

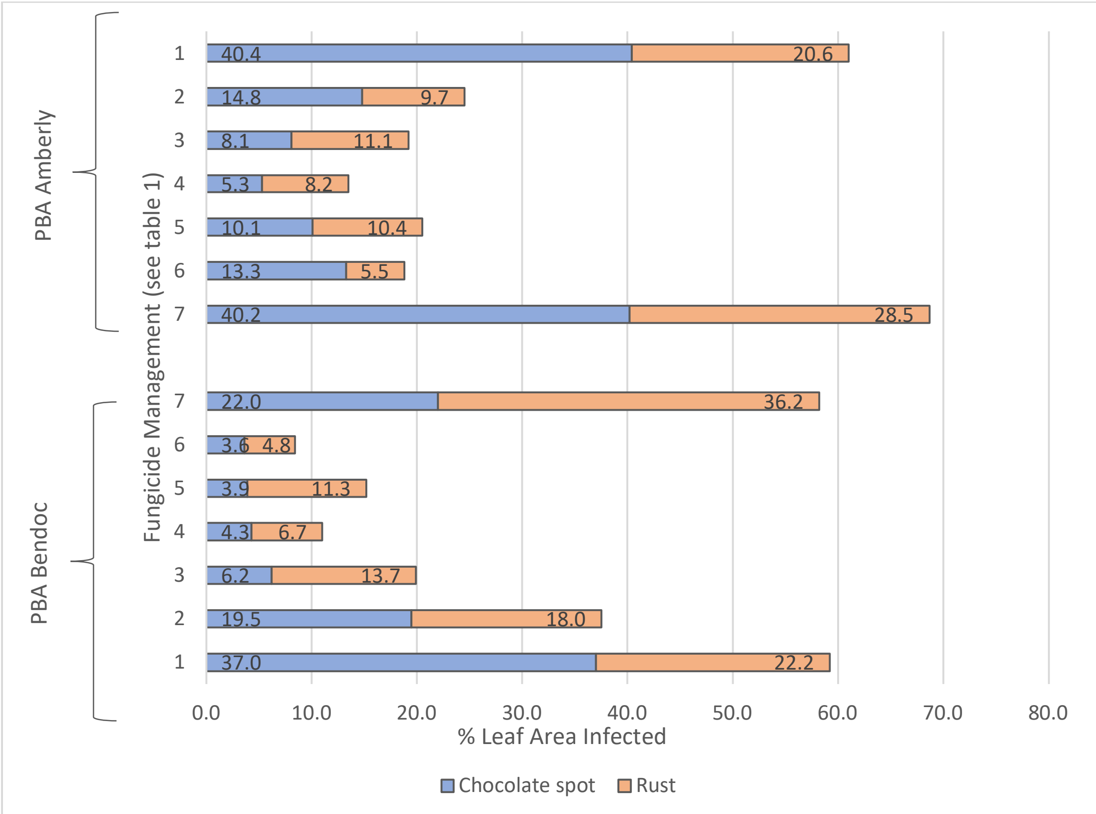


Figure 2. *Effect of fungicide strategy on disease (chocolate spot and rust) on the top third of the canopy (% leaf area infected), assessed on 9 November.*

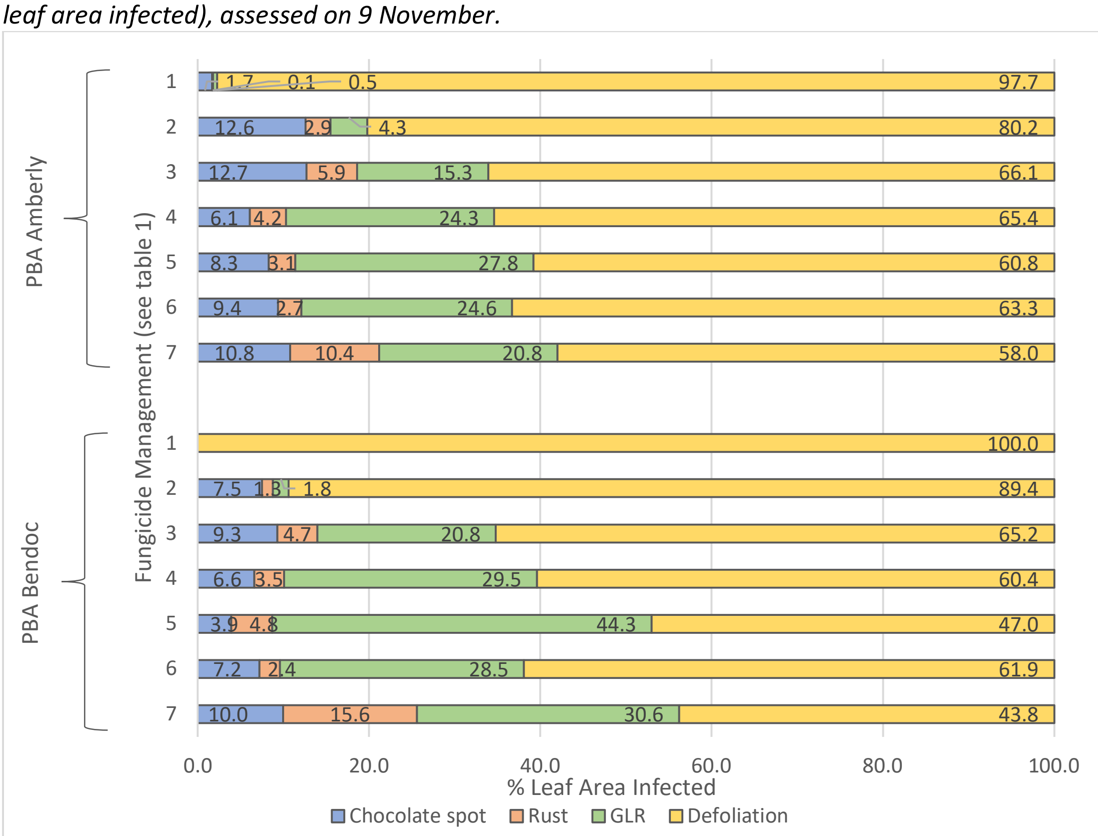


Figure 3. *Effect of fungicide strategy on disease (chocolate spot and rust) and green leaf retention on the middle third of the canopy (% leaf area infected), assessed on 9 November.*

Table 2. *Details of the management levels (kg, g, ml/ha).*

Sowing date:		**1 May**
Variety:		PBA Amberley & PBA Bendoc
Seed Rate:		24 Seeds/m2
Sowing Fertiliser:		100kg MAP
Inoculant		Nodulator
Nitrogen:		Nil
Fungicide:		As per treatment list

Legume Nutrition

The use of grain legumes has the potential to reduce N inputs and increase N use efficiency in following crops and improve overall soil quality. Research has demonstrated that bagged (synthetic) N alone is not necessarily capable of supplying the crop with enough to achieve hyper yielding crops (canola yields >4t/h, and cereal yields >8t/h). As a general rule of thumb, on average 20kg of shoot-N per tonne of dry matter is fixed by grain legumes and the actual amount of N fixed will vary depending on soil type, management, species, and season in the order of 15 — 25 kg (Peoples et al. 2009). However, a very important consideration that is often overlooked is the fact that the N fixation component provides the majority of the N demand of the grain legume crop itself, and a large part of the fixed N is exported in the grain, nodulation may also be reduced on acid soils and N maybe required. A nutrition trial was established at all sites with the aim to investigate whether yields of pulses may be limited by Nitrogen and or micronutrients.

2021 Key Learnings Nutrition Reponses

- There was evidence of improved yields with N at SW Vic. With untreated yielding 6.9t/ha, compared to 7.47t/ha when 200kg N of was applied. Additional trace elements did not further increase yield.
- These data highlight the at high yield potentials the crop may require extra N to achieve a higher yield potential, this will impact nodulation and requires for investigation.
- In the HRZ site at Gnarwarre, seeding density was more important than nutrition. Higher seed densities were beneficial in 2021, 12 seeds/m^2 yielded 6.1t/ha, 25 seeds/m^2 at 7.1t/ha, and 7.79t/ha at 35 seeds/m^2 in PBA Amberley respectively

Crop Nutrition and Seeding Density Experiment in SW Vic

Key Points:

- Higher seed densities were beneficial in 2021, 12 seeds/m^2 yielded 6.1t/ha, 25 seeds/m^2 at 7.1t/ha, and 7.79t/ha at 35 seeds/m^2 in PBA Amberley respectively.
- Samira yields were 7.48t/ha, Amberley 7.1, and Bendoc 6.61t/ha.
- There was also evidence of improved yields with N at SW Vic. With untreated yielding 6.9t/ha, compared to 7.47t/ha when 200kg N of was applied. Additional trace elements did not further increase yield.

Table 1. Influence of faba bean cultivar, seed rate (seeds/m^2) and nutrition on grain yield (t/ha).

Trt	Variety	Seeds (m^2)	Nitrogen (kg N/ha)	Trace Elements	Grain Yield (t/ha)	
1	PBA Amberly	25	---	---	6.90	cd
2	PBA Amberly	25	---	TE and Moly	7.11	bcd
3	PBA Samira	25	---	TE and Moly	7.48	ab
4	PBA Bendoc	25	---	TE and Moly	6.61	d
5	PBA Amberly	25	200N	---	7.47	ab
6	PBA Amberly	25	200N	TE and Moly	7.35	abc
7	PBA Amberly	12	---	TE and Moly	6.10	e
8	PBA Amberly	35	---	TE and Moly	7.79	a
Mean					7.10	
LSD 0.05					0.51	
P Val					<0.001	
CV					4.89	

Table 4. Influence of seed rate (seeds/m^2) and nutrition on canopy structure at crop maturity for PBA Amberly.

Treatment	Dry Matter		Stems		Stem height		Pods		Lowest pod height		Highest pod height		Pod length on stem		Pod-stem density	
Seed rate (m^2) + Nutrition	t/ha		m^2		cm		m^2		cm		cm		cm		Pods/ m	
25	19.1	-	57.2	-	128.6	-	654.9	-	38.1	b	88.2	-	50.2	-	22.8	-
25 +TE	17.2	-	50.6	-	129.3	-	559.6	-	42.1	b	95.2	-	53.1	-	21.3	-
25 +N	18.0	-	56.1	-	130.3	-	566.4	-	41.3	b	91.2	-	49.9	-	20.8	-
25 +N +TE	15.6	-	51.7	-	134.0	-	566.0	-	43.4	b	97.9	-	54.6	-	20.8	-
12 +TE	23.0	-	55.6	-	128.6	-	663.4	-	40.3	b	94.1	-	53.8	-	22.3	-
35 +TE	14.5	-	57.2	-	125.3	-	547.1	-	51.0	a	90.3	-	39.3	-	24.2	-
Mean	17.9		54.7		129.4		592.9		42.7		92.8		50.1		22.0	
LSD 0.05	ns		ns		ns		ns		7.2		ns		ns		ns	
P Val	0.764		0.950		0.749		0.628		0.027		0.540		0.100		0.527	

Table 5. *Details of the management levels (kg, g, ml/ha).*

Sowing date:		**1 May**
Variety:		PBA Amberley, PBA Samira & PBA Bendoc
Seed Rate:		As per treatment list
Sowing Fertiliser:		100kg MAP
Inoculant		Nodulator
Nitrogen:		As per treatment list
Fungicide:	4 Node	Tebuconazole 145ml/ha
	1st Flower	Mancozeb 750 2.0l/ha + Procymidone 240g/ha
	1st Flower+ 14 days	Chlorothalonil 2.3l/ha + Carbendazim 0.5l/ha
	1st Flower+ 28 days	Veritas 0.75l/ha

What makes up a 7t/ha Faba Bean Crop?

Hyper yielding pulse crops are achievable in Northern Vic/Southern NSW. When looking at what makes up a 7t/ha faba bean crop (Table 6), biomass at harvest seems to be a driver for high yields. At Bundalong in 2021, early sowing and a favourable growing season allowed for a biomass production of 14t/ha and with a harvest index of close to 50% was able to convert most of this to yield. At Dookie in 2020 however, a late sowing date didn't give the crop the opportunity to produce the biomass needed to generate hyper yields.

While N content has yet to be calculated, based on our estimates (and using 20kg N fixed per tonne of dry matter rule of thumb) the dry matters achieved equates to between 180 – 280kg N fixed between the lowest and highest treatment, and shows the importance of crop nutrition for N fixation. This is not factoring in how much N would be exported in the crop nor the result of poor nodulation on lower ph. soils, or under higher N treatments. Grain yield, harvest index, and nitrogen removal results have not been processed at the time of publication.

Table 6. Yield components of faba bean crops. Dookie and Bundalong cv. PBA Samira, Finley cv. PBA Bendoc.

Yield Component	Dookie 2020 (Sown 14 May)	Bundalong 2021 (Sown 20 April)	Finley 2020 (Sown 28 April, Irrigated)
Plants/m^2	22	19	20
Stems/m^2	77	58	60
Pods/stem	5.4	8.8	7.6
Pods/m^2	404	491	453
Harvest Dry Matter (t/ha)	9.4	14.0	13.6
Grain Yield (t/ha)	4.0	7.4	7.5
Harvest Index (%)	38.7	47.7	47.4

At Finley, our irrigated research centre, we are able to sow slightly later than dryland as we have the ability supply water when the crop needs it to allow biomass production during the growing season and allow for the best ability to fill pods come the end of the season.

Acknowledgements

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