Hyper Yielding Crops (HYC) and Pulse Agronomy Field Day

14th and 15th October 2021

Inverleigh-Winchelsea Rd, Winchelsea VIC 3241

Regional HYC project partner

Regional Pulse Agronomy project partner

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

SOWING THE SEED FOR A BRIGHTER FUTURE

VISITOR INFORMATION

We trust that you will enjoy your day with us at our Victoria Crop Technology Centre Field Day. Your health and safety is paramount, therefore whilst on the property we ask that you both read and follow this information notice.

HEALTH & SAFETY

- COVID-19: Please ensure you practice social distancing rules, wear a face mask at all times and use the hand sanitiser provided.
- All visitors are requested to follow instructions from FAR Australia staff at all times.
- All visitors to the site are requested to stay within the public areas and not to cross into any roped off areas.
- All visitors are requested to report any hazards noted directly to a member of FAR staff.

FARM BIOSECURITY

- Please be considerate of farm biosecurity. Please do not walk into farm crops without permission. Please consider whether footwear and/or clothing have previously been worn in crops suffering from soil borne or foliar diseases.

FIRST AID

- Should you require any assistance, please ask a member of the FAR Australia team.

LITTER

- We ask that you dispose of all litter considerately.

VEHICLES

- Vehicles will not be permitted outside of the designated car parking areas. Please ensure that your vehicle is parked within the designated area(s).

SMOKING

- There is No Smoking permitted inside any marquee or gazebo.

Thank you for your cooperation, enjoy your morning.

COVID-19

Help us keep COVID-19 away

If you are visiting FAR Australia offices or trial sites, please observe the following good hygiene practices to reduce the risk of COVID-19 infection:

- Sanitise your hands when entering the office or trials site and at regular intervals.

- Wash your hands regularly for 20 to 30 seconds. If soap and water is not available, use an alcohol-based hand sanitiser. Hand sanitiser does not replace washing your hands after using the bathroom.

- Avoid touching your eyes, nose and mouth.

- Cover your mouth and nose when coughing and sneezing with a tissue or cough into your elbow.

- Dispose of used tissues into a bin immediately and wash your hands afterwards.

- 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.

WELCOME TO THE 2021 VICTORIA CROP TECHNOLOGY CENTRE FIELD DAY

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

On behalf of both project teams, I am delighted to welcome you to the 2021 Victoria Crop Technology Centre Field Day. The centre currently hosts two research projects – The GRDC's Hyper Yielding Crops (HYC) project and the GRDC's Pulse Agronomy project.

The GRDC's Hyper Yielding Crops project is a national initiative led by FAR Australia in collaboration with a number of project partners; here in Victoria we are working closely with regional partner Southern Farming Systems.

The GRDC's Pulse Agronomy project is led by Agriculture Victoria in collaboration with FAR Australia.

Today you will have an opportunity to discuss the following:

Hyper yielding Crops:
(Led by Dr Kenton Porker, Darcy Warren, Kat Fuhrmann – FAR Australia).

Canola:
• What does a 5t/ha Canola crop look like?

Cereals
• Water logging lessons in 2021.
• Making fungicides work in new genetics and changing resistance.
• Strategies to achieve 10t/ha.

GRDC Victoria Grain Legumes Closing the economic gap (Led by Jason Brand, Agriculture Victoria and Kat Fuhrmann, FAR Australia).

• Disease & canopy management of Faba Beans

Should you require any assistance throughout the day, please don't hesitate to contact a member of the FAR Australia team who will be more than happy to help.

If you would like to learn more about the results from these GRDC investments, please contact Rachel Hamilton at rachel.hamilton@faraustralia.com.au.

Thank you once again for taking the time to join us today; we hope that you find the presentations useful, and as a result, take away new ideas which can be implemented in your own farming business. Have a great day and we look forward to seeing you again at future project events.

Nick Poole, Managing Director, FAR Australia

Funding Acknowledgements
The Hyper Yielding Crops and Pulse Agronomy project teams would like to place on record their grateful thanks to the Grains Research & Development Corporation (GRDC) for their funding support for this event and featured projects.

Other Acknowledgements
Thank you to our host farmer Ewan Peel for all his support throughout the season.

What are these projects aiming to achieve and how did they originate?

<u>Hyper Yielding Crops</u>

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 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 this project contact:

Rachel Hamilton – HYC Communications and Events, FAR Australia (rachel.hamilton@faraustralia.com.au)
Nick Poole – HYC Project Leader, FAR Australia (nick.poole@faraustralia.com.au)
Jon Midwood - HYC extension coordinator, Techcrop (techcrop@bigpond.com)
Ashley Amourgis, Vic HYC Project Officer, Southern Farming Systems, (aamourgis@sfs.org.au)

Pulse Agronomy Project

A new Grains Research & Development Corporation (GRDC) Investment across eastern Australia aims to close the economic gap in grain legume production. South Australia is led by SARDI (Penny Roberts), Agriculture Victoria (Jason Brand) in Victoria, 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:

Rachel Hamilton – HYC Communications and Events, FAR Australia (rachel.hamilton@faraustralia.com.au)
Darcy Warren – Managing Personnel, FAR Australia (darcy.warren@faraustralia.com.au)

Victoria Crop Technology Centre 2021 Weather Update

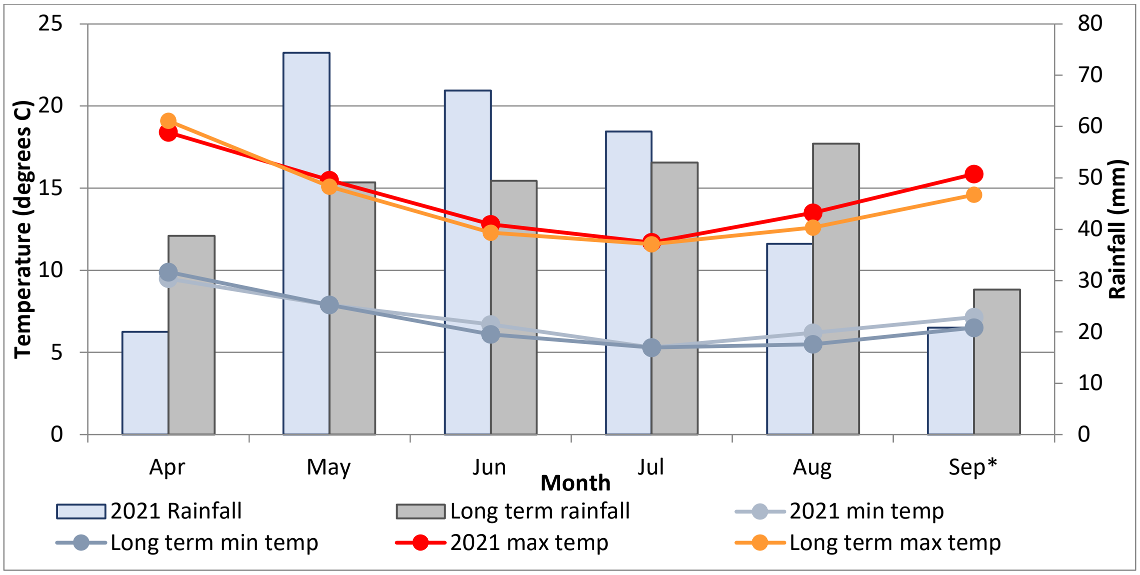

Figure 1. 2021 growing season rainfall so far (as of 15 September) and long-term rainfall (1898-2021) (recorded at Winchelsea (Post Office)), 2021 min and max temperatures and long-term min and max temperatures (2000-2021) (recorded at Colac (Mount Gellibrand)) for the growing season. *Rainfall April to September 15= 278.4mm (Decile 5).*

Note: Rainfall recorded from May to July was higher than the long term averages for those months. High rainfall in January and March meant a full profile of water was present in April
(Jan- Mar Decile 8-9)
**Mean in September also adjusted for the first 15 days of the month.*

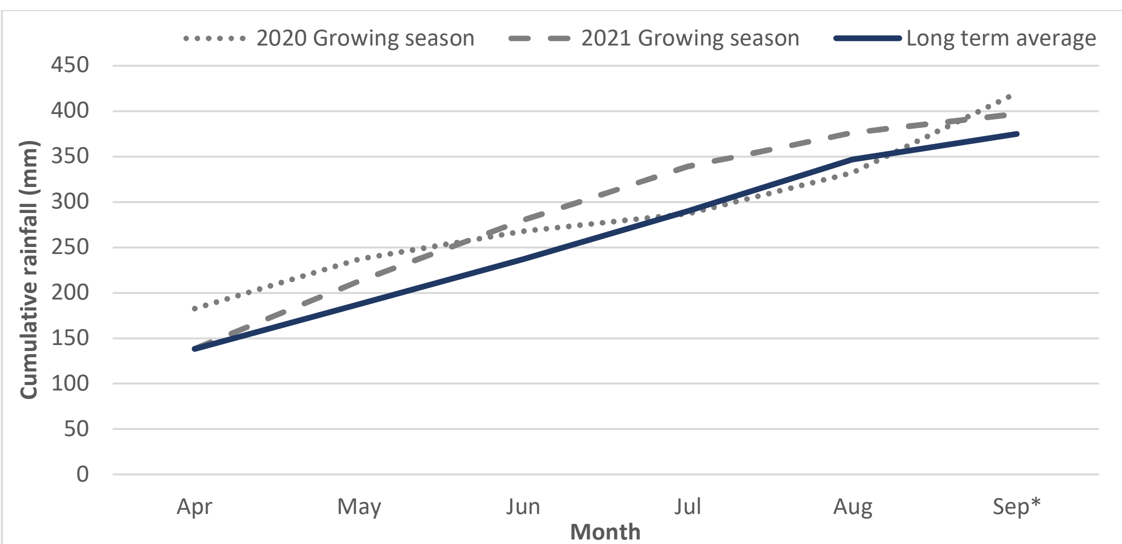

Figure 2. Cumulative growing season rainfall for 2020, 2021 and the long-term average for the growing season.

Hyper Yielding Canola – results from 2020 and research going forward

Rohan Brill, Agronomist Brill Ag.

Key Points

- In 2020, focusing on varieties that achieved both greater biomass but developed at the right time were the most important factor improving harvest index and yield in Hyper yielding Canola trials at Wallendbeen NSW, Gnarwarre Victoria and Millicent SA.
- Nutrition management was the second most important factor, particularly maintaining higher rates of soil fertility
- Fungicide management and seeding rate had small effects on yield outcomes

Yield targets and yields achieved in 2020

The aim of the canola component of the Hyperyielding Crops project is to determine management practices that achieve 5 t/ha canola grain yield in high yield potential environments. Highest yields were close to 5 t/ha (Victoria and South Australia) and above 5 t/ha (NSW) in 2020. At each site, variety choice was the most important factor determining differences in grain yield outcomes. Nitrogen management was the second most important factor at all sites. Fungicide management was a small factor in NSW and Victoria but not significant in South Australia. Altering plant population targets from 15 to 75 plants/m^2 had no effect on yield in NSW or Victoria, but there was a small penalty from the lowest population in South Australia.

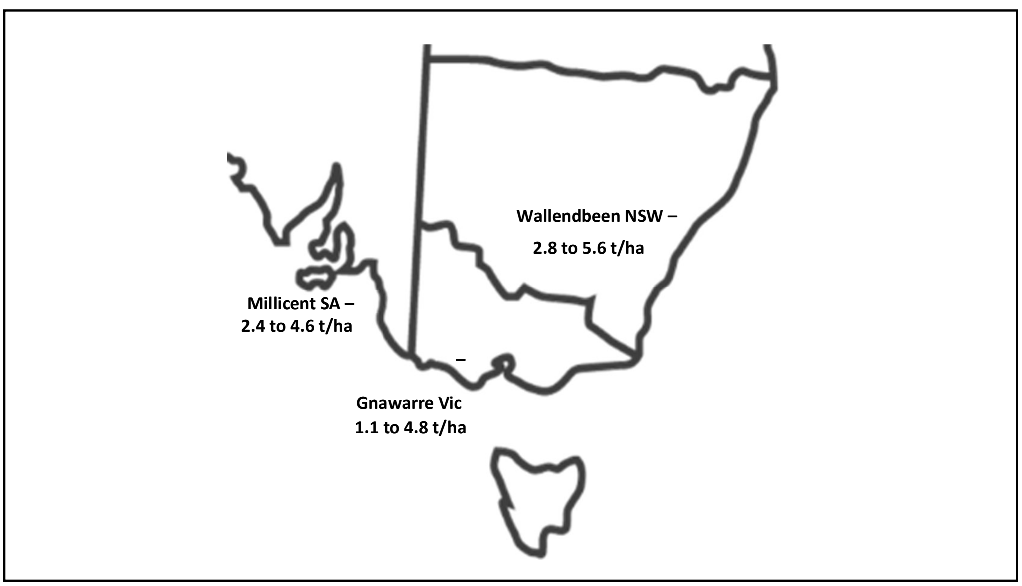

Figure 1 – *Yield of the highest and lowest yielding treatments at three Hyperyielding canola sites in 2020.*

Crop nutrition for Hyperyielding canola

At canola grain yield > 4 t/ha, how can variety choice be more important than nutrient management? In 2020, the Gnawarre site had 78 kg/ha of mineral nitrogen in the top

60 cm of soil. This would be enough to contribute about 1 t/ha of canola grain. More importantly, the site had 2.4% Organic Carbon. With this OC, estimated mineralisation would have been approximately 144 kg/ha. Combined with starter fertiliser, there was enough N to grow about 3 t/ha of canola with no extra N applied, which is close to what was achieved in the nil N treatment in Table 1. There was still a strong yield response to extra applied nitrogen, but not as much as the difference between the highest and lowest yielding varieties in other trials at the site. The application of all N at sowing did not improve yield compared to nil N, but there was no effect of timing when N was applied anywhere from 6-leaf stage to start of flowering.
Most importantly, the yields of between 4.5 and 5 t/ha would not have been achieved if there was not enough paddock fertility to grow > 3 t/ha unfertilised.

Table 1: Response of canola (45Y28 RR) to a range of fertiliser treatments at Gnarwarre, Victoria 2020.

Trt.	**Treatments**	**Nitrogen Kg N/ha**						**Yield (t/ha)**		**Mean (%)**
		Sowing	6L	BV	SF	MF	Total			
1	Nil	16	---	---	---	---	16	3.22	b	74.8
2	33.3%	16	30	---	---	---	46	4.53	a	105.2
3	200%	16 + 90	30	30	30	---	196	4.73	a	110.0
4	100% Upfront	16 + 90	---	---	---	---	106	3.42	b	79.6
5	100% Split	16	30	30	30	---	106	4.61	a	107.1
6	100% Bud visible	16	---	90	---	---	106	4.47	a	103.9
7	100% Start flower	16	---	---	90	---	106	4.49	a	104.3
8	100% Split late foliar	16	30	30	15*	15*	106	4.47	a	103.9
9	100% Split + Manure	16	30	30	30	---	106	4.78	a	111.1
							Mean	4.30		100.0
							LSD (p=0.05)	0.51		11.7
							P Val	<0.001		<0.001

2021 trial program

Pasture and pulse crops can increase organic N availability in the soil which in turn will drive high yield potential. In Hyperyielding canola trials across Australia in 2021, high quality animal manure treatments have been included to determine if they can substitute for the valuable pasture or pulse crop to drive Hyperyielding canola crops.

Hyperyielding canola results

Full results from 2020 are available at https://faraustralia.com.au/wp-content/uploads/2021/04/210325-HYC-Project-2020-Results-Canola-Final.pdf. Results from 2021 will also be made available through the FAR Australia website and various other channels such as through social media and GRDC Updates.

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

Achieving hyper yielding barley crops in Southwest Victoria

Kenton Porker, Nick Poole, Darcy Warren, Tracey Wylie, Aaron Vague, Max Bloomfield, James Rollason, Greta Duff, Brett Davey

Background

The GRDC and FAR Australia led barley Hyper Yielding Crops program has a national framework incorporating genetics x environment x management (GxExM) field experiments to increase yield in the higher rainfall zones. We have an aspirational target to reliably achieve 10t/ha grain yield in all regions of the High Rainfall Zone and remain competitive with wheat. However, the big question is whether the management and germplasm required across the regions is different to achieve this goal of 10t/ha?

After the first year of results there are distinctive differences between regions that help us to dissect the management and genetics required for each high rainfall zone. The fundamental principles of high productivity do not change across rainfall zones, but the timing of aligning critical yield forming periods and intensity of management intervention changes with environment.

Yields were maximised at Gnarwarre through a canopy management program that increased the conversion of biomass into yield by either maintaining green leaf area and or ensuring crops were standing and intercepting light during the critical period

When is the critical period – how does it relate to yield potential and flowering date?

It is important to ensure crops flower on time and are matched to environment, however other constraints such as managing disease, lodging, disease, and waterlogging play an equally important role in Southwest Victoria unlike some other regions. Flowering date is determined by sowing date, variety selection, and to some extent grazing intensity and timing. The reason this is so important is that flowering time aligns the critical period for grain number accumulation. This period is typically 21 days before awn emergence in barley. Across all hyper yield environments an elite screen was conducted in 2020 with the objective to examine the yield potential of new winter and spring germplasm grown under hyper yielding management packages against spring and winter controls in the traditional late April/early May sowing window.

- Six row winter barley was introduced to Australia and evaluated in yield plots for the first-time and flowered during the optimum period in the SA and Vic crop technology centre but were too late in WA. The 6-row winter Pixel was the most consistent winter variety performer and has been progressed to management trials at all HYC centres in 2021.
- Figure 1 shows the relative flowering date of spring germplasm versus winter germplasm from late April sowing in 2020 in Victoria, with Rosalind and RGT Planet being typically earlier, while winter barley flowered at a more optimal time (similar to the highest yielding wheats).
- Despite differences in flowering time the best yielding winter cultivar yielded similar to RGT Planet and Rosalind. This was due to other yield constraints such as lodging, head loss and poor light conditions in October 2020.

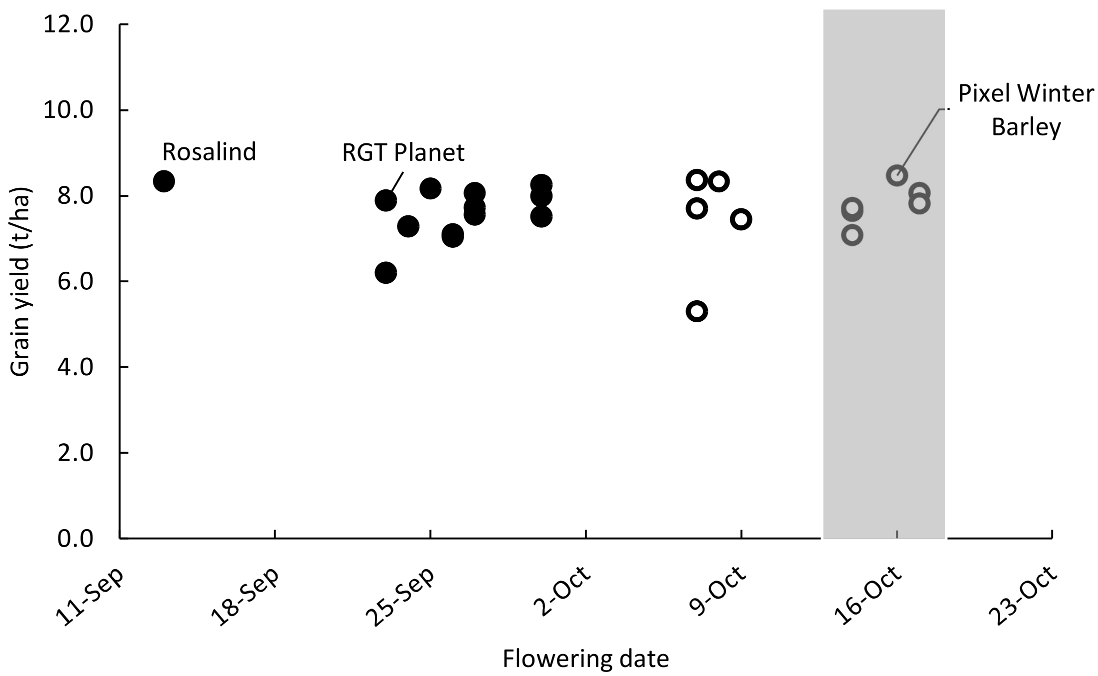

Figure 1. *Flowering time and grain yield responses of spring cultivars (•) and winter cultivars (◦) in the elite screen from late April sowing at Gnarwarre in 2020. Shaded box is the optimal flowering period for wheat at Gnarwarre.*

Yield responses across HRZ environments

- The yields achieved by the highest yielding 2 and 6 row winter barley were comparable with the spring barley control RGT Planet in Vic but not at any other sites due to head loss and lodging in SA, and flowering too late and thus heat and drought in WA (table 2).
- RGT Planet and Rosalind remain among the highest yielding cultivars across all centres and are broadly adapted despite flowering earlier than most other cultivars and remain the benchmarks in adaptation and yield performance.
- Yields greater than 10t/ha were achieved in spring sown barley in Tasmania and the cultivar Laureate was the highest yielding at 11.4 t/ha. This becomes the benchmark yield for the remainder of the project.

Table 1. *Grain yield (t/ha) of the relevant spring controls and best performing introduced or alternate spring, 2 row winter and 6 row winters at each crop technology centre. Shaded treatments within a site are statistically the highest yielding treatments for the site.*

CTC	Rosalind (Fast Spring Control)	RGT Planet (spring control)	Best Spring Alternative		Best 2 Row Winter		Best 6 Row Winter	
SA TOS1[1]	8.3	8.7	9.7	AGTB0245	7.4	Newton	7.1	Pixel
SA TOS2[1]	8.9	9.6	9.8	Laureate	7.3	Cassiopee	---	
Vic[2]	8.3	7.8	8.2	GSP1727-B	8.4	Madness	8.5	Pixel
WA[1]	4.8	4.6	4.9	Laperouse	3.9	Urambie	2.9	Pixel
Tas (spring)[1]	9.2	10.4	11.4	Laureate	---		---	

[1] sites received one PGR, [2] sites received 2 PGR.

Sowing winter or spring barley in SW Victoria?
While it is generally considered early sowing is favoured for southwest Victoria due to maximizing biomass and managing water logging. There are differences in crop development and for managing constraints such as disease, waterlogging damage, and lodging that need to be considered.

Winter barley should in theory work well for southwest Victoria, due to its superior disease resistance and preferred development pattern for earlier sowing. There is a significant gap between the onset of stem elongation and flowering time of spring germplasm compared to winter types from earlier sowing. Early sown crops are generally more tolerant to water logging if the water logging occurs early in the vegetative phase, meaning they can recover yield. However, if like 2021 early sown spring barley develops quickly and the period between stem elongation and awn appearance (critical period) is under waterlogging stress the yield penalty is likely to be greater than later sown crops.

The alternative to this maybe slower developing cultivars Winter which would enable earlier sowing (prior to wet conditions) but they will remain vegetative and more tolerant for longer in the growing season.

In addition, in regions of the HRZ that are more prone to frost the spring types may develop too quickly from April sowing dates and leave crops vulnerable to frost damage. However, as our recent data has highlighted the biggest constraint in winter barley is lodging and head loss. This will require intensive management utilising PGRs and or Grazing.

What else can we achieve with crop management? Exploiting management to better match genetics to environments
The objective of the Genotype x Environment x Management (GEM) trial series was to assess the performance of winter and spring barley germplasm managed under four different management intensities (mid-April to early May sown) at two levels of fungicides. Other management factors included canopy intervention such as the addition a PGR, defoliation and additional Nitrogen.

The data from the GEM confirms findings above for Vic and highlights the effect of cultivar compared to management across environments. The spread between box plots in the visual demonstration below (figure 2) highlights the effect of cultivar, and the spread within the box plot represents the difference in management. Within each boxplot all levels of management are included. At SA, WA, and TAS the effect of cultivar was greater or equal to the variation possible with management, whereas at Victoria management was more important than cultivar. None the less in Planet the effect of management could influence grain yield by + or – 1 t/ha, and a 2 tonne difference between best and worst management in Vic in Planet.

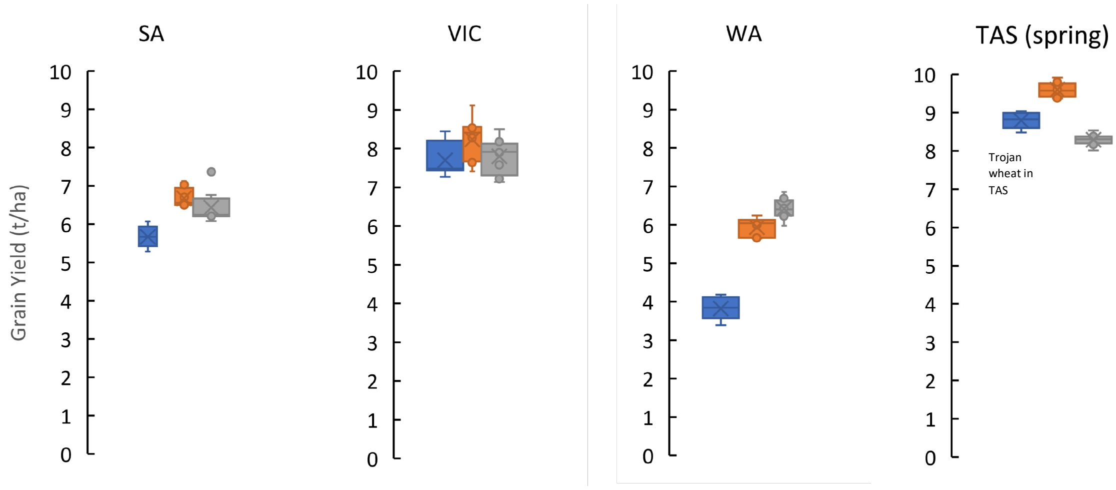

Figure 2. *Boxplot representation blue (•Cassiopee winter barley (Trojan in Wheat in TAS), •RGT Planet, and •Rosalind) grain yields across all management combinations (n = 8 per box plot) and environments (blue = trojan wheat in TAS spring sown).*

Achieving more yield with Planet?
RGT Planet has been the most reliable spring barley and remains the yield benchmark from all sowing dates including early sowing due to its yield potential and standability. Its biggest 'achilles heel' is disease and will need an extremely robust fungicide program.

The key to achieving higher yields in Planet at Gnarwarre in 2020 was a **canopy management program** that **improved the conversion of biomass into grain yield** (higher harvest index) through a fungicide program that managed disease and kept leaves greener for longer, and defoliation that delayed the timing crops were intercepting maximum light interception into more optimal light conditions (figure 3). Other data from SA suggests similar yields can be achieved by later sowing with cheaper fungicide programs.

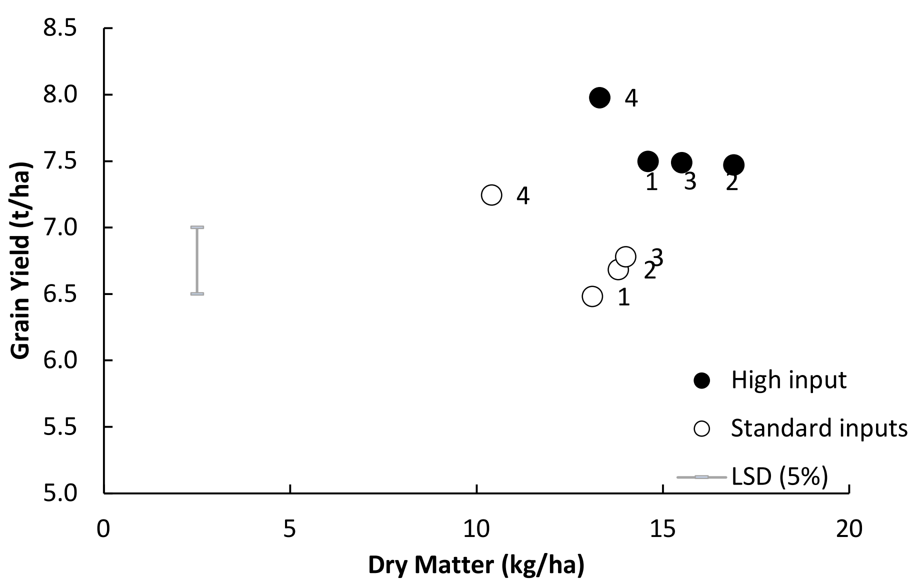

Figure 3. *Relationship between dry matter and grain yield at Gnarwarre in 2020 in RGT Planet under standard and high fungicide inputs. (o) Standard = 500ml Tilt at GS30, followed by 300ml Prosaro at GS39, (•) High Input = 840ml Radial at GS30, followed by 500ml Aviator Xpro at GS39*

The effect of higher input fungicides was significant irrespective of other management practices labelled 1 – 4.

1. Low N
2. High N
3. High N + PGR
4. High N + Defoliation (GS30)

Low N = 148 kg N/ha, and High N = 186 kg N/ha. PGR was applied as 200ml Moddus Evo at GS30 followed by 200ml at GS37. The defoliation was achieved by mowing at GS30.

Disease management in an era of fungicide resistance and reduced sensitivity in cereals

***Nick Poole*[1]*, Tracey Wylie*[1]*, Darcy Warren*[1]*, Kat Fuhrmann*[1]*, Aaron Vague*[1]*, Ben Morris*[1]*, Tom Price*[1]*, Kenton Porker*[1]*, Greta Duff*[2]*, Rohan Brill*[3]** *and* ***Kylie Ireland*[4]**
[1]Field Applied Research (FAR) Australia, [2]Southern Farming Systems (SFS), [3]Brill Ag.
[4]Australian Fungicide Resistance Extension Network (AFREN)

GRDC project code: FAR2004-002SAX, FAR00003, AFREN project (Australian Fungicide Resistance Extension Network) CUR1905-001SAX

Keywords: Disease Management Strategies, Integrated Disease Management (IDM), Fungicide Resistance, Septoria Tritici Blotch (STB), Net Form of Net Blotch (NFNB), Group 11 Quinone Outside Inhibitors - QoI (Strobilurins) and Group 7 Succinate Dehydrogenase Inhibitors (SDHIs), Fungicide resistance

Take home messages

- In seasons that favour higher yield potential, 2020 Hyper Yielding Crop (HYC) research has indicated that one of the most important components in growing high yielding cereal crops is disease management.
- However, fungicide resistance and reduced sensitivity needs to be minimised through integrated management approaches which allow us to successfully and profitably use less fungicide.
- The number of fungicide applications over time is a key driver fuelling the shift (the selection of more resistant strains) in pathogen populations towards fungicide resistance.
- To 'slow the train', growers and advisers need to adopt anti resistance measures when using fungicides that avoid repeating the same active ingredients, and wherever possible, in an integrated disease management (IDM) approach.
- Integrated management strategies include rotating chemistries, using less disease susceptible cultivars and cultural practices to minimise disease.
- A key part of HYC research has been to see if we can use genetic resistance to delay disease progression and fungicide intervention. The aim of this is to encourage less use of fungicide with applications only at key timings to protect the most important leaves.
- Where genetic resistance in wheat cultivars is not sufficient to delay fungicide decisions until later in stem elongation, look to target the following three key timings for fungicide intervention; first node GS31, flag leaf emergence GS39 with an optional third application at head emergence GS59.
- In barley two timings are essential in order to maximise returns with an option for seed treatment in high disease pressure scenarios. These timings were identified as GS31 and awn tipping GS49.
- Avoid repeated use of the same fungicide active ingredients, and in the case of the newer Group 11 QoI (strobilurins) and Group 7 SDHIs, where possible restrict

strategies to just one application per season in order to slow down and help prevent the selection of resistant strains.

So how can we maximise productivity and minimise fungicide resistance development in seasons of high disease pressure?

Firstly, we need to know which are the most problematic pathogens for resistance development, since whilst it's advisable to adopt integrated disease management IDM principles for all diseases, some pathogens are more problematic than others. In Australia it's powdery mildew in wheat (WPM) and barley (BPM), net blotches in barley (both spot and net form) and Septoria tritici blotch (STB) in wheat that are currently the main pathogens affected (Table 1). In addition, the risk of resistance development in these pathogens varies with fungicide mode of action.

- Group 11 QoIs (strobilurins) are at the highest risk of pathogen resistance development, particularly the pathogens responsible for Septoria tritici blotch (STB) in wheat and powdery mildew. Both these pathogens have now overcome strobilurins in different regions of Australia, but so far it is not an issue in WA. Note that the newly discovered barley disease *Ramularia* has overcome Group 11 in Europe and New Zealand.
- Group 7 SDHIs are at moderate to high risk of resistance development in the pathogen with evidence in New Zealand and Europe of pathogen shifts in sensitivity to Ramularia leaf spot in barley and net blotch and STB in Europe. Net blotch pathogens are currently our biggest issue in Australia with reduced sensitivity identified in spot form of NB in WA and net form in regions of SA and Victoria.
- Group 3 DMIs Demethylase Inhibitors (DMIs – triazoles) are generally considered at low to moderate risk, however recent developments in WA in the net blotch pathogen have challenged this view.

Table 1. *Fungicide resistance and reduced sensitivity cases identified in Australian broad acre grains crops.*

Disease	Pathogen	Fungicide Group	Compounds affected	Region	Industry implications
Barley powdery mildew	*Blumeria graminis* f.sp. *hordei*	3 (DMI)	Tebuconazole, propiconazole, flutriafol	Qld, NSW, Vic, Tas, WA	Field resistance to some Group 3 DMI fungicides
Wheat powdery mildew	*Blumeria graminis* f.sp. *tritici*	3 (DMI)	None	NSW, Vic, Tas, NSW	This is a gateway mutation. It does not reduce the efficacy of the fungicide but is the first step towards resistance evolving.
		11 (QoI)	All group 11	Vic, Tas, SA, NSW	Field resistance to all Group 11 fungicides
Barley net-form of net blotch	*Pyrenophora teres* f.sp. *teres*	3 (DMI)	Tebuconazole, propiconazole, prothioconazole	WA	Reduced sensitivity that does not cause field failure

		7 (SDHI)	Fluxapyroxad Bixafen	SA (Yorke Peninsula)	Reduced sensitivity or resistance depending on the frequency population.
Barley spot-form of net blotch	*Pyrenophora teres* f.sp. *maculata*	3 (DMI)	Tebuconazole, epoxiconazole Propiconazole	WA	Field resistance to old generation Group 3 fungicides
		7 (SDHI)	Fluxapyroxad Bixafen	WA (Cunderdin region)	Reduced sensitivity identified in 2020
Wheat Septoria tritici blotch (STB)	*Zymoseptoria tritici*	3 (DMI)	Tebuconazole, flutriafol, propiconazole, cyproconazole, triadimenol	NSW, Vic, SA, Tas	Reduced sensitivity that does not cause complete field failure
Wheat Septoria tritici blotch	*Zymoseptoria tritici*	11 (QoI)	Azoxystrobin Pyraclostrobin	SA	Identified in 2021. Unknown at this stage but if mutation affects performance as Europe then QoIs will decline in their effectiveness

Table 1 definitions

***Reduced sensitivity**: 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.*

***Resistant**: 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.*

Where the cultivar's susceptibility to disease prevents delaying fungicide application until flag leaf (or later in stem elongation) and earlier fungicide intervention is needed (e.g. GS31) to secure the higher yield potential, it's important that we adhere to sound anti resistance measures. These include avoiding repeated use of the same active ingredients/products and in the case of the newer Group 11 QoI (strobilurins) and Group 7 SDHIs, also avoid repeating the same mode of action. This is frequently easier said than done in longer season scenarios since many of the fungicides with better efficacy are also important co-formulation partners in fungicide mixtures carrying two modes of action. However, focussing on the key physiological timings that protect the upper canopy leaves will ensure that the number of applications is not excessive, usually no more than two applications or three at most is sufficient with the most susceptible scenarios.

Anti-resistance measures when using fungicides as part of an Integrated Disease Management (IDM) strategy

- With wheat and barley crops where two to three applications of fungicide are applied, 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 or directly following Systiva with a fungicide containing an SDHI.
- 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.
- Group 3 DMIs (for example; triazoles e.g. epoxiconazole (Opus®) or triazole mixtures (e.g. prothioconazole and tebuconazole (Prosaro®)) 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 as Uniform® containing azoxystrobin, consider foliar fungicide follow ups which have a different mode of action, and therefore, avoiding if possible, a second application of SDHI or QoI fungicides.

Influence of fungicide rate
Growers and agronomists frequently ask the question whether dose rates have an impact on how likely fungicide resistance is to evolve. Resistance comes in many forms and trying to manipulate rates with fungicides should not be seen as the core resistance management strategy. The reality is that using the most appropriate rate for effective disease control is the best strategy for managing resistance. Label rates have been developed to provide robust and reliable control of the target disease.
In many cases the full label rate is the most appropriate rate for control. However, for some diseases, the lower rate from the label range of a fungicide can be used in conjunction with a crop variety that has a good disease resistance rating because disease pressure will be lower. Contrary to what might be the case with other agrichemicals, there is evidence that by using a higher rate than necessary increases the risk of resistance, as removing all of the sensitive individuals provides more opportunity for these resistant individuals to dominate the population and hence be the strain colonising the plant. This is particularly the case with Group 11 QoIs and Group 7 SDHIs fungicides.

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 the 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.

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 for you to report any fungicide resistance instances to your local DPIRD regional pathologist if you believe you are encountering reduced sensitivity or resistance in your broad acre crops.

Investment Acknowledgement: *FAR Australia gratefully acknowledges the investment of the Grains Research and Development Corporation (GRDC) for the AFREN and Hyper Yielding Crops Project which are both national initiatives.*

Collaborating Partners Acknowledgement
FAR Australia gratefully acknowledges the support of all of its research and extension partners in Hyper Yielding Crops project. These are CSIRO, the Department of Primary Industries and Regional Development (DPIRD) in WA, SA Research and Development Institute (SARDI), Brill Ag, Southern Farming Systems (SFS), Techcrop, the Centre for eResearch and Digital Innovation (CeRDI) at Federation University Australia, MacKillop Farm Management Group (MFMG), Riverine Plains Inc and Stirling to Coast Farmers.

We would also like to acknowledge the work of our co-workers and collaborators in AFREN, in particular Dr Fran Lopez from the Centre for Crop and Disease Management (CCDM).
For more information on AFREN and fungicide resistance – Contact:
afren@curtin.edu.au *or* nick.poole@faraustralia.com.au

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Improving yield in Faba Beans across the Medium to High Rainfall Zones

A new Grains Research & Development Corporation (GRDC) Investment across eastern Australia aims to close the economic gap in grain legume production. South Australia is led by SARDI (Penny Roberts), Agriculture Victoria (Jason Brand) in Victoria, 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.

FAR Australia: Kenton Porker, Nick Poole, Tracey Wylie, Kat Fuhrmann, Ben Morris, Tom Price, Darcy Warren.

Key Points:

- Growing more biomass does not always lead to more yield in beans.
- Canopy structure is different to growth stage (development) – consider the effect of temperature on leaf development and onset of flowering.
- The critical period for yield is much later in the high rainfall zone than other regions. Fungicide applications should target protection of leaf material contributing to yield determination.
- GRDC/FAR Australia trials are established to determine the key timings of new fungicide chemistry and interaction with improved genetic resistance.

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.**

The light conditions, and crop stress around flowering time plays a key part in yield determination. For example, a larger canopy can be counter intuitive as this can lead to shading and insufficient radiation for pod set in lower parts of the canopy. This has implications for time of sowing, sowing rate and for row spacing in faba beans. The other factor is that key leaves and canopy layers can be infected with disease and assimilates from photosynthesis are insufficient for pod set.

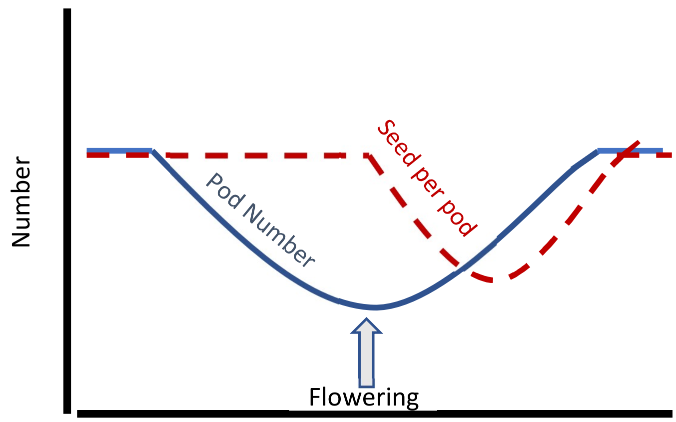


Figure 1. *Effect on the timing of stress on (a) pod number and (b) seed per pod adapted image and based on shading experiments conducted and published by Lake et al 2019.*

When should we apply fungicides in the canopy to offer the greatest return on yield?
This is the key question 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.

Growth is often best described as an increase in dry matter whereas development refers to the progression towards flowering and pod set. These are linked but not the same as each other. For example, a dwarf cultivar compared to a tall cultivar may have large differences in dry matter but a similar progression towards flowering. Beans are an indeterminate crop and the progression towards flowering generally follows a temperature-based model. For example, in most commercial faba bean varieties the onset of flowering will occur after 1200 degree-days (>0°C) have accumulated. This however varies with variety, sowing date, and location as highlighted by FAR Australia legume sites in 2021 at Bundalong, NE Vic; Gnarwarre, SW Vic; Coreen NSW and Millicent SA. This demonstrates how the different thermal environments arrive at this timing up to 10 – 30 days apart.

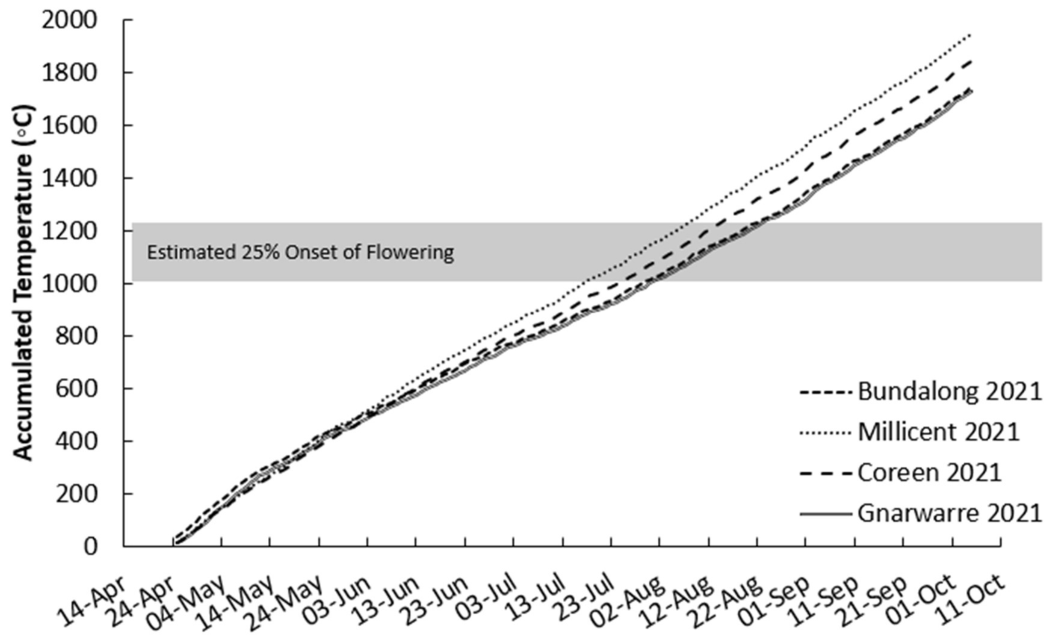


Figure 2. *Differences in accumulated temperature (growing degree days) from 25 April emergence across legume sites in 2021 at Bundalong NE Vic, Gnarwarre SW Vic, Coreen NSW, Millicent SA*

Location: Gnarwarre, Victoria (South West Victoria)
Type of Site (Hub or Spoke): Spoke

Project lead*:* Ag Vic, Jason Brand

Collaborator: FAR Australia

Managing Personnel (and contact details):
Darcy Warren (0455 022 044), darcy.warren@faraustralia.com.au

Average Rainfall: *November-March: 191* mm *April-October: 324* mm

Soil type (description): Heavy clay loam, low pH and prone to water logging

Current Pulse situation: Faba bean is the dominant pulse in this region. Disease is the primary constraint to production. Lentils typically are prone to water logging. This spoke site aims to primarily address disease management in Faba beans, along with demonstration of high yielding strategies in Faba beans and educate growers on the legacy effects and benefits of pulses in the cereal rotation.

Trial 1: Disease Management Faba Beans

Objective: Evaluate the potential to manage disease more sustainably in Faba beans through improving management guidelines that dissect the interaction between fungicide application timing and improved genetic resistance.

Trial 2: High Yielding Beans demonstration

Objective: Evaluate the response of cultivar, seeding density and nutrition to manipulate canopy architecture in a high yielding faba bean Amberley compared to current practice Samira and Bendoc.

What did a 4t/ha Faba Bean Crop look like in 2020

These results were derived from the GRDC funded Southern Pulse Agronomy Project at Dookie in 2020 and mid may sowing date.

FAR Australia: Kenton Porker, Ben Morris, Tom Price.

Key Points:

- Cultivar and plant density have been the two most significant factors influencing yield in these field trials
- Plant population had a greater effect on canopy architecture than cultivar.
- Plant densities of between 22 – 32 plants optimised grain yield and seed number, and is the target density to hit the "sweet spot" for 4t/ha grain yield. This balances the trade-off between increasing stem number and pods per stem.
- Disease pressure has been low in previous experiments and differences in cultivar disease ratings and fungicide strategies have been minimal.

Crop architecture

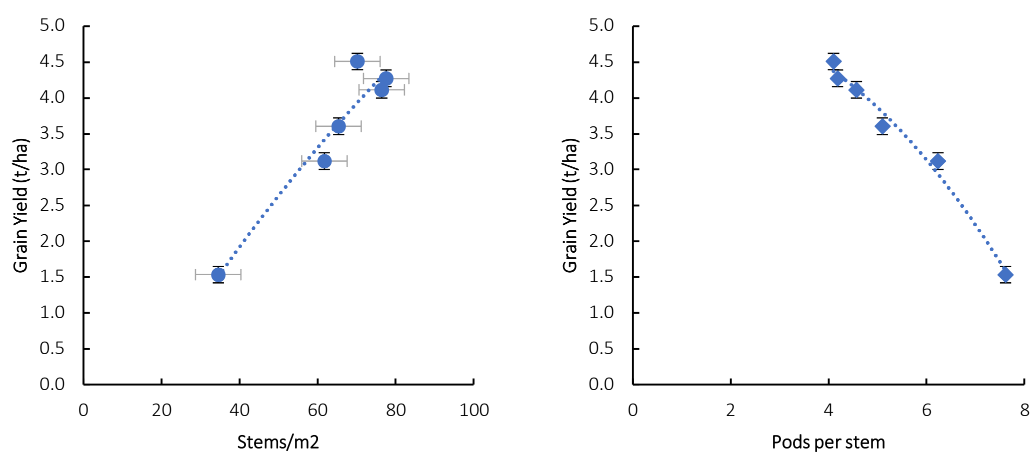


Figure 3. *The relationship between the number of stems per metre square, and the number of pods per stem with grain yield (t/ha) average across all cultivars at Dookie in 2020.*

Increasing stem number, rather than the number of pods per stem increased yield (figure 1). The best way to maximise stems/m^2 has been through **optimising plant density**. The number of stems/m^2 significantly increased with plant population until approximately 25plants/m^2, after which there was no significant difference (mean of three cultivars Figure 4). In contrast pods per stem decreased significantly as population increased from 5 to 22 plants/m^2. Although small decreases were recorded in pods per stem at higher populations there was no significant difference in pods per stem between plant populations of 22 – 32 plants/m^2.

Since lower plant populations produced more pods per stem but significantly less stems/m^2 the conclusion would be that these pods do not produce the seed number and or seed weight to fully compensate for the lower plant population at this sowing date.

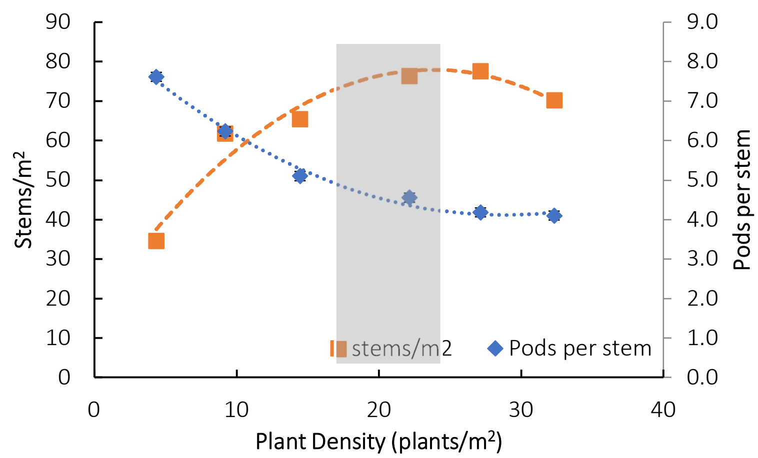


Figure 4. *The relationship between plant density and the number of stems per metre square, and the number of pods per stem averaged across all cultivars at Dookie in 2020. The shaded area represents the sweet spot between maximum stem number and pods per stem required to achieve 4t/ha.*

Grain yield, cultivar choice and seed density

- Yield was maximised at plant populations of 27 – 32 plants/m2(resulting from seed rates of 30 – 45 seeds/m^2) irrespective of cultivar and when disease is managed.
- PBA Bendoc (3.77t/ha) was significantly higher yielding than Samira (3.56t/ha) which in turn was significantly higher yielding than Amberley (3.39t/ha).

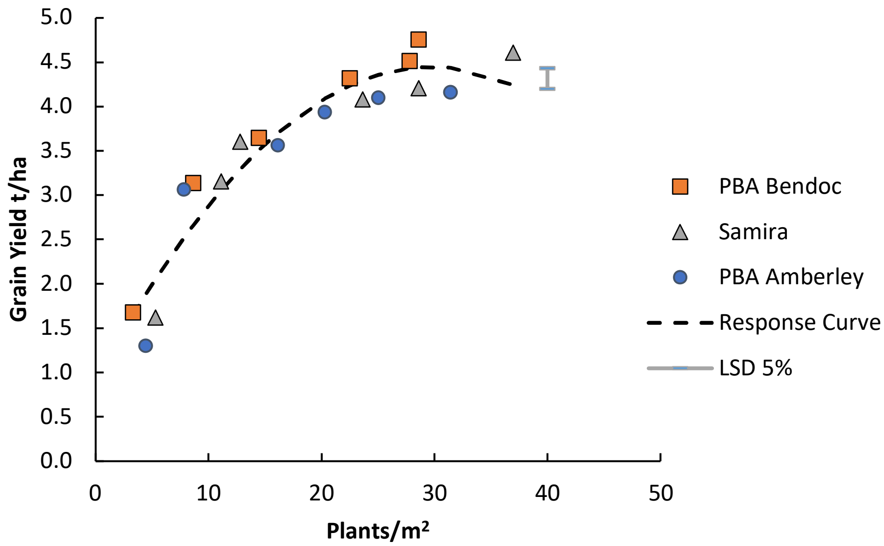


Figure 5. Relationship between plant density (established plants/m2) and grain yield in three cultivars PBA Bendoc, PBA Amberley, Samira in 2020 at Dookie.

With a similar trial in 2019 based on earlier sowing (29th April) populations averaging 21 plants/m^2 (range 18-23 plants/m^2) generated yields of 2.85t/ha compared to 2.94t/ha with populations averaging 28 plants/m^2 (range 26 – 29 plants/m^2). In 2020 with higher yields and later sowing, plant populations averaging 22 plants/m^2 (range 20-24 plants/m^2) yielded significantly less than 27 plants/m^2 (range 25 – 28 plants/m^2) (4.09 t/ha v 4.36 t/ha).

Waterlogging tolerant "Planet"

Prepared by Prof Meixue Zhou, Tasmanian Institute of Agriculture, University of Tasmania

Waterlogging is a serious problem in high rainfall zones of Australia.
Climate change could cause more frequent extreme weather, including rainfall patterns which lead to more frequency of waterlogging events. Currently barley production loss due to waterlogging is estimated to be about $20 m per year.

What can we do to solve waterlogging problem?
For less severe waterlogging, the use of nitrogen can greatly mitigate the damage. When waterlogging is very severe, we have to delay the sowing time to spring which is quite often in Tasmania. Many farmers have used different engineering solutions to improve drainage, including the use of raised bed, surface drainage, controlled traffic farming, strategic deep tillage and sub-soil manuring. Genetic solution with combined agronomic practices is one approach of reducing waterlogging damage.

Genetic solution: any waterlogging tolerance genes exist?
Genotypes showed significant difference in waterlogging tolerance (Fig 1). We have identified a major gene that controls aerenchyma formation (air-filled spaces that help transport air from the above-ground shoots to supply the roots of waterlogged plants) in roots under waterlogging stress. This gene is now used to improve waterlogging tolerance of RGT Planet.

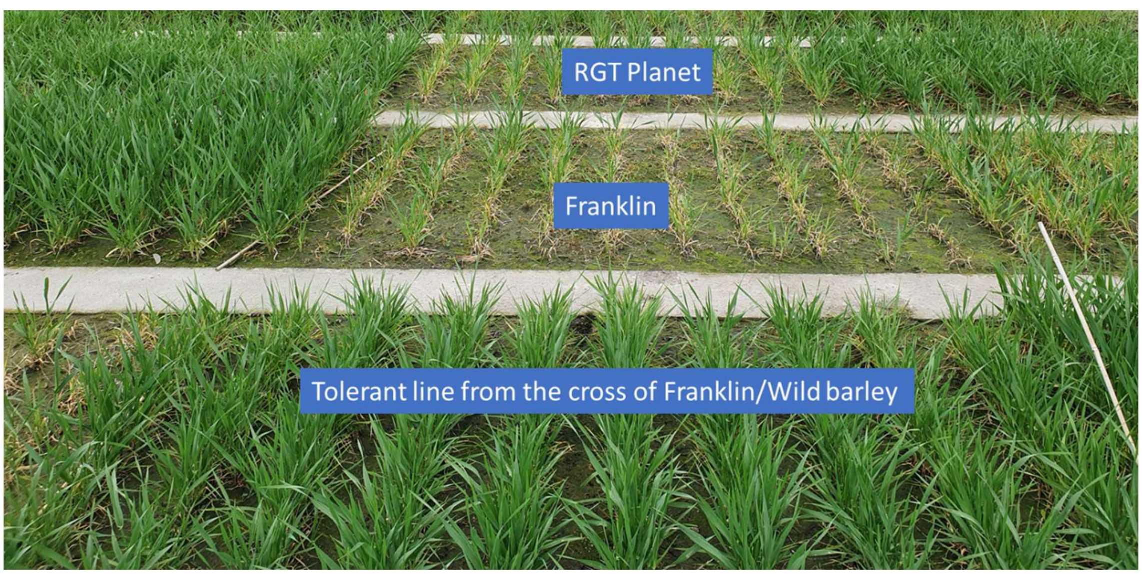


Figure 1. *Waterlogging trials in Tasmania. One month after waterlogging finished. Waterlogging treatment started at 2.5 leaf stage and lasted for two months.*

What does the new waterlogging tolerant "Planet" look like?
We have inserted a single waterlogging tolerance gene into Planet through a backcrossing program. The new line, temporarily named as RP22053, have over 99% Planet backgrounds but with added waterlogging tolerance gene. ***Under control conditions***, there were no significant differences between Planet and RP22053 in yield and quality.

Under waterlogged conditions: RP225003 showed much better waterlogging tolerance (Fig 3), mainly due to better survival of the root system (Fig 4) which led to a lot of dead plants of Planet while no dead plants of RP25003. Those survived plants showed good recovery after waterlogging (Fig 3B-C).

Figure 3. *Waterlogging trial in Tasmania. Right: RP22503; Left: Planet. A: 60 days after waterlogging; B: one week after waterlogging finished; C: one month after waterlogging finished; C: two months after waterlogging finished.*

Figure 4. *Roots of waterlogged plants. Left: roots of RP25003 after two months' waterlogging treatment; right: roots of Planet after two months' waterlogging treatment.*

Fertiliser use can alleviate waterlogging damage when waterlogging is not severe
In the trial which suffered moderate waterlogging, the application of fertiliser significantly improved plant growth. This highlights the synergy between agronomic and genetic solutions.
Early sown Planet showed less damage from waterlogging but may suffer spring frost
We have conducted an early sowing trial and started waterlogging at 5-leaf stage. After two months' waterlogging treatment, no dead plants were noticed in Planet and recovered well after waterlogging finished (Fig 6A,B). However, the spring frost (-1 ℃) caused significant damage which may have confounded yield responses

Conclusion
A new gene has been discovered for barley waterlogging tolerance. The addition of the new gene mitigated the yield reduction under waterlogging by more than 20%, which is 1-2 ton/ha yield increase in long season high rainfall regions. In collaboration with Seed Force, the gene has been

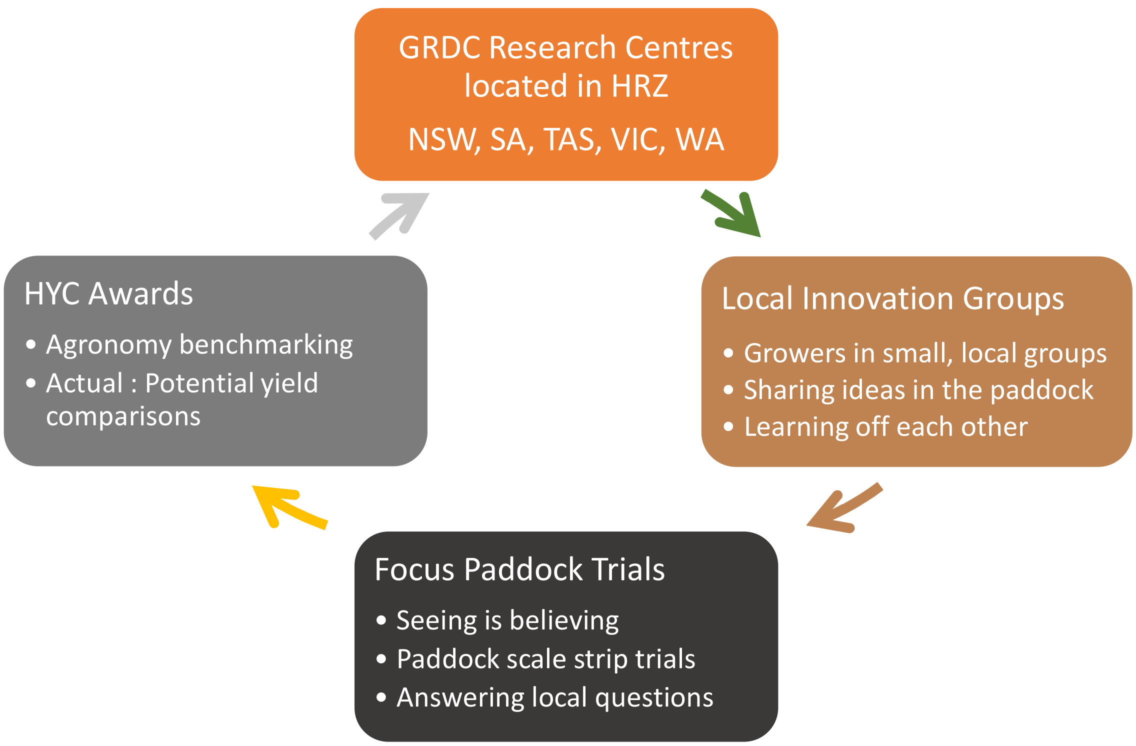
introgressed to RGT Planet. Bulked seeds of the new lines will be available for multi-purpose field trials next year and will be included in FAR Australia's Hyperyielding field research program

Acknowledgements

The research is funded by GRDC "Adapted barley germplasm with waterlogging tolerance for the Southern and Western regions" and supported by Seed Force.

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 2020 SFS set up three innovation groups in southwest 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 five different trials were setup.

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

Focus paddock trials:

1. ***Lonies Focus paddock trial 2020***

Research question: Was there any yield or grain quality advantage to increasing the GS39 (flag leaf fully emerged) fungicide from the grower approach of half rate Radial to either full rate Radial or full rate Opus? The latter treatment was to establish the additional value from adding a Strobilurin fungicide?

Paddock details

Crop	Cereal: Wheat
Variety	Beaufort
Area	212.00ha
Sow Rate	90.00 kg/ha
TSW	42.00g
Seeds Sown	215/m^2
Sow Date	29-04-20
Harvest Date	29-12-20
Harvest Yield	9.39T/ha
Stubble Management	Retained Canola
Row spacing	250mm

Fungicide Treatments at GS39

Treatment	
1. Control - Grower practice	0.25 L/ha Opus + 0.13 L/ha Azoxystrobin (Grower)
2. Full rate triazole + Strobilurin	0.5 L/ha Opus + 0.26 L/ha Azoxystrobin (Double)
3. Full rate triazole	0.5 L/ha Opus (Straight Opus)

Results

Measurement type	Treatment 1	Treatment 2	Treatment 3	Sig Diff
Yield (t/ha)	9.39	9.61	9.44	No
Protein (%)	10.5	9.4	9.9	
Screenings (%)	1.1	1.1	1.0	
Test weight (kg/hL)	77.7	77.0	75.9	

Conclusion

Although both the additional treatments yielded more than the Grower practice there was no statistical difference in yield. The grower practice had the highest protein which was probably due to a slightly lower yield and hence less nitrogen dilution in the grain.

2. ***Duncans Focus paddock trial – 2020***

Research question: What was the most effective PGR programme in a crop of early sown Accroc, in a fertile paddock where lodging was a very high risk?

Paddock details

Crop	Wheat
Variety	Accroc
Sow Rate	90 kg/ha
TSW	45.00g
Seeds Sown	200/m2
Sow Date	12-04-20
Harvest Yield	9.4 T/ha
Seeder type	Tyne (Knife Point)
Row spacing	250mm

Plant Growth Regulator Treatments

Treatment	Product	Timing	Rate l/ha
1. Control	Moddus Evo	GS31	0.4
2. Split PGR	Moddus Evo	GS31 + GS33	0.2 + 0.2
3. Late PGR	Moddus Evo	GS33	0.2
4. Nil PGR	-	-	-

Results

Treatment	Rate/ha	Yield (t/ha)	Lodging (%)
Moddus Evo @ GS 31 + GS 33	0.2L	10.1 a	10
Moddus Evo @ GS 31	0.4L	10.0 a	10
Moddus Evo @ GS 33	0.2L	8.5 b	20
Nil PGR	-	8.4 b	53

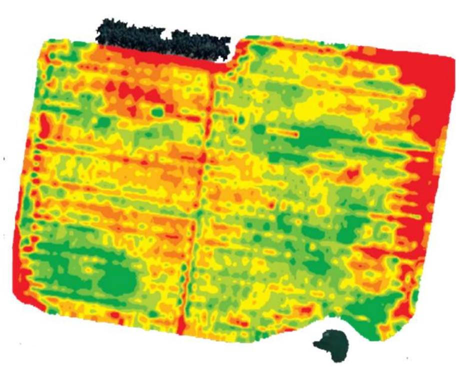
Means followed by the same letter do no significantly differ

Conclusion

The application of plant growth regulator Moddus Evo at GS33 was later than optimum to have the best level of control over the lodging in this crop of Accroc, sown after canola in 2019. The yield was statistically the same as the nil treatment even though it did improve the amount of crop that didn't lodge. The best treatments yielded 1.5t/ha more than either the Nil treatment or the single late application of PGR. There was no difference in yield or % lodged whether the Moddus Evo was split or applied as a single dose; the key point learnt from this focus paddock trial was the importance of applying the PGR at GS31 or very early stem extension.

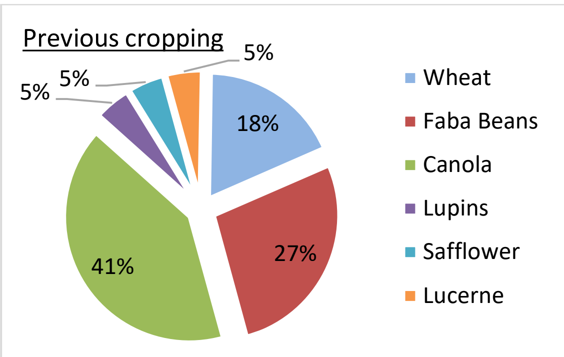
HYC Awards

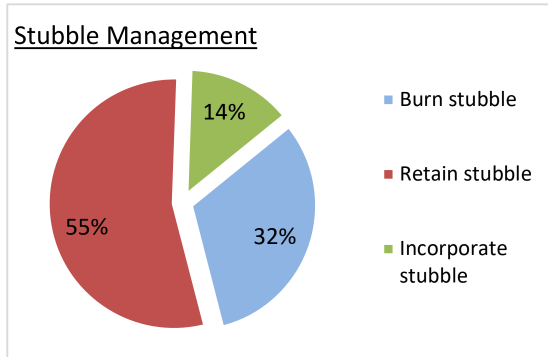
Award paddocks were nominated from the Innovation groups initially, with the aim being to collect and record specific wheat paddock information and to provide an agronomic benchmarking report which compares that paddock to all the others entered, both regionally and nationally. Nominated paddocks had 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 2020 was Ben Findlay from Weatherboard with a 10.4/ha crop of Accroc wheat, sown on the 9th April into a fertile paddock. Will Langley won the award for the highest yield as a percentage of the potential yield in VIC. His crop of Beaufort wheat, sown on the 6th May produced 9.40t/ha which was 96.4% of the 9.75 t/ha potential yield.

The following are an example of some of the agronomic benchmarks produced in the HYC Awards report for VIC in 2020:





Agronomic Factor	Top 20% Award paddocks	Remaining 80%
Yield (t/ha)	9.6	7.4
N applied (kg N/ha)	192	155
Cost of N / tonne yield	$32/t	$33/t
Fungicides ($/ha)	$29	$18
Fungicides ($/t)	$5/t	$4/t
Number of applications	3	2.5
Dry Matter (t/ha)	23.1	24.6
Harvest index	56%	52%
Head count (m2)	597	511
1000 grain weight	45.5	44

Please contact Ashleigh Amourgis (0439 005 071) for information about being part of this exciting project or to enter a wheat crop as a HYC award paddock in 2021.

SOWING THE SEED FOR A BRIGHTER FUTURE

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