TASMANIA CROP TECHNOLOGY CENTRE

Hyper Yielding Crops (HYC) Field Day
18th November 2021

FAR Australia Tasmania Crop Technology Centre, Hagley, Tasmania

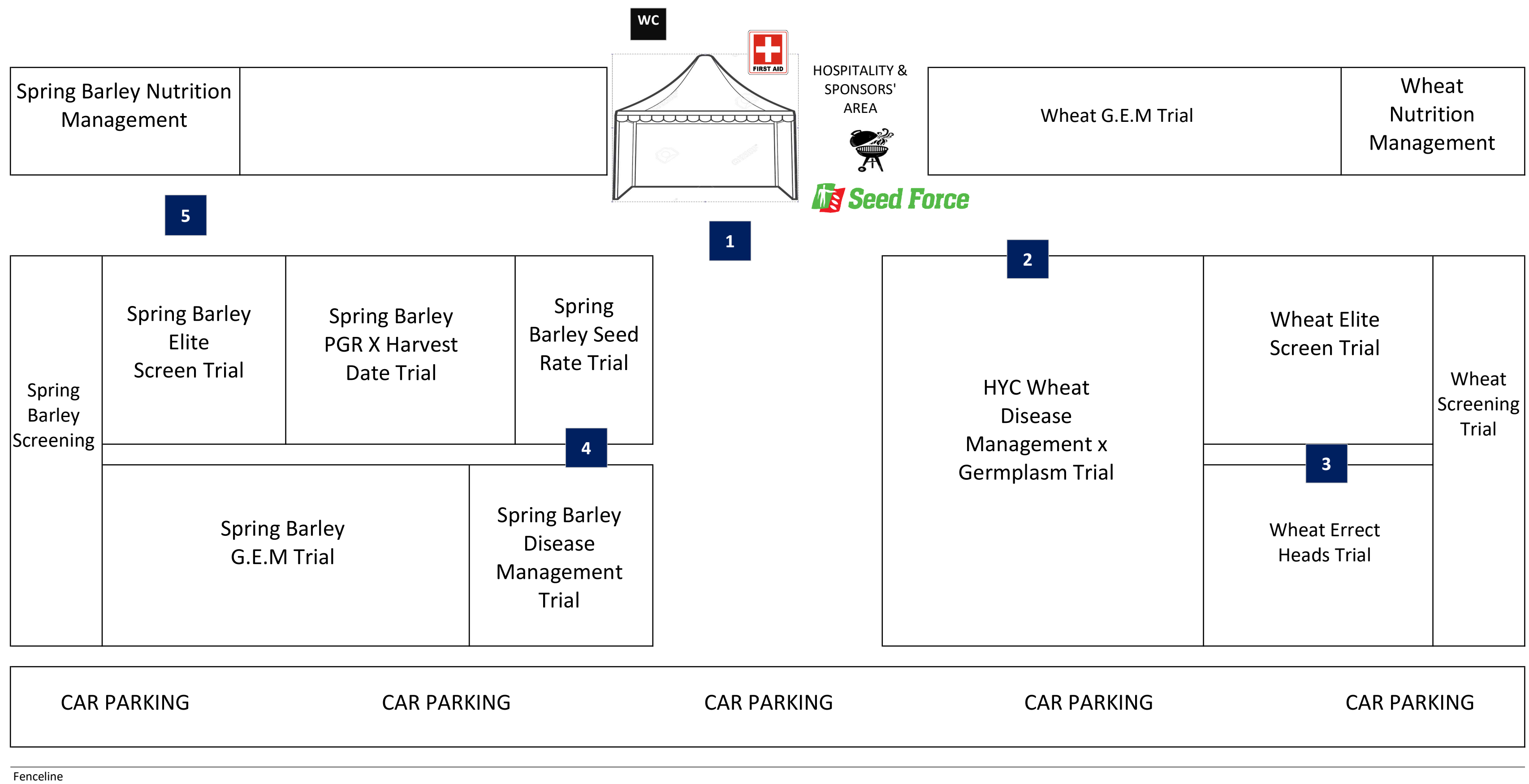
The GRDC Hyper Yielding Crops project is led by FAR Australia in collaboration with:

SOWING THE SEED FOR A BRIGHTER FUTURE

TASMANIA HYC RESEARCH CENTRE

HYPER YIELDING CROPS
TASMANIA SITE PLAN 2021

Timing of sowing
Wheat - 29th April
Spring Barley - 8th September



TASMANIA HYC RESEARCH CENTRE

TIMETABLE

TASMANIA CROP TECHNOLOGY CENTRE FIELD DAY: THURSDAY 18 NOVEMBER 2021

Featuring the GRDC's Hyper Yielding Crops project

In-field presentations	Station No	10:00	10:15	10:45	11:15	11:45	12:15	12:45	1:30	2:15
Lachie Seears, Farmer and Nuffield Scholar Sustainably increasing productivity in the HRZ – where have we come from in the last 10 years and opportunities to close the yield gap further.	1	Welcome and opening address - Peter Carberry, GRDC General Manager Applied Research and Development and Nick Poole, Managing Director FAR Australia	1		2			Lunch kindly sponsored by Seed Force	Seeing is believing' - an informal walk through the labelled trials to view the treatment differences.	Closing address and refreshements kindly sponsored by Seed Force
Nick Poole, FAR Australia Disease management in new genetics, utilising old and new chemistry more sustainably.	2			1		2				
Brett Davey, SFS Erect heads, how is it related to BYDV control and management?	3				1		2			
Naomi Hender, SFS and local grower A farmer's perspective, achieving high yields on farm.	4		2			1				
Darcy Warren, FAR Australia Making spring sown barley more successful and N management for hyper yielding crops.	5			2			1			
In-field presentations	Station No	10:00	10:15	10:45	11:15	11:45	12:15	12:45	1:30	2:15

We would be obliged if you could remain within your designated group number throughout the day.

1	**Group 1**
2	**Group 2**

Thank you for your cooperation.

VISITOR INFORMATION

We trust that you will enjoy your day with us at our Tasmania 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 (if required) 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 day.

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:

- If state regulations require, please wear a face mask.
- 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
TASMANIA CROP TECHNOLOGY CENTRE FIELD DAY

FEATURING THE GRDC'S HYPER YIELDING CROPS (HYC) PROJECT

On behalf of the HYC project team, I am delighted to welcome you to the 2021 Tasmania Crop Technology Centre Field Day. The centre currently hosts the GRDC's Hyper Yielding Crops (HYC) 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 Tasmania we are working closely with regional partner Southern Farming Systems.

Today you will have an opportunity to discuss the following:

This year the emphasis of the sessions is focussed on the practical on farm steps that will enable us to achieve higher productivity and close the yield gap.

- Sustainably increasing productivity in the HRZ – where have we come from in the last 10 years and opportunities to close the yield gap further.
- Erect heads, how is it related to BYDV control and management?
- Making spring sown barley more successful and nutrition management for hyper yielding crops. Nitrogen supply (bagged vs mineral N).
- Disease management in new genetics, utilising old and new chemistry more sustainably.
- A farmer's perspective, achieving high yields on farm.

We are fortunate to have secured the following speakers:

- *Lachie Seears (keynote speaker), Farmer and Nuffield Scholar from SE SA HRZ*
- *Nick Poole and Darcy Warren, FAR Australia*
- *Brett Davey and Naomi Hender, Southern Farming Systems*
- *Jon Midwood, TechCrop*

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 this GRDC investment, please contact Rachel Hamilton at rachel.hamilton@faraustralia.com.au or call 0428 843 456.

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 project.

Other Acknowledgements

Thank you to Peter Carberry, GRDC's General Manager Applied Research and Development for joining us today. Also thanks to our centre host Botanical Resources Australia for all their support throughout the season and to SeedForce for sponsoring today's event.

What is this project aiming to achieve and how did it 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)
Naomi Hender, Tasmania HYC Project Officer, Southern Farming Systems, (nhender@sfs.org.au)

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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Meteorological Data – Hagley, Tasmania

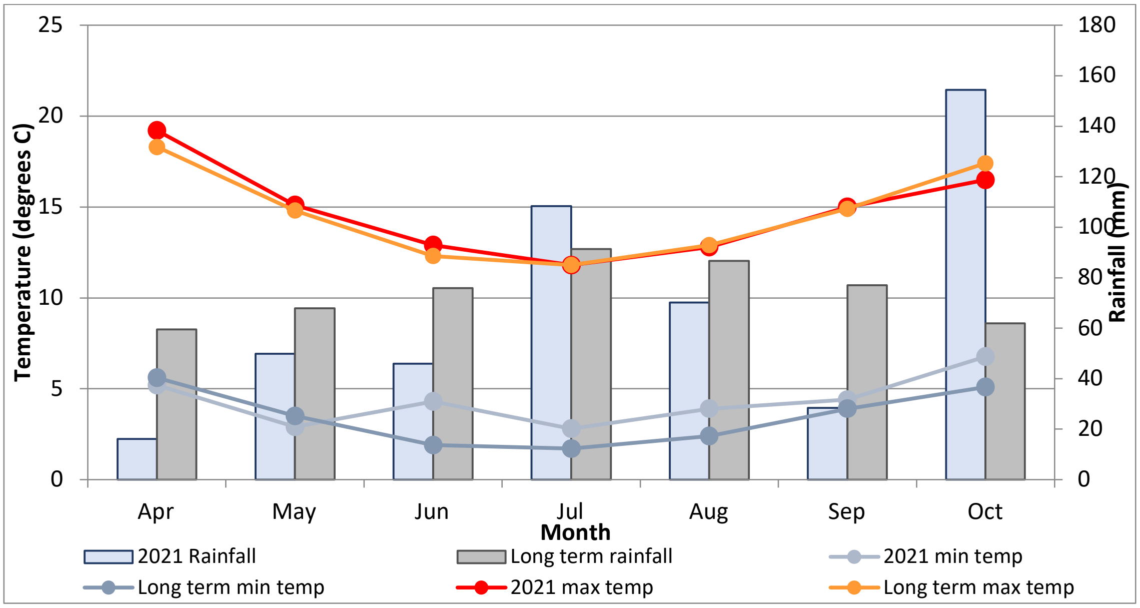


Figure 1. 2021 growing season rainfall so far and long-term rainfall (1978-2021) (recorded at Westbury (Birralee Road)), 2021 min and max temperatures and long-term min and max temperatures (1999-2021) (recorded at Cressy Research Station) for the growing season. *Rainfall April to October= 473.1mm.*

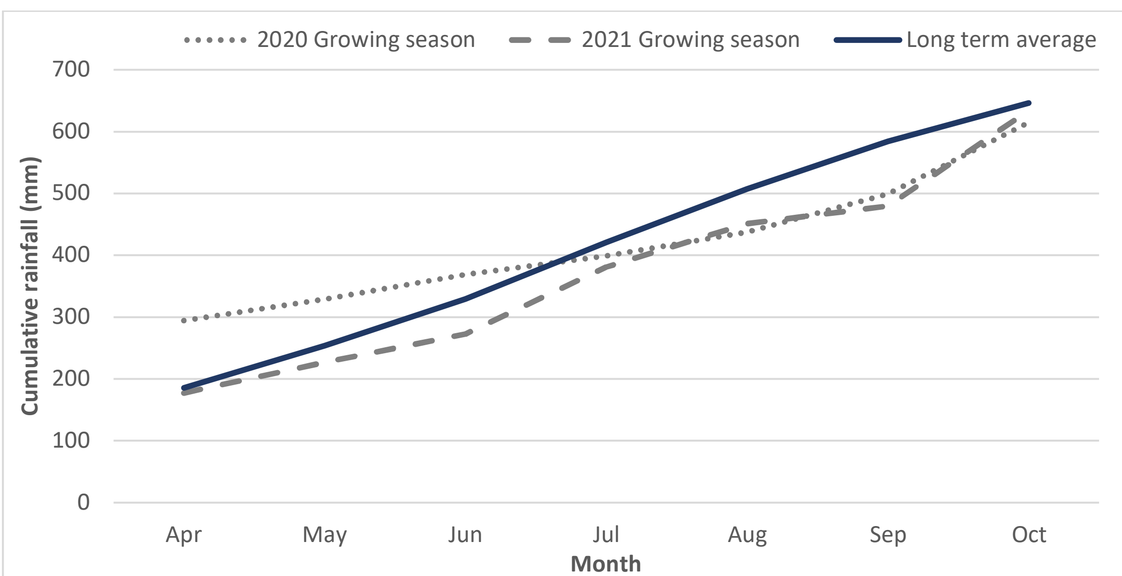


Figure 2. Cumulative growing season rainfall for 2020, 2021 and the long-term average for the growing season.

Sustainably increasing productivity and profitability in the HRZ

Lachie Seears, Farmer and Nuffield Scholar, SE South Australian HRZ

Becoming a member of the 10t club was something that I strived to achieve. The journey for me started back in 2005, where as a 26-year-old newly elected Chairman of the MacKillop Farm Management Group (formerly a sub branch of Southern Farming Systems), I attended a HRZ meeting held near the Melbourne Airport. This is where I first met Nick Poole, who back then was working for FAR in NZ along with Roger Sylvester Bradley who is Head of Crop Performance at the Agricultural Development and Advisory Service (ADAS) in the UK. At this meeting, I was one of only four farmers to attend to help set the direction and put us on a pathway to get us to where we are today - having these fantastic Hyper Yielding Crops (HYC) research centres across five states around Australia.

There are three pillars to the increased productivity and profitability of our business Boonderoo Pastoral Company where we are farming 6,000 ha mixed livestock and cropping farm in the HRZ 30km SW of Lucindale in the lower SE of SA. To be successful the following 'three' need to be working together.

1. THE LAND WE FARM ON: The land on which we farm is crucial; we are always looking at ways to improve soil health, eradicate weeds and control disease and insects pressure. I have seen things come full circle where we were once again going back into full cultivation to help incorporate the high stubble loads that we are now growing.
2. A GOOD TEAM: To achieve the success that we have I wouldn't have been able to do this without the good support from everyone involved from the tireless work from my agronomist James Heffernan who brings the technical knowledge to the table to everyone that helps cultivate, sow, spray and harvest the crop during the year.
3. GOOD MANAGEMENT: This is where I come into it having the ability to set the direction of the business and bring everything together to make sure the business is in a healthy financial situation to be able to fund the costs involved to making sure all the boxes are ticked along the way and ensuring everything happens when it needs to. I think one thing that the person in this pillar has to have is all the technical knowledge. I don't believe it is necessary for them to have all the answers, but what they do have to know is how to make sure they bring the right people in that do have the answers or skills.

THE JOURNEY FROM THEN TO NOW AND BEYOND:

To make plans on how far we can push yields in the future, it is good to look back and understand where we started and what have we changed or refined to get us to where we are now and use this to help us improve in the future.

THEN: Ten years ago, we hosted the MFMG trial site at Boonderoo and that year we had 682mm of annual rainfall and 437mm of GSR (April to October), the main variety of wheat that we were growing was Brennan (7.2 t/ha) and Revenue (8.6 t/ha) was a Brennan replacement.

Gairdner barley was very much a staple of the cropping program and yielded 6.19 t/ha in the trial site. Westminster was still two years from receiving its malt accreditation and achieved a yield of 7.2 t/ha. Oxford was released last year (2010) and looked promising achieving a 7.99 t/ha yield and claimed to have moderate resistance to Net Form of Net Blotch. I remember being excited about this variety and had been growing it since its release and what followed was the quick breakdown of Oxfords resistance to Net form of Net Blotch which was discovered at home. Focus was then shifted to Westminster that went on to be a good variety for a number of years.

While these yields are good at the trial plot size we struggled to be able to achieve these at a paddock or even a whole of crop level. We found that crops would be averaging more around the 5-6 t/ha range for both wheat and barley. Back then we were still burning stubbles and direct drilling at seeding time. Our fungicide strategy was more around a curative strategy.

NOW: Fast forward 10 seasons and the 2020 year looked quite simular with 665mm of rainfall falling annually slightly more GSR with 502mm falling. I had just harvested my last crop of Manning and I was now growing varieties such as RGT Accroc which last year yielded 9.33 t/ha across my whole crop, the best performing paddock yielded 11.1 t/ha. This year we planted Anapurna wheat as replacement for Accroc.

Barley was an exceptional performer and we had just grown the variety Planet that yielded a crop average of 9.4 t/ha with the best performing paddock yielding 10.45 t/ha.

HOW DID WE GET HERE: For us to get to achieve a 50+% increase in yields in the last 10 years we have had to change a few key areas of the crop program. One of the biggest changes has been our access to new varieties coming from European breeding lines. For us to continue to sustainably increase productivity we have gone away from the old ways of burning stubbles and direct drilling and gone back to stubble retention and incorporation with high-speed disc tillage. This has benefited the system in several ways in that we are building soil health and also increasing the germination of any weed seeds to combat issues that have been around for many years such as annual ryegrass. We are sowing generally two weeks earlier than what we were 10 years ago, this is happening because they are long season winter wheats.

Improved chemistry - it is amazing what new products and formulations of herbicides, insecticides and fungicides have come out over the last 10 years. This also relates to the second pillar to have a good team around you.

For us at Boonderoo we have also adopted more of a structured program approach to growing the crop. We set the program at the start of the year around disease and nutrition strategies.

THE FUTURE:

I think to continue to grow hyper yielding wheats sustainability we need more of a methodical planned approach to the process. We need to be able to have the whole season planned out in regard to sowing rates, nitrogen strategies, fungicide program etc.

Variety selection is critical, we need to look at the highest yielding varieties that have a best disease resistance package.

Testing throughout the year will be integral as we need to see an increase in soil testing to see how the balance of nutrients are going. I think there will be a role for an increase in more site-specific soil testing (individual soil tests on a per hectare basis). Timing of every operation that we do during the crop season has an optimal window for it to be done, making sure that operations are performed when they are needed (N applications GS 31-32). In this current Covid-19 world we are in at the moment, being organised and having product on hand is crucial. Moving forward I have inputs in the shed ready to go before we get to the time to perform operation. We are also looking to carry more machinery spare parts to eliminate down time.

I am excited about what is in store for the future and look forward to being able to sit back in 10 years and again see how far we have come!!

Disease control in the face of Septoria resistance to strobilurin fungicides in wheat – how should we respond?

Nick Poole, Dr Kenton Porker, Tracey Wylie, Kat Fuhrmann, Darcy Warren and Max Bloomfield.
Field Applied Research (FAR) Australia, Bannockburn, Victoria 3331, Australia

Key Points:

- *Over the last three years in the high rainfall zones, it's been clear that to produce hyper yielding crops fungicides are essential.*
- *European style three spray programmes based on GS31/32 (1st-2nd node), GS39 (flag leaf) and GS59 (head emergence) timings have provided robust disease control against Septoria tritici blotch (STB) and rusts, in some cases doubling yields with susceptible cultivars.*
- *With the August 2021 announcement that strains of the STB pathogen (Zymoseptoria triitici) had been found in the Millicent (SA) region with resistance to the Group 11 QoI strobilurins (e.g. azoxystrobin, pyraclostrobin)* ***we need to find germplasm that offers greater resistance to this wet weather disease.***
- *With April sown winter wheats, the SA Crop Technology has made good progress in producing data to bring forward high yielding, more STB disease resistant cultivars, these are Anapurna, RGT Cesario and Big Red (AGF004718 and are included in Tasmanian trials in 2021).*
- *These cultivars are presenting as being able to reduce our dependency on three fungicide sprays through better resistance to STB*
- *Since cultivars such as RGT Accroc are moderately susceptible to STB and susceptible to leaf rust, it has not been possible to delay first fungicide timings at GS31 or reduce fungicide expenditure.*
- *This year's research work looks to further establish if delaying first fungicide timing to GS33 (third node) or beyond to flag leaf (GS39) will reduce fungicide expenditure and increase profitability in these more STB resistant cultivars.*
- *Since the development of fungicide resistance is strongly associated with the number of applications we apply (increased selection pressure), any reductions in the number of sprays will increase the longevity of our current fungicide MOAs.*

Please come and view the GRDC STB IDM plots when you visit to the FAR Tasmania Crop Technology Centre set up as part of the Hyper Yielding Crops project.

Profitably using less fungicide with newer more resistant cultivars

The 2020 Hyper Yielding Crops project results from Millicent (SA) illustrated that greater fungicide input associated with 4 units of fungicide over a single flag leaf spray was no higher yielding and only served to be less profitable with cultivars Anapurna, RGT Cesario and Nighthawk. In comparison RGT Accroc gave nearly 4t/ha response to a full fungicide programme over an untreated crop and a 1t/ha advantage to 4 units of fungicide over a single flag leaf fungicide (Table 1).

Table 1. Influence of management strategy and variety on grain yield (t/ha) – Millicent HYC wheat trials 2020 sown 16 April.

	Management Level						
	Untreated		**1 Fungicide Unit** (GS39)		**4 Fungicide Units** (S.trt, GS31, GS39 & GS59)		**Mean**
Cultivar	**Yield**		**Yield**		**Yield**		**Yield**
Trojan (spring)	4.89	mn	5.50	lm	6.07	jkl	**5.49**
Scepter (spring)	4.34	n	5.88	kl	6.23	ijk	**5.48**
Nighthawk (facultative)	6.89	hi	7.40	gh	7.39	gh	**7.22**
Anapurna (winter)	8.22	def	9.65	a	9.65	a	**9.18**
RGT Acrocc (winter)	5.12	m	7.98	efg	8.93	bc	**7.35**
SF Adagio (winter)	6.72	ij	8.49	c-f	8.88	bcd	**8.03**
Calabro (winter)	5.92	kl	7.97	fg	8.49	c-f	**7.46**
RGT Cesario (winter)	8.64	cde	9.45	ab	8.96	bc	**9.01**
Tabasco (winter)	8.00	efg	9.49	ab	9.95	a	**9.15**
Einstein (winter)	6.59	ij	7.96	fg	8.94	bc	**7.83**
LSD Cultivar p = 0.05		0.38 t/ha	P val		<0.001		
LSD Fungicide p=0.05		0.33 t/ha	P val		<0.001		
LSD Cultivar x Fung. P=0.05		0.66 t/ha	P val		<0.001		

If a cultivar has sufficient genetic resistance to prevent early disease development, delaying fungicide applications until flag leaf emergence or at least later into stem elongation e.g. third node (GS33) would have three primary benefits;

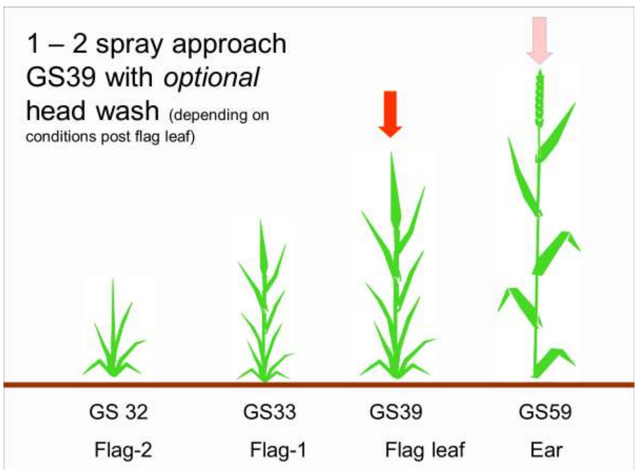
i) It reduces fungicide and application cost expenditure leading to more profitable crops by reducing from three to two or even one application;
ii) it would allow a much better appraisal of whether the seasonal conditions have the potential to support fungicide expenditure (since decisions on rates and products would be made at later development stages that are more important to protect the upper leaves or "*money leaves*"). In those seasons where the spring progressively cuts out it means the flag leaf spray expenditure could be cut back or in MRZ regions removed altogether; and
iii) reducing the number of fungicide applications would reduce the speed of fungicide resistance development in the pathogen by reducing the length of exposure (selection pressure).

So what would one and two spray programmes look like with these more resistant cultivars?

1) Single flag leaf sprays with or without follow up head sprays (1 – 2 spray programmes)

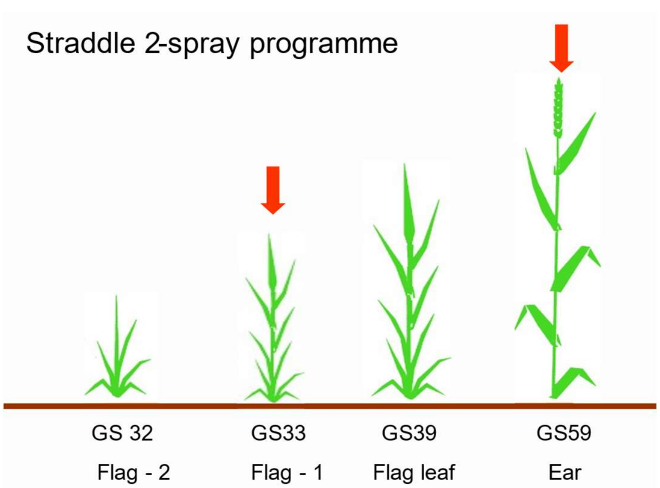
Currently it's difficult to suggest a cultivar choice in Tasmania and the Millicent region that doesn't need fungicides to produce the most profitable crops but newer more resistant cultivars to STB may allow us to apply the first fungicide either at GS33 when flag -1 (F-1) emerges or later at GS39 when the flag leaf emerges.

With the latter approach it's simply whether or not when following the flag spray there is need to follow up with head emergence application. With susceptible cultivars these head emergence applications are more about "topping up" the longevity of protection in the two top leaves rather than just being about protecting the head. We will be looking at these later two spray approaches for more resistant cultivars this season.



2) Straddle spray programmes – GS33 & GS55-59

This is spraying the wheat crop either side of flag leaf (3-4 weeks apart) so that the first spray protects F-1 as it emerges and the second spray protects the flag and head combined. It is called the "straddle" spray approach since it applies fungicide either side of the flag leaf emergence. With the recent advent of more STB resistant cultivars in the UK, this approach is delivering more profitable results in 2021 than the traditional 3 spray programme approach.



“Erect Head” Control in April Sown Wheat.

[1]Nick Poole, Kat Fuhrmann, Tracey Wylie[1], [2]Amanda Pearce & Ian Ludwig, [3]Brett Davey
[1]Foundation for Arable Research (FAR) Australia, Bannockburn, Victoria 3331, Australia
[2]SARDI, Struan Research Centre, Naracoorte SA 5271,
[3]Southern Farming Systems, Longford, TAS, 7301

Over the last two seasons there have been a number of observations indicating that shortly before harvest wheat crops at our SA Crop Technology Centre (CTC) and the Hyper Yielding Cereals research site in Tasmania produce a number of erect heads with poor grain fill. These symptoms show up only 3 -4 weeks before harvest, before which the crop can appear generally healthy. Experiments into managing BYDV and or reduced spikelet fertility continue in the 2021 Tasmania HYC program.

In 2018 it was noted that the cultivars Manning and DS Bennett had lower levels of these erect heads at harvest, suggesting that there was a genetic basis to their protection. Erect heads present themselves as upright and with significantly reduced grain set or spikelet fertility that not often obvious until harvest. There are a number of possible causes (frost effects, poor pollination, stem base disease) that Hyper Yielding Crops (HYC) research is investigating, however it is our understanding that Manning and DS Bennett are the only wheat cultivars with BYDV tolerance that are commercially available in Australia (formerly also MacKellar). In 2019, research was established in Tasmania and SA to look at this in more detail to pin down whether BYDV was linked to erect heads at harvest and whether BYDV tolerant wheat offered a significant advantage. Lower levels of BYDV at the SA CTC led to inconclusive results in 2019 but in Tasmania BYDV tolerance conferred dramatic effects with an early April sown Manning crop compared to a non-tolerant cultivar RGT Relay. In the non-tolerant cultivar where different insecticide regimes (Table 1) were employed, it was clear that where BYDV was fully controlled the number of erect heads at harvest was reduced (Figure 1). The effect of controlling BYDV and erect heads at harvest had significant effects on grain yield (Figure 2) indicating the value of this trait in wheat germplasm grown in the HRZ.

Table 1. Trial treatment list (ml/ha) conducted on BYDV tolerant (cv Manning) and non-tolerant (cv RGT Relay) cultivars.

TRT	Product and Rate (ml/ha)				
	Seed trt	**GS12**	**GS12+2 weeks**	**GS12+4 weeks**	**GS31**
1 & 10					
2 & 11		Karate Zeon 40	Transform 100	Dominex Duo 125	
3 & 12		Karate Zeon 40	Transform 100	Dominex Duo 125	Dominex Duo 125
4 & 13	Pontiac				
5 & 14	Pontiac		Transform 100		
6 & 15	Pontiac		Transform 100	Dominex Duo 125	
7 & 16	Pontiac		Transform 100	Dominex Duo 125	Dominex Duo 125
8 & 17	Pontiac	Karate Zeon 40	Transform 100	Dominex Duo 125	
9 & 18	Pontiac	Karate Zeon 40	Transform 100	Dominex Duo 125	Dominex Duo 125

Please note that the treatment list for this trial was established to identify whether viral issues were the cause of erect heads at harvest. This level of insecticide input was adopted purely for research purposes and presentation of results is not in any way a recommendation.

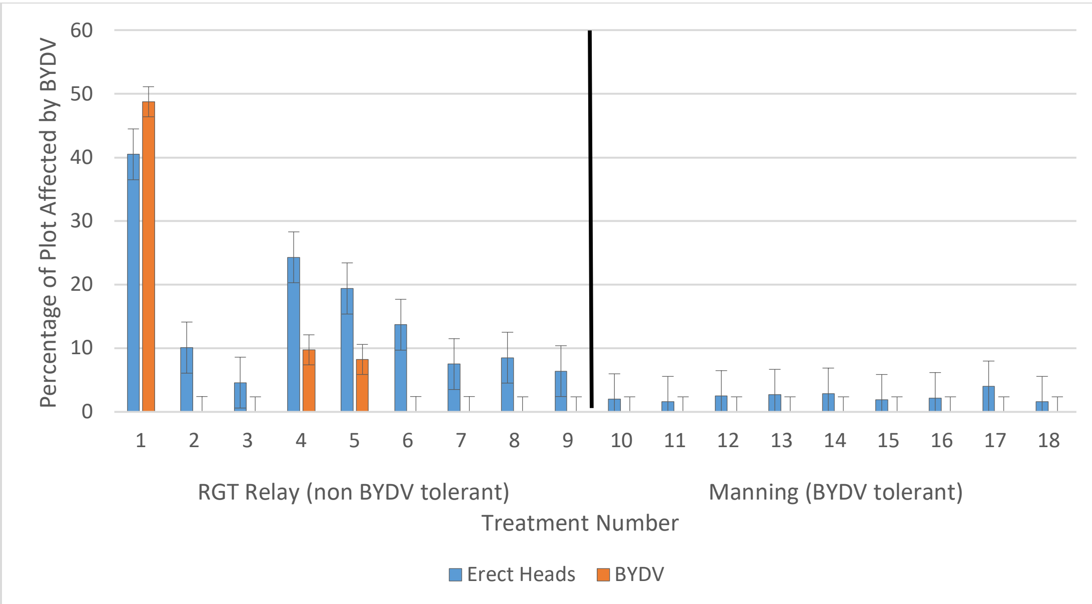


Figure 1. Percentage of plot showing erect heads at crop maturity (GS99) compared to plot BYDV infection, assessed on October 25 (GS37) - HYC Research site, Tasmania 2019.

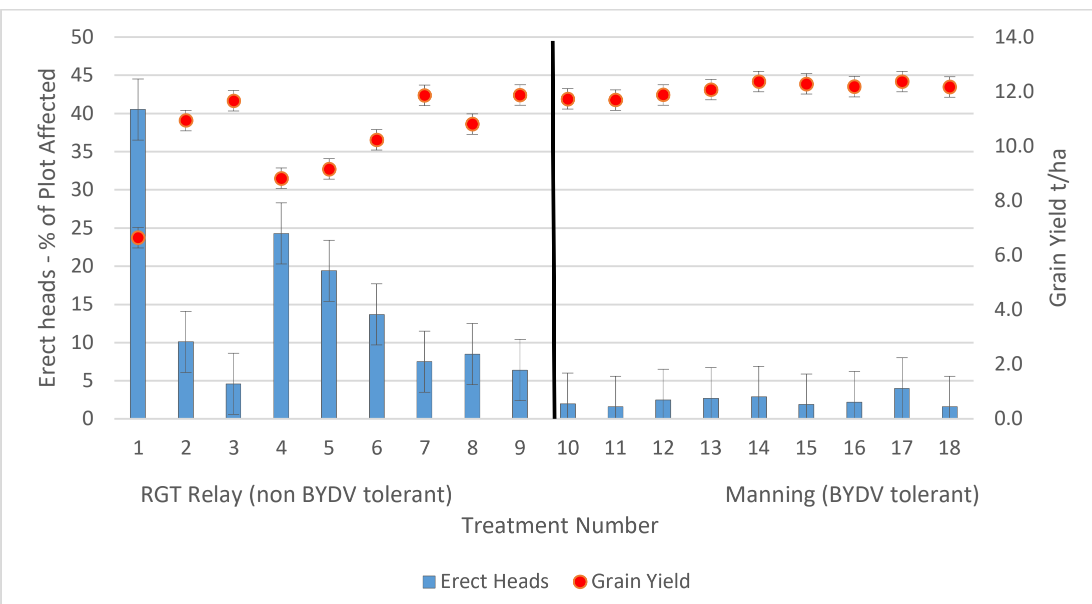


Figure 2. Percentage of plot showing erect heads at crop maturity (GS99) in relation to final grain yield (t/ha) – HYC Research site, Tasmania 2019.

With the introduction of BYDV tolerance into the UK with wheat cultivar RGT Wolverine (first European BYDV resistant cultivar to be released), it is ironic that the only other breeding programmes to achieve this anywhere else in the world was the CSIRO HRZ wheats' programme (now discontinued). The ban on neonicotinoid seed treatments in

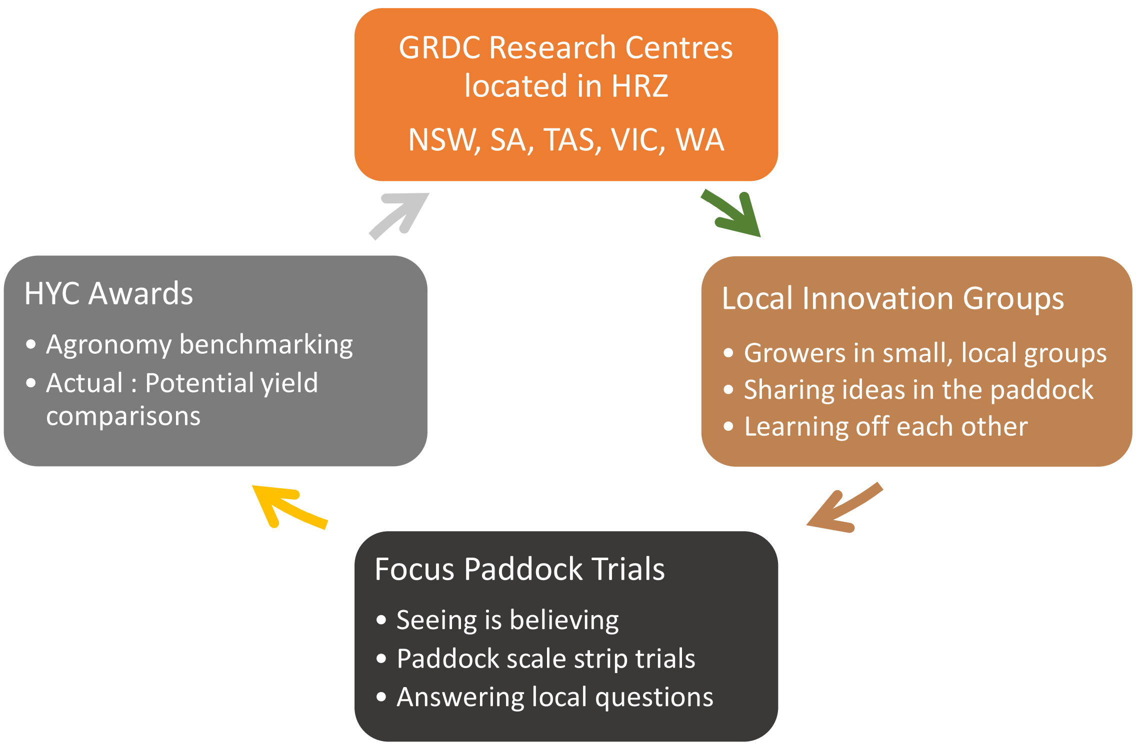
Europe has made this wheat trait even more important. It is our understanding that the technology used in Europe that has resulted in BYDV tolerance is the same as that originally developed here in Australia by CSIRO. The CSIRO BYDV tolerance involved translocating a genetic segment from *Thinopyrum intermedium* (a distant relative of wheat) containing Bdv2 onto a wheat chromosome, via a research line. Recent advances in molecular markers have fast tracked some of these developments. With the prevalence of the green bridge in HRZ regions this breeding trait is ideally suited to maximising HRZ grain production without the use of insecticides.

N.B. Please note that the high levels of insecticide usage in this experimentation was adopted to assess whether virus transmitted by aphids was indeed one of the principal causes of erect head issues in HRZ wheat production.

GRDC Hyper Yielding Crops TAS

Jon Midwood, TecCrop

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 TAS, Southern farming Systems (SFS) have been contracted to run this part of the project with Naomi Hender. 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 two innovation groups in TAS 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 three different trials were setup.

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

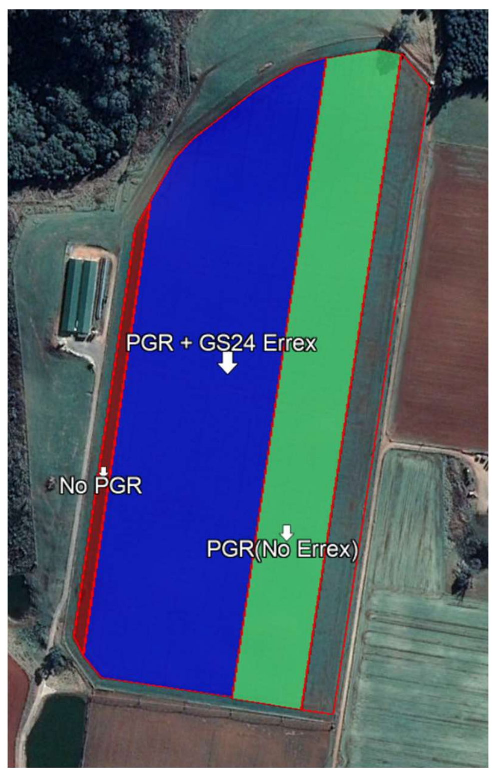
Focus paddock trials:

1. ***Sisters Creek Focus paddock trial 2020***

Research question: What is the difference in final yield from three different PGR programs on a high yielding crop of Einstein wheat?

Paddock details

Crop	Cereal: Wheat
Variety	Einstein
Area	19.00ha
Sow Rate	95 kg/ha
Sow Date	13-05-20
Harvest Date	11-02-21
Harvest Yield	10.96 t/ha
Previous crop	Potatoes
Stubble Management	Cultivator
Row spacing	125mm
Seeder Type	Disc



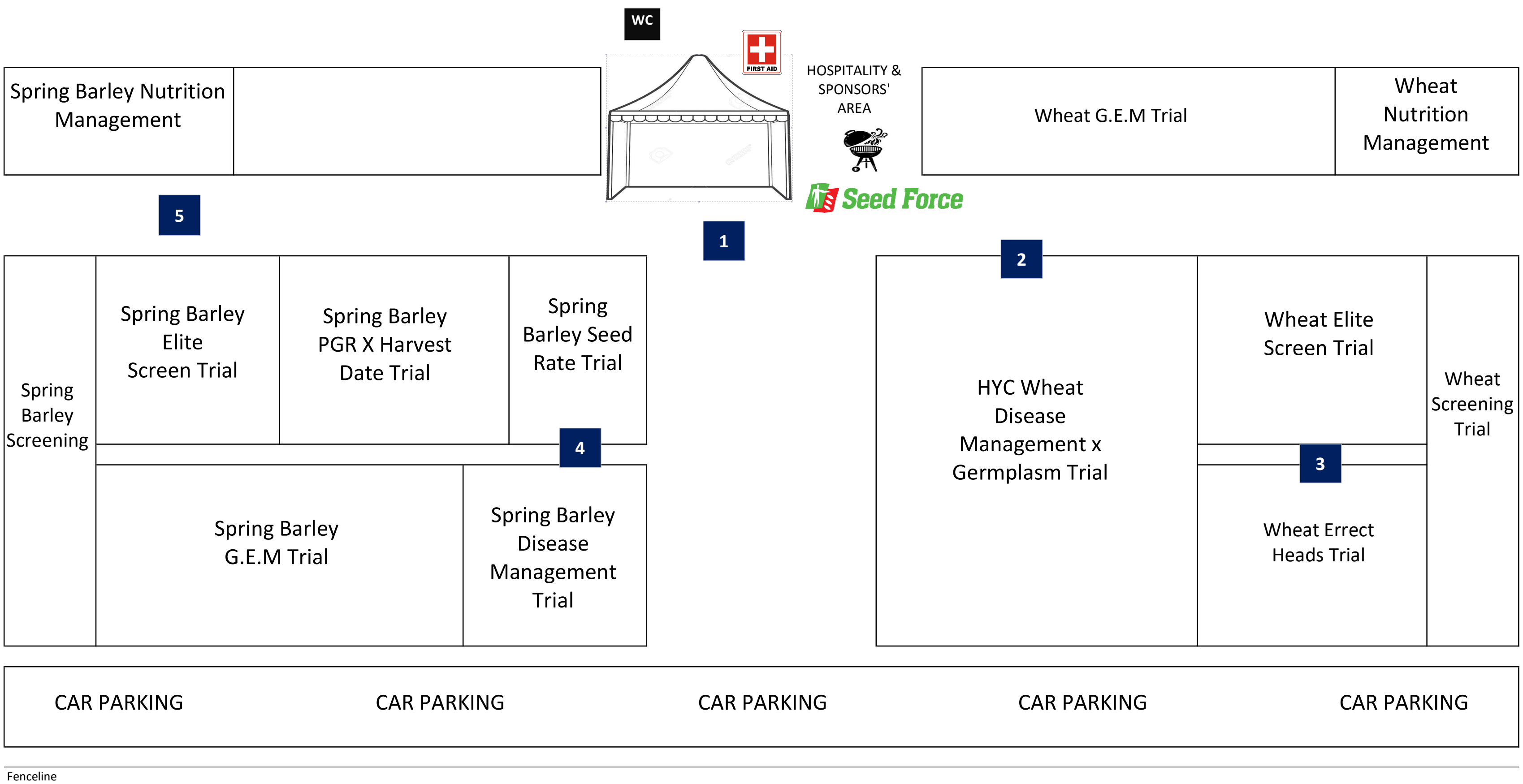
Growth Regulator Treatments

Treatment	**GS24**	**GS31**	**GS32/33**
1. Control - Grower practice		Moddus Evo	Moddus Evo
2. Early Errrex + Moddus Evo	Errex 1.3 l/ha	Moddus Evo	Moddus Evo
3. No PGR	Nil	Nil	Nil

TASMANIA HYC RESEARCH CENTRE

HYPER YIELDING CROPS
TASMANIA SITE PLAN 2021

Timing of sowing
Wheat - 29th April
Spring Barley - 8th September



TASMANIA HYC RESEARCH CENTRE

TIMETABLE

TASMANIA CROP TECHNOLOGY CENTRE FIELD DAY: THURSDAY 18 NOVEMBER 2021

Featuring the GRDC's Hyper Yielding Crops project

In-field presentations	Station No	10:00	10:15	10:45	11:15	11:45	12:15	12:45	1:30	2:15
Lachie Seears, Farmer and Nuffield Scholar Sustainably increasing productivity in the HRZ – where have we come from in the last 10 years and opportunities to close the yield gap further.	1	Welcome and opening address - Peter Carberry, GRDC General Manager Applied Research and Development and Nick Poole, Managing Director FAR Australia	1		2			Lunch kindly sponsored by Seed Force	Seeing is believing' - an informal walk through the labelled trials to view the treatment differences.	Closing address and refreshements kindly sponsored by Seed Force
Nick Poole, FAR Australia Disease management in new genetics, utilising old and new chemistry more sustainably.	2			1		2				
Brett Davey, SFS Erect heads, how is it related to BYDV control and management?	3				1		2			
Naomi Hender, SFS and local grower A farmer's perspective, achieving high yields on farm.	4		2			1				
Darcy Warren, FAR Australia Making spring sown barley more successful and N management for hyper yielding crops.	5			2			1			
In-field presentations	**Station No**	**10:00**	**10:15**	**10:45**	**11:15**	**11:45**	**12:15**	**12:45**	**1:30**	**2:15**

We would be obliged if you could remain within your designated group number throughout the day.

1	**Group 1**
2	**Group 2**

Thank you for your cooperation.

Results

Measurement type	Treatment 1	Treatment 2	Treatment 3	Sig Diff
Yield (t/ha)	11.30 a	10.83 b	10.02 c	Yes
Harvest dry matter (t/ha)		26.1	28.9	n/a
Protein (%)		11.4	12.0	n/a
Screenings (%)		3.0	3.1	n/a
Test weight (kg/hL)		69.0	67.9	n/a

Means followed by the same letter do no significantly differ

Conclusion

There was a 1.3t/ha yield improvement from using no PGR compared to the current grower approach of applying two applications of Moddus Evo at GS31 and GS32. The additional Errex applied during tillering didn't add anything to the final yield but actually reduced the yield by approx. 0.5t/ha. None of the treatments lodged significantly!

2. *Conara Focus paddock trial – 2020*

Research question: What produces the best yield and grain quality from a September sown crop of barley or wheat??

Paddock details

Crop	Barley and Wheat
Variety	Westminster and Crescendo barley, Zanzibar wheat
Sow Rate	110 kg/ha
Sow Date	22-09-20
Harvest Yield	Various
Previous crop	Poppies
Stubble management	Cover Crop sown in March
Seeder type	Tyne (Knife Point)
Row spacing	200mm

Variety Treatments

Treatment	Product	Sown	Rate kg/ha
1. Control	Westminster	22-09-20	110
2. Spring Barley 2	Crescendo	22-09-20	110
3. Spring Wheat	Zanzibar	22-09-20	110

Results

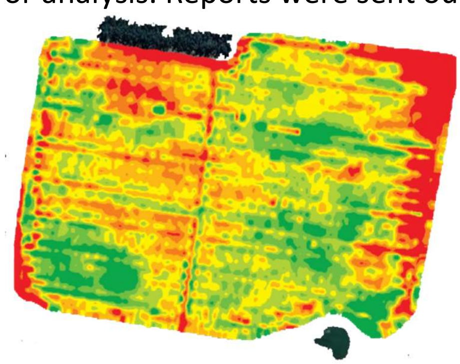
Treatment	Yield (t/ha)	Grain quality
Westminster	7.86	Malt
Crescendo	7.99	Malt
Zanzibar	7.61	Feed

Conclusion

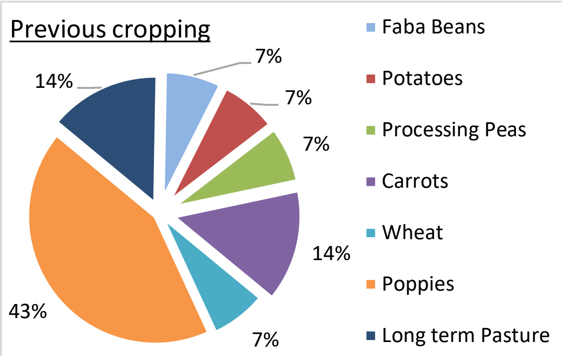
There was not much of a difference in yield between the two barley varieties with a small drop off in yield to the spring wheat variety Zanzibar. As this trial was not statistically analyzed these yield differences cannot and shouldn't be compared directly, as the differences could be due to paddock variability! However, the additional value from growing a malt barley compared to a feed wheat is significant and should be considered when deciding whether to grow spring sown barley or wheat.

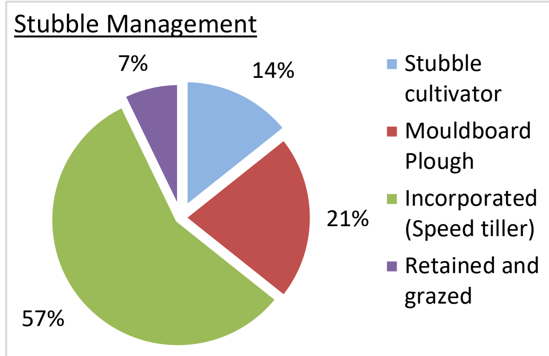
HYC Awards

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 TAS in 2020 was Vaucluse Agricultural from Conara with a 11 t/ha crop of DS Bennett wheat, sown on the 7th May after Faba beans. James Clutterbuck from Hagley won the award for the highest yield as a percentage of the potential yield in TAS. His crop of Calabro wheat, sown on the 18th April produced 10.8 t/ha, which was 89.3% of the 12.09 t/ha potential yield.



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





Agronomic Factor	Top 20% Award paddocks	Remaining 80%
Yield (t/ha)	10.9	9.8
N applied (kg N/ha)	231	201
Cost of N / tonne yield	$51/t	$39/t
Fungicides ($/ha)	$68	$51
Fungicides ($/t)	$6.2/t	$5.2/t
Number of applications	4	2.9
PGR applications	2.3	1.6
Dry Matter (t/ha)	27.2	22.8
Harvest index	51.9%	52.7%
Head count (m2)	480	391
Grains per head	43	38
1000 grain weight	47.5	46.2

Please contact Naomi Hender (0447 122783) for information about being part of this exciting project or to enter a wheat crop as a HYC award paddock in 2021.

Barley agronomy update – Achieving malting barley with high yielding varieties & maximising yield from spring sown barley

Kenton Porker[1] Darcy Warren[1], Kat Fuhrmann[1], Aaron Vague[1], Greta Duff[2], Brett Davey[2], Tracey Wylie[1] and Nick Poole[1].

[1]Field Applied Research (FAR) Australia; [2] Southern Farming Systems (SFS)

GRDC project code: (FAR2004-0025AX)

Keywords

- Barley, spring sowing, phenology, malting, disease, nitrogen

Take home messages

- The Hyper Yielding Crops (HYC) project is a GRDC national investment which aims to push the economically attainable yield boundaries of wheat, barley and canola across five states.
- Spring sown barley, sown on 1 September in northern Tasmania averaged 10t/ha yields and an experimental line from Europe - Laureate – yielded 11.42t/ha which has set a new yield benchmark for barley.
- Spring sown barley yielded higher than spring sown wheat in 2020.
- Variety maturity rankings from autumn plantings do not reflect responses from spring planting dates due to day length. Varieties that developed slower under long days were higher yielding.
- The yield constraints to spring sown barley are consistent with autumn sown, however the agronomic management levers differ in timing and intensity.
- High spring sown barley yields can be achieved by applying fungicides at lower label rates from growth stage 30 to 39.
- Hyper yielding cereal crops cannot be produced with artificial fertiliser alone; N applications are more likely to influence protein than yield on fertile soils.

Background

The Hyper Yielding Crops (HYC) project is a Grains Research & Development Corporation (GRDC) national investment which aims to push the economically attainable yield boundaries of wheat, barley and canola across five states. Through this four-year investment, high yield potential cultivars suited to local environments will be identified and the most appropriate agronomic management tactics – including paddock selection and preparation, canopy management, disease, weed and pest control, and crop nutrition strategies – will be explored to assist grower and adviser decision making. The 2020 experiments hosted at FAR Australia's Tasmania crop technology centre (Hagley) focused on irrigated barley emerging in spring rather than autumn. Most of the common yield constraints to spring sown barley are consistent with autumn sown situations. However, the management solutions required to address them differ in both timing and intensity and will be highlighted using key results from the 2020 HYC trial program. The experiments hosted at the Tasmania crop technology centre (Hagley) were sown on 1 September 2020; 310 millimetres of rain fell during the growing season from September to January, as well as 80mm of supplementary irrigated water applied.

Spring sown barley versus autumn sown cereals

Much of the focus of improving cereal productivity in recent years has been sowing slower developing germplasm earlier. However, unlike wheat, this system has not yet delivered the expected yield gains for barley in the higher rainfall areas. Currently the quicker developing spring barley varieties suited to low – medium rainfall zones such as Rosalind and RGT Planet are also the highest yielding in the higher rainfall zones irrespective of their sowing date. The record yields achieved from spring planting in 2020 highlight later sown spring-sown barley as another high-yielding sequencing option. In a management trial at FAR Australia's Tasmania crop technology centre in 2020 spring sown RGT Planet yielded 9.59t/ha and Rosalind 8.29t/ha, whereas the spring wheat Trojan yielded 8.79t/ha. Spring barley is yielding higher than spring wheat at this sowing date, this is contrary to autumn planted crops where wheat yields are generally greater than that of barley.

The climatic conditions for spring sown barley are more favourable in Tasmania compared to other regions of Australia and may be a more profitable farming system than autumn sown barley. Other benefits include its suitability in rotation to diverse Tasmanian farming systems and other areas with a similar climate. For example, spring planted barley can be grown as a summer crop that is harvested in January or February. This means there is opportunity to grow another crop, such as autumn-sown fodder. There are some major climatic differences that will influence management and germplasm decisions. The obvious climatic differences between autumn/winter sown and spring sown barley are temperature, daylength and rainfall patterns (figure 1). Incoming solar radiation also increases with daylength.

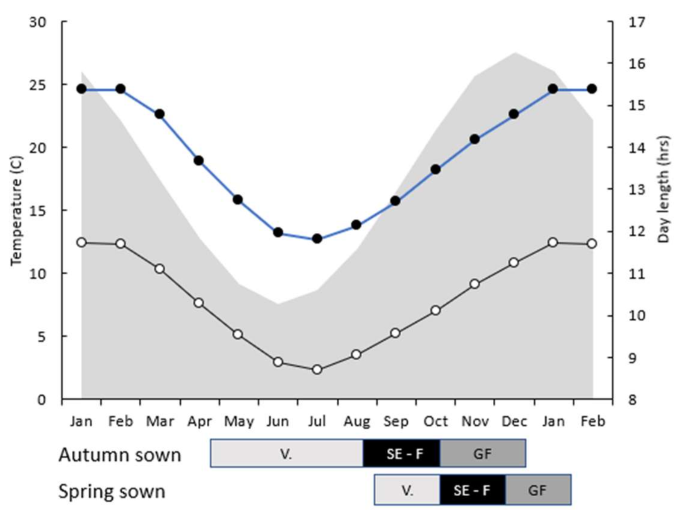


Figure 1. Schematic comparison of crop life cycle, vegetative (V), Stem elongation to flowering (SE-F), and grain filling in spring barley sown in autumn and spring. The mean max temperatures (●) and mean minimum temperatures (○) and shaded area represent the daylength (hrs) at Hagley Tasmania.

Crop development and yield
The relationship between crop development and yield is different for spring sown barley. Spring sown barley has a much shorter life cycle – this has implications for yield development and crop management.

1. Spring sown barley is sown into increasing daylength and temperatures, and thus crop development is typically a lot faster, and the growing season, (particularly the vegetative phase) is reduced relative to autumn and winter sown crops (figure 1); this has implications for yield development, seeding rates and timings of fungicide.
2. The critical period for grain number development occurs under different climatic conditions. Increased solar radiation during this period has the potential to increase yield potential if water is non limiting. However, flowering and thus grain filling is likely to occur later than optimal, and may be exposed to a greater heat stress risk than autumn sown barley; this will require cultivars that can maintain grain weight under these conditions.

Implications for variety choice: Variety maturity rankings from autumn plantings will not reflect responses from spring planting dates.

Varieties differ in development speed and the way they respond to changes in daylength and temperature. Australian breeders have selected germplasm that is adapted for autumn sowing in the lower rainfall zones that have an ability to develop faster under warm temperatures and increasing daylength. In very sensitive varieties, as the days lengthen, the crop requires fewer degree days to flower. Thus a delay in sowing date (i.e. spring planting) will result in a reduction in the duration of the sowing-flowering period because of an increase in mean temperature, as well as in mean photoperiod (figure 1). Very photoperiod sensitive varieties are unlikely to be suited to spring planting because they will develop too quickly during the critical periods for yield formation.

Matching variety to environment: Photoperiod insensitive varieties were higher yielding under spring sown conditions.

The Hyper Yielding Crops (HYC) program evaluated 25 different germplasm including Australian controls, Australian breeding lines and European material for their development and adaptation to spring sowing in 2020. Previous results from the FAR Australia led GRDC Hyper Yielding Cereals Project in Tasmania demonstrated that the optimum flowering time for wheat yields was from 17 October – 7 November. Our 2020 results showed that barley European derived germplasm, with less sensitivity to photoperiod (daylength) achieved the highest yields despite only just finishing stem elongation (Zadok growth stage 37) during this period (1st week of November), whereas quicker Australian material such as Rosalind and Fathom that began to flower in this period were lower yielding (figure 2).

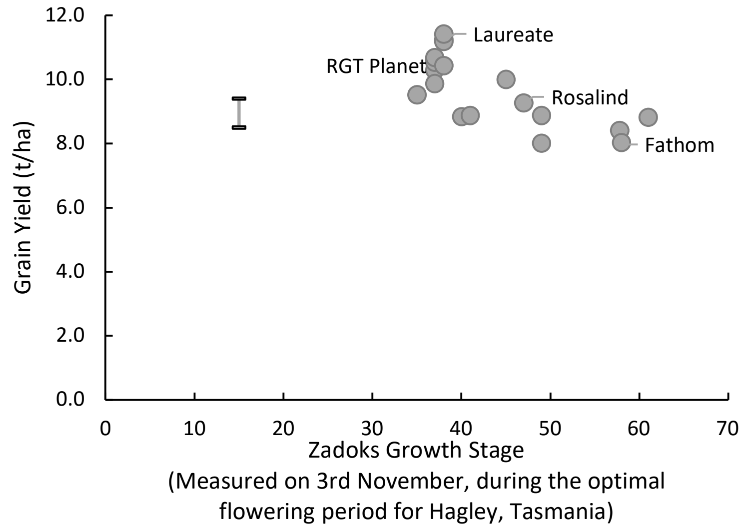


Figure 1. Relationship between Zadok growth stage during the optimal flowering period (3 November) and grain yield in spring sown barley at Hagley, Tasmania 2020 (line = LSD at 95% level of significance).

Variety yield potential

Yields achieved at FAR Australia's Tasmania crop technology centre were the highest across the Hyper Yielding Crops (HYC) program (Table 1) and demonstrated the yield potential and adaptation of barley to spring sown conditions in Tasmania. The highest yielding spring cultivar in this experiment was Laureate at 11.42t/ha compared to the quick spring cultivar control Rosalind at 9.27 t/ha; RGT Planet yielded 10.43t/ha. The long sunny days and cool grain fill conditions allowed for greater biomass accumulation and maintenance of grain weight. Alestar, Fathom, IGB1844, Laperouse, Rosalind and other photoperiod responsive cultivars yielded significantly lower (less than 9.5t/ha) than the cultivars without a strong photoperiod requirement such as RGT Planet, Laureate, HV8 Nitro, and the experimental AGTB0244 line. These results can be found at https://faraustralia.com.au/resource/

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

CTC	Rosalind (quick spring)	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.

What about earlier sown barley?
Earlier sowing, slower developing barley are one potential avenue to increase grain yield in barley. Winter cultivars are slower to develop due to vernalisation. Vernalisation is the requirement by which exposure to low temperature (between 0 – 15C) progresses crop development. Spring barley cultivars typically have little to no vernalisation responses. The cooler temperatures between May and August are generally enough to satisfy any vernalisation requirement in Tasmania, however later plantings will take much longer to satisfy their vernal requirements and flowering would occur under suboptimal conditions. Cultivars with a strong vernalisation requirement are unlikely to be suited to spring planting. Evaluation on the yield response of early sown winter cultivars is being conducted at other Hyper Yielding Crops (HYC) research sites across SA, VIC, and WA. In 2020, six row winter barley was introduced to Australia and evaluated in yield plots for the first-time. In these experiments the highest yielding two and six row winter barley were comparable with the spring barley control RGT Planet in VIC but not at any other sites, this was due to head loss and lodging in SA, and flowering too late and thus heat and drought stress in WA (table 1).

The experimental six row winter experimental line Pixel was the most consistent performer and will progress to management trials in 2021. 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. The spring sown outcomes achieved in Tasmania with the cultivar Laureate at 11.4 t/ha becomes the benchmark yield for the remainder of the project.

Disease management - 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.
Since the growing season is shorter and crops develop faster, spring sowing has the added advantage of reducing disease pressure and lodging which, in turn, reduces expenditure on fungicide and plant growth regulators (PGRs). These results need to be evaluated across multiple seasons, however the first year of trials at the Hagley site demonstrated that high spring sown barley yields, by applying fungicides at lower label rates from growth stage 30 to 39 in susceptible cultivars RGT Planet and HV8 Nitro can be achieved (Table 2). In contrast, autumn sown RGT Planet in other experiments has required more robust fungicide strategies to control disease pressure over the longer season.

Table 2. Influence of disease management strategy and variety of barley grain yield (t/ha) in spring sown barley at Hagley, Tasmania 2020.

Treatment GS00	GS30	GS39-49	RGT Planet Yield (t/ha)		HV8 Nitro Yield (t/ha)		Mean Yield (t/ha)	
---	---	---	9.41	-	8.87	-	**9.14**	**c**
---	Prosaro 300ml/ha	---	9.10	-	9.20	-	**9.15**	**bc**
---	Prosaro 300ml/ha	Radial 840ml/ha	9.39	-	9.34	-	**9.37**	**abc**
Systiva	Prosaro 300ml/ha	Radial 840ml/ha	9.72	-	9.15	-	**9.43**	**a**
---	Radial 840ml/ha	Aviator Xpro 417ml/ha	9.65	-	9.20	-	**9.42**	**ab**
---	Prosaro 150ml/ha	Radial 420ml/ha	9.80	-	9.25	-	**9.52**	**a**
Mean			**9.51**	**-**	**9.17**	**-**	**9.34**	
LSD Variety P=0.05		ns						
LSD Fungicide P=0.05			0.28		**P val**		0.041	
LSD Variety x Fungicide P=0.05			ns		**P val**		ns	

Nutrition

Despite achieving high yields, there were limited yield responses recorded to applied N in the 2020 Hyper Yielding Crops (HYC) results, however protein increases were observed. For example at Millicent in 2020, despite grain protein levels being below 10%, there wasn't any additional yield benefit from an extra 25% and 50% of applied N compared to the standard practice of 130kg N/ha (Table 3). This is a recurring trend with all high yielding experiments, irrespective of sowing date and would suggest high fertility soils fuelled by improved crop rotations rather than applied fertiliser is the pathway to achieve yields greater than 10t/ha. When applying N, the spring-planted trials demonstrated growers can apply more of the crop's nitrogen requirements early in the growing season without negatively impacting yield and achieve lower protein levels for malting. N applied later than stem elongation increased grain protein above malt requirements.

Table 3. Mean yield and protein responses to extra applied Nitrogen (N) and Sulfur (S) at Gnarwarre, VIC and Millicent, SA in 2020

Nitrogen nutrition treatment	Gnarwarre, VIC 2020 Yield (t/ha)		Gnarwarre, VIC 2020 Protein (%)		Millicent, SA 2020 Yield t/ha		Millicent, SA 2020 Protein (%)	
Standard Practice*	7.06	-	10.1	b	8.87	-	9.9	b
Additional 25% N	7.27	-	11.8	a	8.95	-	10.0	b
30kg S + Additional 25% N	7.41	-	12.0	a	9.14	-	9.9	b
Additional 50% N	7.08	-	12.3	a	8.89	-	10.2	a
45kg S + Additional 50% N	7.45	-	11.9	a	9.10	-	10.2	a
Mean	7.25		11.6		8.99		10.0	
LSD (p=0.05)	ns		0.8		0.67		0.1	
P Val	0.305		0.001		0.857		0.001	

*All treatments had 100kg/ha MAP, standard practice = 148kgN/ha at Gnarwarre, and 130kgN/ha at Millicent

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. A milling wheat was also included at spring sowing in Tasmania, and demonstrates yields greater than 8t/ha can be achieved.

The spread between box plots in the visual demonstration below (figure 5) 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.

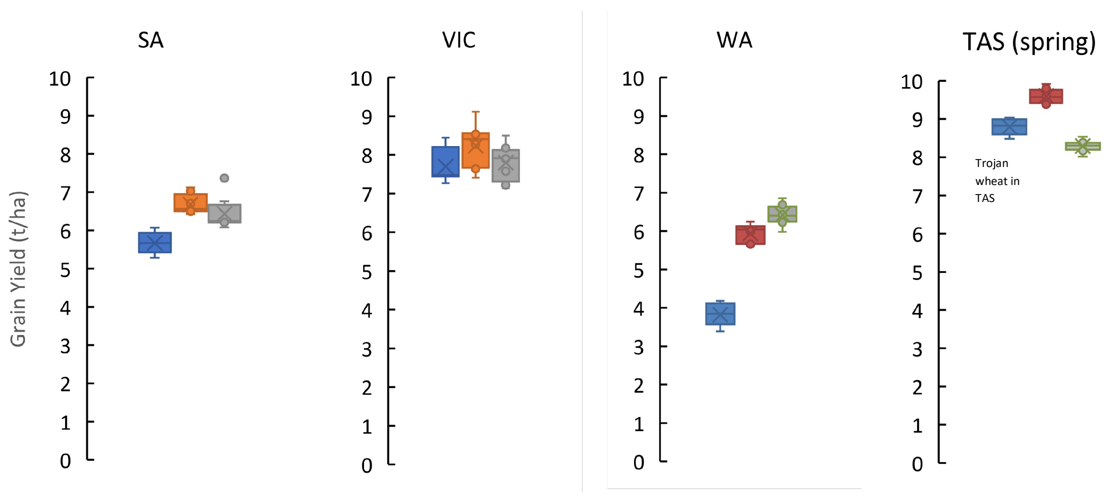


Figure 2. *Boxplot representation blue (•Cassiopee winter barley (Trojan in Wheat in TAS), •RGT Planet, and •Rosalind) grain yields across all management combinations (n = 8 per box plot) and environments (blue = trojan wheat in TAS spring sown).*

Conclusion

The key to achieving higher yields in barley 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 sowing date and or defoliation that delayed the timing crops were intercepting maximum light interception into more optimal light conditions. Time of sowing was also a big factor in disease management and our SA and TAS data suggests similar high yields can be achieved by later sowing with cheaper fungicide programs.

These results are part of a broader GRDC Hyper Yielding Crops (HYC) project and help to determine whether growers have the correct genetic and management tools to reliably achieve high yields in all regions of the southern high rainfall zone (HRZ). The results so far demonstrate date germplasm selection, disease control, and high inherent fertility are the foundations of high yielding systems. Growers seeking more information or detail about the HYC experiments are encouraged to visit the FAR Australia website results: 210325-2020-HYC-Project-2020-Results-Barley-Final.pdf (faraustralia.com.au)

Acknowledgements
The research undertaken as part of this Hyper Yielding Crops (HYC) project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC; the authors would like to thank them for their continued support. Field Applied Research (FAR) Australia gratefully acknowledges the support of all of its research and extension partners in the 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.

Useful resources
FAR Australia website Barley results: 210325-2020-HYC-Project-2020-Results-Barley-Final.pdf (faraustralia.com.au)
Hyper Yielding Crops podcast
https://grdc.com.au/news-and-media/audio/podcast/hyper-yielding-crops-initiative
Hyper Yielding Crops
https://www.youtube.com/watch?v=UYYgzv_9ttA&t=12s
Hyper Yielding Crops podcast
https://soundcloud.com/user-395150285/hyper-yielding-crops-hyc-a-grdc-national-investment
HYC Provisional 2020 Wheat Results
https://faraustralia.com.au/wp-content/uploads/2021/04/210324-HYC-Project-2020-Results-Wheat-Final.pdf
HYC Provisional 2020 Canola Results
https://faraustralia.com.au/wp-content/uploads/2021/04/210325-HYC-Project-2020-Results-Canola-Final.pdf

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The science behind high yielding crops

John Kirkegaard CSIRO

There is nothing that gets a conversation going better at the pub than record-yielding crops. Although there may be some luck involved, there is no magic. We understand a lot about the key factors required to achieve high yields. In this article, I will briefly outline the major factors driving high yield and use a recent world record canola crop (7.2 t/ha) grown right here in Australia to demonstrate the point. The crop was grown at Oberon in NSW in 2020.

(1) Light and temperature in the "critical period"

All crops have a 'critical period" in which the number of grains is set, and grain number drives very high yields. In cereals, the critical period is concentrated in the 3 weeks before flowering. In canola and pulses it is in the period 1-4 weeks after the start of flowering. 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.

To maximise growth, the crop requires cool temperatures – which increase the duration of the critical period - and sunny days which increase photosynthesis for growth.

More photosynthesis for more days means more grain and more yield.

A common way to measure this is the photo-thermal quotient (PTQ) – or CSI – the cool sunny index which is simply (total radiation/average temperature) in the critical period. This ranges from low values of 1.0 in places like Bangladesh up to 2.0 in places like UK and NZ.

It's no surprise that world-record crops are often achieved in places like UK or New Zealand with crop flowering in long summer days, with cool temperatures.

In Australia, typical PTQ's in the critical period may be 1.0 in the Ord River WA, 1.2 at Gatton in QLD, 1.5 at Yanco, 1.7 in Canberra and can vary with season depending on temperature and cloud cover.

The PTQ puts an upper limit on the potential yield in any environment.

(2) Water limited potential

Due to our dry and variable climate, Australian farmers are much more used to thinking of water as the main limiting factor for crop yield. Water is more plentiful in the high rainfall zone or under irrigation, but it will still limit yield in many years.

Rules of thumb to estimate yield potential from water supply have been used and updated since French and Schultz first studied wheat crops in South Australia in the 1980.

The best crop with no other limits on yield will produce 25 kg/ha/mm water supply for cereals and 15 kg/ha/mm for canola.

Water supply (mm) can be estimate as [in-season rainfall + 0.3 x fallow rainfall – 60 (evaporation)].

We often cap this at a maximum of ~500mm as higher amounts are likely to generate runoff or leaching in most soils – there is only so much water that can be held by the soil in a given season.

(3) Nitrogen

We know from numerous published studies that to grow each tonne of grain yield will require a total nitrogen supply to the crop (from soil and fertiliser) of 40kg/ha N for wheat and 80 kg/ha for canola.

We can use this rule of thumb to estimate whether we had a sufficient supply of N to support the yield potential that was possible from the PTQ and the water supply at the site.

Do these factors make sense for the Oberon world record crop?

Light and temperature in the critical period

Oberon is located in the southern Tablelands of NSW at 1000m elevation and features fertile basalt soils. As a result, it experiences very cool conditions through the spring period during the critical period. The winter canola crop (Hyola970) sown in February has an ideal flowering window and avoided frost and heat. Despite above average rainfall in 2020 the critical period was sunny.

The calculated PTQ in 2020 was 1.72, sufficient for **8.0 t/ha canola** or **13 t/ha wheat**.

Water supply

In 2020, the area received a total of 900mm rainfall, evenly distributed throughout the growing season (676mm in season; 214mm in summer fallow) with no periods of waterlogging. This calculates as 680mm water supply, so the maximum 500mm cap was easily reached.

The 500mm total water supply cap was sufficient for **7.5 t/ha canola yield** or **12.5 t/ha wheat yield.**

Nitrogen supply – probably the key in 2020!

The crop was sown in a long-term pasture paddock with no previous cropping history. The grower had run free-range cattle <u>with grain feeders</u> on the paddock in a fattening business for the previous 15 years. Together with the inherent fertility of the basalt soil, this means the crop was likely to be supplied with enormous rates of soil fertility.

The crop received only 103 kg N/ha as fertiliser - 80 kg/ha MAP (8 kg N/ha) at sowing and 200 kg/ha urea top-dressed on 2 September (95 kg N/ha). This means that of the 576 kg N/ha required by the 7.2 t/ha canola crop, around 480 kg N/ha has been provided by the soil! Is this possible?

No soil measurements were taken at the site, but previous measurements of mineral N in southern NSW over many years have shown that it is not uncommon to find 200-300 kg mineral N/ha in the soil to 1.8m depth after removal of long-term pastures. Grain feeding cattle with manure return would have boosted fertility levels even more. In-season mineralisation in such a wet season would also have been high, and up to 200 kg N/ha have mineralised in season after lucerne-based pastures. The very long growing season (Feb-Dec) would have facilitated a long mineralisation period and the deep-rooted winter canola (can root to 4m depth) would have accessed any N moving to deeper layers.

It is likely that the specific paddock history at Oberon provided enormous natural N fertility was the key reason that this crop was able to come very close to its true potential as defined by PTQ and water supply.

Don't forget the excellent agronomy!

Obviously, no crop can reach its potential without excellent management to establish, manage and protect the potential. The timely and effective operations of Peter Brooks (grower) and James Cheetham (agronomist) are clearly a very large part of the success!

Yield potentials in Tasmania Hagley – learnings from research to close the yield gap and raise potential

Kenton Porker, Nick Poole, Tracey Wylie, Max Bloomfield, Kat Fuhrmann. FAR Australia

Based on simple water use efficiency metrics, and the photothermal quotient concept outlined in the John Kirkegaard paper it has been possible to use updated variety yields from FAR experiments at Hagley since 2016 and previous experiments within the GRDC HYC project where water is non limiting to redefine our yield potentials for Tasmania

In high rainfall zones the photothermal quotient may limit yield potential as often as water supply to the crop (coastal, cloudy areas). However, Tasmania is fortunate in that temperatures remain cooler into summer when radiation conditions improve, and thus Tasmania has a higher PTQ than the mainland high rainfall zones Southwest Victoria (Gnarwarre) and South-East South Australia (Millicent) (figure 1).

What this means is that Tasmania is likely to be able to achieve on average of over 14t/ha in wheat, and 12t/ha in Barley. However, closing the gap between actual yield achieved on farm and potential will depend on management to be discussed.

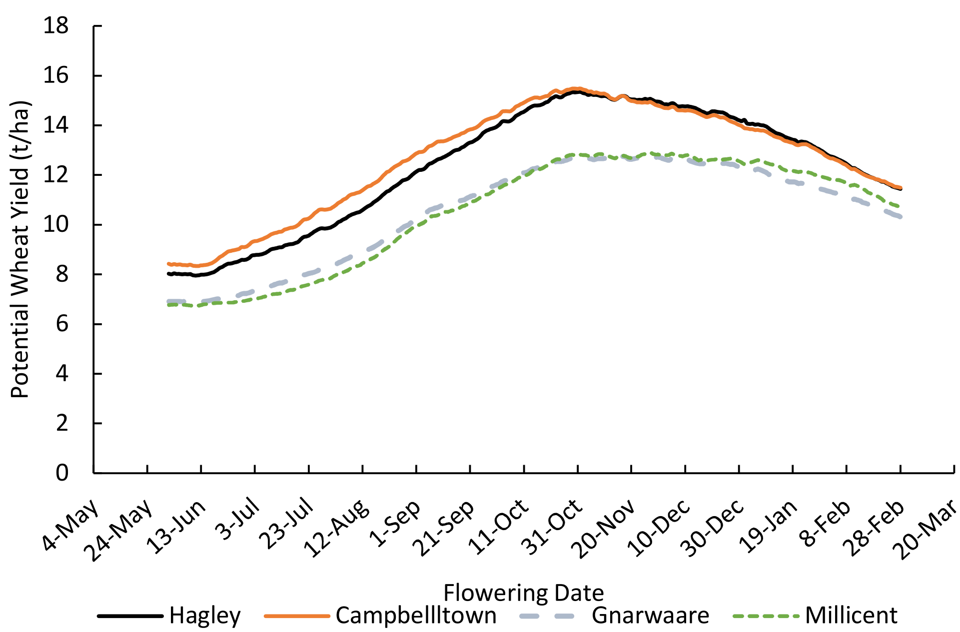

Figure 1. Long term potential yield derived from the photothermal quotient (radiation and temperature) for Hagley TAS, Campbelltown TAS, Millicent SA, Gnarwarre Vic from 1990 - 2020

With supplementary irrigation and the rainfall amounts achieved in Tasmania, crops are also unlikely to be water limited. Therefore, crop management should be focussed on ensuring maximum light interception is achieved in the critical period for yield (the ~28days or 300 degree day period prior to flowering).

What does this mean for crop management?

a) Flowering on time is important to align the critical period with the most optimal conditions for crop growth
b) Crops must have the genetic potential to achieve these aspirational goals. Wheat has a higher yield potential than barley
c) Crop canopies must be managed so that they are as intercepting light and photosynthesis is maximised. Controlling disease and keeping crops standing during the critical period are the two factors when managed corrected that have led to the greatest yields in HYC experiments.
d) Nitrogen Supply must not be limited to achieve the photothermal quotient yield potential, however HYC experiments demonstrate this has not been possible to achieve with bagged Nitrogen and high fertility is required.

Flowering time: choosing a cultivar and sowing date to achieve 14 tonne potential?

For a cereal cultivar to achieve 14t/ha, it needs to have the genetic yield potential to do so, but it must also have the correct flowering behaviour. 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 the 300-degree days period before awn emergence in barley and flowering in wheat which equates to approximately 28 days in most seasons in Tasmania.

New genetics offer improved yield and may convert light and water into yield more efficiently than older genetics in the high rainfall zones. In particularly cultivars that are coming out of Europe where breeding for high yield potential is a greater focus. This is demonstrated in the barley where Laureate and RGT Planet are the highest yielding cultivars, and Accroc, Annapurna, and RGT Calabro in wheat all direct European imports. Breeding programs in Australia are understandably more focused on breeding for improved water use efficiency and earlier flowering for the wheat belt. However, as this data highlights, yield may be limited by light in the majority of seasons rather than by water when flowering early.

Winter Wheat yields are consistently achieving >12tonne:

In Tasmania field experiments of early sowing (Mid – late April) well adapted Australian spring cereal cultivars such as Scepter, Trojan are typically flowering in mid-September and while yields of up to 10tonne have been achieved they have rarely exceeded it. Whereas, slow developing winter feed wheats such as RGT Accroc, Annapurna, and RGT Calabro are flowering during the period from 25th October to 15 November consistently capitalising on improved light conditions and achieving yields greater than 12t/ha. This has translated to substantial increases in wheat yields for the region.

This is because their critical period is aligned with the most optimal conditions to achieve 12t/ha and they flower in the first few weeks of November. 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 and

2). Flowering earlier than this the PTQ yield potential has been less than 10t/ha in more than 50% of years.   While it must be also be noted flowering earlier increases frost risk, and while PTQ increases with later flowering so to does heat risk. However we believe for wheat early to mid November minimises losses to all three stresses frost, heat, and drought (figure 2).

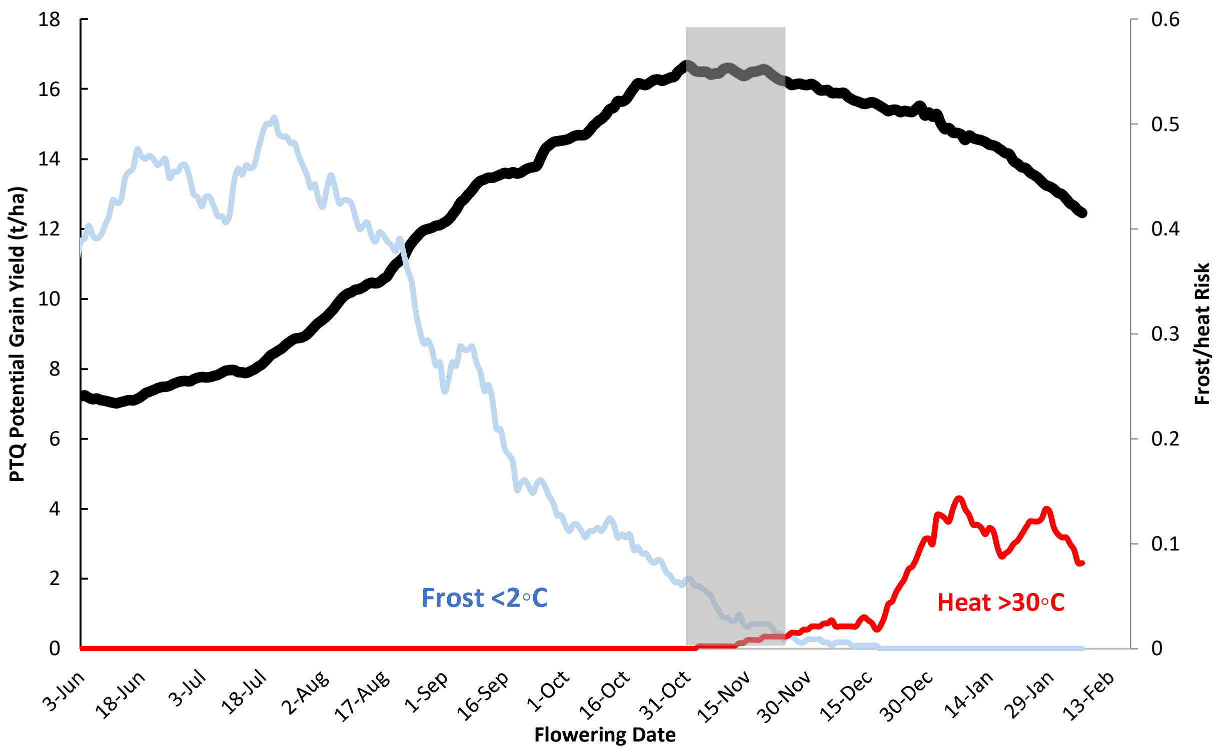

Figure 2. The long term photothermal quotient potential grain yield, and relative frost and heat risk for Hagley Tasmania (from 1990 - 2020), shaded area represents the optimum time of flowering based on these metrics.

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.

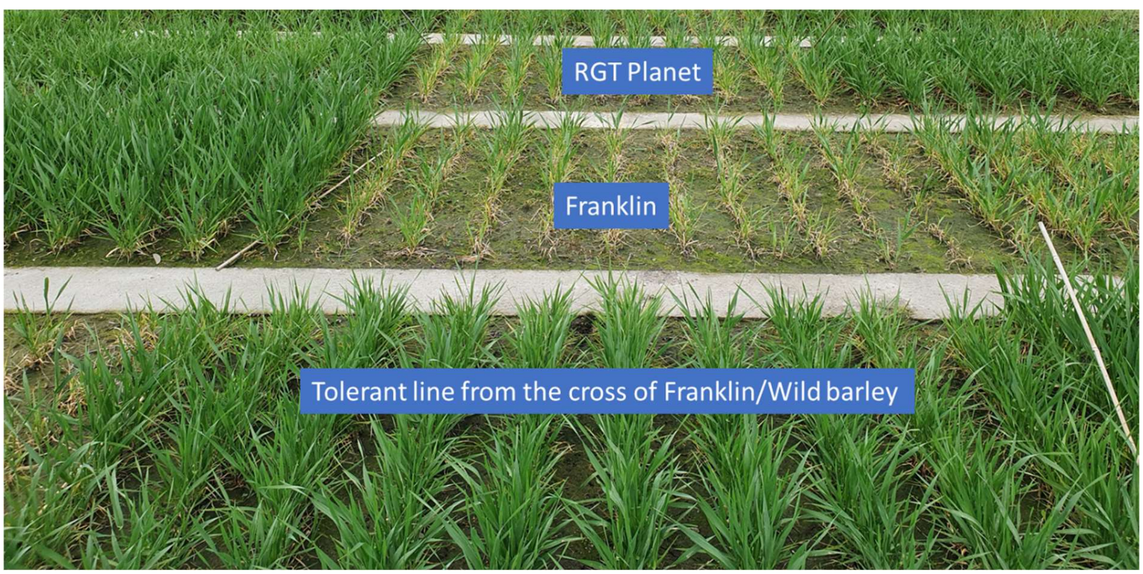

Figure 1. *Waterlogging trials in Tasmania. One month after waterlogging finished. Waterlogging treatment started at 2.5 leaf stage and lasted for two months.*

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

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